Appendix A Biodiversity Connectivity Strategy

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Introduction

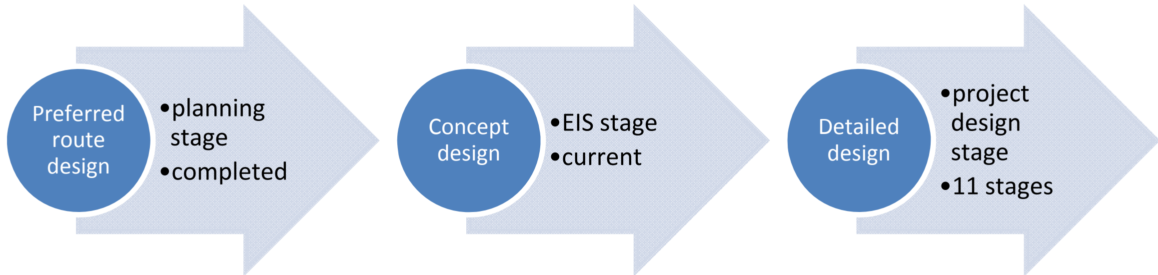
The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The types of impacts on fauna associated with the barrier effect of new roads are well documented (for review see Taylor and Goldingay 2010). Briefly, these effects relate to:

1) Affecting regional and local movement corridors

2) Preventing adequate genetic exchange between populations

3) Decreasing the area of available habitat needed to maintain viable, healthy populations through fragmentation.

The connectivity strategy for the project aims to address the barrier effect that the unmitigated highway construction would have on fauna movements. The strategy has been developed and will continue to develop through a number of stages as outlined below.



The objective of the EIS (concept design) was to review what was done for the preferred route design, which was based on broad outcomes. The concept design aims to focus on target species outcomes for the whole of project and a series of detailed design principles based on these outcomes to take to the next stage of the project.

Preferred route design

The flora and fauna connectivity measures that were incorporated into the preferred route design were based on performance-based outcomes. This approach differs from rigid design criteria, which have been addressed at the concept design and will be addressed in the detailed design phases of the project. The approach taken in developing the preferred route design with regard to connectivity outcomes was to:

- Minimise impact on endangered ecological communities
- Minimise impact on threatened flora and fauna species
- Minimise impact on key habitat areas
- Minimise impact local and regional fauna movement corridors
- Minimise impact on aquatic ecosystems
- Ensure the location and sizing of fauna crossings are such that fauna species are not disadvantaged or threatened by their usage
- Ensure that fauna crossings are placed at locations and appropriately designed to ensure their effectiveness for the targeted species
- Provide adequate passage for fauna species across the upgraded highway, and ensure that fauna is not channelled onto adjoining roads such as the old highway or busy service roads.

Further, in order to target and address the required outcomes, the preferred route design included the consideration of:

- Appropriate location and sizing of fauna crossings at a project specific level applicable to each of the development project sections 1-2, 3-5, 6-8 and 9-11
- Appropriate accommodation of fauna crossings in key habitats and regional corridors
- Indicative locations of fauna fencing
- General arrangements for amphibian-friendly culvert designs
- Minimisation of intrusion into sensitive ecosystems such as endangered ecological communities, SEPP 14 wetlands, key habitats and corridors
- Minimisation of intrusion into nature reserves, national parks and state conservation areas.

Concept design

The environmental assessment has built on this previous work from the concept design to develop a whole of project Biodiversity Connectivity Strategy. The strategy focuses both on design and management actions that can be applied to minimise the barrier effect of the entire proposed highway upgrade.

The goal of the strategy is to maintain connectivity, as well as enhance connectivity where feasible and reasonable near the road corridor. Additionally, the Biodiversity Connectivity Strategy discusses opportunities for protection or revegetation at strategic sites adjoining the project boundary to enhance connectivity. The strategy outlines research and monitoring needs for crossing structures where gaps in knowledge for key taxa have been identified or further monitoring is required to inform decisions regarding future detailed design. The format of the strategy is presented as follows:

- Guiding principles: **the basis for developing whole of project connectivity goals and influence decision making**
- Connectivity strategy goals: **provides a focus for the strategy that is appropriate at a local and regional level**
- Decision-making framework: **presents a framework for meeting the connectivity goals including identification of the issues and how these have been met, outlines future performance monitoring needs and strategic connectivity enhancement opportunities**
- **Connectivity design measures**: summary of structures proposed for the concept design including fencing locations and a set of principles to be adopted in the detailed design.

A.1 Guiding principles

As a first step in developing the strategy a set of guiding principles were devised to assist in developing project specific connectivity goals and decision-making. These guiding principles have been adopted from the *Draft Wildlife Connectivity Guidelines: improving wildlife connectivity on RTA projects* (RTA, 2010) with input from agency stakeholder connectivity workshops (Table A-1).

Table A-1 Guiding principles to assist decision-making for biodiversity connectivity

Guiding principles	Description
Principle 1. Avoid first, mitigate second and if neither is possible, offset.	Avoid fragmenting or creating barriers to movement where feasible and reasonable. • Consider the location of breeding and roosting habitats, critical habitats and known populations of fauna, in particular threatened species • Consider the location of known fauna corridors and key habitats for threatened species Mitigate (ie reduce the severity of any unavoidable impacts) • Use natural connectivity options • Use existing structures if appropriate for threatened species • Use specialised (species or group-specific) structures Offset any residual connectivity impacts by re-establishing connectivity elsewhere in the landscape where reasonable to do so.
Principle 2: Connectivity issues need to be addressed at all stages in project development, commencing with the earliest stage.	The requirement to maintain and enhance connectivity for wildlife needs to be addressed at all stages within a road project. This includes: • Prior assessment and evaluation of threatened species, habitat and populations; species movements and distribution (including habitat mapping) • Identifying the need for and location of connectivity requirements through data and spatial analysis. • Identifying the type of mitigation measure to be employed • Undertaking the research and monitoring required. • Collection of relevant baseline data prior to construction Opportunities to modify the design of a road decreases as the project progresses. The earlier potential wildlife connectivity issues are identified, the greater the opportunity to resolve them, the lesser the cost and the lower the overall impact.
Principle 3: New road projects should aim to increase the level of overall wildlife connectivity within the region.	Existing roads have caused large-scale disruptions to the movement of wildlife. Therefore, opportunities to increase the connectivity of the overall road network for wildlife should be identified and investigated as a part of a road project.
Principle 4: Always consider a landscape-scale perspective when making decisions about mitigation measures.	Many wildlife and ecosystem processes operate at landscape scales, with some wildlife moving tens or hundreds of kilometres. Therefore, assessing the need and location of mitigation measures only within a narrow corridor along the road project is unlikely to meet fully the needs of wildlife. Assessing landscape connectivity includes: • Adjacent land uses • Local and regional corridors and habitat linkages • Future developments adjacent to the corridor and the conditions of approval to those DAs.

Guiding principles	Description
Principle 5: Maintaining connectivity for wildlife in highly cleared landscapes is equally important to maintaining connectivity across large areas of intact habitat.	Animals have limited opportunities to move around landscapes where there has been extensive removal of habitat (eg agricultural or urban/suburban landscapes). Therefore, the small patches and narrow corridors of native vegetation that remain in highly cleared landscapes are very important for maintaining connectivity.
Principle 6: Mitigation should include measures to (i) facilitate the effective crossing of wildlife; (ii) funnel fauna to the crossing location; and (iii) reduce wildlife mortality.	The impacts of roads on wildlife usually include a combination of mortality and loss of connectivity, and mitigation measures need to address the causes of both reduced movement and/or increased mortality. Wildlife mortality due to collision with vehicles can be the greatest immediate threat to populations of wildlife, especially when the rate of mortality is high relative to the size of the population. For example, an increase in the rate of crossing at a location may be redundant if the rate of mortality remains high. Similarly, preventing access to the road via the use of a fauna fence may prevent wildlife mortality, but could also result in the creation of a complete barrier to movement.
Principle 7: Wildlife crossing structures need to be designed to maximise environmental benefit.	Wildlife crossing structures should be designed to facilitate crossings by the target species and by as wide a range of other species as possible. Structures should be designed to principles supported by science and demonstrated to be effective or designed and located on the adoption of the precautionary principle.
Principle 8: Projects should aim to maintain and enhance existing connectivity, rather than removing and then creating new connectivity.	Existing landscape and habitat features at road projects are often valuable for connectivity, and are costly and difficult to replace if destroyed during road construction. For example, retaining tall trees within a suitably wide median may be a suitable crossing option for gliding marsupials, but if removed, regrowth may take 50 or more years to reach a height suitable for use.

A.2 Connectivity goals

As stated, the overall objective of the Biodiversity Connectivity Strategy is to maintain landscape connectivity and investigate opportunities to enhance connectivity as part of the project. The strategy therefore aims to minimise the barrier effect for a wide diversity of fauna species, groups and ecosystems. Based on the guiding principles discussed, specific goals are presented below. These goals form the basis of the decision-making framework.

- Reduce and minimise roadkill
- Avoid and minimise habitat loss and fragmentation
- Maintain and improve movement pathways for all fauna groups
- Maintain and improve population viability and gene flow
- Maintain and improve connectivity
- Identify monitoring needs that build on existing knowledge to ensure the performance of the mitigation.
- Maintain connectivity during construction for aquatic species.

A.3 Decision-making framework

As the next step, the connectivity goals described formed the framework for making decisions regarding optimum location and type of fauna crossing structure needed on the project, and to identify where targeted mitigation measures such as fauna exclusion fencing may be required. The steps taken to achieve these goals are described below while detail on the connectivity measures developed for the project is presented in the following sections.

1. Identify landscape connectivity issues for the whole of project

The identification of landscape connectivity issues was developed through a number of methods this included consultation with the Office of Environment Heritage (OEH) and Department of Primary Industries (DPI) (NSW fisheries) which occurred in the early stages of the route options assessment and preferred route studies and continued through the preparation of the Environment Impact Statement (EIS) with a critical review the strategy.

Initially meetings were held with OEH (the then Department of Environment and Conservation) and DPI (Fisheries) in 2006 and 2007 to discuss connectivity across Broadwater National Park, located in Section 7 of the project. These discussions culminated in the provision of two overpass structures, two underpass structures, a bridge and a glider rope crossing at important locations within the park. These measures were specifically targeted to the fauna species known from the national park.

The Office of Environment and Heritage and DPI (Fisheries) were consulted further on the adequacy of the Biodiversity Connectivity Strategy as part of the EIS in 2011 and 2012 through critical review of the measures proposed and the provision of knowledge on important populations and habitats in the study area. This consultation has contributed to the overall design of the fauna mitigation measures through discussion, review and comments. In particular several locations were identified during stakeholder meetings as important for connectivity based on information and data maintained by the departments.

Further identification of landscape connectivity issues was developed through review of spatial and field survey data for the project and included:

- Identifying the fauna species and populations directly adjoining the upgrade and the conditions which may influence their movements such as access to important habitat or maintenance of gene flow within the population
- Identifying where feasible and reasonable the land tenure and future land use adjoining the project boundary to ensure that planning for connectivity is not hindered in the future as a result of future proposed clearing and development, for example proposed urban or industrial release areas (DCP/LEP zonings)
- Reviewing relevant government funded projects relating to regional connectivity in northern NSW such as the key habitats and corridors project (DECC 2003), climate change corridors project (DECC 2007), and any additional corridors identified in the NSW North Coast Regional Biodiversity Strategy (DECC 2010f). This combined data looks at the broad-scale connectivity within the whole region and assigns priority fauna species to different linkages
- Identifying other local and regional plans for connectivity (eg local government biodiversity strategies, Environmental Protection Zones; DCP/LEP zonings, SEPPs and NSW state forests - Forestry Management Zones)
- Examining the project boundary overlain on current high resolution aerial photography and interrogating the GIS to identify localised habitat linkages not picked up in regional corridors. This included areas of habitat which may become isolated as a result of the project or where revegetation could assist in improving connectivity in regional corridors
- Reviewing the size and location of habitat patches on opposite sides of the project boundary and their suitability as fauna habitat
- Analysing records of roadkill or injured wildlife from the RMS or other organisations such as Wildlife Information Rescue and Education Service (WIRES), Northern Rivers and Clarence Valley Wildlife Carers. These data highlight broad sections of the highway (2-5 kilometres lengths) where roadkill and wildlife injury is high.

A summary of some of the important landscape connectivity issues identified in the study area is identified below.

- Numerous key habitats, regional corridors and climate change corridors were identified in the study area. These regional corridors are also identified in the concept design report alongside the proposed fauna crossing structures and relative to stations along the project boundary to demonstrate the provision of connectivity measures.

Some of the key regional connectivity areas interested by the project boundary include:

- Between Woolgoolga and Glenugie State Forest (project sections 1 and 2) incorporating the northern end of Wedding Bells State Forest, Newfoundland State Forest and the Wells Crossing Flora Reserve, Yuraygir State Recreation Area and the adjacent Yuraygir National Park. This area is part of a broad regional corridor connecting the Dirty Creek Range to southern Yuraygir National Park
- Clarence River floodplain adjacent to the Coldstream and Shark Creek wetlands (project section 3 and 4), including Chaffin Swamp, Pheasant Creek, Coldstream River, Black Snake Creek, Bostocks Gully, Champions Creek, and Chaffin Creek
- Iluka Road to Tabbimoble (project section 6 and 7), including Mororo and Tabbimoble State Forest and linking with Tabbimoble Nature Reserve and Bundjalung National Park

- Broadwater National Park, south of Broadwater (project section 9)
- Habitat near the township of Wardell incorporating the Wardell Heath area and on the northern side of the Richmond River (project section 10)
- The Clarence Valley Council Regional Biodiversity Plan has adopted the OEH key habitats and corridors dataset as a basis for conserving corridors in the LGA. The plan has also added a local corridor in the lower Clarence Valley around Gulmarrad in project section 5
- The Richmond Valley Council Koala habitat planning map has identified primary Koala habitat either side of the project boundary south of Woodburn in project section 7
- The project boundary intersects the key habitats associated with Broadwater National Park through Section 9 and would widen the existing highway corridor in this area.

2. Connectivity goals for key listed fauna populations

The results of the background data analysis and fauna field surveys identify two types of records, i) records of threatened fauna consisting of low density of scattered locations of single species where it is difficult to define the population distribution, and ii) multiple records of the same species over a defined location or habitat type, for example Emu, Rufous Bettong, Koala or Oxleyan Pygmy Perch. The strategy defines the latter as key listed fauna populations.

The project would impact on several key listed fauna populations, including:

- Endangered population of the coastal Emu in the lower Clarence Valley and Yuraygir area and intersected by the project boundary from Pillar Valley to lower Shark Creek (sections 3 and 4). The project would intersect identified important habitat for pre and post breeding life-cycle activities, further information is presented below
- The presence of known and potential habitat for the Oxleyan Pygmy Perch in Section 1 (Cassons Creek and Redbank Creek), Devils Pulpit to Tabbimoble (project section 7), and between Woodburn and Broadwater (Section 9) including MacDonalds Creek and Broadwater National Park
- Local populations of Yellow-bellied Glider and Squirrel Glider from Woolgoolga to Wells Crossing (project sections 1 and 2), Tabbimoble (sections 6 and 7) and Broadwater National Park (project section 9)
- Local populations of Rufous Bettong, Common Planigale and Brush-tailed Phascogale from Woolgoolga, Halfway Creek, Wells Crossing, Glenugie and Pillar Valley (project sections 1 to 3)
- A relatively higher density of records of Spotted-tailed Quoll from Woolgoolga and Halfway Creek north to Wells Crossing (project sections 1 to 2) and Devils Pulpit to Broadwater (sections 7 to 9) suggesting the likely presence of quoll populations in these areas
- Scattered areas of Primary and Supplementary Koala Habitat identified on both sides of the project boundary between Tabbimoble and Woodburn (project section 7) as well as high densities of koala records between Woodburn and Wardell (project sections 9 and 10) including Broadwater National Park. The majority of these records occur to the west of the project boundary but in some locations these cross the corridor around the Richmond River

- Local population of Long-nosed Potoroo in the Wardell Heath (project section 10)
- Giant Barred Frog: Section 1 in the Wedding Bells State Forest and also identified near Halfway Creek in Section 2, and Section 9 Broadwater National Park. Green-thighed Frog potential populations either side of the highway in Section 2 Halfway Creek to Wells Crossing Flora Reserve and Devils Pulpit to Tabbimoble Swamp Nature Reserve (project section 7). Wallum Froglet also Tabbimoble Swamp Nature Reserve (project section 7) and in project section 9 Broadwater National Park along with the Olongburra Frog.

The general connectivity goals presented in Section A2 are applicable to these species. Further species specific connectivity goals are also presented for identified key fauna populations.

Table A-2 Species specific connectivity goals

Important populations	Project section	Connectivity goal
Oxleyan Pygmy Perch & Purple spotted Gudgeon	1 and 7-9	Maintain natural flooding regimes which are required for dispersal of individuals and minimise impacts on critical water quality conditions (appropriate for threatened fish) during construction and operation.
Rufous Bettong	1-3	Reduce and minimise roadkill to maintain viable populations
Common Planigale	1-3	Reduce and minimise roadkill to maintain viable populations
Yellow-bellied Glider	1-2	Promote gene flow and provide functional crossing opportunities
Squirrel Glider	1-4, 7 and 9	Promote gene flow and provide functional crossing opportunities
Brush-tailed Phascogale	1-2 and 7	Reduce and minimise roadkill to maintain viable populations
Emu population	3-4	Maintaining access to important habitat for pre-and post breeding life cycle activities and minimise road mortality to maintain a viable population.
Spotted-tailed Quoll	1-2 and 7-9	Maintain home range movements for individuals, maintenance of connectivity for populations and to prevent and minimise roadkill
Koala	7 and 9-10	Maintain home range movements for individuals, maintenance of connectivity for populations and to prevent and minimise road kill
Long-nosed Potoroo	10	Prevent and minimise roadkill
Giant Barred Frog	1-3, 6-8	Maintain access to important habitat and prevent and minimise roadkill
Green-thighed Frog	2 and 6-7	Maintain access to important habitat
Wallum Froglet	7-9	Maintain access to important habitat
Olongburra Frog	9	Maintain access to important habitat

Connectivity requirements for Emus

The project would impact on a portion of the emu population which uses habitat between Pillar Valley and Shark Creek (sections 3 and 4). Construction of the highway in this location has potential to create a barrier for emus accessing important habitat in pre- and post-breeding life-cycle activities associated with wetland and floodplain habitat from Pillar Valley, north of Tucabia and the Shark Creek area.

The process for identifying and managing emu connectivity requirements on the project is presented in Figure A-1.

At the stage of developing the EIS, steps 1-7 of the process have been conducted and are described below, while steps 8, 9 and 10 relate to detailed design, construction and operational monitoring respectively.

Figure A-1: The process for managing emu connectivity requirements

1. Collect known information on emu behaviour
Includes: expert advice, review of existing records, interviews with landholders, analysis of road kill hot spots

2. Commence research into emu behaviour to fill knowledge gaps.
Includes genetic analysis of emu feathers/dung to characterise population, identify individual movement patters and develop a monitoring baseline

3. Develop goals for emu connectivity measures
Based on information in step 1 and review as research information becomes available

4. Propose emu connectivity measures.
Identify the type, location and number of wildlife connectivity measures required to meet emu connectivity goals.

5. Are emu connectivity measures feasible and reasonable?
Refer to further information below

6. Identify and make provision for precautionary options
Options that could be implemented if research and/or monitoring identify that additional or alternative measures are required.

7. Describe and justify the selected emu connectivity measures

8. Detail design of emu connectivity measures.
The design should include consideration of any new information that comes from Step 2.

9. Construct emu connectivity measures
Construct the emu connectivity measures in accordance with designs in Step 8.

10. Monitor emu connectivity measures.
Review performance of connectivity measures against goals. Depending on outcome of monitoring the following 4 options would be considered in consultation with OEH:

- Maintain wildlife connectivity measures
- Modify design of existing measures where feasible and reasonable
- Construct additional measures identified in Step 6
- Consider additional offset measures to improve connectivity elsewhere

The following information presents further details on the information gathered for steps 1-7 of the emu mitigation approach.

Step 1: Collect known information on emu behaviour

Information on the behaviour of emus in the study area has been gathered through consultation with land managers (OEH) and land owners familiar with the movements and behaviour of emus in the study area in addition to an update and review of existing emu records as provided in the NSW Atlas (updated January 2012) and an analysis of road kill hotspots.

Knowledge on emu groups and their range are based on interpretation and discussion of the annual survey results from NPWS land managers (Gina Hart NPWS and Matt Clarke formerly NPWS) and interviews with property owners in the Pillar Valley to Tyndale area.

Step 2: Commence research into emu behaviour to fill knowledge gaps

From the review of the existing emu population data it is evident that there are gaps in knowledge that could assist the Biodiversity Connectivity Strategy goals. This relates to the lack of accurate information on emu group size, and including the distribution and range of groups and their spatial and temporal movements. Additionally there is no information on the likely efficacy of the proposed crossing structures. These factors contribute to uncertainty as to the level of impact the project would have on the population and highlight a lack of baseline data from which to monitor the impacts post-construction.

Detail on the emu research and monitoring strategy is presented in Appendix B. In brief, the strategy comprises post-construction monitoring of crossing structures and emu movements incorporating a satellite tracking and remote camera study.

The intent of this study is to gather further information that may assist in understanding the impacts of the project on emu movements and habitat use and assess the performance of connectivity measures against goals.

Step 3: Develop goals for emu connectivity measures

Species specific connectivity goals were developed for key fauna populations and have been discussed previously. The goals of the emu connectivity measures are to:

- maintain access for emus to important habitat for pre-and post breeding life cycle activities associated with floodplain wetlands and riparian habitats
- minimise road mortality on the new highway
- maintain connectivity to other subgroups for breeding opportunities

Step 4: Propose emu connectivity measures

The review of existing emu data from step 1 suggest that the population is divided by a number of groups which show fidelity to particular areas and habitat that support important pre and post-breeding life cycle events. The degree of relatedness and interaction between the groups is not known.

The majority of the population is centred on Yuraygir National Park at a considerable distance from the project boundary which includes:

- Southern Yuraygir (Station Creek to Red Rock River)
- Central Yuraygir (Wooli - Diggers Camp - Minnie Water - Sandon [village])
- Northern Yuraygir (Sandon River - Brooms Head - Wooloweyah - James Creek – Taloumbi).

At least two separate groups to these occur within the study area affected by Section 3 and 4 of the project, this includes:

1. A group ranging within the area south of Tucabia from the Coldstream River wetlands in the west to Pillar Valley and Yuraygir National Park in the south and east. Reported to frequent properties around Pillar Valley Creek, Amos Creek, Black Snake Creek, Chaffin Creek and their tributaries including lands around Mitchell Road and Firth Heinz Road. Nesting has been reported above the floodline around the foothills of Chaffin Hill and Mitchell Hill. Emu flocks have been observed grazing in open grassy paddocks to the east and west of Whites Bridge and north to Ellis Swamp and their presence in these areas has extended over longer durations during previous droughts

2. A second group is largely found on the agricultural land and woodlands between Pine Brush and Candole State Forest in the south, including Somervale Flat and the Chainy Waterholes across to Champions Creek in the west and north to Tyndale Swamp, Shark Creek and Green Hill including cane farms around Byrons Lane and McIntyres Lane at Tyndale.

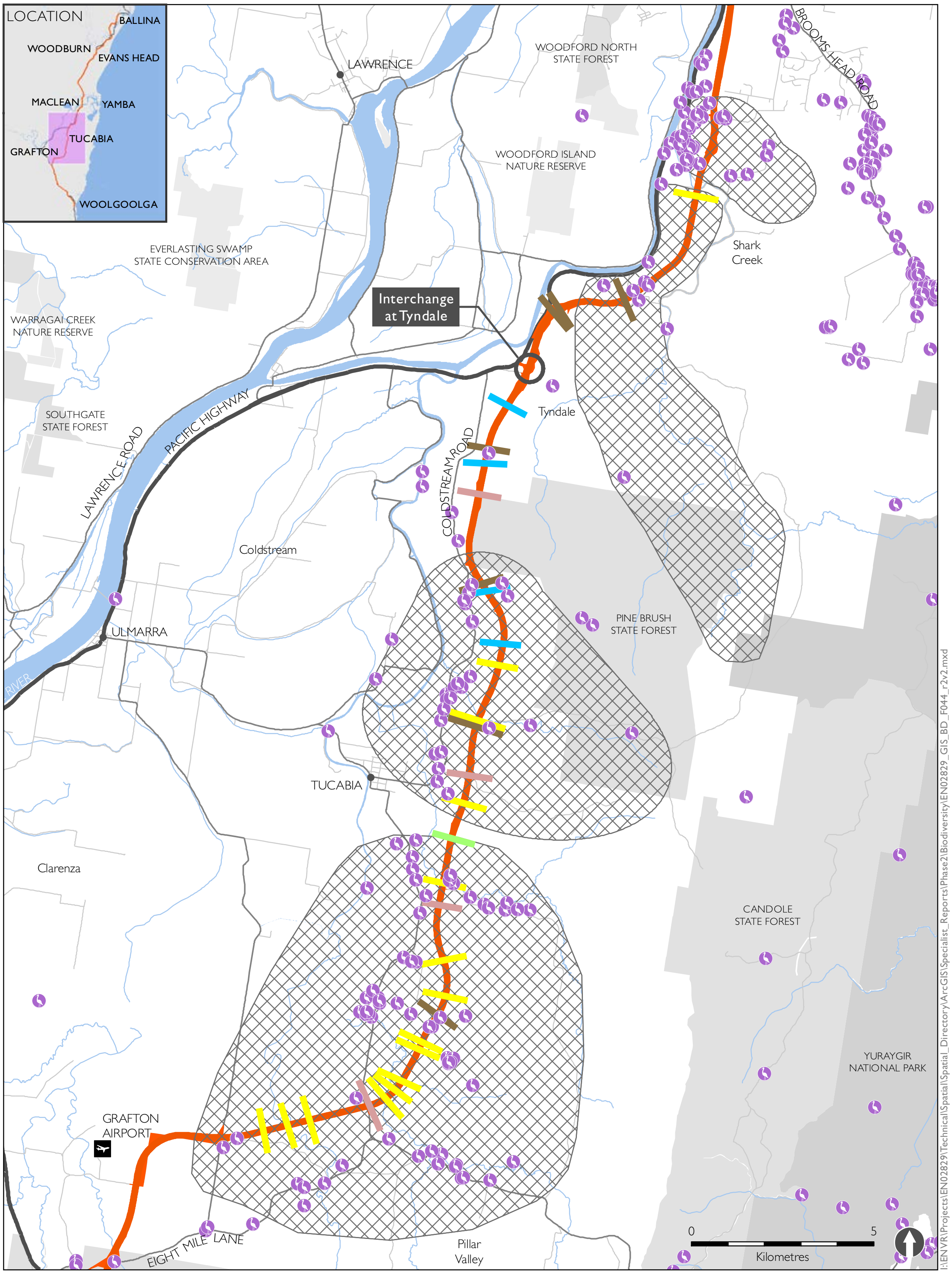
These latter groups are typically active around the floodplain and creek flats including agricultural lands during pre- and post-breeding activities in spring and summer with the cane fields being frequented by adult males raising young. There is some evidence to suggest that nesting occurs above the floodline further east of the project boundary, for example Chaffin Hill and Mitchell Hill and may extend east to the foothills of the Summervale Range. These broad locations where regular movements have been reported are identified on Figure A-2 and these locations were targeted for the placement of crossing structures for emus.

The analysis of emu road kill hotspots was discussed in the working paper**.** This information was used to predict levels of emu collision risk along the project boundary in the critical emu areas identified between Eight Mile Lane at Glenugie and McIntyres Lane at Tyndale.

An index for predicting levels of emu collision risk along the proposed project boundary between Glenugie and Maclean was developed using the analysis of field and spatial data. A total of 53 data points were positioned at one kilometre intervals along the project boundary, commencing at station 33.8 and concluding at station 85.8. Each data point was assigned a low, medium or high emu collision risk rating according to the following criteria:

- The presence of mature forest either side of the project boundary
- Vegetation within five metres of the data point
- Forested land within 500 metres
- A distance of up to five metres to vegetation two metres or taller in height.
- A known emu collision site within one kilometre, three kilometres, and five kilometres
- Presence of water within one kilometre, three kilometres, and five kilometres

Figure A-2 Emu distribution and proposed emu connectivity structures in Section 3 and 4



Woolgoolga to Ballina upgrade project
Upgrade completed to dual carriageway
Existing Pacific Highway
Emu Atlas data records (1980-2012)
Emu connectivity zone
Dedicated Emu Structure
Combined Emu and Bridge Structure
Combined Emu and Drainage Structure
Incidental Emu Structure (road underpass)
Incidental Emu Structure (road overpass)

The collision risk ratings according to the overall index score for each point is presented in Figure A-3, a description of the location of proposed bridges structures has also been presented in the figure. Further description of the bridge specification and design principles is provided in Section A.5. Of the 53 kilometres of project boundary assessed, 17 kilometres is considered 'low' risk for emu collisions, 23 kilometres is considered 'medium' risk, and 13 kilometres is considered 'high' risk.

The southern-most portion of the corridor (between station 33.8-42.8) at Glenugie is mostly low to medium risk for emu collisions. However, at station 43.8 (just north of Wants Lane near Sandy Crossing) the risk category escalates to 'high' for 12 kilometres of corridor (to just north of Bostock Road), and then 'medium' for a further 13 kilometres to the Pacific Highway north of Tyndale. Hence, almost the entire project boundary through Pillar Valley, Tucabia, Coldstream and Tyndale is considered high or medium risk for emu collisions. There is also another 4 kilometres medium-high risk section of the corridor at Shark Creek to McIntyres Lane.

Emu collision sites are usually within 10 metres of mature forest and 40 metres of water, where there is vegetation two metres high or taller within five metres of the road's edge, and no fence between the forest and the road. These significant descriptors were used in the creation of an index to categorise sections of the project boundary according to the risk of emu collisions. A significant portion of the project boundary between Glenugie and Maclean is considered likely to pose medium to high risk of emu collision if unmitigated because much of the corridor passes through mature or regenerating forest.

Fewer emu collisions occur where there is a fence, with a wider cleared roadside verge adjacent to a cleared paddock. This suggests fencing and emu visibility may be important factors in avoiding a collision. High and medium risk portions of the project boundary should be fenced, and regular, appropriate crossing structures installed to reduce the risk of emu collisions. The low risk portions of the project boundary should be assessed for their specific risk factors, and mitigation measures tailored to them, such as maintaining slashed roadside verges where wide grassy areas already exist, avoiding planting of known emu food plants and maintaining existing fencing.

