Warrell Creek to Urunga
Upgrading the Pacific Highway

ENVIRONMENTAL ASSESSMENT

VOLUME 1 ENVIRONMENTAL ASSESSMENT

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10. Flora and fauna

Flora and fauna is identified as a key issue in the Director-General's requirements. A detailed flora and fauna assessment for the Proposal was undertaken and is presented in this chapter. This assessment is supported by Working paper 1 – Flora and fauna.

Director-General's requirements	Where addressed in the EA
Flora and fauna – including but not limited to: ■ threatened terrestrial and aquatic species, populations, ecological communities and/or critical habitat including erosion of genetic stock; and ■ targeted surveys of threatened flora and fauna species including *Marsdenia longiloba* (Slender Marsdenia), *Amorphospermum whitei* (Rusty Plumb), *Acacia chyrsotricha* (Newry Golden Wattle), *Acronychia littoralis* (Scented Acronychia) and *Parsonsia dorrigoensis* (Milky Silkpod); ■ terrestrial habitat and biodiversity including native vegetation loss, habitat fragmentation, weed infestation, wildlife and riparian corridors, riparian habitat, and groundwater-dependant communities; ■ aquatic habitat and biodiversity including wetlands, mangroves, and seagrass; ■ regional scale cumulative impacts and the significance of the impacts of the project in the context of the PHUP; and ■ including consideration of draft *Guidelines for Threatened Species* Assessment (DECC/DPI July 2005) and *Policy and Guidelines for Aquatic Habitat Management and Fish Conservation 1999* (Section 6.4 and 6.5 specifically) (NSW Fisheries, 1999).	Section 10.3 Existing environment Section 10.3.2 Terrestrial vegetation Section 10.3.3 Terrestrial fauna Section 10.3.4 Aquatic fauna Section 10.4.2 Potential flora impacts Section 10.4.3 Potential fauna impacts Section 10.4.4 Potential impacts to aquatic habitats and biodiversity Section 10.4.5 Cumulative impacts Section 10.5 Management of impacts Section 10.5.6 Compensatory habitat

10.1 Background

Flora and fauna issues have been considered during the development of the route options, selection of the preferred route and preparation of the environmental assessment. Data collated from surveys undertaken in the route selection phase of the Proposal (2003-2006) together with targeted surveys along the Proposal in 2007-2008 have been used in this environmental assessment to identify the existing conditions and potential impacts of the Proposal.

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

10.2 Assessment approach

10.2.1 Assessment stages

The terrestrial and aquatic flora and fauna investigations within the study area were conducted in a number of stages as detailed below:

- Review of existing information on protected and threatened flora and fauna species, populations and ecological communities and their habitats within the study area (as listed in the *Commonwealth Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act), *NSW Threatened Species Conservation Act 1995* (TSC Act), *Fisheries Management Act* 1994 (FM Act) and the *National Parks and Wildlife Act* 1974 (NPW Act)).
- Detailed evaluation of the terrestrial and aquatic flora and fauna habitats of the study area, drawing from the results of previous investigations as well as specific ground-truthing and assessment. This aimed to delineate the separate structural habitats of the study area and compile information on the type and availability of habitat features.
- Analysis of those threatened flora and fauna species deemed potential inhabitants of the study area (i.e. potential subject species). This analysis utilised the listings of threatened species in the locality and wider sub-region and the nature of the preferred habitats of these threatened species.
- Design and implementation of flora and fauna field surveys (terrestrial and aquatic) within the study area to describe and map the extent of vegetation communities, compile lists of the biological species diversity and adequately target the potential presence of threatened biota.
- Assessment of the Proposal under the provisions of the State and Commonwealth legislation to determine whether there was likely to be a significant impact from the Proposal on threatened species, populations, ecological communities or their habitats.
- Devise and formulate protective and mitigatory measures that could be applied to minimise potential ecological impacts with due consideration of relevant recovery plans for species and the *Policy and Guidelines for Aquatic Habitat Management and Fish Conservation* (NSW Fisheries 1999) (Sections 6.4 and Section 6.5 specifically).

The various ecological studies for terrestrial and aquatic species undertaken as part of the environmental assessment process are detailed in Working paper 1 – *Flora and fauna.*

10.2.2 Study areas

The study area for the terrestrial flora and fauna investigations was taken to be the design footprint plus a 10 metre buffer to allow flexibility in design. In reality, clearing would be undertaken three metres or five metres from the edge of the construction footprint, with scope to retain individual trees or vegetation communities within the road boundary of the Proposal. The study area also includes any proximal areas that could potentially be affected by the Proposal either directly or indirectly. This included areas within the road boundary, ancillary construction areas, drainage areas and local and regional corridors.

The study area for the aquatic investigations extended upstream and downstream of the twelve creeks and rivers sampled to take into account the fisheries in the locality.

10.2.3 Data collection

The data collection for the environmental assessment involved literature and database reviews and field survey, as described below.

Literature and database reviews for the study area including key habitats, corridor and ecosystem mapping including:

- Discussions with personnel from the DECCW and the DII, including the Aquatic Habitat Protection Unit and Forests NSW.
- A landscape assessment including a review of aerial photography, review of NSW landscapes mapping (Mitchell 2003) and visual analysis of vegetation patches and connectivity across the landscape.
- A review of the Climate Change Wildlife Corridors for north-east NSW (DECC 2007b).
- Anecdotal reports from authorities, local ecologists, naturalists and aquatic studies undertaken by the Ecology Lab.
- DECCW's *Draft Sea Level Rise Policy Statement* (February 2009).

Flora assessment:

- Comprehensive flora field surveys over the three seasons between November 2007 and April 2008 including transects, traverses and quadrat based surveys.
- Targeted survey for *Marsdenia longiloba* (Slender Marsdenia), *Amorphospermum whitei* (Rusty Plum), *Acacia chrysotricha* (Newry Golden Wattle), *Acronychia littoralis* (Scented Achronychia) and *Parsonsia dorrigoensis* (Milky Silkpod). Slender Marsdenia is listed as vulnerable and Scented Achronychia and Milky Silkpod are listed as endangered under the Federal EPBC Act. All are listed as either endangered or vulnerable under the TSC Act.
- Collection of general ecological landscape, baseline and habitat data across the study area between 2003 and 2005 as part of the route options assessment phase. Comprehensive flora field surveys over the three seasons between November 2007 and April 2008 including transects, traverses and quadrat based surveys within the Proposal boundary.

Fauna assessment:

- Development of a robust survey design Development of a robust survey design in accordance with the *Draft Threatened Biodiversity Survey and Assessment Guidelines* (DEC 2004).
- Four seasonal fauna sampling between 2005 and 2008 using various live mammal trapping, cage traps, hair tubes, harp traps (for bats), bat call recording, spotlighting, bird survey, call playbacks, frog and reptile searches, stagwatch surveys and scat searches.
- Targeted surveys for threatened species known or likely to occur in the study area.
- Hollow bearing tree survey.
- Aquatic ecology assessment:
- Electrofishing, bait trapping, fyke netting, macro-invertebrate sampling, gill and seine netting upstream and downstream of the Proposal in freshwater and estuarine waterways traversed by the Proposal.
- Water quality readings at each of the twelve sites.

10.2.4 Assessment team

The team associated with the completion of this assessment is listed in Table 10-1, together with details of their qualifications and role. All work was carried out under the appropriate scientific investigation licences as required under Clause 22 of the National Parks and Wildlife Regulations 2002, Section 132C of the *National Parks and Wildlife Act* 1974 and Section 37 of the FM Act, in addition to animal research authority under the DII.

Table 10-1 Assessment team

Name	Qualification	Role
Chris Thomson	BAppSc	Ecologist - Team Leader Terrestrial Ecology, fauna survey and assessment
Andrew Carty	BEnvSc	Botanist – field surveys, targeted threatened flora surveys, reporting, GIS
Martin Sullivan	BSc	Botanist – field surveys, reporting, condition assessment
Sarah Foy	BSc; MEnvStud	Aquatic Ecologist – fish and macro-invertebrate field surveys, reporting
Vanessa Bain	BEnvSc	Ecologist – fauna field surveys
Dr. Adam Cohen	BEnvSc; PhD	Ecologist – Team Leader Aquatic Ecology, fish surveys and impact assessment
Peta Johnston	BMarSc	Aquatic ecologist, field surveys

10.3 Existing environment

10.3.1 Landscape context

The study area lies within the NSW North Coast Bioregion (Thackway, R. and Cresswell, I. D. 1995). Two hundred and two flora species found in the bioregion are listed in the schedules of the TSC Act. Of these, 108 are endangered, 89 are vulnerable and five are considered extinct in the bioregion (NSW NPWS 2002). A major factor

that contributes to this high species diversity is the location of the Macleay – McPherson overlap zone. This is defined as the area of eastern Australia where the tropical and temperate zones overlap.

The NSW North Coast Bioregion has the second highest proportion of lands under conservation reserves of the NSW Bioregions. In total 1,061,709 hectares or 18.65 per cent of the bioregion is conserved. There are twelve national parks and nature reserves located within 20 kilometres of the Proposal. A number of state forests are located within the landscape, these properties are managed primarily for forestry activities although they also have some conservation values. There are numerous records of threatened flora and fauna species within these state forests.

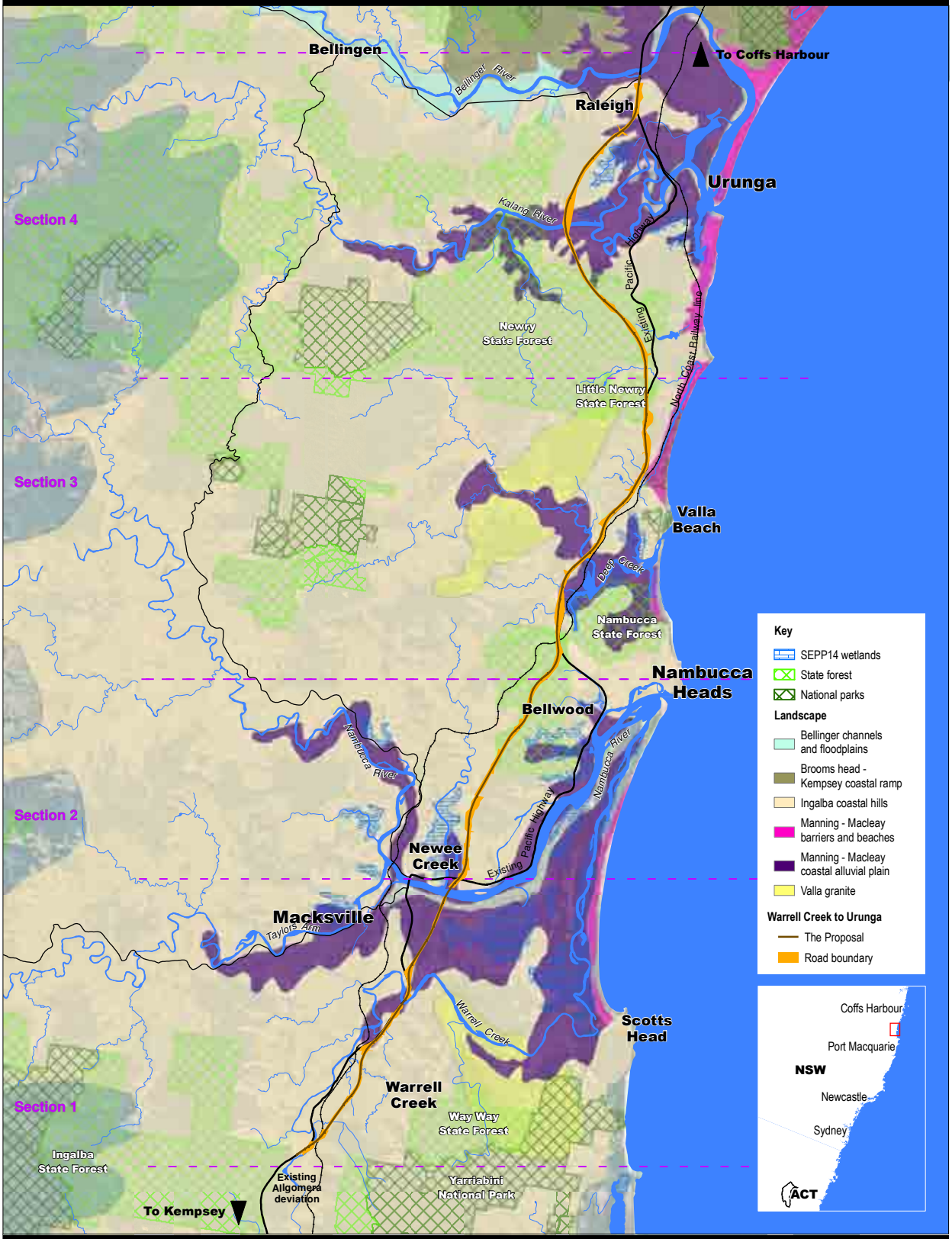
According to the Landscapes of NSW (Mitchell 2003), the study area lies across two landscape types described below and shown in Figure 10-1. The Manning Macleay Coastal Alluvial floodplains are present on the alluvial floodplains of the Nambucca and Kalang Rivers and smaller creeks such as Deep Creek, Boggy Creek and Oyster Creek. Soils are generally dark organic loams and silty clays on the floodplain, gradational brown loam and yellow-brown texture contrast soil on terraces, and organic silty mud in swamps.

The Ingalba Coastal Hills are associated with the slopes on lower Permian slate, phyllite, schistose sandstone and schistose conglomerate with a general elevation of up to 830 metres. Soils include thin, stony gradational loam and sandy loam on slopes grading to yellow brown texture contrast soils on lower slopes and in valleys. Within the study area the Ingalba Coastal Hills can be identified as the hills and slopes rising above the floodplain reaches of the Nambucca and Kalang Rivers. Remnant forested areas are dominated by dry sclerophyll forests with moist sclerophyll forests in gullies.

The Proposal traverses low hills and floodplains associated with the Nambucca, Kalang and Bellinger Rivers. Extensive clearing for agriculture, logging and residential development have been prevalent through many of these areas and are most obvious within Nambucca, Newry and Little Newry state forests, the lands surrounding the townships of Macksville, Nambucca Heads and Urunga and adjoining floodplain areas. Logging within the state forests has been most evident within the easily accessible areas close to tracks and forestry roads in contrast to the steep sloping creek and riparian areas where some remnant tree cover has been retained as creek buffers with fewer disturbances. Comparatively smaller areas of unlogged and selectively logged forests occur on privately owned lands north of the Kalang River where logging has been of a reduced scale.

Much of the pre-European vegetation of the lowland floodplain in the study area would have comprised lowland rainforest, swamp forests, wetlands and wet floodplain eucalypt forests. The vast majority of the vegetation has been cleared due to the fertile soil types for agriculture and proximity of the river and coast for transport and settlement. Fragments of vegetation remaining on the floodplain are characteristic of vegetation associations of the NSW North Coast Bioregion which have been scheduled as endangered ecological communities (EECs) under Part 3 of Schedule 1 of the TSC Act.

FIGURE 10-1 | LANDSCAPE TYPES



10.3.2 Terrestrial vegetation

10.3.2.1 Vegetation Communities

In total, seven vegetation structural types, with 590 different plant species from 132 families were represented in the Proposal study area (see Table 10-3). This total comprises 166 species of monocotyledon, 390 species of dicotyledons, 27 fern species, two cycad species and three conifer species. Of the 590 flora species recorded, 99 (17 per cent) are introduced species, and the remaining 83 per cent are native species indigenous to the local area. Exotic species are dominant along many roadsides, cleared paddocks and areas of disturbed vegetation.

10.3.2.2 Endangered ecological communities

No nationally EECs, as listed under the Commonwealth EPBC Act have been located in the study area. However, several EECs listed in NSW under the TSC Act have been located in the study area. These are described in Table 10-2 and their locations are shown in Figure 10-2.

Table 10-2 Endangered ecological communities within the study area

Vegetation community	Endangered ecological community (*Threatened Species Conservation Act* 1995)	Habitat	Study area section
Mixed floodplain forest	Subtropical Coastal Floodplain Forest of the NSW North Coast Bioregion	Gully areas along creek lines on metasediments and alluvium	1,2,3,4
Lowland rainforest	Lowland Rainforest of the NSW North Coast and Sydney Basin Bioregion	Riparian corridors and alluvial flats	1,2,4
Swamp forest – swamp mahogany/paperbark	Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregion	Floodplain areas on waterlogged humic soils	1,2,3,4
Swamp forest/swamp oak	Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner Bioregion	Floodplain areas on alluvial soils with a saline influence	1,3,4
Freshwater wetland	Freshwater Wetlands on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregion	Low elevated depressions on floodplains, alluvial soils.	1,3,4
Coastal saltmarsh	Coastal Saltmarsh of the NSW North Coast, Sydney Basin and South East Corner Bioregion	Edges of estuaries	2

The condition of the EECs present in the study area was assessed in the field by assigning a subjective rating score based on the degree of naturalness versus modification and disturbance. The structural and floristic diversity, level of weed invasion, the size of the patch and connectivity or proximity to other patches of the same community in the landscape were assessed and used to determine the ecological condition of EECs. Sites were ranked as either high, high-moderate, moderate, low-moderate or low condition. High condition areas include larger patches of intact vegetation that are relatively free of significance disturbance, whilst low condition areas include small fragmented areas of vegetation with an abundance of weed species that have been disturbed from clearing, grazing and other disturbances. Condition classes are shown in Figure 10-2.

