NSW GOVERNMENT

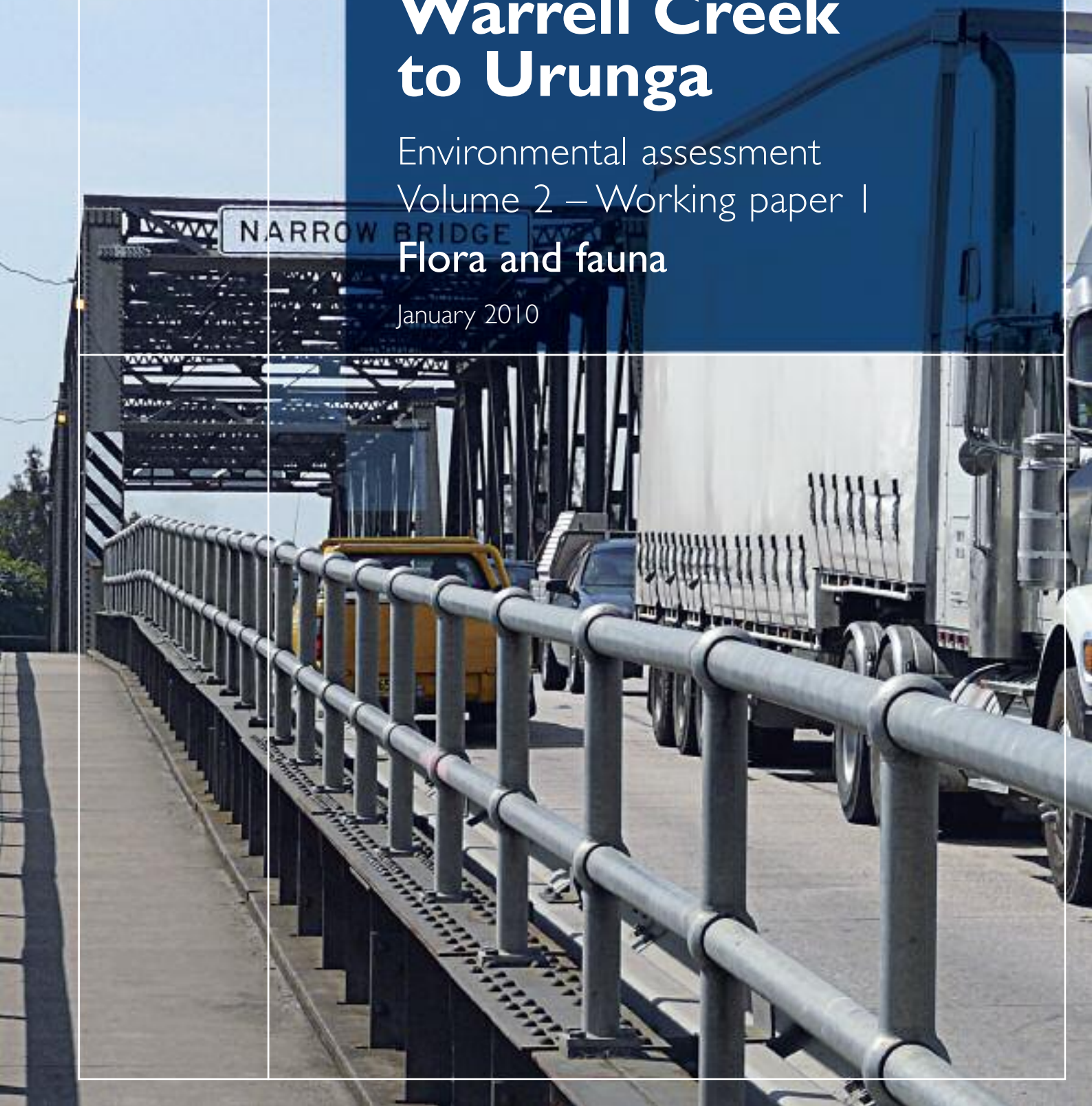
RTA

Upgrading the Pacific Highway

Warrell Creek to Urunga

Environmental assessment
Volume 2 – Working paper 1
Flora and fauna

January 2010



7. References

Adam, P. 1995, Urbanisation and Transport. Pp. 55 - 75 in *Conserving Biodiversity: Threats and Solutions*, Ed. Bradstock, R. A., Auld, T. D., Keith, D. A., Kingsford, R. T., Lunney, D. & Siversten, D. P. Surrey Beatty and Sons & NPWS, Chipping Norton.

Allison, F. R. & Hoye, G. A. 1995, Eastern Little Freetail Bat. In *The Mammals of Australia* (ed. by Strahan, R.). Australian Museum/ Reed Publications, Sydney.

Anderson, J. R. 1993, 'State of the Rivers' Project – Report 2. Implementation Manual, A Report to Department of Primary Industries, Queensland.

Andrews, A. 1990, Fragmentation of habitat by roads and utility corridors: a review in *Aust. Zool*. 26, pp 130 - 141.

ANPC (2004). Guidelines for the Translocation of Threatened Plants in Australia. 2nd Edition. Australian Network for Plant Conservation.

ANSWW 2007. Atlas of NSW Wildlife: Department of Environment and Conservation (NPWS).

ANZECC/ARMCANZ (2000), 'Australian and New Zealand Guidelines for Fresh and Marine Water Quality'. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.

Ausroads (2001). Road Runoff and Drainage: Environmental Impacts and Management Options.

Auld, B.A. & Medd, R.W. 1987, *Weeds - an illustrated botanical guide to the weeds of Australia*, Inkata Press: Sydney.

Bali, R. (2005). *Discussion Paper – Compensating for Edge Effects*. Unpublished report prepared for the Roads and Traffic Authority, Sydney.

Benwell, A. S. (2003). Yelgun to Chinderah Highway Upgrade Three Year Monitoring Report on Translocations of Threatened and Rare Rainforest Plant Species. Report to Abigroup Contractors P/L. Boulton, A.J. and Brock, M A. 1999, 'Australian Freshwater Ecology: Processes and Management'. 250 pp. (Gleneagles Publishing, Adelaide).

Briggs, J. D. & Leigh, J. H., 1996. *Rare or Threatened Australian Plants*. CSIRO Publications.

Burbridge, N.T. (1960). The phytogeography of Australia. *Australian Journal of Botany* 8(2) 75 – 211.

Burris, R.K., and Canter, L.W. (1997). Cumulative impacts are not properly addressed in environmental assessments. *Environmental Impact Assessment Review* 67: *5-18.*

Campbell, A. (ed). 1999. *Declines and Disappearances of Australian Frogs*. Environment Australia, Canberra.

Cavallaro, L., Sanden, K.,Schellhase, J., and Tanaka, M. 2005. *Designing Road Crossings for Safe Wildlife Passage: Ventura County Guidelines*. University of California, Santa Barbara.

Chessman, B. 1995, 'Rapid assessment of rivers using macroinvertebrates: A procedure based on habitat-specific sampling, family level identification, and a biotic index', *Australian Journal of Ecology*, vol. 20, pp. 122-129.

Chessman B. 2003, *SIGNAL 2 – A Scoring System for Macro-invertebrate ('Water Bugs') in Australian Rivers*, Monitoring River Heath Initiative Technical Report no 31, Commonwealth of Australia, Canberra.

Churchill, S. 1998. *Australian Bats*. Reed New Holland Publishers, Sydney.

Clancy, G.P. 1991. *The biology and management of the osprey (Pandion haliaetus) in NSW*. NSW, National Parks and Wildlife Service, Hurstville.

Cogger, H. G. 1992, *Reptiles and Amphibians of Australia*. 4th Ed. Reed Books, Sydney.

Coulson, G.M. 1982. Road kills of macropods on a section of highway in central Victoria. *Wildlife Research*. 9, 21-26.

Cropper, S. 1993, *Management of Endangered Plants*. CSIRO, Canberra.

Debus, S. J. S. 1993, The Mainland masked owl *Tyto novaehollandiae*: a review in Aust. Bird Watcher, 15(4)., pp. 168 - 191.

Debus, S. J. S. & Chafer, C. J. 1994, The powerful owl *Ninox strenua* in New South Wales in *Aust. Birds* 28 supplement, pp. 21 - 39.

Debus, S. J. S. & Rose, A. B. 1994, The masked owl *Tyto novaehollandiae* in New South Wales in *Aust. Birds* 28 supplement, pp. 40 - 64.

Dickman, C. 1991, Use of trees by ground-dwelling mammals: implications for management, pp. 125 - 136 in *Conservation of Australia's Forest Fauna*, ed. Daniel Lunney. Royal Zoological Society of NSW, Mosman.

Dwyer, P. D. 1995b, Common Bent-wing Bat. pp. 494 - 495 in *The Mammals of Australia*, ed. R. Strahan. Australian Museum and Reed, Sydney.

Ecos Environmental Pty. Ltd. 2007. Vegetation Survey of the Preferred Route for the Upgrade of the pacific Highway between Sapphire and Woolgoolga. Prepared for Connell Wagner Pty Ltd, PO Box 538, Neutral Bay.

Eddie, M.W. 2000. Soil landscapes of the Macksville and Nambucca 1:100 000 Sheet.

Environment Australia. 1999, *An Overview of the EPBC Act.*

Environment Australia. 2000. *EPBC Act, Administrative Guidelines on Significance July 2000.*

Fairfull, S. and Witheridge, G. (2003) Why do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings. NSW Fisheries, Cronulla, 16 pp.

Floyd, A. G. (1989). Rainforest Trees of Mainland South-eastern Australia. Inkata

Press, Melbourne.

Floyd A (1990a) Australian rainforests in New South Wales. Volume 1. (Surrey Beatty and Sons: Sydney.)

Floyd A (1990b) Australian rainforests in New South Wales. Volume 2. (Surrey Beatty and Sons: Sydney.)

Forman, R.T.T and Alexander, L.E. (1998). Roads and their major ecological effects. *Ann.Rev.Ecol.Syst*. **29:** 207-31.

Franklin, D. C., Menkhorst, P. W. & Robinson, J. L. 1989, Ecology of the regent honeyeater *Xanthomyza phrygia*. *Emu*.89., pp. 140 - 154.

Franklin, D. C. and Menkhorst, P.W. 1988. A History of the regent honeyeater in South Australia. *South Australian Ornithologist* 30: 141-145.

Franklin, D. C. and Robinson, J.L. 1989. Territorial behaviour of a regent honeyeater at feeding sites. *Australian Bird Watcher* 13: 129-132.

Franklin, D., Menkhorst, P. and Robinson, J. 1987. Field surveys of the regent honeyeater *Xanthomyza phrygia* in Victoria. *Australian Bird Watcher* 12: 91-95.

Garnett, S. (Ed.). 1992, *Threatened and Extinct Birds of Australia*. RAOU / Australian National Parks and Wildlife Service.

Gibbons, P., and Lindenmayer, D.B. (2002). *Tree Hollows and Wildlife Conservation in Australia*. CSIRO Publishing, Canberra.

Gibbons, D. W., Hill, D. A., & Sutherland, W. J. (2000) Birds **in** W. J. Sutherland (Ed.) *Ecological Census Techniques, A Handbook*. Cambridge University Press, Cambridge.

Gibbs, P. McVea, T. & Louden, B. 1999, 'Utilisation of Restored Wetlands by Fish and Invertebrates'. NSW Fisheries Office of Conservation, Pyrmont NSW, Australia. NSW Fisheries Final Report Series No. 16.

Goldingay, R. and Possingham, H. 1995. Area requirements for viable populations of the Australian glider marsupial. Petaurus australis. *Biological Conservation* 73: 161-67.

Goldingay, R.G. and Kavanagh, R.P. 1991. The yellow-bellied glider: a review of its ecology and management considerations. In *Conservation of Australias Forest Fauna.* Edited by D.Lunney, Surrey Beattie and Sons, Sydney.

Gooderham, J. & Tsyrlin, E. (2002), 'The Waterbug Book; A guide to Freshwater Macroinvertebrates of Temperate Australia'. CSIRO Publishing, Victoria, Australia.

Goosem, M.W. 1997. Internal fragmentation: the effects of roads, highways and powerline clearings on movements and mortality of rainforest vertebrates. In 'Tropical Forest Remnants: Ecology, Management and Conservation of Fragmented Communities'. (Eds W.F. Laurance and R.O. Bierragaard Jr.) pp. 241-255, University of Chicago Press: Chicago.

Goosem, M.W. 2001. Effects of tropical rainforest roads on small mammals: inhibition of crossing movements. *Wildlife Research 28, 351-364.*

Griffith, S. 1993. *Conservation status of coastal plant communities in northern New South Wales – a review*. New South Wales National Parks and Wildlife Service.

Harden, G.J. (ed) 2000. *Flora of New South Wales* Volume 1. Royal Botanic Gardens and New South Wales University, Sydney

Harden, G.J. (ed) 2002. *Flora of New South Wales.* Volume 2. Royal Botanic Gardens and New South Wales University, Sydney.

Harden, G.J. (ed) 1992. *Flora of New South Wales* Volume 3. Royal Botanic Gardens and New South Wales University, Sydney

Harden, G.J. (ed) 1993. *Flora of New South Wales.* Volume 4. Royal Botanic Gardens and New South Wales University, Sydney.

Harden, G.J. and Murray, L.J. (eds) 2000. *Flora of New South Wales.* Supplement to Volume 1. Royal Botanic Gardens and New South Wales University, Sydney.

Harden, G., McDonald, W. and Williams, J. (2006) Rainforest Trees and Shrubs – A Field Guide to their identification. Gwen Harden Publishing, Nambucca Heads.

Holway D.A. (2005). Edge effects of an invasive species across a natural ecological boundary. *Biol. Conserv.* 121: 561-7.

Hoye, G. A. & Richards, G. C. 1995, Greater Broad-nosed Bat. pp. 527 - 528 in *The Mammals of Australia* by Strahan, R. (ed). Australian Museum and Reed Books, Sydney.

Hyde, B and Chirgwin, G 2001. *Wildlife Friendly Design of Road Structures.* Unpublished Report to the Roads and Traffic Authority.

Keith, D. 2004, Ocean Shores to Desert Dunes: The Native Vegetation of New South Wales and the ACT, Department of Environment and Conservation NSW, Sydney.

Keith DA, Scott, J (2005) Native vegetation of coastal floodplains- a broad framework for definition of communities in NSW. *Pacific Conservation Biology* **11**, in press.

Kendall and Kendall Ecological Consultants (2003) *Nambucca Catchment Vegetation Survey*. Report prepared for Nambucca Vegetation Sub-committee, 155 pgs.

Kemp, B. 2004. *Wildflowers of the North Coast of New South Wales*. Reed New Holland, Frenchs Forest, Sydney.

Law, B. Chidel, M & Turner, G. 2000. The use by wildlife of paddock trees in farmland. *Pacific Conservation Biology*. Vol **6** (2), 130-143.

McKay, S., Clunie, P., Gillespies, G., Raadik, T., Saddlier, S., O'Brien, T., Ryan T. and Aland, G. (2001). 'Predation by Gambusia holbrooki: a review of the literature'. Report prepared by the Arthur Rylah Institute for Environmental Research for the New South Wales National Parks and Wildlife Service.

Menkhorst, P., Schedvin, N and Geering, D. 1999. regent honeyeater (*Xanthomyza phrygia*) Recovery Plan 2001-2003. Department of Natural Resources and Environment, May 1999.

Milford, H.B. 1999. Soil Landscapes of the Coffs harbour 1:100 000 Sheet. Department of Land and water Conservation, Sydney.

Mitchell, P.B. (2003). NSW ecosystems database mapping unit descriptions. Unpublished report to the NSW National Parks and Wildlife Service, Hurstville.

Murcia C. (1995). Edge effects in fragmented forests: implications for conservation. *Trends in ecology and evolution* 10: 58-62.

Novello, S. and Klohs, R. 1998. Fire Management Planning for National Parks of the Scenic Rim, Part 1: Ecological Considerations. Queensland Parks and Wildlife Service.

NPWS, 2002a. Threatened *Species of the Upper North Coast of NSW: Fauna*. NSW National Parks and Wildlife Service, Hurstville.

NPWS 2002b. *Threatened Species of the Upper North Coast of NSW: Flora*. NSW National Parks and Wildlife Service, Hurstville.

NSW Department of Environment and Conservation 2005. Biometric Assessment Tool. NSW Dept of Environment and Conservation, Hurstville.

NSW Department of Environment and Climate Change, (2003). Key Habitats and Wildlife Corridors in North East New South Wales. http://maps.nationalparks.nsw.gov.au/keyhabs/default.htm

NSW Department of Environment and Climate Change (2007a). Landscape selection process, Key Altitudinal, Latitudinal and Coastal Corridors for response to Climate Change. Dept of Environment and Climate Change, Hurstville.

NSW Department of Environment and Climate Change (2007b). Identification guidelines: Subtropical Coastal Floodplain Forest.

NSW Department of Primary Inductries (2005), PrimeFact10: Instream Structures and Other Mechanisms that Alter Natural Flows. NSW Department of Primary Industries.

NSW Department of Primary Industries PI. (2006), 'What happens after something is listed?'. NSW DPI Fisheries. Available online: http://www.fisheries.nsw.gov.au/threatened_species/general/after_listing. Accessed December 2007.

NSW Department of Primary Industries: Forests 2007. Flora and Fauna Records Nambucca, Newry and Little Newry State Forests. Coffs Harbour.

NSW Fisheries. 1999, Policy and Guidelines: Aquatic Habitat Management and Fish Conservation: (1999 update). Smith, A. & Pollard, D. A. (eds.). NSW Fisheries, Port Stephens Research Centre.

NSW Roads and Traffic Authority 2001, Compensatory Habitat Policy and Guidelines. Providing Compensatory Habitat as Amelioration for Impacts on Habitat Resulting from Road Development, NSW Roads and Traffic Authority, Sydney

NSW Roads and Traffic Authority (RTA) NSW, 2007. 'Warrell Creek to Urunga'. Available at: http://commcons.skm.com.au/macksville-urunga/index.cfm. Accessed December 2007.

NSW Scientific Committee 1999. Lowland rainforest on floodplains in the NSW North Coast bioregion; endangered ecological community listing. http://www.nationalparks.nsw.gov.au/npws.nsf/Content/Lowland+Rainforest+on+Floodplain+in+the+New+South+Wales+North+Coast+Bioregion+endangered+ecological+community+listing

NSW Scientific Committee 2004. Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South-East Corner bioregions; endangered ecological community listing. http://www.nationalparks.nsw.gov.au/npws.nsf/Content/freshwater_wetlands_endangered

NSW Scientific Committee 2004. Subtropical coastal floodplain forest of the NSW North Coast bioregion; endangered ecological community listing. http://www.nationalparks.nsw.gov.au/npws.nsf/Content/subtropical_coastal_floodplain_endangered

NSW Scientific Committee 2004. Swamp Oak floodplain forest of the NSW North Coast, Sydney Basin and South-East Corner bioregions; endangered ecological community listing. http://www.nationalparks.nsw.gov.au/npws.nsf/Content/swamp_oak_floodplain_endangered

NSW Scientific Committee 2004. Swamp sclerophyll forest on coastal floodplains of the NSW North Coast, Sydney Basin and South-East Corner bioregions; endangered ecological community listing. http://www.nationalparks.nsw.gov.au/npws.nsf/Content/swamp_schlerophyll_endangered

NSW Scientific Committee 2004. Coastal saltmarsh in the NSW North Coast, Sydney Basin and South-East Corner bioregions; endangered ecological communities listing. http://www.nationalparks.nsw.gov.au/npws.nsf/Content/Coastal_Saltmarsh_endangered

Quinn, F.C., Williams, J.B., Gross, C.L. and Bruhl, J.J. (1995). Report on Rare or Threatened Plants of North-Eastern New South Wales. Report prepared for the NSW NPWS and Australian Nature Conservation Agency.

Reed, P. & Lunney, D. 1988, Habitat loss: the key problem for the long-term survival of koalas in New South Wales. pp. 9 - 31 in *koala Summit - managing koalas in New South Wales*. Ed. Lunney, D., Urquhart, C. A. & Reed, P., NSW National Parks and Wildlife Service, Hurstville.

Recher, H. 1991. The conservation and management of eucalypt forest birds: resource requirements for nesting and foraging. Pages 25-34 IN *Conservation of Australia's Forest Fauna*, ed Daniel Lunney. Royal Zoological Society of NSW, Mosman.

RTA, 2005. *Macksville to Urunga, Route Options Investigation.* Report prepared by the NSW Roads and Traffic Authority and Sinclair Knight Merz.

Saunders, D. L. and Heinsohn, R. 2008. Winter habitat use by the endangered, migratory swift parrot (*Lathamus discolor*) in New South Wales. *Emu* **108**; 81-89.

Schodde, R & Tidemann, SC. (ed). 1997, *The Reader's Digest Complete Book of Australian Birds*. Reader's Digest Services Pty Ltd, Surrey Hills.

Schulz, M. (1997). The Little Bent-wing Bat *Miniopterus australis* roosting in a tree hollow. *Australian Zoologist* **30**(3): 329.

Sheringham, P. & Westaway, J. 1995. *Significant Vascular Plants of Upper North East of New South Wales.* A report by the NSW National Parks and Wildlife Service for the Natural Resource Audit Council.

Simpson, K. & Day, N. 1996. *Field Guide to the Birds of Australia*. Penguin Books, Ringwood.

Sinclair Knight 2004. Macksville to Urunga: Upgrading the Pacific Highway, Preliminary Biological Report. Prepared for the RTA.

Specht, R.L. 1970. Vegetation, in *The Australian Environment* (G.W Leeper Ed., 4th Edition). CSIRO, Melbourne University Press, Melbourne.

Stanger, M., Clayton, M. Schodde, R. Wombey, J. and Mason, I. 1998. *CSIRO List of Australian Vertebrates. A Reference with Conservation Status.* CSIRO Publishing, Collingwood.

Strahan, R. 1995. *The Mammals of Australia*. Reed Books and Australian Museum, Sydney.

Taylor, B.D. and Goldingay, R.L. 2003. Cutting the carnage: wildlife use of road culverts in north-eastern New South Wales. *Wildlife Research* 30, 529-537.

Taylor, R.J. 1991. *The role of retained strips for fauna conservation in production forests in Tasmania*. pgs 265-70 in *Conservation of Australia's Forest Fauna* (ed) D.Lunney. Royal Zoological Society of NSW, Mosman.

Taylor, R.J. and Mooney, N.J. 1991. Increased mortality of birds on an elevated section of highway in northern Tasmania. *Emu. Vol 91* pp 196-188.

Thackway, R. & Cresswell, I. D. 1995, *An Interim Biogeographic Regionalisation for Australia: a framework for setting priorities in the national reserves system cooperative program*. Australian Nature Conservation Agency, Canberra.

Turak, E., Waddell, N. & Johnstone, G. (2004), 'New South Wales (NSW) AUSRIVAS Sampling and Processing Manual'. Available online: http://ausrivas.canberra.edu.au/ Accessed: August 2007.

Watson, L., and Dallwitz, M.J. 1992 onwards. The families of flowering plants: descriptions, illustrations, identification, and information retrieval. Version: 10th April 2008. http://delta-intkey.com'.

Webster, R. & Menkhorst, P. 1992, The regent honeyeater (*Xanthomyza phrygia*) population status and ecology in Victoria and New South Wales. Arthur Rylah Institute for Environmental Research. Technical Report Series No. 126.

Woodside, D. P. & Long, A. 1984, Observations on the feeding habits of the Greater Broad-nosed Bat, *Nycticeius rueppellii*. *Aust. Mamm*. 7., pp. 121 - 129.

Appendix A Potential Subject Species

A.1 Threatened flora

Species	Legislative Status		Records in study area	Most recent record	Preferred habitat type	Potential to occur in the study area
	Cwlth	NSW				
Acacia chrysotricha Newry golden wattle	-	E	35	2006	Restricted to an area south of Bellingen on the NSW north coast. An understorey species on rainforest edges and in wet or dry eucalypt forest in steep narrow gullies on quartzite soils. Newry golden wattle is relatively short-lived. The seeds which remain in the soil require heat from fire to induce germination. Too-frequent fire may lead to a decline in the population, as gradual exhaustion of the soil-borne seed bank would result, with no replacement of adult plants over time. Records are present in Newry State Forest, approximately 4.5 km west of the Proposal area and there is a record from 1961 approximately 2 km to the east of the study area in Urunga.	Potential
Acronychia littoralis Scented acronychia	E	E	5	2001	Scented acronychia is found between Fraser Island in Queensland and Port Macquarie on the north coast of NSW. Scented acronychia grows in littoral rainforest on sand. The nearest record to the Proposal area is 4 km east of Warrell Creek.	Unlikely. Small areas of marginal habitat present
Amorphospermum whitei (*Niemeyera whitei*) Rusty plum	-	V	24	2005	Occurs in the coast and adjacent ranges of northern NSW from the Macleay River into southern Queensland. Its distributional stronghold is on the mid north coast around Coffs Harbour. Occurs in rainforest and the adjacent understorey of moist eucalypt forest. Recorded adjacent to Boggy Creek in the study area. There are also records 4.5km west of the Proposal area in Newry State Forest and a record adjacent to the Proposal area from 1900 in the Warrell Creek area.	Recorded

Species	Legislative Status		Records in study area	Most recent record	Preferred habitat type	Potential to occur in the study area
	Cwlth	NSW				
Chamaesyce psammogeton Sand spurry	-	E	1	1987	Occurs sparsely along the NSW coast from south of Jervis Bay to Queensland. Grows on fore-dunes and exposed headlands, often with Spinifex (Spinifex sericeus). There is a record approximately 2.5 km east of the Proposal area north of Nambucca Heads.	Unlikely. No suitable habitat present
Cynanchum elegans White-flowered wax plant	E	E	-	-	Restricted to eastern NSW where it is distributed from Brunswick Heads on the north coast to Gerroa in the Illawarra region. The species has been recorded as far west as Merriwa in the upper Hunter River valley. Occurs on the edge of dry rainforest vegetation. Other associated vegetation types include littoral rainforest; Coastal Tea-tree (Leptospermum laevigatum) – Coastal Banksia (Banksia integrifolia) coastal scrub; forest red gum (Eucalyptus tereticornis) aligned open forest and woodland; Spotted Gum (Corymbia maculata) aligned open forest and woodland; and Bracelet Honeymyrtle (Melaleuca armillaris) scrub to open scrub.	Unlikely. Small areas of marginal habitat present
Glycine clandestina		E2	1	2003	Only known from two locations about 200m apart on narrow shelf of a headland immediately south of Scotts Head. Has been recorded 2km west of Nambucca Heads. Dense, low, coastal grassland (largely Kangaroo Grass and other native species) on black soils. Nambucca Glycine occurs with, and may be confused with, Glycine tabacina and Galactia tenuiflora.	Unlikely. No suitable habitat present
Hicksbeachia pinnatifolia Red bopple nut	-	V	-	-	Coastal areas of north-east NSW from the Nambucca Valley north to south-east Queensland. Occurs in subtropical rainforest, moist eucalypt forest and Brush Box (Lophostemon confertus) forest.	Potential

Species	Legislative Status		Records in study area	Most recent record	Preferred habitat type	Potential to occur in the study area
	Cwlth	NSW				
Maundia triglochinoides	-	V	-	-	Restricted to coastal NSW north from Wyong extending into southern Queensland. Former sites around Sydney are now extinct. Grows in swamps, creeks or shallow freshwater 30-60 centimetres deep on heavy clay with low nutrients. Flowering occurs during warmer months and is associated with wetland species such as Triglochin procerum.	Potential
Melaleuca groveana	-	V	1	1998	Widespread, scattered populations in coastal districts north of Port Stephens to southeast Queensland. Grove's Paperbark grows in heath and shrubland, often in exposed sites, at high elevations, on rocky outcrops and cliffs. It also occurs in dry woodlands.	Unlikely. No suitable habitat present
Marsdenia longiloba Slender marsdenia	V	E	5	2000	Scattered sites on the north coast of NSW north from Barrington Tops. Also occurs in south-east Queensland. Subtropical and warm temperate rainforest, lowland moist eucalypt forest adjoining rainforest and, sometimes, in areas with rock outcrops.	Recorded
Parsonsia dorrigoensis Milky silkpod	E	V	13	2005	Milky silkpod is found only in NSW, with scattered populations in the north coast region between Kendall and Woolgoolga. Found in subtropical and warm-temperature rainforest, on rainforest margins, and in moist eucalypt forest up to 800 m, on brown clay soils. Flowers in summer. Appears to be able to withstand, and may even favour, light to moderate physical disturbance.	Potential
Peristeranthus hillii	-	V	-	-	Found in north-eastern NSW, north from Port Macquarie, extending to north-eastern Queensland as far as the Bloomfield River. Restricted to coastal and near-coastal environments, particularly Littoral Rainforest and the threatened ecological community Lowland Rainforest on Floodplain. The species is an epiphyte, growing in clumps on tree trunks and thick vines. Flowers appear during September and October.	Potential

A.2 Threatened fauna

The results of the assessments confirmed the presence of 14 threatened fauna species. An additional 12 species are considered to potentially occur in the study area on the basis of suitable habitat. The potential impacts on these species have been assessed in line with the factors contained in section 5A of the EP&A Act. Species with similar taxonomy or habitat requirements have been grouped together.

Species	Status TSC Act (NSW)	Presence in the study area
Black-necked stork (*Ehippiorhynchus asiaticus*)	Endangered	Confirmed
Spotted-tailed quoll (*Dasyurus maculatus*)	Vulnerable	Potential
Brush-tailed phascogale (*Phascogale tapotafa*)	Vulnerable	Potential
Yellow-bellied glider (*Petaurus australis*)	Vulnerable	Confirmed
Giant barred frog (*Mixophyes iteratus*)	Endangered	Potential
Koala (*Phascolarctos cinereus*)	Vulnerable	Confirmed
Glossy black-cockatoo (*Calyptorhynchus lathami)*	Vulnerable	Confirmed
Square-tailed kite (*Lophiotinia isura*)	Vulnerable	Confirmed
Osprey (*Pandion haliaettus*)	Vulnerable	Confirmed
Migratory nectivores		
Swift parrot (*Lathamus discolour*)	Endangered	Potential
Regent honeyeater (*Xanthomyza phrygia*)	Endangered	Potential
Cave-roosting microchiropteran bats		
Little bentwing-bat (*Miniopterus australis*)	Vulnerable	Confirmed
Eastern bentwing-bat (*Miniopterus schreibersii*)	Vulnerable	Confirmed
Large-footed myotis (*Myotis macropus*)	Vulnerable	Potential
Hollow-roosting microchiropteran bats		
Eastern long-eared bat (*Nyctophilus bifax*)	Vulnerable	Potential
Greater broad-nosed bat (*Scoteanax rueppellii*)	Vulnerable	Confirmed
Eastern freetail-bat (*Mormopterus norfolkensis*)	Vulnerable	Potential
Eastern false pipistrelle (*Falsistrellus tasmaniensis*)	Vulnerable	Confirmed
Yellow-bellied sheathtail-bat (*Saccolaimus flaviventris*)	Vulnerable	Confirmed
Megachiropteran bats		
Grey-headed flying-fox (*Pteropus poliocephalus*)	Vulnerable	Confirmed
Frugivorous birds		
Wompoo fruit-dove (*Ptilinopus magnificus*)	Vulnerable	Confirmed
Rose-crowned fruit-dove (*Ptilinopus regina*)	Vulnerable	Potential
Superb fruit-dove (*Ptilinopus superbus*)	Vulnerable	Potential

Species	Status TSC Act (NSW)	Presence in the study area
Large forest owls		
Powerful owl (*Ninox strenua*)	Vulnerable	Confirmed
Masked owl (*Tyto noveahollandiae*)	Vulnerable	Potential
Sooty owl (*Tyto tenebricosa*)	Vulnerable	Potential

Appendix B Assessment of significance (EP&A Act)

B.1 Threatened flora recorded

B.1.1 *Marsdenia longiloba* - Endangered Species: TSC Act

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Marsdenia longiloba is a slender vine species found in various rainforest types and some moist sclerophyll forests, occurring at scattered locations from Barrington Tops north to southeast Queensland (NPWS 2002b). The ecology of this species has not been studied extensively and many of its life history attributes are largely unknown. This species has mostly been recorded as occurring in low abundance in small population clusters. The populations recorded in the study area consist of scattered individuals occurring in the understorey with various ferns, herbs and other twiners in moist eucalypt forest usually with a dense rainforest subcanopy.

Marsdenia longiloba occurs within seven separate sub-populations along the study area in rainforest and wet sclerophyll forest habitats. Most locations are in Newry, Little Newry and Nambucca State Forests, and there are occurrences on private property north of the Kalang River. It is estimated that these occurrences consist of approximately 156 individuals occurring within an area up to 250 m either side of the Proposal's centreline. The population in these areas is likely to extend further upstream and downstream of some of the surveyed areas, and therefore is likely to consist of a larger population than recorded for this Proposal.

The life cycle attributes for *Marsdenia longiloba* are largely unknown, however assumptions of life history attributes can be drawn from knowledge of other species in the same family (Apocynaceae: Asclepiadoideae). Pollinators are usually insect species including flies and/or beetles. Some species in this family have highly specialised pollination mechanisms which involves trapping insects' by their legs or proboscis between the osmotically elastic anther wings, and withdrawal entailing capture of the pollinia by means of 'sutured corpuscular pollen carriers' (Watson and Dallwitz 2008).

Pollinators of *Marsdenia longiloba* although not specifically known are unlikely to be significantly impacted from the Proposal assuming pollinators comprise flying insect species which occur in relatively large numbers. Several of the sub-populations would be dissected by the Proposal and would therefore impact pollinator movements between individuals on either side of the Proposal. Therefore the movement of genetic material may be impacted in these sub-populations, and could potentially lead to some inbreeding depressions.

Considering the relatively small sub-populations that *Marsdenia longiloba* occurs in, the removal of individuals may limit the potential for out-crossing and could lead to inbreeding

depressions where the majority of the population cluster is removed. Of the 156 individuals estimated to occur within the 500 metre corridor approximately 8 individuals (5 per cent of the population) would be directly impacted and an additional 46 individuals (29.5 per cent of the population) would remain within 30 m of the proposed development and would potentially be indirectly impacted. The remaining 107 individuals (65.5 per cent of the population) would remain at greater than 30 m from the Proposal and would be retained and protected from direct impacts. Only several individuals in each impacted population cluster would be directly removed and therefore a large proportion of the genetic diversity would be retained in each population cluster.

There are numerous records (DECC Atlas 2007) of *Marsdenia longiloba* surrounding the Proposal area at several locations. These records include: areas west of the Proposal area in Nambucca State Forest and surrounding the Nambucca waste management facility; south of the Proposal area in Ngamba Nature Reserve; and north of the Proposal area in the Bellingen region. Habitat for *Marsdenia longiloba* is largely protected in State Forest areas in logging exclusion zones along creeks and gullies.