The review of data on emu behaviour in the study area suggests that emus move through forested habitats and may use this habitat for nesting, but frequent cleared landscapes in farming and cropping land as well as clearings through forests, such as roads, tracks or easements. During the pre and post-breeding life-cycle events in spring and summer there is a correlation with lower-lying lands associated with the floodplain or creek flats and this may be related to dietary and watering requirements. There is a tendency to drink regularly and even bathe occasionally in summer.

The data suggests that the relatively stable environmental conditions associated with the floodplain wetlands and swamps of the Coldstream River, and adjacent Pillar Valley Creek, Chaffin Creek, Champions Creek and Shark Creek including the associated grazing and cane land support reliable food and water resources, both spatially and temporally. The incidence of broad movement pathways and the risk assessment results suggests that any crossing structures targeting this species need to be closely spaced with multiple structures needing to cover a broad distance. The factors considered in located and sizing structures included:

- The distribution of known habitats and movements and in particular the location of wetlands and connectivity of the surrounding landscape to these
- The body size of the emu standing to two metres.

As there is no evidence to suggest that emus would use a culvert or tunnel, and based on the limited effectiveness of these structures for cassowaries, as a precautionary measure it has been assumed that bridges with a minimum below bridge vertical height of 3.6 metres and up to 5.5 metres would present the minimum underpass design for emus.

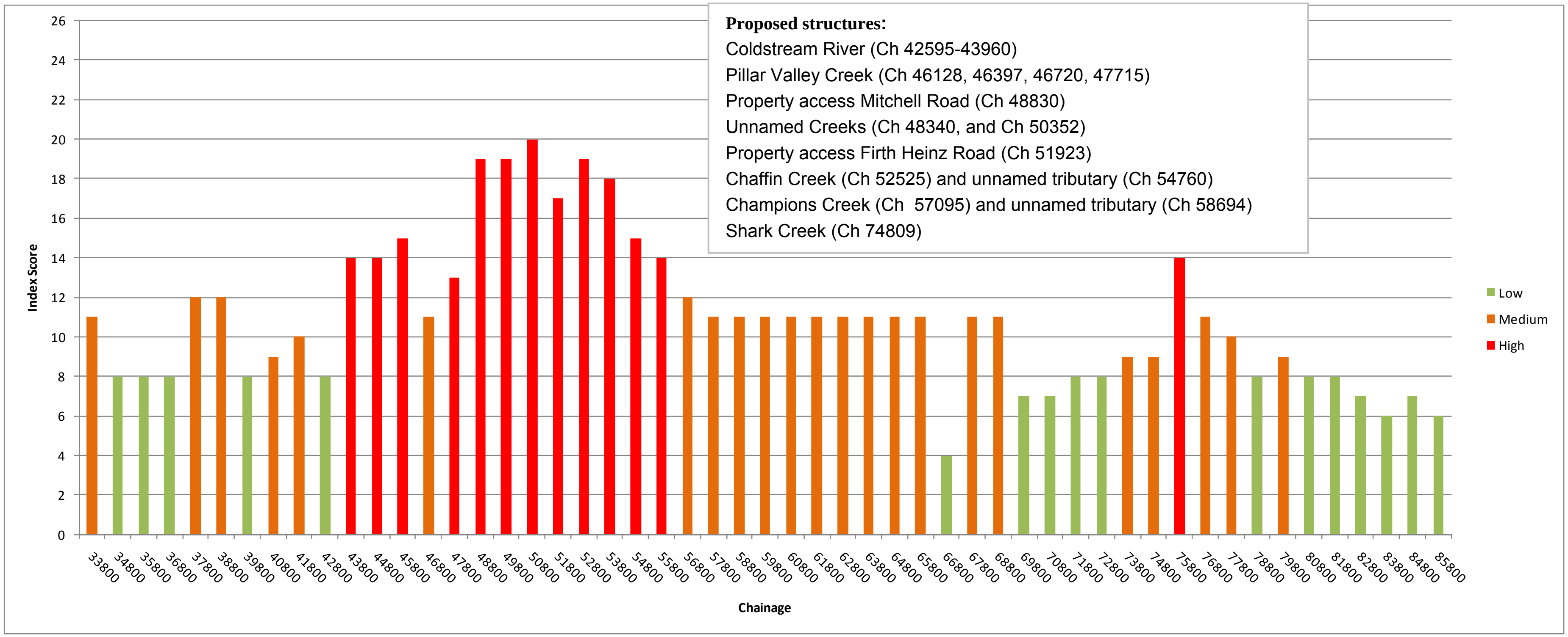


Figure A-3: Emu collision risk at one kilometre intervals along the project boundary between Glenugie and Maclean. (Station 33.8 is at Glenugie; station 85.8 is just north of Maclean)

Step 5: Assess if emu connectivity measures are feasible and reasonable

The following information presents a process for deciding if the proposed emu connectivity measures are feasible and reasonable and represent value for the project and the endangered emu population.

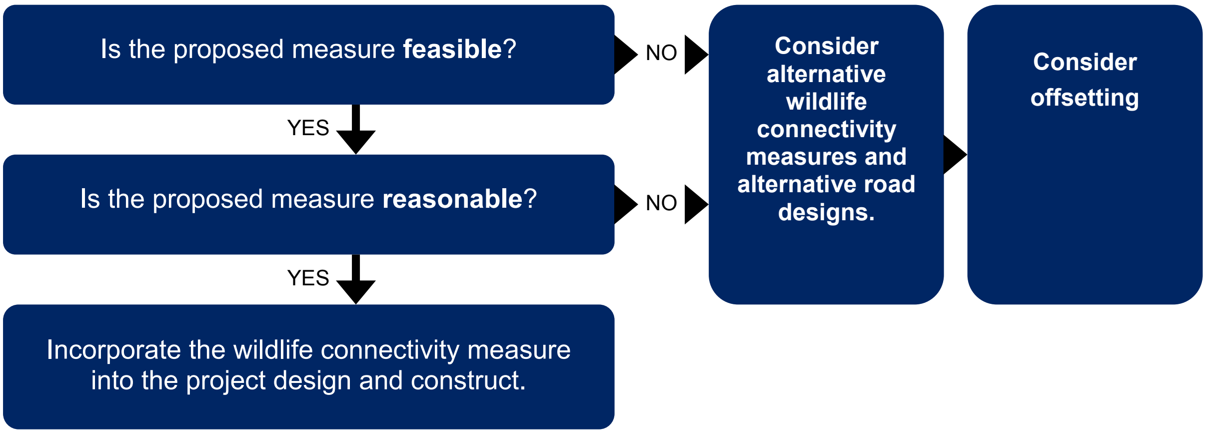


Figure A-4: The process for deciding if a proposed wildlife connectivity measure is feasible and reasonable.

Determining if a proposed wildlife connectivity measure is **feasible:**

Feasibility is defined as “capable of being done, effected, or accomplished”. The feasibility of installing a particular wildlife connectivity measure is dependent on the site, engineering and/or environmental constraints.

Questions that help determine if a wildlife connectivity measure (or suite of measures) is feasible include:

- Can the proposed measure be constructed in this location?
- Can the proposed measure be constructed without unacceptable impacts such as clearing of high conservation value vegetation, impacts on heritage values or impacts on operational road safety?
- Can the proposed measure be safely accessed and maintained?

Determining if a proposed wildlife connectivity measure is **reasonable**

Use your judgement when deciding if wildlife connectivity measures are likely to be reasonable. Take into account the overall benefits, cost and community views of the wildlife connectivity measure.

Consider the following questions when determining if proposed wildlife connectivity measures are likely to be reasonable:

- Are construction costs a reasonable proportion of the budget for the project?
- What is the service life of the measure and what are the costs for replacement?
- Is it likely that the type, size and placement of the measure would mitigate the potential impacts of the project for the target species?
- Is the extent of potential improvement from implementing the measure high compared to its cost? For example, a high-cost structure could be feasibly built but only deliver limited benefits compared to other lower cost options.
- Is the cost of ongoing maintenance of the measure a reasonable proportion of the asset maintenance budget for the project?

Document the justification for proposed wildlife connectivity measures that are not considered to be feasible or reasonable.

<u>What to do if the proposed wildlife connectivity measure is not feasible or reasonable?</u>

When proposed wildlife connectivity measures are not considered feasible or reasonable consider alternative measures, locations and road designs that may still meet the goals for the project.

When it is not possible to avoid or fully mitigate a wildlife connectivity impact, it may be necessary to consider an offset that creates improvements for wildlife at an alternative site. In some situations, investing in an offset site may be a greater benefit for wildlife than connectivity measures at the original impact site.

Step 6: Identify and make provision for precautionary options

As a precautionary measure it has been assumed that bridges with a below bridge vertical height of 3.6 and up to 5.5 metres would present the minimum underpass design for emus. All bridge underpass locations for emus have been designed for hydrological purposes however consideration of the height and length of the structure has been designed for emu crossing.

In some instances a culvert represents the appropriate minimum design for hydrological purposes however as a precautionary option bridges may be considered as an optional design for emu crossing to allow more light penetration and natural area below the structure including retention of the riparian corridor.

As an additional precautionary option, if in the event that underpass structures are not proven to be effective, the design has included provision for a dedicated fauna overpass near Pillar Valley Creek at chainage 48 300. The decision to construct the overpass would follow a suitable period of monitoring to determine the effectiveness of the structures for emus as outlined in Appendix B.

Step 7: Describe and justify the selected emu connectivity measures

Details of the fauna connectivity measures proposed on the project are presented in the concept design report. A summary of these is relation to emu connectivity measures proposed in Sections 3 and 4 includes for the following:

- Eleven bridges between Coldstream River crossing to Shark Creek (ranging between 45 metres and 450 metres in length) with a minimum design height of 3.6 metres which are designed to provide access for emus. Bridges have been designed with a minimum bank width of 4.0 metres from the top of the creek bank to toe of the bridge abutment. This minimum passage way is exceeded in several bridges
- Three local property access underpasses with a minimum design height of 3.6 metres
- Two bridges over cane drains in the Tyndale area south of Shark Creek
- Bridges provided for dedicated emu passage at approximate stations: 59.3, 60.8 and 64.5 in (Section 3) shall maintain a minimum height of 5.5 metres. Dedicated emu passage at approximate station 66.2 shall maintain a minimum height of 4.0m.An additional precautionary option a dedicated overpass crossing has been designed in a cutting between Pillar Valley Creek and Mitchell Road. This would be constructed, only if post-construction monitoring shows that underpasses are not being used
- Road kill impacts on emus would be managed through the provision of purpose built exclusion fencing strategically located in areas between Eight Mile Lane in the south and north to the Shark Creek bridge and McIntyres Lane. The appropriate type of fencing to be used is constrained by localised flooding, while understanding that three and four strand stock fencing does not provide a barrier to emus. Dense brush plantings of *Melaleuca* spp. may be applied between stock fences and road batters in flood prone areas or alternatively fauna exclusion fencing would be placed higher on fill embankments to reduce impacts of flooding on the fauna fence.

The functionality of these structures has been designed with a focus on facilitating emu passage. It is the intention that some flexibility is maintained with this design where feasible to incorporate results from ongoing research into emu movements. In particular the research is focusing on clarifying if there are specific movement pathways within the identified habitat area for emus. Information from the emu research would inform the final designs of Section 3 and 4 which may provide additional structures, modifications or fencing where identified.

As described previously steps 8, 9 and 10 would be conducted at the detailed design, construction and operational stages of the project.

3. Design of connectivity measures to capture maximum fauna use

While the strategy has identified a focus on key listed populations the intention of the Biodiversity Connectivity Strategy is to facilitate fauna passage for all fauna groups and species. A series of technical workshops were conducted to critically review the fauna crossing structures proposed from the initial concept designs for the preferred route. The review considered the whole of project landscape connectivity features discussed previously and targeted fauna groups from all field surveys. The final list of connectivity measures was devised following this review with the inclusion of input from OEH.

Concept design review workshops

The concept design review and workshops focused on overlaying all existing data for threatened species over the project GIS layer which included a combination of threatened species records from the Atlas of NSW Wildlife, threatened fauna identified from the field surveys and local and regional wildlife corridors. The structures used in the concept design where then critically analysed to determine their suitability on a whole of project scale.

This review identified and addressed a number of gaps relating to areas for improvement, these included:

- Addressing the absence of dedicated fauna underpass structures in some regional and local corridor locations across the length of the project including SEPP14 locations, state forests and sub-regional corridors and fauna passage in dry forest habitats
- Addressing the absence of aerial glider crossing structures in some sections to target identified populations of four arboreal mammal species including the threatened Squirrel Glider and Yellow-bellied Glider during the preferred route studies
- Numerous structures were inadequately sized including both underpass structures and bridge structures in terms of their height, particularly where culvert lengths were greater than 50 metres in which case consideration was given to increasing the size. The increase in size was decided based on proven effectiveness from knowledge gained from monitoring underpass use on other RMS projects.
- Reviewing the feasibility of constructing a fauna crossing structure at any specific point due to engineering, topographic and environmental constraints (see discussion above). Particular consideration was given to the risk of increasing fill heights to upsize culverts and the subsequent need to widen fill batters where this may significantly increase habitat clearing
- Designing fauna crossings consistent with structures included on other Pacific Highway upgrades that are proven to have performed well.

Widened medians

In addition to modifying structures opportunities to widen the median along parts of the project boundary to enhance connectivity for gliders was also considered. The aim of widening the median at key strategic locations was to reduce the overall barrier effect of the highway and provide a 'stepping stone' for important arboreal mammal populations. The effect of widening the median also allows for a break in lengthy underpass structures within the median to benefit ground-dwelling fauna. The widening of the median was facilitated at the design workshops and considered:

- The target species and their location, targeting known populations of Yellow-bellied Glider, Squirrel Glider, Rufous Bettong, Spotted-tailed Quoll and Brush-tailed Phascogale
- The median location in terms of important fauna populations but also regional corridors
- Providing maximum benefit to as wider range of fauna species as possible
- Minimising the amount of additional clearing of vegetation that would be required by increasing the width of the project boundary, in particular to avoid additional impacts on threatened ecological communities and threatened species habitat.

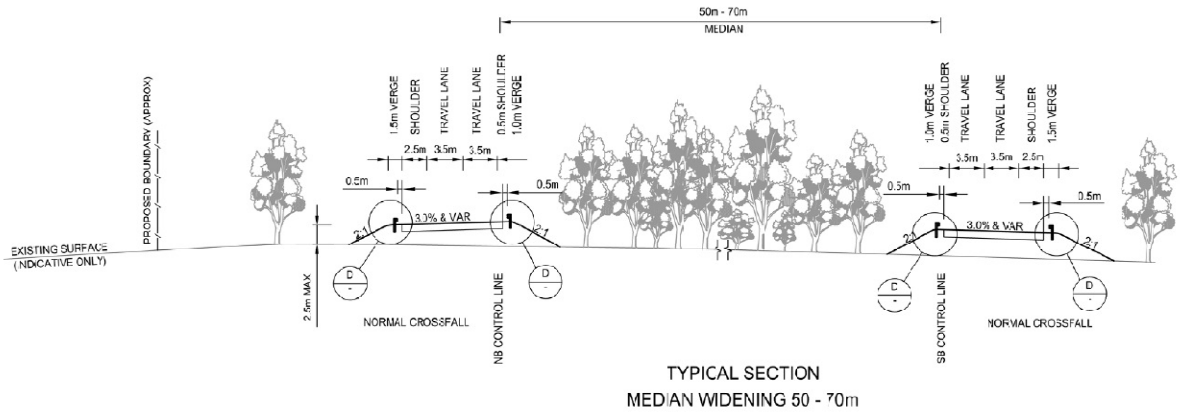
Widened medians were incorporated into the design at three locations:

- Station 4.95 to 6.9 to a minimum medium width of 25 metres over 1.3 kilometres. Positioned within the Dirty Creek sub-regional corridor and providing connectivity with Yuraygir National Park and Newfoundland State Forest, targeting Yellow-bellied Glider, Squirrel Glider, Rufous Bettong, Brush-tailed Phascogale and Spotted-tailed Quoll
- Station 22.55 to 23.8 (0.9 kilometres is a minimum 25 metres wide). Positioned within the Snake Creek subregional corridor and providing connectivity with Newfoundland State Forest (including Wells Crossing Flora Reserve) and Glenugie State Forest east to Yuraygir National Park
- Station 114.1 to 121.1 (2.5 kilometres is a minimum 32 metres wide). Regional and climate change corridor links moist forest / dry forest. Also links key habitats associated with Broadwater National Park, Tabbimoble State Forest and Tabbimoble Nature Reserve. Target Yellow-bellied Glider, Squirrel Glider, Bats, and Brush-tailed Phascogale.

Widening of medians considered other significant ecological values such as minimising the extent of vegetation clearing, minimising impacts on Endangered Ecological Communities and minimising the loss of known threatened species habitat (eg *Eucalyptus tetrapleura*).

Typical cross sections of the widened medians range from 50 to 70 metres in width. If the highway was upgraded to a six land formation, with the additional two lanes within the median, this median width would reduce to minimum of 25 metres. Figure A-5 provides a cross section of a typical widened median.

Figure A-5: Typical cross section of median widening for class M scenario



4. Identify opportunities to enhance or increase connectivity

Having completed the design aspects of the Biodiversity Connectivity Strategy, consideration was given to opportunities to enhance connectivity through strategic revegetation of lands within the proposed road reserve. As far as practical priority was given to:

- Enhancing connectivity in identified local or regional corridors, SEPP 14 wetlands and environmental protection zones (local government environmental plans); particularly where these might provide seasonal foraging resources
- Areas of habitat for important populations
- Known roadkill hotspots
- Conservation and repair priority areas identified in the Northern Rivers Regional Biodiversity Management Plan (DECCW 2010f)
- Cleared landscapes with limited connectivity, aiming to link current isolated patches with potential habitat for threatened species.

The selection of appropriate sites for revegetation was constrained by land tenure and the practicality of acquiring land in desired locations. However, opportunities exist for enhancing connectivity within regional connectivity zones, and these would be a focus of the land acquisition process as part of the project.

In the case where regeneration and/or revegetation measures are required to restore connectivity, this has been addressed in the mitigation section of the working paper. The recommended measures include appropriateness of the revegetation to the area considering surrounding vegetation and habitat for target species and details of the species to be replanted.

A.4 Monitoring needs

Details of a proposed fauna connectivity structures monitoring program are provided in the biodiversity monitoring strategy including performance goals and measures. The objective of program is to assess the effectiveness of various designs of fauna connectivity structures to facilitate movement of target species. Various researchers, the RMS and other road authorities within Australia have gathered an extensive amount of literature reporting on the use and effectiveness of fauna underpass and overpass structures. The monitoring program therefore does not attempt to replicate this data but rather focus on identifying gaps in existing knowledge relating to the use and effectiveness of crossing structures by specific taxa (eg monitoring the use of crossing structures by Emus, Spotted-tailed Quoll, Yellow-bellied Glider and Rufous Bettong).

These species have been targeted within a number of specific locations and structures (as shown in Appendix B) which form the basis of the monitoring program**.**

The monitoring program includes commitments to conduct research that:

- Determines the effectiveness of various designs of fauna crossing structures to facilitate the effective movement of the target species across the highway and avoids injury or death from vehicle strike due to crossing attempts
- The program includes specific goals and measures to review the performance of the crossing structures.

A.5 Proposed connectivity measures

Design principles

The recommendations from the Biodiversity Connectivity Strategy and series of design review workshops have been adopted for the concept design. To provide guidance for development of connectivity structures for the detailed design a set of design principles are provided in Table A-3.

The design principles have been developed specifically for the whole project and draw on the documents *Draft Guidelines for Connectivity* developed by the RMS (RTA, 2010) and the *Fauna Sensitive Road Design Manual* developed by the Queensland Department of Transport and Main Roads (2010). These design principles incorporating the experience gained from extensive fauna crossing monitoring programs conducted by the RMS on the Pacific Highway and Hume Highway.

Design principles meet principles for Ecologically Sensitive Design (ESD). Key ESD elements include:

- Minimal impact on existing vegetation
- Maximising use of combined drainage and fauna passage structures by including raised and/or inverted cells and adding fauna exclusion fencing
- Maximising use of dedicated structures through appropriate plantings and use of fauna furniture in the structure, and natural materials in the structure
- Design of bridges to avoid interruption to fish passage
- Incorporated appropriate fauna friendly landscapes on overpasses
- Use of current scientific knowledge for the design and construction of fauna fencing including frog exclusion fencing for threatened species.

Table A-3 Design principles

<table>
<tr><th>Classification</th><th>Design principles</th></tr>
<tr><td>Bridge and in-stream structures</td><td>

Bridges are the preferred crossing structure for identified Class 1 waterways (Major Fish Habitat), preferably being single-span bridges with the pylons/piers located outside the main channel.
Where feasible and reasonable, the design is to avoid placing piers in permanent water channels and on stream banks, to minimise alteration to water flow and/or damage to stream bank vegetation. This is important for the identified Class 1 waterways
Bridges should be designed with a natural substrate at the abutment, such as soil or vegetation, where feasible and reasonable. Scattered rocks could be included
Bridges should be designed to allow unimpeded water flow, stream bank and riparian vegetation, preferably on both sides of the water course
Bridges should be designed (height, carriageway separation) to allow sufficient light and moisture to encourage growth of vegetation under the structures. Bridges are to be designed with enough separation that would enable 3 metre separation under the ultimate six lane scenario
A minimum width of 3.0 metres is to be retained between the toe of the scour protection and the top of bank to maintain fauna passage below the bridge on both sides except in constrained circumstances where 3.0 metres minimum would be provided on one side and 1-1.5 metres on the other side. This is to be extended to a minimum of 4.0 metres in emu crossing areas identified for project sections 3-5 (Glenugie to Harwood). For effective connectivity, the 3.0 metre passage should consist of a natural substrate with refuge areas (scattered rocks, logs) and landscaping of the habitat corridor approach, not consisting of all rock and not consisting of scour protection. Note: location of piers should not restrict the designated fauna passage area or the width of the passage should be widened to accommodate the pier.
Where bridges can be used as combined emu crossing structure within emu habitat areas (sections 3-5) these structures are to be designed to provide a minimum clearance from ground to soffit of 3.6 metres. This is the minimum design height and where opportunities exist to increase this clearance height associated with greater fill heights then this should be considered for all bridges in sections 3-5. For example the design of dedicated bridges for emus in section 3-4 should be between 4.0 metres and 5.5 metres in height.
The design of bridges (and culverts) is to ensure physical, hydraulic and behavioural barriers are minimised for aquatic fauna movements. Impacts should be minimised by ensuring that:

The natural system flow and velocity is maintained or mimicked as closely as possible
Habitat within a culvert is to be as natural as possible (eg allow rocks and bed materials to infill the culvert base) without compromising the hydraulic function of the culvert
Light penetration is to be as great as possible- noting that skylights within the structures are not supported

Construction activities should aim to not impede the waterway, leaving at least a one metre buffer where feasible and reasonable. The area of the piling pad and temporary crossings should be minimised as much as possible.

</td></tr>
</table>

Classification	Design principles

Land bridges (overpasses)	• The land bridges in Sections 9 and 10 (Broadwater NP and Wardell) are to be designed with a minimum width of 12 metres (8 metres of which is to be excluded from vehicle or pedestrian access). Fencing is not required to separate vehicle track from vegetated component. The preferred design would consist of vehicle access available along the centre (maximum 4 metres width as a dirt track with narrow clearing) and landscaping either side of the access to act as a light and sound buffer from traffic. The track is to allow emergency access only by fire fighting vehicles. It is expected to medium to large sized mammals would use the track and it is likely to be more effective in the middle of the vegetation than off to one side.
	• The land bridge in Section 7 associated with Tabbimoble Swamp Nature Reserve should be a minimum width of 30 metres and is to exclude vehicle access or fencing on the structure
	• Allow scope in the concept design footprint for the construction of a 30 metre wide land bridge at station 48.3. The land bridge would be constructed if monitoring indicated emus are not using either underpass structures or low traffic volume local road overpasses (Firth Heinz Road, (station 51.8), Bostock Road (station 55.5), unnamed property access (station 63.6) and Crowley Road (station 64.9).
	• Approach embankments are to be maximum 1 in 3 grade and to be vegetated
	• Structures are to be planted with indigenous trees, shrubs and grasses that match the surrounding habitat. Plant species should preferably be hardy and drought tolerant and composition should be suited to the target animal species
	• The depth of soil required on the bridge depends on the type of vegetation planned. A minimum of 0.7 metres of soil is required to support shrubs while 1.5 to 2 metres of soil is required to support trees. Due to safety risks associated with travelling public, planting of trees on top of land bridges is unlikely. Planting of suitable tree species is more likely to be undertaken on the approach embankments of the land bridge or where risk analysis indicates that it acceptable level of risk to passing traffic. The detailed design should consider mimicking the vegetation type surrounding the structure. Other factors to be considered for the detailed design include:
	  • Adequate drainage to ensure ongoing plant growth
	  • Landscaping and hydro-mulch mix that establishes different strata layers (low canopy, shrub layer and groundcover)
	  • Landscaping at the approaches that consist of food resources to encourage use of the habitat linkage
	  • Ensure the mulch or other groundcover is not too thick to prevent growth or cause nitrogen deficiency in soil
	  • Fast growing local grasses (and other palatable species) that provide a food source are ideal for attracting macropods
	  • Flowering and seeding plants serve as attractants to birds
	  • Maintain remnant mature vegetation leading up to the bridge abutments to encourage early use of the fauna structure and maintain invertebrate populations
	• Additional features such as leaf litter, logs, rocks, boulders and artificial habitat (eg roofing tiles, concrete pavers) recommended to improve the suitability of the habitat and may encourage use
	• Fauna exclusion fencing is required for a minimum of 200 metres north and south of the land bridge on both sides of the road to funnel fauna to the structure.

Classification	Design principles

Underpasses	• Provide connectivity for fauna at least every 500 metres in areas of fauna habitat, where reasonable and feasible.
	• Plan for minimum 3.0 metres by 3.0 metres culvert size in wildlife corridors (regional and climate change corridors as well as identified local corridors) as well as habitat identified as supporting threatened species where feasible and reasonable where culvert lengths are less than 50 metres long. This is dependent on available fill heights and the sensitivity of vegetation, for example additional impacts to endangered ecological communities should be minimised
	• Dedicated underpasses
	    • Culvert size is dependent on the target species. However, standard underpass size is 3.0 m x 3.0 m and maybe smaller is some circumstances, but not less than 2.4 m x 2.4 m. Where feasible and reasonable koala passage structures should be at least 3.0 metres high to provide safety from wild dogs, dependent on available fill height. This applies particularly in sections 9-10
	    • Bridges or arch structures provided for dedicated emu passage at approximate stations: 59.3, 60.8 and 64.5 in (Section 3) shall maintain a minimum height of 5.5 metres. Dedicated emu passage at approximate station 66.2 shall maintain a minimum height of 4.0m.
	    • Maximum openness is to be provided where the culvert length is greater than 50 metres. As a minimum this should be 3.0 x 3.0 m but should consider larger structures where fill heights allow. Approach grades to the underpass structures would be typically 3:1. Rectangular culverts or structures are to be designed for dedicated structures.
	    • Dedicated underpasses to have a natural substrate, such as soil or mulch. Sandy loam is preferable to prevent the generation of a mud substrate
	    • Provide shelter and/or openness within culvert, specific to the target species. Larger species such as kangaroos and wallabies are likely to prefer more open structures, while small mammals require shelter to encourage use of culvert and reduce the risk of predation
	    • Provide appropriate shelter for wildlife to encourage use and reduce risk of predation
	    • In order to achieve dry passage in dedicated underpasses, the following design principles apply:
	        - Dedicated underpasses are to be located above flow lines, gullies and depressions
	        - Basin outlets should not lead to or run to dedicated underpasses
	        - Basins should not be located in front of underpass structures
	        - Drainage lines and swales should not cross in the front of dedicated underpasses, if so provide log bridges for fauna to cross
	        - Locations are to be ground-truthed to ensure the correct conditions.
	• Combined underpasses
	    • The underpass combines drainage or property access requirements with fauna passage requirements, in some cases including fish passage

Classification	Design principles
	• In cases where continuous culvert length is likely to be greater than 50 m investigate the feasibility of one or more of following measures; alternative structures which maximise openness, altering grade line to reduce overall length and or 'day-lighting' in median or between main carriageway and service road. Where fill heights and engineering constraints allow, an additional dedicated culvert could be placed higher in the fill provided flooding/ afflux issues where not compromised • Rectangular culverts or arch structures are to be designed for combined structures in preference to pipe structures • Provide dry passage that prevents the ponding of water within the structure. Where fish passage is required, first preference is to be given to multi-cell or raised cell system • For aquatic species, the natural width, depth and gradient of the watercourse is to be maintained within the culvert, with no vertical drops created at the entrance or exit. All designs should be in accordance with NSW Fisheries Guideline "Why do Fish Need to Cross the Road" • Relocation or adjustment of the stream bed is to be avoided, where feasible and reasonable • The minimum size for combined culverts (aquatic fauna passage) is to be typically 1.2 x 1.2 metres • Types of culverts to maintain effective fish passage in descending order of preference (1 most preferred) are: 1. Arch culvert: consider for class 1 and class 2 waterways where bridges are not possible or where culvert length is greater than 50 metres 2. Open-bottom box culvert 3. Stream simulation design with buried base box culvert 4. Multicell culverts 5. Closed-bottom box culvert 6. Pipe culvert • Scour protection at the inlet to the structure needs to be minimal and avoid complete coverage of the entrance. Areas of natural substrate are required to encourage usage • Ensure that pathways to fauna underpasses are not affected by noise mounds or ancillary sites or rest areas • Furniture • Fauna furniture is to be incorporated into dedicated structure design and around the entrance, but scattered only and with an adequate setback to prevent any obstruction • Provide a dry ledge or similar within combined underpasses to maintain dry passage. Those without ledges are known to be avoided • Place horizontal logs for passage as high above the base of the opening as practical, allowing 0.6 metre ceiling clearance for fauna passage • Vertical logs are secured to the invert of the concrete base slab and soffit of the culvert ceilings by attachment brackets • Interconnecting logs can provide a dry passage for koalas whilst also providing refuge from predators • Outside and within the culvert: refuge poles (three metres tall and 200 mm diameter) are effective where introduced (feral) predators are likely to attack koalas • It is important to ensure that the poles are located at least three metres away from koala exclusion fencing.