Table 10-3 Vegetation types identified in the study area

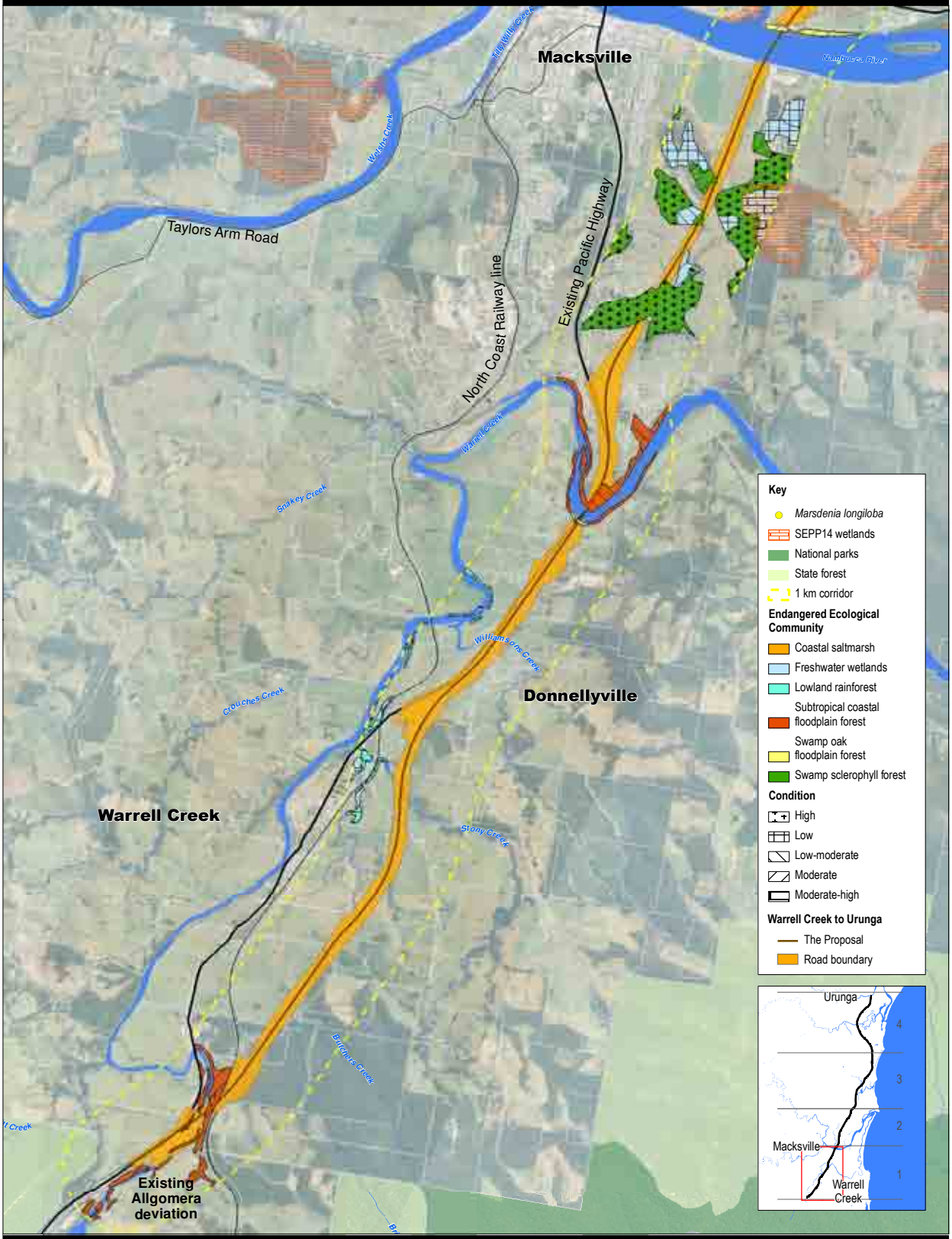
Vegetation structural type	Structure and floristics
Dry sclerophyll forests Dry sclerophyll forest associations occupy upper slopes and crests of the study area. The vegetation structure comprises a canopy dominated by Eucalypts with a diversity of sclerophyll shrubs, grasses and forbs. The structure and diversity of the understory varies depending on the fire regime and degree of disturbance of each area.	Blackbutt association Blackbutt forest occupies the dryer more exposed and elevated areas with well drained soils. This forest type is dominated by Blackbutt (*Eucalyptus pilularis*), with Grey Gum (*Eucalyptus propinqua*), Tallowwood (*Eucalyptus microcorys*), White Mahogany (*Eucalyptus acmenoides*), Ironbark (*Eucalyptus paniculata*) and Pink Bloodwood (*Corymbia intermedia*). Dry blackbutt forest occurs throughout large portions of Nambucca, Newry and Little Newry State Forest and has been heavily logged. This forest contains a moderate diversity of shrub and groundcover species particularly older regrowth. Smooth-barked apple/scribbly gum/bloodwood association. This association typically occurs in slightly elevated coastal lands, adjoining the lower slopes of wetland and swamp forest communities. These communities have fewer impacts from past logging due to an absence of suitable timber species in the canopy. Representative dominant species are Smooth-barked Apple (*Angophora costata*), Scribbly Gum (*Eucalyptus signata*) and Red Bloodwood (*Corymbia gummifera*). The presence of fertile soils and a generally high water table has resulted in these forest types being more floristically and structurally diverse than the surrounding dry blackbutt forests. They also comprise a greater percentage of large remnant trees and subsequently tree hollows, particularly mature Smooth-barked Apple and Red Bloodwood. Scribbly gum/bloodwood association. This association is generally positioned in elevated areas in similar locations to the dry blackbutt dominated communities, although on poorer soils. The largest stands within the study area were located on the ridgelines in the centre of the Nambucca State Forest and the forested portion just to the south. This community exhibits a generally young age structure as a result of the removal of blackbutt in most locations, although there appears to be areas containing larger and more mature trees outside the state forest boundary. Scribbly Gum (*Eucalyptus signata*) dominates this forest type with scattered individuals and small stands of both Blackbutt (*Eucalyptus pilularis*) and Red Bloodwood (*Corymbia gummifera*). The community merges into both the Blackbutt (*Eucalyptus pilularis*) dominated communities and the open forest dominated by Smooth-barked Apple (*Angophora costata*). The understorey typically comprises numerous shrub species, particularly wattles (*Acacia sp.*).
Wet sclerophyll forests These communities occupy the steep sloping creek and riparian areas where remnant tree cover has been retained and to a degree protected from frequent fire regimes. They comprise moist forest types and rainforest communities.	Moist blackbutt association. Moist blackbutt forest occupies areas of relatively fertile and moist soil characteristics, particularly along sheltered creeks and south facing slopes. Characteristic canopy species include Blackbutt (*Eucalyptus pilularis*) and Tallowwood (*Eucalyptus microcorys*) with Flooded Gum (*Eucalyptus grandis*), Grey Ironbark (*Eucalyptus paniculata*), Pink Bloodwood (*Corymbia intermedia*) and occasionally Red Mahogany (*Eucalyptus resinifera*) and Turpentine (*Syncarpia glomulifera*). Within the study area, moist blackbutt forest occurs within Nambucca, Newry and Little Newry State Forests. This habitat type was targeted in surveys for *Marsdenia longiloba*, *Amorphospermum whitei* and *Acacia chyrsotricha.* Flooded gum association. The flooded gum association occurs over a range of topographic positions, however, in the study area this forest type predominantly occurs in the sheltered south facing gullies and along creeklines along the fringe of waterlogged zones. This community type is dominated by Flooded Gum (*Eucalyptus grandis*), Tallowwood (*Eucalyptus microcorys*), Grey Ironbark (*Eucalyptus paniculata*) and occasionally Brush Box (*Lophostemon confertus*) and Turpentine (*Syncarpia glomuifera*). The mid-canopy and small-tree layer is relatively moist and dense and commonly includes mesophilic species such as Cheese Tree (*Glochidion ferdinandi*), Black Wattle (*Callicoma serratifolia*) and Scentless Rosewood (*Synoum glandulosum*). Within the study area this vegetation type occurs in all areas containing forested gullies, including all state forests. Griffith (1993) considers this community to be widespread on the NSW North Coast. This habitat type was targeted in surveys for *Marsdenia longiloba*. *Amorphospermum whitei* and *Acacia chyrsotricha*. *Marsdenia longiloba* was recorded as being present.

Vegetation structural type	Structure and floristics
	White mahogany/grey gum/grey ironbark association. This association occupies mid-slopes and minor gullies in the north-western parts of Nambucca State Forest and steeper slopes between the Kalang River and Short Cut Road. Subject to a long history of logging resulting in an open tree canopy and younger age structure dominated by White Mahogany (*Eucalyptus acmenoides*), Grey Gum (*Eucalyptus propinqua*), and Grey Ironbarks (*Eucalyptus paniculata* and *Eucalyptus siderophloia*). Tallowwood (*Eucalyptus microcorys*) is sub-dominant and Forest oak (*Allocasuarina torulosa*) occupies the lower tree strata. Also represented in lower abundance are Turpentine (*Syncarpia glomulifera*), Blue Gum (*Eucalyptus saligna*), Brush Box (*Lophostemon confertus*), Flooded Gum (*Eucalyptus grandis*) and Pink Bloodwood (*Corymbia intermedia*). *Marsdenia longiloba* was recorded as being present.
Swamp sclerophyll forests Swamp forests refer to vegetation retained or established in low-lying areas experiencing soil waterlogging and typically in proximity to creek flats, wetlands and rivers. Within the study area the best-preserved areas of swamp forest occurs around low-lying wetlands and as small remnant patches along the Bellinger, Nambucca and Kalang Rivers. Much of this community has been subjected to impacts from clearing, draining and grazing and there are no pristine areas of swamp forest along the Proposal.	Swamp mahogany/broad-leaved paperbark association. This community is typically located in low-lying waterlogged land and often positioned between and merging with the paperbark / swamp oak association, as well as rainforest and wet sclerophyll communities and as such the community often includes mesophilic rainforest species in the understorey. Generally characterised by dense stands of Broad-leaved Paperbark (*Melaleuca quinquenervia*) and Bottlebrush (*Callistemon salignus*) within the mid to lower canopy but also occasionally present in the upper canopy. Characteristic species of the overstorey includes Swamp Mahogany (*Eucalyptus robusta*), Red Mahogany (*Eucalyptus resinifera*) and various other tree species at different densities including Forest Red Gum (*Eucalyptus tereticornis*), Flooded Gum (*Eucalyptus grandis*), Gwamp Gum (*Lophostemon sauveolons*) and Smooth-barked Apple (*Angophora costata*). Other indicative species include Prickly-leaved Paperbark (*Melaleuca styphelioides*), Snow-in-Summer (*Melaleuca linariifolia*) and Ball Honeymyrtle (*Melaleuca nodosa*). Within proximity to the Proposal this community is represented to the south of the Kalang River in Newry State Forest and adjacent to South Arm Road, to the south of Raleigh. Broad leaved paperbark/swamp oak association. Primarily dominated by Broad-leaved Paperbark (*Melaleuca quinquenervia*) with a lower density of Swamp Oak (*Casuarina glauca*). This community would have historically been more widespread throughout the floodplain areas particularly south of Macksville although has been extensively cleared for grazing land. Remnant isolated fragments occur in waterlogged areas exhibiting a low dense canopy. Scattered eucalypts are represented in slightly elevated lands, mainly swamp mahogany. Several mature stands of paperbark and swamp oak association are represented in the south of the study area, associated with the floodplains of Warrell Creek and the Nambucca River and also to the north associated with the Kalang and Bellinger Rivers. This community often occurs as a transitional zone in floodplain areas between the swamp mahogany / broad-leaved paperbark association of primarily freshwater environments and the salt-water environments of the swamp oak dominated vegetation. Swamp oak association. Only a small component of this community is represented in the study area, often in areas that are inundated with brackish waters or in low-lying lands adjacent to several watercourses, including Warrell Creek and both the Nambucca and Kalang Rivers. The community is generally represented as stands of almost pure Swamp Oak (*Casuarina glauca*), although occasional paperbarks (*Melaleuca sp.*) or remnant eucalypts may also be represented in fringing areas. This community often adjoins mangrove forest and merges with other swamp and riparian forest types. Monospecific stands of *Casuarina glauca* forest are poorly reserved on the NSW North Coast (Griffith 1993).

Vegetation structural type	Structure and floristics
Rainforest As a result of historical land clearing throughout the Nambucca Valley extant rainforest is restricted to small and isolated linear fragments along creek gullies or as a smaller component of the wet sclerophyll associations. In all cases the canopy is dominated by eucalyptus species with a suite of rainforest tree species represented in the sub-canopy.	Gallery rainforests were noted from the mid and northern sections of the study area through Nambucca and Newry State Forest and north of the Kalang River. It occurs in cool, moist gullies and as riparian vegetation along permanent creeks such as Boggy Creek. The canopy tends to be dominated by eucalyptus species rather than rainforest emergents and is typically associated with Flooded Gum (*Eucalyptus grandis*) although Brush Box (*Lophostemon confertus*) is also dominant. The community includes a diversity of mesophylic species typical of warm temperate gully rainforest pockets in the locality. The canopy often comprises scattered emergent Flooded Gum and Brush Box with a dense sub-canopy of rainforest species, including Bangalow Palm (*Archontophoenix cunninghamiana*), Jackwood (*Cryptocarya glaucescens*), Scentless Rosewood (*Synoum glandulosum*), Scrub Beefwood (*Stenocarpus salignus*), Lily Pilly (*Acmena smithii*), Brush Wilga (*Wilkiea huegeliana*) and several vines including Water Vine (*Cissus hypoglauca*). Groundcovers and shrubs are generally absent. This habitat type was targeted in surveys for *Marsdenia longiloba*, *Amorphospermum whitei, Acronychia littoralis* (Scented Acronychia) and *Parsonsia dorrigoensis* (Milky Silkpod). *Marsdenia longiloba* was recorded as being present.
Wetlands There are few wetlands within the actual study area being limited to small wetlands. Several of the larger wetlands in the locality occur on river flats adjoining the Nambucca and Kalang River as well as Deep Creek and are often within or associated with wetlands listed under SEPP 14. 'Freshwater Wetlands' are listed as an EEC under the TSC Act.	Rush/sedgeland. Wetland communities occur in low-lying areas associated with the floodplain of the larger rivers (Nambucca and Kalang River) and permanent creeks such as Deep Creek and Oyster Creek some of which are listed under State Environmental Planning Policy No.14 – Coastal Wetlands (SEPP 14). Wetland communities in the study area comprise a mix of both freshwater and saltwater flora, evolved through periodic tidal influences on freshwater soaks and drainage depressions. A diversity of sedge and rush species form dense stands in shallow water and fringing areas and are dominated by Eleocharis, Cyperus, Juncus and Schoenoplectus spp, with Saw-sedge (*Gahnia melanocarpa*), Native Rush (*Phragmites australis*) and Cumbungi (*Typha orientalis*).
Estuarine vegetation Estuarine vegetation consists of narrow bands (1-5 m) of mangroves surrounding tidal creeks such as Newee and Deep Creek and large portions of the Kalang and Nambucca River foreshores. Mangrove communities are recognised for providing significant habitat for estuarine fish and are protected as important fish habitat under the *Fisheries Management Act* 1994.	Mangrove association. Narrow linear stands of mangroves up to 10 metres wide have been retained within the tidal zones of both the Kalang and Nambucca Rivers and lower sections of their associated tributaries. This vegetation is dominated by Grey Mangrove (*Avicennia marina*). Mangroves are also present on the southern bank of Deep Creek. Beds of seagrass are present within the lower areas of the Kalang River estuary. Saltmarsh association. Saltmarsh communities are very restricted in distribution and size being limited to several very small and isolated fragments within modified pastures occupying former swamp communities. As for the mangrove community it is restricted to the tidal zones of both the Kalang and Nambucca Rivers and some of the lower portions of their associated tributaries. The saltmarsh association is characterised by the presence of Samphire (*Sarcocornia quinqueflora*), New Zealand Spinach (*Tetragonia tetragonioides*) and Saltwater Couch (*Sporobolus virginicus*).

Vegetation structural type	Structure and floristics
Modified communities Modified communities are defined as former forest associations which have been modified through land clearing and draining for the development of farm land and now exist as introduced pasture, remnant trees with a grassy pasture understorey or regrowth forest either of the same origin or different species. Small isolated fragments of the former forest communities often occur with an understorey dominated by introduced pasture or weeds. Occasional remnant paddock trees have been retained in the landscape.	Cleared grassland and introduced pasture. Cleared grassland and introduced pasture occurs on fertile soils associated with the floodplains of Warrell Creek and the Nambucca River in the south and Deep Creek and the Kalang River through the central and northern parts of the study area. Such areas contain very limited remnant vegetation and are characterised by a generally low native floral diversity. Commonly, scattered remnant trees and small fragmented native vegetation patches are present, as are planted areas for windbreaks and landscaped gardens. The areas are dominated by introduced pasture grasses, including Paspalum (*Paspalum dilatatum*), Rhodes Grass (*Chloris gayana*) and Kikuyu (*Pennisetum clandestinum*). Modified riparian forest. Historically retained on private properties as narrow vegetated strips along watercourses, in otherwise cleared paddocks. This modified vegetation comprises a combination of both native and introduced flora species and often dominated by weeds, particularly Lantana (*Lantana camara*). This vegetation has primarily been retained for the purpose of stabilising and reducing bank erosion and exhibits elements of wet sclerophyll, rainforest and swamp sclerophyll associations. Modified sclerophyll forest. Several relatively small and isolated fragments of dry and wet sclerophyll forest have been retained on private properties throughout the landscape. Such areas are dominated by a suite of eucalypt species as described above depending on the location, soil type and topography and are characterised by remnant trees and a depleted native understorey replaced by grazed pasture or a dense regrowth of weeds where grazing has ceased.