There would potentially be indirect impacts to individuals downstream of the proposed development where runoff during the construction and operation of the proposed highway would enter the gully habitats where *Marsdenia longiloba* occurs. This would potentially alter the hydrology regime and nutrient loads increasing the potential for changes to habitat attributes which may impact life cycle attributes such as germination due to increased competition from weeds and changed soil conditions. Mitigation measures during construction and the implementation of specific design features into the proposed development would potentially minimise these indirect impacts.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal would remove habitat for this species in several areas and potentially lead to biophysical changes to areas of habitat. There is potential for the Proposal to alter habitat attributes of surrounding areas through indirect impacts which potentially include altering of hydrological and nutrient regimes within habitats downstream of the proposed development and edge effects. This could result in habitat changes, including increases in weed abundance, altered soil conditions and sedimentation. These changes may potentially lead to the area of occupancy of the population to be significantly reduced. However mitigation measures during construction and the implementation of specific design features into the proposed development are likely to minimise these indirect impacts.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

The known distributional limit for *Marsdenia longiloba* is between Barrington Tops north to southeast Queensland (NPWS 2002b). Therefore *Marsdenia longiloba* is in the central portions of its distribution in the Nambucca-Urunga area.

How is the Proposal likely to affect current disturbance regimes?

Current disturbance regimes in habitat of *Marsdenia longiloba* mainly comprises weed invasion by *Lantana camara*. The Proposal is likely to contribute to further invasion of *Lantana camara* particularly along the edges of the Proposal where there would be increased sunlight availability. Other indirect impacts such as increased water and nutrients may also aid the growth of *Lantana camara*.

How is the Proposal likely to affect habitat connectivity?

Marsdenia longiloba generally occurs in gully areas running perpendicular to the Proposal. Therefore suitable areas of habitat would be fragmented from the Proposal, with some sub-population being dissected. Pollinator movements may extend across the proposed highway allowing exchange of genetic material between fragmented areas of habitat, assuming flying insects are the main pollinators, however this is largely unknown.

Of the 6 recorded sub-populations of *Marsdenia longiloba*, two occur on both sides of the proposed route alignment within a 500m corridor, and therefore would be dissected by the proposed development. Individuals would be retained on either side of the proposed highway, with direct impacts limited to the proposed road corridor. Another two populations would be impacted on one edge of the population and the two populations on private property have been avoided by the proposed development.

How is the Proposal likely to affect critical habitat?

No critical habitat has been identified for this species.

B.1.2 *Amorphospermum whitei* (syn. *Niemeyera whitei*) Vulnerable Species: TSC Act

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Rusty plum occurs in the coast and adjacent ranges of northern NSW from the Macleay River into southern Queensland, with its distributional stronghold on the mid north coast around Coffs Harbour (NPWS 2002b). It has also been recorded in the Port Macquarie district (Harden 2000).

It occurs in rainforest and the adjacent understorey of moist eucalypt forest, generally below 600 m altitude on the less fertile soils derived from rhyolite or metasediments (Floyd 1989). The ecology of *Amorphospermum whitei* has not been extensively studied and numerous life cycle attributes such as pollination and germination are largely unknown. The large seed is supposedly dispersed by mammal species and is viable for a period of 1-3 months (Novello and Klohs 1998). Once seedlings are established it can take up to six years for the tree to reproduce (Novello and Klohs 1998).

Only one individual of *Amorphospermum whitei* was recorded in the study area on private land adjacent to Boggy Creek, comprising a small tree on the edge of disturbed trail area. This individual is proposed to be removed to accommodate the Proposal. Fruit was found beneath this individual indicating that adequate pollination is occurring to produce viable seed, and that other individuals are likely to be present in the vicinity. There is potential for *Amorphospermum whitei* to occur in other locations of the Boggy Creek catchment on private land to the west of the study area in the same patch of remnant vegetation or in areas of riparian vegetation retained in cleared agricultural landscapes to the west. There are two records of *Amorpospermum whitei* higher in the Boggy Creek catchment in Nambucca State Forest approximately two km to the southwest of the individual recorded in the Proposal area (NSW DPI 2007). Considering that only one individual is proposed to be removed and other individuals are known from the same catchment it is unlikely that the life cycle attributes for *Amorphospermum whitei* would be significantly impacted.

Amorphospermum whitei appears to be relatively widespread in the surrounding locality, as there are numerous records (DECC Atlas 2007; NSW DPI 2007) of *Amorphospermum whitei* surrounding the Proposal area at several locations. These records include: areas west of the Proposal area in Nambucca State Forest and Newry State Forest; a historical record in the Warrell Creek area recorded over 100 years ago in disturbed riparian vegetation approximately 200 m west of the Proposal; and north of the Proposal area in the Bellingen region. Habitat for *Amorphospermum whitei* is largely protected in State Forest areas in logging exclusion zones along creeks and gullies.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal would remove habitat for this species in several areas and potentially lead to biophysical changes to areas of habitat. There is potential for the Proposal to alter habitat attributes of surrounding areas through indirect impacts which potentially include altering of hydrological and nutrient regimes in habitats downstream of the proposed development and edge effects. This could result in habitat changes, including increases in weed abundance, altered soil conditions and sedimentation. Considering that *Amorphospermum whitei* was

recorded in only one location in the study area it is unlikely that the Proposal would lead to the area of occupancy of the population to be significantly reduced from potential changes to areas of suitable habitat. Mitigation measures during construction and the implementation of specific design features into the proposed development are likely to minimise these indirect impacts.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

Rusty plum occurs in the coast and adjacent ranges of northern NSW from the Macleay River into southern Queensland, with its distributional stronghold on the mid north coast around Coffs Harbour (NPWS 2002b). It has also been recorded in the Port Macquarie district (Harden 2000), which would represent the southern limit of the species. Therefore *Amorpospermum whitei* is in the central portions of its distribution in the Nambucca-Urunga area.

How is the Proposal likely to affect current disturbance regimes?

Current disturbance regimes in habitat of *Amorphospermum whitei* mainly comprises weed invasion by *Lantana camara*. In the Boggy Creek area where the only occurrence of *Amorphospermum whitei* in the Proposal area was recorded Broad-leaf Paspalum (*Paspalum wettsteinii*) and other pasture weeds are present along trails in this patch of remnant vegetation. The Proposal is likely to contribute to further invasion of *Lantana camara* particularly along the edges of the Proposal where there would be increased sunlight availability. Other indirect impacts such as increased water and nutrients may also aid the growth of *Lantana camara*.

How is the Proposal likely to affect habitat connectivity?

Amorpospermum whitei generally occurs in gully areas running perpendicular to the Proposal. Therefore suitable areas of habitat would be fragmented from the Proposal. Although no individuals were recorded in the study area in most areas of suitable habitat, individuals are potentially present in areas beyond the study area, and there are records to the west of the Proposal in several areas. Pollinator movements may extend across the proposed highway allowing exchange of genetic material between fragmented areas of habitat, assuming flying insects are the main pollinators, however this is largely unknown. Seed dispersal across the proposed development is likely to be impacted to some degree, as terrestrial fauna movement is likely to be impacted, however seed dispersal by flying mammals and birds is unlikely to be significantly impacted.

How is the Proposal likely to affect critical habitat?

No critical habitat has been identified for this species.

B.2 Threatened flora potentially present

B.2.1 *Acacia chrysotricha* - Endangered Species: TSC Act

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

The distribution of *Acacia chrysotricha* is restricted to an area south of Bellingen on the NSW north coast. It is an understorey species on rainforest edges and in wet or dry eucalypt forest in steep narrow gullies on quartzite soils. It is relatively short-lived and the seeds remain in the soil until disturbed or heated from fire to induce germination. This species is threatened by too-frequent fire which may lead to declines in the population.

Acacia chrysotricha 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. Records are present in Newry State Forest, approximately 4.5 km west of the Proposal area and there is a record from 1961 approximately two km to the east of the study area in Urunga.

This species is not particularly difficult to identify in the field, however a similar looking species *Acacia irrorata* was present in moderate abundance in areas of suitable habitat for this species. These species can readily be distinguished from each other in the field by differences in leaf morphology.

Considering the relatively extensive targeted searches undertaken for this species in areas of suitable habitat, it is unlikely it is present in the study area. The Proposal would result in the removal of approximately 34.4 ha of suitable habitat for this species. In particular areas of Newry State Forest and Nambucca State Forest had suitable areas of habitat comprising narrow gullies on quartzite soils.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal would result in the removal of approximately 34.4 ha of suitable habitat for this species. In particular areas of Newry State Forest and Nambucca State Forest had suitable areas of habitat comprising narrow gullies on quartzite soils.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

The distribution of *Acacia chrysotricha* is restricted to an area south of Bellingen on the NSW north coast. Therefore the restricted distribution of this species suggests where it is found in the local area it is near or at the limit of its distribution.

How is the Proposal likely to affect current disturbance regimes?

Current disturbance regimes in habitat of *Acacia chrysotricha* mainly comprises weed invasion by *Lantana camara*. The Proposal is likely to contribute to further invasion of *Lantana camara* particularly along the edges of the Proposal where there would be increased sunlight availability. Other indirect impacts such as increased water and nutrients may also aid the growth of *Lantana camara*.

How is the Proposal likely to affect habitat connectivity?

Acacia chrysotricha potentially occurs in gully areas running perpendicular to the Proposal. Therefore suitable areas of habitat would be fragmented from the Proposal. Although no individuals were recorded in the study area, individuals are potentially present in areas beyond the study area, and there are records to the west of the Proposal in Newry State Forest. Pollinator movements may extend across the proposed highway allowing exchange of genetic material between fragmented areas of habitat, assuming flying insects are the main pollinators, however this is largely unknown. Seed dispersal across the proposed development is likely to be impacted to some degree, as terrestrial fauna movement is likely to be impacted, however seed dispersal by flying mammals and birds is unlikely to be significantly impacted.

How is the Proposal likely to affect critical habitat?

No critical habitat has been identified for this species.

Acronychia littoralis - Endangered Species: TSC Act

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

The distribution of *Acronychia littoralis* is found between Fraser Island in Queensland and Port Macquarie on the north coast of NSW. 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. The nearest record to the Proposal area is 4 km east of Warrell Creek.

This species is not particularly difficult to identify in the field, however a similar looking species *Acronychia oblongifolia* was present in the study area in moderate abundance in rainforest and wet sclerophyll forest habitats. These species can readily be distinguished from each other by differences in leaf and fruit morphology and the scent of the leaves when crushed.

Considering the relatively extensive targeted searches undertaken for this species in areas of suitable habitat, it is unlikely it is present in the study area. The Proposal would result in the removal of approximately 34.4 ha of marginal habitat for this species.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal would result in the removal of approximately 34.4 ha of suitable habitat for this species. However habitats in the study area are marginal and are unlikely to support this species.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

The distribution of *Acronychia littoralis* is found between Fraser Island in Queensland and Port Macquarie on the north coast of NSW. Therefore this species would not be at the limit of its distribution in the locality.

How is the Proposal likely to affect current disturbance regimes?

Current disturbance regimes in habitat of *Acronychia littoralis* mainly comprises weed invasion by *Lantana camara*. The Proposal is likely to contribute to further invasion of *Lantana camara* particularly along the edges of the Proposal where there would be increased sunlight availability. Other indirect impacts such as increased water and nutrients may also aid the growth of *Lantana camara*.

How is the Proposal likely to affect habitat connectivity?

Acronychia littoralis potentially occurs in gully areas running perpendicular to the Proposal. Therefore suitable areas of habitat would be fragmented from the Proposal. Although no individuals were recorded in the study area, individuals are potentially present in areas beyond the study area. Pollinator movements may extend across the proposed highway allowing exchange of genetic material between fragmented areas of habitat, assuming flying insects are the main pollinators, however this is largely unknown. Seed dispersal across the proposed development is likely to be impacted to some degree, as terrestrial fauna movement is likely to be impacted, however seed dispersal by flying mammals and birds is unlikely to be significantly impacted.

How is the Proposal likely to affect critical habitat?

No critical habitat has been identified for this species.

B.2.2 *Hicksbeachia pinnatifolia* - Vulnerable Species: TSC Act

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Hicksbeachia pinnatifolia is found in coastal areas of north-east NSW from the Nambucca Valley north to south-east Queensland. Preferred habitat comprises subtropical rainforest, moist eucalypt forest and Brush Box (*Lophostemon confertus*) forest.

Red bopple nut was not recorded in the study area despite targeted searches in areas of suitable habitat. This species is not particularly difficult to identify in the field and is easily distinguished from other rainforest species in the study area. 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. The Proposal would result in the removal of approximately 34.4 ha of suitable habitat for this species. Better qualities examples of habitat include rainforest areas of which only 0.58 ha would be removed.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal would result in the removal of approximately 34.4 ha of suitable habitat for this species. Better qualities examples of habitat include rainforest areas of which only 0.58 ha would be removed.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

Hicksbeachia pinnatifolia is found in coastal areas of north-east NSW from the Nambucca Valley north to south-east Queensland. Therefore this species would be at the limit of its distribution in the locality.

How is the Proposal likely to affect current disturbance regimes?

Current disturbance regimes in habitat of *Hicksbeachia pinnatifolia* mainly comprises weed invasion by *Lantana camara*. The Proposal is likely to contribute to further invasion of *Lantana camara* particularly along the edges of the Proposal where there would be increased sunlight availability. Other indirect impacts such as increased water and nutrients may also aid the growth of *Lantana camara*.

How is the Proposal likely to affect habitat connectivity?

Hicksbeachia pinnatifolia potentially occurs in gully areas running perpendicular to the Proposal. Therefore suitable areas of habitat would be fragmented from the Proposal. Although no individuals were recorded in the study area, individuals are potentially present in areas beyond the study area. Pollinator movements may extend across the proposed highway allowing exchange of genetic material between fragmented areas of habitat, assuming flying insects are the main pollinators, however this is largely unknown. Seed dispersal across the proposed development is likely to be impacted to some degree, as terrestrial fauna movement is likely to be impacted, however seed dispersal by flying mammals and birds is unlikely to be significantly impacted.

How is the Proposal likely to affect critical habitat?

No critical habitat has been identified for this species.

B.2.3 *Maundia triglochinoides* - Vulnerable Species: TSC Act

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Restricted to coastal NSW north from Wyong extending into southern Queensland. Grows in swamps, creeks or shallow freshwater 30-60 centimetres deep on heavy clay with low nutrients. Flowering occurs during warmer months and is associated with wetland species such as *Triglochin procerum*.

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 two 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.

This species is not particularly difficult to identify in the field, however similar looking species including *Triglochin microturberosum* and *T.procera* were present in the study area in areas of shallow water. These species can readily be distinguished from each other by differences in leaf and fruit morphology.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal would result in the removal of only a small area of suitable habitat comprising up to two hectares of dams, creeks and wetland areas.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

Maudia triglochinoides is restricted to coastal NSW north from Wyong extending into southern Queensland. Therefore this species would not be at the limit of its distribution in the locality.

How is the Proposal likely to affect current disturbance regimes?

Current disturbance regimes in habitat of *Maundia triglochinoides* are relatively high within these areas mainly comprising impacts from grazing and agricultural weeds on the edges of dams and wetlands. Much of the wetland areas in the study area have been highly impacted from grazing. The aquatic weed species *Salvinia molesta* was recorded in some wetland areas south of the Nambucca River.

How is the Proposal likely to affect habitat connectivity?

Habitat for *Maundia triglochinoides* is unlikely to be significantly impacted from fragmentation as much of the habitat in the study is currently highly fragmented. However *Maundia triglochinoides* potentially occurs in gully areas running perpendicular to the Proposal in deeper creek lines. Therefore suitable areas of habitat would be fragmented from the Proposal.

Although no individuals were recorded in the study area, individuals are potentially present in areas beyond the study area. Pollinator movements may extend across the proposed highway allowing exchange of genetic material between fragmented areas of habitat, assuming flying insects are the main pollinators, however this is largely unknown. Seed dispersal across the proposed development is likely to be impacted to some degree, as terrestrial fauna movement is likely to be impacted, however seed dispersal by flying mammals and birds is unlikely to be significantly impacted.

How is the Proposal likely to affect critical habitat?

No critical habitat has been identified for this species.

B.2.4 *Parsonsia dorrigoensis* - Vulnerable Species: TSC Act

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Parsonsia dorrigoensis is found only in NSW, with scattered populations in the north coast region between Kendall and Woolgoolga. It occurs in subtropical and warm-temperature rainforest, on rainforest margins, and in moist eucalypt forest up to 800 m, on brown clay soils. The Proposal would result in the removal of approximately 34.4 ha of suitable habitat for this

species. Better qualities examples of habitat include rainforest areas of which only 0.58 ha would be removed.

Parsonsia dorrigoensis was not recorded in the study area despite targeted searches in areas of suitable habitat. There are records for this species in the locality. This species is not particularly difficult to identify in the field, however a similar looking species *Parsonsia straminea* is common in the study area in areas of wet sclerophyll and swamp forests. These species can readily be distinguished from each other by differences in leaf morphology and the colour of the exudates (sap).

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal would result in the removal of approximately 34.4 ha of suitable habitat for this species. Better qualities examples of habitat include rainforest areas of which only 0.58 ha would be removed.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

Parsonsia dorrigoensis is found only in NSW, with scattered populations in the north coast region between Kendall and Woolgoolga. Therefore this species would not be at the limit of its distribution in the locality.

How is the Proposal likely to affect current disturbance regimes?

Current disturbance regimes in habitat of *Parsonsia dorrigoensis* mainly comprises weed invasion by *Lantana camara*. The Proposal is likely to contribute to further invasion of *Lantana camara* particularly along the edges of the Proposal where there would be increased sunlight availability. Other indirect impacts such as increased water and nutrients may also aid the growth of *Lantana camara*.

How is the Proposal likely to affect habitat connectivity?

Parsonsia dorrigoensis potentially occurs in gully areas running perpendicular to the Proposal. Therefore suitable areas of habitat would be fragmented from the Proposal. Although no individuals were recorded in the study area, individuals are potentially present in areas beyond the study area, with records present in the locality. Pollinator movements may extend across the proposed highway allowing exchange of genetic material between fragmented areas of habitat, assuming flying insects are the main pollinators, however this is largely unknown. Seed dispersal across the proposed development is likely to be impacted to some degree, as terrestrial

fauna movement is likely to be impacted, however seed dispersal by flying mammals and birds is unlikely to be significantly impacted.

How is the Proposal likely to affect critical habitat?

No critical habitat has been identified for this species.

B.2.5 *Peristeranthus hillii* - Vulnerable Species: TSC Act

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Peristeranthus hillii is found in north-eastern NSW, north from Port Macquarie, extending to north-eastern Queensland and restricted to coastal and near-coastal environments, particularly in Littoral Rainforest and also Lowland Rainforest. The species is an epiphyte, growing in clumps on tree trunks and thick vines.

Peristeranthus hillii 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 and lowland of which the latter does not occur in the study area. The Proposal would result in the removal of approximately 34.4 ha of marginal habitat for this species, of which only 0.58 ha comprises better quality rainforest habitats.

There is a low possibility this species is present in rainforest and wet sclerophyll forests of the study area however these habitats are marginal. Other epiphytic orchid species were recorded in the study area including *Cymbidium madidum, C.sauve, Dendrobium kingianum* and *Plectorrhiza tridentata*. However these species can readily be distinguished from each other by differences in leaf and fruit morphology.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal would result in the removal of approximately 34.4 ha of suitable habitat for this species. Better qualities examples of habitat include rainforest areas of which only 0.58 ha would be removed.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

Peristeranthus hillii is found in north-eastern NSW, north from Port Macquarie, extending to north-eastern Queensland. Therefore this species would not be at the limit of its distribution in the locality.

How is the Proposal likely to affect current disturbance regimes?

Current disturbance regimes in habitat of *Peristeranthus hillii* mainly comprises weed invasion by *Lantana camara*. The Proposal is likely to contribute to further invasion of *Lantana camara* particularly along the edges of the Proposal where there would be increased sunlight availability. Other indirect impacts such as increased water and nutrients may also aid the growth of *Lantana camara*.

How is the Proposal likely to affect habitat connectivity?

Peristeranthus hillii potentially occurs in gully areas running perpendicular to the Proposal. Therefore suitable areas of habitat would be fragmented from the Proposal. Although no individuals were recorded in the study area, individuals are potentially present in areas beyond the study area. Pollinator movements may extend across the proposed highway allowing exchange of genetic material between fragmented areas of habitat, assuming flying insects are the main pollinators, however this is largely unknown. Seed dispersal across the proposed development is likely to be impacted to some degree, as terrestrial fauna movement is likely to be impacted, however seed dispersal by flying mammals and birds is unlikely to be significantly impacted.

How is the Proposal likely to affect critical habitat?

No critical habitat has been identified for this species.

B.3 Endangered ecological communities

B.3.1 Swamp Sclerophyll Forest

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Not applicable

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal would impact approximately 12.47 ha comprising 48 per cent high condition, 47 per cent moderate condition, two per cent low-moderate condition and three per cent in a low condition. There is potential for the Proposal to alter habitat attributes of surrounding areas through indirect impacts such as altering hydrological and nutrient regimes in habitats downstream of the proposed development. There would also be indirect impacts to adjacent areas of vegetation from edge effects increasing light availability which may result in altered

understorey floristics. These indirect impacts could result in increases in weed abundance, altered soil conditions and sedimentation. Changes to local hydrological regimes may result in water being contained for longer periods of time or lowering the watertable potentially resulting in changes to understorey floristics and die-back in the canopy. Mitigation measures during construction and the implementation of specific design features into the proposed development are likely to minimise these indirect impacts.

Larger patches of this community including areas gazetted as SEPP 14 Wetlands such as Bellwood Swamp, areas of Newry State Forest and several other large patches of Swamp Sclerophyll Forest would not be impacted.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

Not applicable

How is the Proposal likely to affect current disturbance regimes?

Current disturbance regimes in Swamp sclerophyll Forest mainly comprise weed invasion and cattle grazing. Some drier patches of this community support low-moderate abundances of *Lantana camara* and where under-scrubbing has been implemented for grazing purposes some pasture grasses and other weed species are present. Salvinia (*Salvinia molesta*) was recorded in this community in the area between Warrell Creek and the Nambucca River.

The Proposal is likely to contribute to further invasion of *Lantana camara* particularly along the edges of the Proposal where there would be increased sunlight availability. Other indirect impacts such as altered water and nutrient regimes may also aid the growth of *Lantana camara.* The proposed development may result in some adjacent areas of the community being excluded from grazing activities, however it is envisaged that the majority of this community retained adjacent to the Proposal would retain most of the current disturbance regimes.

How is the Proposal likely to affect habitat connectivity?

Habitat connectivity for Swamp Sclerophyll Forest would be impacted in several locations along the Proposal area. Patches of Swamp Sclerophyll Forest would be dissected in the area between Warrell Creek and the Nambucca River including a 25 ha patch and wetland and swamp forest habitats currently fragmented by farming land would be further fragmented from the Proposal. Some smaller patches between Nambucca State Forest and Little Newry State Forest adjacent to the existing highway would be impacted however habitat connectivity would not be significantly impacted considering the degree of existing fragmentation in these areas.

How is the Proposal likely to affect critical habitat?

No critical habitat has been identified for this community.

B.3.2 Swamp Oak Floodplain Forest

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Not applicable

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal would directly remove approximately 33.07 ha comprising 15 per cent high condition, 12 per cent moderate-high condition, 45 per cent moderate condition and 28 per cent low-moderate condition. The Proposal may also potentially lead to biophysical changes to adjacent areas of habitat which would remain surrounding the Proposal. The better quality areas of this community being impacted are in the Raleigh area, however generally only small fragmented patches of the community would be impacted by the Proposal. Larger areas of the community would remain in surrounding areas including patches in the Raleigh area and surrounding Deep Creek.

There is potential for the Proposal to alter habitat attributes of surrounding areas of Swamp Oak Floodplain Forest through indirect impacts such as altering hydrological and nutrient regimes in habitats downstream of the proposed development and edge effects. This could result in increases in weed abundance, altered soil conditions and sedimentation. Altering hydrological regimes may result in changes to understorey floristics and canopy dieback. Mitigation measures during construction and the implementation of specific design features into the proposed development are likely to minimise these indirect impacts.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

Not applicable

How is the Proposal likely to affect current disturbance regimes?

Current disturbance regimes within Swamp Oak Floodplain Forest mainly comprise weed invasion and cattle grazing. Some drier patches of this community support low-moderate abundances of *Lantana camara* and where under-scrubbing has been implemented for grazing purposes some pasture grasses and other weed species are present including Groundsel Bush (*Baccharis halimifolia*). The Proposal is likely to contribute to further invasion of *Lantana*

camara particularly along the edges of the Proposal where there would be increased sunlight availability. Other indirect impacts such as altered water and nutrient regimes may also aid the growth of *Lantana camara.*

Several areas of the community where agricultural activities including grazing have been previously implemented such as patches on both sides of the highway in the Raleigh area are now regenerating. Regeneration could be facilitated in some of these areas as part of the Proposal, particularly on RTA owned land where the Raleigh interchange is proposed to be situated.

How is the Proposal likely to affect habitat connectivity?

There would be some minor impacts to habitat connectivity for Swamp Oak Floodplain Forest along the Proposal area. Thin strips of the community along the edges of the Nambucca River and Deep Creek which provide some connectivity along the edge of these waterways would be dissected. Small to medium patches in the Raleigh area would be further fragmented however direct impacts are limited to the edges of these patches, and therefore would not significantly impact connectivity. Habitat connectivity would not be significantly impacted considering the degree of existing fragmentation of Swamp Oak Floodplain Forest along the Proposal area.

How is the Proposal likely to affect critical habitat?

No critical habitat has been identified for this community.

B.3.3 Subtropical Coastal Floodplain Forest

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal would directly remove 12.49 ha of Subtropical Coastal Floodplain Forest comprising 39 per cent high condition, 26 per cent moderate-high condition, 18 per cent moderate condition, 15 per cent low-moderate condition and two per cent low condition. There is potential for the Proposal to alter habitat attributes of surrounding areas through indirect impacts such as altering hydrological and nutrient regimes in habitats downstream of the proposed development and edge effects. This could result in increases in weed abundance, altered soil conditions and sedimentation. Changes to local hydrological regimes may result in water being contained for longer periods of time or lowering the watertable potentially resulting in changes to understorey floristics and die-back in the canopy. Mitigation measures during construction and the implementation of specific design features into the proposed development are likely to minimise these indirect impacts.

Medium sized areas of this community would remain surrounding the Proposal in Newry State Forest. Other occurrences of this community in the locality include Urunga Lagoon and some areas of remnant vegetation on the Kalang River and Nambucca River Floodplain.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

Not applicable

How is the Proposal likely to affect current disturbance regimes?

Current disturbance regimes in Subtropical Coastal Floodplain Forest mainly comprise weed invasion and cattle grazing. Some drier patches of this community support low-moderate abundances of *Lantana camara* and where under-scrubbing has been implemented for grazing purposes some pasture grasses and other weed species are present including Broad-leaf Paspalum (*Paspalum wettsteinii*).

The Proposal is likely to contribute to further invasion of *Lantana camara* particularly along the edges of the Proposal where there would be increased sunlight availability. Other indirect impacts such as altered water and nutrient regimes may also aid the growth of *Lantana camara.*

How is the Proposal likely to affect habitat connectivity?

Habitat connectivity for Subtropical Coastal Floodplain Forest would be impacted in several locations along the Proposal area. Thin strips of this community on the edge of the Kalang River and Warrell Creek which provide some level of connectivity along these waterways would be dissected by the Proposal. Larger patches of Subtropical Coastal Floodplain Forest would be dissected in Newry State Forest comprising two areas approximately 23 ha and 13 ha. Some smaller patches in Little Newry State Forest and surrounding Boggy Creek adjacent to the existing highway would be impacted however habitat connectivity would not be significantly impacted considering the degree of existing fragmentation in these areas.

How is the Proposal likely to affect critical habitat?

No critical habitat has been identified for this community.

B.3.4 Lowland Rainforest

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Not applicable

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal would directly remove approximately 0.6 ha comprising 100 per cent high condition. There is potential for the Proposal to lead to biophysical changes to adjacent areas of habitat which would remain surrounding the Proposal. The majority of the community impacted comprises small fragmented patches in the Warrell Creek area. This community is very rare in the study area, generally only occurring as disturbed patches in cleared agricultural landscapes. Areas of this community would remain in surrounding areas including patches on the northern side of the Nambucca River and in the Warrell Creek areas.

Some gully areas in larger patches of remnant vegetation in Nambucca and Newry State Forest, and in the Raleigh area have affinities to this community, occurring as a subcanopy in moist sclerophyll forest types. Although these areas have not been classified under the definition of this EEC they still have significance, providing habitat for flora species which occur in this community.

There is potential for the Proposal to alter habitat attributes of surrounding areas of Lowland Rainforest through indirect impacts such as altering hydrological and nutrient regimes and creating edge effects in habitats downstream of the proposed development. This could result in increases in weed abundance, altered soil conditions and sedimentation. Mitigation measures during construction and the implementation of specific design features into the proposed development are likely to minimise these indirect impacts.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

Not Applicable

How is the Proposal likely to affect current disturbance regimes?

Current disturbance regimes in Lowland Rainforest mainly comprise weed invasion and cattle grazing. Weed species occur in moderate-high abundance in disturbed patches of the community including Camphor Laurel (*Cinnamonum camphora*) and *Lantana camara*. The Proposal is likely to contribute to further invasion of *Lantana camara* particularly in gully areas along the edges of the Proposal where there would be increased sunlight availability. Other indirect impacts such as altered water and nutrient regimes may also aid the growth of *Lantana camara.* Mitigation measures during construction and the implementation of specific design features into the proposed development are likely to minimise these indirect impacts.

How is the Proposal likely to affect habitat connectivity?

There would be some minor impacts to habitat connectivity for Lowland Rainforest along the Proposal area. Thin strips of the community along the edges of Upper Warrell Creek which provide some connectivity would be impacted. Small isolated patches in largely cleared agricultural areas in the Warrell Creek area would be further fragmented. Habitat connectivity would not be significantly impacted considering the degree of existing fragmentation of Lowland Rainforest along the Proposal area.

How is the Proposal likely to affect critical habitat?

No critical habitat has been identified for this community.

B.3.5 Freshwater Wetlands

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Not Applicable

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal would directly impact approximately 1.58 ha of Freshwater Wetlands comprising 13 per cent high condition, 11 per cent moderate condition, 20 per cent low-moderate condition and 56% low condition in grazed agricultural areas. Generally only small disturbed areas of the community occurring in cleared paddock areas and power easements would be impacted by the Proposal. Several pond areas in agricultural lands would also be impacted. Larger areas of the community with a higher ecological condition would remain in surrounding areas including near Deep Creek and between Warrell Creek and the Nambucca River.

There is potential for the Proposal to alter habitat attributes of surrounding areas of Freshwater Wetlands through indirect impacts such as altering hydrological and nutrient regimes in habitats downstream of the proposed development, potentially resulting in increases in nutrient levels and sedimentation. Mitigation measures during construction and the implementation of specific design features into the proposed development are likely to minimise these indirect impacts.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

Not Applicable

How is the Proposal likely to affect current disturbance regimes?

Current disturbance regimes in Freshwater Wetlands mainly comprise weed invasion, cattle grazing and high nutrient levels. Areas of this community in paddock areas support a mix of native wetland flora and various pasture weeds on the edges of these areas. Salvinia (*Salvinia molesta*) was recorded in one area of this community between Warrell Creek and the Nambucca River. There is potential for indirect impacts such as higher nutrient and sedimentation levels to contribute to a higher abundance of water weeds. Grazing activities would continue following the Proposal in areas of Freshwater Wetlands in paddock areas.

How is the Proposal likely to affect habitat connectivity?

There would be some minor impacts to habitat connectivity for Freshwater Wetlands along the Proposal area. Thin strips of the community in agricultural areas on the southern side of the Nambucca River would be impacted on the edges. Small to medium patches in the power easement in the Raleigh area would also be further fragmented. Habitat connectivity would not be significantly impacted considering the degree of existing fragmentation of Freshwater Wetlands along the Proposal area, and impacts are generally confined to edges of these areas.

How is the Proposal likely to affect critical habitat?

No critical habitat has been identified for this community.

B.4 Threatened fauna

B.4.1 Black-necked stork

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

The evidence gathered from background review and field surveys suggest that black-necked stork is rare and restricted in distribution in the immediate study area. The scattering of records are centred around a large freshwater wetland on the Kalang River floodplain located between the northern arm of the river and South Arm Road (Figure 4-12). Residences on the Kalang River floodplain (north and south) report that storks are occasionally observed in grazed paddocks and swamp vegetation particularly on the northern side of the river near this location suggesting that these modified habitats are also providing important foraging habitat for local black-necked stork s. Movements are likely to occur between the permanent swamp and ephemeral paddock soaks during high rainfall periods.

Important life-cycle components for the species would constitute breeding, feeding, sheltering and refuge and movements. No nest sites have been identified in the study area, nor would be impacted by the Proposal. There is data available on nesting in the study area however it is

assumed that at least one nest site may occur in the lower Kalang River floodplain in the vicinity of South Arm Road to Newry Island. There are numerous opportunities for nesting adjacent to the identified wetland which would remain outside of the Proposal footprint. There are no other large freshwater wetland habitats in the study area and therefore potential habitat comprises modified grazing land especially periodically inundated floodplain areas. Such habitats are widespread and well represented. The Proposal would not impact directly on the identified wetland habitat north of the Kalang River currently providing shelter and refuge and feeding habitat. However the road would traverse cleared grazing land on the floodplain where storks have occasionally been observed foraging. Measures to manage potential indirect impacts via nutrient run-off into known black-necked stork habitat have been addressed in the report and form a component of the Flora and Fauna Management Plan (FFMP) as a component of the Construction Environmental Management Plan (CEMP).

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The black-necked stork typically occupies shallow freshwater wetlands on floodplains which may include natural and modified wetlands and adjacent floodplain swamps and forests. Threats to wetland habitats include:

- Changes in natural flow regimes.
- Degradation through pollution and salinisation.
- Loss of habitat through clearing and draining.

The identified habitat for black-necked stork in the study area is as described above, being limited to a single wetland on the Kalang River floodplain in addition to surrounding modified farmland habitats used for foraging. The latter are very common and widespread. Other potential habitats include Gumma Swamp, south of Warrell Creek and to the east of the alignment. The Proposal would not directly impact on wetland habitat suitable for this species.

There is potential for changes in natural flow regimes and increased nutrient inputs into these habitats via the addition of new infrastructure in the catchment. These issues have been addressed adequately through the provision of numerous drainage structures (culverts and sediment ponds) located along the length of the alignment. Potential impacts from runoff during construction are to be managed through the development of a CEMP and FFMP.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

The species is widespread across coastal northern and eastern Australia, becoming increasingly uncommon further south into NSW, and rarely south of Sydney. The study area does not represent the species limit of distribution.