Classification	Design principles
Canopy bridges	A canopy bridge is a rope or pole suspended above the traffic, either from vertical poles or from trees to provide tree-canopy connectivity. This structure is used by arboreal and scansorial (climbing) species. • Further investigations would be undertaken during the design phase prior to siting structures to determine the size of the largest animal most likely to use the structure • Design to provide a minimum seven metre clearance above the ground for sufficient height above traffic and traffic noise. Generally the greater the distance between the canopy bridge and traffic the more effective the structure • The canopy bridge is to be attached to suitable poles located at a safe distance from the road edge. The exact location of the poles is to be determined at the design stage and should consider the use of targeted arboreal mammal surveys and survey of habitat trees adjacent to the road • If support poles are used in the median metal guards should be used to prevent animals descending support poles to the ground in highway median strips • Canopy bridges must be linked to adjacent habitat for target species (habitat trees) eg via ropes or ladders tied off from the poles into surrounding trees. Nearby trees are essential to link the canopy bridge into the surrounding vegetation • Design should avoid conflict with adjacent powerlines and other service infrastructure • Safety requirements are to be complied with when structural supports are placed in the road median or road edge. These may need safety barrier or guardrail protection • Rope ladder designs should be provided over rope tunnel or single rope designs as research indicates these attract more species • Due to the consequences of road ladder falling on passing traffic, poles shall be made from treated timber.
Glider poles	• Poles should be constructed from standard electricity pole (untreated timber preferable), or suitable tree salvaged from site • Design should avoid conflict with adjacent powerlines and other service infrastructure • Design to ensure the height of the glider pole and cross beam is relative to the length of the glide required to traverse the road (refer to Goldingay and Taylor 2009; and Goldingay et al 2011). Consider height of poles, height of crossbars and distance between poles • Predator shields and pipes should be installed to discourage avian predators and provide shelter. Designs may include one or more cross bars, shelter pipes, and predator shields • Glider poles and landing points must be close enough together and high enough that glide trajectory does not intersect traffic or the ground. Research on sugar, mahogany and squirrel gliders shows an average glide angle is 30.5º with a one metre loss in height for every 1-2 metres in glide length. Detailed design should use trigonometry rules to determine the specific requirements at each site • The glide trajectory must easily clear the traffic (ie at least 2 m above truck height) and any roadside fencing, with projected landings above the ground by 1 or 2 metres), although parallel designs have been successful

Classification	Design principles
	• Trees beside roads that create a tree-gap of 20 metres (two-lane road) or 43 metres (four-lane road) would need to be at minimum 13 metres and 25 metres in height, respectively, to enable animals to safely glide across the road • Further investigations would be undertaken during the design phase prior to siting structures to determine that habitat trees for gliders would be within gliding distance of poles in both directions and that adjacent habitat is suitable for gliders • Additional poles may be required to enable linkages to habitat • The landscape plan should consider the placement of suitable tree species around structures so that over time (eg 20–40 years), trees can replace artificial structures. (Gliders are likely to prefer natural trees to cross therefore revegetation is desirable). Existing trees should be retained in the road verge or median wherever possible • The design should avoid 'one-way' crossings: where poles may be high enough to glide from one side to the other, but not back. This occurs where poles or vegetation is shorter/lower on the landing side and therefore not high enough to facilitate the return glide • Safety requirements are to be complied with when structural supports are placed in the road median or road edge. These may need safety barrier or guardrail protection.
Widened medians	• Further investigations would be undertaken during the design phase prior to siting structures to determine tree-heights. In particular all trees above 20 metres in height are to be identified and retained, where practicable • Survey during the design phase in the median and the edge of the road corridor are to confirm food and shelter resources for arboreal mammals. Additionally, a survey for gliders at each location would confirm the species present and potential glide paths feed trees or den sites • Where feasible and reasonable, the width of the linear vegetation clearing for the construction corridor is to be kept sufficiently small to allow the tree canopy to remain continuous, or where not continuous, sufficiently small to allow gliders (and other volant species) to safely traverse the clearing • Dedicated and combined culverts which are intersected by the widened median should be placed in locations where shorter trees occur (< 20 metres) or within gaps in vegetation to minimise the amount of clearing required in the median. A break in the middle of the culvert also preferred to keep the length as short as possible. Fauna exclusion fencing perpendicular to the road is required to funnel fauna across the median rather than dwelling within the median or turning back onto the carriageway • Ensure drainage is not altered significantly by the final layout and elevation of the carriageway, survival of median vegetation depends on appropriate drainage conditions to be met • Ensure the mitigation is not affected by other structures or facilities, including drainage, ancillary facilities, basins, and fencing or barriers.

Classification	Design principles

Fauna fencing	• Refer to the concept design for fauna crossing structures and broad locations where fauna fencing is required. Indicative fencing locations have been identified based on the presence of local and regional corridors and known records of threatened fauna species. The fencing locations are broad only and may increase, decrease or shift depending on the outcomes of the detailed design. Elevation and potential flooding constraints and urban design considerations would all need to be considered in the locating of fauna fencing
	• Fencing must be integrated with crossing structures by guiding animals towards the crossing structure and preventing access to the road. Fencing is typically constructed on both sides of the road; otherwise animals are easily trapped on the road. In general fencing is to extend at least 200 metres either side of the structure, although this is dependent on topography and vegetation, location of intersections or other infrastructure. Steep batters in cuttings may be used as natural barrier. Minimise clearing of endangered ecological communities
	• Where frog fencing is required, it would extend a minimum of 50 metres either side of crossing structure
	• Fencing should be continuous and at their ends have a 'return area' to guide animals back into habitat rather than onto the road
	• The type of fencing at each location must take into consideration the following factors:
	    • Specific purpose
	    • Specific species
	    • Maintenance considerations
	    • Cost-effectiveness
	    • Land use
	    • Topography
	    • Vegetation
	    • Property access requirements
	• Perpendicular fencing is required in widened medians to direct fauna across the median and ensures that fauna do not colonise habitat within the median or turn back onto the road
	• Fence height must prevent animals from jumping over (eg at least 1.8 metres for kangaroos, 40 –60 centimetres for amphibians)
	• The size of the mesh must prevent the target species from climbing through. A fence with large mesh for large animals can include fine mesh at the base to prevent small species from climbing through
	• The fence must prevent animals from digging underneath. Construct metal flaps at the base of fencing where the fence crosses drainage lines to ensure fauna cannot pass under the fence at these points
	• Fencing may need a floppy-top or overhang to prevent animals from climbing over. Koala fences need a floppy top and amphibian fences need an overhang. The type of fencing required would depend on the target species in each section. A general floppy top fence would be appropriate for all sections with the addition of barrier for Brush-tailed Phascogale to be added in Section 1-3 and 6-8.
	• Fauna fencing must not endanger wildlife (eg barbed wire must not be used as birds, bats and gliders become entangled and die)
	• Barbed wire is to be avoided on stock fencing near crossing zones, particularly near glider crossing points. Alternatively cover the wire with poly pipe

Classification	Design principles

	• Escape mechanisms must be provided to allow animals to exit the fenced area where stock fencing and fauna fencing is used in close proximity. Large tree stumps, built earthen berms or escape poles on the roadside of exclusion fencing can be used to allow fauna to escape the road corridor
	• Conduct surveys of routes, paths and home-ranges of fauna before installation of fencing and escape structures. Fencing should account for repetitive pathway behaviour, as many species are averse to changing paths and would try to use the same path even if it is blocked
	• Implement measures to stop animals entering the road at the end of fauna exclusion fencing resulting in fauna roadkill hotspots eg fence 'returns'
	• Fauna fencing must be installed with knowledge of other fauna which may impact upon the design of fauna fencing (for example amphibians)
	• To prevent colonisation of sediment and detention basins by cane toads (*Bufo marinus*), these structures are to be fenced using frog proof fencing. This measure would apply to sections 5-11 (Harwood to Ballina)
	• Maintenance
	  • Fencing would require regular inspection and maintenance. A vehicle access track adjacent to the fence would facilitate rapid inspection and repair. Where overgrown vegetation that breaches the fence is likely, the vehicle track would also permit slashing of vegetation. In other locations, tracks should be avoided or on the road side of the fence
	  • Maintenance of fencing is critical to identify and repair breaches, periodic inspections are likely to be required
	• Amphibian fencing
	  • The need for purpose built frog fencing is identified in the concept design. Frog fencing is to consist of a 5 mm insertion rubber clamped to a galvanised backing plate then attached to a chain wire fence. The current design standard is 400-500 mm high with a 150 mm wide sloped roof to discourage amphibian access. This can be attached to other fauna fencing and must be installed to a minimum of 50 metres from the waterway
	  • Fencing in areas of Giant Barred Frog and Green-thighed Frog should be minimum 1000 mm in height
	  • Amphibian fences must be buried at least 10 cm or alternatively pegged down to prevent frogs crawling under. Mesh size for amphibians is < 4 mm
	• Emu fencing
	  • Fencing in emu crossing zones should be at least two metres in height with chain mesh, not strand fences. Fencing is to occur a minimum one kilometre from the crossing zone and must fence where permanent water quality basins occur except where basins are adjacent to the bridges. These don't need to be fenced as these can act as attractants
	  • If fencing is not possible in flood prone areas occupied by emu habitat, a natural barrier could be formed through very dense plantings of paperbark (*Melaleuca* spp.) or Swamp Oak (*Casuarina glauca*) along the road edge. These planted buffers should be placed between property boundaries and the toe of the batter and should extend at least 4-5 metres wide. The plantings are to be high density so as to form a natural barrier
	  • As part of the design phase, seek input from members of community experienced with handling/rearing emus.

Classification	Design principles

	• Construction barriers
	  ◦ Where construction barrier fencing is used, for example jersey kerbs, it is important to consider nocturnal fauna movements by placing gaps in the barrier at a minimum of every 500 metres. Alternatively barrier fencing with gaps incorporated into the design are effective, particularly near riparian areas
	  ◦ Temporary frog fencing during construction should consist of heavy duty, UV protected material and trenched into the ground.

Vegetation / Landscaping	• Riparian corridors to be protected during construction works and any areas of riparian vegetation impacted by construction are to be rehabilitated to a pre-determined benchmark condition to be specified in the CEMP. • Revegetation actions around crossing structures should consider the height and density of vegetation so as not to screen the structure from view, but also aim to provide some cover for fauna approaching and exiting the structure • Roadside plantings in emu crossing zones should not be within the first 40 metres of the road unless there is fauna exclusion fencing in place or as part of the exclusion barrier discussed above. In particular, common landscape species such as *Gahnia*, *Lomandra* and *Dianella* spp. represent food plants for emus and may attract them to the road edge and should avoid being planted. • Plantings under bridges in emu crossing zones including the approaches to the crossing are to use grasses or low ground covers and avoid dense plantings of trees including low trees such as Acacia or Casuarina. This is to leave the opening clear. Ground cover crops such as soybean and oats or rye grass could be used on disturbed ground around the approaches to the bridge to attract emus to the crossing zone • Plantings around dedicated and combined underpasses is to ensure that entrances to the structure do no obscure the structure and provide a clear line of sight • It is important for landscaping at entrances not to intrude / shadow the window of the entrances • Landscaping should use locally indigenous species and should target key fauna food resources to encourage usage either side of the structure and thus provide the habitat linkage to the structure.
Maintenance of crossing structures	• The RMS currently conducts periodic monitoring and maintenance of exclusion fencing and underpass structures on the Pacific Highway and this program would be extended to include the upgrade from Woolgoogla to Ballina. This would involve inspections of fauna fencing and temporay and permnant repairs. Culverts would be checked for debris or vegetation blocking the entrance at appropriate intervals and maintenance would be ongoing as part of the RMS usual scheduled road maintenance activities.

Summary of final connectivity structures

A summary of proposed connectivity structures is provided in Table A-4. Table A-5 details each connectivity structure identified as part of the concept plan. The structure table aims to identify the design solutions and functionality of each structure with reference to the following structure categories:

- **Dedicated fauna structures:** Structures that have been designed specifically for fauna passage. This includes overpass structures which also serve as dual National Park access points or emergency vehicle access
- **Combined fauna structures:** Culvert or arch structures that are designed for the dual purpose of accommodating drainage and fauna passage. These structures facilitate fauna passage via the inclusion, within a drainage culvert, of special features such as a raised bench or lowered central floor for elevated dry passage or a raised cell that remains dry during normal rainfall but may take flow during heavy rainfall. In terms of emu connectivity structures, these are all associated with bridges which have been located for hydrological purposes however the length, height, fencing and strategic landscaping decisions have been planned to meet emu passage needs
- **Incidental fauna structures:** Drainage structures, including box or pipe culverts that are large enough to accommodate fauna passage and that may be used by fauna.

In conjunction with these connectivity structures, fauna fencing is proposed as part of the project. Fauna fencing requirements are detailed in Table A-3.

This summary is based on the concept design for the project, and the locations would be subject to some refinement during detailed design. Any changes would be made in line with the design principles identified in the Strategy.

Table A-4 Overview of the proposed fauna connectivity measures

Project section	Proposed fauna crossing structures	Relevant corridors*
1-2	A combination of dedicated and combined fauna crossing structures were designed in key habitat and corridor locations, which included the following: • Five bridges with fauna passage beneath and retained along river banks • Twenty combined drainage / fauna passage culverts in wet areas • Four dedicated underpasses in dry sclerophyll forest for fauna movements • One dedicated underpass in swamp forest • Two canopy rope crossings and three glider pole crossings targeting gliders • Widened median.	Corindi Connector (ccc) Yamba-Nymboida (ccc) Coastal Range (ccc) Dirty Creek Range and Lazyman Creek (kc) New-Sherwood (kc) Yuraygir-Sherwood (kc) Halyway Creek (kc) Coffs Coast Regional Zone (lc)

Project section	Proposed fauna crossing structures	Relevant corridors*
3-5	A number of bridge and culverts have been currently proposed for emus in Section 3-5. These have been designed initially for hydrological function although the length and height has been designed for emu passage. The current thinking is around providing bridges The specific structures for emus include: • Thirteen bridges between Coldstream River crossing to Shark Creek (ranging between 45 metres and 450 metres in length) with a minimum design height of 3.6 metres which are designed to provide access for emus. Bridges have been designed with a minimum bank width of 4.0 metres from the top of the creek bank to toe of the bridge abutment • Three local property access underpasses with a design height of 3.6 metres • Two bridges over cane drains in the Tyndale area south of Shark Creek • Four combined road overpasses/underpasses • Four arch structures 5.5 metres high. For the remaining fauna species in Sections 3-5, a combination of dedicated and combined fauna crossing structures have been designed in key habitat and corridor locations which include the following: • Thirteen bridges with fauna passage beneath and retained along river banks • Eleven combined culverts in wet areas designed for combined drainage and fauna crossing capabilities • One combined property access underpasses in wet sclerophyll forest for fauna movements located adjacent to Yaegl Nature Reserve • Three local property access underpasses with a design height of 3.6 metres • Three rope crossings for arboreal mammals targeted known locations of Squirrel glider and sugar glider	Lower Clarence (ccc) Coastal Range (ccc) Chaffin Swamp and Chaffin Hill, Coldstream Wetlands (lc)
6-7	A combination of dedicated and combined fauna crossing structures have been designed in key habitat and corridor locations, which included the following: • One dedicated overpass structure linking Tabbimoble Swamp Nature Reserve (80 metres x 30 metres) • Three bridges including two across identified major waterways and potential habitat for Oxleyan Pygmy Perch. • Dedicated dry sclerophyll forest underpass structure, within known wildlife crossing location linking Mororo State Forest	Iluka-Richmond Range (ccc) Broadwater-Bungawalbin (ccc) Lower Clarence (ccc) Richmond Range-Bungawalbin (ccc) Mororo-Gibberage (kc) Bundjalung – Devils Pulpit (kc) Bundjalung-Tabbimobile (kc)

Project section	Proposed fauna crossing structures	Relevant corridors*
	• One dedicated culvert structure in dry sclerophyll forest for fauna movements • One canopy rope crossing structure linking Doubleduke State Forest • One glider pole crossing structure linking Tabbimoble State Forest • Three combined culverts in wet areas designed for combined drainage and fauna capabilities • Widened median.	
8-11	• Three fauna overpasses in total. Two fauna overpasses (12 m wide) to maintain connectivity for Broadwater National Park, and a third fauna overpass at Coolgardie Scrub providing connectivity with the Wardell Heath • Two frog and small mammal underpasses (1.2 x 1.2 m) near to paperbark swamp and wetland vegetation within Broadwater National Park corridor • A glider / possum rope structure at the northern end of the Broadwater National Park corridor, near to vegetation and a second rope structure north of the Richmond River • Access beneath the bridge at Richmond River at both abutments for fauna, in particular along the northern bank which is a valuable ecological area. Access at the southern abutment would be about 300 m in length and ranging from three metres to 10 metres in height. Access at the northern abutment would be about 50 metres in length and seven metres high at the highest point • Four viaducts about 20 metres long between the Richmond River and Coolgardie Road • Three bridges with fauna passage beneath and retained along river banks • Twelve drainage culverts minimum 1.2 metres high between the Richmond River and Coolgardie Road (with a further six culverts minimum 0.9 metres high) • Underpass structure that retains fish passage. The underpass was designed in consultation with the DII and would be designed so that the Oxleyan Pygmy Perch habitat is protected from predatory mosquito fish by keeping the drainage across the project unconnected during the majority of flood events.	Alstonville plateau link (lc) Broadwater-Bungawalbin (ccc) Uralba-Tuckean Swamp (ccc) Broadwater (kc) Wardell-Tuckean (kc) Emigrant Creek (kc)

*Key corridor (kc), climate change corridors (ccc) and local corridors (lc)

Table A-5 Proposed fauna connectivity measures for concept design

RCBC – Reinforced Concrete Box Culvert; RCP – Reiforced Conctrete Pipe; Stat – refers to station and distance along the project in kilometres; m = metres; wth = width; hgt = height; CC – refers to Climate Change corridor as identified by NSW OEH

Stat (km)	Project Section	Name	CROSSING STRUCTURES							BIODIVERSITY INPUTS										
			Structure type	Lgth (m)	Cell no.	RCBC wth (m)	RCBC hgt (m)	Bridge length x width	Waterway Class	Functionality	Design Change for Fauna Provisions	Targeted fauna group / spp.	Intersect Key Habitat, or Corridor or CC Corridor (OEH)	Assummed connectivity	Intersect wth range of Emu pop	Within pot habitat for Ox Pygmy Perch	Assoc wth widened median	Fauna fencing req	Fauna notes / Recommendations	Target structure in monitoring program
0.325	1	Arrawarra Gully	RCBC	50	9	2.400	0.900		Class 3 & 4	Incidental										
1.400	1		RCBC	43	3	2.400	1.200		Class 3 & 4	Incidental										
1.500	1		ARBOREAL CROSSING	65						Dedicated	Existing crossing provided by CHCC to be extended								Rope crossing required to match another proposed in an adjacent project. Advice following Connectivity workshop 24 April 2012	
1.860	1		RCBC	43	1	2.500	1.200		Class 3 & 4	Incidental			Yes							
1.980	1		RCBC	43	1	2.500	1.200		Class 3 & 4	Incidental			Yes							
2.100	1		RCBC	41	2	3.000	2.400		Class 3 & 4	Combined		Frogs, small-medium mammals, reptiles	Yes	SEPP14 Wetland and Wedding Bells SF, link with Coffs Regional Park (Zone 7a)				chainage 1500 to 2200	Dependent on revegetation of existing cleared area to restore link	
2.511	1	Kangaroo Trail Road	BRIDGE OVERPASS					80.6 x 10		Incidental			Yes							
2.820	1		RCBC	43	1	3.000	2.700		Class 3 & 4	Incidental			Yes							
3.160	1		RCP	43	2				Class 3 & 4	Incidental			Yes							
3.545	1	Corindi River	BRIDGE					90.5 x 10.5	Class 1	Combined		Fish, small-large mammals, frogs, reptiles	Yes	major fish habitat		Yes		chainage 3050 to 4000	Oxleyan Pygmy Perch Mitigation measures apply	
3.885	1		RCBC	39	6	2.700	1.200			Incidental			Yes							
4.010	1	Corindi Floodplain	BRIDGE					300.5 x 10.5	Class 3 & 4	Combined		Rufous Bettong, + small- large mammals, herpetofauna	Yes					No	large bridge 300 m across sparsely vegetated floodplain	
4.365	1		RCBC	43	3	2.700	1.200			Incidental										
4.685	1	Cassons Creek	BRIDGE					75.5 x 10.5	Class 1	Combined		Oxleyan Pygmy Perch, small-medium mammals, herpetofau		major fish habitat		yes		yes	Oxleyan Pygmy Perch Mitigation measures apply	

Stat (km)	Project Section	Name	CROSSING STRUCTURES							BIODIVERSITY INPUTS										
			Structure type	Lgth (m)	Cell no.	RCBC wth (m)	RCBC hgt (m)	Bridge length x width	Waterway Class	Functionality	Design Change for Fauna Provisions	Targeted fauna group / spp.	Intersect Key Habitat, or Corridor or CC Corridor (OEH)	Assumed connectivity	Intersect wth range of Emu pop	Within pot habitat for Ox Pygmy Perch	Assoc wth widened median	Fauna fencing req	Fauna notes / Recommendations	Target structure in monitoring program
												na								
4885	1		RCBC	45	2	3.000	0.900		Class 3 & 4											
4950	1		RCBC	50	10	3.000	0.900		Class 3 & 4											
	1		RCBC	17	1	1.800	1.200			Incidental						Yes		Yes		
5.380	1	Redbank Creek Tributaries	RCP	21	1				Class 1	Incidental		Oxleyan Pygmy Perch	Yes			Yes	Yes	Yes	Oxleyan Pygmy Perch Mitigation measures apply	
5.660	1	Redbank Creek Tributary (service road)	RCBC	17	1	2.400	1.200		Class 1	Combined		Oxleyan Pygmy Perch	Yes	major fish habitat		Yes	Yes	Yes	Oxleyan Pygmy Perch Mitigation measures apply	
5.670	1	Redbank Creek Tributary (service)	RCBC	48	2	2.400	0.900		Class 1	Combined		Oxleyan Pygmy Perch	Yes	major fish habitat		Yes			Oxleyan Pygmy Perch Mitigation measures apply	
6.132	1	Corindi Local Access Road	BRIDGE					76.6 x 10.5 - Creek in 22m back span		Incidental						Yes	Yes	Yes		
6.170	1	Redbank Creek Tributaries	RCBC	24	1	3.000	0.900		Class 1	Incidental		Oxleyan Pygmy Perch				Yes	Yes	Yes	Oxleyan Pygmy Perch Mitigation measures apply	
6.220	1	Redbank Creek Tributaries	RCBC	48	1	3.000	0.900		Class 1	Incidental		Oxleyan Pygmy Perch				Yes	Yes	Yes	Oxleyan Pygmy Perch Mitigation measures apply	
6.650	1	Redbank Creek Tributaries	RCBC	75	2	2.400	1.500		Class 1	Incidental		Oxleyan Pygmy Perch	Yes			Yes		Yes	Oxleyan Pygmy Perch Mitigation measures apply	
6.670	1	Redbank Creek Tributaries	RCBC	14	1	3.000	0.900		Class 1	Incidental		Oxleyan Pygmy Perch	Yes			Yes		Yes	Oxleyan Pygmy Perch Mitigation measures apply	
6.650	1	Redbank Creek Tributaries	RCBC	67	2	2.400	1.500		Class 1	incidental		Oxleyan Pygmy Perch	Yes			Yes		Yes	Oxleyan Pygmy Perch Mitigation measures apply	
6.780	1		FAUNA CROSSING - RCBC	48	1	3.000	3.000			Dedicated	Designed for fauna only	Rufous Bettong, Spotted-tailed Quoll, Oxleyan Pygmy Perch	Yes			Yes		Yes	Oxleyan Pygmy Perch Mitigation measures apply	Yes Rufous Bettong
7.180	1	Redbank Creek Tributaries	RCP	67	1				Class 1			Oxleyan Pygmy Perch				Yes			Oxleyan Pygmy Perch Mitigation measures apply	
7.285	1		RCBC	65	1	3.000	3.000		Class 3 & 4	Combined		Rufous Bettong, Spotted-tailed Quoll	Yes					Yes		Yes Rufous Bettong

Stat (km)	Project Section	Name	CROSSING STRUCTURES							BIODIVERSITY INPUTS										
			Structure type	Lgth (m)	Cell no.	RCBC wth (m)	RCBC hgt (m)	Bridge length x width	Waterway Class	Functionality	Design Change for Fauna Provisions	Targeted fauna group / spp.	Intersect Key Habitat, or Corridor or CC Corridor (OEH)	Assumed connectivity	Intersect wth range of Emu pop	Within pot habitat for Ox Pygmy Perch	Assoc wth widened median	Fauna fencing req	Fauna notes / Recommendations	Target structure in monitoring program
7.410	1		RCP	99	1				Class 3 & 4	Incidental			Yes					Yes		
8.500	1		RCBC	76	2	1.200	0.900		Class 3 & 4	Incidental			Yes					Yes		
8.510	1		FAUNA CROSSING - RCBC	70	1	3.000	3.000			Dedicated	Designed for fauna only	Rufous Bettong, Spotted-tailed Quoll	Yes					Yes		Yes Rufous Bettong
8.585	1		RCBC	143	2	0.900	0.600		Class 3 & 4	Incidental								Yes		
8.705	1		RCBC	115	2	0.900	0.600		Class 3 & 4	Incidental								Yes		
8.920	1		RCBC	41	2	0.900	0.600		Class 3 & 4	Incidental								Yes		
8.975	1	Range Road Interchange	BRIDGE					31.5 x 12.0		Incidental								Yes		
9.560	1		RCP	71	1				Class 3 & 4	Incidental								Yes		
10.085	1		RCBC	97	1	3.000	2.400		Class 3 & 4	Incidental			Yes						POSSIBLE REVEGETATION SITE FOR INVESTIGATION TO RESTORE CONNECTIVITY	
10.345	1		RCBC	69	2	2.100	0.900		Class 3 & 4	Incidental			Yes							
10.745	1	Dundoo Creek	RCBC	55	2	3.000	3.000		Class 3 & 4	Combined		Rufous Bettong, Spotted-tailed Quoll	Yes	Dirty Creek Range to Newfoundland SF and Yuraygir SRA				Yes		Yes Rufous Bettong
11.095	1		RCP	70	1				Class 3 & 4	Incidental			Yes							
11.500	1		RCP	47	3				Class 3 & 4	Incidental			Yes							
11.770	1		RCP	116	2				Class 3 & 4	Incidental			Yes							
11.785	1		FAUNA CROSSING - RCBC	71	1	3.000	3.000			Dedicated	Designed for fauna only		Yes							
11.895	1		RCP	30	1				Class 3 & 4	Incidental			Yes							
12.325	1		RCBC	41	1	3.000	3.000		Class 3 & 4	Combined		Koala, Spotted-tailed Quoll	Yes	Dirty Creek Range to Newfoundland SF and Yuraygir SRA				Yes	Exact location of poles to be decided at final design stage and to link with existing tall trees in the road verge and median or hollow-bearing trees.	YES
12.510	1		RCP	15	1				Class 3 & 4	Incidental			Yes							

Stat (km)	Project Section	Name	CROSSING STRUCTURES							BIODIVERSITY INPUTS										
			Structure type	Lgth (m)	Cell no.	RCBC wth (m)	RCBC hgt (m)	Bridge length x width	Waterway Class	Functionality	Design Change for Fauna Provisions	Targeted fauna group / spp.	Intersect Key Habitat, or Corridor or CC Corridor (OEH)	Assumed connectivity	Intersect wth range of Emu pop	Within pot habitat for Ox Pygmy Perch	Assoc wth widened median	Fauna fencing req	Fauna notes / Recommendations	Target structure in monitoring program
12.750	1		ARBOREAL CROSSING	65						Dedicated	Designed for fauna only	Yellow-bellied Glider, Squirrel Glider	Yes	Dirty Creek Range to Newfoundland SF and Yuraygir SRA						
12.885	1		RCBC	43	1	3.000	3.000		Class 3 & 4	Combined		Rufous Bettong, Spotted-tailed Quoll, Common Planigale	Yes	Dirty Creek Range to Newfoundland SF and Yuraygir SRA				Yes		YES
13.190	1		RCP	20	2				Class 3 & 4	Incidental			Yes							
13.315	1		RCBC	25	2	3.000	3.000		Class 2	Combined		Rufous Bettong, Spotted-tailed Quoll, Common Planigale	Yes	Dirty Creek Range to Newfoundland SF and Yuraygir SCA				Yes	provide break in the culvert between the dual carriage and the service road as the structure is too long	YES
13.315	1		RCBC	35	2	3.000	3.000		Class 2	Combined		Rufous Bettong, Spotted-tailed Quoll, Common Planigale	Yes	Dirty Creek Range to Newfoundland SF and Yuraygir SCA				Yes	provide break in the culvert between the dual carriage and the service road as the structure is too long	YES
13.380	1		RCP	30	1				Class 3 & 4	Incidental			Yes					Yes		
13.835	1		RCBC	68	1	3.000	3.000		Class 3 & 4	Combined		Rufous Bettong, Spotted-tailed Quoll, Common Planigale	Yes	Dirty Creek Range to Newfoundland SF and Yuraygir SCA				Yes	Culverts have been split to reduce length across the service road. POSSIBLE REVEGETATION SITE FOR INVESTIGATION TO RESTORE CONNECTIVITY	YES
14.055	1		RCP	72	2				Class 3 & 4	Incidental										
14.185	1		RCP	17	1				Class 3 & 4	Incidental										
14.280	1		RCBC	68	2	3.000	3.000		Class 3 & 4	Combined										
14.290	1		RCP	15	2				Class 3 & 4	Incidental										
15.660	1	Grays Road Overpass (M)	BRIDGE					66 x 9.0												