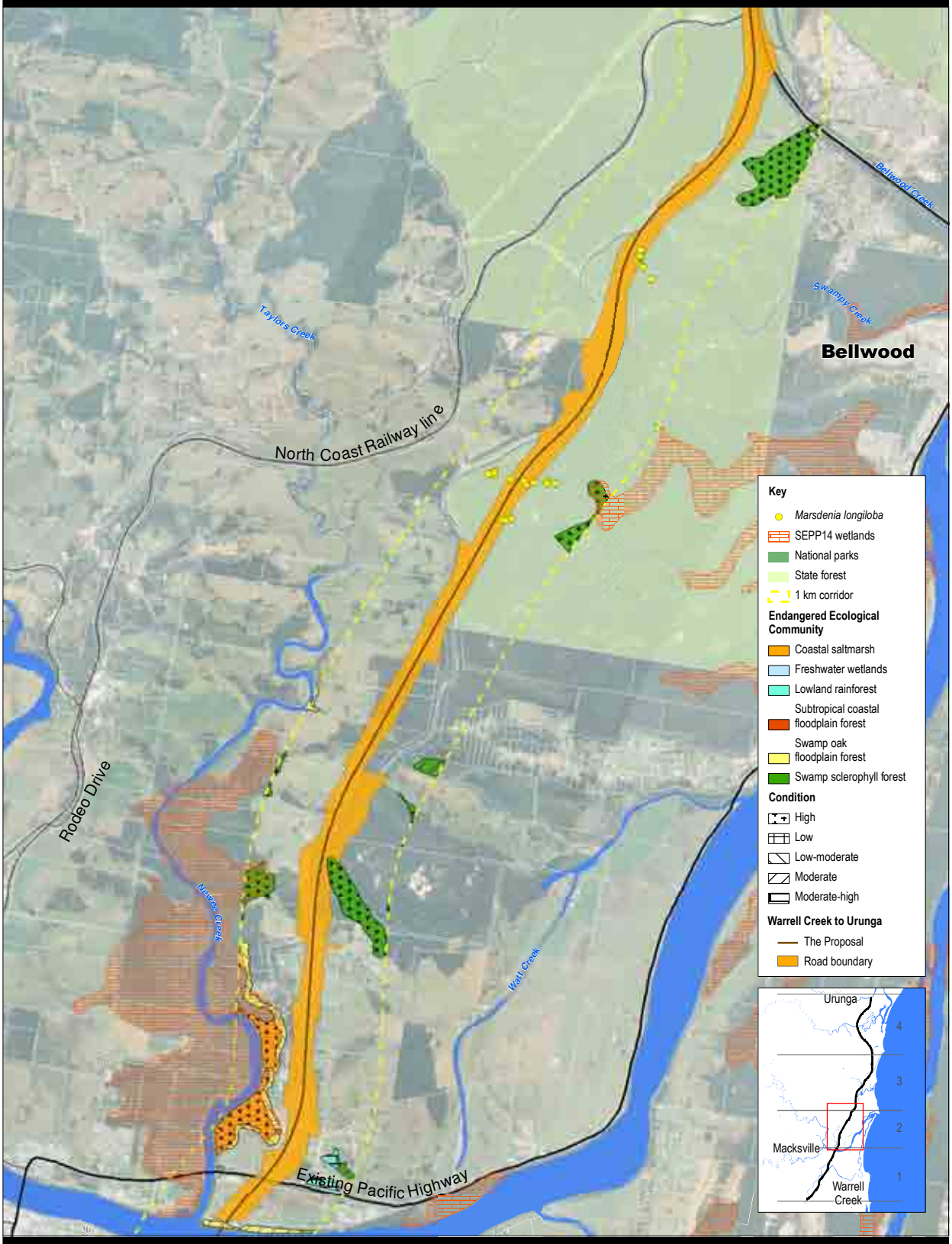
FIGURE 10-2 a | LOCATIONS OF ENDANGERED ECOLOGICAL COMMUNITIES — SECTION 1 OF 4



Warrell Creek to Urunga - Upgrading the Pacific Highway

0 400 800 Metres

FIGURE 10-2 b | LOCATIONS OF ENDANGERED ECOLOGICAL COMMUNITIES SECTION 2 OF 4



Warrell Creek to Urunga - Upgrading the Pacific Highway

0 400 800 Metres

FIGURE 10-2 c | LOCATIONS OF ENDANGERED ECOLOGICAL COMMUNITIES SECTION 3 OF 4

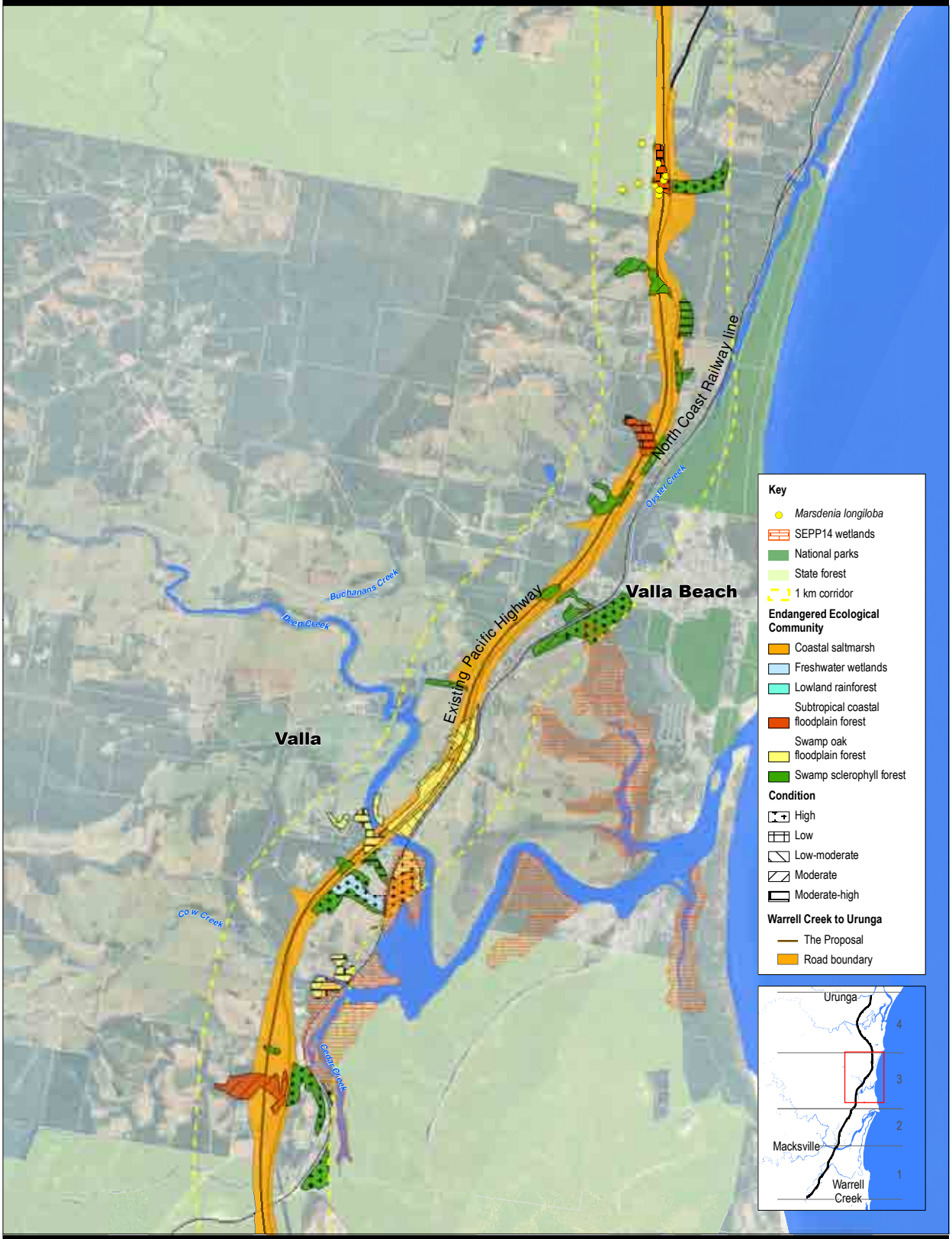
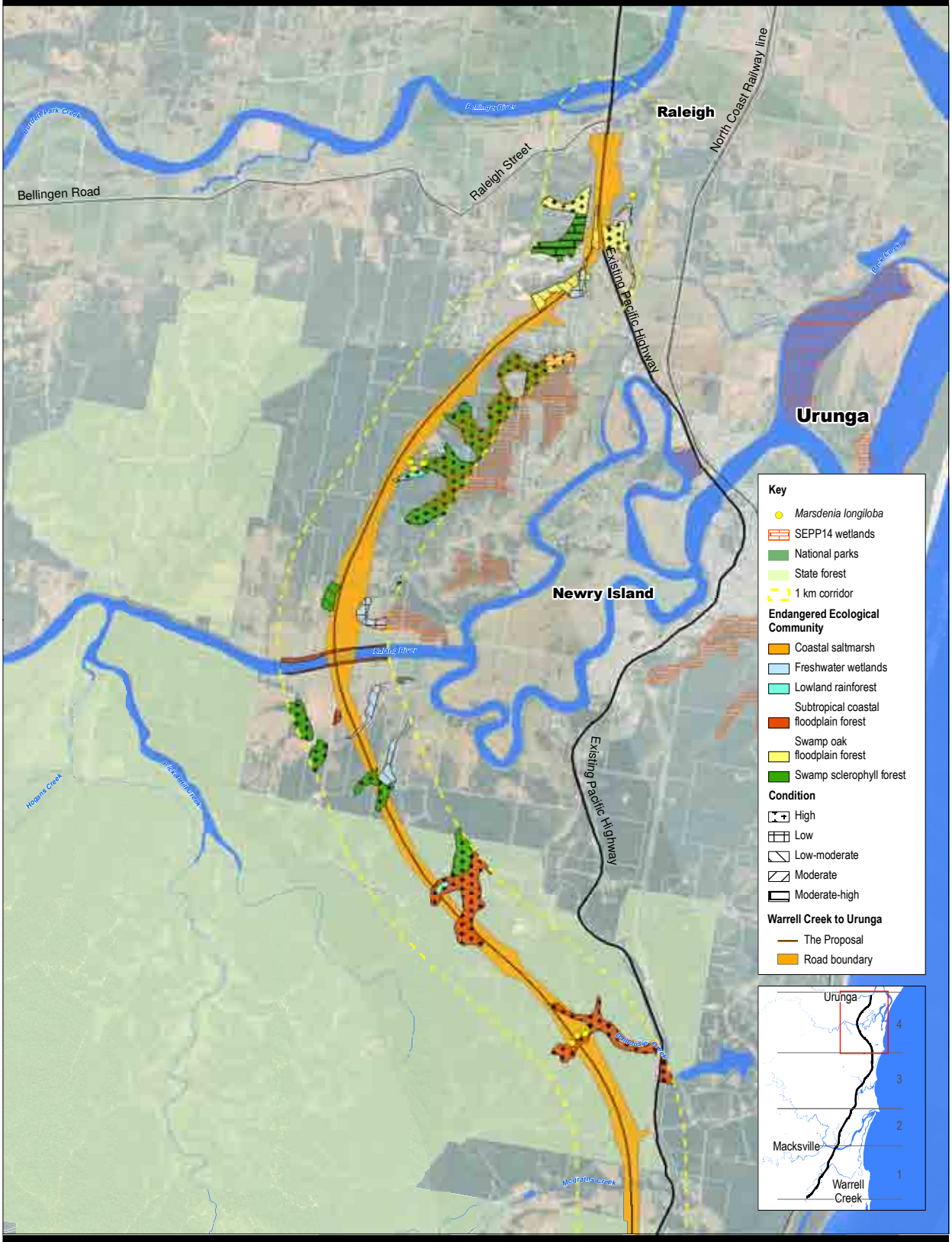


FIGURE 10-2 d | LOCATIONS OF ENDANGERED ECOLOGICAL COMMUNITIES — SECTION 4 OF 4



10.3.2.3 Threatened species

Of the native flora species represented in the Proposal corridor, there was one nationally vulnerable species (also listed as endangered in NSW), one NSW listed vulnerable species, two rare or threatened Australian plants species (RoTAP) and five species considered to be regionally significant in the local area.

Of the 12 threatened species identified, eight have suitable habitat attributes in the study and have potential to be present. Targeted surveys were conducted to locate rare or threatened plant species occurring, or with the potential to occur within the study area including those specifically highlighted in the Director General's requirements including Marsdenia longiloba (Slender Marsdenia), Amorphospermum whitei (Rusty Plum), Acacia chrysotricha (Newry Golden Wattle), Acronychia littoralis (Scented Achronychia) and Parsonsia dorrigoensis (Milky Silkpod). In addition to the species specified in the Director General's requirements, targeted surveys also were also conducted for Peristeranthus hillii, Maundia triglochinoides and Hicksbeachia pinnatifolia (Red Bopple Nut). Of these only Slender Marsdenia and Rusty Plum were identified.

Table 10–4 provides the results of the surveys for threatened plant species protected under State and Commonwealth legislation. Individual threatened species found to be present include Slender Marsdenia which is listed as vulnerable under Commonwealth legislation and endangered under NSW legislation and rusty plum which is listed as vulnerable under NSW legislation. In addition to the species in Table 10–4 seven rare species listed under the RoTAP database (Briggs and Leigh 1996) and other flora species which are at the limit of their distribution, are generally uncommon in the area or are regarded as being regionally significant were located in the study area. These are listed in Table 10–5.

10.3.3 Terrestrial fauna

10.3.3.1 Habitat types

Five fauna habitat types (Table 10-6) are represented in the study area in association with the structural vegetation types described in Table 10-3. The distribution of habitats is shown in Figure 10-3. The highest diversity of fauna was found to occur in the moist and swamp forest habitats, particularly those located on privately owned land. Despite the level of disturbance in the habitats of the state forests, these habitats represented the largest fragments of bushland in the study area and as such are identified as key habitats and important corridors and are of high conservation value due to their relative size and strategic location, linking the coast to extensive forests to the west of the study area.

Table 10-4 Threatened flora located within the Proposal corridor

Species	Conservation status			Distribution and abundance
	Cwlth (EPBC Act)	NSW (TSC Act)	RoTAP	
Slender Marsdenia (*Marsdenia longiloba*)	V	E	3RC-	Slender Marsdenia occurs in six locations associated with gullies and creek line habitats. Locations include Nambucca, little Newry and Newry State Forest as well as a private property. The total number of individuals within these populations was estimated to comprise approximately 156 individuals.
Rusty Plum (*Amorphospermum whitei*)	-	V	3RCa	This species was recorded in the Boggy Creek area. Only one individual was recorded.
Newry Golden Wattle *(Acacia chrysotricha)*	-	E	2R	Newry Golden Wattle was not recorded in the study area despite targeted searches in areas of suitable habitat. In particular areas of Newry State Forest and Nambucca State Forest had suitable areas of habitat comprising narrow gullies on quartzite soils. There are records of this species to the west of the study area in Newry State Forest.
Scented Acronychia (*Acronychia littoralis*)	E	E	3ECi	Scented Acronychia was not recorded in the study area despite targeted searches. The preferred habitat for this species is littoral rainforest on sand which does not occur in the study area. There is a low possibility this species is present in rainforest and wet sclerophyll forests of the study area however these habitats are marginal.
Red Bopple Nut (*Hicksbeachia pinnatifolia*)	-	V	3RC	Red Bopple Nut was not recorded in the study area despite targeted searches in areas of suitable habitat. There are no records for this species in the locality, however this species is recorded as occurring from Nambucca Valley to southeast Queensland. Red bopple nut may occur in rainforest and wet sclerophyll forests habitats in the study area, however better quality examples of habitat are restricted to a few small areas of rainforest.
Maudia triglochinoides	-	V	-	*Maudia triglochinoides* was not recorded in the study area despite targeted searches in wetlands, creeks and dams with shallow freshwater 30-60 centimetres deep. The Proposal would result in the removal of only a small area of suitable habitat comprising up to 2 hectares of dams, creeks and wetland areas. There are several creeks and farms dams which provide suitable habitat for *Maudia triglochinoides*, however many of the wetland habitats in the study area are relatively disturbed and generally provide marginal habitat qualities. There are no records of this species in the locality.

Species	Conservation status			Distribution and abundance
	Cwlth (EPBC Act)	NSW (TSC Act)	RoTAP	
Milky Silkpod (*Parsonsia dorrigoensis*)	E	V	2VCi	Milky Silkpod was not recorded in the study area despite targeted searches in areas of suitable habitat. There are records for this species in the locality.
Brown Fairy-chain Orchid (*Peristeranthus hillii*)	-	V	-	Brown Fairy-chain Orchid is an epiphytic orchid that was not recorded in the study area despite targeted searches in areas of suitable habitat. There are no records for this species in the locality. The preferred habitat for this species is littoral rainforest which does not occur in the study area. There is a low possibility this species is present in rainforest and wet sclerophyll forests of the study area however these habitats are marginal.

V=vulnerable, E= endangered, RoTAP=Rare or Threatened Australian Plant

RoTAP Codes

2 = geographic Range in Australia less than 100km

3 = geographic Range in Australia greater than 100km

V = Vulnerable – at risk over longer period (20-50years)

E= Endangered – at risk within 10-20 years.

R = Rare – uncommon plants with no current threats

K = Poorly known – taxon that is suspected but not definitely known to belong to one of the above categories

C = Reserved

a = 1000 plants or more know from conservation reserves

i = less than 100 plants in conservation reserves

- = reserved population size not accurately known

Table 10-5 Rare and regionally significant flora recorded in the study area

Threatened Flora	Status	Source, Distribution and Abundance
Artanema fimbriatum	Regionally significant, southern limit	Southern limit listed as the Brunswick River (PlantNET 2008). This species was recorded in several locations between Nambucca State Forest and Newry State Forest.
Swamp Lily (*Crinum pedunculatum*)	Regionally significant, sparse species occurring in depleted habitat	Listed as a regionally significant species (Kendall and Kendall 2003). Occurs in areas of swamp forest at several locations, including areas adjacent to Warrell Creek at the southern end of the study area.
Cymbidium madidum	Regionally significant, southern limit	Southern limit Clarence River (PlantNET 2008), distribution in the study area represent extreme southern limit. Occurs in several locations at the northern end of the study area including private property north of the Kalang River.
Cyperus filipes	Regionally significant	Listed as a regionally significant species (Kendall and Kendall 2003). Occurs in protected areas in Newry State Forest, and on private property north of the Kalang River.
Eucalyptus ancophila	RoTAP: 2K	Recorded in several gully areas in Nambucca and Newry State Forest.
Swamp Turpentine (*Lophostemon sauveolens*)	Regionally significant, southern limit	The southern limit for this species is Scotts Head (PlantNET 2008), and is listed as a regionally significant species (Kendall and Kendall 2003).
Corky Milk Vine (*Marsdenia lloydii*)	Regionally significant	Listed as a regionally significant species (Kendall and Kendall 2003). Occurs at numerous locations along the entire study area.

Table 10-6 Terrestrial fauna habitats

Habitat type	Description
Dry open forests	Dry open forest habitats occupy approximately 65 per cent of the route corridor. These are largely contained within Nambucca, Newry and Little Newry State Forests although also on privately owned lands. Of particular importance to fauna is the diversity of canopy plant species which provide seasonal food and shelter resources for nectarivorous and foliovorous birds and mammals. Additional features of importance include an abundance of logs and dense understorey in parts providing sheltering and breeding opportunities for reptiles and small ground dwelling mammals. In general, the dry forest habitats present appear to lack maturity and indeed their value has been reduced from the long history of logging and burning. Hollow-bearing trees and standing dead trees are scarce and the resulting lack of nesting and denning opportunities is likely to have restricted populations of hollow-dependent fauna from competition. The dry open forests support species rich populations of birds (i.e. 70 species) represented from several families. Other fauna represented included 28 mammal species, dominated by rodents, microchiropteran bats, gliders, and possums and 13 reptile species dominated by skinks. Diversity and abundance across the open forest sites reflected the degree of disturbance.