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

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. The impacts of fragmentation on flora and fauna and threatened species identified in this study area are difficult to determine without more extensive population viability assessments. It is important to note however that all areas of habitat affected by the Proposal have already been fragmented in the past by roads, clearing for agriculture and power easements. The Proposal would be contributing to this cumulative fragmentation of habitat in the landscape, however the impact on black-necked stork is not expected to significant. The potential habitat of the species is outside of the road corridor (in terms of wetlands) and widespread (in terms of agricultural land). Further, the species is not dependent on continuous habitat and capable of moving long distances to access habitat resources.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.2 Swift parrot and regent honeyeater

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

The distribution of records for both species in the mid north coast of NSW has been consistently associated with lowland coastal forests dominated by swamp mahogany (*Eucalyptus robusta*) or drier forests and woodlands comprising a high density of Spotted Gum (*Corymbia maculata*) (Menkhorst 1999). The latter species is not present in the study area. The association with this habitat type is a result of the presence of winter flowering eucalypts and the reliance by these nomadic species on the seasonally available winter food resources (nectar).

The study area would constitute non-breeding habitat for a proportion of the population of both species. The Macksville to Urunga study area is not considered a critical area for the regent honeyeater (D.Geering, NPWS, *pers.comm*) or swift parrot (D.Saunders, *pers comm*). The swamp forest communities that are present do contribute to the overall availability of habitat for these species in coastal NSW however, and may be particularly important as refuge sites during drought when trees from other districts such as the inland Box Ironbark woodlands of NSW and Victoria may be experiencing poor flowering conditions. Indeed records from the study area are relatively continuous extending over a 30 year period (1977-2007), indicating that the region from Macksville to Coffs Harbour may constitute seasonally important foraging and refuge habitat for these species. The current potential for these species to occur based on the presence of potential foraging habitat is expected to remain after completion of the Proposal such that foraging and movement life-cycle activities would not be impacted.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

Swamp sclerophyll forest is listed as an endangered ecological community (TSC Act), with some areas also listed under SEPP 14 as protected coastal wetlands, examples of such areas occur in Nambucca State Forest. All areas of EEC and SEPP 14 wetland were identified in the original route options investigation (SKM 2005) and the selection of the preferred route was chosen to minimise impacts on these significant ecological areas. In achieving this, the impacts on fauna species dependent on the swamp forest communities, such as the regent honeyeater and swift parrot, have also been considered.

From the mapping of potential habitat for these species in proximity to the Proposal it is evident that there are three categories of habitat characterised by high, medium and low quality areas

(refer SKM 2005b). An overlay of the preferred highway route was used to calculate the loss of potential habitat for these species from the study area. The Proposal would potentially involve removal of up to 5.94 ha of high quality habitat, 5.86 ha of medium and 0.67 ha of low-moderate quality habitat from the study area. This loss is considered low and of little significance to populations of the swift parrot and regent honeyeater. Large areas of high quality habitat are represented outside the road footprint in Nambucca and Newry State Forest to the east of the Proposal, and in private land to the south of Raleigh also to the east of the Proposal. Continued visitation to the region is expected following construction of the Proposal.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

The swift parrot extends from its summer breeding grounds in Tasmania, from where it disperses to over-winter in southeast mainland Australia. Some individuals range north to Queensland, but the majority over-winter in Victoria and central and eastern NSW (Saunders and Heinsohn 2008). The species returns to Tasmania in September. The study area constitutes a small percentage of the known distribution of the species and does not represent its geographical limit.

The regent honeyeater was formerly distributed in about 300 km of the eastern Australian coast from approximately 100 km north of Brisbane to Adelaide (Franklin *et al.* 1989); however, it is no longer found in South Australia (Franklin and Menkhorst 1988) or western Victoria (Franklin *et al.* 1987) and records from Queensland are uncommon. Sightings now centre on a few sites in north-eastern Victoria, along the western slopes of the Great Dividing Range to Tenterfield, the Warrumbungle Ranges and Parkes in the west, and the central coast of NSW. The total population is estimated at close to 1500 individuals (Webster and Menkhorst 1992).

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, examples include the loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient and sediment loads into aquatic habitats, and the presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes via additional vegetation clearing and altering of hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusion of these measures suggests minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

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. It is important to note however that all areas of habitat affected by the Proposal have already been fragmented in the past by roads, clearing for agriculture and power easements. The Proposal would be contributing to this cumulative fragmentation of habitat in the landscape. As stated the impacts of fragmentation may be most evident in Nambucca, Newry and Little Newry State Forest. The dominant habitat types in these locations comprise dry sclerophyll forest of blackbutt and tallowwood and are not suited to the swift parrot or regent honeyeater due to the minimal presence of winter flowering eucalypts. Suitable habitats are represented in swamp sclerophyll communities on floodplains which exist as smaller fragments and less impacted by fragmentation associated with the Proposal.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.3 Grey-headed flying-fox

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

The grey-headed flying-fox was recorded at four locations along the proposed route from widely dispersed locations and no specific habitat type. There were no camps or roost sites identified in the survey area. The grey-headed flying-fox inhabits a wide range of habitats including rainforest, mangroves, paperbark forests, wet and dry sclerophyll forests and cultivated areas. Camps are often located in gullies, typically close to water, in vegetation with a dense canopy. Known roost sites for this species in the regional area are located at Bowraville and Yarrhapinni and an unconfirmed site at Urunga. None of these are located in proximity to the Proposal.

The Grey-headed flying-fox feeds on nectar and pollen of native trees, in particular Eucalyptus Melaleuca, Banksia and Ficus and fruits of rainforest trees and vines. The combined area of Nambucca State Forest (1697 ha), Little Newry (194 ha) and Newry State Forest (3921 ha)

through which the Proposal passes is 5812 ha. This represents extensive areas of potential foraging habitat for the species in the State forests. The clearing of approximately 253 ha of potential foraging habitat for this species is required (based on proposed footprint). This represents a relatively minor impact for this species in the local area. In relation to the available habitat in adjacent land surrounding areas, the Proposal is not considered likely to affect this species at the local level. The proposed action would not result in the decrease in size of the population in the local area and would not impact on a known roost site.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

As stated, the clearing of approximately 253 ha of potential foraging habitat for this species represents a relatively minor impact for this species in the local area. In relation to the available habitat in adjacent land surrounding the highway, the Proposal is not considered likely to affect this species at the local level. The proposed action would not result in the decrease in size of the population in the local area and would not impact on a known roost site.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

The grey-headed flying-fox has a large distribution in a range of 200 km from the eastern coast of Australia, from Bundaberg in Queensland to Melbourne in Victoria. The species is not at the limit of its distribution in the study area.

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small

vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

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. It is important to note however 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 habitat in the landscape.

Highly mobile species such as bats and birds are expected to be less impacted by fragmentation and the grey-headed flying-fox is particularly well adapted to accessing widely spaced habitat resources given its mobility and preference for seasonal fruits and blossom.

A strategic approach to mitigating the effects of fragmentation from the Proposal should be developed by focusing on re-establishing links with historically isolated fragments of habitat in proximity to the new road. These opportunities should be investigated along with increasing the size of smaller remnant fragments adjoining the road. The greatest potential for this exists in low-lying agricultural areas adjoining the corridor.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.4 Yellow-bellied glider

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

A group of three to four individuals was recorded in Nambucca State Forest at Sites D2 and D3 between Bellwood Road and Allans Road. A number of potential den trees were also identified in this area. The historical presence of this species has been noted throughout Nambucca State Forest and Newry State Forest, with formal records maintained by State Forests dating back to 1999. Based on these records the distribution of the species is widespread across Nambucca State Forest and surrounding localities, occurring both east and west of the proposed highway. These observations suggest the Proposal would impact on the territory of a least one family group of gliders occurring in the vicinity of Old Coast Road and Bellwood Road. This family group would constitute a portion of a larger population extending to the east and west possibly also east of the existing Pacific Highway around Valla and Valla Nature Reserve. Other populations have been recorded in Way Way State Forest.

The species is threatened by the loss of suitable food trees and nesting hollows, as well as intense fires which alter the dynamics of natural forests (Klippel 1992). The clearing of habitat and forest harvesting methods leading to even-aged stands pose a threat as even-aged stands leads to a decrease in hollow bearing trees necessary as dens.

The home range for the species has been estimated at 60 ha (Goldingay and Kavanagh 1991). *P.australis* tends to show a pattern of seasonal use of its home range due to a dependence on certain food types that are only available from particular forest types at particular times of the year (Kavanagh 1984; Goldingay 1992). The home ranges also appear to function as territories, with vocalisations serving to advertise and maintain their integrity (Goldingay 1992).

The foraging behaviour of the species is diverse and responsive to changes in tree phenology such as periods of flowering and bark shedding (Kavanagh 1984). Smooth barked eucalypts are considered to be important to the species due to the diversity of foraging substrates they provide (Forestry Commission of NSW 1993).

The species is mainly nocturnal, sheltering in nests in tree hollows lined with leaves during the day (Gilmore and Parnaby 1994). The species requires relatively large tree hollows because family groups share den sites (Gibbons & Lindenmayer 1997). Dominant males may live with up to five females and their young.

There is a lack of data on the dynamics of the local population (i.e. size, number of family groups and home range territories) to make informed decisions about impacts on life-cycle activities. However based on a precautionary principle it is assumed that the road would further fragment known habitat and remove some habitat trees. The issue of movement and dispersal has been addressed by the proposed widening of the median through the northern end of Nambucca State Forest and also Newry State Forest which was specifically located at strategic glider locations. Where possible the design footprint was refined to avoid identified habitat trees. These issues have addressed movements and denning opportunities for the species. Food resources are widespread and abundant and the extent of clearing required in Nambucca State Forest is not expected to significantly to significantly reduce following the construction of the Proposal.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal is likely to remove a portion of the home range territory of at least one family group of gliders including possible denning trees. There is no specific data on the home range of this group or known den trees, so the extent of this impact is not known, although data on the species suggest home ranges can extend as large as 60 ha (Goldingay and Kavanagh 1991). This group is part of a larger population which extends into the surrounding state forests and possibly

private lands to the south and east. Individuals have also been recorded in Newry State Forest in contiguous habitats to the north. Additionally the subject area is part of a larger east west corridor suggesting other populations are likely to occur to the west of the study area. Other populations have been identified in Way Way State Forest and Yarrahappini National Park to the south and east.

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 throughout the remaining portions of Nambucca State Forest to the east and west of the route.

Yellow-bellied gliders need to occupy large home ranges as there food resources are seasonal and often widely dispersed. Therefore most of the habitats in the study area are likely to provide foraging habitat for yellow-bellied gliders apart from wetland and mangrove communities. Therefore the Proposal would remove up to 253 ha of habitat for this species, however yellow-bellied gliders would be unlikely to occupy isolated fragments which are included in this figure.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

The yellow-bellied glider is found along the eastern seaboard to the western slopes of the Great Divide, from southern Queensland to Victoria (NPWS 2002) and is not at the limit of its distribution in the study area.

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared

agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

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. In Nambucca State Forest an area of up to 1000 ha would be separated to the east of the new road. This habitat was identified as being occupied by a population of yellow-bellied gliders. While the proportion of habitat remaining to the east of the road (c.1000 ha) is considered sufficiently large to support populations of this 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. The widened median is predicted to be accessible by yellow-bellied gliders given the narrow carriageway to be traversed on either side (approximately 40 m). The impacts of fragmentation on yellow-bellied glider are difficult to determine without more extensive population viability assessment, however provided the widened vegetated medians are utilised by yellow-bellied gliders impacts to this species from fragmentation would be minimised.

The impact of 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 fauna underpass structures are also proposed through portions of Newry State Forest to maintain opportunities for fauna crossing.

The widening of the median 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 section 6 of this report.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.5 Koala

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Evidence of koala was recorded in this study in Nambucca State Forest on the western side of the rail line several hundred metres west of the proposed route. State Forests (DII) have reported numerous records of koalas in the western parts of Newry State Forest, also to the west of the study area. There are a scattering of records along the coast around Valla. These data suggest the presence of a local population of koalas, centred around Newry State Forest with possible sub-populations along the coast north of Nambucca Heads.

Important life-cycle activities for koalas include foraging, shelter and refuge, movements and breeding. The koala feeds predominantly on the foliage of certain species of eucalypts. Likely food trees in the region include primary browse trees such as forest red gum, swamp mahogany, grey gum, tallowwood and Sydney blue gum. Occasional browse trees such as blackbutt, broad-leaved paperbark, and red mahogany are also common in the region. There are marked changes in diet throughout the year and at different sites (Martin & Lee 1984; Reed *et al.* 1990).

Breeding is seasonal with mating taking place during October to February and most births occurring between November and late March. Females become sexually mature at two to three years and males at around three to four years. The species appears to be polygamous with the ranges of dominant males overlapping the range of several females (Lee & Martin 1988; Mitchell 1990).

The Proposal would remove potential habitat for the species through the clearing of vegetation communities containing identified food tree 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 northwest of the route and there is little evidence to suggest that koala populations or movements are centred on the proposed route. The potential for east-west movements from the coast at Valla to the west via Newry State Forest have been considered in the design and location of fauna underpass structures combined with widening of the median and fauna exclusion fencing to facilitate movements and minimise vehicle strike mortalities.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

In coastal northern NSW, populations have been estimated to range from one animal every 45 hectares to one every 4.5 ha (average one every 20-25 ha) (Austeco 1994). Most young disperse at two to three years of age and females remain in their natal area (Martin 1983). There are no data available on the size of local populations or the extent of potential habitat. The Proposal would remove potential habitat for the species through the clearing of vegetation communities

containing the identified food tree 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 northwest of the route and there is little evidence to suggest that koala populations or movements are centred on the proposed route.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

The koala occurs throughout eastern Australia through Queensland, NSW and Victoria and the study area is not the limit of distribution for this species.

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

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. These habitats accommodate the majority of potential habitat for koala and recorded observations in the study area. It is important to note however that all areas of habitat affected by the Proposal have already been fragmented in the past by roads, clearing for agriculture and power easements. The Proposal would be contributing to this cumulative fragmentation of habitat in the landscape.

Appropriate measures have been incorporated into the design of the road to minimise the impacts of fragmentation on this species by incorporating a wider median through the northern end of Nambucca State Forest and placing fauna underpass structures in strategic locations. Further widening of the median and fauna underpass structures are also proposed through portions of Newry State Forest to maintain opportunities for fauna crossing.

A strategic approach to mitigating the effects of fragmentation from the Proposal should be developed by focusing on re-establishing links with historically isolated fragments of habitat in proximity to the new road. These opportunities should be investigated along with increasing the size of smaller remnant fragments adjoining the road. The greatest potential for this exists in low-lying agricultural areas adjoining the corridor.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.6 Spotted-tailed quoll

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Preferred habitat includes dry and moist sclerophyll forests where they den in rock caves, hollow logs or trees and would feed in nearby cleared areas (State Forests of NSW 1995a). Suitable habitat is well represented in the larger fragments of forest in the study area, particularly state forests and adjoining private properties. The species was not recorded during this study however is expected to occur. The species is an opportunistic predator and would feed on a variety of prey including macropods, birds, reptiles, arboreal mammals and small terrestrial mammals (Mansergh 1983). The Proposal would remove potential habitat for the species and its prey, leading to further fragmentation of habitat, a known threat to the species. Measures to conserve fauna corridors and movement avenues for terrestrial fauna have been incorporated into the Proposal. Breeding, foraging and movement life-cycle opportunities would remain in the region and likely to sustain local populations.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

Preferred habitat includes dry and moist sclerophyll forests where they den in rock caves, hollow logs or trees and would feed in nearby cleared areas (State Forests of NSW 1995a). Suitable habitat is well represented in the larger fragments of forest in the study area, particularly state forests and adjoining private properties. The Proposal would remove potential habitat for the species and its prey, leading to further fragmentation of habitat, a known threat to

the species. The Proposal would result in the removal of up to 255 ha for this species. The overall reduction of habitat is a small proportion of the available potential habitat.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

The spotted-tailed quoll occurs throughout eastern Australia through Queensland, NSW, Victoria and Tasmania and the study area is not the limit of distribution for this species.

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

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. These areas provide potential habitat for spotted-tailed quoll largely because of their size and continuity with forests to the west. It is important to note however 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 habitat in the landscape.

The impacts of fragmentation may be most evident in Nambucca State Forest in section 2, where an area of up to 1000 ha of forested lands would be separated to the east of the road.

Measures have been planned to minimise the impacts of fragmentation and 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.

The impact of 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 fauna underpass structures are also proposed through portions of Newry State Forest to maintain opportunities for fauna crossing.

A strategic approach to mitigating the effects of fragmentation from the Proposal should be developed by focusing on re-establishing links with historically isolated fragments of habitat in proximity to the new road. These opportunities should be investigated along with increasing the size of smaller remnant fragments adjoining the road. The greatest potential for this exists in low-lying agricultural areas adjoining the corridor.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.7 Brush-tailed phascogale

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

The brush-tailed phascogale is largely arboreal, occupying a variety of habitats, particularly open dry sclerophyll forest with little groundcover (Cuttle 1982). The home range of the species is exclusive and densities are correspondingly low. Female brush-tailed phascogales occupy a home range of 37 hectares, and males occupy 86 hectares with their home ranges overlapping the female home range (Traill and Coates 1993; Soderquist and Ealey 1994). Evidence of local populations in the study area has not been identified, however suitable habitat is widespread and common and populations are considered to persist following development of the Proposal.

The diet of this species consists mainly of arthropods, such as spiders and centipedes, as well as small invertebrates including cockroaches, beetles and bull ants (Cuttle 1982). Phascogales would also forage on the ground and eucalypt nectar is extensively utilised when trees are flowering (Traill and Coates 1993). The diet is not particularly specialised to a degree that clearing for the Proposal would significantly affect foraging requirements.

The brush-tailed phascogale has a three week mating season which occurs mid May to early July. Following mating, the pair nests in tree hollows with narrow entrances. After forming the nest, the male would soon die through what is believed to be stress related illness induced by excessive copulative behaviour (Traill and Coates 1993). The Proposal would remove hollow-

bearing trees suitable as nesting sites for the species and lead to further fragmentation and reduction of mature forest from the region. Suitable habitat is widespread and common providing continued habitat for local populations.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The brush-tailed phascogale is largely arboreal, occupying a variety of habitats, particularly open dry sclerophyll forest with little groundcover (Cuttle 1982). Such habitats are particularly well represented in the region, particularly on ridges and low hills where clearing has been less severe than river flats. The Proposal would result in the removal of up to 253 ha for this species. The overall reduction of habitat is a small proportion of the available potential habitat. Populations are considered to persist following development of the Proposal.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

The brush-tailed phascogale occurs throughout eastern Australia to the western slopes of the Great Divide from southern Queensland, NSW and Victoria (NPWS 2002) and the study area is not the limit of distribution for this species.

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

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. These areas provide potential habitat for populations of brush-tailed phascogale. It is important to note however that all areas of habitat affected by the Proposal have already been fragmented in the past by roads, clearing for agriculture and power easements. The Proposal would be contributing to this cumulative fragmentation of habitat in the landscape.

The impacts of fragmentation may be most evident in Nambucca State Forest in section 2, where an area of up to 1000 ha of forested lands would be separated to the east of the road. Measures have been planned to minimise the impacts of fragmentation and 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.

The impact of 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 fauna underpass structures are also proposed through portions of Newry State Forest to maintain opportunities for fauna crossing.

A strategic approach to mitigating the effects of fragmentation from the Proposal should be developed by focusing on re-establishing links with historically isolated fragments of habitat in proximity to the new road. These opportunities should be investigated along with increasing the size of smaller remnant fragments adjoining the road. The greatest potential for this exists in low-lying agricultural areas adjoining the corridor.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.8 Glossy black-cockatoo

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

The glossy black-cockatoo inhabits mountain forests, coastal woodlands, open forest, riparian vegetation and partially cleared areas from sea level to 1000 metres. This species distribution is linked to its reliance on their primary food source, the seeds of *Allocasuarina torulosa, A. verticillata* and *A. littoralis*.

Groups of this species (two to twenty individuals) are known to occupy an area permanently, though individuals and sub groups may move around in this area (Blakers *et al* 1984). It is generally unknown what size this area must be, but it is closely linked to the density of *Allocasuarina* species.

A hollow limb or hole, often is a tall dead tree in a forest clearing, is typically used for roosting (Forshaw and Cooper 1978). Blackbutt (*Eucalyptus pilularis*) is known to be used for nesting (Mount King Ecological Surveys 1993) and this species is very common in the study area. This species requires large cavities for nesting and breeding which occurs from March to August (Mount King Ecological Surveys 1993) however, the main breeding season is from April to June (Simpson and Day 1997).

A population was identified in the northern half of the study area, north from Nambucca State Forest to Raleigh, comprising of several groups occupying parts of Nambucca, Newry and Little Newry state Forest as well as dry sclerophyll forest habitats on privately owned lands north of the Kalang River and east of the existing Pacific Highway near Valla. This distribution was determined through observation of birds and feeding signs and collation of database records**.** Food resources in the study area include *Allocasuarina torulosa* and *Allocasuarina littoralis* which are a very common component of the extensive blackbutt open forest community (MU1) throughout the study area. No nest sites were located in the study area, however several potential sites (large tree hollows) were identified in proximity to the route.

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 is unlikely to significantly impact on this situation, despite the loss of food resources. There is potential to remove large hollow-bearing trees which may currently or potentially provide nest sites. These are an uncommon feature in the landscape as a result of the historical land uses. Where feasible these have been identified near the route and refinement of the design carried out to minimise their removal. Further surveys of habitat trees have been recommended as a component of the CEMP (and FFMP) which would be particularly important if construction commences between April and June.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

This species distribution in the study area is linked to the distribution of their primary food source, the seeds of *Allocasuarina torulosa* and *A. littoralis* which are a common component of the extensive blackbutt open forest community (MU1) (refer Figure 3-7 to Figure 3-10). MU1 is very common throughout Nambucca, Newry and Little Newry state Forest as well as dry

sclerophyll forest habitats on privately owned lands north of the Kalang River and east of the existing Pacific Highway near Valla. The Proposal would clear up to 129 ha of blackbutt open forest a portion of which would provide potential habitat for this species. Nesting resources comprising larger tree hollows are also most abundant in this community.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

The species occurs throughout coastal eastern Australia through Queensland to the Victoria border.

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

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. It is important to note however 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 habitat in the landscape.

Highly mobile species such as bats and birds are expected to be less impacted by fragmentation and the glossy black-cockatoo population in the study area appears to be well adapted to accessing widely spaced habitat resources given its mobility and specific diet.

A strategic approach to mitigating the effects of fragmentation from the Proposal should be developed by focusing on re-establishing links with historically isolated fragments of habitat in proximity to the new road. These opportunities should be investigated along with increasing the size of smaller remnant fragments adjoining the road. The greatest potential for this exists in low-lying agricultural areas adjoining the corridor.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.9 Large Forest Owls (powerful owl, masked owl and sooty owl)

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

All three species are known to occupy very large territories particularly in fragmented areas, which is a reflection of their high mobility and diversity of prey species taken. Whilst the three species are known to occasionally roost by day in dense thickets of vegetation or foliage their nesting requirements are more specialised being totally dependent on suitably large tree-hollows generally found in the trunks of tall and mature trees.

Their dependence on this specific habitat feature restricts the local distribution of the species at least for breeding life-cycle requirements and highlights their vulnerability to increased clearing and fragmentation. Generally foraging territory is more widespread and may occur throughout a variety of habitat types depending on the species, with the powerful owl ranging from swamp forest to wet and dry sclerophyll, preferably in wet gullies for roosting and the barking owl and masked owl favouring the more open forest and woodland types for foraging, particularly on the edge of open lands such as agricultural lands.

Targeted searches were carried out at all times during the field surveys for the presence of suitable tree-hollows (potential nest sites) for these birds. These are considered very scarce along the route corridor and nesting opportunities are considered very limited. As the incidence of potential roost / nest hollows in the study area is minimal it is considered unlikely that the Proposal would constitute a significant impact on local populations of these species. The removal of 253 ha of forest habitat would impact on the habitat of prey species for these owls and increase fragmentation which may have an impact on juvenile dispersal.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

As the incidence of potential roost / nest hollows in the study area is very minimal it is considered unlikely that the Proposal would constitute a significant impact on local populations of these species. There is potential to impact on an unidentified nest tree of one of these species and further survey of habitat trees is required prior to construction. The removal of 253 ha of forest habitat would impact on the habitat of prey species for these owls and increase fragmentation which may have an impact on juvenile dispersal and establishment of new pairs.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

All three species occurs throughout eastern Australia through Queensland, NSW and Victoria and the study area is not the limit of distribution for these species.

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

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. These areas provide potential habitat for large forest owls largely

because of their size and continuity with forests to the west. It is important to note however 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 habitat in the landscape.

The impacts of fragmentation may be most evident in Nambucca State Forest in section 2, where an area of up to 1000 ha of forested lands would be separated to the east of the road. Measures have been planned to minimise the impacts of fragmentation and 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.

The impact of 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.

A strategic approach to mitigating the effects of fragmentation from the Proposal should be developed by focusing on re-establishing links with historically isolated fragments of habitat in proximity to the new road. These opportunities should be investigated along with increasing the size of smaller remnant fragments adjoining the road. The greatest potential for this exists in low-lying agricultural areas adjoining the corridor.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.10 Frugivorous Birds (Wompoo Fruit-Dove, Superb Fruit-Dove and Rose-crowned Fruit-Dove)

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

The wompoo fruit-dove was recorded in the 2005 surveys in the upper reaches of Boggy Creek several hundred metres to the west of the proposed alignment. No other observations were recorded from the detailed surveys of the route however there are additional records in the Atlas of NSW Wildlife database (DECCW) for the study area and the presence of rainforest plant species associated with gullies suggest the presence of suitable habitat. All species are 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.

These bird species forage on fruits from native rainforest trees and shrubs as well as the introduced Camphor Laurel. Therefore, these species are threatened primarily by the destruction of habitat by clearing for development and agriculture. The Proposal would involve removal of a small percentage of moist forest habitat which supports rainforest species in the understorey (c. 63 ha) which is marginal for the species and up to 0.58 ha of lowland rainforest which is better suited. The current potential for these species to forage in the study area is considered to remain following the works and the impacts on life-cycle activity would be very minimal. The proposed Proposal is considered unlikely to significantly disrupt the life-cycle of these frugivorous birds such that any viable local population would be placed at risk of extinction.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The Proposal would involve removal of a small percentage of moist forest habitat (c. 63 ha) which is marginal for the species and up to 0.58 ha of lowland rainforest which is better suited. Local populations are expected to be small and nomadic compared to those to the west of the study area in the Dorrigo / Bellingen area where subtropical rainforest habitats are more widespread.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

Distributed throughout subtropical and tropical eastern Australia, the study area is not the limit of distribution for these species.

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

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. These areas provide potential habitat for Frugivorous birds largely because of their size and continuity with forests to the west. It is important to note however 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 habitat in the landscape.

These large birds are capable of moving large distances to access seasonally available fruits. Much of their habitat requirements would be met in rainforest gullies and creeklines which are poorly represented in the study area. These species are not totally reliant on continuous habitat connectivity.

A strategic approach to mitigating the effects of fragmentation from the Proposal should be developed by focusing on re-establishing links with historically isolated fragments of habitat in proximity to the new road. These opportunities should be investigated along with increasing the size of smaller remnant fragments adjoining the road. The greatest potential for this exists in low-lying agricultural areas adjoining the corridor.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.11 Osprey

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Several breeding pairs of osprey are expected to occur in the catchment of the Nambucca and Kalang Rivers. Nest sites have generally been recorded in floodplain areas, near swamps or estuaries and often in dead trees near the forest edge. One active nest was located in the study area during 2008, recorded on private property south of Deep Creek in 50 m of the existing

Pacific Highway. Nesting was reported to have occurred at this location for several years. Other nests reported north of Martels Road and Champions Lane in 2005 were blown out of the tree and collapsed by the 2007-08 surveys and incident which is expected to be common for this species given the preference for isolated dead trees. Individuals are commonly observed in the floodplain and estuarine habitats across the study area.

The Proposal would not directly impact on a currently known nest site, however further survey is required prior to construction to determine the location of new sites constructed since the survey. The existing nest on the southern side of Deep Creek and east of the existing highway would not be impacted at given its current location (i.e. 50 m from the highway) it is unlikely that the new carriageway to be constructed to the west of the existing road would significantly impact on the site.

The impacts on foraging habitat would be minimal based on the availability in the region and the mobility of the species.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

As stated, there would be no impact on nesting habitat. Ospreys prey on fish, predominantly saltwater species, and take their prey from beaches, estuaries and tidal stream areas. The Proposal would impact on this habitat through the construction of bridges over the Nambucca and Kalang River, as well as Deep Creek and Oyster Creek. The magnitude of this impact is considered relatively small in the scale of available habitat and unlikely to place significant pressure on the regional populations.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

Cosmopolitan species, the osprey occurs through coastal Australia and is not at the limit of its distribution in the study area.

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include

construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

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. These areas do not provide optimum habitat for the osprey which is typically associated with open agricultural landscapes and forest edges on floodplains along with riparian vegetation and tidal estuarine rivers and streams. The reduction in connectivity is not expected to impact significantly on this species.

A strategic approach to mitigating the effects of fragmentation from the Proposal should be developed by focusing on re-establishing links with historically isolated fragments of habitat in proximity to the new road. These opportunities should be investigated along with increasing the size of smaller remnant fragments adjoining the road. The greatest potential for this exists in low-lying agricultural areas adjoining the corridor.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.12 Square-tailed kite

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

The square-tailed kite prefers coastal and sub-coastal open forest and woodlands on fertile soils with abundant prey species being present (Debus *et al*. 1993; Marchant and Higgins 1993). A common feature of the kite's habitat is the presence of profuse eucalypt blossom and attendant nectivorous birds (Debus *et al*. 1993) on which the square-tailed kite preys. On the coast, the kite appears to prefer the drier forest types on the foothills and coastal plains, which is consistent with the observation and records occurring in the study area. Records of the species appear to be associated with the extensive dry sclerophyll forest habitats on low hills.

No nest sites were located along the proposed alignment during the surveys nor have been reported in the vicinity of the route in the local State Forests. Further surveys are recommended prior to construction. The Proposal would not impact on breeding activities of local populations of the square-tailed kite. Potential habitat for foraging and roosting is very common and widespread for this species in the region and the impacts on this life-cycle activity is expected to be minimal.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The square-tailed kite prefers coastal and sub-coastal open forest and woodlands on fertile soils with abundant prey species being present (Debus *et al*. 1993; Marchant and Higgins 1993). Dry sclerophyll forest habitats are very common and widespread throughout the region particularly further west of the study area. The Proposal would remove up to 144 ha of blackbutt open forest considered suitable for this species. This total is a small percentage of the habitat available in the region.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

This species occurs throughout eastern and northern Australia. The study area is not the limit of distribution for this species.

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared

agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

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. These areas provide potential habitat for the square-tailed kite largely because of their size and continuity with forests to the west. It is important to note however 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 habitat in the landscape.

The impacts of fragmentation may be most evident in Nambucca State Forest in section 2, where an area of up to 1000 ha of forested lands would be separated to the east of the road. The impact of reduced connectivity is not expected to significantly impact on this species which is wide-ranging and highly mobile, capable of moving across cleared and urbanised landscapes to access suitable habitats.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.13 Black Bittern

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

The black bittern occurs in thick vegetation at margins of watercourses, swamps, billabongs, mudflats and mangroves in tidal creeks and rivers, also streamside vegetation in shrubland or low forest (Marchant and Higgins 1990). The species feeds on small fish and invertebrates. Breeding occurs in densely vegetated wetlands between September and April (Pizzey and Knight 1997). Suitable habitat for this species in the study area is limited to one large wetland on the floodplain north of the Kalang River and eastern side of South Arm Road. This habitat would not be impacted directly by the proposed alignment and potential indirect impacts are to be monitored and controlled during construction and operation. Other smaller freshwater wetlands identified in the study area typically lack dense fringing vegetation and are considered sub-optimal. Life-cycle activities of any local population are unlikely to be impacted.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

The black bittern occurs in thick vegetation at margins of watercourses, swamps, billabongs, mudflats and mangroves in tidal creeks and rivers, also streamside vegetation in shrubland or low forest (Marchant and Higgins 1990). Suitable habitat for this species in the study area is limited to one large wetland on the floodplain north of the Kalang River and eastern side of South Arm Road. This habitat would not be impacted directly by the proposed alignment and potential indirect impacts are to be monitored and controlled during construction and operation.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

The species occurs throughout coastal and sub-coastal areas of south-western, northern and eastern Australia. In NSW it occurs in coastal valleys principally at low elevations. The species distribution is not restricted to the study area.

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

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. These areas are not suitable habitat for the species and the impact of fragmentation is not expected to significantly affect this species.

A strategic approach to mitigating the effects of fragmentation from the Proposal should be developed by focusing on re-establishing links with historically isolated fragments of habitat in proximity to the new road. These opportunities should be investigated along with increasing the size of smaller remnant fragments adjoining the road. The greatest potential for this exists in low-lying agricultural areas adjoining the corridor.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.14 Tree-roosting microchiropteran Bats

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Vegetation in the study area provides potential foraging and roosting habitat for the assessed species (Greater Broad-nosed Bat, Eastern False Pipistrelle and Eastern Freetail-bat and Eastern Long-eared Bat). These bat species frequent a variety of habitat types ranging from rainforest to wet and dry sclerophyll forest, woodland and open modified landscapes.

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. The Proposal would remove approximately 253 ha of forest habitat and which provides potential foraging habitat. Much of this habitat 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.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

These bat species frequent a variety of habitat types ranging from rainforest to wet and dry sclerophyll forest, woodland and open modified landscapes.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

None of these tree roosting threatened bat species are at the limit of their distribution in the study area. Dry and moist sclerophyll forest habitats are very common and widespread

throughout the region particularly further west of the study area. The Proposal would remove up to 253 ha of forest habitat considered suitable for these species. This total is a small percentage of the habitat available in the region.

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

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. These areas provide potential habitat for tree-roosting forest dwelling bats. It is important to note however 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 habitat in the landscape.

The impacts of fragmentation may be most evident in Nambucca State Forest in Section 2, where an area of up to 1000 ha of forested lands would be separated to the east of the road. The impact of 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. The effects of reduced habitat connectivity are expected to be lower for highly mobile species such as bats.

A strategic approach to mitigating the effects of fragmentation from the Proposal should be developed by focusing on re-establishing links with historically isolated fragments of habitat in proximity to the new road. These opportunities should be investigated along with increasing the size of smaller remnant fragments adjoining the road. The greatest potential for this exists in low-lying agricultural areas adjoining the corridor.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.15 Cave-roosting microchiropteran Bats

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

The site provides potential foraging habitat for the assessed species (Large Bentwing-bat, little bentwing-bat and large-footed myotis). The little bentwing-bat was recorded from at least two locations foraging in clearings near moist and open forest habitats. These species are predominantly cave-roosting bats, although a small colony of little bentwing-bats has been observed roosting in a hollowed tree trunk (Schulz 1997) and large-footed myotis have been recorded roosting under old timber bridges. No timber bridges would need to be removed to accommodate the Proposal. Similarly no caves or abandoned mine shafts have been recorded in the proposed route corridor and the Proposal is not expected to impact on the roosting life-cycle activities of these species.