Stat (km)	Project Section	Name	CROSSING STRUCTURES							BIODIVERSITY INPUTS										
			Structure type	Lgth (m)	Cell no.	RCBC wth (m)	RCBC hgt (m)	Bridge length x width	Waterway Class	Functionality	Design Change for Fauna Provisions	Targeted fauna group / spp.	Intersect Key Habitat, or Corridor or CC Corridor (OEH)	Assumed connectivity	Intersect wth range of Emu pop	Within pot habitat for Ox Pygmy Perch	Assoc wth widened median	Fauna fencing req	Fauna notes / Recommendations	Target structure in monitoring program
17.020	2		ARBOREAL CROSSING							Dedicated	Designed for fauna only	Yellow-bellied Glider, Squirrel Glider	YES	Dirty Creek Range to Newfoundland SF and Yuraygir SCA					Exact location of poles to be decided at final design stage and to link with existing tall trees in the road verge and median or hollow-bearing trees.	Yes
19.660	2		RCBC	42	2	3.000	2.400		Class 3 & 4	Incidental			Yes							
19.885	2		RCP	63	2				Class 3 & 4	Incidental			Yes							
20.065	2		RCP	30	2				Class 3 & 4	Incidental			Yes							
20.425	2		RCP	40	1				Class 3 & 4	Incidental			Yes							
20.650	2		RCBC	48	4	3.000	2.400		Class 3 & 4	Combined		Rufous Bettong, Brush-tailed Phascogale	Yes	Yuraygir NP, Yuraygir SCA and Wells Crossing Flora Reserve				Yes		Yes
20.718	2	Halfway Creek	BRIDGE					50.5 x 11	Class 1	Combined		Rufous Bettong, Brush-tailed Phascogale	Yes	Yuraygir NP, Yuraygir SCA and Wells Crossing Flora Reserve, Major Fish Habitat				Yes		Yes
21.295	2	Halfway Creek (M)	BRIDGE					64 x 12.0												
-	~~2~~	~~Halfway Creek~~	~~BRIDGE~~	-	-	-	-	~~60.5 x 13 NB~~	-		-									Yes
20.880	2		RCBC	43	1	3.000	2.400		Class 3 & 4	Combined	Height increased from 1.8m to 2.4m for fauna connectivity	Rufous Bettong, Brush-tailed Phascogale	Yes	Yuraygir NP, Yuraygir SCA and Wells Crossing Flora Reserve				Yes		Yes
21.290	2		RCBC	50	1	3.000	3.000		Class 3 & 4	Combined		Rufous Bettong, Brush-tailed Phascogale	Yes	Yuraygir NP, Yuraygir SCA and Wells Crossing Flora Reserve				Yes		Yes
21.300	2	Luthers Road underpass (M)	BRIDGE					66m x 11	Class 3 & 4											

Stat (km)	Project Section	Name	CROSSING STRUCTURES							BIODIVERSITY INPUTS										
			Structure type	Lgth (m)	Cell no.	RCBC wth (m)	RCBC hgt (m)	Bridge length x width	Waterway Class	Functionality	Design Change for Fauna Provisions	Targeted fauna group / spp.	Intersect Key Habitat, or Corridor or CC Corridor (OEH)	Assummed connectivity	Intersect wth range of Emu pop	Within pot habitat for Ox Pygmy Perch	Assoc wth widened median	Fauna fencing req	Fauna notes / Recommendations	Target structure in monitoring program
22.373	2	Wells Crossing	BRIDGE					60.5 x 11	Class 1	Combined		Rufous Bettong, Brush-tailed Phascogale	Yes	Wells Crossing Flora Reserve, Major Fish Habitat				Yes		Yes
22.790	2		RCP	25	1				Class 3 & 4											
22.885	2		RCP	30	1				Class 3 & 4	Incidental			Yes				Yes			
23.125	2		RCBC	22		3.000	2.400			Dedicated	Height increased from 1.8m to 2.4m for fauna connectivity.	Rufous Bettong, Brush-tailed Phascogale	Yes	Wells Crossing Flora Reserve			Yes	Yes	Fauna fencing required perpendicular to the road within the median to direct fauna across the median	Yes
23.125	2		RCBC	22		3.000	2.400			Dedicated	Height increased from 1.8m to 2.4m for fauna connectivity.	Rufous Bettong, Brush-tailed Phascogale	Yes	Wells Crossing Flora Reserve			Yes	Yes	Fauna fencing required perpendicular to the road within the median to direct fauna across the median	Yes
23.745	2		RCBC	43	1	3.000	1.800		Class 3 & 4				Yes							
24.575	2		RCBC	46	1	3.000	2.400		Class 3 & 4	Combined	Height increased from 1.8m to 2.4m for fauna connectivity.	Rufous Bettong, Brush-tailed Phascogale	Yes	Glenugie State Forest			57 m		To be upsized to 2.4m specifically for fauna connectivity. Advice following Connectivity workshop 24 April 2012	
24.665	2		RCBC	53	1	3.000	1.800		Class 3 & 4	Incidental	Can be upsized	Rufous Bettong, Brush-tailed Phascogale	Yes	Glenugie State Forest			73 m		To remain at 1.8m. Advice following Connectivity workshop 24 April 2012	
25.950	2		RCBC	45		3.000	2.400			Dedicated	Designed for fauna only								3x 2.4m dedicated fauna structure. Advice following Connectivity workshop 24 April 2012	
25.525	2		RCP	58	2				Class 3 & 4	Incidental			Yes							
25.960	2		RCP	64	1				Class 3 & 4	Incidental			Yes							
26.395	2		RCP	51	1				Class 3 & 4	Incidental			Yes							
27.420	2		RCBC	104	1	3.600	2.400		Class 3 & 4	Combined		Rufous Bettong, Brush-tailed Phascogale	Yes	Glenugie State Forest				Yes		
29.330	2		RCBC	25	1	2.400	2.400		Class 3 & 4											
29.380	2			25	1			9.0 x 3.0m Bebo	Class 3 & 4	Incidental			Yes							

			CROSSING STRUCTURES							BIODIVERSITY INPUTS										
Stat (km)	**Project Section**	**Name**	Structure type	Lgth (m)	Cell no.	RCBC wth (m)	RCBC hgt (m)	Bridge length x width	Waterway Class	Functionality	Design Change for Fauna Provisions	Targeted fauna group / spp.	Intersect Key Habitat, or Corridor or CC Corridor (OEH)	Assumed connectivity	Intersect wth range of Emu pop	Within pot habitat for Ox Pygmy Perch	Assoc wth widened median	Fauna fencing req	Fauna notes / Recommendations	Target structure in monitoring program
								Arch												
29.840	2		RCBC	25	1	2.400	1.500		Class 3 & 4	Incidental			Yes							
30.180	2		RCBC	25	1	2.400	2.400		Class 3 & 4	Incidental			Yes							
30.800	2		RCBC	25	2	2.400	2.100		Class 3 & 4	Incidental			Yes							
34.800	3	Glenugie Southbound Loading Ramp	BRIDGE OVERPASS					60.6 x 9		Incidental	nil		Yes							
34.940	3		RCP	33	2				Class 3 & 4	Incidental	nil		Yes							
35.230	3		RCBC	65	2	2.400	2.400		Class 3 & 4	Combined	nil	Rufous Bettong	Yes	Glenugie State Forest				Fence from 35000 to 80200	protection and connectivity for Rufous Bettong	Yes
35.996	3	Eight Mile Lane	BRIDGE OVERPASS	50		2.400	1.800	99.6 x 8.2 - Creek in 25m back span	Class 3 & 4	Incidental	nil		Yes							
36.100	3		RCBC	28	6	2.400	1.800		Class 3 & 4	Incidental	nil		Yes							
36.110	3	1 culvert required at low points	RCP	20	1				Class 3 & 4	Incidental	nil		Yes							
36.120	3	1 culvert required at low points	RCP	47	1				Class 3 & 4	Incidental	nil		Yes							
36.398	3	Pheasant Ck	BRIDGE					75.5 x 11 to 16.1	Class 3 & 4	Combined	nil	Rufous Bettong	Yes	Glenugie Creek and Pheasant Creek				Fence from 35000 to 80200	protection and connectivity for Rufous Bettong	Yes
37.100	3		RCP	76	2				Class 3 & 4	Incidental	nil		Yes							
37.320	3		RCBC	69	2	2.400	2.400		Class 3 & 4	Combined	nil	Rufous Bettong	Yes	Glenugie Creek and Pheasant Creek				Fence from 35000 to 80200	protection and connectivity for Rufous Bettong	Yes
37.600	3		RCP	63	1				Class 3 & 4	Incidental	nil		Yes							
37.815	3		RCP	61	4				Class 3 & 4	Incidental	nil		Yes							
38.065	3		RCP	59	2				Class 3 & 4	Incidental	nil		Yes							
38.262	3	Old Six Mile Road	BRIDGE OVERPASS					60.6 x 8.2		Incidental	nil		Yes							
38.525	3		RCP	76	2				Class 3 & 4	Incidental	nil		Yes							
38.530	3		RCP	25	2				Class 3 & 4	Incidental	nil		Yes							
39.070	3		RCP	30	2				Class 3	Incidental	nil		Yes							

Stat (km)	Project Section	Name	CROSSING STRUCTURES							BIODIVERSITY INPUTS										
			Structure type	Lgth (m)	Cell no.	RCBC wth (m)	RCBC hgt (m)	Bridge length x width	Waterway Class	Functionality	Design Change for Fauna Provisions	Targeted fauna group / spp.	Intersect Key Habitat, or Corridor or CC Corridor (OEH)	Assumed connectivity	Intersect wth range of Emu pop	Within pot habitat for Ox Pygmy Perch	Assoc wth widened median	Fauna fencing req	Fauna notes / Recommendations	Target structure in monitoring program
									& 4											
39.080	3		RCP	134	2				Class 3 & 4	Incidental	nil		Yes							
39.690	3	Unnamed Tributary of Glenugie Creek	RCBC	28	11	3.000	1.200		Class 3 & 4	Combined	nil	Rufous Bettong, herpetofauna	Yes					Fence from 35000 to 80200		
40.160	3		RCP	51	4				Class 3 & 4	Incidental	nil		Yes							
41.419	3	Avenue Road	BRIDGE OVERPASS					60.6 x 8.2		Incidental	nil		Yes							
	3	Transverse culvert required	RCP	20	1				Class 3 & 4	Incidental	nil		Yes							
41.550	3		RCP	70	2				Class 3 & 4	Incidental	nil		Yes							
42.541	3	Coldstream River 1	BRIDGE					135.5 x 10.5	Class 1	Combined (Emu)	Bridge lifted to at least 3.6 m clearance to soffit for emu clearance	Emu, medium to large mammals including Rufous Bettong, herpetofauna, major fish habitat	Yes	Coldstream wetlands	Yes			Fence from 35000 to 80200		Yes, emu strategy
43.121	3	Coldstream River 2	BRIDGE					315.5 x 10.5	Class 1	Combined (Emu)	Bridge lifted to at least 3.6 m clearance to soffit for emu clearance	Emu, medium to large mammals including Rufous Bettong, herpetofauna, major fish habitat	Yes	Coldstream wetlands	Yes			Fence from 35000 to 80200		Yes, emu strategy
43.906	3	Coldstream River 3	BRIDGE					180.5 x 10.5	Class 1	Combined (Emu)	Bridge lifted to at least 3.6 m clearance to soffit for emu clearance	Emu, medium to large mammals including Rufous Bettong, herpetofauna, major fish habitat	Yes	Coldstream wetlands	Yes			Fence from 35000 to 80200		Yes, emu strategy
45.545	3	Wooli Road	BRIDGE OVERPASS					60.5 x 12.5		Incidental (Emu)	nil				Yes					
46.074	3	Pillar Valley Creek 1	BRIDGE					100.6 x 10.5 NB and 11.9 SB	Class 1	Combined (Emu)	Bridge lifted to at least 3.6 m clearance to soffit for emu clearance	Emu, medium to large mammals including Rufous Bettong, herpetofauna, major	Yes	Clarence floodplain wetlands to Yuraygir NP	Yes			Fence from 35000 to 80200		Yes, emu strategy

Stat (km)	Project Section	Name	CROSSING STRUCTURES							BIODIVERSITY INPUTS										
			Structure type	Lgth (m)	Cell no.	RCBC wth (m)	RCBC hgt (m)	Bridge length x width	Waterway Class	Functionality	Design Change for Fauna Provisions	Targeted fauna group / spp.	Intersect Key Habitat, or Corridor or CC Corridor (OEH)	Assumed connectivity	Intersect wth range of Emu pop	Within pot habitat for Ox Pygmy Perch	Assoc wth widened median	Fauna fencing req	Fauna notes / Recommendations	Target structure in monitoring program
												fish habitat								
46.344	3	Black Snake Creek	BRIDGE					100.6 x 10.5 NB and 11.9 SB.	Class 1	Combined (Emu)	Bridge lifted to at least 3.6 m clearance to soffit for emu clearance	Emu, medium to large mammals including Rufous Bettong, herpetofauna, major fish habitat	Yes	Clarence floodplain wetlands to Yuraygir NP	Yes			Fence from 35000 to 80200	No action. Advice following Connectivity workshop 24 April 2012	Yes, emu strategy
46.666	3	Pillar Valley Creek 3	BRIDGE					75.5 x 10.5 NB and 11.9 SB	Class 3 & 4	Combined (Emu)	Bridge lifted to at least 3.6 m clearance to soffit for emu clearance	Emu, medium to large mammals, herpetofauna	Yes	Clarence floodplain wetlands to Yuraygir NP	Yes			Fence from 35000 to 80150	No action. Advice following Connectivity workshop 24 April 2012	Yes, emu strategy
47.020	3		RCBC	46	4	3.000	1.500		Class 3 & 4	Incidental	nil		Yes		Yes					
47.662	3	Pillar Valley Creek 4	BRIDGE					75.5 x 10.5	Class 1	Combined (Emu)	Bridge lifted to at least 3.6 m clearance to soffit for emu clearance	Emu, medium to large mammals including Rufous Bettong, herpetofauna, major fish habitat	Yes		Yes			Fence from 35000 to 80200	No action. Advice following Connectivity workshop 24 April 2012	
47.925	3	Unnamed tributary of Pillar Valley Creek (near station 48000)	BRIDGE					60 x 10.5	Class 3 & 4											
48.100	3		FAUNA CROSSING - ROPE	65						Dedicated	Designed for fauna only	Squirrel Glider, Sugar Glider	Yes	Dry open sclerophyll forest on sand	Yes			Fence from 35000 to 80200		
48.761	3	Mitchell Road	BRIDGE					35.5 x 10.5 NB and 11.6 SB		Incidental (Emu)	Share access and Emu Crossing	Emu, medium to large mammals including Rufous Bettong, herpetofau	Yes	Clarence floodplain wetlands to Yuraygir NP	Yes			Fence from 35000 to 80200		Yes, emu strategy

Stat (km)	Project Section	Name	CROSSING STRUCTURES							BIODIVERSITY INPUTS										
			Structure type	Lgth (m)	Cell no.	RCBC wth (m)	RCBC hgt (m)	Bridge length x width	Waterway Class	Functionality	Design Change for Fauna Provisions	Targeted fauna group / spp.	Intersect Key Habitat, or Corridor or CC Corridor (OEH)	Assumed connectivity	Intersect wth range of Emu pop	Within pot habitat for Ox Pygmy Perch	Assoc wth widened median	Fauna fencing req	Fauna notes / Recommendations	Target structure in monitoring program
												na								
48.750	3		RCP	15	3				Class 3 & 4	Incidental	nil		Yes		Yes					
48.770	3		RCP	15	3				Class 3 & 4	Incidental	nil		Yes		Yes					
48.762	3		RCP	60	3				Class 3 & 4	Incidental	nil		Yes		Yes					
49.265	3	North of Pillar Valley 1	BRIDGE					120.0 x 10.5 NB and 11.6 SB	Class 3 & 4	Combined (Emu)	Bridge lifted to at least 3.6 m clearance to soffit for emu clearance	Emu, medium to large mammals including Rufous Bettong, herpetofauna	Yes	Clarence floodplain wetlands to Yuraygir NP	Yes			Fence from 35000 to 80200		Yes, emu strategy
49.450	3		RCBC	55	6	3.600	1.500		Class 3 & 4	Incidental	nil		Yes		Yes					
50.095	3		RCP	67	2				Class 3 & 4	Incidental	nil		Yes		Yes					
50.299	3	North of Pillar Valley 2	BRIDGE					45.0 x 10.5	Class 3 & 4	Combined (Emu)	Bridge lifted to at least 3.6 m clearance to soffit for emu clearance	Emu, medium to large mammals including Rufous Bettong, herpetofauna	Yes	Clarence floodplain wetlands to Yuraygir NP	Yes			Fence from 35000 to 80200		Yes, emu strategy
50.500	3		FAUNA CROSSING - ROPE	65						Dedicated	Designed for fauna only	Squirrel Glider, Sugar Glider	Yes	Dry open sclerophyll forest on sand	Yes			Fence from 35000 to 80200	Exact location of poles to be decided at final design stage and to link with existing tall trees in the road verge and median or hollow-bearing trees.	
50.830	3		RCP	51	3				Class 3 & 4	Incidental	nil		Yes		Yes					
51.430	3		RCBC	62	1	2.400	3.600		Class 3 & 4	Combined (Emu)	nil	Emu, medium to large mammals including Rufous Bettong, herpetofauna	Yes	Clarence floodplain wetlands to Yuraygir NP	Yes			Fence from 35000 to 80199		Yes, emu strategy

Stat (km)	Project Section	Name	CROSSING STRUCTURES							BIODIVERSITY INPUTS										
			Structure type	Lgth (m)	Cell no.	RCBC wth (m)	RCBC hgt (m)	Bridge length x width	Waterway Class	Functionality	Design Change for Fauna Provisions	Targeted fauna group / spp.	Intersect Key Habitat, or Corridor or CC Corridor (OEH)	Assumed connectivity	Intersect wth range of Emu pop	Within pot habitat for Ox Pygmy Perch	Assoc wth widened median	Fauna fencing req	Fauna notes / Recommendations	Target structure in monitoring program
51.865	3	Firth Heinz Road	BRIDGE					60.6 x 7.2		Incidental (Emu)	ACTION - Allow for future widening by 6.0m for fauna connectivity	Emu, medium to large mammals including Rufous Bettong, herpetofauna	Yes	Clarence floodplain wetlands to Yuraygir NP	Yes			Fence from 35000 to 80150		
52.438	3	Chaffin Creek	BRIDGE					75.0 x 10.5	Class 1	Combined (Emu)	Bridge lifted to at least 3.6 m clearance to soffit for emu clearance	Emu, medium to large mammals including Rufous Bettong, herpetofauna, major fish habitat	Yes	Clarence floodplain wetlands to Yuraygir NP	Yes			Fence from 35000 to 80200		Yes, emu strategy
52.605	3		RCBC	60	6	3.600	2.100		Class 3 & 4	Combined (Emu)	nil	small to medium mammals including Rufous Bettong and herpetofauna	Yes	Chaffin Swamp to Chaffin Hill	Yes			Fence from 35000 to 80150		
53.710	3		RCBC	63	1	3.600	3.600		Class 3 & 4	Combined (Emu)	nil		Yes	Chaffin Swamp to Chaffin Hill				Fence from 35000 to 80199		Yes, emu strategy
53.850	3		ARBOREAL CROSSING	65						Dedicated	Designed for fauna only	Squirrel Glider, Sugar Glider	Yes	Dry open sclerophyll forest on sand	Yes			Fence from 35000 to 80200	Exact location of poles to be decided at final design stage and to link with existing tall trees in the road verge and median or hollow-bearing trees.	
54.706	3	Unnamed tributary of Chaffin Creek (near station 54600)	BRIDGE					90 x 10.5	Class 3 & 4	Combined (Emu)	Bridge lifted to at least 3.6 m clearance to soffit for emu clearance	Emu, medium to large mammals including Rufous Bettong, herpetofauna	Yes	Clarence floodplain wetlands to Yuraygir NP	Yes			Fence from 35000 to 80200		Yes, emu strategy
55.060	3		RCBC	53	6	1.500	1.500		Class 3 & 4	Incidental	nil				Yes					
55.499	3	Bostock Road	BRIDGE OVERPASS					60.6 x 7.2		Incidental (Emu)	ACTION - Allow for future widening by 6.0m for fauna connectivity	Emu, medium to large mammals including Rufous Bettong, herpetofauna		Clarence floodplain wetlands to Yuraygir NP	Yes			Fence from 35000 to 80200		Yes, emu strategy
55.830	3		RCP	48	2				Class 3	Incidental	nil				Yes					

			CROSSING STRUCTURES							BIODIVERSITY INPUTS										
Stat (km)	**Project Section**	**Name**	Structure type	Lgth (m)	Cell no.	RCBC wth (m)	RCBC hgt (m)	Bridge length x width	Waterway Class	Functionality	Design Change for Fauna Provisions	Targeted fauna group / spp.	Intersect Key Habitat, or Corridor or CC Corridor (OEH)	Assummed connectivity	Intersect wth range of Emu pop	Within pot habitat for Ox Pygmy Perch	Assoc wth widened median	Fauna fencing req	Fauna notes / Recommendations	Target structure in monitoring program
									& 4											
56.898	3	Somervale Road	BRIDGE					31.5 x 10.5 and 11.0		Incidental (Emu)	Share access and Emu Crossing	Emu, medium to large mammals including Rufous Bettong, herpetofauna		Clarence floodplain wetlands to Yuraygir NP	Yes			Fence from 35000 to 80200		Yes, emu strategy
57.027	3	Champions Creek	BRIDGE					88.0 x 10.5		Combined (Emu)	Bridge lifted to at least 3.6 m clearance to soffit for emu clearance	Emu, medium to large mammals including Rufous Bettong, herpetofauna		Clarence floodplain wetlands to Yuraygir NP	Yes			Fence from 35000 to 80200		Yes, emu strategy
58.225	3		RCBC	50	2	3.000	0.900		Class 3 & 4	Incidental	nil				Yes					
58.639	3	North of Champions Creek	BRIDGE					75.5 x 10.5	Class 3 & 4	Combined (Emu)	nil				Yes					
59.285	3		ARCH	60	1		5.500			Combined (Emu)	Provide 5.5 m clearance for emu if fill batter allows.									
60.100	3		RCBC	50	1	2.400	1.200		Class 3 & 4	Incidental	nil				Yes					
60.815	3		ARCH	60	1		5.500		Class 3 & 4	Combined (Emu)	Provide 5.5 m clearance for emu if fill batter allows.									
61.046	3	Property Access	BRIDGE					35.5 x 10.5		Incidental (Emu)	Share access and Emu Crossing	Emu, medium to large mammals including Rufous Bettong, herpetofauna		Clarence floodplain wetlands to Yuraygir NP	Yes			Fence from 35000 to 80200		Yes, emu strategy
61.070	3		RCP	20	1				Class 3 & 4	Incidental	nil				Yes					
61.815	3		RCBC	52	3	2.100	0.900		Class 3 & 4	Incidental	nil				Yes					
61.915	3		RCP	52	1				Class 3 & 4	Incidental	nil				Yes					
62.230	3		RCBC	66	4	3.000	1.800		Class 3 & 4	Incidental	nil				Yes					
62.820	3		RCBC	49	2	2.400	0.900		Class 3 & 4	Incidental	nil				Yes					
63.610	3		RCP	121	4				Class 3 & 4	Incidental	nil				Yes					

Stat (km)	Project Section	Name	CROSSING STRUCTURES							BIODIVERSITY INPUTS										
			Structure type	Lgth (m)	Cell no.	RCBC wth (m)	RCBC hgt (m)	Bridge length x width	Waterway Class	Functionality	Design Change for Fauna Provisions	Targeted fauna group / spp.	Intersect Key Habitat, or Corridor or CC Corridor (OEH)	Assummed connectivity	Intersect wth range of Emu pop	Within pot habitat for Ox Pygmy Perch	Assoc wth widened median	Fauna fencing req	Fauna notes / Recommendations	Target structure in monitoring program
63.634	3	Property Access	BRIDGE OVERPASS					100.6 x 7.2		Incidental (Emu)	ACTION - Allow for future widening by 6.0m for fauna connectivity	Emu, medium to large mammals including Rufous Bettong, herpetofauna		Clarence floodplain wetlands to Yuraygir NP	Yes			Fence from 35000 to 80200		Yes, emu strategy
63.930	3		RCP	118	2				Class 3 & 4	Incidental	nil				Yes					
64.195	3		RCBC	95	1	3.000	1.800		Class 3 & 4	Incidental	nil				Yes					
64.505	3		ARCH	60	1		5.500			Combined (Emu)	Provide 5.5 m clearance for emu if fill batter allows.									
64.911	3	Crowleys Road Property Access	BRIDGE OVERPASS					60.6 x 6.0		Incidental (Emu)	ACTION - Allow for future widening by 6.0m for fauna connectivity	Emu, medium to large mammals including Rufous Bettong, herpetofauna		Clarence floodplain wetlands to Yuraygir NP	Yes			Fence from 35000 to 80200		Yes, emu strategy
65.490	3		RCP	54	3				Class 3 & 4	Incidental	nil				Yes					
66.035	3		RCP	59	2				Class 3 & 4	Incidental	nil				Yes					
66.190	3		ARCH	60	1		4.000			Dedicated (emu)	Provide 4.0m clearance for emu if fill batter allows.	Emu, medium to large mammals including Rufous Bettong, herpetofauna		Clarence floodplain wetlands to Yuraygir NP	Yes			Fence from 35000 to 80200		Yes, emu strategy
66.220	3		RCBC	65	1	2.100	0.750		Class 3 & 4	Incidental	nil				Yes					
66.500	3		RCBC	67	1	2.100	0.750		Class 3 & 4	Incidental	nil				Yes					
67.150	3		RCP	25	2				Class 3 & 4	Incidental	nil				Yes					
67.175	3		RCP	111	3				Class 3 & 4	Incidental	nil				Yes					
67.452	3	Tyndale Southbound unloading ramp	BRIDGE	300				36.5 x 10.7		Incidental	nil				Yes					
67.390	3		RCP	94	2				Class 3 & 4	Incidental	nil				Yes					
67.445	3		RCP	70	2				Class 3 & 4	Incidental	nil				Yes					
68.010	3		RCP	89	2				Class 3 & 4	Incidental	nil				Yes					

			CROSSING STRUCTURES							BIODIVERSITY INPUTS										
Stat (km)	**Project Section**	**Name**	Structure type	Lgth (m)	Cell no.	RCBC wth (m)	RCBC hgt (m)	Bridge length x width	Waterway Class	Functionality	Design Change for Fauna Provisions	Targeted fauna group / spp.	Intersect Key Habitat, or Corridor or CC Corridor (OEH)	Assumed connectivity	Intersect wth range of Emu pop	Within pot habitat for Ox Pygmy Perch	Assoc wth widened median	Fauna fencing req	Fauna notes / Recommendations	Target structure in monitoring program
68.075	3		RCP	66	2				Class 3 & 4	Incidental	nil				Yes					
68.430	3		RCP	25	4				Class 3 & 4	Incidental	nil				yes					
68.690	4		RCP	45	4				Class 3 & 4	Incidental					Yes					
68.970	4		RCP	45	4				Class 3 & 4	Incidental					Yes					
69.145	4	Bondi Hill Road connection	BRIDGE OVERPASS					70.6 x 7.2		Incidental					Yes					
69.367	4	Tyndale Southbound offload ramp	BRIDGE OVERPASS					120.6 x 9.6		Incidental					Yes					
70.455	4	Tyndale Cane Drain 1	BRIDGE					18 x 11m, 12.5m, 8m	Class 3 & 4	Combined (Emu)	REFER PDF	Emu			Yes			Fence from 35000 to 80200	Needs to maintain 2.5 m along each bank for emu access	Yes, emu strategy
71.055	4		RCBC	44	2	3.300	1.800		Class 3 & 4	Incidental					Yes					
71.124	4	Byrons Lane	BRIDGE OVERPASS					60.6 x 7.2	Class 3 & 4	Incidental					Yes					
71.680	4		RCBC	43	3	1.800	1.800		Class 3 & 4	Incidental					Yes					
72.590	4		RCBC	85	3	1.800	0.900		Class 3 & 4	Incidental					Yes					
73.015	4		RCBC	50	1	3.600	1.800		Class 3 & 4	Incidental					Yes					
73.423	4	Tyndale Cane Drain 2	BRIDGE					15 x 11	Class 3 & 4	Incidental					Yes					
74.755	4	Shark Creek	BRIDGE					448.6 x 10.5	Class 1	Combined (Emu)	raise to 3.6 m for emus	Emu, medium to large mammals including Rufous Bettong, herpetofauna, major fish habitat			Yes			Fence from 35000 to 80200	Needs to maintain 2.5 m along each bank for emu access	Yes, emu strategy
75.565	4		RCBC	59	1	3.600	2.400		Class 3 & 4	Combined		Small to medium mammals		Local corridor	Yes			Fence from 35000 to 80200		
75.880	4		ARBOREAL CROSSING	65						Dedicated	New Rope Crossing	possums		Local corridor	Yes			Fence from 35000 to 80200	Exact location of poles to be decided at final design stage and to link with existing tall trees in the road verge and median or hollow-bearing trees.	