Habitat type	Description
Moist closed forests	Smaller linear fragments and regrowth moist forests occur in sheltered gullies and along creek areas and occupy approximately 15 per cent of the study area. Generally the moist forest communities adjoin and grade into open forest habitats and as such the majority of fauna occurring in these areas would utilise both habitat types and are not exclusively linked to either. However, the moist forest habitats tend to exhibit a higher floristic diversity and may comprise a greater percentage of fruiting and flowering resources which are particularly important for specialist frugivorous fauna. Similarly a larger percentage of dead standing trees or mature trees were found to occur in moist gullies where fire has been suppressed. As such hollow-dependent fauna may be more concentrated in gully areas. In some instances these habitats are found in association with flowing streams that are suited to a small diversity of stream dwelling frog species. It is apparent that these moist forest habitats are limited in extent and provide essential habitat for a small range of threatened fauna species known from the NSW North Coast and as such are regionally significant. Despite the smaller size the moist forest habitats were found to support a species rich assemblage of birds (i.e. 63 species), other fauna represented included 26 mammal species mostly microchiropteran bats, possums, gliders and bandicoots. 11 species of frogs and 11 reptile species were also identified.
Swamp forests	Swamp forest habitat refers to the vegetation retained or established in low-lying areas adjoining creeks, wetlands and rivers. Along the Proposal corridor, the best-preserved areas of swamp forest occur around the lower reaches of creeks and as small fragments on the floodplains. The dominant species vary from individual stands of one tree species to combinations of species which may include swamp mahogany, red mahogany, paperbarks or swamp oak. The swamp forest habitats are generally characterised by high structural diversity and provide dense cover for ground-dwelling mammals and birds. Swamp mahogany is a winter flowering eucalypt and important food resource for nectarivorous fauna. Other important habitat features present include large trees, tree hollows and logs, and persistent surface water in poorly drained areas providing important refuge habitat for frogs. The swamp forests support the most species rich populations of frogs (i.e. 14 species) represented by both ground-dwelling and tree frogs. Other fauna represented included 28 bird species, mainly small cover-dependent birds such as wrens and thornbills, 11 species of mammals and 6 reptile species.
Aquatic and estuarine habitats	Permanent and ephemeral creeks, freshwater wetlands and farm dams provide high value fauna habitat and often represent significant features in the landscape, particularly within modified agricultural and floodplain landscapes. Such areas provide habitat for fauna dependent on aquatic and semi aquatic habitats, especially frogs, some reptiles and several common wader and waterbird species and can exhibit a comparatively species rich habitat. Riparian habitats may also provide important fauna movement corridors and provide refuge during fire and drought events. The Proposal crosses the Nambucca River in the south and the Kalang River in the north. These river channels provide significant estuarine fauna habitats including open water, intertidal sandflats, sandy shores and oyster leases and provide important habitat for bird groups such as waders, waterfowl, cormorants, pelicans, herons, oystercatchers and their allies. This includes the osprey (*Pandion haliaetus*), a threatened raptor that requires extensive areas of open water for fishing, frequenting fresh and saline habitats and adjacent coastal forests with tall trees for nesting. Several osprey and nest sites have been recorded on the Nambucca and Kalang River floodplains across the study locality. Fauna represented in freshwater and aquatic habitats included 10 species of bird, 10 frog species and four reptile species.
Modified habitats	Modified fauna habitats comprise former forest lands that have been cleared for grazing and subsequently exist as grassy paddocks with small isolated fragments of disturbed tree cover. Such open habitats provide few important habitat features for fauna and generally comprise lower faunal diversity as a result of the degree of disturbance. In general, these areas lack significant vegetation or habitat for threatened species and are dominated by common and introduced fauna, particularly those tolerant of modified landscapes. Although the value of isolated mature remnant trees has been documented previously in terms of their ability to provide food and sheltering resources for mobile fauna species (Law, et al. 2000). These features, particularly large dead trees are often selected as preferred nest sites for raptors including the threatened osprey (Clancy 1991) as a result of their absence from forest habitats.

Nambucca, Newry and Little Newry State Forests are known to be important habitat for a number of threatened species including Koala, Yellow-bellied Glider, Glossy Black Cockatoo, Square-tailed Kite and several microchiropteran bats.

Moist sclerophyll forests with rainforest understorey located in steeper gullies and drainage lines have a high floristic diversity as a consequence of being protected from frequent fires. They contain more hollow-bearing trees and a diversity of food resources and sheltering microhabitats for threatened species such as the Wompoo and Superb Fruit Dove, Grey-headed Flying Fox, Powerful Owl, Yellow-bellied Glider, Glossy Black Cockatoo, Square-tailed Kite and several micropchiropteran bats.

Many of the swamp forest habitats have been disturbed through clearing, draining and grazing, particularly on the floodplain and any remaining areas are of high conservation value. They comprise a high diversity of frog and reptile species.

Habitat trees comprise hollow bearing trees and standing dead trees and are used by a variety of species. These are sparsely scattered through the landscape and provide potential nesting hollows for species such as Glossy Black Cockatoo, Powerful Owl and Yellow-bellied Glider.

10.3.3.2 Threatened species

A total of 203 terrestrial fauna species were recorded in the study area comprising 125 bird, 36 mammal, 24 reptile and 18 amphibian species. Fourteen vertebrate fauna species of conservation significance were recorded in surveys undertaken between 2005 and 2008. Of the 14 species, the Grey-headed Flying Fox is considered vulnerable under both Federal (EPBC Act) and State (TSC Act) legislation. The remaining 13 species are all considered vulnerable under the TSC Act, except the Black-necked Stork which is listed as endangered. Threatened fauna species identified during survey (confirmed) and those which have been previously recorded in the area are listed in Table 10-7. The 14 fauna species of conservation significance are listed along with species that have been recorded in wildlife atlas (DECC 2008) and are considered to potentially occur in the study area. Migratory bird species are listed in Table 10-8.

Nine EPBC Act listed migratory bird species were identified during the field investigations, as shown in Table 10-8. However, the majority of species were considered uncommon and widespread with no specific congregations or habitat represented. The most widespread and abundant species was the Cattle Egret present through cleared farmland, and Rufous Fantail and Black-faced Monarch in moist, densely forested gullies. White-throated Needletail were observed in the study area on several occasions.

FIGURE 10-3a | FAUNA HABITATS, THREATENED FAUNA AND PROPOSED FAUNA CROSSING LOCATIONS **SECTION 1 OF 4**

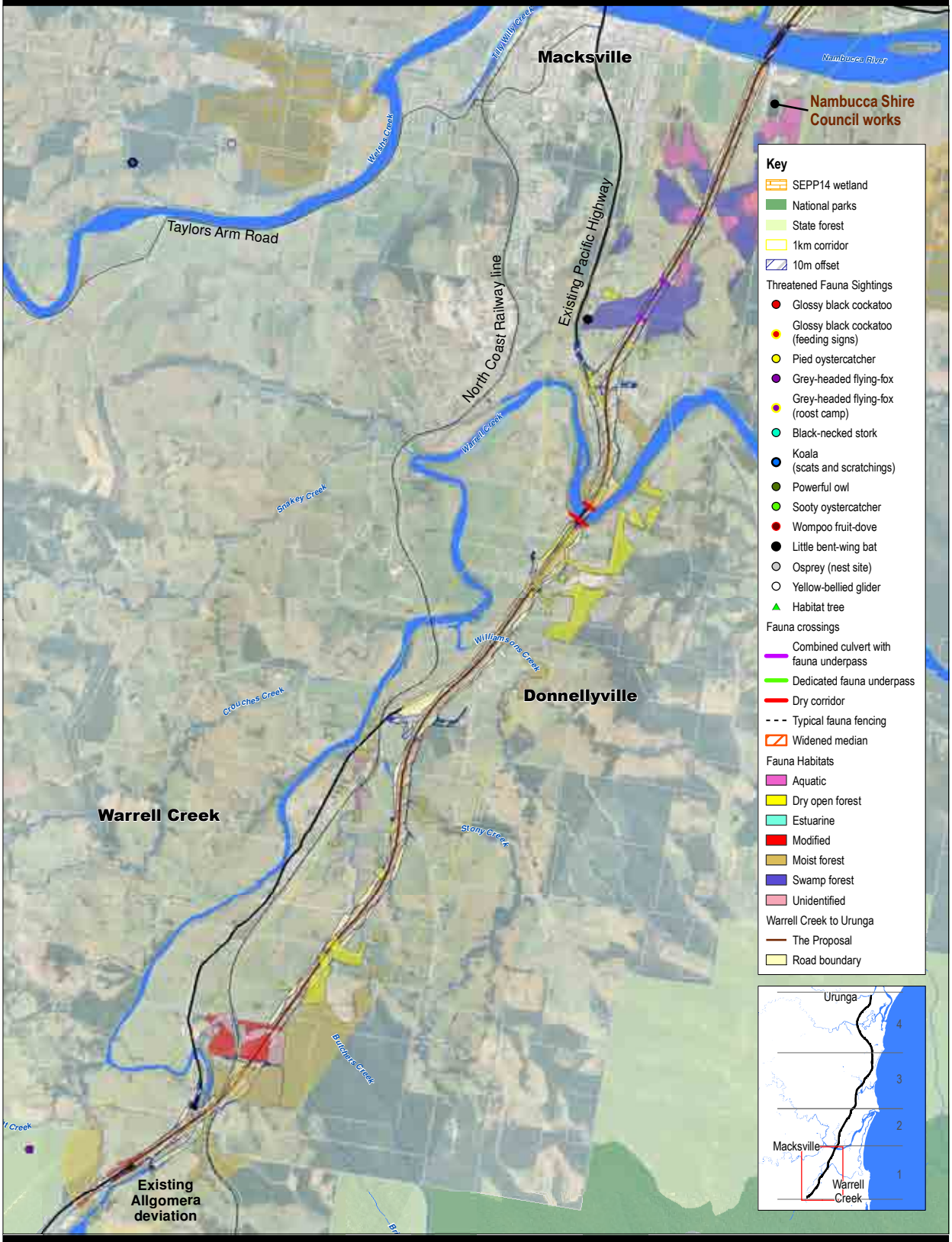


FIGURE 10-3b | FAUNA HABITATS, THREATENED FAUNA AND PROPOSED FAUNA CROSSING LOCATIONS **SECTION 2 OF 4**

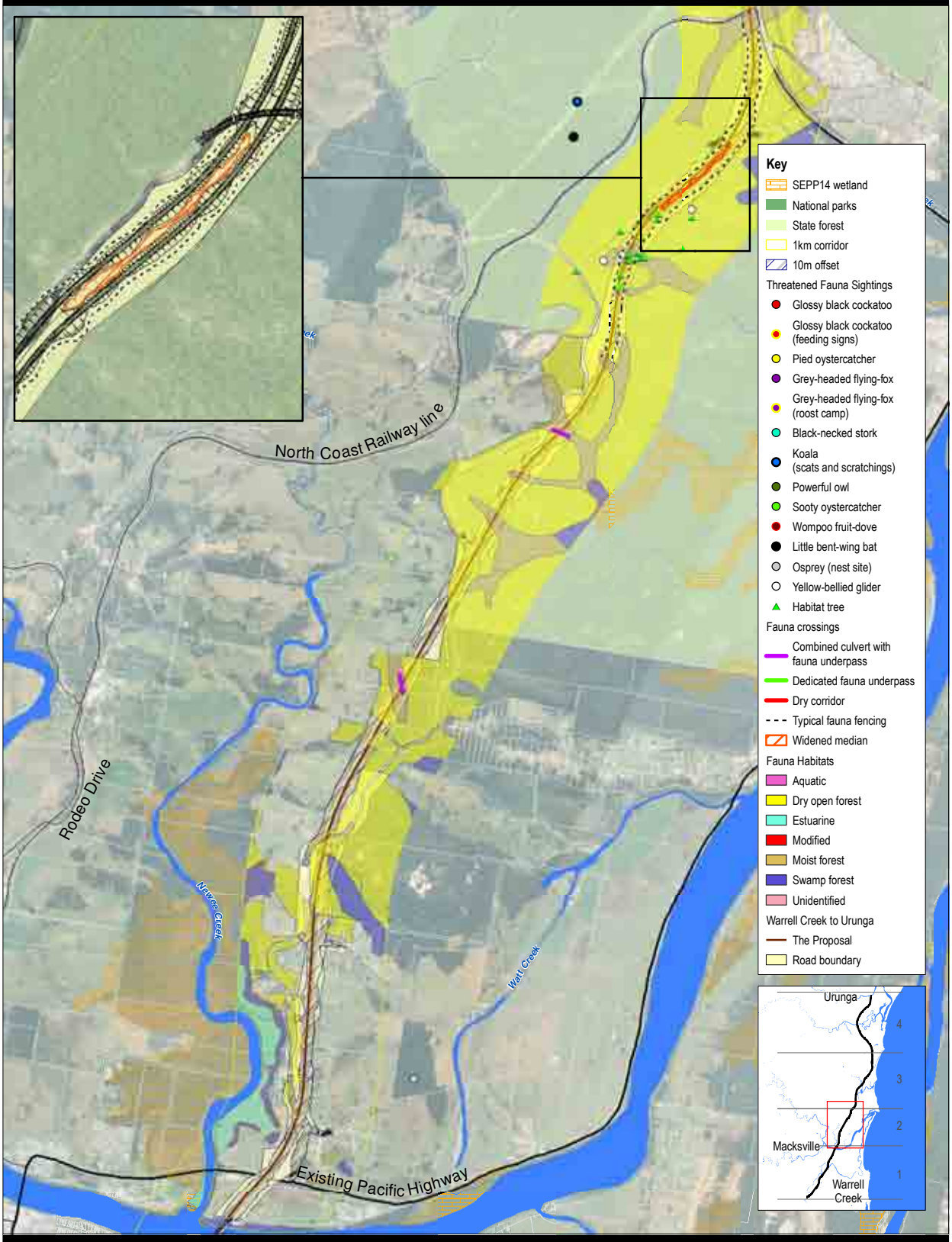
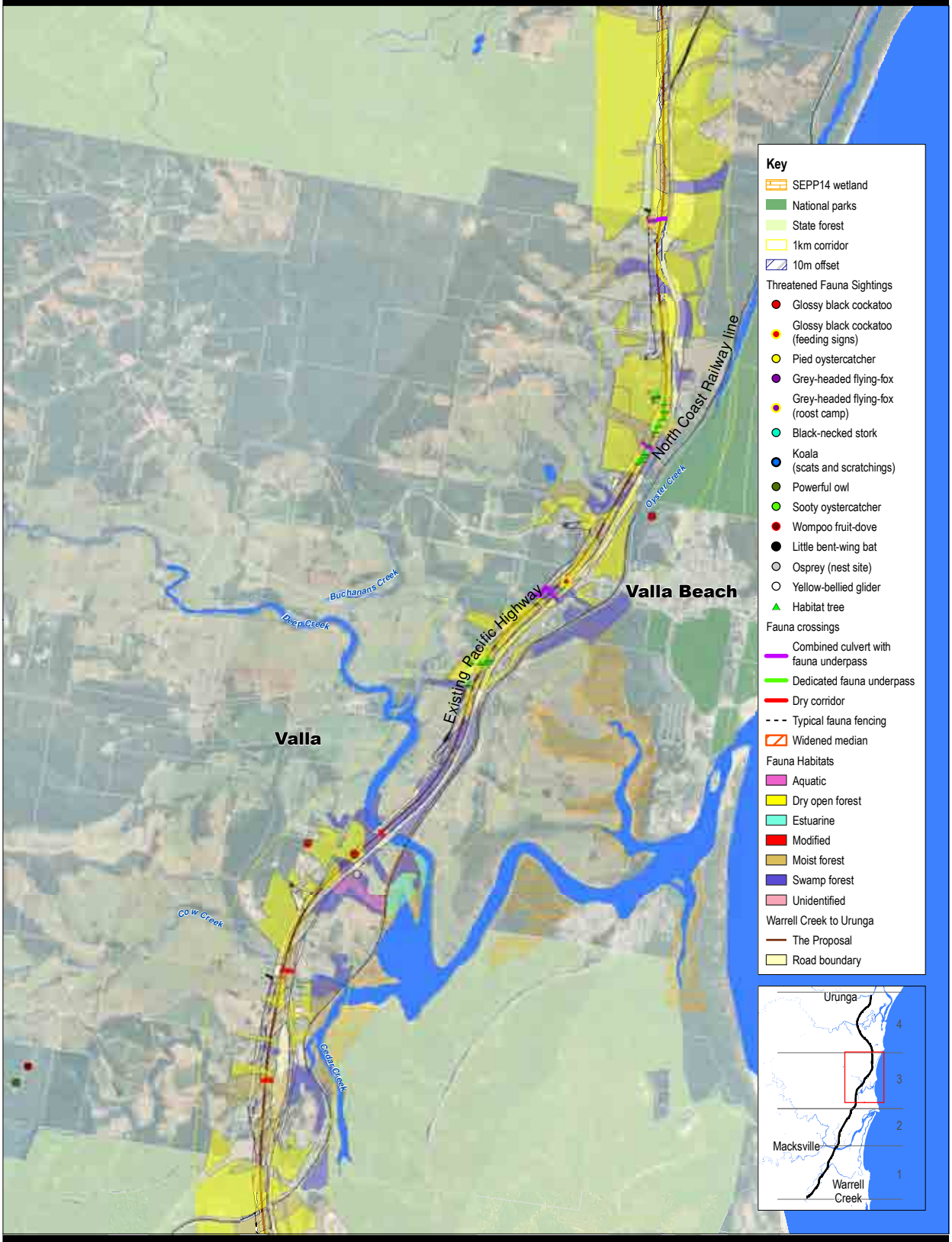