The Proposal would remove approximately 253 ha of forest habitat and which provides potential foraging habitat for *Miniopterus* spp. 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 life-cycle events for a local population of these bat species and continued foraging over the site and adjacent lands could be expected. Large-footed myotis hunt over water bodies for small fish and invertebrates and may frequent freshwater wetlands and estuaries as well as creeks and farm dams. Impacts on foraging habitat would result from the Proposal however the overall magnitude of impact is small.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

Impacts on known or potential roosting habitat are not expected. The Proposal would remove approximately 253 ha of forest habitat and which provides potential foraging habitat for the Bentwing-bats. 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 life-cycle events for a local population of these bat species and continued foraging over the site

and adjacent lands could be expected. Large-footed myotis hunt over water bodies for small fish and invertebrates and may frequent freshwater wetlands and estuaries as well as creeks and farm dams. Impacts on foraging habitat would result from the Proposal however the overall magnitude of impact is small.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

None of these cave-roosting threatened bat species are at the limit of their distribution in the study area.

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

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. These areas provide potential habitat for forest dwelling bats. It is important to note however 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 habitat in the landscape.

The impacts of fragmentation may be most evident in Nambucca State Forest in section 2, where an area of up to 1000 ha of forested lands would be separated to the east of the road. The impact of 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. The effects of reduced habitat connectivity are expected to be lower for highly mobile species such as bats.

A strategic approach to mitigating the effects of fragmentation from the Proposal should be developed by focusing on re-establishing links with historically isolated fragments of habitat in proximity to the new road. These opportunities should be investigated along with increasing the size of smaller remnant fragments adjoining the road. The greatest potential for this exists in low-lying agricultural areas adjoining the corridor.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

B.4.16 Giant barred frog

How is the Proposal likely to affect the lifecycle of a threatened species and/or population?

Giant barred frogs forage in deep, damp leaf-litter in rainforests, moist eucalypt forest and adjacent dry eucalypt forest slopes (NPWS 2002). They breed around shallow, flowing rocky streams from late spring to summer. Several creeks and drainage lines in the northern half of the study area through Nambucca, Little Newry and Newry State forest were identified as potential habitat for this species. The Proposal would impact on potential habitat via direct traverse of several small streams and gullies. The impact would be linear and restricted to the construction footprint comprising the road design with a 10 m buffer. 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. Direct impacts on populations would not be widespread and indirect impacts can be managed appropriately.

How is the Proposal likely to affect the habitat of a threatened species, population or ecological community?

Several creeks and drainage lines in the northern half of the study area through Nambucca, Little Newry and Newry State forest were identified as potential habitat for this species. However no individuals were recorded despite an extensive survey effort and sampling during optimum high rainfall events in summer (i.e. >200 mm in a week).

It is possible that the species no longer occurs in the study area on the basis of it absence during surveys which may be a factor of the frequency and intensity of fires in the landscape and associated reduction in leaf litter. The stronghold for this species in NSW is the Dorrigo area as determined by the expansive areas of rainforest habitat present in the ranges to the west of the Nambucca valley. The closely related giant barred frog (*Mixophyes fasciolatus*) was commonly recorded during the detailed surveys in moist forest habitat however this species is probably more tolerant of disturbed habitats which dominate the study area. On the basis of suitable habitat it is assumed that the species is present.

This species is threatened by reduction in water quality from sedimentation or pollution, altered hydrological regimes, frequent fire and the reduction of leaf litter, vegetation clearing. The Proposal would impact on potential habitat via direct traverse of several small streams and gullies. The impact would be linear and restricted to the construction footprint. 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.

Does the Proposal affect any threatened species or populations that are at the limit of its known distribution?

Coast and ranges from south-east Queensland to the Hawkesbury River in NSW. North-east NSW, particularly the Coffs Harbour-Dorrigo area is a stronghold for the species. The species is not at the limit of its distribution in the study area (NPWS 2002b).

How is the Proposal likely to affect current disturbance regimes?

A range of disturbance regimes currently exist and reflect the historical and current land-uses of the study area, such as loss of mature forest and tree hollows, weed invasion, inappropriate fire regimes, draining of swamps, increased nutrient loads in aquatic habitats, and presence of introduced predators. The introduction of a new road has the potential to further affect some of these disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process was designed to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The inclusions of these measures suggest minimal additional affect of the disturbance regimes beyond the current situation.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small

vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

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. Several creeks and riparian habitat in the state forests provide potential habitat for this species and these would be traversed by the highway. All drainage areas would incorporate either bridge or culvert structures which theoretically provide a passage for fauna movements particularly suited to riparian dependent species such as the giant barred frog.

A strategic approach to mitigating the effects of fragmentation from the Proposal should be developed by focusing on re-establishing links with historically isolated fragments of habitat in proximity to the new road. These opportunities should be investigated along with increasing the size of smaller remnant fragments adjoining the road. The greatest potential for this exists in low-lying agricultural areas adjoining the corridor.

How is the Proposal likely to affect habitat connectivity?

The landscape surrounding the study area supports a mosaic of vegetation fragments which reflects the history of clearing for farming and development. There is an abundance of small vegetation patches in the 1-10 ha range followed by the 10-50 ha range occupying the cleared agricultural landscape on lower floodplain areas. Of these, the larger patches occur on more elevated lands.

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. It is important to note however that all areas of habitat affected by the Proposal have already been fragmented in the past by roads, clearing for agriculture and power easements. The Proposal would be contributing to this cumulative fragmentation of habitat in the landscape. The impacts of fragmentation may be most evident in Nambucca State Forest in section 2, where an area of up to 1000 ha of forested lands would be separated to the east of the road. Potential habitat for this species occurs in freshwater creeks in dense moist forested gullies. Measures have been planned to minimise the impacts of fragmentation on these habitats and 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.

The impact of 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 fauna underpass structures are also proposed through portions of Newry State Forest to maintain opportunities for fauna crossing.

A strategic approach to mitigating the effects of fragmentation from the Proposal should be developed by focusing on re-establishing links with historically isolated fragments of habitat in proximity to the new road. These opportunities should be investigated along with increasing the size of smaller remnant fragments adjoining the road. The greatest potential for this exists in low-lying agricultural areas adjoining the corridor.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

Appendix C Assessment of Significance (EPBC Act)

C.1 Endangered species

C.1.1 Swift parrot and Regent honeyeater

Lead to a long-term decrease in the size of a population

Both species are regarded as winter-visitors to this region, and their presence would depend predominantly on the flowering of swamp mahogany (*Eucalyptus robusta*) and forest red gum (*E.tereticornis*) to provide food resources. Both tree species are present in low abundance and the study area is considered only marginal for the swift parrot and regent honeyeater. The largest patches of potential foraging habitat are present as SEPP 14 wetland areas in Nambucca and Newry State Forests. These areas have been avoided as part of the route options study and would not be impacted by the Proposal. The study area would constitute non-breeding habitat for a proportion of the population of both species

Reduce the area of occupancy of the species

Both species are wide ranging and highly mobile, semi-nomadic species with patchy and sporadic distribution across coastal NSW. Their presence in the study area is seasonally dependent and influenced by drought and rain periods affecting the flowering of preferred tree species. Therefore there is no defined area of occupancy in the study area.

Evidence gathered on the movements of both species suggest that visits to the coastal swamp mahogany forests are not consistent every year and depend on flowering of the Box-Ironbark woodlands on the south western slopes of NSW and Victoria (Menkhorst et al 1999; swift parrot Recovery Team 2001; Geering 2004). The Proposal would have minor impacts on small areas of potential habitat for these species.

Fragment an existing population into two or more populations

Potential habitat for these species as identified in this report occurs in small and fragmented patches present throughout the study area and already fragmented by existing roads and cleared land. Furthermore, both species are highly mobile and semi-nomadic capable of accessing patchy food resources. There are no defined areas of habitat in the study area that are exclusively occupied by these species and the Proposal would not fragment a population of the swift parrot or regent honeyeater,

Adversely affect habitat critical to the survival of the species

The study area would constitute non-breeding habitat for a proportion of the population of both species. The Macksville to Urunga study area is not considered a critical area for the regent honeyeater (D.Geering, NPWS, *pers.comm*) or swift parrot (D.Saunders, *pers comm*).

Disrupt the breeding cycle of a population

The study area would constitute non-breeding habitat for a proportion of the population of both species

Modify, destroy, remove, isolate or decrease the availability or quality of the habitat to the extent that the species is likely to decline

The area of vegetation potentially removed as a result of the Proposal is not considered significantly large or of a high quality to lead to the decline of these species in NSW. The Proposal would impact on only 5.94 ha of high quality habitat and approximately 5.86 ha of medium quality and 0.66 ha of low quality habitat. This is minimal in relation to the extent of potential habitat in the North Coast Bioregion.

Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the critically endangered or endangered species habitat

Many of the bushland remnants which occur in the study area exhibit high levels of weed invasion and the Proposal avoids the largest patches of potential habitat identified in this study. Any Proposal to remove natural vegetation would be supported by the RTA's standard revegetation and landscaping work methods including follow up weed removal.

Introduce disease that may cause the species to decline

The types of activities involved in the planning and construction of the Proposal, or operation of the highway are not consistent with introducing bird diseases.

Interfere with the recovery of the species

The Proposal and proposed highway construction would not conflict with the recovery of these two species. The Proposal has been selected on the basis of avoiding high quality habitats for these species.

C.1.2 Giant barred frog

Lead to a long-term decrease in the size of a population

Evidence of a local population was not determined from the results of the surveys or background review. However several creeks and drainage lines in the northern half of the study area through Nambucca, Little Newry and Newry State forest were identified as potential habitat for this species. The Proposal would impact on this potential habitat via the direct traverse of several small streams and gullies. The impact would be linear and restricted to the construction footprint. Suitable design measures have been incorporated to provide fauna passage and protect the waterway during construction and operation to ensure such potential habitat is not significantly impacted. Therefore direct impacts on populations would not be widespread and key threats can be managed suggesting that a decrease in the size of population is unlikely.

Reduce the area of occupancy of the species

Due to the absence of records of this species in the study area it is not possible to identify the area of occupancy of a population. The extent of potential habitat and hence possible distribution of a population was determined through identification of suitable habitat. The Proposal would impact on potential habitat via direct traverse of several small streams and gullies. The impact would be linear and restricted to the construction footprint. Design measures have been incorporated to minimise the direct and indirect impact.

Fragment an existing population into two or more populations

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. Several creeks and riparian habitat in the state forests provide potential habitat for this species and these would be traversed by the highway. All drainage areas would incorporate either bridge or culvert structures which theoretically provide a passage for fauna movements particularly suited to riparian dependent species such as the giant barred frog.

Adversely affect habitat critical to the survival of the species

There is currently no evidence, based on extensive field survey and review of historical records, to suggest that a population occurs in the study area. Conversely there are numerous records to the west of the corridor, up to several kilometres away and extending to the Dorrigo plateau, that are associated with sub-tropical rainforest. This habitat type is not present in the study area.

While the presence of potential habitat for this species has been identified in the study area and would be impacted to a degree as discussed previously, this habitat is not considered critical to the survival of the species in Australia.

Disrupt the breeding cycle of a population

The species breeds around shallow, flowing rocky streams from late spring to summer. On the basis that the Proposal construction would extent over 2-3 years, there is the potential for the activity to disrupt the breeding cycle of a population. Measures to minimise impacts on waterways during construction are to be implemented as part of the CEMP.

Modify, destroy, remove, isolate or decrease the availability or quality of the habitat to the extent that the species is likely to decline

Giant barred frogs inhabit deep, damp leaf-litter in rainforests, moist eucalypt forest and adjacent dry eucalypt forest slopes (NPWS 2002). Several creeks and drainage lines in the northern half of the study area through Nambucca, Little Newry and Newry State forest were identified as potential habitat for this species. The stronghold for this species in NSW is the Dorrigo area as determined by the expansive areas of sub-tropical rainforest habitat present in the ranges to the west of the Nambucca Valley. Similar habitats are absent from the study area.

The Proposal would impact on potential habitat via direct traverse of several small streams and gullies. The impact would be linear and restricted to the construction. 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.

Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the critically endangered or endangered species habitat

The potential for weed invasion is considered possible with a Proposal of this nature and appropriate controls are required during the construction and operation of the road to reduce this threat as it may have long term implications for the habitat of threatened species. The management of invasive species would be managed under the guidance of the CEMP and OEMP.

Introduce disease that may cause the species to decline

This species is adversely impacted by chytrid fungus. The construction of the Proposal has potential to introduce chytrid fungus through the movements of heavy vehicles and earth moving equipment into the study area. The current status of chytrid fungus in the region is not

known and hygiene protocols should be introduced which as a minimum include washdown of vehicles brought in from other projects.

Interfere with the recovery of the species

The Proposal and proposed highway construction would not conflict with the recovery of this species. The route has been selected on the basis of avoiding high quality habitats for threatened fauna.

C.2 Potentially occurring endangered flora species

C.2.1 *Acronychia littoralis*

Lead to a long-term decrease in the size of a population

There is a low possibility this species is present in rainforest and wet sclerophyll forests of the study area however these habitats are marginal. The nearest record to the Proposal area is 4km east of Warrell Creek. Considering the relatively extensive targeted searches undertaken for this species in areas of suitable habitat, it is unlikely it is present in the study area. The Proposal would result in the removal of approximately 34.4 ha of marginal habitat for this species.

Reduce the area of occupancy of the species

The distribution of *Acronychia littoralis* is found between Fraser Island in Queensland and Port Macquarie on the north coast of NSW. The preferred habitat for this species is littoral rainforest on sand which does not occur in the study area. The Proposal is unlikely to impact the area of occupancy for this species considering the lack of suitable habitat.

Fragment an existing population into two or more populations

No known populations would be fragmented by the Proposal.

Adversely affect habitat critical to the survival of the species

The preferred habitat for this species is littoral rainforest on sand which does not occur in the study area. Therefore habitats in the study area are unlikely to be critical for the survival of this species.

Disrupt the breeding cycle of a population

Pollination and seed dispersal mechanisms for *Acronychia littoralis* are unlikely to be impacted by the Proposal.

Modify, destroy, remove, isolate or decrease the availability or quality of the habitat to the extent that the species is likely to decline

The preferred habitat for this species is littoral rainforest on sand which does not occur in the study area. Therefore habitats in the study area are unlikely to be critical for the survival of this species.

Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the critically endangered or endangered species habitat

The potential for weed invasion is considered possible with a Proposal of this nature and appropriate controls are required during the construction and operation of the road to reduce this threat as it may have long term implications for the habitat of threatened species. The management of invasive species would be managed under the guidance of the CEMP and OEMP.

Introduce disease that may cause the species to decline

This species is adversely impacted by *Phytophora* fungus. The construction of the Proposal has potential to introduce *Phytophora* fungus through the movements of heavy vehicles and earth moving equipment into the study area. The current status of *Phytophora* fungus in the region is not known and hygiene protocols should be introduced which as a minimum include washdown of vehicles brought in from other projects.

Interfere with the recovery of the species

The Proposal and proposed highway construction would not conflict with the recovery of this species. The route has been selected on the basis of avoiding high quality habitats for threatened species.

C.2.2 Parsonsia dorrigoensis

Lead to a long-term decrease in the size of a population

The Proposal would result in the removal of approximately 34.4 ha of suitable habitat for this species. Better qualities examples of habitat include rainforest areas of which only 0.58 ha would be removed.

Parsonsia dorrigoensis was not recorded in the study area despite targeted searches in areas of suitable habitat. There are records for this species in the locality. This species is not particularly difficult to identify in the field.

Reduce the area of occupancy of the species

Parsonsia dorrigoensis is found only in NSW, with scattered populations in the north coast region between Kendall and Woolgoolga. *Parsonsia dorrigoensis* is not at the limit of its distribution in the locality. The Proposal would result in the removal of approximately 34.4 ha of suitable habitat for this species. Better qualities examples of habitat include rainforest areas of which only 0.58 ha would be removed.

Fragment an existing population into two or more populations

Parsonsia dorrigoensis was not recorded in the study area despite targeted searches in areas of suitable habitat. Therefore the proposal would not result in the fragmentation of a known population.

Adversely affect habitat critical to the survival of the species

Parsonsia dorrigoensis was not recorded in the study area despite targeted searches in areas of suitable habitat. The Proposal would result in the removal of approximately 34.4 ha of suitable habitat for this species. Better qualities examples of habitat include rainforest areas of which only 0.58 ha would be removed. Considering the small area of optimal habitat being removed and this species was not located in the study area despite targeted searches, the proposal is unlikely to significantly impact this species.

Disrupt the breeding cycle of a population

Pollination and seed dispersal mechanisms for *Parsonsia dorrigoensis* are unlikely to be impacted by the Proposal.

Modify, destroy, remove, isolate or decrease the availability or quality of the habitat to the extent that the species is likely to decline

Parsonsia dorrigoensis was not recorded in the study area despite targeted searches in areas of suitable habitat. The Proposal would result in the removal of approximately 34.4 ha of suitable habitat for this species. Better qualities examples of habitat include rainforest areas of which only 0.58 ha would be removed. Considering the small area of optimal habitat being removed and this species was not located in the study area despite targeted searches, the proposal is unlikely to lead to declines in the species population.

Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the critically endangered or endangered species habitat

The potential for weed invasion is considered possible with a Proposal of this nature and appropriate controls are required during the construction and operation of the road to reduce this threat as it may have long term implications for the habitat of threatened species. The management of invasive species would be managed under the guidance of the CEMP and OEMP.

Introduce disease that may cause the species to decline

This species is adversely impacted by *Phytophora* fungus. The construction of the Proposal has potential to introduce *Phytophora* fungus through the movements of heavy vehicles and earth moving equipment into the study area. The current status of *Phytophora* fungus in the region is not known and hygiene protocols should be introduced which as a minimum include washdown of vehicles brought in from other projects.

Interfere with the recovery of the species

The Proposal and proposed highway construction would not conflict with the recovery of this species. The route has been selected on the basis of avoiding high quality habitats for threatened species habitat.

C.3 Vulnerable species

C.3.1 *Marsdenia longiloba*

Lead to a long-term decrease in the size of an important population

Marsdenia longiloba is a slender vine species found in various rainforest types and some moist sclerophyll forests, occurring at scattered locations from Barrington Tops north to southeast Queensland (NPWS 2002b). The ecology of this species has not been studied extensively and many of its life history attributes are largely unknown. *Marsdenia longiloba* occurs in numerous National Parks in northern NSW and southeast Queensland. This species has mostly been recorded as occurring in low abundance in small population clusters. The populations recorded in the study area are regarded as being “important populations” as described under the EPBC Act due to them being relatively large populations.

Marsdenia longiloba occurs in seven separate sub-populations along the study area in rainforest and wet sclerophyll forest habitats. Most locations are in Newry, Little Newry and Nambucca State Forests, and there is one occurrence in private property north of the Kalang River. It is estimated that these occurrences consist of approximately 156 individuals occurring in an area

up to 250 m either side of the Proposal centreline. The population in these areas is likely to extend further upstream and downstream of some of the surveyed areas, and therefore is likely to consist of a larger population than recorded for this Proposal.

Of the 156 individuals estimated to occur in the 500 metre corridor approximately 12 individuals (8 per cent of the population) would be directly impacted and an additional 32 individuals (20 per cent of the population) would remain in 30 m of the proposed development and would potentially be indirectly impacted. The remaining 112 individuals (72 per cent of the population) would remain at greater than 30 m from the Proposal and would be retained and protected from direct impacts. Mitigation measures employed for the Proposal would minimise any potential for indirect impacts, including edge effects and changes in biophysical conditions

There would potentially be indirect impacts to individuals downstream of the proposed development where runoff during the construction and operation of the proposed highway would enter the gully habitats where *Marsdenia longiloba* occurs. This would potentially alter the hydrology regime and nutrient loads increasing the potential for changes to habitat attributes which may impact individuals in these areas. Mitigation measures during construction and the implementation of specific design features into the proposed development would potentially minimise these indirect impacts.

Reduce the area of occupancy of an important population

Of the six recorded populations of *Marsdenia longiloba*, two occur on both sides of the proposed route alignment in a 500m corridor, and therefore would potentially be dissected by the proposed development. Individuals would be retained on either side of the proposed highway, with direct impacts limited to the proposed road corridor. Another two populations would be impacted on one edge of the population and the populations on private property have been avoided by the proposed development. The area of occupancy would be reduced in these four impacted populations, although the linear nature of the Proposal limits the direct impacts to these populations.

There is potential for the Proposal to contribute to indirect impacts through altering hydrological and nutrient regimes in habitats downstream of the proposed development which could potentially result in habitat changes, leading to the area of occupancy of the population to be significantly reduced. However mitigation measures during construction and the implementation of specific design features into the proposed development would potentially minimise these indirect impacts.

Fragment an existing important population into two or more populations

Marsdenia longiloba generally occurs in gully areas running perpendicular to the Proposal. Therefore suitable areas of habitat would be fragmented from the Proposal, with some sub-populations being dissected. Pollinator movements could potentially extend across the proposed highway allowing exchange of genetic material between fragmented areas of habitat, assuming flying insects are the main pollinators, however this is largely unknown.

Of the 6 recorded sub-populations of *Marsdenia longiloba*, two occur on both sides of the proposed route alignment in a 500m corridor, and therefore would potentially be dissected by the proposed development. Individuals would be retained on either side of the proposed highway, with direct impacts limited to the proposed road corridor. Another two populations would be impacted on one edge of the population and the two populations on private property have been avoided by the proposed development. Therefore of the six sub-populations, two would be fragmented into two sub-populations, two would be impacted on one side of the sub-population and two would not be directly impacted.

Adversely affect habitat critical to the survival of the species

Habitat critical to the survival of a species refers to areas that are necessary:

- For activities such as foraging, breeding, roosting, or dispersal.
- For the long-term maintenance of the species including the maintenance of other species essential to the survival of the species, such as pollinators.
- To maintain genetic diversity and long-term evolutionary development.
- For the reintroduction of populations or recovery of the species.

The habitats where *Marsdenia longiloba* was recorded included moderately degraded areas impacted by weed invasion, logging activities, fire and cattle grazing. Although these areas have been degraded, there were better quality pockets of native vegetation cover where the majority of *Marsdenia longiloba* individuals were recorded. Assuming that these habitats would be further impacted over time particularly from weed invasion unless long-term management actions are implemented; these areas are unlikely to be optimal for the long-term survival of the species.

Direct impacts would be limited to the proposed development area comprising a relatively small area of the available habitat for this species in the local area. There is potential for the Proposal to contribute to indirect impacts through altering hydrological and nutrient regimes in habitats downstream of the proposed development, which could potentially result in habitat changes, leading to further weed invasion in areas of habitat downstream. Although mitigation measures

would potentially limit the degree of indirect impacts to the surrounding areas of habitat for *Marsdenia longiloba*, the Proposal is likely to contribute to existing threatening processes which would affect these areas of habitat.

Marsdenia longiloba is reserved in numerous National Parks in northern NSW and southeast Queensland. Better quality examples of habitat are likely to be present within these conservation reserves where threatening processes are limited.

Disrupt the breeding cycle of an important population

The life cycle attributes for *Marsdenia longiloba* are largely unknown, however assumptions of life history attributes can be drawn from knowledge of other species in the same family (Apocynaceae: Asclepiadoideae). Pollinators are usually insect species including flies and/or beetles. Some species in this family have highly specialised pollination mechanisms which involves trapping insects' by their legs or proboscis between the osmotically elastic anther wings, and withdrawal entailing capture of the pollinia by means of ‘sutured corpuscular pollen carriers’ (Watson and Dallwitz 2008).

The breeding cycle may be disrupted from the Proposal impacting pollinator populations. Two of the sub-populations are being fragmented into two sub-populations by the Proposal and therefore pollination across the proposed highway may be impacted. This may potentially lead to inbreeding depression where there is not sufficient exchange of genetic material between fragmented sub-populations. Considering the breeding cycle of *Marsdenia longiloba* is largely unknown potential impacts to pollination, seed dispersal and germination from the Proposal are difficult to quantify. Monitoring and adaptive management of populations as part of the mitigation measures for the Proposal may provide valuable information to better manage populations of *Marsdenia longiloba*.

Modify, destroy, remove, or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The Proposal would decrease the area of habitat available for *Marsdenia longiloba*, however these areas of habitat include moderately degraded areas impacted by weed invasion, logging activities, fire and cattle grazing. Indirect impacts from the Proposal would potentially contribute to these existing threatening processes through altering hydrology and nutrient regimes; however these impacts can be limited through the implementation of suitable mitigation measures. Although *Marsdenia longiloba* seems to be resilient to some habitat disturbance, further disturbances may lead to declines in the population. Considering the linear nature of the proposed development which runs perpendicular to most of the gully habitats

where *Marsdenia longiloba* occurs, habitat removal would be limited to the direct impact area and relatively extensive areas of habitat would remain surrounding the Proposal.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species habitat

The Proposal could potentially result in the spread and aid the growth of invasive species currently present in the population of *Marsdenia longiloba* such as *Lantana camara*. Changes to hydrological and nutrient regimes in these areas as a result of the Proposal may further encourage weed growth. Although the Proposal is unlikely to result in the establishment of new invasive species in the habitat of *Marsdenia longiloba*, provided adequate mitigation measures are implemented, the Proposal may potentially contribute to aiding the growth of invasive species currently present in these areas of habitat.

Mitigation measures would be implemented to minimise impacts from nutrient loads, sedimentation and altered hydrology regimes. Weed management should be implemented during the construction phase of the Proposal to limit the spread of exotic weed species, including appropriate disposal of exotic vegetative material and propagules.

Introduce disease that may cause the species to decline

Diseases which may impact *Marsdenia longiloba* include the introduction of Root Rot Fungus (*Phytophora cinnamomi*) and other plant pathogens. Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the Proposal, impacts from plant pathogens would be minimised. Monitoring and management actions for the retained populations as part of the mitigation measures of the Proposal should be carried out in a way that minimises the risk of the spread of disease from plant pathogens.

Interferes substantially with the recovery of the species

The Proposal would not conflict with the recovery actions proposed for *Marsdenia longiloba*. Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protecting fencing, ongoing monitoring of populations and weed control within habitat areas.

C.3.2 Grey-headed flying-fox

Lead to a long-term decrease in the size of an important population

As stated, the clearing of approximately 253 ha of potential foraging habitat for this species represents a relatively minor impact for this species in the local area. In relation to the available habitat in adjacent land surrounding the highway, the Proposal is not considered likely to affect

this species at the local level. The proposed action would not result in the decrease in size of the population in the local area and would not impact on a known roost site.

Reduce the area of occupancy of an important population

The Proposal would remove approximately 253 ha of vegetation potentially used by this species for foraging. This is a small percentage of the foraging habitat available throughout the distributional range of the Grey-headed Flying fox in Australia. The Proposal is not expected to significantly impact on food resources available for local populations of the grey-headed flying-fox. This species is wide ranging a capable of exploiting seasonally available and wide spread food resources.

Fragment an existing important population into two or more populations

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. It is important to note however 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 habitat in the landscape.

Highly mobile species such as bats and birds are expected to be less impacted by fragmentation and the grey-headed flying-fox is particularly well adapted to accessing widely spaced habitat resources given its mobility and preference for seasonal fruits and blossom. The Proposal would not fragment an important population of the grey-headed flying-fox.

Adversely affect habitat critical to the survival of the species

Habitat critical to the survival of a species refers to areas that are necessary for activities such as:

- Foraging, breeding, roosting, or dispersal.
- For the long-term maintenance of the species including the maintenance of other species essential to the survival of the species, such as pollinators.
- To maintain genetic diversity and long-term evolutionary development.
- For the reintroduction of populations or recovery of the species.

The proposed area of disturbance represents a very small fraction of the potential foraging habitat for the grey-headed flying-fox in the mid north coast region. This species typically exhibits very large home ranges and grey-headed flying-fox are known to travel distances of at least 15km from roost sites to access seasonal foraging resources (Tidemann 1995). No

evidence of a roosting colony of the grey-headed flying-fox occurs in proximity to the study area. Habitat in the study area is not considered critical for this species.

Disrupt the breeding cycle of an important population

No evidence of a roosting colony of the grey-headed flying-fox occurs in proximity to the study area and the Proposal would not impact on breeding cycles.

Modify, destroy, remove, or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The Proposal would remove approximately 253 ha of vegetation potentially used by this species for foraging. There would be a decrease in the availability of habitat in the region however this decrease represents a very small fraction of the potential foraging habitat for the grey-headed flying-fox in the mid north coast region and is unlikely to lead to a decline in any local populations.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species habitat

The potential for weed invasion is considered possible with a project of this nature and appropriate controls are required during the construction and operation of the road to reduce this threat as it may have long term implication for the habitat of threatened species. Grey-headed flying-fox forage on a very wide diversity of flora and are unlikely to be dependent on roadside verges. The management of invasive species would be managed under the guidance of the CEMP and OEMP.

Introduce disease that may cause the species to decline

There are no known disease issues affecting this species. The Proposal is unlikely to increase feral animal abundance or the potential for significant disease vectors to affect local populations.

Interferes substantially with the recovery of the species

The Proposal and proposed highway construction would not conflict with the recovery of this species. The route has been selected on the basis of avoiding high quality habitats for threatened fauna.

C.3.3 Spotted-tailed quoll

Lead to a long-term decrease in the size of an important population

Suitable habitat is well represented in the larger fragments of forest in the study area, particularly the state forests and adjoining private properties including the edges of open farmland. The species was not recorded during this study however is expected to occur. The species is an opportunistic predator and would feed on a variety of prey including macropods, birds, reptiles, arboreal mammals and small terrestrial mammals (Mansergh 1983). The Proposal would remove potential habitat for the species and its prey, leading to further fragmentation of habitat, a known threat to the species. Measures to conserve fauna corridors and movement avenues for terrestrial fauna have been incorporated into the Proposal. The generally modified nature of the habitats in the study area suggests that further modification is unlikely to decrease the population. There is no evidence to indicate that there is an important population in the study area.

Reduce the area of occupancy of an important population

The species typically has a large home range and occupies a diversity of habitat types. It is therefore difficult to identify the area of occupancy. Theoretically, quolls could occur in any of the larger forest fragments of the study area. Preferred habitat includes dry and moist sclerophyll forests. Suitable habitat is well represented in the larger fragments of forest in the study area, particularly state forests and adjoining private properties. The Proposal would remove potential habitat for the species however the overall reduction of habitat is a small proportion of the available potential habitat.

Fragment an existing important population into two or more populations

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. These areas provide potential habitat for spotted-tailed quoll largely because of their size and continuity with forests to the west. It is important to note however 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 habitat in the landscape.

Measures have been planned to minimise the impacts of fragmentation and 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. Further

widening of the median and fauna underpass structures are also proposed through portions of Newry State Forest to maintain opportunities for fauna crossing.

Adversely affect habitat critical to the survival of the species

Habitat critical to the survival of a species refers to areas that are necessary for activities such as

- Foraging, breeding, roosting, or dispersal.
- For the long-term maintenance of the species including the maintenance of other species essential to the survival of the species, such as pollinators.
- To maintain genetic diversity and long-term evolutionary development.
- For the reintroduction of populations or recovery of the species.

Some of the larger habitats represented in the study area are suitable for populations of spotted-tailed quoll however, they do not constitute habitat that is critical for the long-term maintenance of the species.

Disrupt the breeding cycle of an important population

Given the large home ranges of this species, potentially only a small number of individuals may be present in the lands surrounding the study area. While there are no cave sites present there may be suitably large hollow logs providing potential den sites for breeding. There is potential therefore to impact on the breeding cycle of a small proportion of the population.

Modify, destroy, remove, or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

Suitable habitat is well represented in the larger fragments of forest in the study area, particularly the state forests and adjoining private properties including the edges of open farmland. Given the large home ranges of this species, potentially only a small number of individuals may be present in the lands surrounding the study area.

The Proposal would remove potential habitat for this small number of individuals, leading to further fragmentation of habitat. The impacts are not likely to cause the species to decline in the region. Measures to conserve fauna corridors and movement avenues for terrestrial fauna have been incorporated into the Proposal.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species habitat

The potential for weed invasion is considered possible with a project of this nature and appropriate controls are required during the construction and operation of the road to reduce this threat as it may have long term implication for the habitat of threatened species. The management of invasive species would be managed under the guidance of the CEMP and OEMP.

Introduce disease that may cause the species to decline

There are no known diseases issues affecting this species. The Proposal is unlikely to increase feral animal abundance or the potential for significant disease vectors to affect local populations.

Interferes substantially with the recovery of the species

The Proposal and proposed highway construction would not conflict with the recovery of this species. The route has been selected on the basis of avoiding high quality habitats for threatened fauna.

C.4 Migratory species

Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles or altering hydrological cycles), destroy or isolate an area of important habitat for a migratory species

Nine listed migratory bird species (EPBC Act) were identified from the field investigation, refer to **Table 4-6** in text which also includes potential species based on the presence of suitable habitat. The majority of species were considered uncommon and widespread vagrants with no specific populations represented. The most widespread and abundant species was cattle egret present throughout cleared farmland and rufous fantail and black-faced monarch in moist densely forested gullies. White-throated Needletail were observed in the air on several occasions flying over the study area and not specific to any habitat type.

There is no evidence to suggest that an area of important habitat exists in the study area for any of the identified migratory species.

Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species

There is no evidence to suggest that an area of important habitat exists in the study area for any of the identified migratory species. Suitable measures would be incorporated into the Proposal to control the spread of weeds during the construction and operation of the road.

Seriously disrupt the lifecycle (breeding, feeding, migration or resting behaviour) of an ecologically significant proportion of the population of a migratory species

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 population of a migratory species.

Appendix D Flora list

KEY TO SYMBOLS USED IN APPENDIX D

ABBREVIATIONS:

i = introduced (i.e. not indigenous to Australia)

t = listed as a threatened species under State and/or Commonwealth legislation

r = RoTAP species

spp. = several species of the one genus (sometimes occurring as a hybrid swarm)

sp. = unidentified species[4]

sp. aff. = unidentified species with characteristics similar to the indicated species or genus[3]

? = unconfirmed species[4]

var. = variety

subsp. = subspecies

cv. = cultivar (i.e. a anthropogenic form of the species)

agg. = an aggregate of several yet to be defined species

NOTES:

1. Recent 'synonyms' include misapplied names.

2. The inclusion of Boraginaceae in Lamiales is tentative.

3. A sample flora assemblage obtained from a short term survey, such as the present one, cannot be considered to be comprehensive, but rather indicative of the actual flora assemblage. It can take many years of flora surveys to record all of the plant species occurring in any area, especially species that are only apparent in some seasons.

4. Not all species can be accurately identified in a 'snapshot' survey due to absence of flowering or fruiting material, etc.