Stat (km)	Project Section	Name	CROSSING STRUCTURES							BIODIVERSITY INPUTS										
			Structure type	Lgth (m)	Cell no.	RCBC wth (m)	RCBC hgt (m)	Bridge length x width	Waterway Class	Functionality	Design Change for Fauna Provisions	Targeted fauna group / spp.	Intersect Key Habitat, or Corridor or CC Corridor (OEH)	Assumed connectivity	Intersect wth range of Emu pop	Within pot habitat for Ox Pygmy Perch	Assoc wth widened median	Fauna fencing req	Fauna notes / Recommendations	Target structure in monitoring program
75.920	4		ARBOREAL CROSSING							Dedicated	New Glider poles	Gliders		Local corridor	Yes			Fence from 35000 to 80200	Exact location of poles to be decided at final design stage and to link with existing tall trees in the road verge and median or hollow-bearing trees.	
76.450	4		RCBC	55	1	2.400	2.400		Class 3 & 4	Combined	ACTION - Increase height increased from 1.2m to 2.4 for fauna connectivity and adjust any fauna fencing	Small to medium mammals		Local corridor	Yes			Fence from 35000 to 80199	Increase height of culvert. Advice following Connectivity workshop 24 April 2012	
77.030	4	McIntyre Lane	BRIDGE					60 x 13.5												
82.960	5		RCP	55	1				Class 3 & 4	Incidental										
83.100	5	Koala Drive	BRIDGE					30.0 x 15.8NB 12.8SB		Combined		Small to medium mammals, herpetofauna		Yaegl Nature Reserve				Fencing from 82500 to 85100		
85.600	5		RCP	58	1				Class 3 & 4											
	5	Clarence River - Harwood bridge	BRIDGE					1.323km x 21.8	Class 1	Incidental		Major Fish Habitat								
87.520	5		RCBC	37	46	3.000	2.100		Class 3 & 4	Incidental										
87.740	5		RCBC	38	3	3.000	2.100		Class 3 & 4	Incidental										
87.800	5	Watts Lane	BRIDGE OVERPASS					40.6 x14.0		Incidental										
88.270	5		RCBC	75	46	3.000	2.100		Class 3 & 4	Incidental										
88.780	5		RCBC	58	60	3.000	2.100		Class 3 & 4	Incidental										
89.260	5		RCBC	23	6	3.000	2.100		Class 3 & 4											
89.340	5	Seperntine Channel	BRIDGE					77.5 x 10.5	Class 1	Incidental		Major Fish Habitat								
90.770	5	Serpentine Channel Road North	BRIDGE OVERPASS					60.6 x 9.7		Incidental										
93.990	5	Clarence River North Arm	BRIDGE					216.6 x 10.5	Class 1	Combined		Major Fish Habitat								
94.280	5		RCBC	38	20	3.000	2.100		Class 3 & 4											

Stat (km)	Project Section	Name	CROSSING STRUCTURES							BIODIVERSITY INPUTS										
			Structure type	Lgth (m)	Cell no.	RCBC wth (m)	RCBC hgt (m)	Bridge length x width	Waterway Class	Functionality	Design Change for Fauna Provisions	Targeted fauna group / spp.	Intersect Key Habitat, or Corridor or CC Corridor (OEH)	Assumed connectivity	Intersect wth range of Emu pop	Within pot habitat for Ox Pygmy Perch	Assoc wth widened median	Fauna fencing req	Fauna notes / Recommendations	Target structure in monitoring program
99.730	6		FAUNA CROSSING - RCBC	45	1	3.000	2.400			Dedicated	New dedicated fauna crossing added 2.4m high	small to medium mammals	Yes	Bundjalung NP and Mororo State Forest				Fencing from 97900 to 101300	Is a culvert structure at least 2.4m possible in this location? If not, and not required for hydrology, this structure to be removed. Advice following Connectivity workshop 24 April 2012	
99.730	6	Mororo Creek?	RCP	44	1				Class 3 & 4	Incidental			Yes							
	6	Mororo Creek?	RCP	13	1				Class 3 & 4	Incidental			Yes							
	6	Mororo Creek?	RCP	71	2				Class 3 & 4	Incidental			Yes							
100.640	6		RCBC	71	1	2.400	1.800		Class 3 & 4	Combined		small to medium mammals	Yes	Bundjalung NP and Mororo State Forest				Fencing from 97900 to 101300	No action, unable to upsize. Advice following Connectivity workshop 24 April 2012	
101.100	6		FAUNA CROSSING - RCBC	38	1	3.000	2.400			Dedicated	Designed for fauna only								New dedicated structure 3 x 2.4. Advice following Connectivity workshop 24 April 2012	
101.190	6		RCP	12	2				Class 3 & 4	Incidental			Yes							
101.200	6		RCP	14	2				Class 3 & 4	Incidental			Yes							
101.290	6		RCP	20	2				Class 3 & 4				Yes							
101.541	6	Tabbimoble Creek	BRIDGE					132.0 x 10.5	Class 1	Combined		small to medium mammals and herpetofauna, Major fish habitat	Yes	Local corridor connects Bundjalung NP				Fence from 101300 to 101900		
102.080	6		RCP	12	2				Class 3 & 4	Incidental										
102.720	6		RCP	27	2				Class 3 & 4	Incidental										
102.853	6	Tabbimoble Overflow	BRIDGE					88 x 10.5	Class 1	Incidental		Major Fish Habitat							Oxleyan Pygmy Perch mitigation measures apply	
102.928	6	Tabbimoble Overflow	BRIDGE					66 x 3.5	Class 1	Incidental		Major Fish Habitat							Oxleyan Pygmy Perch mitigation measures apply	
103.790	6		RCBC	41	4	1.200	1.200		Class 3 & 4	Incidental										
103.930	6		RCP	44	3				Class 3 & 4	Incidental										
103.950	6		RCBC	46	3	1.200	1.200		Class 3 & 4	Incidental			Yes							
104.260	6		RCP	30	1				Class 3 & 4	Incidental			Yes	Bundjalung SCA						

			CROSSING STRUCTURES							BIODIVERSITY INPUTS										
Stat (km)	**Project Section**	**Name**	Structure type	Lgth (m)	Cell no.	RCBC wth (m)	RCBC hgt (m)	Bridge length x width	Waterway Class	Functionality	Design Change for Fauna Provisions	Targeted fauna group / spp.	Intersect Key Habitat, or Corridor or CC Corridor (OEH)	Assumed connectivity	Intersect wth range of Emu pop	Within pot habitat for Ox Pygmy Perch	Assoc wth widened median	Fauna fencing req	Fauna notes / Recommendations	Target structure in monitoring program
104.430	6		RCP	29	1				Class 3 & 4	Incidental			Yes	Bundjalung SCA						
104.460	6		RCP	8	1				Class 3 & 4	Incidental			Yes	Bundjalung SCA						
104.490	6		RCP	36	2				Class 3 & 4	Incidental			Yes	Bundjalung SCA						
104.590	6		RCP	18	3				Class 3 & 4	Incidental			Yes	Bundjalung SCA						
104.680	6		RCP	17	2				Class 3 & 4	Incidental			Yes	Bundjalung SCA						
104.880	6		RCP	20	2				Class 3 & 4	Incidental			Yes	Bundjalung SCA						
105.120	6		RCP	21	2				Class 3 & 4	Incidental			Yes	Bundjalung SCA						
105.520	6		RCP	20	2				Class 3 & 4	Incidental			Yes	Bundjalung SCA						
	6		RCP	25	2				Class 3 & 4	Incidental			Yes	Bundjalung SCA						
111.550	7		ARBOREAL CROSSING							Dedicated	New poles added	Gliders and possums	Yes	Tabbimoble State Forest to Bundjalung NP		Yes		Yes	Exact location of poles to be decided at final design stage and to link with existing tall trees in the road verge and median or hollow-bearing trees.	
111.760	7		RCBC	28	1	1.200	0.450		Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes			Apply OPP Mitigation Measures	
112.210	7		RCP	6	1				Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes			Apply OPP Mitigation Measures	
113.310	7		RCP	22	16				Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes			Apply OPP Mitigation Measures	
113.620	7		RCP	20	1				Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes			Apply OPP Mitigation Measures	
113.730	7		RCP	14	2				Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes			Apply OPP Mitigation Measures	
113.920	7	Unknown Watercourse at around 114.000	BRIDGE					15 x 11	Class 1	Combined		Oxleyan Pygmy Perch	Yes			Yes - known presence			Advice following Connectivity workshop 24 April 2012. Apply OPP Mitigation Measures. To be a single span bridge structure. DESIGNER COMMENT - This is an existing 20 cell piped culvert that is to be extended on both sides. Hydrologist will need to advise of bridge dimension	
114.220	7		RCP	18	1				Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes			Apply OPP Mitigation Measures	

Stat (km)	Project Section	Name	CROSSING STRUCTURES							BIODIVERSITY INPUTS										
			Structure type	Lgth (m)	Cell no.	RCBC wth (m)	RCBC hgt (m)	Bridge length x width	Waterway Class	Functionality	Design Change for Fauna Provisions	Targeted fauna group / spp.	Intersect Key Habitat, or Corridor or CC Corridor (OEH)	Assumed connectivity	Intersect wth range of Emu pop	Within pot habitat for Ox Pygmy Perch	Assoc wth widened median	Fauna fencing req	Fauna notes / Recommendations	Target structure in monitoring program
114.280	7	Serendipity Rd Overpass (M)	BRIDGE					60 x 11.0	Class 2			Oxleyan Pygmy Perch				Yes			Apply OPP Mitigation Measures	
114.540	7		RCP	14	1				Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes			Apply OPP Mitigation Measures	
114.810	7		RCP	41	4				Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes			Apply OPP Mitigation Measures	
-	~~7~~	-	~~RCP~~	~~16~~	~~1~~	-	-	-	Class 2		-	Oxleyan Pygmy Perch	Yes			Yes			Apply OPP Mitigation Measures	
115.272	7	Tabbimoble Floodway No.1	BRIDGE					88.0 x 10.5	Class 2	Combined		Oxleyan Pygmy Perch, small to medium mammals, herpetofauna	Yes	Double Duke SF to Tabbimoble Swamp NR		Yes			Apply OPP Mitigation Measures	
115.610	7	Tabbimoble Floodway No.1	RCP	25	1				Class 2		-	Oxleyan Pygmy Perch							Apply OPP Mitigation Measures	
115.880	7		RCP	20	1				Class 2			Oxleyan Pygmy Perch	Yes			Yes			Apply OPP Mitigation Measures	
115.880	7		RCP	15	1				Class 2			Oxleyan Pygmy Perch							Apply OPP Mitigation Measures	
116.220	7		RCP		1				Class 3 & 4											
116.400	7		ARBOREAL CROSSING	65				65.0 x 0.4		Dedicated	New rope crossing added	Gliders and possums	Yes	Double Duke SF to Tabbimoble Swamp NR		Yes	Yes	111600 to 128400	Exact location of poles to be decided at final design stage and to link with existing tall trees in the road verge and median or hollow-bearing trees.	
116.600	7		RCP	25	1				Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes	Yes		Apply OPP Mitigation Measures	
-	~~7~~	-	-	~~26~~	~~2~~	-	-	-	Class 2		-	Oxleyan Pygmy Perch	Yes			Yes	Yes		Apply OPP Mitigation Measures	
-	~~7~~	-	-	~~27~~	~~2~~	-	-	-	Class 2		-	Oxleyan Pygmy Perch	Yes			Yes	Yes		Apply OPP Mitigation Measures	
117.300	7		RCP	44	1				Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes	Yes		Apply OPP Mitigation Measures	
117.410	7		RCP	22	1				Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes	Yes		Apply OPP Mitigation Measures	
117.890	7		RCP	25	1				Class 2			Oxleyan Pygmy Perch	Yes			Yes	Yes		Apply OPP Mitigation Measures	

Stat (km)	Project Section	Name	CROSSING STRUCTURES							BIODIVERSITY INPUTS										
			Structure type	Lgth (m)	Cell no.	RCBC wth (m)	RCBC hgt (m)	Bridge length x width	Waterway Class	Functionality	Design Change for Fauna Provisions	Targeted fauna group / spp.	Intersect Key Habitat, or Corridor or CC Corridor (OEH)	Assumed connectivity	Intersect wth range of Emu pop	Within pot habitat for Ox Pygmy Perch	Assoc wth widened median	Fauna fencing req	Fauna notes / Recommendations	Target structure in monitoring program
117.900	7		RCP	27	1				Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes	Yes		Apply OPP Mitigation Measures	
	7		RCBC	40	2	1.200	0.900		Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes			Apply OPP Mitigation Measures	
118.810	7		RCP	38	1				Class 2			Oxleyan Pygmy Perch	Yes			Yes			Apply OPP Mitigation Measures	
118.828	7	Tabbimoble Nature Reserve Fauna Bridge	LAND BRIDGE					72.6 x 12.2		Dedicated	New Bridge added	Spotted-tailed Quoll, Koala, Brush-tailed Phascogale (small, medium & large mammals, birds & herpetofauna)	Yes	Double Duke SF to Tabbimoble Swamp NR		Yes		111600 to 128400		Yes
	7								Class 2			Oxleyan Pygmy Perch	Yes			Yes			Apply OPP Mitigation Measures	
	7								Class 2			Oxleyan Pygmy Perch	Yes			Yes			Apply OPP Mitigation Measures	
119.800	7		RCP	36	1				Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes			Apply OPP Mitigation Measures	
120.020	7		RCP	25	1				Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes			Apply OPP Mitigation Measures	
-	~~7~~	-	~~RCP~~	~~9~~	~~1~~	-	-	-	Class 2		-	Oxleyan Pygmy Perch				Yes			Apply OPP Mitigation Measures	
	7			23					Class 2			Oxleyan Pygmy Perch				Yes			Apply OPP Mitigation Measures	
120.680	7		RCBC	27	1	1.500	0.900		Class 3 & 4	Incidental										
121.590	7		RCBC	21	2	1.500	0.600		Class 3 & 4											
122.280	7	Oakey Creek	RCBC	43	2	3.000	1.800		Class 2			Oxleyan Pygmy Perch				Yes			Apply OPP Mitigation Measures	
122.290	7	Oakey Creek	RCP	42	3				Class 2	Incidental		Oxleyan Pygmy Perch				Yes			Apply OPP Mitigation Measures	
122.550	7		RCBC	50	3	3.000	2.400		Class 3 & 4	Combined	Changed to box culvert 2.4m h	small-medium mammals, herpetofauna		Local Corridor				111600 to 128400		
122.780	7		RCP	18	1				Class 3 & 4	Incidental										
123.40	7		RCP	24	1				Class 3	Incidental			Yes							

Stat (km)	Project Section	Name	CROSSING STRUCTURES							BIODIVERSITY INPUTS										
			Structure type	Lgth (m)	Cell no.	RCBC wth (m)	RCBC hgt (m)	Bridge length x width	Waterway Class	Functionality	Design Change for Fauna Provisions	Targeted fauna group / spp.	Intersect Key Habitat, or Corridor or CC Corridor (OEH)	Assumed connectivity	Intersect wth range of Emu pop	Within pot habitat for Ox Pygmy Perch	Assoc wth widened median	Fauna fencing req	Fauna notes / Recommendations	Target structure in monitoring program
0									& 4											
123.590	7	Nortons Gully	RCBC	55	4	3.000	2.400		Class 2	Combined	Increase to 3 x 3.4 RCBC	small-medium mammals, herpetofauna	Yes	Local Corridor and key fish habitat		Yes		111600 to 128399	Apply OPP Mitigation Measures	
124.010	7		RCP	65	1				Class 3 & 4	Incidental			Yes							
124.480	7	Unknown Watercourse at around 124.500	RCBC	27	2				Class 2	Incidental		Oxleyan Pygmy Perch				Yes			Apply OPP Mitigation Measures	
130.020	8		RCBC	54	2	3.000	1.500		Class 3 & 4	Incidental										
130.107	8	Tuckombil Canal	BRIDGE					150.5 x 12.5 NB and 150.5 x 10.5 SB	Class 1	Combined		macropods, Major fish habitat		floodplain grasslands						
130.475	8		RCBC	44	20	3.000	1.800		Class 2	Incidental		Oxleyan Pygmy Perch				Yes			Apply OPP Mitigation Measures	
130.740	8		RCBC	40	2	3.600	1.500		Class 2	Incidental		Oxleyan Pygmy Perch				Yes			Apply OPP Mitigation Measures	
131.066	8	Woodburn Floodway Viaduct 1	BRIDGE					75.5 x10.5	Class 2	Combined		Oxleyan Pygmy Perch				Yes			Apply OPP Mitigation Measures	
131.970	8		RCBC	51	15	3.600	0.900		Class 2	Incidental		Oxleyan Pygmy Perch				Yes			Apply OPP Mitigation Measures	
132.155	8	Woodburn - Evans Head Road	BRIDGE OVERPASS					60.6 x 14.0	Class 2	Incidental		Oxleyan Pygmy Perch				Yes			Apply OPP Mitigation Measures	
132.120	8		RCBC	50	1	1.500	1.500		Class 2	Incidental		Oxleyan Pygmy Perch				Yes			Apply OPP Mitigation Measures	
132.530	8		RCP	55	1				Class 2	Incidental		Oxleyan Pygmy Perch				Yes			Apply OPP Mitigation Measures	
133.330	8		RCBC	62	20	3.300	1.200		Class 3 & 4			Oxleyan Pygmy Perch								
133.140	8		RCP	37	1				Class 2	Incidental		Oxleyan Pygmy Perch				Yes			Apply OPP Mitigation Measures	
133.550	8		RCP	74	1				Class 2	Incidental		Oxleyan Pygmy Perch				Yes			Apply OPP Mitigation Measures	
134.600	8	Unnamed Watercourse at Around 134.700	RCBC	41	1	1.800	1.200		Class 1	Combined		Oxleyan Pygmy Perch		fish habitat waterways		Yes - known presence			Apply OPP Mitigation Measures. Revegetation of waterway to improve condition and connectivity	

Stat (km)	Project Section	Name	CROSSING STRUCTURES							BIODIVERSITY INPUTS										
			Structure type	Lgth (m)	Cell no.	RCBC wth (m)	RCBC hgt (m)	Bridge length x width	Waterway Class	Functionality	Design Change for Fauna Provisions	Targeted fauna group / spp.	Intersect Key Habitat, or Corridor or CC Corridor (OEH)	Assumed connectivity	Intersect wth range of Emu pop	Within pot habitat for Ox Pygmy Perch	Assoc wth widened median	Fauna fencing req	Fauna notes / Recommendations	Target structure in monitoring program
135.170	8		RCBC	58	1	0.750	~~0.450~~		Class 2	Incidental		Oxleyan Pygmy Perch				Yes			Apply OPP Mitigation Measures	
135.280	8		RCBC	51	1	0.750	~~0.450~~		Class 2	Incidental		Oxleyan Pygmy Perch				Yes			Apply OPP Mitigation Measures	
135.530	8		RCBC	56	1	2.400	0.750		Class 2	Incidental		Oxleyan Pygmy Perch				Yes			Apply OPP Mitigation Measures	
135.590	8		RCBC	48	1	2.400	0.750		Class 2	Incidental		Oxleyan Pygmy Perch				Yes			Apply OPP Mitigation Measures	
136.535	8		RCBC	49	1	0.900	0.600		Class 2	Incidental		Oxleyan Pygmy Perch				Yes			Apply OPP Mitigation Measures	
136.475	8	Unnamed Tributary of Macdonalds Creek (at around 136.450	RCBC	43	1	0.900	0.600		Class 2	Incidental		Oxleyan Pygmy Perch				Yes			Apply OPP Mitigation Measures	
136.666	8	McDonalds Creek	BRIDGE					18.5 x 11.0	Class 1	Combined	Now spans creek due to OPP	Oxleyan Pygmy Perch	Yes	fish habitat waterways		Yes - known presence			Apply OPP Mitigation Measures	
137.370	8		RCBC	22	1	2.100	~~0.450~~		Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes			Apply OPP Mitigation Measures	
137.555	8		RCP	59	1				Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes			Apply OPP Mitigation Measures	
138.180	9		RCP	43	1				Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes			Apply OPP Mitigation Measures	
138.430	9		FAUNA CROSSING - RCBC	85	1	1.200	1.200			Dedicated	Increased to 1.2 x 1.2	Small mammals, herpetofauna	Yes	Broadwater National Park		Yes		Fencing from 137800 to 141000		Yes
138.796	9	Broadwater National Park Fauna Bridge 1	LAND BRIDGE					90.4 x 12.2		Dedicated	Width of fauna passage increased from 6m to 8m	Koala, small to large mammals, birds, herpetofauna	Yes	Broadwater National Park		Yes		Fencing from 137800 to 141000		Yes
139.440	9		FAUNA CROSSING - RCBC	85	1	1.200	1.200			Dedicated	Increased to 1.2 x 1.2	Small mammals, herpetofauna	Yes	Broadwater National Park		Yes		Fencing from 137800 to 141000		Yes
139.918	9	Broadwater National Park Fauna Bridge 2	LAND BRIDGE					80.3 x 12.2		Dedicated	Width of fauna passage increased from 6m to 8m	Koala, small to large mammals, birds, herpetofauna	Yes	Broadwater National Park		Yes		Fencing from 137800 to 141000		Yes

Stat (km)	Project Section	Name	CROSSING STRUCTURES							BIODIVERSITY INPUTS										
			Structure type	Lgth (m)	Cell no.	RCBC wth (m)	RCBC hgt (m)	Bridge length x width	Waterway Class	Functionality	Design Change for Fauna Provisions	Targeted fauna group / spp.	Intersect Key Habitat, or Corridor or CC Corridor (OEH)	Assummed connectivity	Intersect wth range of Emu pop	Within pot habitat for Ox Pygmy Perch	Assoc wth widened median	Fauna fencing req	Fauna notes / Recommendations	Target structure in monitoring program
140.620	9		ARBOREAL CROSSING	150						Dedicated	Designed for fauna only	gliders, possums	Yes	Broadwater National Park		Yes		Fencing from 137800 to 141000	combine with revegetation of crown land adjacent to NP to increase connectivity	
140.470	9		RCP	10	1				Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes		Fencing from 137800 to 141000	Apply OPP Mitigation Measures	
140.820	9		RCBC	49	1	2.400	2.700		Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes		Fencing from 137800 to 141000	Apply OPP Mitigation Measures	
141.180	9	Montis Gully?	RCBC	53	3	2.100	1.200		Class 2	Incidental		Oxleyan Pygmy Perch				Yes			Apply OPP Mitigation Measures	
141.890	9	Unnamed tributary of Montis Gully?	RCBC	55	3	1.500	1.500		Class 2	Incidental		Oxleyan Pygmy Perch habitat upstream				Yes			Apply OPP Mitigation Measures	
142.240	9		BRIDGE					15 x 11.0 NB x 11.3 SB	Class 2	Combined		Oxleyan Pygmy Perch								
142.600	9		RCBC	42	1	0.750	0.450		Class 2	Incidental		Oxleyan Pygmy Perch				Yes			Apply OPP Mitigation Measures	
142.679	9	Broadwater Evans Head Road	BRIDGE OVERPASS					60.6 x 17.9	Class 2	Incidental		Oxleyan Pygmy Perch				Yes			Apply OPP Mitigation Measures	
142.730	9		RCP	48	2				Class 2	Incidental		Oxleyan Pygmy Perch				Yes			Apply OPP Mitigation Measures	
142.620	9		RCP	17	1				Class 2	Incidental		Oxleyan Pygmy Perch				Yes			Apply OPP Mitigation Measures	
	9		RCP	16	1				Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes			Apply OPP Mitigation Measures	
	9		RCBC	28	1	0.600	0.600		Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes			Apply OPP Mitigation Measures	
	9		RCP	28	1				Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes			Apply OPP Mitigation Measures	
	9		RCP	28	1				Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes			Apply OPP Mitigation Measures	
	9		RCBC	20	1	0.900	0.600		Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes			Apply OPP Mitigation Measures	
	9		RCBC	20	1	0.600	0.600		Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes			Apply OPP Mitigation Measures	

Stat (km)	Project Section	Name	CROSSING STRUCTURES							BIODIVERSITY INPUTS										
			Structure type	Lgth (m)	Cell no.	RCBC wth (m)	RCBC hgt (m)	Bridge length x width	Waterway Class	Functionality	Design Change for Fauna Provisions	Targeted fauna group / spp.	Intersect Key Habitat, or Corridor or CC Corridor (OEH)	Assumed connectivity	Intersect wth range of Emu pop	Within pot habitat for Ox Pygmy Perch	Assoc wth widened median	Fauna fencing req	Fauna notes / Recommendations	Target structure in monitoring program
	9		RCBC	20	1	1.200	0.600		Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes			Apply OPP Mitigation Measures	
	9		RCP	16	1				Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes			Apply OPP Mitigation Measures	
	9		RCP	16	1				Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes			Apply OPP Mitigation Measures	
	9		RCBC	16	3	2.100	~~0.450~~		Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes			Apply OPP Mitigation Measures	
143.200	9		RCBC	44	3	2.100	0.450		Class 2	Combined		Oxleyan Pygmy Perch	Yes	fish habitat waterways		Yes		Fence from 142800 to 145120	Apply OPP Mitigation Measures	
143.410	9	Eversons Creek	RCBC	16	1	2.100	0.450		Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes			Oxleyan Pygmy Perch mitigation measures apply	
143.430	9	Eversons Creek	RCBC	44	1	3.600	0.600		Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes			Oxleyan Pygmy Perch mitigation measures apply	
143.450	9	Eversons Creek	RCP	16	1				Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes			Oxleyan Pygmy Perch mitigation measures apply	
143.490	9	Eversons Creek	RCP	16	1				Class 2	Incidental		Oxleyan Pygmy Perch	Yes			Yes			Oxleyan Pygmy Perch mitigation measures apply	
143.630	9		RCBC	17	1	0.600	0.450		Class 2	Incidental			Yes							
143.790	9		RCBC	52	1	3.600	1.200		Class 3 & 4	Combined		Small-medium mammals, herpetofauna	Yes	Local corridor connects Broadwater National Park to floodplain habitats				Fence from 142800 to 145119	combine with revegetation of offset sites to increase connectivity	
144.290	9		RCBC	45	1	1.800	0.450		Class 3 & 4	Incidental			Yes							
144.770	9		RCBC	46	2	3.300	0.600		Class 3 & 4	Incidental			Yes							
145.106	10	Broadwater Viaduct 3	BRIDGE					75.5 x 10.5 NB and 75.5 x 10.5-12.5 SB	Class 3 & 4	Combined		macropods, birds	Yes	floodplain grasslands				Fence from 142800 to 145120		
145.287	10	Richmond River	BRIDGE					789.3 x 11.5 x 2 (Stitched)	Class 1	Combined		macropods, birds, major fish habitat	Yes	floodplain grasslands						
146.010	10		RCP	13	1				Class 3 & 4	Incidental			Yes							
146.060	10		RCP	13	1				Class 3 & 4	Incidental			Yes							

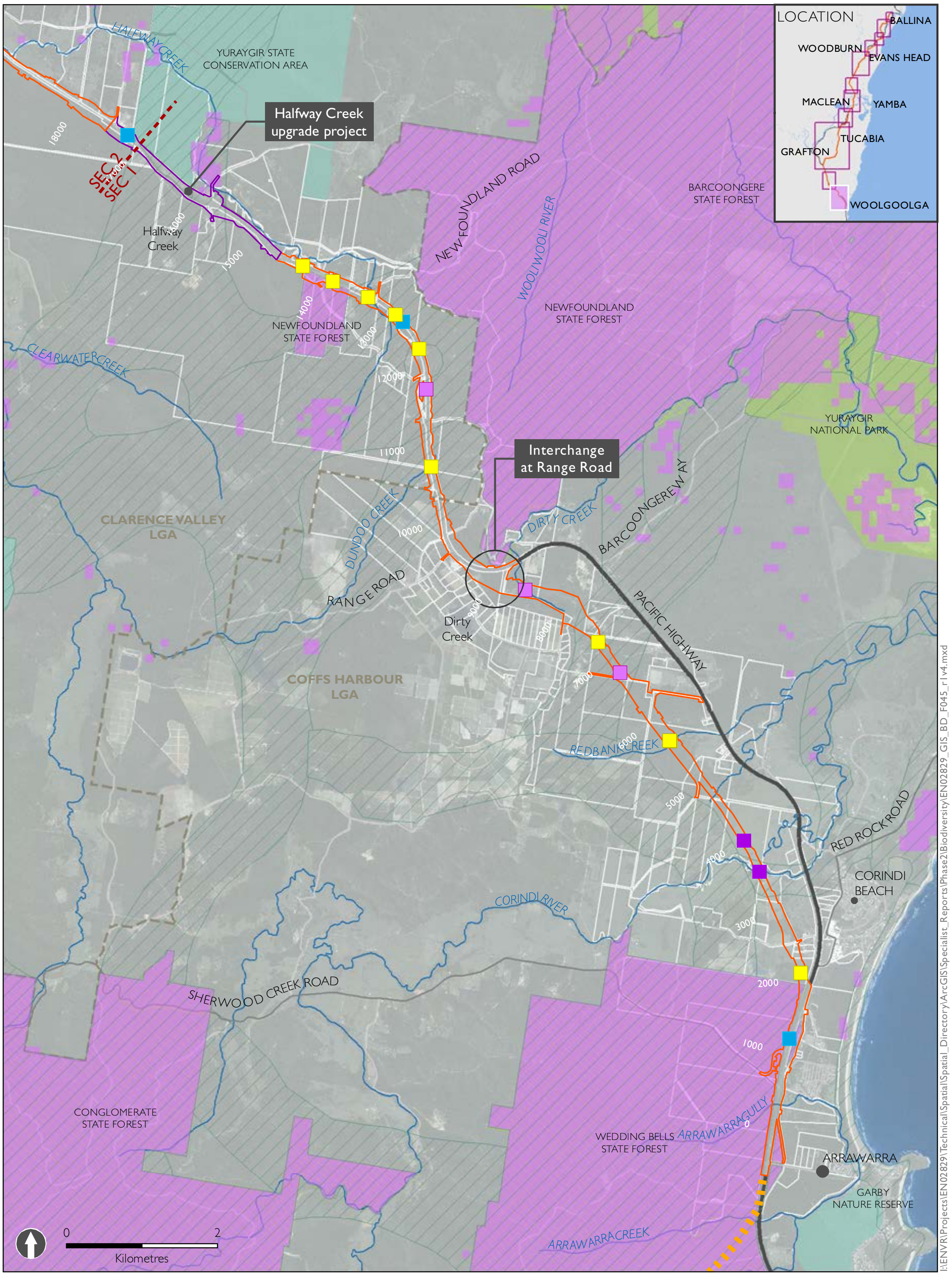
Stat (km)	Project Section	Name	CROSSING STRUCTURES							BIODIVERSITY INPUTS										
			Structure type	Lgth (m)	Cell no.	RCBC wth (m)	RCBC hgt (m)	Bridge length x width	Waterway Class	Functionality	Design Change for Fauna Provisions	Targeted fauna group / spp.	Intersect Key Habitat, or Corridor or CC Corridor (OEH)	Assumed connectivity	Intersect wth range of Emu pop	Within pot habitat for Ox Pygmy Perch	Assoc wth widened median	Fauna fencing req	Fauna notes / Recommendations	Target structure in monitoring program
146.360	10		RCBC	44	2	3.000	3.000		Class 3 & 4	Combined	Additional cell added for fauna and property to be split	Koala, small to large mammals, Black Bittern, herpetofauna	Yes	Regional link across Richmond River, CC assemblage. Links two key habitats				Fence for koalas from 146100 to 159700	Koala furniture, Revegetation of acquired property to reinforce connectivity	
146.600	10		RCBC	52	1	3.000	0.900		Class 3 & 4	Incidental			Yes							
147.180	10		RCBC	62	2	3.000	0.900		Class 3 & 4	Incidental			Yes						Advice following Connectivity workshop 24 April 2012. Increase to 2.4m (this is if the dedicated structure below is not possible).	
148.145	10		RCBC	83	1	3.000	0.600		Class 3 & 4	Incidental										
148.270	10		RCBC	58	1	1.500	0.600		Class 3 & 4	Incidental										
148.595	10		RCBC	43	1	3.300	0.900		Class 3 & 4	Incidental			Yes							
148.795	10		RCBC	12	1	1.200	0.900		Class 3 & 4	Incidental			Yes							
148.918	10	Old Bagotville Road	BRIDGE OVERPASS					55.5 x 9.7	Class 3 & 4	Incidental			Yes							
148.890	10		RCBC	22	1	1.500	0.900		Class 3 & 4	Incidental			Yes							
148.970	10		RCP	24	1				Class 3 & 4	Incidental										
142.227	10	Wardell Viaduct 4: Bingal Creek	BRIDGE					18.0 x 11.0	Class 3 & 4	Combined			Yes	Regional link across Richmond River, CC assemblage. Links two key habitats				Fence for koalas from 146100 to 159700		
150.030	10		RCBC	46	3	3.600	1.500		Class 3 & 4	Combined		Small-medium mammals, herpetofauna	Yes	fish habitat waterways. Links two regional corridors				Fence for koalas from 146100 to 159700	Revegetated acquired properties to re-establish important landscape link	
150.520	10		RCBC	42	1	2.400	1.500		Class 3 & 4	Combined		Small-medium mammals, herpetofauna	Yes	fish habitat waterways. Links two regional corridors				Fence for koalas from 146100 to 159700	Revegetated acquired properties to re-establish important landscape link	
150.600	10		RCBC	42	5	3.600	1.650		Class 3 & 4	Combined		Small-medium mammals, herpetofauna	Yes	fish habitat waterways. Links two regional corridors				Fence for koalas from 146100 to 159700	Revegetated acquired properties to re-establish important landscape link	
150.63	10		RCBC	12	3	3.600	0.600		Class 3	Incidental			Yes							