FIGURE 10-3c | FAUNA HABITATS, THREATENED FAUNA AND PROPOSED FAUNA CROSSING LOCATIONS **SECTION 3 OF 4**



Warrell Creek to Urunga - Upgrading the Pacific Highway

0 400 800 Metres

FIGURE 10-3d | FAUNA HABITATS, THREATENED FAUNA AND PROPOSED FAUNA CROSSING LOCATIONS SECTION 4 OF 4

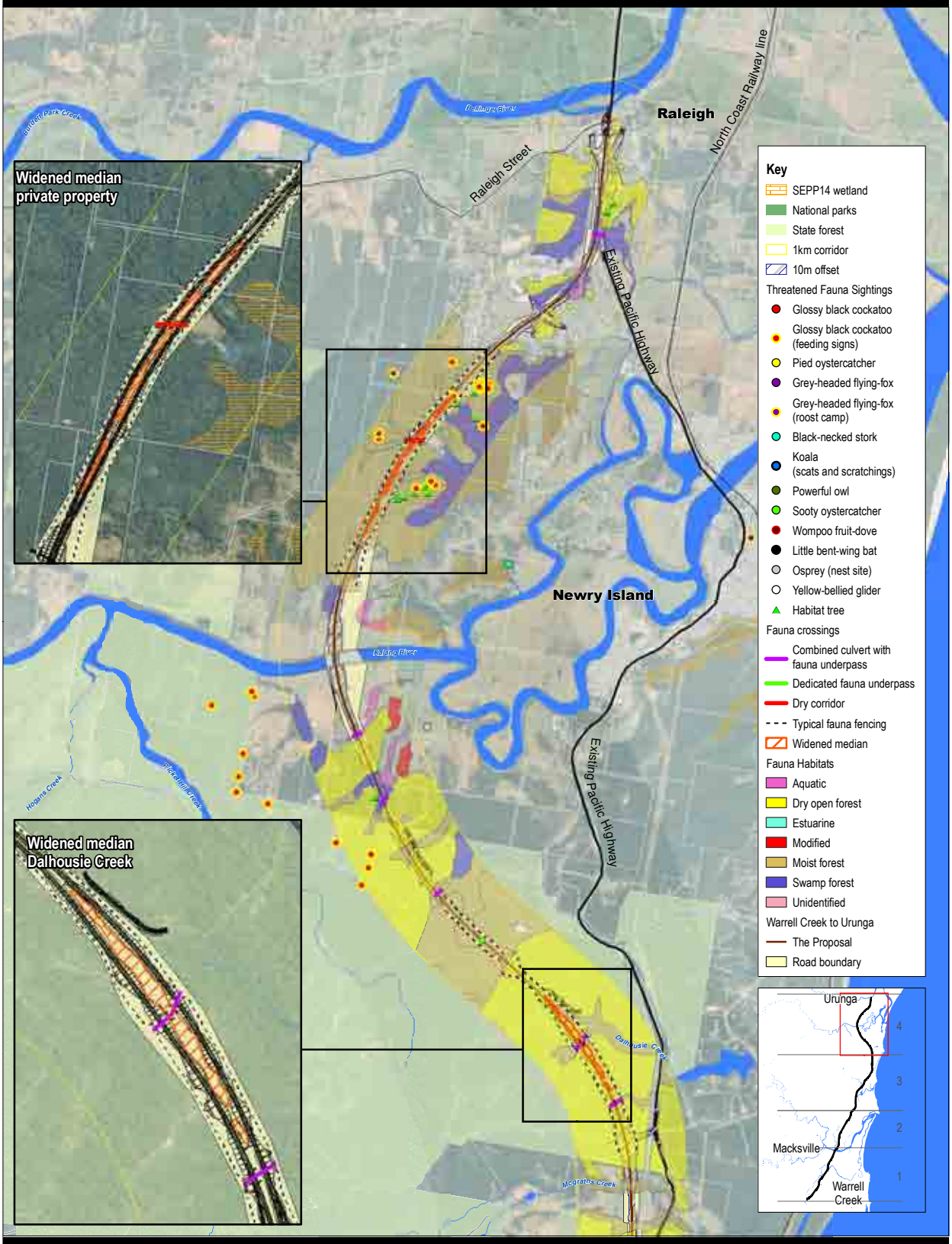


Table 10-7 Threatened fauna

Species	Status Federal (EPBC Act)	Status NSW (TSC Act)	Presence in the study area
Black-necked Stork (*Ehippiorhynchus asiaticus*)		Endangered	Confirmed
Spotted-tailed Quoll (*Dasyurus maculatus*)	Vulnerable	Vulnerable	Potential
Brush-tailed Phascogale (*Phascogale tapotafa*)		Vulnerable	Potential
Yellow-bellied Glider (*Petaurus australis*)		Vulnerable	Confirmed
Koala (*Phascolarctos cinereus*)		Vulnerable	Confirmed
Glossy Black-Cockatoo (*Calyptorhynchus lathami*)		Vulnerable	Confirmed
Square-tailed Kite (*Lophiotinia isura*)		Vulnerable	Confirmed
Emu (*Dromaius noveahollandia*)		Endangered	Potential
Black Bittern (*Ixobrychus flavicollis*)		Vulnerable	Potential
Red-tailed Black Cockatoo (*Calyptorhynchus banksii*)	Endangered	Endangered	Potential
Osprey (*Pandion haliaettus*)		Vulnerable	Confirmed
Amphibians			
Green and Golden Bell Frog (*Litoria aurea*)	Endangered	Endangered	Potential
Giant Barred Frog (*Mixophyes iteratus*)	Endangered	Endangered	Potential
Migratory nectivores			
Swift Parrot (*Lathamus discolour*)	Endangered	Endangered	Potential
Regent Honeyeater (*Xanthomyza phrygia*)	Endangered	Endangered	Potential
Cave-roosting Microchiropteran Bats			
Little Bentwing-bat (*Miniopterus australis*)		Vulnerable	Confirmed
Eastern Bentwing-bat (*Miniopterus schreibersii*)		Vulnerable	Confirmed
Common Blossom bat (*Syconycteris australis*)		Vulnerable	Potential
Hollow-roosting Microchiropteran Bats			
Greater Broad-nosed Bat (*Scoteanax rueppellii*)		Vulnerable	Confirmed
Eastern Freetail-bat (*Mormopterus norfolkensis*)		Vulnerable	Potential
Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)		Vulnerable	Confirmed
Megachiropteran bats			
Grey-headed Flying-fox (*Pteropus poliocephalus*)	Vulnerable	Vulnerable	Confirmed
Yellow-bellied Sheathtail bat (*Saccolaimus flaviventris*)		Vulnerable	Confirmed

Species	Status Federal (EPBC Act)	Status NSW (TSC Act)	Presence in the study area
Frugivorous Birds			
Wompoo Fruit-dove (*Ptilinopus magnificus*)		Vulnerable	Confirmed
Large Forest Owls			
Powerful Owl (*Ninox strenua*)		Vulnerable	Confirmed
Masked Owl (*Tyto noveahollandiae*)		Vulnerable	Potential
Sooty Owl (*Tyto tenebricosa*)		Vulnerable	Potential

Table 10-8 Migratory bird species within the study area

Scientific name	Common name	Habitats[1]						Recorded in the study area
		DSF	MSF	SSF	FW	EST	RC	
Bubulcus ibis	Cattle Egret						•	•
Ardea alba	Great Egret			•	•		•	•
Haliaeetus leucogaster	White-bellied Sea-eagle						•	•
Pandion haliaetus	Osprey			•		•	•	•
Gallinago hardwickii	Latham's Snipe						•	•
Lathamus discolor	Swift Parrot							
Hirundapus caudacutus	White-throated Needletail	•	•				•	•
Merops ornatus	Rainbow Bee-eater							
Xanthomyza phrygia	Regent Honeyeater							
Rhipidura rufifrons	Rufous Fantail	•	•					•
Monarcha melanopsis	Black-faced Monarch	•	•	•				•
Monarcha trivirgatus	Spectacled Monarch							
Acrocephalus australis	Australian Reed-warbler						•	•

[1] DSF – Dry sclerophyll forest, MSF - moist sclerophyll forest, SSF - swamp sclerophyll forest, FW -freshwater wetlands, EST -estuary, RC – rural and cleared land.

10.3.4 Aquatic fauna

Freshwater and estuarine habitats were surveyed to determine the baseline for species distribution within waterways between Warrell Creek and Urunga during 2007 and 2008. The findings are shown in Table 10-9. Full details of the species identified are provided in Working paper 1 – *Flora and fauna*.

Table 10-9 Aquatic fauna recorded as part of the field investigations

Habitat	Location	Species
Freshwater	Butchers Creek, Rosewood Creek, Stony Creek, Williamson Creek, Boggy Creek, Cow Creek and Oyster Creek.	273 fish were caught from 12 species. The most widely distributed was the Striped Gudgeon (*Gobimorphus australis*) and the Empire Gudgeon (*Hypseleotris compressa*). No state or nationally threatened species were present. One exotic species, the Mosquito Fish (*Gambusia holbrooki*) was identified. 60 families of macroinvertebrates were identified from 450 individuals recorded. None of the families were state or nationally threatened or protected.
Estuarine	Warrell Creek, Nambucca River, Deep Creek, Kalang River, Bellinger River	4836 fish were caught from 17 species. The most widely distributed species at all sites was the Grass Shrimp (*Macrobrachium intermedium)*. The Estuary Perchlet (*Ambassis marianus*), Estuary Perch (*Macquaria colonorum*), Flathead Gudgeon (*Philypnodon grandiceps*) and Sea Mullet (*Mugil cephalus*) were also widely distributed across the sites. No state or nationally listed species were recorded.

There were two migratory species identified in the study area, namely the Australian bass, one specimen of which was recorded from the Kalang River and Estuary Perch, which was recorded in Warrell Creek, Deep Creek and the Kalang River.

10.4 Potential impacts on flora and fauna

10.4.1 General impacts

Potential impacts on ecology have been minimised and avoided where possible during route selection and development of the concept design for the Proposal. During this process, a number of important measures to reduce or avoid potential impacts relating to key threatening processes have been incorporated in the Proposal design.

The main impact on flora would be during the construction phase of the Proposal, while potential impacts on fauna could occur both during construction and operation phases of the Proposal. Likely and potential impacts associated with Proposal would include the loss of threatened plant species and endangered ecological communities, fragmentation of habitats and wildlife corridors, barrier effects on wildlife and riparian corridors (such as the erosion of genetic stock), edge effects (such as weed invasion, pests and disease), disturbance to aquatic and riparian habitats potentially resulting in contamination and siltation of waterways, and cumulative impacts in association with the Pacific Highway Upgrade Program. These potential impacts, and others, have been described in the sections below.

Key threatening processes are processes that threaten, or could threaten, the survival or evolutionary development of species, populations or ecological communities. The Proposal would contribute to two key threatening processes listed under the NSW TSC Act and FM Act. These are:

- Clearing of native vegetation.
- Removal of dead wood, in-stream woody debris and dead trees.

The environmental management measures identified to avoid and/ or minimise the impacts on ecology are detailed in Section 10.5 and the *Draft Statement of Commitments* (refer Appendix D).

10.4.2 Potential flora impacts

10.4.2.1 Native vegetation and habitat loss

Approval is being sought for works to be undertaken within the construction footprint including batters, cuttings and ancillary sites, plus a 10 metre buffer. In reality, this provides a worst case scenario for clearing and impacts on native flora and fauna. The area of clearance would not be this extensive and is likely to be in the region of three to five metres from the edge of the footprint. Obtaining approval for this additional area ensures there is sufficient space to allow for slight modifications during detailed design, and providing these do not extend outside the area assessed, would be covered by the approval. Where clearing is required within the buffer area, there is the potential to retain individual plants or communities, and protect them through the construction process. It is the RTA's aim to reduce clearing of individual native species and EECs where possible on this Proposal.

The construction corridor and area of potential impact (10 metre buffer) equates to 431 hectares of which 255 hectares (59 per cent) is occupied by native vegetation, which includes approximately 60 hectares of endangered ecological community. The remaining 176 hectares (41 per cent) consists of cleared agricultural land, plantations, modified rural residential zones and river crossings.

Loss of native vegetation communities would predominantly occur where the alignment passes through Nambucca, Newry and Little Newry state forests and vegetation parcels on private land north of the Kalang River. Much of this loss relates to the dry sclerophyll forest communities which are widespread and abundant in the region. The area of vegetation directly impacted by a 10 metre, five metre and three metre buffer is presented in Table 10-10. The area of habitat loss associated with that vegetation is presented in Table 10-10.

Table 10-10 Direct impact of the Proposal on native vegetation and fauna habitats

Vegetation associations	Corresponding fauna habitat type	Impacted area (hectares)		
		10 metre buffer	5 metre buffer	3 metre buffer
Dry open forest – blackbutt	Dry sclerophyll forest	144.11	123.84	114.93
Moist open forest – white mahogany/grey gum/ironbark	Moist sclerophyll forest	28.76	24.79	22.99
Moist open forest – flooded gum		21.91	18.73	17.33
Mixed floodplain forest (EEC)		12.49	10.69	9.98
Swamp forest – swamp mahogany/paperbark (EEC)	Swamp sclerophyll forests	12.47	11.02	10.33
Swamp forest – swamp oak (EEC)		33.07	9.17	8.62
Lowland rainforest (EEC)	Rainforest	0.58	0.52	0.50

Vegetation associations	Corresponding fauna habitat type	Impacted area (hectares)		
		10 metre buffer	5 metre buffer	3 metre buffer
Freshwater wetlands (EEC)	Freshwater wetlands	1.58	1.22	1.09
Mangroves	Estuarine	0.19	0.15	0.14
Total		255.15	200.13	185.90

10.4.2.2 Endangered ecological communities

Table 10-10 shows there would be a loss of 186-255 hectares of vegetation as a result of the Proposal. Approximately 30-60 hectares (16-24 per cent) of this can be characterised into five separate EECs (listed under the TSC Act). No EECs listed under the EPBC Act were identified. Table 10-11 provides details of the potential impact on these EECs and their condition applying a 10 metre construction buffer.

Table 10-11 Direct impact of the Proposal on EECs (TSC Act) with a 10 metre buffer

Endangered ecological community	Direct impact (ha) (EEC quality)					Total (ha)
	Low	Low-mod	Mod	Mod-high	High	
Swamp Sclerophyll Forest on Coastal Floodplain	0.38	0.29	5.86	-	5.94	12.47
Subtropical Coastal Floodplain Forest	0.24	1.93	2.23	3.25	4.84	12.49
Swamp Oak Floodplain Forest	-	9.21	14.88	3.86	5.12	33.07
Lowland Rainforest on Floodplain	-	-	-	-	0.6	0.6
Freshwater Wetlands on Coastal Floodplains	0.88	0.31	0.18	-	0.21	1.58
Total	1.5	11.74	23.15	7.11	16.71	60.21

The greatest impact in terms of area (33 hectares) would be the removal of Swamp Oak Floodplain Forest, of which over 70 per cent was identified as of low to moderate condition. This is located in areas north of Nambucca River, around Deep Creek and in the vicinity of Short Cut Road. Approximately 12 per cent of each of Swamp Sclerophyll Forest on Coastal Floodplain and Subtropical Coastal Floodplain Forest would be removed. Only small areas of lowland rainforest and freshwater wetlands would be impacted. If the area of removal can be reduced to the three metre or five metre construction buffer there is the potential to decrease the overall loss of EECs, particularly for Swamp Oak Floodplain Forest.

These losses represent a relatively small proportion of the total remaining area of each EEC on the Macleay Coastal Floodplain. It is estimated that approximately 700 hectares of swamp sclerophyll forest, 400 hectares of Swamp Oak Floodplain Forest and 11,000 hectares of freshwater wetlands on the coastal floodplain are remaining. The total extent of remaining Subtropical Coastal Floodplain Forestand Lowland Rainforest on Floodplain is not known.

10.4.2.3 Threatened flora species

The impact on threatened flora species was assessed using the Threatened species assessment guidelines: the assessment of significance (DECC 2007c) for species listed under the TSC Act and the Significant Impact Guidelines – Matters of National Environmental Significance (Department of Environment and Heritage 2006) for species listed under the EPBC Act Table 10-12 provides details of the potential impacts on the threatened flora.

Targeted surveys of the distribution and abundance of vulnerable species Marsdenia longiloba were undertaken and resulted in the modification and refinement of the design of the Proposal in several locations to reduce direct and indirect impacts on identified populations. As Table 10-12 shows, the Proposal would result in the loss of 12 individual Marsdenia longiloba (8 per cent of the population). The table also indicates that this impact could be reduced if individuals are retained within the construction corridor. An additional 32 individuals have the potential to be indirectly impacted as they occur within the road boundary of the Proposal. The remaining 112 individuals (72 per cent) would remain in surrounding areas outside the road boundary.

One specimen of the Rusty Plum located in riparian vegetation along Boggy Creek would be removed. This was the only individual found in the study area and the extent of the local population is not known. Removal of this individual would be considered a significant impact on the local and regional population.

Table 10-12 Threatened flora

Species	Conservation status		Conclusion of assessment
	Cwlth	NSW	
Slender Milkvine (*Marsdenia longiloba*) - a slender vine, growing to five metres in height in moist open forest	V	E	Occurs in seven sub-populations along the route in Nambucca State Forest, Little Newry State Forest and within densely vegetated private properties to the north of the Kalang River. Five of the populations would be directly impacted to some degree. The total number within these populations was estimated to comprise 156 individual plants, of which 12 would be directly impacted with a 10 metre buffer. However this impact can be reduced if individuals are retained within the construction corridor. An additional 32 would potentially be indirectly impacted as they occur within the road boundary of the Proposal and may be subject to altered biophysical conditions. The Proposal would lead to changes in potential habitat for colonisation of the species, resulting from increased run-off of untreated surface water and edge effects, resulting in increased potential for weed invasion. Life cycle attributes of remaining plants are unlikely to be significantly impacted from habitat fragmentation.
Rusty Plum (*Amorphospermum whitei*) - a medium-sized tree with typical habitat consisting of gully rainforest or wet sclerophyll forest with a well developed rainforest understory	-	V	Removal of one individual. The Proposal would potentially lead to changes in potential habitat for colonisation of the species, resulting from increased runoff to untreated surface and edge effects, mostly resulting in increased weed evasion. Life cycle attributes are unlikely to be significantly impacted from habitat fragmentation.

V=vulnerable, E=endangered

10.4.2.4 Edge effects

Introducing edges as a result of the Proposal has the potential to impact the existing vegetation structure through alterations to the chemical and physical environment such as changes to sunlight availability, hydrological regimes and soil nutrients.