SCIENTIFIC NAMES & AUTHORITIES:

Scientific names & families are those used in the *Flora of NSW* as maintained by the Royal Botanic Gardens (http://.plantnet.rbgsyd.gov.au).

Orders and higher taxa are based on Angiosperm Phylogeny Group (2003).

For sake of simplicity, scientific names in this list do not include authorities. These can be found in the *Flora of NSW.*

Classification/ Scientific name	Common Name	
Ferns		
ADIANTACEAE		
Adiantum hispidulum	Rough Maidenhair	
Cheilanthes sieberi subsp. *sieberi*	Slender Cloak-fern	
ASPLENIACEAE		
Asplenium australasicum	Birds-nest Fern	
AZOLLACEAE		
Azolla pinnata	Rufous Azolla	
BLECHNACEAE		
Blechnum cartilagineum	Gristle Fern	
Blechnum indicum	Swamp Water-fern	
Blechnum wattsii	Hard Water-fern	
Doodia aspera	Prickly Rasp-fern	
Doodia caudata	Small Rasp-fern	
CYATHEACEAE		
Cyathea australis	Rough Tree-fern	
Cyathea cooperi	Scaly Tree-fern	
Cyathea leichhardtiana	Prickly Tree-fern	
DAVALLIACEAE		
Nephrolepis cordifolia	Fishbone Fern	i
DENNSTAEDTIACEAE		
Calochlaena dubia	False Bracken	
Histiopteris incisa	Bats-wing Fern	
Hypolepis muelleri	Harsh Ground-fern	
Pteridium esculentum	Bracken	
DRYOPTERIDACEAE		

Classification/ Scientific name	Common Name	
Lastreopsis spp.	Shield-fern	
GLEICHENIACEAE		
Gleichenia dicarpa	Pouched Coral-fern	
LINDSAEACEAE		
Lindsaea linearis	Screw Fern	
Lindsaea microphylla	Lacy Wedge-fern	
OSMUNDACEAE		
Todea barbara	King Fern	
POLYPODIACEAE		
Platycerium bifurcatum	Elk-horn Fern	
Platycerium superbum	Stag-horn Fern	
SALVINIACEAE		
Salvinia molesta	Salvinia	i
THELYPTERIDACEAE		
Christella dentata	Christella	
Cyclosorus interruptus	Cyclosorus	
Cycads		
ZAMIACEAE		
Lepidozamia peroffskyana	Burrawang	
Macrozamia spp.	Burrawang	
Conifers		
ARAUCARIACEAE		
Araucaria cunninghamii	Hoop Pine	
PINACEAE		

Classification/ Scientific name	Common Name	
Pinus elliotti	Slash Pine	i
PODOCARPACEAE		
Podocarpus elatus	Brown Plum-pine	
Flowering Plants - Dicotyledons		
ACANTHACEAE		
Avicennia marina	Grey Mangrove	
Brunoniella australis	Blue Trumpet	
Pseuderanthemum variable	Pseuderanthemum	
AMARANTHACEAE		
Alternanthera denticulata	Lesser Joyweed	
AMYGDALACEAE		
Prunus spp.		
ANACARDIACEAE		
Euroschinus falcata	Ribbonwood	
APIACEAE		
Centella asiatica	Swamp Pennywort	
Cyclospermum leptophyllum	Slender Celery	i
Hydrocotyle peduncularis	Hairy Pennywort	
Hydrocotyle tripartita	Tre-foil Pennywort	
Trachymene incisa subsp. *incisa*	Native Carrot	
APOCYNACEAE		
Araujia hortorum	Moth Vine	i
Gomphocarpus fruticosus	Narrow-leaved Cotton Bush	i
Marsdenia longiloba	Slender Milk Vine	t
Marsdenia loydii		

Classification/ Scientific name	Common Name	
Marsdenia rostrata	Common Milk Vine	
Marsdenia suaveolens	Scented Marsdenia	
Melodinus australis	Southern Melodinus	
Nerium oleander	Oleander	i
Parsonsia straminea	Common Silkpod	
Tabernaemontana pandacaqui	Banana Bush	
ARALIACEAE		
Astrotricha latifolia	Broad-leaf Star-hair	
Cephalaralia cephalobotrys	Climbing Panax	
Polyscias murrayi	Pencil Cedar	
Polyscias sambucifolia	Elderberry Panax	
Schefflera actinophylla	Umbrella Tree	
ASTERACEAE		
Ageratina adenophora	Crofton Weed	i
Ageratina houstonianum	Blue Bilygoat Weed	i
Ambrosia spp.	Ragweed	i
Aster subulatus	Wild Aster	i
Baccharis halimifolia	Groundsel Bush	i
Bidens pilosa	Cobblers Peg	i
Centipida minima subsp. *minima*	Spreading Sneeze Weed	
Centratherum punctatum subsp. australianum		i
Chrysocephalum apiculatum	Yellow Buttons	
Cirsium vulgare	Spear Thistle	i
Conyza spp.	Fleabane	i
Cotula australis	Lawn Cotula	
Cotula coronopifolia	Water Buttons	

Classification/ Scientific name	Common Name	
Crassocephalum crepidoides	Thickhead	i
Enydra fluctuans	Enydra	
Epaltes australis	Spreading Nut-heads	
Erechtites valerianifolia	Brazilian Fireweed	i
Euchiton sphaericus		
Gamochaeta spicata	Cudweed	i
Hypochoeris radicata	Flatweed	i
Lagenophora stipitata	Bottle-daisy	
Leptinella longipes	Leptinella	
Olearia nernstii	Daisy-bush	
Ozothamnus diosmifolius	Tall Paperdaisy	
Senecio linearifolius	Fireweed Grounsel	
Senecio madagascariensis	Fireweed	i
Sigesbeckia orientalis	Indian Weed	
Sonchus oleraceus	Common Sow-thistle	i
Tagetes minuta	Stinking Roger	i
Vernonia cinerea var. *cinerea*	Vernonia	
BIGNONIACEAE		
Jacaranda mimosifolia	Jacaranda	i
Pandorea jasminoides	Bower Vine	
Pandorea pandorana	Wonga Vine	
BORAGINACEAE		
Ehretia acuminata var. *acuminata*	Koda	
BRASSICACEAE		
Lepidium africanus	Peppercress	i
CAMPANULACEAE		

Classification/ Scientific name	Common Name	
Wahlenbergia spp.	Bluebell	
CAPPARACEAE		
Capparis arborea	Coastal Native Orange	
CAPRIFOLIACEAE		
Lonicera japonica	Honeysuckle	i
CARYOPHYLLACEAE		
Stellaria media	Common Chickweed	i
CASUARINACEAE		
Allocasuarina littoralis	Black She-oak	
Allocasuarina torulosa	Forest Oak	
Casuarina glauca	Swamp Oak	
CELASTRACEAE		
Celastrus subspicata	Large-leaf Staff Vine	
Denhamia pittosporoides subsp. pittosporoides	Veiny Denhamia	
Maytenus silvestris	Forest Maytenus	
CHENOPODIACEAE		
Einadia hastata	Shrubby Berry-saltbush	
Sarcocornia quinqueflora	Samphire	
Suaeda australis	Seablite	
CLUSIACEAE		
Hypericum gramineum	Narrow-leaf St. Johns Wort	
Hypericum japonicum	Matted St. Johns Wort	
CONVOLVULACEAE		
Dichondra repens	Kidney Weed	
Ipomoea cairica	Coastal Morning Glory	i
Ipomoea indica	Blue Morning Glory	i

Classification/ Scientific name	Common Name
Ipomoea purpurea	Purple Morning Glory
Polymeria calycina	Woodland Bindweed
CUNONIACEAE	
Callicoma serratifolia	Black Wattle
Schizomeria ovata	Crab-apple
DILLENIACEAE	
Hibbertia aspera	Rough Guinea-flower
Hibbertia dentata	Twining Guinea-flower
Hibbertia linearis	Narrow-leaf Guinea-flower
Hibbertia scandens	Climbing Guinea-flower
Hibbertia vestita	Hairy Guinea-flower
DROSERACEAE	
Drosera sphathulata	Common Sundew
EBENACEAE	
Diospyros australis	Black Plum
Diospyros pentamera	Myrtle Ebony
ERICACEAE	
Leucopogon juniperinus	Juniper Beard-heath
Leucopogon lanceolatus var. gracilis	
Monotoca scoparia	Prickly Broom-heath
Trochocarpa elliptica	Tree Heath
ELAEOCARPACEAE	
Elaeocarpus obovatus	Hard Quandong
Elaeocarpus reticulatus	Blueberry Ash
Sloanea australis	Maidens Blush
Sloanea woollsii	Yellow Carabeen

i

Classification/ Scientific name	Common Name	
Tetratheca thymifolia	Thyme-leaf Black-eyed Susan	
EUPHORBIACEAE		
Acalypha nemorum		
Alchornea ilicifolia	Native Holly	
Baloghia inophylla	Brush Bloodwood	
Breynia oblongifolia	Breynia	
Claoxylon australe	Brittlewood	
Croton verreauxii	Green Native Cascarilla	
Glochidion ferdinandi var. ferdinandi	Cheese Tree	
Glochidion ferdinandi var. pubens	Cheese Tree	
Omalanthus populifolius	Bleeding Heart	
Phyllanthus gunnii	Blunt Spurge	
Poranthera microphylla	Small Poranthera	
Ricinus communis	Castor Oil Plant	i
EUPOMATIACEAE		
Eupomatia laurina	Bolwarra	
FABACEAE		
CAESALPINIOIDEAE		
Senna pendula var. *glabrata*	Cassia	i
Senna septemtrionalis	Cassia	i
FABOIDEAE		
Austrosteenisia blackii	Blood Vine	
Crotalaria lanceolata subsp. lanceolata		
Daviesia ulicifolia	Gorse Bitter-pea	
Derris involuta	Derris	
Desmodium nemorosum		

Classification/ Scientific name	Common Name	
Desmodium rhytidophyllum	Rusty Tick-trefoil	
Desmodium varians	Slender Tick-trefoil	
Erythrina x *sykesii*	Coral Tree	i
Glycine clandestina agg.	Twining Glycine	
Glycine tabacina agg.		
Gompholobium pinnatum	Pinnate Wedge-pea	
Hardenbergia violacea	Purple Twining-pea	
Hovea acutifolia		
Indigofera australis	Native Indigo	
Jacksonia scoparia	Dogwood	
Lespedeza striata	Japanese Clover	i
Kennedia rubicunda	Dusky Coral Pea	
Macroptilium atropurpureum	Siratro	i
Pultanaea retusa	Blunt-leaf Bush-pea	
Pultanaea villosa	Wallaby Tails	
Trifolium repens	White Clover	i
Vigna luteola	Dalrymple Vigna	
Zornia dyctiocarpa var. dyctiocarpa	Zornia	
MIMOSOIDEAE		
Acacia baileyana	Cootamundra Wattle	
Acacia binervata	Two-veined Hickory	
Acacia concurrens	Curracabah	
Acacia falcata	Sickle Wattle	
Acacia fimbriata	Fringed Wattle	
Acacia floribunda	Sally Wattle	
Acacia implexa	Hickory	

Classification/ Scientific name	Common Name
Acacia irrorata subsp. *irrorata*	Rough Green Wattle
Acacia irrorata subsp. *velutinella*	
Acacia linifolia	Flax-leaf Wattle
Acacia longifolia	Sydney Golden Wattle
Acacia longissima	Thin-leaf Wattle
Acacia maidenii	
Acacia melanoxylon	Blackwood
Acacia myrtifolia	Myrtle Wattle
Acacia podalyriifolia	Queensland Silver Wattle i
Acacia ulicifolia	Prickly Moses
Archidendron grandiflorum	Pink Lace Flower
Parachidendron pruinosum	Snow-wood
FLACOURTIACEAE	
Scolopia braunii	Flintwood
GENTIANACEAE	
Centaurium spicatum	Spiked Centaury
GERANIACEAE	
Geranium solanderi var. *solanderi*	Native Cranesbill
GOODENIACEAE	
Dampiera sylvestris	
Dampieria stricta	Blue Dampieria
Goodenia hederacea subsp. *hederacea*	Ivy-leaf Goodenia
Goodenia heterophylla	Variable-leaf Goodenia
Goodenia ovata	Ovate Goodenia
Goodenia paniculata	Panicled Goodenia
Goodenia rotundifolia	

Classification/ Scientific name	Common Name	
HALORAGACEAE		
Gonocarpus humilis		
Gonocarpus chinensis		
Gonocarpus micranthus subsp. *micranthus*	Creeping Raspwort	
Gonocarpus teucroides	Raspwort	
Myriophyllum spp.	Water-milfoil	
LAMIACEAE		
Lycopus australis	Australian Gipsywort	
Mentha satureioides	Creeping Mint	
LAURACEAE		
Beilschmiedia elliptica	Grey Walnut	
Cassytha glabella	Devils Twine	
Cassytha pubescens	Devils Twine	
Cinnamomum camphora	Camphor Laurel	i
Cinnamomum oliveri	Oliver's Sassafras	
Cinnamomum virens	Red-barked Sassafras	
Cryptocarya glaucescens	Native Laurel	
Cryptocarya microneura	Murrogun	
Cryptocarya obovata	Pepperberry	
Cryptocarya rigida	Forest Maple	
Endiandra discolor	Rose Walnut	
Endiandra sieberi	Cork Wood	
Litsea australis	Brown Bolly Gum	
Litsea reticulata	Bolly Gum	
Neolitsea dealbata	White Bolly Gum	
LOBELIACEAE		

Classification/ Scientific name	Common Name	
Isotoma fluviatilis subsp. Borealis	Swamp Isotoma	
Lobelia alata	Angled Lobelia	
Lobelia gibbosa	Lobelia	
Lobelia gracilis	Trailing Lobelia	
Lobelia trigonocaulis	Forest Lobelia	
Pratia concolor	Poison Pratia	
Pratia purpurescens	White Root	
LOGANIACEAE		
Mitrasacme alsinoides		
LORANTHACEAE		
Amyema miquelii	Drooping Mistletoe	
Amylotheca dictyophleba	Rainforest Mistletoe	
LYTHRACEAE		
Lythrum hyssopifolia	Hyssop Loosestrife	
MALACEAE		
Cotoneaster glaucophyllus	Cotoneaster	i
MALVACEAE		
Abutilon oxycarpum	Straggly Lantern-bush	
Hibiscus heterophyllus	Native Rosella	
Hibiscus splendens	Pink Cottonwood	
Modiola caroliniana	Red-flowered Mallow	i
Sida rhombifolia	Paddys Lucerene	i
MENISPERMACEAE		
Sarcopetalum harveyanum	Pearl Vine	
Stephania japonica	Snake Vine	
MONIMIACEAE		

Classification/ Scientific name	Common Name	
Daphnandra micrantha	Socket Wood	
Doryphora sassafras	Sassafras	
Palmeria scandens	Anchor Vine	
Wilkiea huegeliana	Wilkiea	
MELASTOMATACEAE		
Melastoma affine	Native Lassiandra	
MELIACEAE		
Dysoxylum fraserianum	Rosewood	
Dysoxylum rufum	Hairy Rosewood	
Melia azedarach	White Cedar	
Synoum glandulosum	Scentless Rosewood	
Toona ciliata	Red Cedar	
MENYANTHACEAE		
Nymphoides geminata	Marshwort	
Villarsia exaltata	Villarsia	
Villarsia reniformis		
MORACEAE		
Ficus benjamina	Weeping Fig	i
Ficus coronata	Creek Sandpaper Fig	
Ficus frasei	Frasers Sandpaper Fig	
Ficus rubiginosa	Port Jackson Fig	
Ficus watkinsiana	Strangling Fig	
Maclura cochinchinensis	Cockspur Thorn	
Trophis scandens subsp. scandens	Burny Vine	
MYRSINACEAE		
Anagallis arvensis	Pimpernell	i

Classification/ Scientific name	Common Name
Ardisia crenata	Coral Berry
Embelia australiana	Embelia
Myrsine howittiana	Brush Muttonwood
Myrsine variabilis	Variable Muttonwood
MYRTACEAE	
EUCALYPTS	
Angophora costata	Smooth-barked Apple
Corymbia gummifera	Red Bloodwood
Corymbia intermedia	Pink Bloodwood
Corymbia maculata	Spotted Gum
Eucalyptus acmenoides	White Mahogany
Eucalyptus ancophila	
Eucalyptus grandis	Flooded Gum
Eucalyptus microcorys	Tallowwood r
Eucalyptus paniculata subsp. *paniculata*	Grey Ironbark
Eucalyptus pilularis	Blackbutt
Eucalyptus propinqua	Small-fruited Grey Gum
Eucalyptus resinifera subsp. *hemilampra*	Red Mahogany
Eucalyptus robusta	Swamp Mahogany
Eucalyptus saligna	Sydney Blue Gum
Eucalyptus siderophloia	Northern Grey Ironbark
Eucalyptus signata	Northern Scribbly Gum
Eucalyptus tereticornis	Forest Red Gum
OTHER MYRTACEAE	
Acmena smithii	Lilly Pilly
Archirhodomyrtus beckleri	Rose Myrtle

Classification/ Scientific name	Common Name
Sannantha similis	
Backhousia myrtifolia	Grey Myrtle
Baeckea linifolia	Weeping Baeckea
Callistemon salignus	Willow Bottlebrush
Callistemon viminalis	Weeping Bottlebrush n
Gossia acmenoides	Scrub Ironwood
Leptospermum juniperinum	Prickly Teatree
Leptospermum polygalifolium	Yellow Tea-tree
Lophostemon confertus	Brush Box
Lophostemon sauveolens	Swamp Turpentine
Melaleuca linariifolia	Snow-in-Summer
Melaleuca quinquenervia	Broad-leaved Paperbark
Melaleuca styphelioides	Prickly Paperbark
Pilidiostigma glabrum	
Rhodamnia rubescens	Brush Turpentine
Rhodomyrtus psidioides	Native Guava
Sannantha similis	
Syncarpia glomulifera	Turpentine
Syzygium australe	Brush Cherry
Syzygium luehmannii	Small-leaved Lilly Pilly
Syzygium oleosum	Blue Lilly Pilly
Tristaniopsis laurina	Water Gum
Waterhousea floribunda	Weeping Lilly Pilly
NYCTAGINACEAE	
Pisonia umbellifera	
NYMPAEACEAE	

Classification/ Scientific name	Common Name	
Nymphaea spp.	Waterlily	
OLEACEAE		
Jasminum suavissimum		
Ligustrum lucidum	Large-leaf Privet	i
Ligustrum sinense	Small-leaf Privet	i
Notelaea longifolia	Large Mock Olive	
Notelaea venosa	Smooth Mock Olive	
Olea paniculata	Native Olive	
ONAGRACEAE		
Ludwigia peploides subsp. *montevidensis*	Water Primrose	
OXALIDACEAE		
Oxalis chnoodes		
Oxalis exilis	Yellow Oxalis	
Oxalis perennans		
PASSIFLORACEAE		
Passiflora edulis	Passion-fruit	i
Passiflora herbertiana	Yellow Passion-flower	
Passiflora subpeltata	White Passion-flower	i
PHYTOLACCACEAE		
Phytolacca octandra	Inkweed	i
PITTOSPORACEAE		
Billardiera scandens	Apple-berry	
Pittosporum multiflorum	Orange Thorn	
Pittosporum revolutum	Yellow Pittosporum	
Pittosporum undulatum	Native Daphne	
PLANTAGINACEAE		

Classification/ Scientific name	Common Name	
Plantago lanceolata	Plantain	i
Plantago major	Large Plantain	i
POLYGONACEAE		
Acetosa sagittata	Rambling Dock	i
Persicaria decipiens	Slender Knotweed	
Persicaria dichotoma		
Persicaria hydropiper	Water Pepper	
Persicaria lapathifolia	Pale Knotweed	
Persicaria strigosa	Spotted Knotweed	
Rumex crispus	Curled Dock	i
PROTEACEAE		
Banksia ericifolia	Heath-leaved Banksia	n
Banksia integrifolia	Coastal Banksia	
Banksia serrata	Saw Banksia	
Banksia spinulosa var. *collina*	Hill Banksia	
Grevillea spp. (hybrid)		
Grevillea robusta	Silky Oak	n
Hakea salicifolia	Willow Hakea	
Helicia glabriflora	Smooth Helicia	
Lomatia silaifolia	Crinkle Bush	
Persoonia stradbronensis		
Stenocarpus sinuatus	Firewheel Tree	
RANUNCULACEAE		
Clematis aristata	Toothed Clematis	
Ranunculus inundatus	River Buttercup	
RHAMNACEAE		

Classification/ Scientific name	Common Name	
Alphitonia excelsa	Red Ash	
Pomaderris ferruginea		
ROSACEAE		
Rubus ellipticus	Yellow Raspberry	i
Rubus fruticosus agg.	Blackberry	i
Rubus hillii	Braod-leaf Bramble	
Rubus nebulosus	Green-leaved Bramble	
Rubus parviflorus	Small-leaf Bramble	
Rubus rosifolius	Rose-leaf Bramble	
ROUSSEACEAE		
Abrophyllum ornans	Native Hydrangea	
RUBIACEAE		
Atractocarpus benthamianus		
Cyclophyllum longipetalum	Coast Canthium	
Hodgkinsonia ovatiflora		
Morinda jasminoides	Morinda	
Opercularia aspera	Common Stinkweed	
Pomax umbellata	Pomax	
Psychotria loniceroides	Hairy Psychotria	
Psydrax lamprophylla	Large-leaved Canthium	
Richardia brasiliensis	Mexican Clover	i
Richardia stellaris		i
RUTACEAE		
Acronychia oblongifolia	Common Acronychia	
Asterolasia correifolia		
Citrus limonia	Lemon	i

Classification/ Scientific name	Common Name	
Melicope hayesii	Small-leaved Doughwood	
Melicope micrococca	White Euodia	
Zieria smithii	Sandfly Zieria	
SALICACEAE		
Salix babylonica	Weeping Willow	i
SANTALACEAE		
Exocarpos cupressiformis	Cherry Ballart	
SAPINDACEAE		
Alectryon subcinereus	Native Quince	
Arytera divaricata	Coogera	
Cupaniopsis anacardioides	Tuckeroo	
Cupaniopsis parviflora	Small-leaved Tuckeroo	
Diploglottis cunninghamii	Native Tamarind	
Dodonaea triquetra	Hop Bush	
Elattostachys nervosa	Green Tamarind	
Guioa semiglauca	Guioa	
Jagera pseudorhus	Foambark Tree	
Mischocarpus australis		
Mischocarpus pyriformis subsp. *pyriformis*	Pear-fruited Tamarind	
SAPOTACEAE		
Niemeyera whitei	Rusty Plum	t
Planchonella australis	Black Apple	
SCROPHULARIACEAE		
Artanema fimbriatum		
Veronica calycina	Common Speedwell	
SOLANACEAE		

Classification/ Scientific name	Common Name	
Duboisia myoporoides	Poison Corkwood	
Solanum aviculare	Kangaroo Apple	
Solanum erianthum	Potato Tree	
Solanum mauritianum	Wild Tobacco	i
Solanum nigrum	Black Nightshade	i
Solanum prinophyllum	Forest Nightshade	
Solanum stelligerum	Star Nightshade	
STACKHOUSIACEAE		
Stackhousia muricata		
STERCULIACEAE		
Commersonia fraseri	Brush Kurrajong	
Heritiera actinophylla	Black Booyong	
Heritiera trifoliolata	White Booyong	
Rulingia dasyphylla	Kerrawang	
Seringea arborescens	Seringia	
STYLIDIACEAE		
Stylidium debile	Frail Trigger Plant	
SYMPLOCACEAE		
Symplocos stawellii	White Hazelwood	
Symplocos thwaitesii	Buff Hazelwood	
THYMELEACEAE		
Pimelea linifolia subsp. *linifolia*	Slender Rice Flower	
Wikstroemia indica	Wikstroemia	
ULMACEAE		
Trema tomentosa	Native Peach	
VERBENACEAE		

Classification/ Scientific name	Common Name	
Clerodendrum tomentosum	Hairy Clerodendrum	
Duranta repens	Pigeonberry	i
Gmelina leichardtii	White Beech	
Lantana camara	Lantana	i
Verbena bonariensis	Purple Top	i
Verbena rigidus	Creeping Verbena	i
VIOLACEAE		
Hybanthus monopetalus	Slender Violet-bush	
Hybanthus stellarioides		
Viola betonicifolia	Showy Violet	
Viola hederacea	Ivy-leaf Violet	
VISCACEAE		
Notothixos incanus		
VITACEAE		
Cayratia clematidea	Slender Grape	
Cissus antarctica	Water Vine	
Cissus hypoglauca	Five-leaf Water Vine	
Cissus opaca	Pepper Vine	
Cissus sterulliifolia		
Tetrastigma nitens	Three-leaf Water Vine	
WINTERACEAE		
Tasmannia insipida	Brush Pepperbush	
AGAVACEAE		
Agave spp.	Century Plant	

Classification/ Scientific name	Common Name	
ALLIACEAE		
Agapanthus spp.	Agapanthus	i
ALSTROEMERIACEAE		
AMARYLLIDACEAE		
Crinum pedunculatum	Stream Lily	
ANTHERICACEAE		
Caesia parviflora var. parviflora	Pale Grass-lily	
Thysanotus tuberosus subsp. *tuberosus*	Common Fringe-lily	
Tricoryne elatior	Yellow Rush-lily	
ARACEAE		
Alocasia brisbaniensis	Cunjevoi	
Arum italicum	Italian Arum Lily	i
Gymnostachys anceps	Caterpiller Flower	
ARECACEAE		
Archontophoenix cunninghamiana	Bangalow Palm	
Calamus muelleri	Southern Lawyer Cane	
Linospadix monostachya	Walking Stick Palm	
Livistona australis	Cabbage Tree Palm	
ASPARAGACEAE		
Protasparagus aethiopicus	Asparagus Fern	i
Protasparagus plumosus	Climbing Asparagus Fern	i
ASTELIACEAE		
Cordyline stricta	Narrow-leaf Palm-lily	
CANNACEAE		
Canna indica	Canna lily	i
COMMELINACEAE		

Classification/ Scientific name	Common Name	
Commelina cyanea	Scurvy Weed	
Tradescantia albiflora	Wandering Jew	i
CYPERACEAE		
Baumea articulata	Jointed Twig-rush	
Baumea juncea	Slender Twig-rush	
Baumea rubiginosa	Soft Twig-rush	
Baumea teretifolia	Wrinkle-nut Twig-rush	
Carex appressa	Tussock Tassel-sedge	
Carex fascicularis	Drooping Tassel-sedge	
Cyperus brevifolius	Mullumbimby Couch	
Cyperus eragrostis	Umbrella Sedge	i
Cyperus exaltatus	a tall leafy-bract sedge	
Cyperus filipes		
Cyperus imbecillis		
Cyperus polystachyos	Bunchy Flat-sedge	
Cyperus sesquiflorus	Mullumbimy Couch	
Cyperus unioloides		
Eleocharis dietrichiana	Spike-rush	
Eleocharis gracilis	Slender Spike-rush	
Eleocharis sphacelata	Tall Spike-rush	
Fimbristylis dichotoma	Common Fringe-rush	
Gahnia aspera	Rough Saw-sedge	
Gahnia clarkei	Tall Saw-sedge	
Gahnia sieberiana	Red-fruited Saw-sedge	
Isolepis cernua	Nodding Club-rush	
Isolepis inundata	Club-rush	

Classification/ Scientific name	Common Name	
Lepidosperma concavum		
Lepidosperma laterale	Variable Sword-sedge	
Lepidosperma viscidum		
Ptilothrix deusta	Ptilanthelium	
Schoenoplectus litoralis	Coast Club-rush	
Schoenoplectus mucronatus	Angled Club-rush	
Schoenoplectus validus	River Club-rush	
Schoenus apogon	Common Bog-rush	
Schoenus melanostachys	Black Bog-rush	
DIOSCOREACEAE		
Dioscorea transversa	Native Yam	
FLAGELLARIACEAE		
Flagellaria indica	Whip Vine	
HYDROCHARITACEAE		
Valisneria gigantea	Eel-weed	
HYPOXIDACEAE		
Curculigo ensifolia		
Hypoxis hygrometrica var. *villosisepela*	Yellow Weather-grass	
IRIDACEAE		
Aristea ecklonii		
Patersonia sericea var. *sericea*	Basal-leaf Purple-flag	
Sisyrinchium sp. A	Scourweed	i
Watsonia meriana cv. 'Bulbillifera'	Wild Watsonia	i
JUNCACEAE		
Juncus continuus	Sand Rush	
Juncus cognatus	Rush	i

Classification/ Scientific name	Common Name	
Juncus kraussii subsp. *australiensis*	Saltmarsh Rush	
Juncus mollis		
Juncus planifolius	Broadleaf Rush	
Juncus polyanthemus	Many-flowered Rush	
Juncus usitatus	Common Rush	
JUNCAGINACEAE		
Triglochin microtuberosum	Small-tubered Water Ribbons	
Triglochin procerum sens. st.	Twisted Water Ribbons	
Triglochin striatum	Streaked Arrowgrass	
LILIACEAE		
Lilium formosum	Formosa Lily	i
LOMANDRACEAE		
Lomandra confertifolia subsp. *rubiginosa*	Slender Mat-rush	
Lomandra filiformis subsp. *coriacea*	Wattle Mat-rush	
Lomandra longifolia subsp. *longifolia*	Spiny Mat-rush	
Lomandra multiflora subsp. *multiflora*	Many-flowered Mat-rush	
LUZURIAGACEAE		
Eustrephus latifolius	Wombat Berry	
Geitonoplesium cymosum	Scrambling Lily	
ORCHIDACEAE		
Calanthe triplicata	Christmas Orchid	
Chiloglottis spp. ?	Ant Orchid	
Chiloglottis trilabra		
Corybas barbarae	Helmet-orchid	
Cryptostylis erecta	Stried Hood	
Cymbidium madidum		

Classification/ Scientific name	Common Name	
Cymbidium suave	Snake Flower	
Dendrobium kingianum	Pink Rock Orchid	
Dipodium variegatum	Hyacinth Orchid	
Microtis unifolia	Onion-orchid	
Plectorrhiza tridentata	Tangle Orchid	
Pterostylis spp.	Greenhood	
Sarcochilus spp.		
Siranthes sinensis var. *australis*	Austral Ladies Tresses	
Thelymitra spp.	Sun-orchid	
PHILYDRACEAE		
Philydrum lanuginosum	Frogsmouth	
PHORMIACEAE		
Dianella caerulea var. *caerulea*	Leafy Blue Flax Lily	
Dianella caerulea var. *producta*	Stemmed Blue Flax Lily	
Dianella tasmanica		
POACEAE		
Andropogon virginicus	Whisky Grass	i
Aristida ramosa	Three-awned Spear Grass	
Aristida vagans	Three-awned Spear Grass	
Arundo donax	Giant Reed	i
Axonopus fissifolius	Carpet Grass	i
Bothriochloa macra	Red-leg Grass	
Briza maxima	Quaking Grass	i
Briza minor	Shivery Grass	i
Bromus catharticus	Prarie Grass	i
Capillipedium spicigerum	Scented-top Grass	

Classification/ Scientific name	Common Name	
Chloris gayana	Rhodes Grass	i
Cymbopogon refractus	Barbed Wire Grass	
Cynodon dactylon	Common Couch	n
Deyeuxia quadriseta	Reed Bent-grass	
Dichelachne micrantha	Short-hair Plume Grass	
Digitaria parviflora	Small-flower Finger Grass	
Echinochloa crus-galli	Barnyard Grass	i
Echinopogon caespitosus	Hedgehog Grass	
Echinopogon ovatus	Hedgehog Grass	
Ehrharta erecta	Panic Veldtgrass	i
Entolasia marginata	Margined Panic	
Entolasia stricta	Wiry Panic	
Eragrostis spp.	Lovegrass	
Eragrostis brownii	Brown's Lovegrass	
Eragrostis curvula	African Lovegrass	i
Eragrostis tenuifolia	Elastic Grass	i
Eriochlora crebra	Cup Grass	
Hemarthria uncinata var. uncinata	Matgrass	
Hyparrhenia hirta	Coolatai Grass	i
Imperata cylindrica	Blady Grass	
Isachne globosa	Swamp Millet	
Ischaemum australe var. australe	Ischaemum	
Joycea pallida	Red-anthered Wallaby Grass	
Lachnagrostis filiformis	Blown Grass	
Lolium spp. (hybrid swarm)	Rye Grass	i
Melinis repens	Red Natal Grass	i

Classification/ Scientific name	Common Name	
Microlaena stipoides var. *stipoides*	Weeping Grass	
Oplismenus aemulus	Broad-leaf Beard-grass	
Oplismenus imbecillis	Narrow-leaf Beard-grass	
Oplismenus undulatifolius var. *mollis*	Basket Grass	
Ottochloa gracillima		
Panicum maximum var. *maximum*	Guinea Grass	i
Paspalidium aversum		
Paspalum dilatatum	Paspalum	i
Paspalum distichum	Water Couch	
Paspalum orbiculare	Ditch Millet	
Paspalum urvillei	Vasey Grass	i
Paspalum vaginatum	Salt-water Couch	
Paspalum wettsteinii	Broad-leaf Paspalum	i
Pennisetum clandestinum	Kikuyu	i
Phragmites australis	Common Reed	
Poa labillardieri	Tussock Grass	
Poa siebriana	Snowgrass	
Setaria gracilis	Slender Pigeon Grass	i
Setaria sphaceulata	South African Pigeon Grass	i
Sporobolus africanus	Parramatta Grass	i
Sporobolus creber	Slender Rats Tail Grass	
Sporobolus virginicus var. *minor*	Saltmarsh Couch	
Stenotaphrum secundatum	Buffalo Grass	i
Themeda australis	Kangaroo Grass	
Zoysia macrantha	Prickly Couch	
RIPOGONACEAE		

Classification/ Scientific name	Common Name
Ripogonum album	White Supplejack
Ripogonum fawcettianum	Small Supplejack
SMILACACEAE	
Smilax australis	Lawyer Vine
Smilax glyciphylla	Sweet Sarsparilla
TYPHACEAE	
Typha orientalis	Broad-leaf Cumbungi
UVULARIACEAE	
Schelhammera undulata	Lilac Lily
Tripladenia cunninghamii	Kresigia
XANTHORRHOEACEAE	
Xanthorrhoea macronema	Narrow-scape Grass-tree
ZINGIBERACEAE	
Alpinia caerulea var. *caerulea*	Native Ginger

Appendix E Vegetation community descriptions

Map Unit 1: Open Forest - Blackbutt
Canopy: *Eucalyptus pilularis, Eucalyptus microcorys, Corymbia intermedia, Eucalyptus propinqua, Syncarpia glomulifera, Angophora costata, Eucalyptus acmenoides, Corymbia gummifera* Subcanopy: *Allocasuarina torulosa, Glochidion ferdinandi, Synoum glandulosum, Alphitonia excelsa, Allocasuarina littoralis*
Structure: Canopy 15-25m; 30-50% foliage cover Subcanopy 8-15m; 10-40% foliage cover
Shrubs: *Dodonaea triquetra, Polyscias sambucifolia, Indigofera australis, Acacia falcata, Daviesia ulicifolia, Leptospermum polygalifolium, Acacia longifolia, Hibbertia vestia, Pultenaea rutusa, Persoonia stradbrokensis, Acacia myrtifolia, Acacia ulicifolia, Monotoca scoparia, Jacksonia scoparia, Pimelea linifolia, Lomatia silaifolia, Lantana camara* Grasses: *Entolasia stricta, Imperata cylindrica, Themeda australis* Herbs: *Pteridium esculentum, Pratia purpurascens, Dampiera stricta, Viola hederacea, Patersonia sericea, Goodenia heterophylla, Thysanotus tuberosus, Pseuderanthemum variable, Dianella caerulea, Tricoryne elatior* Sedges/Rushes: *Lepidosperma laterale, Lomandra filiformis, Gahnia clarkei, Lomandra longifolia* Vines/Twiners: *Hardenbergia violacea, Glycine clandestina, Hibbertia scandens, Billardiera scandens, Cassytha glabella, Desmodium rhytophyllum, Rubus hillii, Eustrephus latifolius, Geitonoplesium cymosum*
Weed Abundance: Weed species are generally restricted to disturbed/regenerating areas of this community such as the edges of the existing highway. Some trails in the State Forest areas are dominated by *Paspalum wettsteinii* and *Lantana camara* is abundant in some sheltered areas with higher soil moisture content.
Equivalent Communities: Ecosystem 34: Dry Grassy Blackbutt-Tallowwood (Kendall & Kendall 2003); Ecosystem 72: Low Relief Coastal Blackbutt (Kendall & Kendall 2003); North Coast dry sclerophyll Forests (Keith 2006).
Rare and Threatened Species: *Marsdenia longiloba* (Endangered, *TSC Act*; Vulnerable EPBC Act) occurs in sheltered locations of this community in ecotonal areas between this community and moist forest communities in gully areas.
Status: Very Common

Map Unit 2: Mixed Floodplain Forest
Canopy: *Eucalyptus grandis, Eucalyptus tereticornis, Melaleuca quinquenervia, Casuarina glauca, Eucalyptus siderophloia, Eucalyptus resinifera, Corymbia intermedia* Subcanopy: *Glochidion ferdinandi, Alphitonia excelsa, Schizomeria ovata, Melaleuca styphelioides, Guioa semiglauca, Ficus coronata, Acmena smithii, Archontophoenix cunninghamiana, Livistonia australis, Endiandra discolor, Sloanea woollsii, Acronychia oblongifolia, Synoum glandulosum, Cryptocarya rigida, Backhousia myrtifolia, Allocasuarina torulosa*
Structure: Canopy 20-30m; 40-60% foliage cover Subcanopy 8-15m; 30-90% foliage cover
Shrubs: *Tabernaemontana pandacaqui, Lantana camara, Breynia oblongifolia, Notelaea venosa, Diospyros australis, Wilkiea huegeliana, Litsea reticulata, Croton verreauxii, Cordyline stricta, Clerodendrum tomentosum, Myrsine variabilis, Pittosporum multiflorum, Polyscias sambucifolia, Psychotria loniceroides, Tasmannia insipida, Archirhodomyrtus beckleri* Grasses: *Entolasia marginata, Oplismenus imbecillis, Oplismenus aemulus, Paspalum wettsteinii* Herbs: *Pseuderanthemum variable, Calanthe triplicata, Dianella caerulea, Blechnum cartilagineum, Doodia aspera, Lobelia gracilis, Viola hederacea, Tripladenia cunninghamii, Hydrocotyle peduncularis, Hypolepis muellerii, Alpinia caerulea* Sedges/Rushes: *Gahnia clarkei, Lomandra longifolia* Vines/Twiners: *Cissus hypoglauca, Pandorea pandorana, Parsonsia straminea, Dioscorea transversa, Cissus steruliifolia, Smilax australis, Ripogonum fawcettianum, Morinda jasminoides, Rubus nebulosus, Stephania japonica, Rubus parviflora, Rubus hillii, Cissus antarctica, Geitonoplesium cymosum*
Weed Abundance: *Lantana camara* is abundant in some areas of this community, and is particularly dense in the ecotonal areas where the subcanopy is not as thick and there is more sunlight reaching the shrub layer. Lantana camara is generally absent or occurs in low abundance where there is a thick subcanopy of rainforest species. Some trails in the State Forest areas which traverse through this community are dominated by *Paspalum wettsteinii*, and this species has spread into this community in some areas.