Stat (km)	Project Section	Name	CROSSING STRUCTURES							BIODIVERSITY INPUTS										
			Structure type	Lgth (m)	Cell no.	RCBC wth (m)	RCBC hgt (m)	Bridge length x width	Waterway Class	Functionality	Design Change for Fauna Provisions	Targeted fauna group / spp.	Intersect Key Habitat, or Corridor or CC Corridor (OEH)	Assumed connectivity	Intersect wth range of Emu pop	Within pot habitat for Ox Pygmy Perch	Assoc wth widened median	Fauna fencing req	Fauna notes / Recommendations	Target structure in monitoring program
0									& 4											
150.765	10		RCBC	12	4	3.600	0.600		Class 3 & 4	Incidental			Yes							
151.000	10		RCBC	12	1	1.800	0.450		Class 3 & 4	Incidental			Yes							
151.933	10	Wardell Viaduct 6	BRIDGE					18.0 x 11.0	Class 3 & 4	Combined		macropods, herpetofauna		floodplain grasslands				Fence for koalas from 146100 to 159700		
151.930	10		RCBC	15	4	3.600	0.900		Class 3 & 4	Incidental										
152.220	10		RCP	45	1				Class 3 & 4	Incidental										
152.220	10		RCP	13	1				Class 3 & 4	Incidental										
152.380	10		RCP	16	1				Class 3 & 4	Incidental			Yes							
152.530	10		RCBC	26	1	0.900	0.450		Class 3 & 4	Incidental			Yes							
152.570	10		RCP	13	1				Class 3 & 4	Incidental			Yes							
152.660	10		RCBC	13	1	2.700	0.900		Class 3 & 4	Incidental			Yes							
152.780	10		RCBC	45	3	2.700	0.900		Class 3 & 4	Incidental			Yes							
152.790	10		RCBC	46	3	3.000	0.900		Class 3 & 4	Incidental			Yes							
152.795	10		RCBC	13	2	1.500	0.450		Class 3 & 4	Incidental			Yes							
152.800	10		RCBC	13	1	2.400	0.450		Class 3 & 4	Incidental			Yes							
152.843	10	Wardell Road	BRIDGE OVERPASS					78.9 x 14.0	Class 3 & 4	Incidental			Yes							
152.840	10		RCBC	25	1	1.500	0.900		Class 3 & 4	Incidental			Yes							
153.055	10		RCBC	13	2	3.300	0.600		Class 3 & 4	Incidental			Yes							
153.060	10		RCBC	41	2	1.500	0.450		Class 3 & 4	Incidental			Yes							
154.355	10		RCBC	16	1	0.600	0.450		Class 3 & 4	Incidental			Yes							
154.405	10		RCBC	16	1	1.500	0.450		Class 3 & 4	Incidental			Yes							
154.555	10		RCBC	16	1	1.500	0.450		Class 3 & 4	Incidental			Yes							
154.655	10		RCP	15	1				Class 3 & 4	Incidental			Yes							
154.655	10		RCBC	15	1	3.000	0.600		Class 3 & 4	Incidental			Yes							
154.655	10		RCBC	42	2	1.800	0.450		Class 3 & 4	Incidental			Yes							
154.655	10		RCBC	15	1	4.200	0.600		Class 3 & 4	Incidental			Yes							
155.15	10		RCBC	13	2	1.500	0.450		Class 3	Incidental										

Stat (km)	Project Section	Name	CROSSING STRUCTURES							BIODIVERSITY INPUTS										
			Structure type	Lgth (m)	Cell no.	RCBC wth (m)	RCBC hgt (m)	Bridge length x width	Waterway Class	Functionality	Design Change for Fauna Provisions	Targeted fauna group / spp.	Intersect Key Habitat, or Corridor or CC Corridor (OEH)	Assumed connectivity	Intersect wth range of Emu pop	Within pot habitat for Ox Pygmy Perch	Assoc wth widened median	Fauna fencing req	Fauna notes / Recommendations	Target structure in monitoring program
5									& 4											
155.155	10		RCBC	42	1	2.700	0.600		Class 3 & 4	Incidental										
155.409	10	Property Access Underpass	BRIDGE					15.0 x 11.0	Class 3 & 4	Combined										
155.405	10		RCBC	12	2	2.400	0.450		Class 3 & 4	Incidental										
155.905	10		RCBC	50	2	3.600	0.600		Class 3 & 4	Incidental										
156.006	10	North Wardell Fauna Bridge	LAND BRIDGE					62.0 x 12.2		Dedicated	Width of fauna passage increased from 6m to 8m	Koala, Long-nosed Potoroo	Yes	Wardell Heath				Fence for koalas from 146100 to 159700	Include koala furniture and glider poles on the overpass	Yes
156.305	10		RCBC	52	4	3.300	1.200		Class 3 & 4	Combined		Long-nosed Potoroo	Yes	Wardell Heath				Fence for koalas from 146100 to 159700	numerous koala records	Yes
156.955	10		RCBC	53	3	1.800	1.200		Class 3 & 4	Combined		Long-nosed Potoroo	Yes	Wardell Heath				Fence for koalas from 146100 to 159700	numerous koala records	Yes
157.155	10		RCBC	58	2	1.800	1.200		Class 3 & 4	Incidental			Yes							
157.487	10	Coolgardie Road	BRIDGE OVERPASS					57.6 x 14.0	Class 3 & 4	Incidental			Yes							
157.305	10		RCBC	78	1	2.400	1.800		Class 3 & 4	Incidental			Yes							
157.435	10		RCBC	46	1	1.500	0.900		Class 3 & 4	Incidental			Yes							
157.435	10		RCBC	25	1	1.500	0.900		Class 3 & 4	Incidental			Yes							
157.435	10		RCBC	36	1	1.500	0.900		Class 3 & 4	Incidental			Yes							
157.555	10		RCBC	29	1	3.000	0.900		Class 3 & 4	Incidental			Yes							
157.605	10		RCBC	27	4	4.200	2.100		Class 3 & 4	Combined			Yes					Fence for koalas from 146100 to 159700	numerous koala records. Potential for offset and revegetation north of the interchange to strengthen connectivity	
157.655	10		RCBC	59	2	3.600	1.800		Class 3 & 4	Combined			Yes					Fence for koalas from 146100 to 159700	numerous koala records. Potential for offset and revegetation north of the interchange to strengthen connectivity	
157.655	10		RCBC	27	3	2.100	1.800		Class 3 & 4	Incidental			Yes							

Stat (km)	**Project Section**	**Name**	CROSSING STRUCTURES							BIODIVERSITY INPUTS										
			Structure type	Lgth (m)	Cell no.	RCBC wth (m)	RCBC hgt (m)	Bridge length x width	Waterway Class	Functionality	Design Change for Fauna Provisions	Targeted fauna group / spp.	Intersect Key Habitat, or Corridor or CC Corridor (OEH)	Assummed connectivity	Intersect wth range of Emu pop	Within pot habitat for Ox Pygmy Perch	Assoc wth widened median	Fauna fencing req	Fauna notes / Recommendations	Target structure in monitoring program
157.825	10	North Wardell Viaduct 7: Ravelles Creek	BRIDGE					17.5 X 13 - 13.5 NB, 14.8 - 15.6 SB	Class 2	Combined		Small-medium mammals, herpetofauna	Yes					Fence for koalas from 146100 to 159700	numerous koala records. Potential for offset and revegetation north of the interchange to strengthen connectivity	
158.850	11		RCBC	45	4	3.600	1.800		Class 3 & 4	Combined		Small-medium mammals, herpetofauna	Yes	Local corridor connects Richmond River to Uralba Nature Reserve					Advice following Connectivity workshop 24 April 2012. Keep in- as combined structure	
158.850	11		RCBC	25	4	3.600	1.800		Class 3 & 4	Combined		Small-medium mammals, herpetofauna	Yes	Local corridor connects Richmond River to Uralba Nature Reserve					Advice following Connectivity workshop 24 April 2012. Keep in- as combined structure	
159.830	11	Whytes Lane	BRIDGE OVERPASS					55.6 x 12.5	Class 3 & 4	Incidental			Yes							
163.000	11			47	5				Class 3 & 4	Incidental			Yes							
164.650	11	Emigrant Creek – Smith Drive	BRIDGE					221.9 x 12.5	Class 1	Combined		Major fish habitat + small-medium mammals, herpetofauna		local riparian corridor						

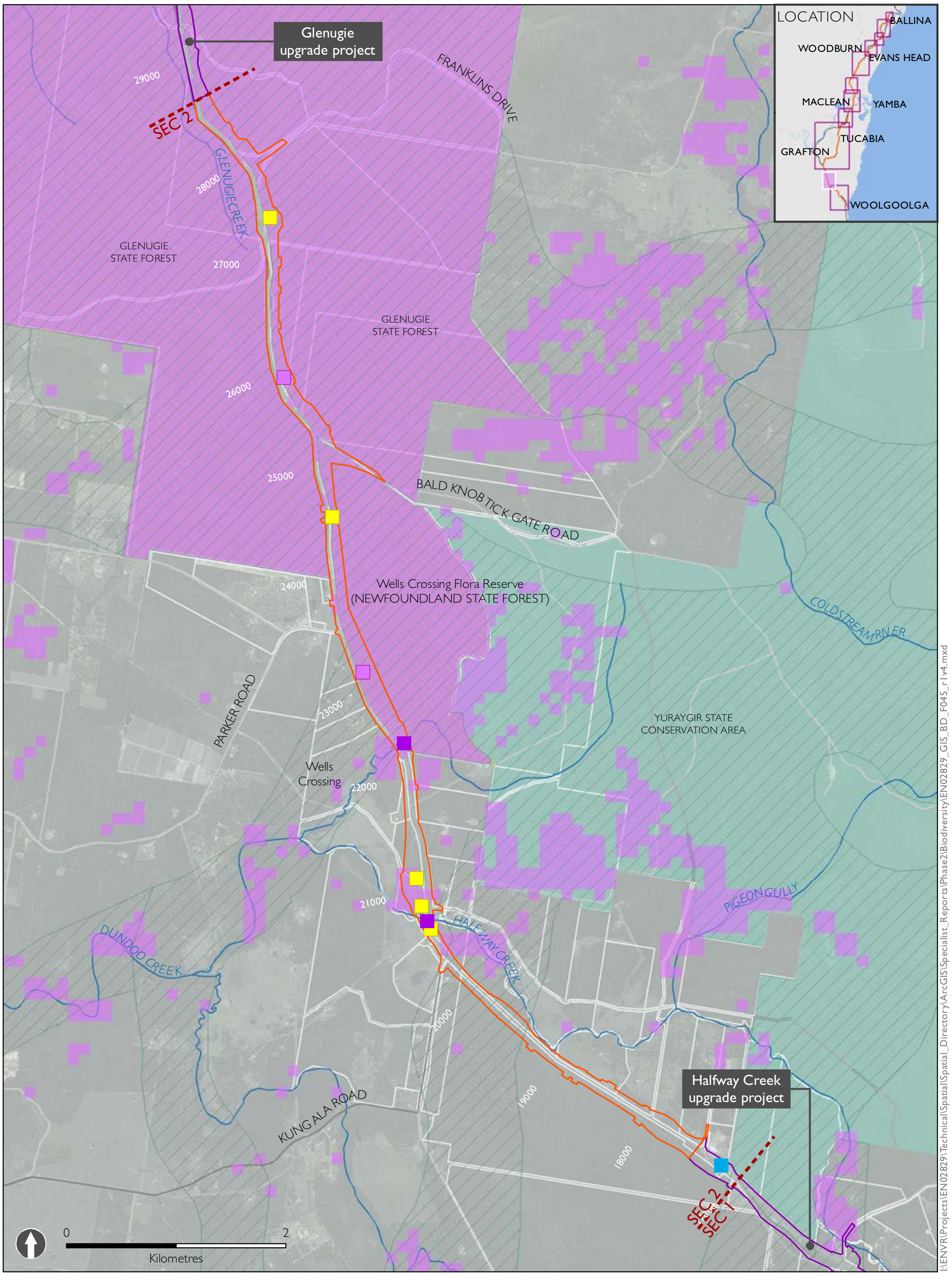
Figure A-6 Section 1 - Fauna connectivity structures



The project
Upgrade completed to dual carriageway
Upgrade under construction
Existing Pacific Highway
Fauna corridors
Key fauna habitat

Fauna connectivity structures
- Combined (bridge)
- Combined (*Oxleyan Pygmy Perch*)
- Combined (fauna and emu)
- Combined (emu and bridge structure)
- Combined (emu and drainage structure)
- Combined (culvert)
- Dedicated Arboreal
- Dedicated Overpass
- Dedicated Underpass
- Incidental Emu Structure (road overpass)
- Incidental Emu Structure (road underpass)

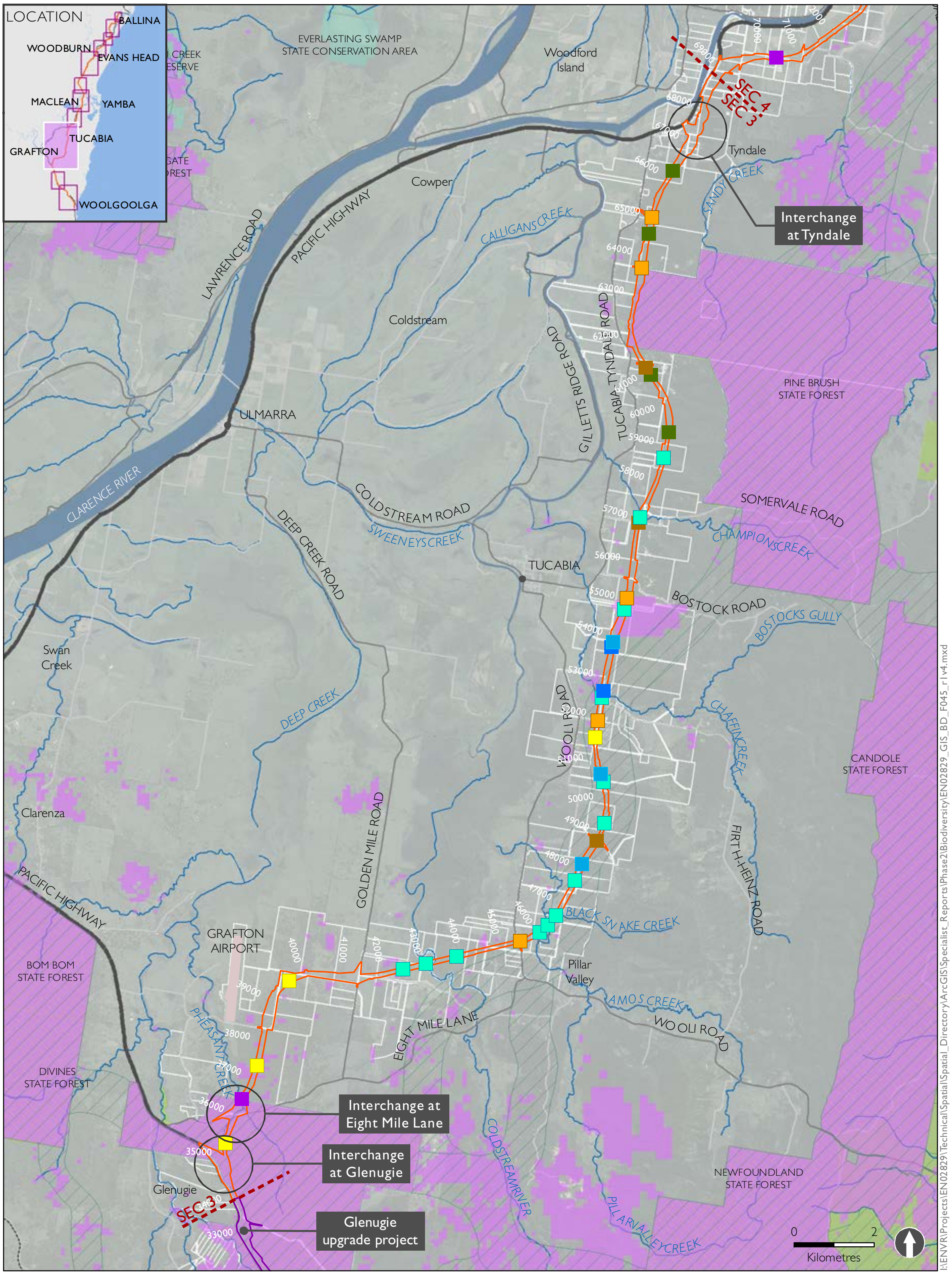
Figure A-7 Section 2 - Fauna connectivity structures



The project
Upgrade completed to dual carriageway
Upgrade under construction
Existing Pacific Highway
Fauna corridors
Key fauna habitat

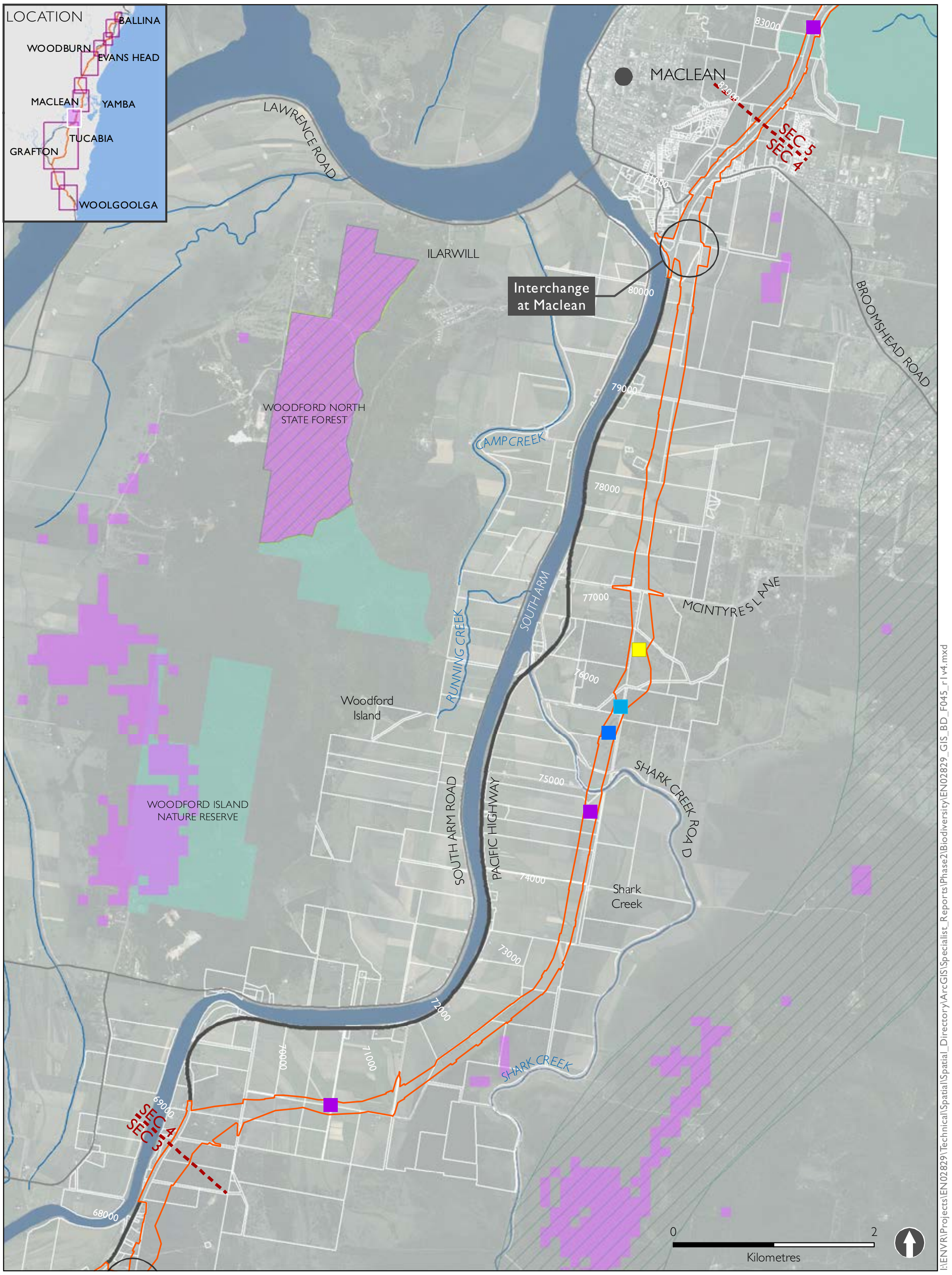
Fauna connectivity structures
- Combined (bridge)
- Combined (*Oxleyan Pygmy Perch*)
- Combined (fauna and emu)
- Combined (emu and bridge structure)
- Combined (emu and drainage structure)
- Combined (culvert)
- Dedicated Arboreal
- Dedicated Overpass
- Dedicated Underpass
- Incidental Emu Structure (road overpass)
- Incidental Emu Structure (road underpass)

Figure A-8 Section 3 - Fauna connectivity structures



The project	Fauna connectivity structures	Combined (culvert)
Upgrade completed to dual carriageway	Combined (bridge)	Dedicated Arboreal
Upgrade under construction	Combined (*Oxleyan Pygmy Perch*)	Dedicated Overpass
Existing Pacific Highway	Combined (fauna and emu)	Dedicated Underpass
Fauna corridors	Combined (emu and bridge structure)	Incidental Emu Structure (road overpass)
Key fauna habitat	Combined (emu and drainage structure)	Incidental Emu Structure (road underpass)

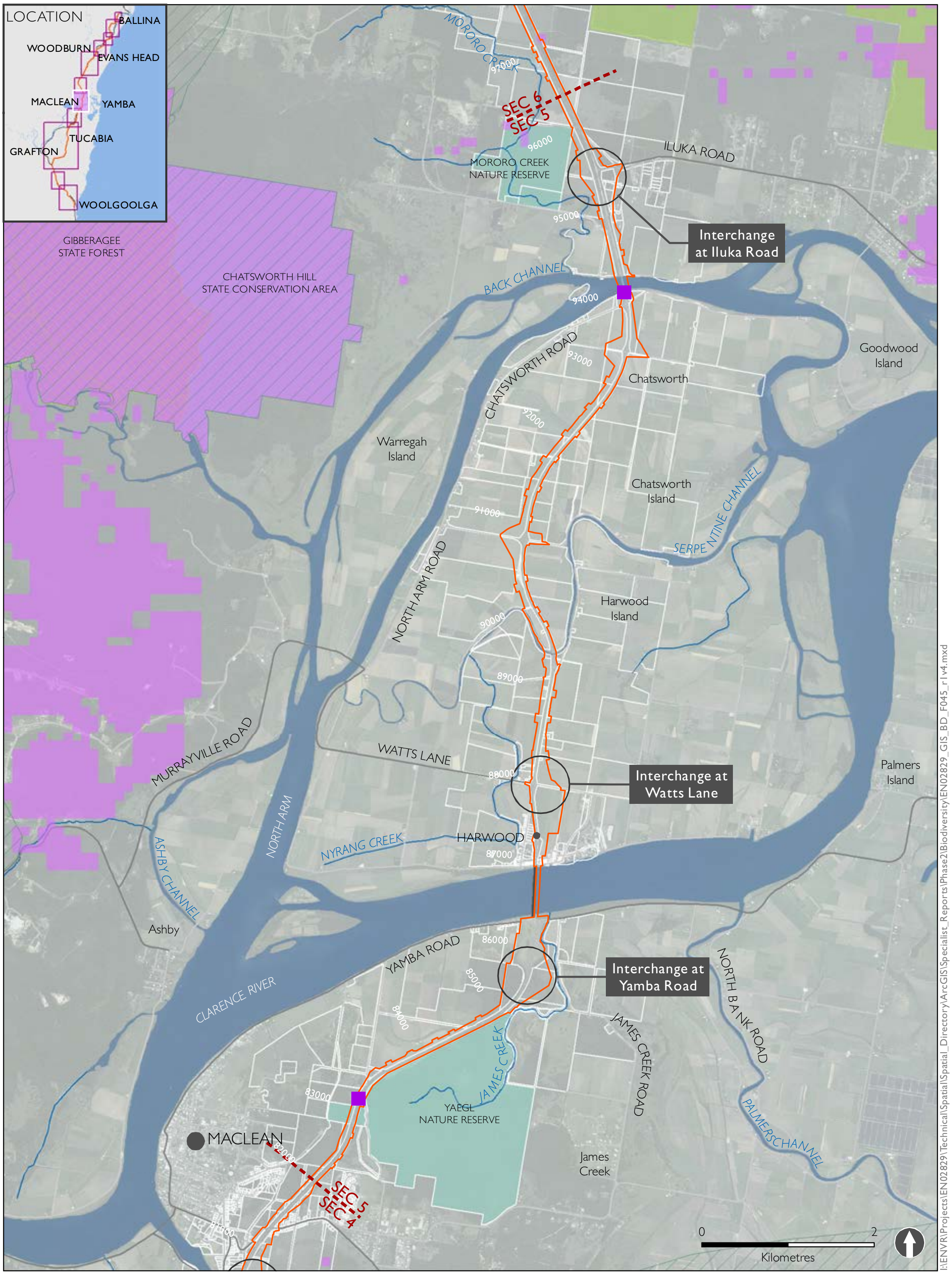
Figure A-9 Section 4 - Fauna connectivity structures



The project
Upgrade completed to dual carriageway
Upgrade under construction
Existing Pacific Highway
Fauna corridors
Key fauna habitat

Fauna connectivity structures
- Combined (bridge)
- Combined (*Oxleyan Pygmy Perch*)
- Combined (fauna and emu)
- Combined (emu and bridge structure)
- Combined (emu and drainage structure)
- Combined (culvert)
- Dedicated Arboreal
- Dedicated Overpass
- Dedicated Underpass
- Incidental Emu Structure (road overpass)
- Incidental Emu Structure (road underpass)

Figure A-10 Section 5 - Fauna connectivity structures

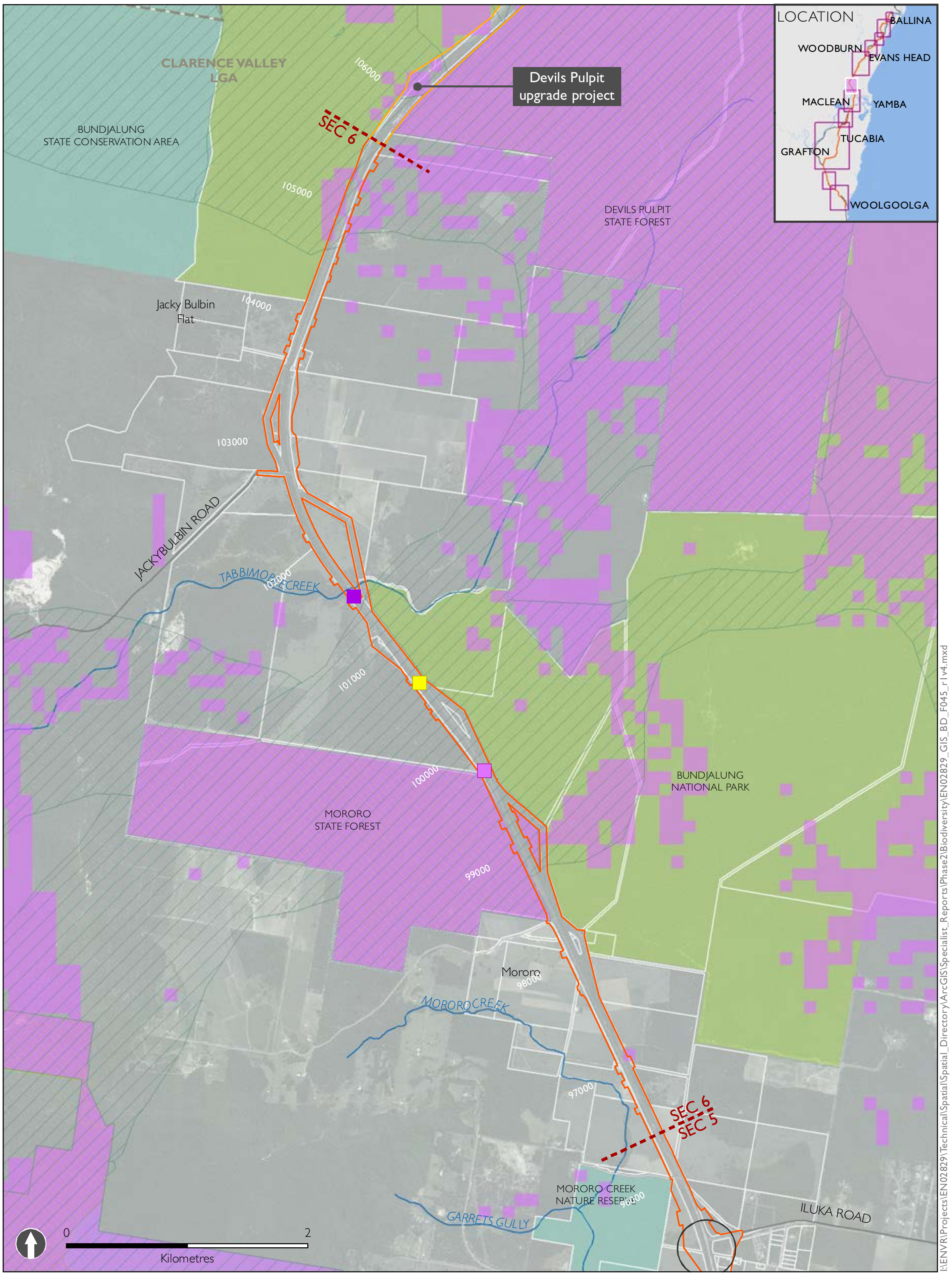


- The project
- Upgrade completed to dual carriageway
- Upgrade under construction
- Existing Pacific Highway
- Fauna corridors
- Key fauna habitat

Fauna connectivity structures

- Combined (bridge)
- Combined (*Oxleyan Pygmy Perch*)
- Combined (fauna and emu)
- Combined (emu and bridge structure)
- Combined (emu and drainage structure)
- Combined (culvert)
- Dedicated Arboreal
- Dedicated Overpass
- Dedicated Underpass
- Incidental Emu Structure (road overpass)
- Incidental Emu Structure (road underpass)