The edge effects would be expected to be greatest where the Proposal would create 'new' edges, such as through large areas of remnant vegetation in Nambucca and Newry state forests and private forested lands north of the Kalang River. The edge effects were estimated to extend for a distance of up to 50 metres into the area fragmented. The extent of possible edge effect impacts for the Proposal were calculated based on 0.6:1 ratio consistent with the data presented by Bali (2005) (i.e. 0.6 x 50 m wide) along the length of the Proposal footprint only (taking into account only where a new edge is created through vegetation and not adjoining the existing highway or cleared land). This calculation resulted in a total area of impact of about 126 hectares.

The higher light availability in particular may favour invasive species such as Lantana Camara which could shade out native understorey species. Slender Milkvine (Marsdenia longiloba) which would be retained in habitats adjacent to the Proposal are likely to be impacted from edge effects, including competition with weed species and changes to physical attributes such as sunlight, hydrological regimes and soil nutrients.

10.4.2.5 Erosion of genetic stock

This is the process whereby an already limited gene pool of a species of plant or animal diminishes even more when individuals from the surviving population die off without getting a chance to breed with others. Low genetic diversity in a population of wild animals and plants leads to a further diminished gene pool, inbreeding and a weakening immune system and fast tracks that species towards extinction.

The direct removal of vegetation and fauna habitat and the associated fragmentation of habitat have the potential to have long-term impacts on genetic diversity in flora and fauna. This impact would be greatest on species with high levels of endemism and in particular species with small restricted home ranges within the study area.

None of the flora species identified from the field surveys are considered to be restricted in distribution within the study area, with all species recorded known to occur across the entire North Coast Bioregion. The recording of the Slender Milkvine (Marsdenia longiloba) in this location is consistent with the southern limit of the species distribution, a factor of climatic conditions and not habitat fragmentation. This factor highlights the importance of local populations and the consideration of the individuals in the design of the Proposal.

10.4.2.6 Groundwater dependent communities

Groundwater dependent ecosystems in the study area include terrestrial vegetation, base flows in streams, aquifers, or wetlands. Those vegetation communities and habitats with the greatest potential to be affected by changing ground-water levels consist of terrestrial vegetation and wetlands located in the low-lying floodplain areas intersected by the route of the Proposal, including:

- Swamp oak floodplain forest.

- Swamp sclerophyll forest.
- Subtropical coastal floodplain forest.
- Lowland rainforest.
- Freshwater wetlands.

Other communities within riparian areas may have some level of ground-water dependence, including wet sclerophyll forests in proximity to creek flats. The Proposal may impact on vegetation by either, altering runoff and aquifer recharge rates, and potentially altering the sub-surface flow. Potential blocking of drainage passages could also occur which has the potential to effectively raise the upslope water table and killing vegetation by root inundation, whilst lowering the downslope water table.

Wetland crossings have been generally avoided within the study corridor with the exception of a small number of isolated wetlands occurring in cleared agricultural areas. Such sites have been highly disturbed from grazing, pasture improvement and weed invasion. One higher quality area of this community is present adjacent to the eastern side of the existing highway near Deep Creek which comprises open areas of water, dense sedges and interspersed paperbarks.

The most likely impacts to groundwater dependent communities are from altered hydrology regimes which change groundwater levels. For example, cuttings required in gully areas may intersect the watertable and effect groundwater levels downstream, including SEPP14 wetlands. There are several areas where cuttings in gullies areas are required and there would be potential impacts to the ecology of several drainage lines as a result of changes to groundwater flow, including:

- Gully areas in Nambucca, Newry and Little Newry state forests.
- Creeks and gullies on private property including Boggy Creek, Deep Creek and gully areas in the relatively extensive areas of remnant vegetation north of the Kalang River.
- Major river crossings including the Kalang and Nambucca Rivers.

There is potential for EECs adjacent to the Proposal to be impacted from altered hydrology and experience die-back and/or changes to floristics and vegetation structure.

10.4.3 Potential fauna impacts

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

10.4.3.1 Habitat removal

The habitat types along the corridor include dry sclerophyll forests, moist sclerophyll forests/rainforest, swamp sclerophyll forests, freshwater wetlands and mangroves. These habitats provide fauna resources such as hollow bearing trees, fallen timber and leaf litter, dense understorey vegetation, grassy understorey vegetation, winter

flowering flora species and creeks and drainage lines. The area of loss from each of the habitat types is shown in Table 10-10.

The majority of habitat removal is from the cleared and modified agricultural and semi-rural land. Although the diversity of this habitat type is considered low in comparison to the moist or dry forests, the isolated remnant paddock trees provide nesting and sheltering opportunities for a range of potential species including threatened species such as osprey.

Where vegetation clearance is required the greatest habitat loss is from the dry forests. These forests have been modified and degraded to differing degrees as a result of logging and altered fire regimes. However, the dry forests provide a range of microhabitat features including shelter and food resource capable of supporting breeding populations and refuge for a diversity of sedentary and transient fauna including several listed threatened species.

10.4.3.2 Habitat fragmentation

Habitat fragmentation is the division of a single (contiguous) area of bushland into two or more areas. This has the potential to disrupt wildlife movement corridors, genetic exchange, decrease the available area of habitat and increasing edge effects. Large areas of contiguous habitat are particularly important for species which have large habitat ranges such as spotted-tail quoll and large forest owls. The larger the area of habitat, the greater the potential carrying capacity and the higher the chance of finding a mate. Large areas of contiguous habitat also decrease the likelihood of local extinctions from stochastic events such as wildfire and disease as individuals can repopulate an area more effectively.

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

The landscape surrounding the Proposal area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. The Proposal would increase the fragmentation of habitat in the landscape by impacting on several contiguous forest areas, particularly the larger fragments associated with Nambucca and Newry State Forest in Section 2 of the study area and private forested land to the north of the Kalang River in Section 4. While the impacts of fragmentation on flora and fauna and threatened species in the study area are difficult to determine without more extensive population viability assessments, it is important to note that all areas of habitat affected by the Proposal have already been fragmented in the past by roads, clearing and power easements. The Proposal would be contributing to this cumulative fragmentation of the habitat in the landscape.

The impacts of additional fragmentation would be most evident in Nambucca State Forest in Section 2, where an area of up to 1000 hectares of forested lands would be separated to the east of the road. This habitat was identified as being occupied by a population of yellow-bellied gliders as well as other threatened species including Marsdenia longiloba, Glossy Black-cockatoo, Masked Owl, and a number of microchiropteran bats. While the proportion of

habitat remaining to the east of the road (around 1000 hectares) is considered sufficiently large to support populations of these species, further measures are required to minimise the impacts of fragmentation. Such measures have been considered in the design of the road by incorporating a wider median through the northern end of Nambucca State Forest and placing fauna underpass structures in strategic locations along the route within wildlife corridors and areas which would be used by fauna. Highly mobile species such as bats and birds are expected to be less impacted by fragmentation. The location of the fauna underpasses and widened medians can be seen in Figure 10-3a to Figure 10-3d.

The impact of additional fragmentation in Newry State Forest is difficult to assess as this area is already fragmented from coastal habitats to the east in Valla Nature Reserve as a result of the existing Pacific Highway and existing wide electricity transmission easements. Further widening of the median and construction of fauna underpass structures are also proposed through portions of Newry State Forest to maintain opportunities for fauna crossing.

Up to 360 hectares of habitat would be fragmented to the east of the Proposal in Section 4 and associated with forest on private lands. This area provides important habitat for the local population of glossy black-cockatoo and would remove a portion of potential habitat. This species is expected to be able to cross the new roadway with limited constraint.

To mitigate the effects of fragmentation from the Proposal it would be beneficial to re-establish links with historically isolated fragments of habitat in proximity to the new road through increasing the size of smaller remnant fragments adjoining the road. Particular opportunities for this exist in low-lying agricultural areas adjoining the corridor. To offset the residual impacts of the Proposal, a biodiversity offset package would be developed in consultation with the DECCW (refer to Section 10.5 and Appendix D - *Draft Statement of Commitments*). Other mitigation measures to reduce the fragmentation impact of the Proposal include widening the median and the inclusion of fauna crossing structures to facilitate movements across the road. This is particularly aimed at providing movement opportunities for gliders (i.e. Yellow-bellied glider, Squirrel Glider, Sugar Glider, Greater Glider, and Feathertail Glider) by reducing the barrier effect of two carriageways side by side. Natural vegetation and tree cover would be retained within the median in key corridor locations as identified in Table 10-14.

10.4.3.3 Edge effects and weed infestation

The fragmented habitats are also subject to potential edge effects which can include increased fauna mortality during construction and in the long term, modified animal behaviour and a modified physical and chemical environment and a spread of exotic species. These impacts would be most profound for moist vegetation communities where invasive weed species are likely to increase, which would act to shade out native understorey species and affect fauna habitats. Edge effects can potentially be reduced through general mitigation and rehabilitation measures as described in Section 10.5.4.

The highest priority is to implement measures that aim to minimise and intersect surface water run-off into adjacent remnant vegetation. Dense roadside seeding and plantings using a diversity of local indigenous plant species may also help to reduce the affects of rapid weed invasion into disturbed edge habitats.

10.4.3.4 Erosion of genetic stock

The Proposal would isolate the habitat remaining on the eastern (coastal) side of the highway to some degree. Less mobile fauna species such as terrestrial and arboreal mammals, reptiles and amphibians conserved on the eastern side of the highway would have greater difficulty accessing the areas and potential mates to the west beyond the highway. The potential issues associated with genetic erosion are reduced for highly mobile species (particularly bats and birds).

Examples of potential isolation of fauna populations include:

- The fragmentation of approximately 1000 hectares of forest in the vicinity of the Old Coast Road associated with a portion of the Nambucca State Forest and adjoining property to the south which would remain isolated on the eastern side of the highway. The large proportion of habitat retained may lessen the impacts on genetic isolation. However, the absence of opportunities for genetic dispersal means there is the potential for significant longer term impacts on remaining populations of species such as the yellow-bellied glider.
- The cumulative loss of connectivity is expected to impact on coastal forests such as the Valla Nature Reserve and surrounding habitats located to the east of the proposed traverse of Little Newry and Newry State Forests.
- Measures to mitigate these impacts have been addressed via the appropriate placement of dedicated, combined and incidental fauna underpasses and the proposed widening of the median at these locations to minimise the barrier effect of the dual carriageway and to provide a 'stepping stone' opportunity for gliders. These measures are detailed in Table 10-13 and Table 10-14. Fish friendly crossings of culverts would be included where required to maintain fish passage within creeks.

10.4.3.5 Impact on wildlife corridors (including riparian corridors)

Wildlife corridors play an important role for biodiversity conservation particularly as they allow for migration and dispersal of plants and animals, reduce competition, and provide refuge and important movement pathways for maintaining genetic diversity in populations. Corridors are particularly important in fragmented and agricultural areas as they provide pathways for fauna movement for species that are reluctant to move through cleared landscapes. Outside of the state forests, strips of vegetation have been retained mostly along road reserves such as the existing Pacific Highway and as riparian habitat along creeks and rivers. There are very few areas of high corridor value in the study area due to the extent of previous clearing and the existing network of roads and rail. The Proposal would sever 12.7 kilometres of regional 'moist' and 11.9 kilometres of key corridors as identified by the DECCW. Moist corridors have been identified by the DECCW, as areas most likely to be used by fauna species which utilise mesic (moist) environments.

Fauna species most likely to benefit from adequate wildlife corridors include migratory species, species in search of unoccupied habitats, species which make small scale migrations seasonally and species with a large habitat range including large forest owls, Koalas, spotted-tail quoll, brush-tailed phascogales, gliders and some bird species. These wildlife corridors are particularly important for fauna during large disturbances such as wildfire and habitat clearance. Many fauna species may disperse from an area due to high levels of competition with other fauna species or to seek out seasonal food resources such as flowering trees and shrubs.

Fauna crossings have been included in the concept design of the Proposal and have been located to ensure movement within the existing wildlife corridors are maintained. The location of the fauna crossings are shown in Table 10-13 and Table 10-14 and Figure 10-3a to Figure 10-3d.

10.4.3.6 Impact on riparian habitat

Riparian habitat is represented along the banks of the major river ecosystems in the study area (i.e. Nambucca and Kalang) as well as several named creeks including Warrell Creek, Boggy Creek, Deep Creek, Newee Creek and Oyster Creek. Other riparian vegetation is found in gully habitat representing moist forest, swamp forest or rainforest habitat adjoining open forest on slopes. The addition of bridges or culverts at the creeks and rivers along the highway would require removal of riparian vegetation to accommodate the new crossings. Riparian habitat varies from narrow linear strips of vegetation (<5 m wide) and restricted to river banks adjoining agricultural lands to broader strips in low-lying fringes of the tidal creek systems. The riparian vegetation in the study area consists of:

- Mixed floodplain forest situated in the riparian zones of Warrell Creek, the Kalang River, Boggy Creek and Oyster Creek, comprises both narrow bands and broader patches.
- Swamp oak forest and swamp mahogany / paperbark forest which is represented along the edges of Warrell Creek, Deep Creek and the Nambucca River, generally as restricted linear strips and small patches adjoining cleared agricultural lands.
- Estuarine vegetation consisting of narrow bands (<five metres) of mangroves surrounding tidal creeks such as Newee and Deep Creek and large portions of the Kalang and Nambucca River foreshores. Mangrove communities are recognised for providing significant habitat for estuarine fish and are protected as important fish habitat under the FM Act. This association occurs along banks of tidal estuaries subject to inundation by salt-laden water. Two species are represented, Grey Mangrove (*Avicennia marina*) and River Mangrove (*Aegiceras corniculatum*).

Impacts on riparian vegetation would occur directly within the road footprint of the Proposal at proposed bridge locations and indirectly through changes to local hydrological regimes and edge effects, including possible shading of proximal vegetation and potential weed invasion. The exact area to be directly lost as a result of the Proposal is difficult to quantify as many sites are very narrow and small in area. Mangroves and swamp oak are difficult to quantify as they are particularly restricted in distribution and may occur as single rows of trees located along river banks. An example includes the northern bank of the Kalang River adjoining South Arm Road. An estimate of the area of mangrove directly impacted by a 10 metre, five metre and three metre buffer is presented in Table 10-10.

Impacts on riparian habitats adjoining the road footprint are to be mitigated through minimising the construction footprint at all proposed bridge crossings, installing run-off storage structures, minimising erosion and rehabilitation post-construction through plantings of locally indigenous riparian species.

10.4.3.7 Wildlife injury and mortality

The potential for wildlife injury or death would occur during both the construction and operation phases of the Proposal. During the initial stages of construction, the clearing of vegetation may result in injury or death of resident

fauna. Species at risk include nocturnal species such as possums and gliders which shelter during the day, and ground dwelling species such as snakes, lizards and amphibians, and small mammals which may not be able to move fast enough or cover large enough distances to avoid clearing activities. There is also the risk of displaced fauna succumbing to predation or stress induced by competing with existing resident populations for resources, particularly shelter/refuge habitat.

Operation of the Proposal introduces an increased risk of wildlife injury or mortality as a result of wildlife being struck by vehicles. The risk is greatest for less mobile species, which may include small terrestrial mammals, reptiles and amphibians. The greater the distance fauna must travel across the road, the greater the risk of collision. The upgrade section of the Proposal would potentially result in an increased risk of road kill or injury because the additional sections of road (additional carriageway and local access road) that must be crossed by fauna. To mitigate this risk, 36 fauna crossings and associated fauna fencing, have been included in the concept design at locations where the highway bisects relatively large areas of native vegetation where fauna are likely to cross and at known wildlife corridors. These are listed in Table 10-13 and shown in Figure 10-3a to Figure 10-3d and have been designed to allow dry passage during wet periods via the inclusion of raised outer cells and internal ledges. Dry passage access has been included for fauna under major bridge crossings. In addition, one dedicated fauna crossing has been included within a key and regional wildlife corridor (as identified by the DECCW) within Newry State Forest to provide passage for both riparian and non-riparian fauna.

Table 10-13 Indicative fauna crossings

Approximate chainage	Details	Indicative size and configuration [1]	Fauna crossing
3760	Box culvert	3 x 3600 x 3600	Incidental
5760	Box culvert	3000 x 1200	Incidental
6320	Fauna corridor under bridge over Warrell Creek		
6510	Fauna corridor under bridge over Warrell Creek		
8450	Box culvert	14 x 3600 x 1800	Incidental
9220	Box culvert	14 x 3600 x 2100	Incidental
13285	Box culvert	2400 x 1200	Combined
15885	Box culvert	2400 x 1200	Combined
16630	Box culvert	3 x 3600 x 1200	Combined
17205	Box culvert	2400 x 1500	Combined
17720	Box culvert	2400 x 2400	Adjacent dedicated crossing
18515	Box culvert	2400 x 1200	Combined
19350	Circular culvert	750	Incidental
19820	Box culvert	5 x 2400 x 2100	Combined

Approximate chainage	Details	Indicative size and configuration [1]	Fauna crossing
20880	Fauna corridor under bridge over Boggy Creek		
21740	Fauna corridor under bridge over Cow Creek		
23040	Fauna corridor under bridge over Deep Creek		
24305	Box culvert	2700 x 900	Incidental
25255	Box culvert	2400 x 2400	Combined
26535	Box culvert	5 x 3600 x 1200	Combined
27845	Circular culvert	4 x 1200	Incidental
28275	Circular culvert	3 x 1200	Incidental
28565	Box culvert	2 x 2400 x 1200	Incidental
29215	Circular culvert	2 x 1200	Incidental
30855	Box culvert	2100 x 900	Combined
31510	Box culvert	4 x 2100 x 1200	Combined
32075	Box culvert	2400 x 1200	Combined
33395	Circular culvert	3 x 1200	Incidental
33880	Box culvert	2400 x 1200	Incidental
34380	Box culvert	3 x 2700 x 1200	Combined
34615	Box culvert	3 x 2700 x 1200	Incidental
35095	Box culvert	23 x 3600 x 3000	Combined
36905	Box culvert	2 x 2400 x 1200	Combined
37950	Fauna corridor under bridge		
38330	Box culvert	2 x 3000 x 1500	Combined
39990	Box culvert	17 x 3300 x 2100	Incidental

[1]- The indicative size and configuration would be further refined during the detailed design phase.