Map Unit 2: Mixed Floodplain Forest
Equivalent Communities: Ecosystem 154: Wet Flooded Gum-Tallowwood (Kendall & Kendall 2003); Ecosystem 168; Rainforest (Kendall & Kendall 2003); Ecosystem 73: Lowland Red Gum; North Coast Wet Sclerophyll Forests (Keith 2006).
Rare and Threatened Species: *Marsdenia longiloba* (Endangered, *TSC Act*; Vulnerable EPBC Act) occurs in this community where the soil drainage is better, generally comprising slightly elevated areas adjacent to drainage lines and ecotonal areas between this community and Blackbutt Open Forest. *Amorphospermum whitei* was recorded in one location adjacent to Boggy Creek on private property. One RoTAP species *Eucalyptus ancophila* is present in this community in Nambucca and Newry State Forests.
Status: EEC. Subtropical Coastal Floodplain Forest

Map Unit 3: Moist Forest – White Mahogany / Grey Gum / Ironbark
Canopy: *Eucalyptus acmenoides, Eucalyptus propinqua, Eucalyptus siderophloia, Syncarpia glomulifera, Corymbia intermedia, Eucalyptus resinifera, Eucalyptus microcorys, Eucalyptus grandis, Eucalyptus paniculata* Subcanopy: *Allocasuarina torulosa, Allocasuarina littoralis, Synoum glandulosum, Myrsine howittiana, Acacia melanoxylon*
Structure: Canopy 18-25m; 30-60% foliage cover Subcanopy 8-12m; 30-50% foliage cover
Shrubs: *Tabernaemontana pandacaqui, Lantana camara, Cordyline stricta, Notelaea venosa, Wilkiea huegeliana* Grasses: *Entolasia marginata, Entolasia stricta, Oplismenus imbecillis, Imperata cylindrica, Oplismenus aemulus, Poa siebriana* Herbs: *Calochlaena dubia, Pseuderanthemum variable, Dianella caerulea, Blechnum cartilagineum, Lagenophora stipitata, Goodenia heterophylla, Gymnostachys anceps, Schelhammera undulata* Sedges/Rushes: *Lomandra longifolia, Gahnia clarkei* Vines/Twiners: *Morinda jasminoides, Hibbertia dentata, Pandorea pandorana, Parsonsia straminea, Smilax australis, Ripogonum fawcettianum, Smilax glyciphylla, Cissus hypoglauca*
Weed Abundance: Apart from a moderate abundance of Lantana camara, this community is relatively free of invasive weed species. *Lantana camara* has a higher abundance on the edges of this community due to additional light aiding its growth in these areas.
Equivalent Communities: Ecosystem 85: Mixed Moist Hardwood (Kendall & Kendall 2003); North Coast Wet Sclerophyll Forests (Keith 2006).
Rare and Threatened Species: *Marsdenia longiloba* (Endangered, *TSC Act*; Vulnerable EPBC Act) occurs in this community on private property on the northern side of the Kalang River where infestations of *Lantana camara* are low-moderate. It generally occurs in more sheltered locations of this community on lower slopes.
Status: Moderately Common

Map Unit 4: Moist Forest – Flooded Gum
Canopy: *Eucalyptus grandis, Lophostemon confertus, Syncarpia glomulifera, Eucalyptus microcorys, Eucalyptus acmenoides, Eucalyptus resinifera, Eucalyptus pilularis* Subcanopy: *Allocasuarina torulosa, Synoum glandulosum, Callicoma serratifolia, Glochidion ferdinandi, Alphitonia excelsa, Schizomeria ovata, Melaleuca styphelioides, Guioa semiglauca, Ficus coronata, Acmena smithii, Endiandra discolor*
Structure: Canopy 18-35m; 30-50% foliage cover Subcanopy 5-10m; 20-50% foliage cover

Shrubs: *Dodonaea triquetra, Breynia oblongifolia, Lantana camara, Cordyline stricta, Ozothamnus diosmifolius, Acacia floribunda, Wilkiea huegeliana*

Grasses: *Entolasia marginata, Entolasia stricta, Oplismenus imbecillis, Oplismenus aemulus, Paspalum wettsteinii*

Herbs: *Calochlaena dubia, Pseuderanthemum variable, Dianella caerulea, Blechnum cartilagineum, Alpinia caerulea*

Sedges/Rushes: *Lomandra longifolia, Gahnia aspera, Gahnia clarkei*

Vines/Twiners: *Stephania japonica, Geitonoplesium cymosum, Marsdenia lloydii, Morinda jasminoides, Hibbertia dentata, Pandorea pandorana, Cissus hypoglauca*

Weed Abundance: Supports a moderate to high abundance of *Lantana camara*, with higher abundances on the edges of this community due to additional light aiding growth in these areas. Some trails in the State Forest areas which traverse through this community are dominated by *Paspalum wettsteinii*, and this species has spread into the understorey of this community in some areas.

Equivalent Communities: Ecosystem 154: Wet Flooded Gum-Tallowwood (Kendall & Kendall 2003); Ecosystem 85: Mixed Moist Hardwood (Kendall & Kendall 2003)

Rare and Threatened Species: *Marsdenia longiloba* (Endangered, *TSC Act*; Vulnerable EPBC Act) occurs in this community on private property on the northern side of the Kalang River where infestations of *Lantana camara* are low-moderate. It generally occurs in more sheltered locations of this community on lower slopes. One RoTAP species *Eucalyptus ancophila* is present in this community in Nambucca and Newry State Forests.

Status: Moderately Common

Map Unit 5: Lowland Rainforest

Emergents: *Eucalyptus grandis, Lophostemon confertus*

Canopy: *Glochidion ferdinandi, Alphitonia excelsa, Schizomeria ovata, Guioa semiglauca, Ficus coronata, Acmena smithii, Archontophoenix cunninghamiana, Livistonia australis, Endiandra discolor, Sloanea woollsii, Acronychia oblongifolia, Backhousia myrtifolia, Syzygium australe, Litsea australis, Syzygium luehmannii, Tristaniopsis laurina, Jagera pseudorhus, Rhodomyrtus psidioides, Sloanea australis, Acacia melanoxylon, Waterhousea floribunda, Callicoma serratifolia, Syzygium oleosum, Rhodamnia rubescens, Backhousia myrtifolia, Diospyros pentamera, Cryptocarya obovata, Neolitsea dealbata, Cupaniopsis anacardioides, Ficus rubignosa, Cryptocarya glaucescens, Symplocos thwaitesii, Archidendron grandiflorum, Myrsine howittiana, Cryptocarya microneura, Scolopia braunii, Melaleuca styphelioides, Cinnamonum camphora*

Structure:

Canopy 20-30m; 40-60% foliage cover

Subcanopy 8-15m; 30-90% foliage cover

Shrubs: *Linospadix monostachya, Litsea reticulata, Croton verreauxii, Cordyline stricta, Clerodendrum tomentosum, Myrsine variabilis, Pittosporum multiflorum, Polyscias sambucifolia, Psychotria loniceroides, Tasmannia insipida, Archirhodomyrtus beckleri, Synoum glandulosum, Cryptocarya rigida, Tabernaemontana pandacaqui, Lantana camara, Eupomatia laurina, Breynia oblongifolia, Notelaea venosa, Diospyros australis, Wilkiea huegeliana, Cyathea australis*

Grasses: *Entolasia marginata, Oplismenus imbecillis, Oplismenus aemulus*

Herbs: *Pseuderanthemum variable, Blechnum cartilagineum, Doodia aspera, Hypolepis muellerii, Alpinia caerulea, Calochlaena dubia*

Epiphytes: *Cymbidium madidum, Asplenium australasicum, Platycerium bifurcatum, Plectorrhiza tridentata*

Vines/Twiners: *Cissus hypoglauca, Pandorea pandorana, Parsonsia straminea, Dioscorea transversa, Cissus steruliifolia, Calamus muellerii, Smilax australis, Ripogonum fawcettianum, Morinda jasminoides, Rubus nebulosus, Stephania japonica, Rubus parviflora, Rubus hillii, Cissus antarctica, Geitonoplesium cymosum, Celastrus subspicatus*

Weed Abundance: *Lantana camara* is present mainly on the edges of this community, and is particularly dense in the ecotonal areas where the subcanopy is not as thick and there is more sunlight reaching the shrub layer. *Lantana camara* is generally absent or occurs in low abundance where there is a thick subcanopy of rainforest species. Some trails in the State Forest areas which traverse through this community are dominated by *Paspalum wettsteinii*, and this species has spread into this community in some areas.

Equivalent Communities: Ecosystem 154: Wet Flooded Gum-Tallowwood (Kendall & Kendall 2003); Ecosystem 168; Rainforest (Kendall & Kendall 2003); Ecosystem 73: Lowland Red Gum; North Coast Wet Sclerophyll Forests (Keith 2006).

Rare and Threatened Species: *Marsdenia longiloba* (Endangered, *TSC Act*; Vulnerable EPBC Act) occurs in this community where the soil drainage is better, generally comprising slightly elevated areas adjacent to drainage lines and ecotonal areas between this community and Blackbutt Open Forest. *Amorphospermum whitei* was recorded in one location adjacent to Boggy Creek on private property. One RoTAP species *Eucalyptus ancophila* is present in this community in Nambucca and Newry State Forests.

Map Unit 5: Lowland Rainforest
Status: EEC. Subtropical Coastal Floodplain Forest

Map Unit 6: Swamp Forest – Swamp Mahogany / Paperbark
Canopy: *Eucalyptus robusta, Melaleuca quinquenervia, Eucalyptus resinifera* Subcanopy: *Lophostemon sauveolens, Callistemon salignus, Melaleuca linariifolia, Glochidion ferdinandi, Elaeocarpus reticulatus, Melaleuca styphelioides*
Structure: Canopy 15-18m; 30-60% foliage cover Subcanopy 8-10m; 20-40% foliage cover
Shrubs: *Melastoma affine, Lantana camara, Omalanthus populifolius, Acacia irrorata, Cordyline stricta* Grasses: *Phragmites australis, Entolasia marginata, Oplismenus aemulus, Entolasia stricta, Hemarthria uncinata* Herbs: *Hypolepis muellerii, Lycopus australis, Christella dentata, Blechnum indicum, Triglochin procerum, Lobelia alata, Goodenia paniculata, Persicaria dichotoma* Sedges/Rushes: *Carex appressa, Gahnia clarkei, Schoenus apogon, Juncus usitatus, Baumea rubignosa* Vines/Twiners: *Parsonsia straminea, Stephania japonica*
Weed Abundance: Apart from a moderate abundance of *Lantana camara* in areas, this community is relatively free of invasive weed species. No weed species are present in very wet areas where standing water is present.
Equivalent Communities: Ecosystem 142: Swamp Mahogany (Kendall & Kendall 2003).
Rare and Threatened Species: None recorded
Status: EEC. Swamp Sclerophyll Forest

Map Unit 7: Swamp Forest – Swamp Oak
Canopy: *Casuarina glauca, Melaleuca quinquenervia* Subcanopy: *Melaleuca styphelioides, Callistemon salignus, Glochidion ferdinandi, Lophostemon sauveolens*
Structure: Canopy 10-18m; 40-70% foliage cover Subcanopy 8-10m; 20-60% foliage cover
Shrubs: *Lantana camara, Baccharis halimifolia* Grasses: *Phragmites australis, Entolasia marginata, Oplismenus imbecillis, Paspalum wettsteinii, Imperata cylindrica* Herbs: *Hypolepis muellerii, Viola hederacea, Blechnum indicum, Crinum pedunculatum* Sedges/Rushes: *Baumea juncea, Juncus usitatus, Gahnia clarkei* Vines/Twiners: *Parsonsia straminea*
Weed Abundance: Some areas of this community adjacent to the existing highway have thick growth of *Lantana camara* and other weed species including *Baccharis halimifolia* on the edges and in disturbed areas of the community. Some areas of this community in agricultural areas have thick growth of pasture grasses and weeds such as *Setaria sphacelata* and *Axonopus affinis*. Generally no weed species are present in very wet areas where standing water is present.
Equivalent Communities: Ecosystem 143: Swamp Oak (Kendall & Kendall 2003).
Rare and Threatened Species: None recorded
Status: EEC. Swamp Oak Floodplain Forest

Map Unit 8: Freshwater Wetlands
Dominant/Common Species: *Phragmites australis, Juncus usitatus, Typha orientalis, Villarsia exaltata, Myriophyllum spp., Villarsia reniformis, Ludwigia peploides subsp. montevidensis, Nymphaea spp., Nymphoides geminate, Philydrum lanuginosum, Baumea rubignosa, Carex appressa, Baumea articulata, Ranunculus inundatus, Cyperus polystachyos, Eleocharis sphacelata, Baumea juncea, Isolepis inundata, Fimbristylis dichotoma, Schoenoplectus mucronatus, Eleocharis gracilis, Juncus planifolius, Hemarthria uncinata*
Weed Abundance: Areas of this community occurring in paddock areas often have several pasture species present such as *Setaria sphacelata* and *Axonopus affinis*.
Equivalent Communities: Ecosystem 141: Swamp (Kendall & Kendall 2003).
Rare and Threatened Species: None recorded
Status: EEC. Freshwater Wetlands

Map Unit 9: Mangrove Forest

Canopy: *Avicennia marina* Subcanopy: *Aegiceras corniculatum*
Structure: Canopy 5-8m; 20-70% foliage cover Subcanopy 1-4m; 20-60% foliage cover
Weed Abundance: No exotic species were recorded in these communities
Equivalent Communities: Ecosystem 77: Mangrove (Kendall & Kendall 2003).
Rare and Threatened Species: None recorded
Status: Protected as important fish habitat under the Fisheries Management Act 1991.

Appendix F Fauna list

KEY TO SYMBOLS USED IN APPENDIX F

ABBREVIATIONS

Nomenclature follows Stanger *et al* (1997)

Habitat

DSF - Dry Sclerophyll Forest

MSF - Moist Sclerophyll Forest / Riparian Forest

SSF - Swamp Sclerophyll Forest

FW - Freshwater Wetland

EST - Estuarine / River

RC - Rural and Cleared Agricultural Lands

Previous records: includes species recorded during previous fauna surveys in the general locality (refer to references)

a. Smith *et al* (1995) ; b. Gunninah (1998) ; c. Kendall & Kendall (1991), d. Atlas of NSW Wildlife (DECCW); e. State Forests records (DII)

Status

E1 - Schedule 1 endangered species (TSC Act)

V - Schedule 2 vulnerable species (TSC Act)

M - migratory species (EPBC Act)

BIRDS

Family/Scientific Name	Common Name	Status	Habitats						Previous Records
			DSF	MSF	SSF	FW	EST	RC	
Megapodiidae									
Alectura lathami	Australian Brush-turkey								a
Phasianidae									
Coturnix ypsilophora	Brown Quail		•						
Anatidae									

Family/Scientific Name	Common Name	Status	Habitats						Previous Records
			DSF	MSF	SSF	FW	EST	RC	
Chenonetta jubata	Australian Wood Duck					•		•	c
Cygnus atratus	Black Swan					•		•	
Anas superciliosa	Pacific Black Duck					•		•	c
Anas castanea	Chestnut Teal					•			
Oxyura australis	Blue-billed Duck	V							d
Anhingidae									
Anhinga melanogaster	Darter					•			
Phalacrocoracidae									
Phalacrocorax sulcirostris	Little Black Cormorant					•			
Phalacrocorax varius	Pied Cormorant					•			
Pelecanidae									
Pelecanus conspicillatus	Australian Pelican					•			
Ardeidae									
Bubulcus ibis	Cattle Egret	M						•	c
Egretta garzetta	Little Egret								
Ardea intermedia	Intermediate Egret						•		
Ardea alba	Great Egret	M			•	•		•	c
Egretta novaehollandiae	White-faced Heron					•		•	c
Ixobrychus flavicollis	Black Bittern	V							d
Botaurus poiciloptilus	Australasian Bittern	V							d
Threskiornithidae									
Threskiornis molucca	Australian White Ibis					•		•	c
Threskiornis spinicollis	Straw-necked Ibis								c
Platalea regia	Royal Spoonbill					•			
Ciconiidae									

Family/Scientific Name	Common Name	Status	Habitats						Previous Records
			DSF	MSF	SSF	FW	EST	RC	
Ephippiorhynchus asiaticus	Black-necked Stork	E1				•			d
Accipitridae									
Accipiter novaehollandiae	Grey Goshawk				•				
Accipiter fasciatus	Brown Goshawk			•					
Aquila audax	Wedge-tailed Eagle		•						
Haliaeetus leucogaster	White-bellied Sea-Eagle	M						•	c
Haliastur indus	Brahminy Kite						•		c
Haliastur sphenurus	Whistling Kite		•						
Lophoictinia isura	Square-tailed Kite	V	•						d
Elanus axillaris	Black-shouldered Kite			•					c
Pandion haliaetus	Osprey	V, M			•		•	•	c
Falconidae									
Falco longipennis	Australian Hobby		•						
Falco cenchroides	Nankeen Kestrel							•	
Gruidae									
Grus rubicunda	Brolga	V							d
Rallidae									
Gallirallus philippensis	Buff-banded Rail							•	
Porphyrio porphyrio	Purple Swamphen					•		•	c
Fulica atra	Eurasian Coot							•	
Scolopacidae									
Gallinago hardwickii	Latham's Snipe	M						•	
Rostratulidae									
Rostratula benghalensis australis	Painted Snipe (Aust subsp)	E1							d
Jacanidae									

Family/Scientific Name	Common Name	Status	Habitats						Previous Records
			DSF	MSF	SSF	FW	EST	RC	
Irediparra gallinacea	Comb-crested Jacana	V							d
Charadriidae									
Vanellus miles	Masked Lapwing							•	c
Columbidae									
Ptilinopus regina	Rose-crowned Fruit-Dove	V							d
Ptilinopus superbus	Superb Fruit-Dove	V							d
Ptilinopus magnificus	Wompoo Fruit-Dove	V		•					a,d
Columba leucomela	White-headed Pigeon			•					c
Macropygia amboinensis	Brown Cuckoo-Dove		•	•					a, b
Geopelia placida	Peaceful Dove								a
Geopelia humeralis	Bar-shouldered Dove			•					
Chalcophaps indica	Emerald Dove			•					
Phaps chalcoptera	Common Bronzewing		•	•	•				
Ocyphaps lophotes	Crested Pigeon							•	c
Leucosarcia melanoleuca	Wonga Pigeon			•	•				c
Cacatuidae									
Calyptorhynchus banksii	Red-tailed Black-Cockatoo								d
Calyptorhynchus lathami	Glossy Black-Cockatoo	V	•	•					b,d
Calyptorhynchus funereus	Yellow-tailed Black-Cockatoo		•					•	a
Cacatua galerita	Sulphur-crested Cockatoo		•					•	
Eolophus roseicapillus	Galah		•					•	
Psittacidae									
Trichoglossus haematodus	Rainbow Lorikeet		•	•					a, b, c
Trichoglossus chlorolepidotus	Scaly-breasted Lorikeet		•	•	•			•	a, c
Glossopsitta concinna	Musk Lorikeet		•						

Family/Scientific Name	Common Name	Status	Habitats						Previous Records
			DSF	MSF	SSF	FW	EST	RC	
Glossopsitta pusilla	Little Lorikeet		•						
Alisterus scapularis	Australian King-Parrot			•					a, b
Platycercus elegans	Crimson Rosella								a, b
Platycercus adscitus eximius	Eastern Rosella		•	•					a, c
Lathamus discolor	Swift Parrot	E1, M							d
Cuculidae									
Cacomantis flabelliformis	Fan-tailed Cuckoo		•	•					a, b
Cacomantis variolosus	Brush Cuckoo			•					a, b
Chalcites lucidus	Shining Bronze-Cuckoo		•	•					a
Eudynamys orientalis	Pacific Koel		•						
Scythrops novaehollandiae	Channel-billed Cuckoo		•	•	•			•	a
Centropodidae									
Centropus phasianinus	Pheasant Coucal		•	•					c
Strigidae									
Ninox boobook	Southern Boobook		•	•	•				a
Ninox strenua	Powerful Owl	V		•					d
Tytonidae									
Tyto novaehollandiae	Masked Owl	V							d,e
Tyto capensis longimembris	Australian Grass Owl	V							d
Tyto tenebricosa	Sooty Owl	V							d
Podargidae									
Podargus ocellatus	Marbled Frogmouth	V							d
Podargus strigoides	Tawny Frogmouth		•	•	•			•	a, b
Aegothelidae									
Aegotheles cristatus	Australian Owlet-nightjar		•						a

Family/Scientific Name	Common Name	Status	Habitats						Previous Records
			DSF	MSF	SSF	FW	EST	RC	
Apodidae									
Hirundapus caudacutus	White-throated Needletail	M	•	•				•	
Alcedinidae									
Alcedo azurea	Azure Kingfisher					•			
Dacelo novaeguineae	Laughing Kookaburra		•	•	•				a,b,c
Todiramphus sanctus	Sacred Kingfisher		•	•	•	•			a,b,c
Meropidae									
Merops ornatus	Rainbow Bee-eater	M							d
Coraciidae									
Eurystomus orientalis	Dollarbird		•	•					a
PITTIDAE									
Pitta versicolor	Noisy Pitta								a
Climacteridae									
Cormobates leucophaea	White-throated Treecreeper		•	•					a,b
Maluridae									
Malurus cyaneus	Superb Fairy-wren		•	•	•				a,b,c
Malurus lamberti	Variegated Fairy-wren		•						a
Pardalotidae									
Pardalotus punctatus	Spotted Pardalote		•						a
Pardalotus striatus	Striated Pardalote		•						a,b
Acanthizidae									
Gerygone olivacea	White-throated Gerygone			•	•				b
Smicrornis brevirostris	Weebill		•						
Acanthiza lineata	Striated Thornbill		•	•	•				a,b

Family/Scientific Name	Common Name	Status	Habitats						Previous Records
			DSF	MSF	SSF	FW	EST	RC	
Acanthiza pusilla	Brown Thornbill		•	•	•				a,b,c
Sericornis frontalis	White-browed Scrubwren		•	•	•				b,c
Meliphagidae									
Myzomela sanguinolenta	Scarlet Honeyeater			•					a,b
Acanthorhynchus tenuirostris	Eastern Spinebill		•						a,b,c
Xanthomyza phrygia	Regent Honeyeater	E1, M							d
Meliphaga lewinii	Lewin's Honeyeater		•	•	•				
Lichenostomus chrysops	Yellow-faced Honeyeater		•	•	•				a,b
Phylidonyris niger	White-cheeked Honeyeater		•	•					a,c
Manorina manorina	Bell Miner			•					
Manorina melanocephala	Noisy Miner			•					
Anthochaera chrysoptera	Little Wattlebird		•	•					a
Anthochaera carunculata	Red Wattlebird		•	•					
Philemon corniculatus	Noisy Friarbird		•	•					a,b
Philemon citreogularis	Little Friarbird								
Petroicidae									
Eopsaltria australis	Eastern Yellow Robin		•	•	•				a
Eupetidae									
Psophodes olivaceus	Eastern Whipbird		•	•	•				a,b
Neosittidae									
Daphoenositta chrysoptera	Varied Sittella								a
Pachycephalidae									
Pachycephala pectoralis	Golden Whistler		•	•					a,c
Pachycephala rufiventris	Rufous Whistler		•	•					a,b
Colluricincla harmonica	Grey Shrike-thrush		•	•					a,b,c

Family/Scientific Name	Common Name	Status	Habitats						Previous Records
			DSF	MSF	SSF	FW	EST	RC	
Falcunculus frontatus	Eastern Shrike-tit		•	•					a
Dicruridae									
Rhipidura albiscapa	Grey Fantail		•	•	•				a,b,c
Rhipidura rufifrons	Rufous Fantail	M	•	•					a
Rhipidura leucophrys	Willie Wagtail							•	b,c
Myiagra rubecula	Leaden Flycatcher			•					a
Myiagra inquieta	Restless Flycatcher		•						
Monarcha melanopsis	Black-faced Monarch	M	•	•	•				a,b
Monarcha trivirgatus	Spectacled Monarch	M							a
Grallina cyanoleuca	Magpie-lark			•					a,b,c
Dicrurus bracteatus	Spangled Drongo		•		•				a,c
Campephagidae									
Coracina novaehollandiae	Black-faced Cuckoo-shrike		•	•	•				a,b
Coracina papuensis	White-bellied Cuckoo-shrike		•						a,b
Coracina lineata	Barred Cuckoo-shrike	V							d
Coracina tenuirostris	Cicadabird		•	•					a
Oriolidae									
Oriolus sagittatus	Olive-backed Oriole		•	•	•				a
Sphecotheres vieilloti	Australasian Figbird		•						
Artamidae									
Artamus cyanopterus	Dusky Woodswallow								a
Strepera graculina	Pied Currawong		•	•				•	a,b
Cracticus nigrogularis	Pied Butcherbird		•						
Cracticus torquatus	Grey Butcherbird			•					b,c
Gymnorhina tibicen	Australian Magpie		•	•	•			•	a,b,c

Family/Scientific Name	Common Name	Status	Habitats						Previous Records
			DSF	MSF	SSF	FW	EST	RC	
Corvidae									
Corvus orru	Toresian Crow		•					•	c
Corvus coronoides	Australian Raven			•	•				a,b
Ptilonorhynchidae									
Ailuroedus crassirostris	Green Catbird			•				•	a,b
Ptilonorhynchus violaceus	Satin Bowerbird			•					a,b
Sericulus chrysocephalus	Regent Bowerbird			•					
Motacillidae									
Anthus australis	Australian Pipit							•	
Estrildidae									
Neochmia temporalis	Red-browed Finch		•	•	•				a,b
Stagonopleura guttata	Diamond Firetail	V							d
Dicaeidae									
Dicaeum hirundinaceum	Mistletoebird		•						
Hirundinidae									
Hirundo neoxena	Welcome Swallow		•						
Petrochelidon nigricans	Tree Martin		•						
Petrochelidon ariel	Fairy Martin		•					•	
Sylviidae									
Acrocephalus australis	Australian Reed-Warbler	M						•	
Cisticolidae									
Cisticola exilis	Golden-headed Cisticola							•	
Zosteropidae									
Zosterops lateralis	Silvereye		•						a
Introduced Species									

Family/Scientific Name	Common Name	Status	Habitats						Previous Records
			DSF	MSF	SSF	FW	EST	RC	
Columbidae									
Streptopelia chinensis	Spotted Turtle-Dove							•	
Sturnidae									
Acridotheres tristis	Common Myna							•	c
Sturnus vulgaris	Common Starling							•	c
	Total		**70**	**63**	**28**	**16**	**3**	**35**	

MAMMALS

Family/Scientific Name	Common Name	Status	Habitats					Previous records
			DSF	MSF	SSF	FW	RC	
Tachyglossidae								
Tachyglossus aculeatus	Short-beaked Echidna		•					a,b
Dasyuridae								
Antechinus stuartii	Brown Antechinus		•	•				
Dasyurus maculatus	Spotted-tailed Quoll	NV, V						d
Phascogale tapoatafa	Brush-tailed Phascogale	V						d
Peramelidae								
Isoodon macrourus	Northern Brown Bandicoot		•					
Perameles nasuta	Long-nosed Bandicoot		•	•				
Phascolarctidae								
Phascolarctos cinereus	Koala	V	•	•	•			a,d,e
Petauridae								
Petaurus australis	Yellow-bellied Glider	V	•	•				d,e
Petaurus norfolcensis	Squirrel Glider	V						d
Petaurus breviceps	Sugar Glider		•	•				

Family/Scientific Name	Common Name	Status	Habitats					Previous records
			DSF	MSF	SSF	FW	RC	
Pseudocheiridae								
Pseudocheirus peregrinus	Common Ringtail Possum			•	•			
Petauroides volans	Greater Glider							a,b
Acrobatidae								
Acrobates pygmaeus	Feathertail Glider		•					
Phalangeridae								
Trichosurus caninus	Short-eared Possum			•				
Trichosurus vulpecula	Common Brushtail Possum		•	•	•			a,b,c
Macropodidae								
Wallabia bicolor	Swamp Wallaby		•	•	•			a,c
Macropus rufogriseus	Red-necked Wallaby							
Macropus giganteus	Eastern Grey Kangaroo						•	a
Pteropodidae								
Pteropus poliocephalus	Grey-headed Flying-fox	NV, V	•	•	•			a,d
Rhinolophidae								
Rhinolophus megaphyllus	Eastern Horseshoe-bat							b
Emballonuridae								
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	V		•				d
Molossidae								
Tadarida australis	White-striped Freetail-bat		•	•				
Mormopterus sp.2 (planiceps)	Little Mastiff-bat		•	•	•			
Mormopterus norfolkensis	Eastern Freetail-bat	V						b,d
Vespertilionidae								
Vespadelus darlingtoni	Large Forest Bat			•				
Nyctophilus gouldi	Gould's Long-eared Bat			•				

Family/Scientific Name	Common Name	Status	Habitats					Previous records
			DSF	MSF	SSF	FW	RC	
Nyctophilus geoffroyi	Lesser Long-eared Bat		•					b
Miniopterus schreibersii oceanensis	Eastern Bentwing-bat	V	•	•				d
Miniopterus australis	Little Bentwing-bat	V	•	•	•			a,b,d
Chalinolobus gouldii	Gould's Wattled Bat		•	•	•			
Chalinolobus morio	Chocolate Wattled Bat			•				b
Falsistrellus tasmaniensis	Eastern False Pipistrelle	V	•	•				
Scoteanax rueppellii	Greater Broad-nosed Bat	V	•					d
Scotorepens orion	Eastern Broad-nosed Bat		•	•				a
Vespadelus pumilus	Eastern Forest Bat		•	•	•			a,b
Vespadelus regulus	Southern Forest Bat		•	•				
Vespadelus vulturnus	Little Forest Bat		•	•				b
Vespadelus darlingtoni	Large Forest Bat			•				
Muridae								
Rattus fuscipes	Bush Rat		•	•	•			a,b
Melomys cervinipes	Fawn-footed Melomys		•	•	•			a
INTRODUCED								
Canidae								
Canis lupus	Dingo, domestic dog							a
Vulpes vulpes	Fox		•					a
Leporidae								
Oryctolagus cuniculus	Rabbit						•	
Muridae								
Rattus rattus	Black Rat		•	•				b
Mus musculus	House Mouse		•					
	Total		**28**	**28**	**11**	**0**	**1**	

REPTILES

Family/Scientific Name	Common Name	Status	Habitats					Previous Records
			DSF	MSF	SSF	FW	RC	
Chelidae								
Chelodina longicollis	Eastern Snake-necked Turtle					•		
Pygopodidae								
Lialis burtonis	Burton's Snake-lizard		•	•				
Agamidae								
Pogona barbata	Bearded Dragon		•					b
Physignathus lesueurii	Eastern Water Dragon					•		
Varanidae								
Varanus varius	Lace Monitor		•					b
Scincidae								
Lygisaurus foliorum	Tree-base Litter-skink		•					
Carlia tetradactyla	Southern Rainbow-skink		•	•	•			
Cryptoblepharus virgatus	Cream-striped Shinning-skink		•	•	•			
Ctenotus robustus	Robust Ctenotus		•	•				
Egernia major	Land Mullet			•				
Egernia striolata	Tree Skink		•					
Lampropholis delicata	Dark-flecked Garden Sunskink			•	•			a,b
Lampropholis guichenoti	Pale-flecked Garden Sunskink		•					a,b
Menetia greyii	Common Dwarf Skink		•					
Morethia boulengeri	South-eastern Morethia Skink		•					
Saiphos equalis	Three-toed Skink			•				
Eulamprus quoyii	Eastern Water-skink					•	•	

Family/Scientific Name	Common Name	Status	Habitats					Previous Records
			DSF	MSF	SSF	FW	RC	
Eulamprus tenuis	Barred-sided Skink			•				
Tiliqua scincoides	Eastern Blue-tongue						•	
Boidae								
Morelia spilota spilota	Diamond Python			•	•			
Elapidae								
Cryptophis nigrescens	Eastern Small-eyed Snake			•				
Hemiaspis signata	Black-bellied Swamp Snake		•	•	•			
Pseudechis porphyriacus	Red-bellied Black Snake				•	•	•	
Pseudonaja textilis	Eastern Brown Snake						•	
Vermicella annulata	Bandy-bandy		•					
	Total		**13**	**11**	**6**	**4**	**4**	

AMPHIBIANS

Family/Scientific Name	Common Name	Status	Habitats					Previous records
			DSF	MSF	SSF	FW	RC	
Myobatrachidae								
Adelotus brevis	Tusked Frog			•	•			
Limnodynastes peronii	Brown-striped Frog			•	•	•	•	a
Limnodynastes tasmaniensis	Spotted Grass Frog				•			
Mixophyes fasciolatus	Great Barred Frog			•	•			
Mixophyes iteratus	Giant Barred Frog	E1						d
Pseudophryne coriacea	Red-backed Toadlet		•	•	•	•		a
Crinia signifera	Common Eastern Froglet			•	•	•	•	a

Crinia tinnula	Wallum Froglet	V						d
Uperoleia laevigata	Smooth Toadlet			•	•			
Hylidae								
Litoria aurea	Green and Golden Bell Frog	E1						d
Litoria caerulea	Green Tree Frog			•			•	
Litoria chloris	Red-eyed Tree Frog			•	•	•		
Litoria dentata	Bleating Tree Frog				•			
Litoria fallax	Eastern Dwarf Tree Frog			•	•	•		a,b
Litoria freycineti	Freycinet's Frog					•		
Litoria latopalmata	Broad-palmed Frog					•		a
Litoria nasuta	Rocket Frog					•		
Litoria peronii	Peron's Tree Frog				•	•	•	a
Litoria tyleri	Tyler's Tree Frog			•	•	•		
Litoria verreauxii	Verreaux's Frog				•		•	
Litoria revelata	Revealed Frog			•	•			
	Total		**1**	**11**	**14**	**10**	**5**	

Appendix G Photographic Plates

Appendix G Photo Plates

Plate 1: Moist Sclerophyll Forest in Nambucca State Forest showing dense *Lantana camara* thickets.