Figure A-11 Section 6 - Fauna connectivity structures



The project
Upgrade completed to dual carriageway
Upgrade under construction
Existing Pacific Highway
Fauna corridors
Key fauna habitat

Fauna connectivity structures
Combined (bridge)
Combined (*Oxleyan Pygmy Perch*)
Combined (fauna and emu)
Combined (emu and bridge structure)
Combined (emu and drainage structure)
Combined (culvert)
Dedicated Arboreal
Dedicated Overpass
Dedicated Underpass
Incidental Emu Structure (road overpass)
Incidental Emu Structure (road underpass)

Figure A-12 Section 7 - Fauna connectivity structures

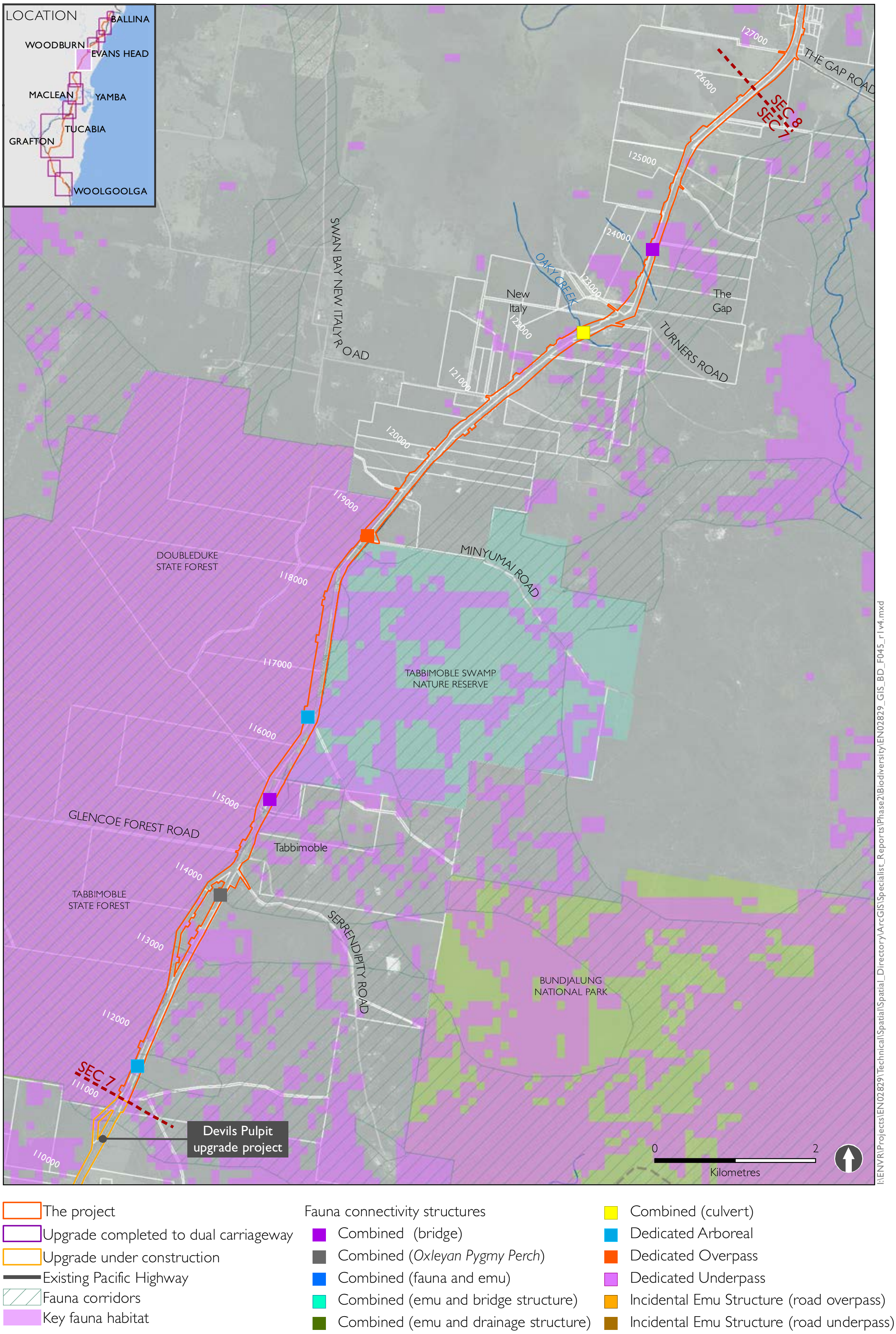
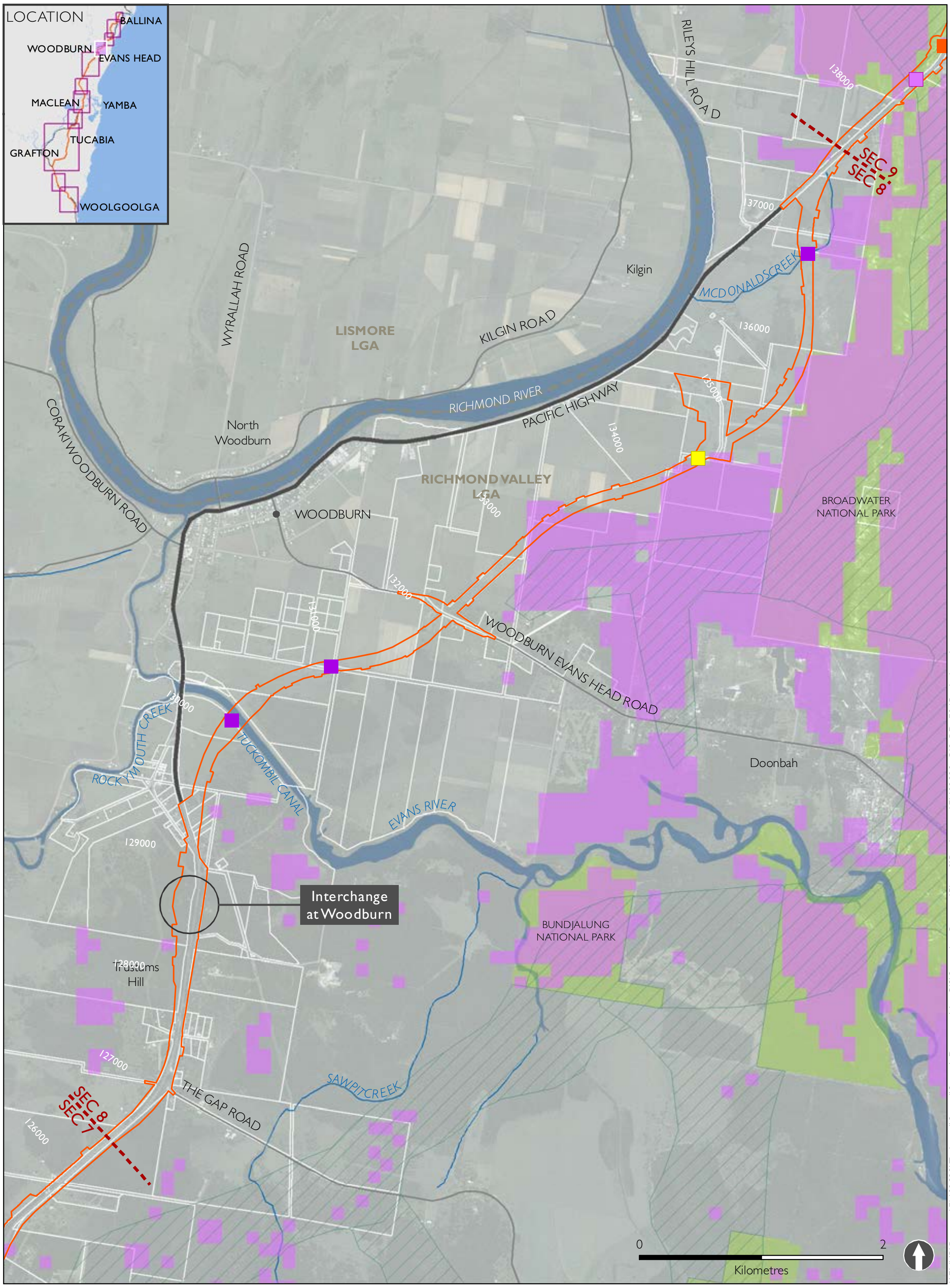


Figure A-13 Section 8 - Fauna connectivity structures



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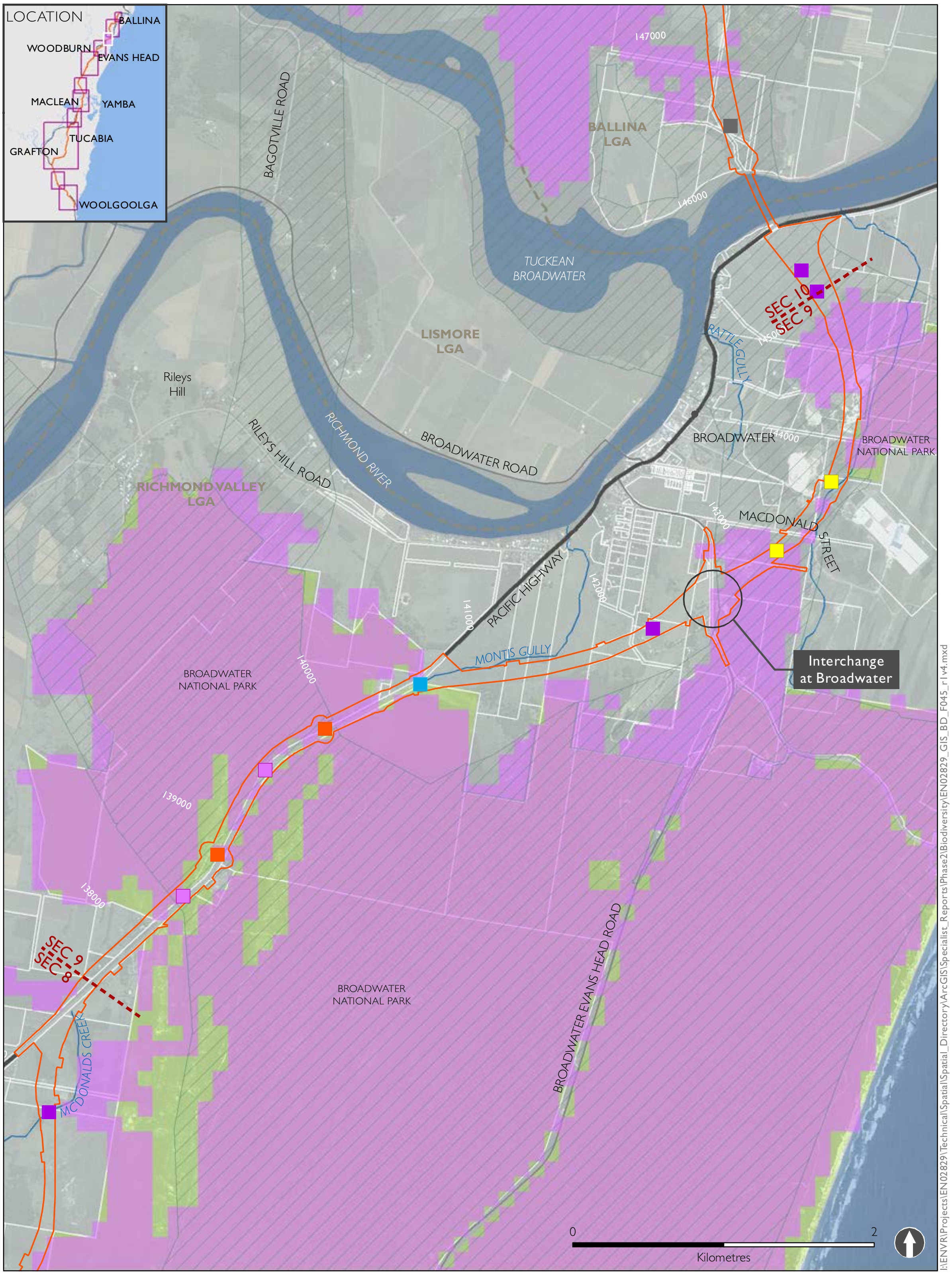
- The project
- Upgrade completed to dual carriageway
- Upgrade under construction
- Existing Pacific Highway
- Fauna corridors
- Key fauna habitat

Fauna connectivity structures

- Combined (bridge)
- Combined (*Oxleyan Pygmy Perch*)
- Combined (fauna and emu)
- Combined (emu and bridge structure)
- Combined (emu and drainage structure)
- Combined (culvert)
- Dedicated Arboreal
- Dedicated Overpass
- Dedicated Underpass
- Incidental Emu Structure (road overpass)
- Incidental Emu Structure (road underpass)

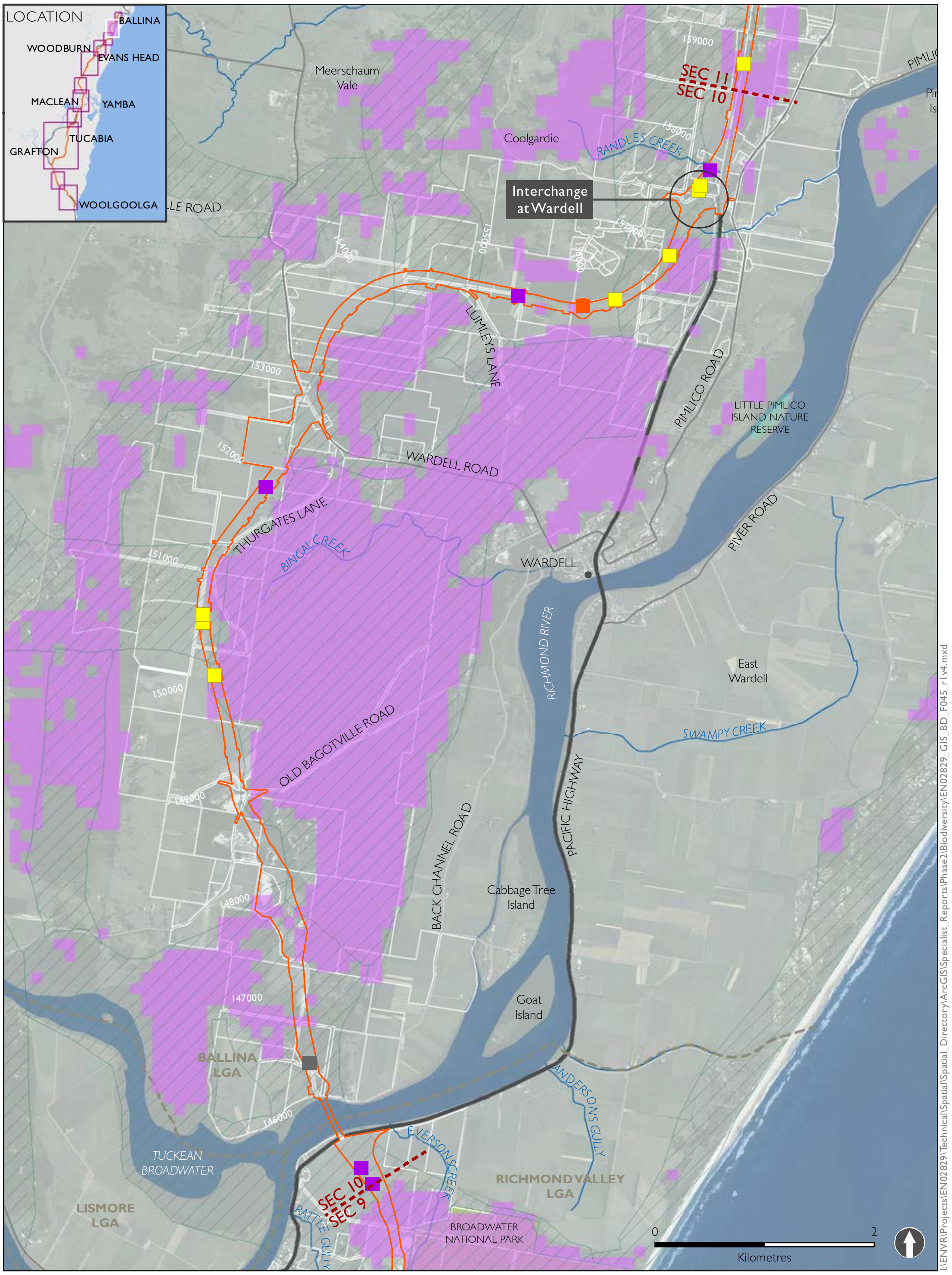
Figure A-14 Section 9 - Fauna connectivity structures



The project
Upgrade completed to dual carriageway
Upgrade under construction
Existing Pacific Highway
Fauna corridors
Key fauna habitat

Fauna connectivity structures
- Combined (bridge)
- Combined (*Oxleyan Pygmy Perch*)
- Combined (fauna and emu)
- Combined (emu and bridge structure)
- Combined (emu and drainage structure)
- Combined (culvert)
- Dedicated Arboreal
- Dedicated Overpass
- Dedicated Underpass
- Incidental Emu Structure (road overpass)
- Incidental Emu Structure (road underpass)

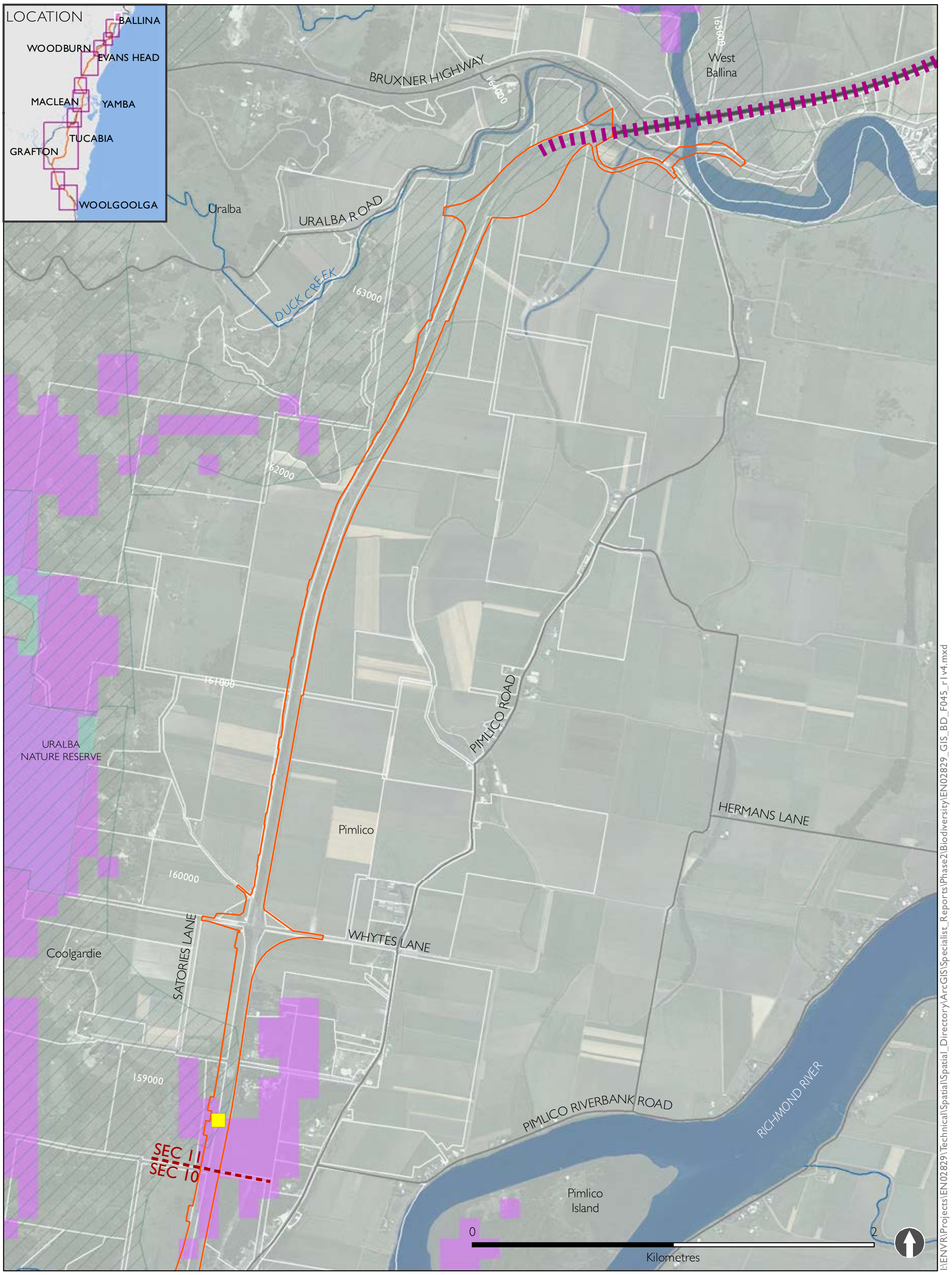
Figure A-15 Section 10 - Fauna connectivity structures



The project
Upgrade completed to dual carriageway
Upgrade under construction
Existing Pacific Highway
Fauna corridors
Key fauna habitat

Fauna connectivity structures
- Combined (bridge)
- Combined (*Oxleyan Pygmy Perch*)
- Combined (fauna and emu)
- Combined (emu and bridge structure)
- Combined (emu and drainage structure)
- Combined (culvert)
- Dedicated Arboreal
- Dedicated Overpass
- Dedicated Underpass
- Incidental Emu Structure (road overpass)
- Incidental Emu Structure (road underpass)

Figure A-16 Section 11 - Fauna connectivity structures



The project
Upgrade completed to dual carriageway
Upgrade under construction
Existing Pacific Highway
Fauna corridors
Key fauna habitat

Fauna connectivity structures
- Combined (bridge)
- Combined (*Oxleyan Pygmy Perch*)
- Combined (fauna and emu)
- Combined (emu and bridge structure)
- Combined (emu and drainage structure)
- Combined (culvert)
- Dedicated Arboreal
- Dedicated Overpass
- Dedicated Underpass
- Incidental Emu Structure (road overpass)
- Incidental Emu Structure (road underpass)

Connectivity Strategy References

Woolgoolga to Wells Crossing Route Options Report (RTA, 2005a).

Woolgoolga to Wells Crossing Preferred Route Report (RTA, 2006b).

Woolgoolga to Wells Crossing Concept Design Report (RTA, 2008a).

Wells Crossing to Iluka Road Route Options Development Report (RTA, 2005b).

Wells Crossing to Iluka Road Preferred Route Report (RTA, 2006c).

Wells Crossing to Iluka Road Concept Design Report (RTA, 2009a).

Discussion paper on Tyndale to Maclean alternative route (RTA, 2010a).

Tyndale to Maclean Alternative Alignment Decision Report (RTA, 2011b)

Iluka Road to Woodburn Concept Design Report (RTA, 2006d).

Iluka Road to Woodburn Preferred Concept Design Report (RTA, 2008b).

Woodburn to Ballina Route Options Development Report (RTA, 2005c).

Woodburn to Ballina Upgrade Preferred Route Report (RTA, 2005d).

Woodburn to Ballina Upgrade Concept Design Report (RTA, 2008c).

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Appendix B Biodiversity monitoring strategy

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B.1 Introduction and objectives

It is proposed to progress the project to detailed design and construction by staging successive upgrades, with each stage comprising one or more of the 11 project sections discussed. To ensure a consistent approach to monitoring biodiversity for each future construction stage, an overarching biodiversity monitoring strategy has been developed.

The objective of the strategy is to provide a framework to guide the development of a project Biodiversity Monitoring Program to monitor the effectiveness of the mitigation measures proposed for threatened species across the project as a whole and individual project sections.

The strategy therefore identifies the proposed content and structure of the Biodiversity Monitoring Program, including a list of the key target species and specific details on the monitoring methodology for each, details on structures and locations to be monitored relevant to project sections, and outline of the monitoring actions required to monitor the effectiveness of the mitigation measures and adaptive management and reporting measures.

B.2 Structure of the program

The Ecological Monitoring Program shall be developed and implemented in consultation with the EPA. The primary aim of the Program is to measure the effectiveness of proposed mitigation measures to be implemented for the project and allow for their modification if necessary. The Program will include the collection of baseline data, followed by the full duration of construction and from the opening of the project to traffic until it can be demonstrated that the effectiveness of the mitigation measures has been achieved. Initially this is expected to be reported over five successive monitoring years, after which a final review of the outcomes would be reported. The Program shall include as a minimum:

1) Monitoring the effectiveness of fauna crossing structures including fauna exclusion fencing
2) Monitoring the effectiveness of widened medians
3) Riparian and aquatic habitat condition monitoring
4) Performance reporting including adaptive management framework
5) Installation and monitoring of wildlife nest boxes
6) Monitoring the impacts on threatened flora and fauna species adjacent to the alignment

B.3 Content of the program

The Program would be structured into a single overall document that address the content described in points 1-4 above. Point 5 would be addressed via a separate Nest Box Management Plan as discussed below and monitoring of the impacts on threatened species (Point 6) would be addressed via the threatened species management sub-plans as part of the Flora and Fauna Management Plan previously described in Section 5.3.2.

The Monitoring Program will include the following content:

- Clear goals and objectives that are SMART (Specific, Measurable, Achievable, Realistic and Timely).
- Long-term monitoring that considers whether the impact of the barrier effect of the highway has been eliminated or satisfactorily ameliorated is necessary. This should include road mortality and the use of connectivity structures. The program is to continue until such time as the effectiveness of mitigation measures can be demonstrated to have been achieved over a minimum of five successive monitoring periods following establishment of vegetation planted as part of mitigation and after opening of the project to traffic.
- The monitoring program should adopt a target species or taxa approach rather than a structure by structure approach. This focus is due to the fact that there is considerable existing data on the use of underpass structures by fauna in Australia, however a lack of evidence on specific species and taxa, for example Rufous Bettong. The list of suggested target species is discussed below.
- Monitoring should include sufficient data prior to construction to allow comparison with post-construction data and include reference sites nearby without mitigation.
- To determine success of connectivity structures this would comprise collection of data regarding road mortality, species composition and abundance of passage users (including evidence of completed crossings), together with population and genetic structure of target fauna in adjacent habitats.
- An adaptive monitoring program that assesses the effectiveness of the proposed mitigation measures and allows their modification if necessary. In this regard performance measures need to be quantified.
- Provision for annual reporting of monitoring results.

1. Use of connectivity structures

Impacts to fauna will be reduced via the use of fauna crossing structures. The key objective is to maintain terrestrial fauna connectivity via a large number of underpasses, land bridges and canopy rope bridges and glider poles.

The Biodiversity Connectivity Strategy focuses on threatened species identified as important populations occurring adjacent to the project boundary and species for which there is currently limited information concerning the effectiveness of fauna crossing structures. The goal for monitoring fauna crossing structures is to determine the effectiveness of the proposed fauna crossing structures to facilitate effective movement of these target species and avoid injury or death due to vehicle collision.

The program is to take a species approach whereby target species and the key locations and structures for the target species are identified. The pre-selection of appropriate sites will maximise the chance of collecting robust data for the species. The program should commence at least 12 months prior to construction, to give sufficient time to find a population of the target species. If no population is found within the designated section within 6 months of commencing the baseline work, then an alternative project section would be sought.

Target species

The target species and relevant project sections are as follows:

- Rufous Bettong – sections 1-3
- Brush-tailed Phascogale – sections 1-2 and Section 6 and 7
- Common Planigale – section 1-3
- Emu population - sections 3-4
- Spotted-tailed Quoll – section 1-2 and 7
- Koala – section 7, section 9 and 10
- Long-nosed Potoroo – section 10
- Yellow-bellied Glider – sections 1-2
- Squirrel Glider – sections 1-2, 7 and 9.
- Giant Barred Frog – section 1-3, 6-8
- Oxleyan Pygmy Perch – sections 1-2, and 6-9

Objectives and methods

- Identify objectives, performance measures and corrective actions
- The monitoring program will identify specific crossing structures to be targeted in each of these project sections.
- Baseline surveys are required to establish the presence of the target species and to refine the location of the structures to be monitored. The surveys should be completed prior to construction.

- The survey method, timing and duration for collection of baseline surveys for the target species to be consistent with DEC (2004) survey guidelines and with consideration to relevant DSEWPAC species survey guidelines. The program would consider systematic landscape-scale replication.
- Identify the monitoring technique for each structure in the program including the proposed method, equipment, timing and duration. Suggested techniques would include motion sensor cameras, sand plot monitoring, hair tubes and scat searches. The frequency and duration of these techniques is to be described.
- Timing of monitoring of fauna underpasses would coincide with the breeding seasons and juvenile dispersal periods of the target threatened fauna species which are to be identified in the monitoring program. Movement of these fauna species is more likely during breeding and dispersal periods as individuals seek mates, expand home ranges and juveniles disperse from natal areas, potentially resulting in higher underpass usage.
- The success of the structure will be determined by the complete passage from each of the species.
- Fauna mortality is to be monitored at the specific locations identified in the program. The degree of success of the fauna fencing will be determined by the absence of specific road struck fauna for the target species. The monitoring of fauna fencing will occur during the operational stage and details of this would be described in the Flora and Fauna Management Plan.
- Post-construction monitoring would extend for up to 5 years post-construction to account for the fact that the structure would be most effective once revegetation works near fauna structures provide sufficient cover for fauna.
- Monitoring of the rope bridges would commence when the project becomes operational. As the monitoring procedure requires minimal effort (person-hours), monitoring would be undertaken at each site continuously for the first year.
- Additional monitoring of crossing structures may be required after these designated timeframes if performance measures (identified below) are not met or a need for monitoring beyond this period is recognised. The need for additional monitoring would be reviewed in consultation with OEH and DSEWPaC.

Performance measures

Performance of the fauna crossing structures and associated fauna fencing would be measured by achievement of the following possible outcomes:

- Complete passage of underpasses, overpasses and arboreal crossing structures by a diversity of native fauna species
- Complete passage of crossing structures by the target species
- No fauna vehicle strikes
- No breaches in fauna fencing.

2. Monitoring of medians

The goal for monitoring the vegetated median is to determine the effectiveness of the widened median to facilitate effective movement of the target species and avoid injury or death due to vehicle collision. Widened medians were incorporated into the design at three locations:

- Station 4.950 to 6.900 (Section 1)
- Station 22.5500 to 23.800 (Section 2)
- Station 114.100 to 121.100 (Section 7).

The target species are gliders and the timing of monitoring of vegetated medians would coincide with the breeding seasons and dispersal periods of target glider species.

The monitoring survey method and effort for the target species is to be outlined in the program and should consider the use of trapping, hair-tubes and spotlighting.