The approach to selecting fauna crossing locations was based on a review of typical fauna within the area and opportunities for use of combined drainage structures, such as box culverts and bridges as fauna crossings. This focused on providing dedicated fauna underpasses for species of high conservation value (i.e. Koala, quoll and phascogale) in addition to a range of structures for a diversity of common fauna. The locations of the proposed combined and incidental fauna crossings were then subject to detailed review and additional structures added where appropriate. Long-term monitoring of fauna underpass structures has shown success for a range of small to medium sized fauna in eastern Australia (e.g. Goosem 1997; 2001, AMBS 2001, 2002a, 2002b and Taylor and

Goldingay 2003). This includes ground-dwelling mammals as large as Red-necked Wallaby and Swamp Wallaby, reptiles and some arboreal mammals such as the Koala which have been reported using box culverts (2.4 x 1.2 metre and 3 x 3 metre) and 10 metre spanning bridge and arch structures (AMBS 2001, 2002a, 2002b).

Large mammals (such as Eastern Grey Kangaroo) require much wider and higher areas for daily movements. Factors that are considered to deter larger terrestrial fauna from using underpass structures include flooding, boggy ground, presence of stumps blocking the entrance or long, narrow (and therefore dark) passages. These factors have been considered in the design of underpass structures for the Proposal, which include cells raised above the flood level and light within the median in longer passages. Images of typical fauna crossings are provided in Chapter 6 – *Description of the Proposal*.

With all terrestrial fauna, security from predators is important. Therefore, it is necessary to provide a clear line of sight to light and vegetation at both ends of the crossing where possible. For smaller species, provision of protective cover and structures such as ledges or horizontal logs that are designed to restrict access by larger predators would aid their security. Approaches to the structure should allow good visibility, provide some protective cover and not be obscured by dense vegetation.

Large fauna require exclusion fencing for guidance through the crossing structure and to prevent access to the carriageway. Fencing is to be provided at strategic locations including each of the three widened medians (internal and external) and up to 500 metres on either side of dedicated fauna underpass structures shown in Table 10-13 and Table 10-14 and Figure 10-3a to Figure 10-3d.

Table 10-14 Details of the proposed widening of the median for terrestrial and arboreal fauna crossing

Location	Average median width (metres)	Length of widening (metres)
Section 2 – Nambucca State Forest	50	300
Section 4 – Dalhousie Creek, Newry State Forest	50-80	800
Section 4 – Private property	40	900
Total		2 km

10.4.3.8 Threatened fauna

The results of the assessments confirmed the presence of 14 threatened fauna species of conservation significance. An additional 13 species are considered to potentially occur in the study area on the basis of suitable habitat. These are listed in Table 10-7. Species with similar taxonomy or habitat requirements have been grouped together.

Threatened species listed under the TSC Act and recorded during surveys of the study area, or with the potential to occur in the study area, were assessed using the Threatened species assessment guidelines: the assessment of

significance (DECC 2007). A summary of the likely impacts on the species listed in Table 10-7 and are presented below, with further details available in Working paper No 1 – *Flora and fauna*.

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

10.4.3.9 Reptiles and amphibians

Of the 24 reptile species recorded in the study area, all identified are considered common and widespread species in eastern NSW. Eighteen frog species were recorded across all habitat types with tree frogs the most abundant. No threatened species were identified during survey. However, the green and golden bell frog has previously been recorded south of Macksville, but is since thought to be locally extinct. In addition the great barred frog has the potential to occur in several creeks and drainage lines in the northern half of the study area, through Nambucca, Little Newry and Newry State Forests. The Proposal has the potential to impact on this species as it would directly traverse streams and rivers across the study area. Design measures have been incorporated to provide appropriate fauna passage and protection of waterways during construction and operation to ensure potential habitat is not impacted further.

10.4.3.10 Birds

A total of 125 bird species were recorded during the field investigations, representing a moderately high species richness due primarily to the diversity of habitats available, topographic variation and floristic diversity in the study area. Several of these species are of conservation significance including Black-necked Stork, Glossy Black-cockatoo, Square-tailed Kite, Osprey, Wompoo Fruit-dove and Powerful Owl. A number of nocturnal bird species were also recorded including the Australian Owlet Nightjar, Tawny Frogmouth, Southern Boobook and Powerful Owl. These nocturnal species roost predominantly in tree hollows, although may also roost in dense foliage.

The Black Necked Stork was mainly associated with the wetland on the Kalang River floodplain. However, other wetlands in the study area provide potential habitat. This and other wetlands would not be significantly impacted by the Proposal.

The Osprey is associated with waterbodies including coastal waters, inlets, lakes, estuaries, beaches, offshore islands and sometimes along inland rivers. The Osprey feeds on fish over clear open water and may nest on the ground, on sea cliffs or in trees. Several breeding pairs are expected to occur in the catchment of the Nambucca and Kalang Rivers, and one active nest site was recorded near Deep Creek in 2008. While the Proposal would have a negligible impact on the foraging habitat of this species, and no impact on the identified nest site, there is the potential for other nest sites to be built which may be impacted. For the Osprey, although the loss of habitat is unlikely to significantly impact on this species, there is the potential for loss of nest sites. As such it would be necessary to survey the area prior to construction.

No nest sites of the Square Tailed Kite were located along the Proposal or within the affected areas of state forests. The potential habitat for foraging and roosting is very common and widespread for this species. Therefore, the

impact on breeding activities of the local populations is not considered significant. However, a survey would be undertaken to identify nest sites prior to construction.

A population of the Glossy Black Cockatoo was identified in the northern half of the study area, north from Nambucca State Forest to Raleigh, comprising several groups occupying parts of Nambucca, Newry and Little Newry State Forests as well as dry sclerophyll forest habitats on private land north of the Kalang River and east of the existing Pacific Highway near Valla. The abundance of food resources and distributional range of the local population together with the high mobility of the species suggests there are several localised family groups in the study area and that these are adapted to moving across modified landscapes to access food resources. The Proposal would clear up to 144 hectares of blackbutt open forest, a portion of which would provide potential habitat for this species. However, this loss is unlikely to represent a significant impact, despite the loss of food resources. There is the potential to remove large hollow bearing trees lying in close proximity to the Proposal, which may currently or potentially provide nest sites. Further surveys of habitat trees would be necessary prior to construction.

The Wompoo Fruit Dove is wide-ranging and locally nomadic, capable of moving large distances between remnant vegetation in response to the sporadic availability of food resources. Local populations are expected to be small and nomadic compared to west of the study area in the Dorrigo / Bellingen area where subtropical rainforest habitats are more widespread. The Proposal would involve removal of a small percentage of moist forest habitat (circa 65 hectares) which is marginal for the species and up to one hectare of lowland rainforest which is better suited. The potential for these species to forage in the study area is expected to remain following the works and the impacts on life-cycle activity would be very minimal.

There is also a low incidence of potential roost sites/nest hollows for the Powerful Owl. Again, a survey would be required prior to construction to minimise the impacts to potential nests. The loss of vegetation resulting from the Proposal would potentially impact on the prey species of these owls and increased fragmentation of habitat may impact on the dispersal of juveniles.

The Proposal is not considered likely to have a significant impact on the other threatened bird species that could potentially occur within the study area. However, a survey for nesting sites and hollow bearing trees would be undertaken prior to construction to minimise impacts on any previously unidentified species.

10.4.3.11 Mammals

A total of 29 mammal species were recorded during the surveys undertaken in the study area comprising six species of ground dwelling mammals, seven species of arboreal mammals and 16 bat species. Of these species, eight were listed as threatened species, being the Grey-headed Flying Fox, Spotted-tailed Quoll, Koala, Brushtailed Phascogale, cave and tree roosting bats and yellow bellied gliders

The Grey-headed Flying Fox is listed as vulnerable under both NSW and Commonwealth legislation. It inhabits a wide range of habitats including rainforest, mangroves, paperbark forests, wet and dry sclerophyll forests and cultivated areas. The Proposal would clear approximately 253 hectares of potential foraging habitat for this species. This represents a relatively minor impact for the species in the local area. This area is also used as potential

foraging habitat for Miniopterus spp. (Cave Roosting bats). Comparable habitats are well represented through the locality and regional area and it is unlikely that the Proposal would have a significant impact on the foraging life-cycle events for a local population of these bat species and continued foraging over the site and adjacent lands could be expected. The same 253 hectares would provide habitat and potential foraging habitat for tree-roosting bats. Important life-cycle activities include roosting and breeding and are typically associated with tree hollows as well as foraging for insect prey which occurs in a variety of habitat types. The size of local populations is not known, although expected to be moderately large given the expanses of suitable habitat. Much of the habitat to be removed has been identified as of young age or even age and the abundance of hollows is very low throughout the corridor. Nonetheless the Proposal would involve clearing of habitat trees. Comparable habitats are very well represented throughout the locality and regional area and it is unlikely that the Proposal would have a significant impact on the foraging or roosting life-cycle events for local populations of these bat species and continued presence in the locality could be expected.

The Spotted Tailed Quoll, which is expected to occur in the area, is an opportunistic predator and would feed on a variety of prey including macropods, birds, reptiles, arboreal mammals and small terrestrial mammals. The Proposal would remove part of its habitat and associated prey, leading to further fragmentation of habitat, a known threat to the species. Provided measures to conserve fauna corridors and movement avenues have been incorporated into the Proposal, then breeding and foraging opportunities likely to sustain local populations would remain in the region.

There is evidence that Koalas are present in Nambucca State Forest and along the coast around Valla. Potential habitat for Koalas would be lost as a result of the vegetation clearing, areas of which would contain identified tree food species. The impact of this activity on the local population is likely to be minimal as suitable food resources are common and widespread in the region, particularly to the north west of the route. As such there is little evidence to suggest that Koala populations or movements are centred around the Proposal route.

The Brush-tailed Phascogale is likely to occur in the study area. This species inhabits a range of arboreal environments, particularly dry sclerophyll forest with little ground cover. Despite the proposed vegetation loss, these habitats are well represented in the study area, and populations would persist following development of the highway route.

The Proposal is likely to remove a portion of the home range territory of at least one family group of yellow-bellied gliders, including possible denning trees. This group is part of a larger population which extends into the surrounding state forests and private land. Individuals have also been recorded in Newry State Forest in contiguous habitats to the north. Additionally, this area is part of a larger east-west corridor suggesting other populations are likely to occur to the west of the study area. The long term persistence of yellow-bellied gliders requires a landscape mosaic of old growth trees which meets both their foraging and sheltering needs. Such habitat is present through the remaining portions of Nambucca State Forest to the east and west of the route. In order to assist with movement across the Proposal in this location, the median has been widened through the northern end of Nambucca State Forest and also Newry State Forest which was specifically located at strategic glider locations. Where possible the concept design footprint has been refined to avoid identified habitat trees.

10.4.3.12 Migratory fauna

Nine migratory bird species listed under the EPBC Act were identified from the field investigations together with four more potential species based on the presence of suitable habitat. These migratory species are listed in Table 10-8.

The majority of migratory species identified were considered uncommon and widespread vagrants with no specific populations represented in the study area. From the field investigations conducted, there is no evidence to suggest that an area of important habitat exists or that the study area is occupied by an ecologically significant proportion of a migratory species population.

The rufous fantail occupies wet forests and less often open forests. The Proposal would require the removal of a combined area of approximately 253 hectares of open forest and rainforest communities. Due to the availability of suitable habitat in the remaining areas of state forest, the impacts on this species as a result of the Proposal are not considered significant on a local, regional or state level.

The Black-faced Monarch occupies tangled understoreys of rainforest and eucalypt forest. The Proposal would require the removal of a combined area of approximately 253 hectares. Alternative habitat for the Black-faced Monarch is available in the remaining areas of state forest. As such, the Proposal is considered unlikely to affect this species at a local, regional or state level.

The White Throated Needletail would occasionally roost in trees and feeds on flying insects, such as termites, ants, beetles and flies which it catches in flight. The Proposal would not affect foraging areas for this species and would have negligible impact on roosting sites. Therefore the Proposal is not considered likely to impact this species on a local, regional or state scale.

10.4.4 Potential impacts to aquatic habitats and biodiversity

No State or Commonwealth listed macroinvertebrate or fish species were identified in the freshwater and estuarine habitats occurring within the study area. The aquatic species identified during the field investigations are listed in Table 10-9.

Estuary Perch (Macquaria marianus) was found to be present in Warrell Creek, Deep Creek and the Kalang River and one Australian bass was captured from the Kalang River. These are migratory species and to ensure their lifecycles are not adversely impacted during construction, activities which are likely to cause impact to these species within the waterway should be timed to occur outside of the spawning period of June through to August.

The preferred habitat of the Eastern Cod is clear, flowing streams with rocky beds and deep holes with plenty of boulders or large woody debris (snags). This habitat is not present within the study area and therefore the Eastern Cod and its habitat would not be affected by the Proposal.

Potential impacts on aquatic habitats include overshadowing, pollution of waterways and change to the hydrological regime. Potential water quality issues and mitigation measures are addressed in Chapter 16 – *Water quality and hydrology* of this environmental assessment. The greatest potential for impact on local waterways is during

construction, therefore, the adoption of best practice water quality controls and protection measures would be implemented to minimise impact on aquatic habitats.

The activities with the potential to impact on the aquatic flora and fauna during construction and operation include:

- Installation of in-stream structures such as pylons is listed as a key threatening process under the *Fisheries Management Act 1*994. Culverts and causeways can modify the natural flow of rivers by increasing, decreasing or altering the seasonality, frequency, magnitude and timing of flow which can disrupt natural reproductive cues, and natural sediment movement patterns. Culverts can also act as a physical barrier to native fish and invertebrates. The construction of bridges is not considered a key threatening process as the impact on flow is considered minimal.
- Increased sedimentation and erosion, which is considered a threatening process under the *Fisheries Management Act* 1994. Increased suspended solids can impact fish and macroinvertebrate abundance through clogging gill structures and benthic smothering. Increased particulates in the water column can also reduce water infiltration which may limit plant growth and influence predator foraging behaviour.
- Removal of in-stream woody debris (snags) is listed as a key threatening process under the *Fisheries Management Act* 1994 as it can provide crucial habitat to juvenile fish, macroinvertebrates and other aquatic organisms.
- Predation by exotic species and in particular the Mosquito Fish (*Gambusia holbrooki*) which is most likely to occur in highly disturbed freshwater streams.

The Proposal has been developed so that the existing hydrological regime would generally be maintained through the use of culverts and bridges where required. Detailed design of culverts would provide fish friendly crossings where applicable and culverts combined with fauna crossings so that barriers to fauna passage are not created. In operation, runoff from the Proposal would be directed to sedimentation basins before being discharged. The operational basins would be located in positions along significant water courses, to protect sensitive environmental areas from an unexpected spill from an incident.

The main operational activity that would impact the associated watercourses is increased traffic flow, which may lead to increased pollutant load in the road run-off. Road run-off can contain a variety of pollutants, which may impact negatively on the aquatic environment and in turn reduce commercial and recreational fishing viability, including aquaculture present in the study area. Pollutants can include cigarette butts, nutrients, heavy metals, pesticides, herbicides and petroleum hydrocarbons. Management and mitigation measures have been proposed to reduce the amount of pollutants entering the waterways as described in Chapter 6 – *Description of the Proposal*.

Management and mitigation measures have been proposed to reduce the amount of pollutants entering the waterways as described in Section 6.5.6. These have been based on Road Runoff and Drainage: Environmental Impacts and Management Options (Austroads 2001) and Procedure for selecting treatment strategies to control road runoff (RTA 2003) as outlined in Chapter 16 – *Water quality and hydrology* and Working paper 5 – *Water (Flooding and water quality)*.

10.4.5 Cumulative impacts

10.4.5.1 Regional scale

At the landscape scale, the major potential ecological impacts of increasing road networks are likely to be the disruption of landscape processes and loss of biodiversity (Forman and Alexander 1998). An extensive and complex road network is already in existence in the study area and the Proposal would be a contributor to this network. However, as the Proposal would, in effect, traverse a landscape which is already dominated by human activities, such as farming, logging and urban development, as opposed to a completely forested landscape, the cumulative impacts on biodiversity could reasonably be expected to have a low detectability.

Notwithstanding this fact, the Proposal would contribute to an increased density of roads versus remaining habitat in the region. Impacts could be offset to a degree by the re-establishment of a few large patches of forest and habitat on currently cleared areas in the region. Any such efforts would be based on the objective of reducing habitat fragmentation by re-establishing connectivity and increasing forest patch sizes. Further details of the rehabilitation and compensation measures are detailed in Section 10.5.5 and 10.5.6.

10.4.5.2 Cumulative impacts of the Pacific Highway Upgrade Proposal

The ecological impacts of the combined Pacific Highway upgrade projects are detailed in Table 10-15. The total contribution of the 12 existing projects to vegetation loss equated to approximately 1798 hectares and the removal of approximately 370 hectares of EEC. The loss of up to approximately 255 hectares of vegetation as a result of the Proposal represents approximately 14 per cent of the cumulative vegetation loss and 16 per cent of the cumulative EEC loss.

In the context of the Pacific Highway upgrade, the Proposal would result in additional habitat loss and fragmentation, particularly in areas where a bypass of the existing Pacific Highway would occur through the state forests. The Pacific Highway Upgrade Program would result in the installation of a barrier to east and west movement along the entire length of the upgrade. However, the area along the east coast through which the Pacific Highway Upgrade Program runs is subject to settlement with residences and associated infrastructure having caused significant habitat loss and fragmentation to date. Through the route selection process, options with significant direct impacts on vegetation were removed or altered to reduce impacts. Similarly, fauna crossings facilities have been included in the design of the Pacific Highway Upgrade Program to increase the permeability of the infrastructure to local species.

Opportunities for revegetation of acquired land parcels would be investigated as part of the detailed design to help to offset some of the vegetation losses associated with the Proposal.

Table 10-15 Approximate habitat loss associated with the Pacific Highway Upgrade Program

Project name	Project stage	Project length[1] (km)	Vegetation disturbance[1] (ha)	EEC disturbance[1] (ha)
Proposed upgrade Banora Point	Project approval	2.5	7.7	3.82
Tintenbar to Ewingsdale	Environmental assessment completed	17	10	2
Woodburn to Ballina	Preferred route selected	36	131	56
Iluka Road to Woodburn	Concept design selected	35	Not yet available	Not yet available
Wells Crossing to Iluka Road – Glenugie upgrade	Environmental assessment completed	7.3	85	5.3
Wells Crossing to Iluka Road (remaining)	Concept design selected	63.6	345	55
Woolgoolga to Wells Crossing	Concept design selected	27	230	51 (preliminary estimate)
Sapphire to Woolgoolga upgrade	Project approval	25	83.1	18.2
Coffs Harbour Bypass	Concept design selected	55	21.0	Concept design selected
Warrell Creek to Urunga	Environmental assessment being finalised	42	255	60.3
Kempsey to Eungai	Project approval	40	286	63
Oxley Highway to Kempsey	Environmental assessment being finalised	37	229	66
F3 to Raymond Terrace	Preferred route selected	14	49.0	Not yet available
Total		401.4	1731.8	380.62

[1] Approximate distances and areas.