Plate 2: Dense Broad-leaf Paspalum (*Paspalum wettsteinii*) along trail through Moist Sclerophyll Forest in Nambucca State Forest

Plate 3: Close up of *Marsdenia longiloba* in the study area.

Plate 4: trailing habit of *Marsdenia longiloba* in the study area.

Plate 5: Areas of Saltmarsh and Mangroves in the background surrounding Newee Creek.

Plate 6: Small wetland area adjoining Swamp Forest between Warrell Creek and the Nambucca River.

Plate 7: Tyler's Tree Frog (*Litoria tyleri*) in Swamp Forest area shown in Plate 8.

Plate 8: Eastern Sedge-frog (*Litoria fallax*) in wetland area shown in Plate 6.

Plate 9: Flooded area of Swamp Forest between Warrell Creek and the Nambucca River.

Plate 10: Area of Swamp Sclerophyll Forest adjoining the northern end of Newry State Forest

Plate 11: Disturbed Freshwater Wetland in paddock area on northern side of Kalang River.

Plate 12: Disturbed Freshwater Wetland adjoining Swamp Oak Floodplain Forest in power easement in Raleigh area.

Plate 13: Lowland Rainforest within Newry State Forest

Plate 14: Moist Sclerophyll Forest in gullies of Nambucca State Forest which provides habitat for *Marsdenia longiloba*.

Plate 15: Blackbutt Open Forest in Nambucca State Forest.

Plate 16: Blackbutt Open Forest adjoining Blackbutt Road.

Appendix H Swift Parrot and Regent Honeyeater specialist report

Macksville to Urunga
Upgrading the Pacific Highway

ASSESSING THE IMPACT OF THE PREFERRED ROUTE ON THE NATIONALLY ENDANGERED SPECIES: SWIFT PARROT AND REGENT HONEYEATER

September 2005

Pacific Highway Upgrade
Macksville to Urunga

ASSESSING THE IMPACT OF THE PREFERRED ROUTE ON THE NATIONALLY ENDANGERED SPECIES: SWIFT PARROT AND REGENT HONEYEATER

■ September 2005

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Contents

1. Introduction

1.1 Background

The NSW Roads and Traffic Authority (RTA) propose to upgrade the Pacific Highway between Macksville and Urunga (herein referred to as the study area). A preferred route has been recommended following the investigation of a number of route options. This report assesses the potential impacts and significance on two nationally endangered bird species, the Regent Honeyeater (*Xanthomyza phrygia*) and Swift Parrot (*Lathamus discolour*) in relation to the route recommended by the project value management workshop.

1.2 Aims

The Regent Honeyeater and Swift Parrot are both listed as 'endangered species' under the schedules of the Commonwealth *Environment Protection and Biodiversity Conservation Act,* 1999 and the NSW *Threatened Species Conservation Act,* 1995. Recoveries plans have been prepared for both species (refer to Swift Parrot Recovery Team 2001 and Menkhorst *et al* 1999).

The objectives of this study were to:

- Investigate records of the Regent Honeyeater and Swift Parrot in relation to the study area and broader investigation area through a review of available databases and relevant ecological literature and discussions with experts familiar with these species;
- Identify the type and extent of potential habitat within proximity to the recommended Pacific Highway route;
- Assess the impact of the recommended route on the habitat of the Regent Honeyeater and Swift Parrot in the context of the regional distribution of the species and its habitat;
- Address the national guidelines of significance under the provisions of the EPBC Act to assess the potential impact of the recommended route on these matters on national environmental significance (i.e. the Regent Honeyeater and Swift Parrot); and
- Address the significance of impacts on these state listed species under Section 5a of the EP&A Act and TSC Act (i.e. 8-part test).

2. Description of species

The following section provides an overview of the ecology of the Swift Parrot and Regent Honeyeater to provide a basis for the assessment of the potential significance of the study area and proposed route to each of these species.

2.1 Conservation status

Both the Swift Parrot (*Lathamus discolor*) and Regent Honeyeater (*Xanthomyza phrygia*) are listed as nationally endangered species under the Commonwealth *Environment Protection and Biodiversity Conservation Act*, 1999 (EPBC Act). Both species are also listed as endangered in New South Wales under Schedule 1 of the *Threatened Species Conservation Act*, 1995 (TSC Act).

2.2 Swift Parrot

Distribution and Population Size

The swift parrot breeds only in Tasmania and migrates to mainland Australia in autumn where it remains over the winter season before retuning to Tasmania around September each year (Garnett 1992; Swift Parrot Recovery Team 2001). Surveys conducted in Tasmania during the breeding season estimate a population size of 940 pairs (Swift Parrot Recovery Team 2001).

During the winter season it is semi-nomadic and the population spreads over a wide area predominantly in Victoria and New South Wales, and extending as far north as south-eastern Queensland and west to Adelaide (Garnett 1992). Until recently it was believed that in NSW, swift parrots forage mostly in the western slopes region and also along the inland slopes of the Great Dividing Range, but are patchily distributed along the north and south coasts on NSW. However, recent evidence indicates that the forests on the coastal plains from southern to northern NSW are also extremely important during the winter migration (Swift Parrot Recovery Team 2001)..

Over-wintering foraging Habitat

This species is generally very gregarious and can occur, at times, in populations of several hundred individuals, feeding on flowering Eucalypts. Swift Parrots will also feed on lerps and the secretions of hemipterans, however the nectar of flowering Eucalypts is preferred (Garnett 1992). The principal over-wintering habitat of the species on the mainland is recognised as the box-ironbark forests and woodlands of the inland slopes of the Great Dividing Range in Victoria and New South Wales (Kennedy and Overs 2001).

Within the coastal lowland forests of NSW, the species shows a preference for wet swamp habitat dominated by Swamp Mahogany (*Eucalyptus robusta*). Forests dominated by Spotted Gum (*Corymbia maculata*) and Red Bloodwood (*Corymbia gummifera*) are also visited. In northern NSW, Narrow-leaved Ironbark (*Eucalyptus crebra*), Forest Red Gum (*Eucalyptus tereticornis*) and

Yellow Box (*Eucalyptus melliodora*) may be important and there is evidence that the parrots preferentially select larger trees for foraging (Kennedy 2000).

Current threats

Woodlands and forests within the parrot's over-wintering range continue to be reduced and fragmented as a result of clearing for agriculture, plantation development and urban and coastal subdivision (Swift Parrot Recovery Team 2001). The movements of this species are poorly understood, although it appears that this species congregates in areas where winter-flowering Eucalypts are blossoming profusely. The potential for the species to occur in a particular area of coastal NSW varies greatly from year to year depending on the intensity and extent of winter-flowering eucalypts (i.e. food resources).

2.3 Regent Honeyeater

Distribution and population size

The Regent Honeyeater was formerly distributed within about 300 km of the eastern Australian coast from approximately 100 km north of Brisbane to Adelaide (Franklin *et al.* 1989); however, it is no longer found in South Australia (Franklin and Menkhorst 1988) or western Victoria (Franklin *et al.* 1987) and records from Queensland are uncommon. Sightings now centre on a few sites in north-eastern Victoria, along the western slopes of the Great Dividing Range to Tenterfield, the Warrumbungle Ranges and Parkes in the west, and the central coast of New South Wales. Reports occasionally occur elsewhere (Garnett 1992). The total population is estimated at close to 1500 individuals (Webster and Menkhorst 1992).

Regent Honeyeaters apparently form small flocks, and move according to the flowering times of the preferred tree species (Klippel 1992). Although patterns of seasonal movement are poorly understood, a degree of regularity at some sites where Regent Honeyeaters are well-known to occur has been confirmed (Ley and Williams 1994, Ley *et al.* 1996, Geering and French 1998). There has been no recorded breeding of this species in the study area, the nearest known breeding sites are to the west around Armidale (Oliver *et al* 1998). Coastal areas from Macksville to Coffs Harbour are not considered important breeding areas for Regent Honeyeater (D.Geering, Recovery Plan co-ordinator, NPWS, *pers.comm*)

Habitat

Temperate eucalypt woodland and forests including forest edges, woodlands, farmlands and urban areas which contain mature Eucalypts are utilised by this species. Associations of Red Ironbark (*Eucalyptus sideroxylon*), White Box (*Eucalyptus albens*), Yellow Box (*Eucalyptus melliodora*), Yellow Gum (*Eucalyptus leucoxylon*) and Red Box (*Eucalyptus polyanthemos*) appear to be important. However these accounts are from the slopes and plains of NSW and none of these tree species are present in the Macksville to Urunga study area.

In coastal New South Wales, Regent Honeyeaters are reported to use riparian forests of River Oak (*Casuarina cunninghamiana*) and Swamp Mahogany (*Eucalyptus robusta*). Wet lowland coastal forest dominated by Swamp Mahogany (*Eucalyptus robusta)* are now known to comprise important refuge habitat for Regent Honeyeaters during drought periods when the inland Box-Ironbark forests are stressed and not flowering (Menkhorst *et al* 1999), though visits to the coastal Swamp Mahogany forests are not consistent every year and depend on flowering of the preferred Box-Ironbark woodlands to the west (Geering 2004).

One study, comparing occupied sites to nearby unoccupied sites, found that areas occupied appear to have noticeably larger trees, a greater percentage of trees in flower, and a taller shrub layer than surrounding unoccupied sites (Oliver 2000). Webster & Menkhorst (1992) found that structure appeared to be more important than floristics, and the density of the shrub layer of habitats varied from luxuriant but scattered to almost non-existent, and did not appear to be a critical factor. The birds did appear to seek large, mature, copiously flowering eucalypts, with an abundant nectar flow.

The ecology of the Regent Honeyeater is poorly known. This omnivorous species feeds on insects, taken from the branches and foliage of trees, and nectar, especially of Eucalypt species. Studies suggest that 88% of the time spent foraging was devoted to nectar-feeding, and only 8% of time was spent gleaning insects (Oliver 2000).

Threats

The causal factors involved in the drastic decline of Regent Honeyeater populations are not well understood, but habitat loss, degradation and fragmentation of habitat and drought are considered major contributors. Given the species documented large-scale movements to search for flowering resources, the loss of habitat has reduced stepping stones between dispersed feeding areas, such as coastal New South Wales (Geering 2004).

3. Methods and results

3.1 Records in the study area

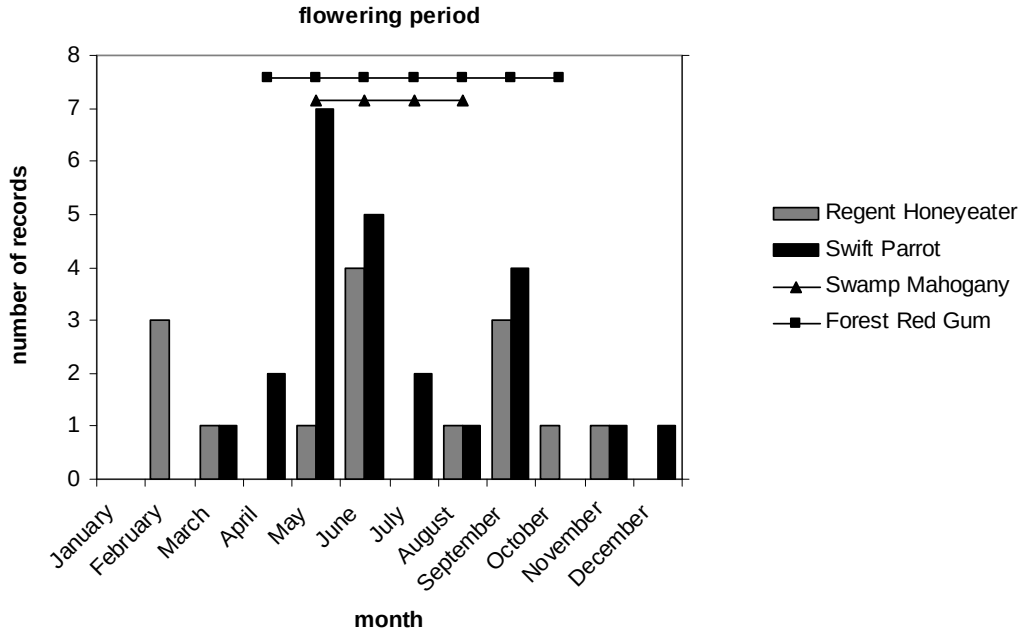
There are relatively few records of the Regent Honeyeater and Swift Parrot between the coastal towns of Macksville and Urunga, particularly in comparison to the number of records around Port Macquarie to the south and Coffs Harbour to the north. The concentration of records at these major towns may however be related to the higher population density and subsequent greater probability of reported sightings. A list of records for both species encompassing the area from Macksville to Moonee Beach, north of Coffs Harbour is presented in Table 1 and illustrated in Figure 1.

Table 1. Records of Regent Honeyeater and Swift Parrot from Macksville to Coffs Harbour
(Source: DEC Atlas of NSW Wildlife).

Date	Species	Number	Easting	Northing	Description of Location
13/06/1977	Regent Honeyeater	5	509610	6642415	South of Boambee Creek, Toormina
1/06/1983	Swift Parrot	-	513500	6657600	Moonee Beach Nature Reserve
1/07/1983	Swift Parrot	-	513500	6657600	Moonee Beach Nature Reserve
25/05/1985	Regent Honeyeater	2	514500	6657100	Moonee Beach Nature Reserve
1/06/1985	Regent Honeyeater	3	514000	6658000	Moonee Beach Nature Reserve
3/06/1985	Regent Honeyeater	1	514000	6658000	Moonee Beach Nature Reserve
28/09/1990	Regent Honeyeater	3	512000	6648100	Coffs Harbour Botanic Gardens
26/09/1990	Swift Parrot	2	512700	6649600	Park Beach, Coffs Harbour
20/11/1990	Swift Parrot	2	512700	6649600	Park Beach, Coffs Harbour
13/04/1991	Swift Parrot	5	513100	6648900	Park Beach, Coffs Harbour
13/08/1991	Swift Parrot	2	512700	6649600	Park Beach, Coffs Harbour
23/09/1991	Regent Honeyeater	3	512000	6648100	Coffs Harbour Botanic Gardens
29/09/1991	Regent Honeyeater	2	512700	6648900	East of Coffs Creek
18/10/1991	Regent Honeyeater	2	509987	6674704	Northwest of Moonee Beach
1/05/1992	Swift Parrot	5	512500	6651000	Jordons Creek, Korora
20/08/1995	**Regent Honeyeater**	**2**	**492022**	**6601784**	**Macksville Golf Course**
30/09/1997	Swift Parrot	20	515100	6657600	Moonee Beach Nature Reserve
31/03/1998	Swift Parrot	4	515100	6657600	Moonee Beach Nature Reserve
1/04/1998	Swift Parrot	4	515100	6657600	Moonee Beach Nature Reserve
1/07/1998	Swift Parrot	6	512950	6652750	Korora
11/09/1998	Swift Parrot	10	512950	6652750	Korora
12/09/1998	Swift Parrot	5	512950	6652750	Korora
12/06/1999	Swift Parrot	30	515100	6657600	Moonee Beach Nature Reserve
20/05/2000	Swift Parrot	10	515100	6657600	Moonee Beach Nature Reserve
26/05/2000	Swift Parrot	20	515100	6657600	Moonee Beach Nature Reserve
15/06/2000	Swift Parrot	6	518650	6670100	Moonee
1/12/2000	Swift Parrot	2	510800	6648000	Coffs Harbour
15/11/2001	Regent Honeyeater	1	500000	6671969	Kangaroo River State Forest
5/02/2002	Regent Honeyeater	2	501200	6678400	Kangaroo River State Forest
10/02/2002	Regent Honeyeater	1	501150	6678300	Kangaroo River State Forest

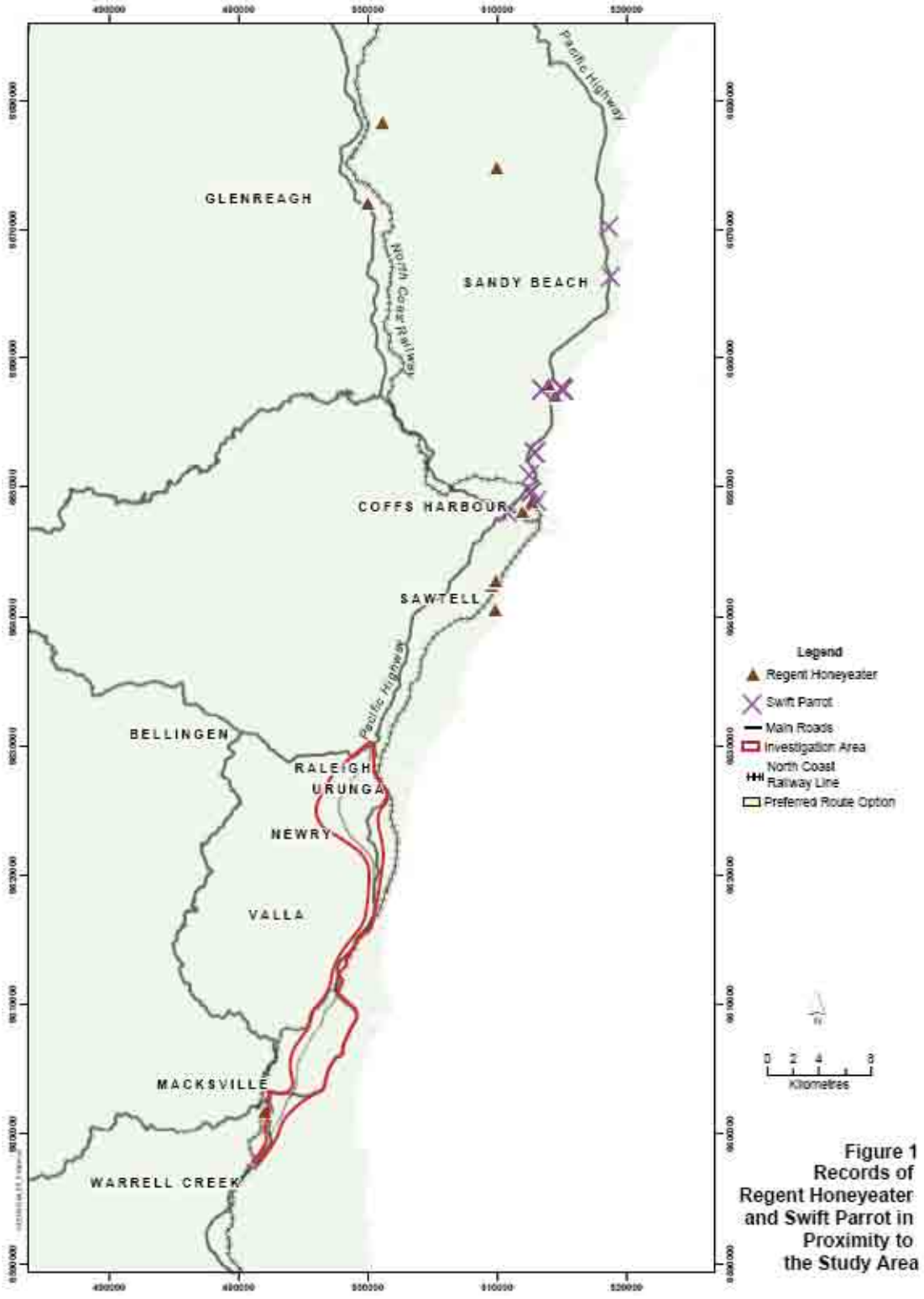
Date	Species	Number	Easting	Northing	Description of Location
14/02/2002	Regent Honeyeater	2	501152	6678187	Kangaroo River State Forest
6/06/2002	Regent Honeyeater	1	509905	6642753	East of Boambee Creek
28/05/2002	Swift Parrot	150	503055	6582530	Kangaroo River State Forest
29/05/2002	Swift Parrot	100	503055	6582530	Kangaroo River State Forest
30/05/2002	Swift Parrot	10	515100	6657600	Moonee Beach Nature Reserve
31/05/2002	Swift Parrot	2	518810	6666325	Moonee
16/06/2002	Swift Parrot	25	515000	6657700	Moonee Beach Nature Reserve
17/06/2002	Swift Parrot	27	515000	6657700	Moonee Beach Nature Reserve
10/03/2005	Regent Honeyeater	1	509850	6640500	Sawtell

Records from the study area are relatively continuous extending over a 28 year period (1977-2005), indicating that the region from Macksville to Coffs Harbour may constitute seasonally important foraging and refuge habitat for these species. Analysis of the records for both species over this period indicates peaks in detection around the months from May to September. This is to be expected and coincides with the autumn-winter season and the flowering period of Swamp Mahogany (*Eucalyptus robusta*) and Forest Red Gum (*E.tereticornis*).



Wet lowland coastal forests dominated by Swamp Mahogany (*Eucalyptus robusta)* are identified as significant foraging habitat for both Regent Honeyeater and Swift Parrot in coastal New South Wales (Menkhorst *et al* 1999; Swift Parrot Recovery Team 2001) and Forest Red Gum (*E.tereticornis*) is also considered important for the Swift Parrot in coastal areas. The flowering period for these species is consistent with the majority of sightings for both species in the coastal area from Port Macquarie to Coffs Harbour.

Figure 1. Records of Regent Honeyeater and Swift Parrot within proximity to the study area



3.2 Distribution of potential habitat

Within the study area Swamp Mahogany (*Eucalyptus robusta)* is a component of the Swamp Sclerophyll Forest as described in the preliminary biological working paper (SKM 2004). This community type is typically located along low-lying freshwater creeks and gullies and often associated with SEPP 14 wetland areas. All swamp sclerophyll sites were revisited for this study to assess the presence of *E.robusta.* At all sites the dominant tree species was found to be Broad-leaved Paperbark (*Melaleuca quiquenervia*) and *E.robusta* was only represented as a sub-dominant species along with Forest Red Gum (*E. tereticornis*), Flooded Gum (*E. grandis*) and Smooth-barked Apple (*Angophora costata*). Other indicative species include Prickly-leaved Paperbark (*Melaleuca styphelioides*), Snow-in-summer (*Melaleuca linariifolia*) and Ball Honeymyrtle (*M. nodosa*).

At each of the swamp forest sites, the extent of *E.robusta* present in the tree canopy was quantified by determining the percentage of trees present within a 100x100 m quadrat and from random observations relative to all trees within the quadrat. Habitat where the percentage of *E.robusta* was estimated at less than 5% were considered marginal (low quality), 5-30% medium quality and greater than 30% high quality. The distribution of potential habitat in the study area is presented in **Figure 2.**

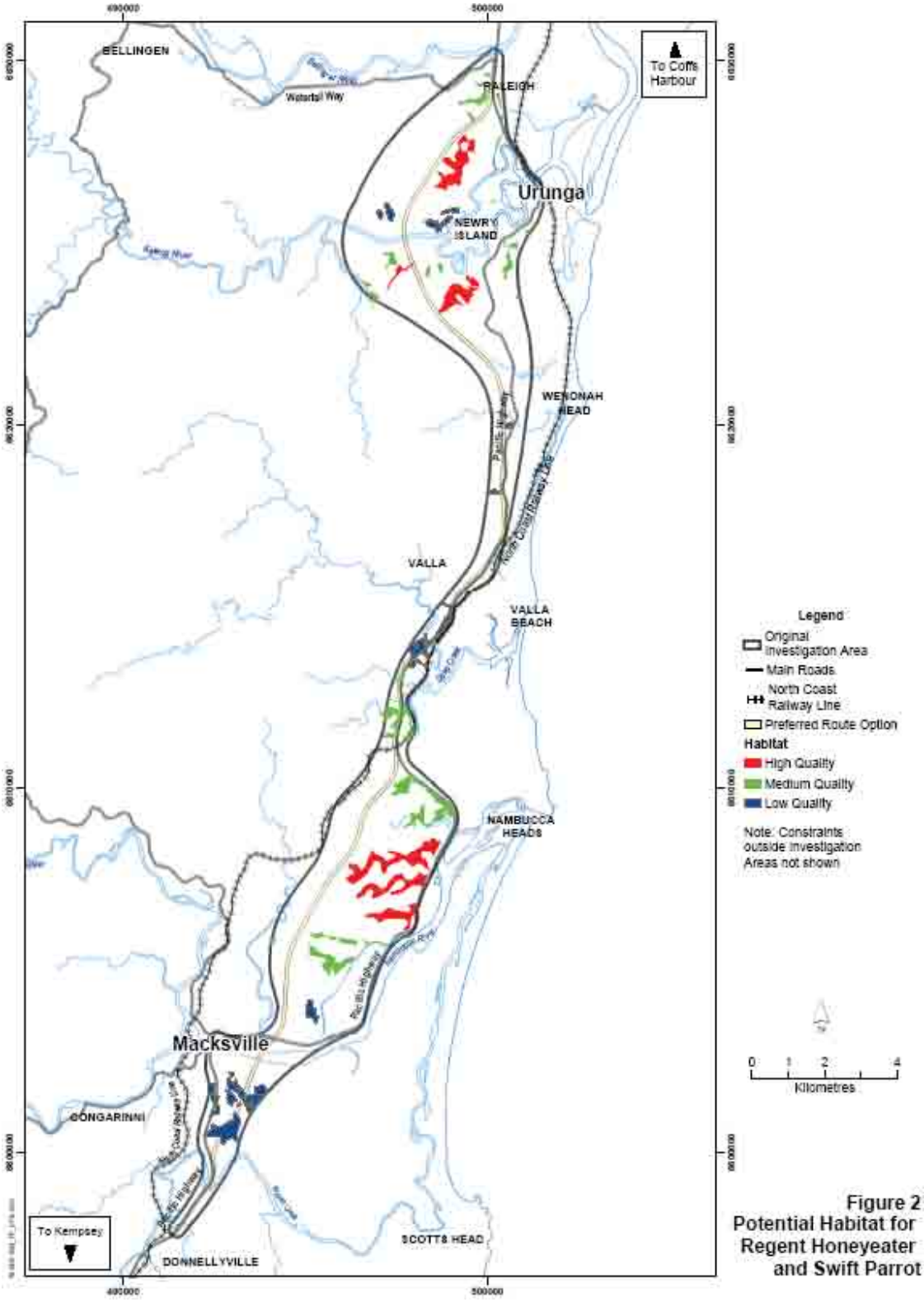
Within the study area the best examples of potential habitat are represented in Bellwood Swamp at the southern end of Nambucca State Forest (Section 2), to the south of the Kalang River and near South Arm Road, south of Raleigh (Section 4). These sites comprise a high percentage of *E.robusta* as a component of the community.

3.3 Targeted surveys

As both the Regent Honeyeater and Swift Parrot are semi-nomadic species that move large distances in search of flowering resources, their presence in a particular area of coastal NSW is unpredictable. This makes targeted surveys difficult without large groups of surveyors and previous knowledge of known sites. The primary focus of this study was to identify the distribution and quality of potential foraging habitat for both species within the study area. As a secondary aim, targeted searches were conducted for both species where flowering trees were noted and visits to known sites were conducted to compare the quality of the habitat to that within the study area.

Potential habitat was identified from aerial photography, topographic maps and vegetation survey data derived from SKM (2005). Potential habitat was identified on the basis of the dominant eucalypt species in the canopy, in particular the presence of wet lowland forests with *E. robusta*) (refer Figure 2 for distribution).

Figure 2. Distribution of potential habitat within the study area



Vegetation comprising Forest Red Gum (*E.tereticornis*) and Red Bloodwood (*Corymbia maculata*) were also targeted, although these species occurred in very low densities and were scattered throughout the study area and were therefore difficult to map.

A number of private properties within the study area were identified as containing potential habitat and these were visited during the period 15-19 August 2005. An attempt was made to visit all the properties where this community was identified, however due to difficulties contacting all landholders prior to the visit some properties were not accessed, these were assessed based on previous knowledge of the study area (SKM 2005). A total of 16 properties were visited which included several locations within Newry and Nambucca State Forests.

Bird census was conducted at each property during morning periods, which involved a random search listening for calls of the target species and obtaining visual identification of all bird species. Greater survey effort was concentrated around individuals and groups of flowering trees where encountered. Trees with copious flowers were re-visited on consecutive days. Aggregations of other nectarvorous birds, particularly Scaly-breasted Lorikeet (*Trichoglossus chlorolepidotus*) and Rainbow Lorikeet (*T.haematodus*), which could often be heard from a distance, were also used as a guide to locate flowering trees and search for the target species. Swift Parrots are often found in cohort with these other nectaravorous species..

Sites where Regent Honeyeater and Swift Parrot have been recorded previously outside of the study area were visited during the survey period to investigate if birds were present during the study period, as well as to assess resource availability and the condition of these habitats relative to those present in the study area and within proximity to the proposed route. Sites were visited at Moonee Beach Nature Reserve north of Coffs Harbour as both species have been recorded from this location in recent years (NPWS, Coffs Harbour office, *pers.comm*), and Nambucca Heads.

Swift Parrot’s and Regent Honeyeater’s were not identified in the study area during targeted surveys.

4. Assessment of impacts

4.1 Importance of the study area

Coastal forests dominated by Swamp Mahogany (*E.robusta*) are recognised as important habitat for both the Swift Parrot and Regent Honeyeater. This habitat type is considered relatively scarce in the Macksville to Urunga study area, which is dominated by coastal Blackbutt (*E.pilularis*) open forest (SKM 2005). However, swamp forests are represented in lowland areas along drainage lines, where Swamp Mahogany (*E.robusta*) is a component of the plant community.

The distribution of swamp sclerophyll forest is generally restricted to creek lines and gullies in the study area (refer Figure 2). However the actual percentage of *E.robusta* as a component of this community varies across sites and is generally low within most sites being dominated by the Broad-leaved Paperbark (*Melaleuca quinquenervia*). Forests dominated by Paperbark are mapped in Figure 2 as low quality, whereas those with a higher percentage of *E.robusta* are considered medium to high quality potential habitat.

Griffith (1991) considered swamp sclerophyll forest dominated by *E.robusta* to be poorly conserved on the NSW north coast and this community as been recently listed as an endangered ecological community under the schedules of the TSC Act due to its highly fragmented and reduced status. Furthermore *E.robusta* is considered an important keystone species for a variety of nectivorous fauna including threatened bird and mammal species and an important food tree species for the Koala (*Phascolarctos cinereus*). Any areas of swamp forest in coastal NSW that contain *E.robusta* are considered valuable as fauna habitat.

The Macksville to Urunga study area is not considered a critical area for the Regent Honeyeater (D.Geering, NPWS, *pers.comm*) or Swift Parrot. The swamp forest communities that are present do contribute to the overall availability of habitat for these species in coastal NSW however, and may be particularly important as refuge sites during drought when trees from other districts such as the inland Box Ironbark woodlands of NSW and Victoria may be experiencing poor flowering conditions.

Suitable foraging habitat for these species is best represented within the larger fragments of swamp sclerophyll forest located in Nambucca and Newry State Forest.

4.2 Impact of the preferred route on potential habitat

Swamp sclerophyll forest is listed as an endangered ecological community (EEC) under the schedules of the TSC Act. Some swamp sclerophyll areas are also listed under the State Environmental Protection Plan 14 (SEPP 14) as protected coastal wetlands, examples of such areas occur in Nambucca State Forest.

All areas of EEC and SEPP 14 wetland were identified in the original route options investigation (SKM 2005) and the selection of the preferred route was chosen to minimise impacts on these significant ecological areas. In achieving this, the impacts on fauna species dependent on the swamp forest communities, such as the Regent Honeyeater and Swift Parrot, have also been considered.

From the mapping of potential habitat in proximity to the preferred route it is evident that there are three categories of habitat characterised by high, medium and low quality areas (refer Figure 2). An overlay of the preferred highway route was used to calculate the loss of potential habitat for these species from the study area. The extent of removal of potential habitat areas as a result of the preferred route is:

- High 0.3ha
- Medium 5.6ha; and
- Low 19.0ha

The distribution of potential habitat shown in Figure 2 indicates that high quality areas are best represented in Nambucca and Newry State Forest to the east of the preferred route, and within private land to the south of Raleigh also to the east of the preferred route.

4.3 Environmental Planning and Assessment Act, 1979

The *EP&A Act* 1979 was amended by the *TSC Act* 1995. The outcome of any threatened species assessment should be that developments and activities are undertaken in an environmentally sensitive manner, and that appropriate measures are undertaken to minimise adverse effects on threatened species or their habitats.

Section 5A of the EP&A Act outlines eight questions that provide a guide to determining the significance of impacts from the proposed development on threatened species (i.e. the 8-part test). The Swift Parrot and Regent Honeyeater are listed as endangered species under Schedule 1 of the TSC Act, and therefore are subject to the provisions of the 8-part test.

Determining authorities have an obligation under the *EP&A Act* to consider whether a proposal is likely to significantly affect threatened species, populations or ecological communities, or their habitats. In this regard, the determining authority must take into account Section 5A of the *TSC Act* (ie. the eight-part test).

4.3.1 8-part Test

Swift Parrot (*Lathamus discolor*) and Regent Honeyeater (*Xanthomyza phrygia*)

(a) in the case of a threatened species, whether the life cycle of the species is likely to be disrupted such that a viable local population of the species is likely to be placed at risk of extinction.

The presence of both species in the study area would depend predominantly on the flowering of Swamp Mahogany (*E. robusta*) and to a lesser extent Forest Red Gum (*E.tereticornis*) and Red Bloodwood (*Corymbia gummifera*) which occurs during the winter season.

The distribution of swamp sclerophyll forest containing *E.robusta* is generally restricted to creek lines and gullies in the study area. However the actual percentage of Swamp Mahogany (*E.robusta*) as a component of this community varies across sites and is generally low within most sites being dominated by the Broad-leaved Paperbark (*Melaleuca quinquenervia*). The distribution of potential habitat was mapped (refer Figure 2) and indicates that high quality areas are best represented in Nambucca and Newry State Forest to the east of the preferred route and also within private land to the south of Raleigh, and also east of the preferred route.

The preferred route will potentially involve removal of up to 0.3ha of high quality habitat, 5.6ha of medium and 19ha of low quality habitat from the study area. This loss is considered low and of little significance to populations of the Swift Parrot and Regent Honeyeater. Continued visitation to the region is expected following construction of the highway upgrade.

(b) In the case of an endangered population, whether the life cycle of the species that constitutes the endangered population is likely to be disrupted such that the viability of the population is likely to be significantly compromised

The Swift Parrot and Regent Honeyeater are scheduled as endangered species in NSW and there are no endangered populations listed of this species.

(c) in relation to the regional distribution of the habitat of a threatened species, population or ecological community, whether a significant area of known habitat is to be modified or removed.

For the purposes of this assessment and the '8-part test' the 'region' referred to in part (c) is the entire North Coast Biogeographic Region. The Swift Parrot is a winter visitor to the north coast of NSW. Both this species and the Regent Honeyeater move considerable distances in search of flowering resources. As the nature of this resource is sporadic, the movements of these species depend on flowering irruptions and are not necessarily tied to specific areas. Both species are documented to exhibit a high degree of site fidelity (i.e. repeated visits to known areas), however accounts of the species between Macksville and Coffs Harbour are not consistent each year

indicating that individuals may only visit during favourable flowering seasons and are not critically tied to the presence of winter-flowering species which occur in the study area.

The areas of potential habitat addressed within this assessment (ie. the study area) constitute only a fraction of the area of known habitat for these species within the NSW north coast. Furthermore, whilst the study area is expected to provide important habitat resources and assist in life-cycle events for this species, thus contributing as an area of potential habitat, such resources are not solely restricted to the preferred route area and are better represented outside of this area, for example Moonee Nature Reserve at Coffs Harbour. Therefore the potential habitat to be impacted by the preferred route is not considered to be a significant area in relation to the regional distribution of habitat for the Swift Parrot and Regent Honeyeater.

(d) whether an area of known habitat is likely to become isolated from currently interconnecting or proximate areas for a threatened species, population or ecological community.

Most vegetation within the study area has been heavily fragmented by rural and urban development, including the existing Pacific Highway. Based on the movements and records of these species in the north coast region, both species are adapted to finding and accessing fragmented habitats and isolated flowering trees. The preferred highway route will not result in the isolation of potential habitat for these wide-ranging semi-nomadic species. The largest areas of intact forest occur within Nambucca and Newry State Forest and these high quality habitats will be retained to the east of the road footprint.

(e) Whether critical habitat will be affected

No areas of critical habitat have been listed for the Swift Parrot in the study area

(f) whether a threatened species, population or ecological community, or their habitats are adequately represented in conservation reserves (or other similar protected areas) in the region.

For the purposes of this assessment and the '8-part test' the 'region' referred to in part (f) is the entire North Coast Biogeographic Region. The Swift Parrot and Regent Honeyeater are semi-nomadic species and movements depend on the availability of seasonally fluctuating flowering resources. Vegetation communities of particular importance in the region for these species include coastal Swamp Mahogany and Forest Red Gum forests. Within the region these forest types have been disproportionately removed for development and agriculture. Indeed the habitat type is poorly conserved (Griffith 1991).

The Swift Parrot has been recorded in Crowdy Bay and Yurygir National Parks as well as Lake Innes, Limeburners Creek and Moonee Beach Nature Reserves. The Regent Honeyeater has been

recorded in Hat Head, Yuraygir, Bundjalung, Broadwater and Nightcap National Parks as well as Moonee Beach, Sherwood and Bilinudgel Nature Reserve and Bundjalung Crown Reserve.

It is reasonable to suggest that the habitat of the Swift Parrot and Regent Honeyeater is inadequately represented in conservation reserves in the 'region'. However, this factor is unlikely to reflect a significant concern in relation to the proposal as the habitats which are represented do not constitute a significant area of known habitat and indeed extensive areas of comparable habitat occur throughout the North Coast Bioregion that will not be impacted by the proposal.

(g) whether the development or activity proposed is of a class of development or activity that is recognised as a threatening process.

Clearing of native vegetation is recognised as a major factor contributing to the loss of habitat for these species. The associated impact of this threatening process are well documented and include the destruction of habitat, fragmentation of bushland, riparian zone degradation, increased habitat for invasive species and loss or disruption of ecological function.

Of particular importance relating to the proposed highway route and in assessing the impact on the Swift Parrot and Regent Honeyeater associated with land clearance, is that the proposed route has been specifically selected with an objective of minimising impacts on vegetation among other environmental variables. In achieving this, the route selected avoids the majority of the swamp forest habitat favoured by the Swift Parrot and Regent Honeyeater.

(h) whether any threatened species, population or ecological community is at the limit of its known distribution.

The Swift Parrot extends from its summer breeding grounds in Tasmania, from where it disperses to over-winter in southeast mainland Australia. Some individuals range north to Queensland, but the majority over-winter in Victoria and central and eastern New South Wales. The species returns to Tasmania in September. The study area constitutes a small percentage of the known distribution of the species and does not represent its geographical limit.

4.3.2 Conclusion

The results of the 8-part test for the Regent Honeyeater and Swift Parrot indicate that impacts on these species as a result of the preferred Pacific Highway route are minimal and negligible. While both species are regular visitors to the mid north coast region, the limited extent of habitat present within the Macksville to Urunga study area and lack of records suggests that the study area does not support regionally significant habitat. Furthermore, several large areas of high quality potential habitat for these species have been identified and will not be impacted by the preferred route. The

current potential for these species to utilise habitat within the study area is expected to remain following the construction of the preferred route.

4.4 Environmental Protection and Biodiversity Conservation Act, 1999

The EPBC Act regulates any development or activity if it is likely to have a significant impact on any of the following matters of national environmental significance:

- World Heritage properties
- National Heritage List places
- wetlands listed under the Ramsar Convention as wetlands of international importance
- nationally threatened species and ecological communities listed under the EPBC Act
- migratory species listed under the EPBC Act
- the Commonwealth marine environment; and
- nuclear actions.

As the Swift Parrot and Regent Honeyeater are listed as nationally endangered species under the EPBC Act, the proposal is therefore subject to assessment under the provisions of the Act. This assessment provides an appraisal as to whether the project would lead to a significant impact on either species based on the information presented from a desktop review and field studies. The assessment is used to determine if the proposal should be referred to the Department of Environment and Heritage for approval with regard to the Swift Parrot and Regent Honeyeater.

The Australian Government has a bilateral agreement with the NSW Government accrediting the environmental assessment processes of the EP&A Act and TSC Act. The 8-part test undertaking in the previous section indicates that a significant impact would be avoided. Further assessment under the guidelines of the EPBC Act is discussed below, by indicating ***whether the project will*:**

Lead to a long-term decrease in the size of the population.

Both species are regarded as winter-visitors to this region, and would depend predominantly on the flowering of Swamp Mahogany and Forest Red Gum to provide food resources. Both tree species are present in low abundance and the study area is considered only marginal for the Swift Parrot and Regent Honeyeater. The largest patches of potential foraging habitat are present as SEPP 14 wetland areas within Nambucca and Newry State Forests. These areas have been avoided as part of the route options study and will not be impacted by the preferred route.

Reduce the area of occupancy of the species or important population

Both species are wide ranging and highly mobile, semi-nomadic species with patchy and sporadic distribution across coastal New South Wales. Their presence in the study area is seasonally dependent and influenced by drought and rain periods affecting the flowering of preferred tree species. Therefore there is no defined area of occupancy within the study area.

Evidence gathered on the movements of both species suggest that visits to the coastal Swamp Mahogany forests are not consistent every year and depend on flowering of the Box-Ironbark woodlands on the south western slopes of NSW and Victoria (Menkhorst et al 1999; Swift Parrot Recovery Team 2001; Geering 2004). The proposal will have minor impacts on small areas of potential habitat for these species.

Fragment an existing population into two or more populations

Potential habitat for these species as identified in this report occurs in small and fragmented patches present throughout the study area and already fragmented by existing roads and cleared land. Furthermore, both species are highly mobile and semi-nomadic capable for accessing patchy food resources. There are no defined areas of habitat in the study area that are exclusively occupied by these species and the preferred route would not fragment a population of the Swift Parrot or Regent Honeyeater,

Adversely affect habitat critical to the survival of these species

The register of critical habitat under the EPBC Act does not apply to land potentially critical to these species or to land present within the study area.

Disrupt the breeding cycle of the species

The Swift Parrot breeds in Tasmania, and no breeding sites of the Regent Honeyeater have been documented for coastal northern NSW.

Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline

The area of vegetation potentially removed as a result of the proposed surface construction areas is not considered significantly large or of a high quality to lead to the decline of these species in NSW. The preferred route would impact on only 0.3ha of high quality habitat, and approximately 5.6ha of medium quality and 19ha of low quality habitat. This is minimal in relation to the extent of potential habitat in the North Coast Bioregion.

Result in invasive species that are harmful to a threatened species becoming established in the habitat of the threatened species

Many of the bushland remnants which occur in the study area exhibit high levels of weed invasion and the preferred route avoids the largest patches of potential habitat identified in this study.

Any proposal to remove natural vegetation would be supported by the RTA's standard revegetation and landscaping work methods including follow up weed removal.

Interfere with the recovery of the species

The preferred route and proposed highway construction would not conflict with the recovery of these two species. The preferred route has been selected on the basis of avoiding high quality habitats for these two species.

5. Conclusion

The results of this assessment for the Regent Honeyeater and Swift Parrot indicate that impacts on these species as a result of the preferred Pacific Highway route are minimal and negligible. While both species are regular visitors to the mid north coast region, the limited extent of habitat present within the study area and the lack of records for these species suggests that the area between Macksville and Urunga does not support regionally significant habitat for these species.

Therefore the assessment concludes that habitat potentially removed as a result of the preferred highway route is not considered significantly large or of a high quality to lead to the decline of these species in NSW. Several large areas of high quality potential habitat for these species have been identified between Macksville and Urunga that will not be impacted by the preferred route. As a result, the current potential for the Swift Parrot and Regent Honeyeater to utilise habitat within the study area is expected to remain following the development of the preferred Pacific Highway route from Macksville to Urunga.

6. References

Garnett, S. (ed). 1992, *Threatened and Extinct Birds of Australia*. RAOU Report No. 82. Royal Australasian Ornithologists Union and Australian National Parks and Wildlife Service.

Kennedy, S.J. 2000. *A winter survey of the Swift Parrot in coastal New South Wales*. Unpublished report to NPWS, Southern Directorate.

Kennedy, S.J. and Overs, A.E. 2001. Foraging ecology and habitat use of the Swift Parrot on the south-western slopes of New South Wales. *Corella* **25.**68-74.

Klippel, K. 1992. *Wildlife Data Search - threatened animal species of New South Wales*. Total Environment Centre, Sydney.

Franklin, D. C. and Menkhorst, P.W. 1988. A History of the Regent Honeyeater in South Australia. *South Australian Ornithologist* 30: 141-145.

Franklin, D. C. and Robinson, J.L. 1989. Territorial behaviour of a Regent Honeyeater at feeding sites. *Australian Bird Watcher* 13: 129-132.

Franklin, D., Menkhorst, P. and Robinson, J. 1987. Field surveys of the Regent Honeyeater *Xanthomyza phrygia* in Victoria. *Australian Bird Watcher* 12: 91-95.

Geering, D (ed). 2004. *Where the Regent's Roam*. Newsletter, Volume **13**, May 2004

Geering, D. and French, K. 1998. Breeding biology of the Regent Honeyeater *Xanthomyza phrygia* in the Capertee Valley, New South Wales. *Emu* **98**: 104-116.

Ley, A. & Williams, B. 1994, The domestic life of the Regent Honeyeater in *Wingspan* 13., pg. 27.

Ley, A. J., Oliver, D. L. and Williams, B. 1996. Observations on colour-banded Regent Honeyeaters *Xanthomyza phrygia. Corella* 20: 88-92.

Menkhorst, P., Schedvin, N and Geering, D. 1999. Regent Honeyeater (*Xanthomyza phrygia*) Recovery Plan 2001-2003. Department of Natural Resources and Environment, May 1999.

Oliver, D.L., Andrew, J.L., and Williams, B. 1998. Breeding success and nest site selection of the Regent Honeyeater *Xanthomyza phrygia* near Armidale, New South Wales. *Emu* **98**, 97-103.

Oliver, D.L. 2000. Foraging Behaviour and Resource Selection of the Regent Honeyeater *Xanthomyza phrygia* in Northern New South Wales. *Emu* **100**, 12-30.

Readers Digest., 1997. *Readers Digest Complete Book of Australian Birds.* Readers Digest Services Pty Ltd, Sydney.

SKM, 2005. *Macksville to Urunga Upgrading the Pacific Highway: Preliminary Biological Report, Working Paper.* Sinclair Knight Merz, Sydney.

Swift Parrot Recovery Team, 2001. *Swift Parrot Recovery Plan.* Department of Primary Industries, Water and Environment, Hobart.

Webster, R. & Menkhorst, P. 1992. The Regent Honeyeater (*Xanthomyza phrygia*) population status and ecology in Victoria and New South Wales. Arthur Rylah Institute for Environmental Research. *Technical Report Series No. 126*.

Appendix I Species listings

Fisheries Management Act 1994 (NSW)

- **Table 7-1 – Endangered Aquatic Fauna Species as listed under the NSW *FM Act* (1994)**

Freshwater	
Austrocordulia leonardi	Sydney Hawk Dragonfly
Craterocephalus fluviatilis	Murray Hardyhead
Maccullochella ikei	Eastern Freshwater Cod
Maccullochella macquariensis	Trout Cod
Nannoperca oxleyana	Oxleyan Pygmy Perch
Notopala sublineata	River Snail
Estuarine	
Pristis zijsron	Green Sawfish
Marine	
Carcharias taurus	Grey Nurse Shark
Thunnus maccoyii	Southern Bluefin Tuna

- **Table 7-2 - Distribution of Endangered Aquatic Fauna Species as listed under the NSW *FM Act* (1994)**

Species	**Distribution**
Freshwater	
Austrocordulia leonardi	The known distribution of the species includes three locations in a small area south of Sydney, from Audley to Picton. The species is also known from the Hawkesbury-Nepean, Georges River and Port Hacking drainages.
Craterocephalus fluviatilis	They were once widespread and abundant in the Murray and Murrumbidgee river systems in southern NSW.
Maccullochella ikei	Only found naturally in several isolated tributaries of the Clarence River.
Maccullochella macquariensis	Once abundant and widespread in the southern Murray-Darling river system.
Nannoperca oxleyana	Endemic to the coastal region of eastern Australia, from northern NSW to south-eastern Queensland. Populations are most common on the coastal floodplains of NSW where they disperse between water bodies during localised flood events.
Notopala sublineata	Once common and widespread in the Murray-Darling river system.
Estuarine	
Pristis zijsron	From northern NSW to south of Wollongong.
Marine	
Carcharias taurus	Julian Rocks (Byron Bay) Fish Rock (South West Rocks) Green Island (South West Rocks)

	The Pinnacle (Forster) Big and Little Seal Rocks (South of Forster) Little Broughton Island (North of Port Stephens) Magic Point (Maroubra - Sydney) Bass Point (Shellharbour) Tollgate Islands (Batemans Bay) Montague Island (Narooma)
Thunnus maccoyii	Occurs from northern NSW (300 S) to the Victorian border, normally on the seaward side of the continental shelf

- **Table 7-3 – Endangered Fish Populations as listed under the NSW *FM Act* (1994)**

Freshwater	
Ambassis agassizii	Olive Perchlet (western New South Wales population)
Mogurnda adspersa	Purple Spotted Gudgeon (western New South Wales population)

- **Table 7-4 – Distribution of Endangered Fish Populations as listed under the NSW *FM Act* (1994)**

Species	**Distribution**
Freshwater	
Ambassis agassizii	The western population of the olive perchlet are now found only at a few sites in the Darling River drainage.
Mogurnda adspersa	Purple spotted gudgeons occur in inland drainages of the Murray-Darling basin.

- **Table 7-5 - Marine Vegetation Species Presumed Extinct as listed under the NSW *FM Act* (1994)**

Vanvoorstia bennettiana	Bennetts Seaweed

- **Table 7-6 - Distribution of Marine Vegetation Species Presumed Extinct as listed under the NSW *FM Act* (1994)**

Species	**Distribution**
Vanvoorstia bennettiana	Last known sites Port Jackson & Sydney Harbour

- **Table 7-7 – Vulnerable Aquatic Fauna Species as listed under the NSW *FM Act* (1994)**

Freshwater	
Archaeophya adamsi	Adams Emerald Dragonfly
Bidyanus bidyanus	Silver Perch

Branchinella buchananensis	Buchanans Fairy Shrimp
Macquaria australasica	Macquarie Perch
Nannoperca australis	Southern Pygmy Perch
Estuarine	
Epinephelus daemelii	Black Cod
Marine	
Carcharodon carcharias	Great White Shark

- **Table 7-8 - Distribution of Vulnerable Aquatic Fauna Species as listed under the NSW *FM Act* (1994)**

Species	Distribution
Freshwater	
Archaeophya adamsi	Only known from a few sites in the greater Sydney region.
Bidyanus bidyanus	Once widespread and abundant throughout most of the Murray-Darling river system.
Branchinella buchananensis	Gidgee and Burkanoko Lakes in the north-west of NSW.
Macquaria australasica	They are found in the Murray-Darling Basin and parts of south-eastern coastal NSW, including the Hawkesbury and Shoalhaven catchments.
Nannoperca australis	Once widely distributed throughout the Murrumbidgee and Murray River systems, also recently been discovered in the upper Lachlan River catchment.
Estuarine	
Epinephelus daemelii	All of NSW coast line.
Marine	
Carcharodon carcharias	All of NSW coast line.

- **Table 7-9 – Vulnerable Marine Vegetation Species as listed under the NSW *FM Act* (1994)**

Nereia lophocladia	Marine Brown Alga

- **Table 7-10 - Distribution of Vulnerable Marine Vegetation Species as listed under the NSW *FM Act* (1994)**

Species	Distribution
Nereia lophocladia	Muttonbird Island at Coffs Harbour

Appendix J Sample location maps


NORTH BANK
BELLINGEN
RALEIGH
MARX HILL
FERNMOUNT
MYLESTOM
SUNNY CORNER
MOUNT GLADSTONE
TARKEETH
RALEIGH SOUTH
HENRY ISLAND
SOUTH URUNGA
BRIERFIELD
KENNAICLE CREEK
SPICKETTS CREEK
NEWRY
Newry State Forest
WENONAH HEAD
PICKETT HILL
MISSABOTTI
VALLA
VALLA BEACH
BOWRAVILLE
HOWES CREEK
NAMBUCCA HEADS
TEWINGA
BELLWOOD
NORTH MACKSVILLE
CONGARINNI NORTH
TALARM
MACKSVILLE
PACIFIC HWY
Macksville Sewage Treatment Plant
CONGARINNI
UTUNGUN
SCOTTS HEAD
DONNELLYVILLE
WARRELL CREEK
GRASSY HEAD
WAY WAY
Legend
Water Quality Sites
SEPP14 Wetlands
Property Boundaries
WC2U Road design
PACIFIC HIGHWAY
Kilometres
URUNGA
MACKSVILLE
WARRELL CREEK
SKM
Warrell Creek to Urunga
Water Quality Site Locations

ENVIRONMENTAL ASSESSMENT | SINCLAIR KNIGHT MERZ

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Appendix K Historic data

Table 3: Species of fish recorded in the Nambucca and Bellinger River basins. The location of each study is given in relation to the investigation area (i.e. upstream, within, downstream). 1 = The Ecology Lab (1998), 2= Gibbs *et al*. (1999), 3 = Llewellyn (1983), 4 = Bishop (1993). 5 = Storrs

Family name	**Species name**	**Common name**	1 Nambucca (upstream)	2 Warrell (Downst.)	3 Bellinger (upstream)	4 Bellinger (upstream)	5 Bellinger (upstream)
Anguillidae	*Anguilla australis*	Short finned eel	✓				✓
	Anguilla reinhardtii	Long finned eel	✓		✓	✓	✓
	Hyperlophus vittatus	Sandy sprat		✓			
	Potamalosa richmondia	Freshwater herring			✓	✓	✓
Retropinnidae	*Retropinna semoni*	Australian smelt	✓		✓	✓	✓
Galaxiidae	*Galaxias olidus*	Mountain galaxias					✓
	Galaxias maculatus	Common galaxidas					✓
Cyprinidae	*Cyprinus carpio*	European carp				✓	
Plotosidae	*Tandanus tandanus*	Freshwater catfish			✓	✓	✓
Belonidae	*Tylosurus gavialoides*	Stout longtom		✓			
Poeciliidae	*Gambusia holbrooki*	Mosquito fish	✓	✓	✓	✓	
Melanotaenidae	*Melanotaenia duboulayi*	Duboulay's Rainbowfish	✓		✓	✓	✓
Hemiramphidae	*Hyporhamphus regularus*	River garfish		✓			
	Arrhamhus sclerolepis	Snub-nosed gar				✓	
Atherinidae	*Pseudomugil signifer*	Southern blue-eye	✓	✓	✓	✓	✓
Syngnathidae	*Urocampus carnirostrus*	Hairy pipefish		✓			
	Vanacampus margaritifer	Mother of pearl pipefish		✓			
Scorpaenidae	*Centropogon australis*	Fortescue		✓			
	Notesthes robusta	Bullrout	✓		✓	✓	✓
Chandidae	*Ambassis jacksoniensis*	Port Jackson glassfish		✓		✓	

Continued

Table 3: Continued

Family name	Species name	Common name	1 Nambucca (upstream)	2 Warrell (Downst.)	3 Bellinger (upstream)	4 Bellinger (upstream)	5 Bellinger (upstream)
	Ambassis marianus	Ramsey's glassfish		✓			
	Ambassis agassizii	Olive perchlet			✓		
Platycephalidae	*Platycephalus fuscus*	Dusky flathead		✓	✓	✓	✓
Percichthyidae	*Macquaria colonorum*	Estuary perch			✓		
	Macquaria novemaculeata	Australian bass				✓	✓
Apogonidae	*Siphamia spp.*	Siphonfish					
	Siphamia roseigaster	Silver siphonfish		✓			
Sillaginidae	*Sillago ciliata*	Sand whiting		✓			
Pomotomidae	*Pomatomus saltatrix*	Tailor					
Carangidae	*Caranx spp.*	Trevally		✓			
	Pseudocaranx dentex	White trevally					
	Scomberoides lysan	Queenfish		✓			
	Gnathanodon speciosus	Golden trevally					
Sparidae	*Acanthopagrus australis*	Yellow-finned bream		✓		✓	
Terapontidae	*Pelates quadrilineatus*	Four-lined trumpeter		✓			
	Pelates sexlineatus	Eastern striped trumpeter		✓			
	Terapon jarbua	Crescent perch		✓			
Lutjanidae	*Lutjanus russeli*	Moses Perch		✓			
Gerreidae	*Gerres subfasciatus*	Silver biddy		✓		✓	
Sciaenidae	*Argyrosomus japonicus*	Mulloway					
Girellidae	*Girella tricuspidata*	Luderick				✓	
Sparidae	*Chrysophrys auratus*	Snapper		✓			
	Rhabdosargus sarba	Tarwhine		✓			

Continued

Table 3: Continued

Family name	Species name	Common name	1 Nambucca (upstream)	2 Warrell (Downst.)	3 Bellinger (upstream)	4 Bellinger (upstream)	5 Bellinger (upstream)
Monodactylidae	*Monodactylus argenteus*	Silver batfish		✓			
Kyphosidae	*Girella tricuspidata*	Blackfish		✓			
	Microcanthus strigatus	Stripey		✓			
Mugilidae	*Liza argentea*	Flat-tail mullet	✓	✓			
	Mugil cephalus	Sea mullet	✓	✓	✓	✓	
	Myxus elongatus	Sand mullet		✓			
	Myxus petardi	Freshwater mullet	✓		✓	✓	✓
	Valamugil georgii	Fantail mullet					
Scatophagidae	*Scatophagus argus*	Spotted scat		✓			
Labridae	Unknown Labridae	Groper		✓			
	Achoerodus viridis	Eastern blue groper		✓			
Blenniidae	*Petroscirtes lupus*	Brown sabretooth blenny		✓			
Gobiidae	*Redigobius macrostoma*	Largemouth goby		✓			
	Arenigobius bifrenatus	Half bridled goby		✓			
	Favonigobius exquisitus	Exquisite sand goby		✓			
	Favonigobius tamarensis	Tamar goby		✓			
	Gobiopterus semivestitus	Glass goby		✓			
Eleotrididae	*Butis butis*	Bony-snouted gudgeon		✓			
	Gobiomorphus australis	Striped gudgeon	✓	✓	✓	✓	✓
	Gobiomorphus coxii	Cox's gudgeon	✓			✓	✓
	Hypseleotris compressa	Empire gudgeon	✓	✓	✓	✓	
	Hypseleotris galii	Firetail gudgeon	✓	✓			
	Hypseleotris spp.	Unidentified Gudgeon	✓	✓			
	Philypnodon grandiceps	Flathead gudgeon	✓	✓		✓	✓

Continued

Table 3: Continued

Family name	Species name	Common name	1 Nambucca (upstream)	2 Warrell (Downst.)	3 Bellinger (upstream)	4 Bellinger (upstream)	5 Bellinger (upstream)
	Philypnodon spp.	Dwarf flathead gudgeon	✓	✓			
Gobiidae	*Pandaculus lidwilla*	Dwarf goby		✓			
	Parkraemeria ornata	Goby		✓			
	Pseudogobius olorum	Blue-spot goby		✓			
	Mugilogobius paludis	Mangrove goby		✓			
Nomeidae	*Psenes arafurensis*	Banded driftfish		✓			
Monacanthidae	*Juvenile Monacanthidae*	Leatherjacket		✓			
	Meuschnia freycineti	Six spine leatherjacket		✓			
	Meuschnia trachylepis	Yellow-finned leatherjacket		✓			
	Paramonacanthus otisensis	Dusky leatherjacket		✓			
Tetraodontidae	*Marilyna pleurosticta*	Toadfish		✓			
	Tetractenos hamiltoni	Common toadfish		✓			

Appendix L Water quality results

Water quality parameters reported between 26th November and 30th November 2007

Site name	Coordinates*	Electrical conductivity (µS/cm)	DO (ppm)	DO (% sat)	pH	Turbidity (NTU)	Temperature (°C)
Williamson Creek Site 1a	491 705 / 6598 052	254	-	*	6.38	42	20.5
Williamson Creek Site 1a	491 498 / 6598 010	315	-	65	6.45	24	22.3
Boggy Creek Site 4b	497 549 / 6612 023	625	-	20.7	6.26	12.4	21.3
Cow Creek Site 5a	497 619 / 6613 038	258	5.75	-	6.28	0	25.4
Cow Creek Site 5b	497 728 / 6612 920	14700	4.5	-	6.5	5.9	25.8
Unnamed Tributary to Oyster Creek 7a	500 188 / 6616 493	203	2.5	-	6.18	7.5	24.3
Unnamed Tributary to Oyster Creek 7b	500 323 / 6616 504	270	4.2	-	6.34	11	23.3

* Due to equipment malfunction

- Not recorded

Water quality parameters reported between 14th July and 17th July 2008

Site name	Coordinates	Electrical conductivity (µS/cm)	DO (ppm)	DO (% sat)	pH	Turbidity (NTU)	Temperature (°C)
Butchers Creek Site W2a	489895/6594912	147.67	5	49.4	4.8	3.6	14.62
Butchers Creek Site W2b	489761/6594917	148	3.43	34.2	4.65	2.07	14.49
Rosewood Creek Site W3a	490468/6595871	250	7.27	72.17	6.44	6.5	15.12
Rosewood Creek Site W3b	490458/6596225	239.33	3.4	64.53	5.1	8.4	15.53
Stony Creek Site W4a	490908/6596713	425.33	6.47	62.4	6.12	24	14.21
Stony Creek Site W4b	490772/6596913	438	8.13	79.1	5.64	17.73	14.67

Appendix M Macroinvertebrate results

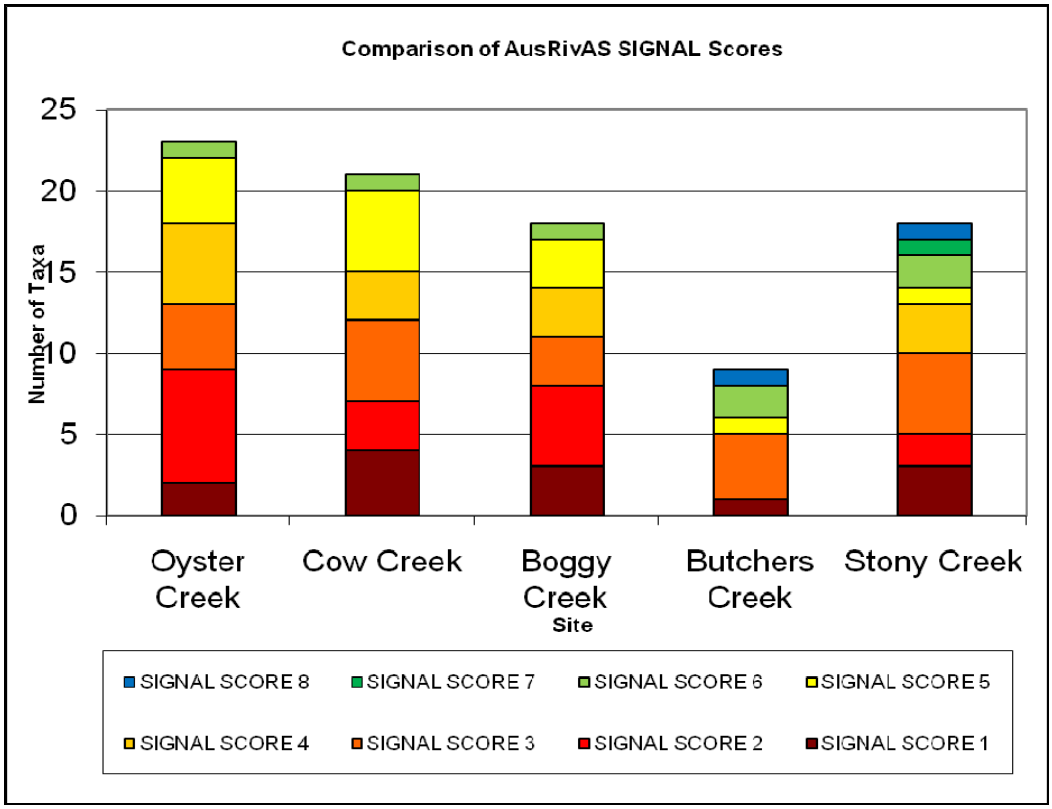
- **AusRivAS modelling output**

Site	Butchers Creek	Stony Creek	Cow Creek	Boggy Creek	Oyster Creek
NTE50	9.92	13.67	10.49	10.49	10.46
NTP50	13	18	13	13	13
NTC50	6	9	8	8	8
OE50	0.61	0.66	0.76	0.76	0.76
E50Signal	4.24	4.43	3.92	3.91	3.93
O50Signal	4.83	4	3.38	3.13	2.75
OE50Signal	1.14	0.9	0.86	0.8	0.7
E0Signal	4.3	4.74	3.92	3.92	3.93
O0Signal	4.22	3.76	3.62	3.23	3.6
OE0Signal	0.98	0.79	0.92	0.82	0.91
Band	B	B	B	B	B

- **Summary water quality statistics**

Parameter	No. Replicates	Boggy Creek	Cow Creek	Oyster Creek	Butchers Creek	Stony Creek	ANZECC/ ARMCANZ (2000) trigger values
pH	3	7.11	7.22	**6.99**	**4.65**	**6.12**	7.0 - 8.5
Conductivity	3	485.67	245	258.33	148	425.33	
Salinity	3	0.24	0.1	0.1133	0.08	0.24	
Turbidity (NTU)	3	**102.03**	**17.93**	**71.8**	2.07	**24**	0.5 - 10
Dissolved Oxygen (%	3	**3.37**	**51.43**	**32.3**	**34.2**	62.4	80 - 110
Temperature	3	17.45	22.55	21.31	14.49	14.21	
Alkalinity (mg/L	1	40	35	35	11	16	

- **Comparison of AusRivAS SIGNAL scores**



- **AusRivAS band scores (observed to expected ratios)**