10.5 Management of impacts

The potential impact on native flora and fauna has been considered during the route investigation phase and subsequently through the refinement of the concept design of the Proposal. During this process a number of important measures to reduce and avoid potential impacts have been built into the design of the Proposal. Mitigation measures to minimise the impacts on the local environment during construction and operation are detailed in Sections 10.5.1 to 10.5.10 and have been included in Appendix D - *Draft Statement of Commitments*. These requirements would be incorporated in the construction environmental management plan, which would be prepared prior to construction in consultation with relevant government departments and local councils. Management measures identified below are listed only once. However, some measures are relevant to more than one area.

10.5.1 Native vegetation and fauna habitat loss

10.5.1.1 Flora

Commitments identified to manage identified impacts to native flora include:

- Identification of threatened plants and vegetation to be retained and protected during construction would be undertaken by a qualified ecologist.
- Location and tagging of threatened plant species is to be undertaken along the construction corridor prior to clearing for construction.
- Installation of protective fencing to mark the limits of clearing (i.e. 'no-go' areas) surrounding the construction footprint to ensure that vehicles and other direct disturbances associated with road construction, such as construction compounds and stockpiles sites, do not enter adjacent vegetation, particularly endangered ecological communities and widened medians to avoid the spread of weeds and plant pathogens.
- Education of construction workers in relation to proposed protection measures through the site induction process.
- Where vegetation is to be retained, vegetation management measures are to be implemented, including weed removal, native plantings, broadcasting of collected native seed and relocation of specific habitat resources such as bush rocks, hollow logs, hollow tree trunks and branches.
- Seed collection of native plant species to be removed from the construction footprint would be undertaken prior to commencement of clearing and seed stored for use in revegetation works.
- Seeds from the individual rusty plum plant would be collected, propagated and planted in areas of suitable habitat adjacent to the Proposal such as Boggy Creek and gully areas within state forests that are protected as riparian exclusion zones.
- The feasibility of translocating the individual Rusty Plum plant affected and Slender Milkvine, would be investigated and, if deemed to be feasible, a translocation strategy would be developed and implemented in consultation with the DECCW and in accordance with relevant guidelines such as *Guidelines for Translocation of Threatened Plants in Australia* (ANPC 2004).
- Vegetation clearing where *Marsdenia longiloba* is present adjacent to the construction footprint is to be strictly minimised and controlled. Protective fencing is to be installed surrounding identified locations of this plant to avoid incursions from construction machinery and the potential spread of weeds and plant pathogens.
- Native vegetation cleared from the construction footprint is to be mulched along with collection of topsoil for reuse in rehabilitation works and erosion control. Mulch and topsoil should not be stockpiled in 'no-go' areas and cleared vegetation should not be pushed into 'no-go' areas.
- During the initial stages of clearing for the Proposal, the collection of topsoil is to be carried out to preserve the soil stored seed bank for reuse in revegetation/rehabilitation post construction, particularly construction. Sclerophyll species in particular are suitable for tube stock propagation and hydro-seeding in roadside verges. Where applicable, collected seed should be utilised for species which are unlikely to be present in the seed-bank of salvaged soil, such as species from the Myrtaceae, Casuarinaceae and Proteaceae plant families.

- Clearing of EECs to be restricted to the minimum area possible and protected vegetation outside the construction corridor to be clearly flagged and signed.
- Revegetation/rehabilitation of the site should be conducted progressively during the construction phase to ensure the use of collected topsoil and seed and to develop different successional stages of rehabilitation.
- A weed management plan is to be prepared as part of the flora and fauna management sub plan, outlining weed management actions to be carried out during construction to prevent the spread of weeds and plant pathogens.
- Erosion and sediment controls and their maintenance are to be used during construction of the Proposal in accordance with the 'Blue Books' (Landcom 2004 and DECC 2008). These structures would aim to limit excess nutrients and water entering the habitat of threatened species and communities.
- There is a risk that altered groundwater levels may result in impacts to EECs in floodplain areas. Potential changes to existing surface and groundwater levels would be minimised through appropriate placement and design of culverts and providing adequate drainage to reflect existing conditions.

10.5.1.2 Fauna

Commitments to manage identified impacts to native fauna include:

- A suitably qualified ecologist would undertake searches in the construction footprint for native fauna immediately prior to clearing activities. Searches would include nests and large hollow-bearing trees and target habitats of hollow dwelling species, Koalas and frogs. During the proposed clearing works, an experienced wildlife handler should be present to retrieve any displaced fauna and release the fauna into adjacent habitats safe from construction work.
- Re-survey immediately prior to construction to identify nest locations for Osprey, Black-necked Stork and brolga. The location of the identified Osprey nest would be checked to confirm if it is present before clearing commences.
- Provide dedicated and incidental fauna crossing structures at key locations for forest fauna species identified to target the range of large, medium and smaller species present such as Yellow-bellied Glider, Koala and Giant Barred Frog.
- A fauna rescue framework for clearing has been developed by the RTA in consultation with the DECCW and would be used as a basis for developing a protocol for the handling and translocation of fauna during construction.
- Nest boxes are to be installed, where required, in accordance with specialist advice and in consultation with the DECCW, prior to construction, to replace hollow resources that are proposed to be removed.
- Fauna species found in areas to be cleared would be relocated prior to clearing activities into suitable habitat as close as possible to the area in which they were found.

- Habitat features and resources for native fauna (such as hollow logs and bush rocks) would be distributed along the route of the Proposal where feasible and reasonable. Such relocation would be undertaken in a manner to limit damage to existing vegetation and would not occur in high condition remnant vegetation.
- Bridges at Warrell Creek, Nambucca River, Deep Creek and the Kalang River and culverts identified in this environmental assessment as having a potential role in fauna crossing, would be designed to facilitate fauna movements (see Figure 10-3a to Figure 10-3d).
- Waterway crossings would be designed to facilitate fish passage in consultation with relevant government agencies.
- Mature trees to be retained within the median as a stepping stone for the glider population are to be specifically protected and lopping or pruning is not to be undertaken without expert advice. A strategy would be developed in consultation with Forests NSW, for monitoring the Yellow-bellied Glider population in the affected area of Nambucca State Forest as part of the flora and fauna management plan. This would need to include the identification of home range territories in proximity to the highway, den locations, monitoring movements (marking and radio-tagging), particularly across the future road, and long term fecundity.
- Fauna exclusion fencing (e.g. floppy-top fencing) would be erected along the Proposal at appropriate locations shown in Figure 10-3a to Figure 10-3d to direct fauna movement towards fauna-crossing structures. This would be subject to routine monitoring to check for damage.
- Water quality control measures would be installed as early as possible in the construction program and would be designed / selected to meet identified receiving water objectives to protect the habitats of threatened wetland birds.
- Strategies would be developed to deal with incidents involving individual animals during construction activities in consultation with the DECCW officers, WIRES and/or other relevant local wildlife carer groups.

10.5.2 Habitat fragmentation and wildlife corridors

The primary mechanism for reducing the incidence of habitat fragmentation and its subsequent impacts was developed as part of the route investigation phase. The subsequent refinement of the route and development of the concept design of the Proposal involved further consideration of habitat fragmentation. Where possible, areas of disturbance were located on one side of a vegetation community so as to avoid additional fragmentation and increased edge effects.

Other proposed measures to mitigate the impacts of fragmentation include:

- Native and locally indigenous plants would be used in the landscaping and disturbed areas would be progressively revegetated.
- Weeds in areas disturbed by construction activities would be managed for a minimum of two years after construction completion.

- Review opportunities for re-establishing links with historically isolated fragments of habitat in proximity to the new road to mitigate the effects of fragmentation from the Proposal. Further details are provided in Section 10.5.6.

10.5.3 Barrier effects and impacts on wildlife and riparian 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. Although it is not possible to design a single crossing structure that accounts for all species, it is feasible to develop a strategy for making the Proposal more permeable to wildlife passage for a wider diversity of species. This approach has been incorporated in the Proposal by including two key design considerations:

- Widening of the median at important locations.
- Provision of dedicated, combined and incidental fauna underpass structures.

The median would be widened in three locations in Section 2 – Nambucca State Forest, Section 4 – Dalhousie Creek, Newry State Forest and Section 4 – private property. The details of width and length of the area of proposed widening is provided in Table 10-14 and Figure 10-3a to Figure 10-3d. Fauna underpass structures and exclusion fencing are to be used in conjunction with the wider median to provide a temporary refuge and safe passage for ground-dwelling fauna. Proposed measures to mitigate the impacts of barrier effects include:

- Provision of a minimum of 34 combined or incidental fauna underpass structures plus one dedicated fauna underpass and additional dry passage for fauna under major bridge crossings (Warrell Creek, Nambucca River, Boggy Creek, Cow Creek, Deep Creek and Kalang River) for species including Koala, quoll and phascogale as detailed in Table 10-13.
- Underpasses and culverts would include some cells raised above the flood level and light within the median in longer passages would be included in the design. A clear line of sight to light and vegetation would be included at both ends of the crossing wherever possible.
- For smaller species, provision of protective cover and structures such as ledges or horizontal logs that are designed to restrict access by larger predators would aid their security. Approaches to the structure would be managed to ensure that vegetation does not obscure the entrance or exit.
- Combined drainage culverts and bridge structures with fauna passage capabilities would be designed to allow dry passage during non-extreme wet periods via the inclusion of raised outer cells or internal ledges.
- Exclusion fencing would be installed around the crossing structures to prevent access to the carriageway for up to 500 metres either side.
- Bridges and culverts have been designed in accordance with the Fairfull and Witheridge guidelines (2003) *Why do fish need to cross the road? Fish passage requirements for waterway crossings*.
- Construction of 'fishways' at potential barriers to enable migration of fish and macroinvertebrates during construction and operation.

- Construction activities over Warrell Creek, Nambucca River, Deep Creek and the Kalang Rivers would be management to minimise the potential impacts on migratory species such as the Estuary Perch and Australian bass particularly during the spawning season between June and August. Specific management measures for each of the waterways are provided in Working paper 1 – *Flora and fauna*.

10.5.4 Edge effects and control of weeds, pests and diseases

During construction there is the potential for noxious and invasive weeds to be spread via earthworks and clearing activities, from seeds and other propagules in the soil and vegetative material. Rehabilitation and weed strategies would include:

- Development of a rehabilitation and weed control strategy as part of the construction environmental management plan, with specific mitigation measures for control of the spread of weeds and habitat rehabilitation, particularly along roadside verges, adjacent to culvert entrances and bridge pylons.
- A protocol would be developed for weed infested areas to ensure that all potential weed propagules from soil and vegetative material are appropriately disposed of.
- To minimise the potential for various pests and diseases to be introduced to the study area, the following activities would be incorporated into the construction management plan. All construction equipment would be washed or brushed down prior to arriving on-site to remove all sediments and debris.
- Washing procedures to ensure that insect pests and their eggs/larvae are not present on equipment such as red imported fire ants, large earth bumblebees, feral honeybees, yellow crazy ant and cane toad.
- Bacteria, viruses and other diseases would also be removed from equipment through washing such as *Phytophthora cinnamomi*, amphibian chytrid fungus and beak and feather disease.

10.5.5 Habitat rehabilitation

Opportunities for habitat rehabilitation would be investigated. The greatest potential for habitat rehabilitation exists in low-lying agricultural areas adjoining the Proposal corridor. To reduce or to compensate for the impacts associated with habitat loss, the following rehabilitation measures would be incorporated into the construction management plan

- Roadside verges would be rehabilitated adjacent to culvert entrances and bridge pylons.
- Consideration of the potential for increasing the size of smaller remnant habitat fragments adjoining the road.
- Topsoil would be salvaged from areas of cleared vegetation with low weed abundance.
- Seed collection would be undertaken before and during vegetation clearing activities from sclerophyll species, Slender Milkvine and Rusty Plum, suitable for tube-stock propagation and hydro-seeding in roadside verges.

10.5.6 Offsetting environmental impacts

Planning for the Proposal in regard to biodiversity values along the road corridor has generally followed the hierarchy of principles, being:

1) Avoid impact.
2) Minimise impact.
3) Mitigate impact.

Where impacts are unavoidable, mitigation and management measures are incorporated into the Proposal to reduce impacts. These have included provision of 36 fauna underpasses, two kilometres of widened vegetated medians, and 20 kilometres of fauna fencing to provide fauna movement and connectivity between fragmented habitats. In some instances there are residual impacts that cannot be adequately mitigated, for example the net loss of native fauna habitat. Accordingly, the RTA is committed to developing offset agreement in consultation with the DECCW. Options for offsetting include, but are not limited to:

- Management by the DECCW or the DII:
  - Purchase freehold property and transfer into NSW National Parks Estate.
  - Purchase freehold property and transfer into Forests NSW Estate, with a management zoning of Zone 1 (Special Protection).
  - Negotiation with Forests NSW for extension of existing portions of Zone 1.
- Management by RTA:
  - Negotiation with Forests NSW to transfer land currently identified as Zone 4 (General Management) and preserve in a "road reserve" under RTA management.
- Management non-government conservation organisations or by private landholders:
  - Secure additional native vegetation protected through an appropriate legal instrument that ensures the land is managed for conservation transfer ownership to non-government conservation organisations.
  - Negotiation of a conservation agreement under the *National Parks and Wildlife Act* 1974 or *Nature Conservation Trust Act* 2001 with private landowners.

It is envisaged the quantum of the offsets would be based on a set-ratio approach offset impacts to EECs and broad vegetation types on a like for like basis that clearly accounts to loss of native vegetation and associated edge effects.

In addition to providing land offsets the RTA may also consider, in consolation with the DECCW including additional revegetation in strategic locations and or investment in management research related to the rehabilitation and protection relevant threatened species.

10.5.7 Wildlife mortality

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

- Adjoining vegetation would be maintained to limit overhang of fences or other barriers.
- Flora species used in landscaping would be selected such that wildlife is not attracted for feeding or other purposes, except at the proposed fauna crossings.

10.5.8 Aquatic disturbance

Water quality impacts on the aquatic environment would be controlled through the construction environmental management plan which would include a soil and water management plan as described in Chapter 6 – *Description of the Proposal*. This plan would comply with the principles and practices in:

- *RTA Road Design Guide, Section 7 – Stormwater Management and Drainage Design and Section 8 – Erosion and Sedimentation* (RTA 2000b).
- *Managing Urban Stormwater: Soils and Construction* (Department of Housing 2004).
- *Soils & Construction, Volume 1, 2004, and Volumes 2C and 2D, 2008 manuals* (known as the Blue Book).

Additional measures proposed to manage impacts on aquatic habitats include:

- Retention of large woody debris within watercourses where possible.
- In-stream structures such as bridges and culverts have been designed and managed to minimise any potential impact to flow regimes and fishways would be constructed at potential barriers to enable the migration of fish and macroinvertebrates during construction and operation where applicable.
- Riparian and aquatic habitat would be protected during construction works with fencing and any mangroves or areas of riparian vegetation impacted by construction would be rehabilitated.
- Management of acid sulphate soil to ensure sulphuric acid leachate does not enter watercourses as described in Chapter 18 – *Soils characteristics and erosion controls*.
- Inclusion of appropriate erosion and sediment controls and silt curtains would be deployed in situ where required where any dredging or excavation of sediments is required.
- Any management measures adopted would be consistent with the *DPI Policy and Guidelines: Aquatic Habitat Management and Fish Conservation*.

10.5.9 Management of regional scale impacts

The cumulative impacts that the Proposal would contribute to would be minimised by the mitigation measures and compensatory habitat outlined in this assessment. Other mitigation measures outlined in this section would contribute to minimising cumulative impacts for vegetation loss, EEC loss, threatened species, groundwater dependent communities and wildlife corridors.

10.5.10 Monitoring

An adaptive monitoring program would be developed to assess the effectiveness of mitigation and offset measures and allow for refinement and modification of these measures if monitoring results suggest that this is required. The program would be implemented prior to construction to establish baseline numbers of threatened flora and fauna and would continue for a minimum of two years after construction is complete. A monitoring protocol would be developed for threatened plant species. Further details are provided in Section 6.2.3 of Working paper 1 – Flora and fauna.

10.6 Summary

Potential impacts to flora and fauna issues were considered at each of the planning and development stages of the Proposal, including the development and selection of the corridor and route options, as well as development and selection of the preferred route.

Likely and potential impacts associated with Proposal include the loss of threatened plant species and endangered ecological communities, fragmentation of habitats and wildlife corridors, barrier effects on wildlife and riparian corridors (such as the erosion of genetic stock), edge effects (such as weed invasion, pests and disease), disturbance to aquatic and riparian habitats potentially resulting in contamination and siltation of waterways, and cumulative impacts in association with the Pacific Highway Upgrade Program.

Targeted surveys of the distribution and abundance of threatened and endangered species and communities were conducted. Assessment in relation to the potential impact on these species and communities identified during the surveys and those species potentially occurring were also undertaken.

Of the threatened terrestrial species identified, there is the potential for significant impacts on the plant species Marsdenia longiloba (Slender Marsdenia) in the absence of appropriate mitigation measures being implemented as part of the Proposal.

The mitigation measures proposed to be implemented in order to minimise the impacts on Marsdenia longiloba include the protection and relocation of individual plants within the road corridor during the construction of the Proposal where feasible.

The Proposal would result in the loss of 255 hectares of native vegetation (based on a 10 metre buffer from the construction footprint) including approximately two hectares of wetland and mangroves. The majority of vegetation to be removed is located within state forests and private properties within Section 4 of the Proposal. Habitat compensation and rehabilitation measures would be developed in consultation with the DECCW during the detailed design phase of the Proposal in order to mitigate anticipated habitat fragmentation and wildlife corridor impacts.

There is unlikely to be significant residual impacts associated with the construction and operation of the Proposal, following the adoption of the proposed mitigation and management measures identified in this environmental assessment.

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