Performance of vegetated medians would be measured by achievement of the following:

- Identification of or evidence of presence of target gliding mammals within vegetated medians
- Identification of or evidence of presence of other native fauna species within vegetated medians

3. Riparian and aquatic habitat monitoring

- The program will outline a methodology for monitoring of riparian and aquatic habitat condition in sensitive receiving waters adjacent to the project. The program will identify locations to be monitored and include assessment methods with consideration of reference locations where no impacts are experienced.
- The methods is expected to use appropriate systematic methods and landscape-scale replication based on a visual habitat assessment of all streams to be traversed by the project or within close proximity to the proposed construction area is to completed using the NSW AUSRIVAS field methodology.
- Monitoring would include recording the aquatic and riparian vegetation present, substrate type, water quality (if water was present), habitat types and general condition and health of the reach.
- Information on stream health and aquatic habitat will be used as part of the adaptive management program.
- The timing of the surveys for each section is to be provided in the program including pre-construction and post-construction duration and should be sufficient to allow any changes and/or degradation of aquatic habitat for threatened fish species to be recorded and appropriate mitigation measures implemented as part of the adaptive management program. As a minimum the program should commence a minimum of 6 months prior to construction.

4. Reporting

The Biodiversity Monitoring Program will include provision for annual reporting of monitoring results to the EPA and DSEWPAC. As the program will focus on performance indicators and provide an adaptive management framework, the outcomes of these would be reported in the monitoring program annual reports.

5. Nest box Management Plans

A nest box management plan would be developed as a separate document to the monitoring program as part of the FFMP with separate plans prepared for each construction stage of project. The number and type of nest boxes required on each project section would be determined during the pre-clearance surveys based on the number, quality and size of the hollows that would be removed from the project section(s). The nest box management plans would detail the specifications for nest box dimensions, installation requirements, locations of nest boxes and ongoing monitoring and maintenance. The plan would allow for installation of 70% of nest boxes prior to the removal of any vegetation.

Data to be collected in the pre-clearance survey would include number of hollows and their estimated size classes so the suitability of each resource could be assigned to various fauna groups (i.e. microchiropteran bats, scansorial mammals, gliders, possums). The density of hollows within the habitat adjacent to the corridor should be identified so that next boxes can be targeted in areas with low hollow density and the locations and quantities of the nest boxes to be installed can be identified.

6. Threatened species sub-plans

Monitoring of impacts on threatened species and their habitat would be addressed via preparation of specific threatened species management plans. The content of these plans is described in Section 5.2.3. The plans will address species with a high likelihood of impact from the project and focus on detailed design avoidance measures, construction and post-construction monitoring and adaptive management actions.

Appendix C Biodiversity offset strategy

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C.1 Introduction

Background

The NSW Roads and Maritime Services (RMS) is planning to upgrade a 155 kilometre section of the Pacific Highway, starting from around five kilometres north of Woolgoolga to six kilometres south of Ballina on the North Coast of New South Wales. The Woolgoolga to Ballina Upgrade ('the Project') forms part of the Pacific Highway Upgrade Program, a joint commitment by the NSW State Government and the Federal Government to upgrade the Pacific Highway between Hexham and the Queensland border.

While the project is for a four-lane motorway standard upgrade, the construction and opening of the project would be staged. Staging could include some sections being constructed and opened initially as a four-lane arterial standard upgrade.

The project does not include the Pacific Highway upgrades at Glenugie and Devils Pulpit, which are located between Woolgoolga and Ballina, as Glenugie is now complete and Devils Pulpit is under construction. Together with the Glenugie and Devils Pulpit upgrades, the project would complete a total of 164 kilometres of upgraded highway between Woolgoolga and Ballina.

The RMS approach in planning of the Project and developing the offset strategy has followed a hierarchy of principles with regard to biodiversity values being avoidance, mitigation and offset as detailed. Each of these is discussed below.

Design avoidance, mitigation and offsetting measures

Impacts on biodiversity have been avoided where possible through consideration of the flora and fauna data gathered during the background review and field surveys. This information was used to illustrate the ecological values, constraints and opportunities.

The siting of infrastructure including the concept design was designed where possible to avoid remnant vegetation and habitat. The result has been to minimise the project footprint as much as possible and retain important vegetation and landscape connectivity.

Further surveys of hollow-bearing habitat trees, nests and vegetation clearing limits would be required prior to completing the final design and construction of the project in an attempt to refine the footprint where feasible and reasonable.

A detailed mitigation framework is provided which outlines provisions for project specific environmental management plans. These plans would be prepared prior to construction and would identify the areas of focus, provide a set of objectives and actions required to restore, maintain and monitor the success of the plan with an adaptive approach.

It is recognised that impacts on threatened ecological communities and habitat for threatened fauna species could not be avoided due to the nature of the proposed development, being linear infrastructure. As such residual impacts have been identified. The assessment has identified and quantified the impacts on biodiversity including the loss of threatened ecological communities and habitat for threatened species.

Roads and Maritime Services policy

NSW Roads and Maritime Services (RMS) would provide biodiversity offsets, where there is a loss of biodiversity above the thresholds identified in the RMS Guideline: *Biodiversity Offsets* (RMS 2011), after all reasonable and feasible measures to avoid, minimise and mitigate impact have been implemented. Where offsets are required, RMS would prepare a Biodiversity Offset Package for the project that identifies the method for determining the offset amount and location and the most effective options for implementing the offsets.

The Woolgoolga to Ballina Upgrade Biodiversity Offset Strategy would allow a consistent and transparent approach to be adopted for the project and allow the process of identification of suitable offsets to be commenced.

Director-General's requirements

This Biodiversity Offset Strategy has been prepared to address the NSW Department of Planning and Infrastructure (DoP&I) Director-General's requirements (DGRs) issued for assessment of the project under Part 5.1 of the NSW EP&A Act for both terrestrial and aquatic ecology.

The DGRs require:

'the details of available offset measures to compensate the biodiversity impacts of the project where offset measures are proposed to address residual impacts, consistent with the Principles for the use of biodiversity offsets in NSW'

Commonwealth Government environmental offsets policy

For further consideration it is recommended that the proposed environmental offsets are consistent with the Commonwealth Governments policy statement with respect to environmental offsets under the EPBC Act (DSEWPAC 2012e). In particular the offset strategy aims to address the overarching principles outlined in the policy. In this regard the environmental offsets would be targeted to the matter protected by the EPBC Act that is being impacted. As the project will impact on vegetation communities containing habitat for nationally listed threatened flora and fauna it is critical that the offsets contain these same vegetation types and in similar condition.

The offset would, as a minimum, be commensurate with the magnitude of the impacts of the development and ideally deliver outcomes that are 'like for like'. In this respect it will be important to target comparably vegetation / habitat types.

Biodiversity Offset Strategy objectives

The objective of the Biodiversity Offset Strategy is to identify a package of offsets to achieve a neutral or net beneficial biodiversity outcome for the region as a result of the project. The measures used to gauge success of this objective will be:

- An outcome that maintains or improves biodiversity values;
- Successfully securing the long-term (in perpetuity) protection and management of lands containing threatened species and ecological communities and habitat for threatened species (key habitat);
- Meeting the minimum requirements for offsets as specified in the conditions of approval;
- The total area of lands used to offset the biodiversity impacts shall exceed the residual direct and indirect (edge effects) impacts; and
- The process for setting the scope and quantum of the biodiversity offsets is transparent and justifiable on environmental, social and economic grounds.

The strategy would be applied consistently across the project from approval to offset the impacts identified in the EIS. Where there is scope to reduce the identified impact through the detailed design phase for each of the eleven sections, the refined impact footprint would be considered in the calculations of offsets.

Integration with other ecological reports

The Biodiversity Offset Strategy is part of a suite of reports that document how the biodiversity impacts of the project will be mitigated or offset, and how mitigation actions will be managed and monitored. Once potential offset sites are secured, additional documentation will be required to demonstrate the suitability of these site/s to offset the impacts of the project to achieve a neutral or net beneficial biodiversity outcome.

Existing environment

The project traverses a mix of floodplains, low hills and ranges as well as coastal environmental features including wide valleys, channels, swamps and terraces typical of the alluvial plains of the Clarence and Richmond rivers (Morgan 2001b, Mitchell 2003). This also includes the low hills and plains of the Manning River, Macleay River and Evans River.

Several coastal ranges occur in the east of the study area, the most prominent being the Summervale Range, incorporating Shark Creek and Pillar Valley ranges in the south and the coastal Ballina and Blackwall Ranges between Wardell and Ballina. Remaining areas have been formed by coastal barriers such as dunes, swamps and lagoons on Quaternary coastal sands with an elevation up to 25 metres.

Throughout many of these areas extensive clearing for agriculture, logging and residential development has been prevalent. In total 26 biometric vegetation types are represented in the study area, within which, six threatened ecological communities (TEC) listed under the TSC Act and were identified and one TEC listed under the EPBC Act.

Full details regarding the existing physical and biological attributes of the study area are provided in the Biodiversity Assessment for the EA.

Report structure

The structure of this Biodiversity Offset Strategy is as follows:

- Section C.2 identifies the impacts of the project to vegetation, habitat and threatened species, populations and ecological communities.
- Section C.3 details the management of biodiversity impacts, following the principles of avoiding, minimising and mitigating.
- Section C.4 details the principles and the decision making framework for determining offset measures.
- Section C.5 provides conclusions.

C.2 Potential impacts of the project

Potential impacts on flora and fauna have been minimised and avoided where possible throughout route selection and development of the concept design for the project. Prior to construction the concept design may be further refined.

Vegetation and habitat

The project would clear about 948 hectares of native remnant vegetation, affecting a number of vegetation types as described in Table C-1Table 4-1. These clearing estimates have been calculated based on the construction footprint (the road construction footprint including water quality and sediment basins plus an additional 10 metre allowance for construction). The project impacts on areas of key habitat that comprises threatened ecological communities and habitat for threatened species. These impacts occur across the project area and are summarised in Table C-1

Table C-1 also identifies the area of edge effects for biometric vegetation type. Edge effects have been based on a 50 metre wide edge from the construction footprint. A comprehensive review on edge effects and their compensation (Bali 2000 & 2005) suggests that a 1:1 ratio is not considered appropriate as it implies that edge habitat is unsuitable for and will not be used by any species. Instead it is considered that on average that the edge zone is 60% less suitable. Therefore, only 60% of a 50 metre strip of edge affected habitat should apply to all key habitats removed along the new road corridor. This takes into account that edge effects reduce the quality of habitat, but do not completely remove their habitat values. Therefore, taking into account only areas where a new edge is created through vegetation, the extent of possible edge effect impacts for the project is around 431.6 ha.

Table C-1 does not include clearing that may be required for potential ancillary facilities beyond this construction footprint. The loss of vegetation associated with potential ancillary facilities would equate to an additional 25 hectares.

Table C-1 Direct and indirect impacts on vegetation and fauna habitat

Biometric vegetation association*	Vegetation formation (Keith 2004)^	Direct loss (detailed vegetation mapping)	Edge effects (based on CRAFTI and detailed mapping)	TEC / highly cleared
Black Bean - Weeping Lilly Pilly Riparian Rainforest of the North Coast	Rainforest	1.4	0.5	Highly cleared 75%
Blackbutt - Bloodwood Dry Heathy Open Forest on Sandstones of the Northern North Coast	Shrubby dry sclerophyll forest	79.7	28.9	No
Blackbutt Grassy Open Forest of the Lower Clarence Valley of the North Coast	Wet sclerophyll forest	46.2	11.3	No
Coast Cypress Pine Shrubby Open Forest of the North Coast Bioregion	Shrubby dry sclerophyll forest	27.4	5	TEC
Coastal Floodplain Sedgelands, Rushlands, and Forblands	Freshwater wetland	3.0	0.8	TEC
Coastal Heath on Sands of the North Coast	Heathland	0.2	2	No
Flooded Gum - Tallowwood - Brush Box Moist Open Forest of the Coastal Ranges of the North Coast	Wet sclerophyll forest	2.0	1.6	No
Forest Red Gum - Swamp Box of the Clarence Valley Lowlands of the North Coast	Grassy woodland	73.9	29.4	TEC
Grey Gum - Grey Ironbark Open Forest of the Clarence Lowlands of the North Coast	Dry sclerophyll shrub/grass forest	48.2	7.1	No
Hoop Pine - Yellow Tulipwood Dry Rainforest of the North Coast	Rainforest	0.5	0.3	TEC
Mangrove - Grey Mangrove Low Closed Forest of the NSW Coastal Bioregions	Saline wetland	1.5	0.4	Highly cleared 75%
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast	Grassy woodland	34.7	30.6	TEC
Needlebark Stringybark - Red Bloodwood Heathy Woodland on Sandstones of the Lower Clarence of the North Coast	Shrubby dry sclerophyll forest	58.2	15.4	No
Orange Gum (*Eucalyptus bancroftii*) Open Forest of the North Coast	Shrubby dry sclerophyll forest	11.5	6	Highly cleared 75%
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast	Swamp sclerophyll forest	49.5	17.1	TEC
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast	Wet sclerophyll forest	46.2	16.7	No

Biometric vegetation association*	Vegetation formation (Keith 2004)^	Direct loss (detailed vegetation mapping)	Edge effects (based on CRAFTI and detailed mapping)	TEC / highly cleared
Scribbly Gum - Needlebark Stringybark Heathy Open Forest of Coastal Lowlands of the Northern North Coast	Shrubby dry sclerophyll forest	71.9	35.5	No
Spotted Gum - Grey Box - Grey Ironbark Dry Open Forest of the Clarence Valley Lowlands of the North Coast	Dry sclerophyll shrub/grass forest	2.1	10.3	No
Spotted Gum - Grey Ironbark - Pink Bloodwood Open Forest of the Clarence Valley Lowlands of the North Coast	Dry sclerophyll shrub/grass forest	144.8	124.2	No
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	Grassy woodland	28.5	0	TEC
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	Swamp sclerophyll forest	44.2	18.4	TEC
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	Swamp sclerophyll forest	56.2	21.5	TEC
Tallowwood Dry Grassy Forest of the Far Northern Ranges of the North Coast	Dry sclerophyll shrub/grass forest	53.0	23	No
Turpentine Moist Open Forest of the Coastal Hills and Ranges of the North Coast	Wet sclerophyll forest	44.5	17.6	No
Wet Heathland and Shrubland of Coastal Lowlands of the North Coast	Freshwater wetland	10.0	3.7	Highly cleared 75%
White Booyong - Fig Subtropical Rainforest of the North Coast	Rainforest	8.6	4.3	TEC
TOTALS		**948**	**431.6**	
Cleared and Modified	N/A	870.1		

Threatened species

There is likely to be direct impacts on a number of threatened flora and fauna species recorded or potentially occurring in the proposal area. Major populations of threatened flora species recorded in the study area include *Angophora robur, Arthraxon hispidus, Eucalyptus tetrapleura, Melaleuca irbyana, Maundia triglochinoides, Cyperus aquatilis,* and *Lindsaea incisa*. Direct impacts are likely on the known and potential habitat of 62 threatened vertebrate fauna species and potentially four threatened invertebrate species and three threatened fish species. Threatened flora and fauna species potentially impacted from the proposal are listed below in Table C-2, including species recorded and potentially occurring in the proposal area.

Table C-2 Threatened species potentially impacted by the project

Species	Common name	Records in 10 km of project	TSC Act	EPBC Act	project section
THREATENED FAUNA					
Wetland birds					
Anseranas semipalmata	Magpie Goose	20	V	-	2-6, 8-11
Botaurus poiciloptilus	Australasian bittern	8	E1	E	1-4, 7-11
Ephippiorhynchus asiaticus	Black-necked stork	1383	E1	-	1-11
Grus rubicundus	Brolga	189	V	-	1-11
Irediparra gallinacea	Comb-Crested Jacana	48	V	-	3-9
Ixobrychus flavicollis	Black Bittern	15	V	-	1-3, 6-7, 9
Amaurornis molucanna	Pale-vented Bush Hen	18	V	-	9-10
Stictonetta naevosa	Freckled Duck	3	V	-	3-5
Rostratula australis	Australian Painted Snipe	11	V	V	1-11
Large forest owls					
Ninox strenua	Powerful Owl	117	V	-	1-11
Ninox connivens	Barking Owl	49	V	-	1-11
Tyto novaehollandiae	Masked Owl	67	V	-	1-11
Tyto tenebricosa	Sooty Owl	4	V	-	1-2
Frugivorous rainforest birds					
Cyclopsitta diophthalma coxeni	Double-Eyed Fig-Parrot	0	CE	E1	9-11
Ptilinopus magnificus	Wompoo fruit-Dove	155	V	-	1-2, 6-11
Ptilinopus regina	Rose-crowned Fruit Dove	124	V	-	1-2, 8-11
Ptilinopus superbus	Superb fruit-Dove	10	V	-	1-2, 8-11
Coracina lineata	Barred cuckoo-shrike	21	V	-	1-2, 6-11
Cave-roosting microbats					
Chalinolobus dwyeri	Large-eared Pied Bat	1	V	V	1-7
Miniopterus australis	Little Bent-wing Bat	221	V	-	1-11
Miniopterus schreibersii oceanensis	Eastern Bent-wing Bat	20	V	-	1-11
Myotis macropus	Southern Myotis	29	V	-	1-11
Vespadelus troughtoni	Eastern Cave Bat	3	V	-	1-11
Tree-roosting microbats					
Chalinolobus nigrogriseus	Hoary Wattled Bat	66	V	-	1-11
Falsistrellus tasmaniensis	Eastern False Pipistrelle	8	V	-	1-11
Kerivoula papuensis	Golden-tipped Bat	15	V	-	1-11
Mormopterus beccarii	Beccari's Freetail-Bat	4	V	-	1-11
Mormopterus norfolkensis	Eastern Freetail-Bat	15	V	-	1-11
Nyctophilus bifax	Eastern Long-Eared Bat	48	V	-	1-11
Saccolaimus flaviventris	Yellow-bellied Sheathtail-	12	V	-	1-11

Species	Common name	Records in 10 km of project	TSC Act	EPBC Act	project section
	Bat				
Scoteanax rueppellii	Greater Broad-nosed Bat	35	V	-	1-11
Gliders					
Petaurus australis	Yellow-bellied Glider	288	V	-	1-9
Petaurus norfolcensis	Squirrel Glider	144	V	-	1-11
Arboreal snakes					
Hoplocephalus bitorquatus	Pale-headed Snake	0	V	-	1-3, 6-8
Hoplocephalus stephensii	Stephens' banded snake	8	V	-	1-3, 6-8
Diurnal raptors					
Hieraaetus morphnoides	Little Eagle	36	V	-	1-11
Erythrotriorchis radiatus	Red Goshawk	15	CE	V	1-11
Lophoictinia isura	Square-tailed Kite	36	V	-	1-11
Fish					
Nannoperca oxleyana	Oxleyan Pygmy Perch	48	E	E	1-2, 6-11
Mogurnda adspersa	Purple-spotted Gudgeon	2	E		1-2, 6-11
Maccullochella ikei	Eastern Freshwater Cod	10	E	E	3-5
Other fauna species					
Calyptorhynchus lathami	Glossy black-cockatoo	314	V	-	1-7
Dromaius novaehollandiae	Coastal Emu	511	E2	-	3-5
Glossopsitta pusilla	Little Lorikeet	104	V	-	1-11
Lathamus discolor	Swift Parrot	17	E	E, M1	1-11
Lichenostomus fasciogulari	Mangrove Honeyeater	62	V		4-5, 8-10
Pandion haliaetus	Eastern Osprey	699	V	Mi	1-11
Pezoporus wallicus wallicus	Ground Parrot (eastern subsp.)	57	V	-	8-10
Tyto capensis	Eastern Grass Owl	78	V	-	1-11
Xanthomyza phrygia	Regent Honeyeater	5	E1	E, Mi	1-11
Petalura litorea	Coastal Petaltail	1	E		7-10
Pteropus poliocephalus	Grey-headed Flying-Fox	396	V	V	1-11
Syconycteris australis	Common Blossom-Bat	29	V	-	8-11
Aepyprymnus rufescens	Rufous Bettong	208	V	-	1-8
Cercartetus nanus	Eastern Pygmy-Possum	1	V	-	1-11
Dasyurus maculatus maculatus (SE population)	Spotted-tailed Quoll	64	V	E1	1-11
Phascogale tapoatafa	Brush-tailed Phascogale	117	V	-	1-9
Phascolarctos cinereus	Koala	567	V	V	1-11
Planigale maculata	Common Planigale	35	V	-	1-11
Potorous tridactylus tridactylus	Long-nosed Potoroo	9	V	V	1-3, 6-11
Crinia tinnula	Wallum Froglet	99	V	-	1-11
Litoria brevipalmata	Green-thighed Frog	6	V		1-10
Litoria olongburensis	Olongburra Frog	31	V	V	1-11
Mixophyes iteratus	Giant Barred Frog	48	E1	E1	1-4, 6-10
Climacteris picumnus	Brown Treecreeper	48	V	-	1-7
Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subsp.)	53	V	-	1-3, 6-7
Burhinus grallarius	Bush stone-curlew	36	E1	-	1-3
Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subsp.)	166	V	-	1-4, 6-10
Phyllodes imperialis southern subsp.	Pink Underwing Moth	1	E	E	9-11
Nurus atlas	Atlas Rainforest Ground Beetle	1	E		9-11

Species	Common name	Records in 10 km of project	TSC Act	EPBC Act	project section
THREATENED FLORA					
Acronychia littoralis	Scented Acronychia	39	V	E	9-11
Angophora robur	Sandstone Rough Barked Apple	48	V	V	3-4
Archidendron hendersonii	White Lace Flower	20	V	-	8-11
Arthraxon hispidus	Hairy Joint-grass	5709	V	V	8-11
Centranthera cochinchinensis	Swamp Foxglove	3	E	-	1-11
Cryptocarya foetida	Stinking Cryptocarya	47	V	V	8-11
Cyperus aquatilis	Water Nutgrass	5	E	-	6-7
Dendrobium melaleucaphilum	Spider Orchid	3	E	-	1-11
Desmodium acanthocladum	Thorny Pea	4	V	V	8
Endiandra hayesii	Rusty Rose Walnut	10	V	V	8-11
Endiandra muelleri subsp. bracteata	Green-leaved Rose Walnut	6	E	-	8-11
Eucalyptus tetrapleura	Square fruited Ironbark	240	V	V	2
Grevillea quadricauda	Four-tailed Grevillea	7	V	V	3
Isoglossa eranthemoides	Isoglossa	1	E	E	9-11
Lindsaea incisa	Slender Screw Fern	13	E	-	1-3, 6-11
Macadamia tetraphylla	Rough-shelled Bush Nut	102	V	V	7-11
Marsdenia longiloba	Slender Marsdenia	14	E	V	1-11
Maundia triglochinoides	-	4	V	-	1-11
Melaleuca irbyana	Weeping Paperbark	39	E	-	1-4, 6-8
Olax angulata	Square-stemmed Olax	0	V	-	1-3
Oberonia titania	Red flowered King of the Fairies	12	V	-	1-11
Peristeranthus hillii		7	V	-	9-11
Prostanthera cineolifera	Singleton Mint Bush	0	V	V	7
Prostanthera palustris	*Swamp Mint Bush*	8	V	V	7
Quassia sp. 'Moonee Creek'	Moonie Quassia	70	E	E	1-3, 9-11
Syzygium hodgkinsoniae	Red Lily Pilly	26	V	V	8-11
Tinospora tinosporoides	Arrow Head Vine	51	V	V	10
THREATENED ECOLOGICAL COMMUNITIES					
Subtropical Coastal Floodplain Forest	-	-	E		1-10
Swamp Sclerophyll Forest	-	-	E		1-10
Swamp Oak Floodplain Forest	-	-	E		1-10
Freshwater Wetlands	-	-	E		1-10
Lowland Rainforest	-	-	E	CE	3, 10-11
Coastal Cypress Pine Forest	-	-	E		9-11

Barrier impacts

The project has potential to isolate remnant vegetation patches and create barriers to the movement of small ground-dwelling mammals, reptiles and amphibians and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project upgrade would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (such as sections 3 to 4 and 9 to 10).

There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River. Contiguous areas of forest are generally associated with state forests, national parks and conservation reserves, which have been partitioned in the landscape over time. Any impacts on these lands associated with the project would occur along the outer boundaries of the property and would not divide these larger important areas of habitat. This feature of the project alignment, in addition sections consisting largely of a duplication of the existing highway corridor, suggests that further large-scale fragmentation of habitat on a regional scale has been avoided by the project route selection.

However, the widening of the existing Pacific Highway in some areas would exacerbate the current barrier effect of the highway on regional and local populations of general flora and fauna The loss of connectivity has potential to impact on populations of several listed fauna species as determined by ecological surveys undertaken 2006 to 2012, review of NSW Atlas data identifying broad population hotspots and through consultation with Office of Environment and Heritage.

These species include:

- Coastal Emu - the endangered population of the lower Clarence Valley and Yuraygir area is intersected by the project from Pillar Valley to lower Shark Creek (section 3 and 4). The project would bisect important habitat for pre and post breeding life-cycle activities
- Oxleyan Pygmy Perch - known and potential habitat for the species in Section 1 (Cassons Creek and Redbank Creek), Devils Pulpit to Tabbimoble (Section 7), and between Woodburn and Broadwater (Section 9) including MacDonalds Creek and Broadwater National Park
- Yellow-bellied Glider and Squirrel Glider - important populations exist from Woolgoolga to Wells Crossing (sections 1 and 2), at Tabbimoble (section 6 and 7) and Broadwater National Park (Section 9)
- Rufous Bettong, Common Planigale and Brush-tailed Phascogale - important populations exist from Woolgoolga, Halfway Creek, Wells Crossing, Glenugie and Pillar Valley (sections 1 to 3)

- Spotted-tailed Quoll - a relatively higher density of records of from Woolgoolga and Halfway Creek north to Wells Crossing (sections 1 to 2) and Devils Pulpit to Broadwater (sections 7 to 9) suggesting the likely presence of quoll populations in these areas
- Koala - scattered areas of Primary and Supplementary Koala Habitat identified on both sides of the project boundary between Tabbimoble and Woodburn (Section 7) as well as high densities of koala records between Woodburn and Wardell (sections 9 and 10) including Broadwater National Park. The majority of these records occur to the west of the project boundary but in some locations these cross the project around the Richmond River
- Long-nosed Potoroo in the Wardell Heath (Section 10)
- Giant Barred Frog, Green-thighed Frog and Olongburra Frog (sections 1 to 3 and 6 to 9)

As part of the response to mitigate and minimise this barrier effect for these species, RMS has developed a strategy with the aim of providing connectivity structures and enhancing landscape connectivity where feasible and reasonable in strategic locations. The Biodiversity Connectivity Strategy is detailed in Chapter 5 and Appendix A of the EA for the project.

Throughout the largely cleared or fragmented habitats, smaller east-west vegetated corridors are likely to play an important role in the wider corridor network. These include those fragmented by the existing highway such as at Yaegl Nature Reserve or Tabbimoble Nature Reserve to Doubleduke State Forest. The project would increase the level of isolation or fragmentation of some patches of vegetation that follow in an east-west direction. An increase in the width of the road is likely to increase this barrier effect for some species and in some sections where regional corridors have been identified, (such as the Dirty Creek Range to Yuraygir National Park or Bundjalung National Park). This would be the case particularly for ground-dwelling and arboreal mammals. Mobile species such as birds and bats may not be as affected by the increase in road corridor width.

Roads act as a barrier or filter to the movement of vertebrates (eg Mansergh and Scotts 1989; Alexander and Waters 2000; van der Ree 2006). Animal movement may involve daily travel through a home range, seasonal migration associated with changes in habitat use or breeding events, or the dispersal of individuals from their natal areas (Taylor and Goldingay 2011). A barrier effect may result from a behavioural aversion to a road. There have been few studies in Australia to understand this effect, however those that have been done reveal that diverse responses can be expected among mammalian taxa. Rodents of different genera showed a gradient of responses to crossing road clearings, from no inhibition to severe inhibition (Goosem 2001). Squirrel Gliders regularly crossed a high-volume two-lane highway, whereas females appeared to be inhibited from crossing a high-volume four-lane highway with a median strip (van der Ree 2006).

Habitat fragmentation

Fragmentation of habitat would be greatest where the project deviates from the existing Pacific Highway. This occurs on a large scale through sections 3 to 4 and sections 9 to 10. Portions of the landscape in these regions are already largely cleared; particularly the alluvial floodplain areas of the Coldstream River and Richmond River where vegetation is heavily fragmented and a mosaic of different sized remnants exist. However, Section 3 would traverse the western foothills of the Summervale Range from Pillar Valley to Tyndale and this route would fragment remnant open forest habitats in moderate and high quality condition over a distance of around 23 kilometres. This includes fragmentation of a portion of the identified Sandstone Rough-barked Apple (*Angophora robur*) population and known and potential habitat for a range of threatened and common fauna species expected in Sections 3 and 4. Much of this habitat occurs on sandy soil that is identified as having a high density of hollow-bearing trees and generally higher fauna species richness. This habitat includes a range of old growth forests with minimal evidence of past logging particularly between Pine Brush State Forest and the interchange at Tyndale.

The second area of major deviation from the existing highway occurs south of the Richmond River to the interchange with the existing highway north of Wardell, a distance of around 12 kilometres. This would fragment habitats of a local and regional scale of importance. These habitats are of such importance partly due to the already increased isolation of the Wardell Heath from the Blackwall Range and the localised east-west wildlife corridors that are situated north of the Richmond River.

Loss of connectivity between smaller habitat patches can cause the loss of genetic diversity in populations (Forman *et al*. 2003). As fragmentation proceeds, stochastic forces add to potential declines caused by a dwindling supply of habitat. Some species are at greatest risk in fragmented landscapes than others and this relates to the biological characteristics of the species. In this regard species that share similar adaptations to habitat niches and similar life-cycle traits are assumed to be impacted in a similar way, for example microchiropteran bats, gliders, nectarivorous and insectivorous birds, large forest owls.

In a comprehensive literature review of the effects of fragmentation, Henle et al (2004) showed that sensitivity to habitat fragmentation is caused by similar traits in plants and animals. Indeed species with particular traits may be more sensitive to fragmentation. Based on the literature review, these authors documented those ecological traits that showed a positive correlation to fragmentation sensitivity. This data is used to highlight a number of threatened species from the study area which may be more susceptible to the effects of fragmentation. However it is evident from the review that indicators of sensitivity to fragmentation are scale-dependent (eg Metzer 2000) and that there is no consistent response to habitat fragmentation, such that it is not possible to predict which species would be impacted the most or to what extent.

Hollow-bearing trees

The loss of hollow-bearing trees is listed as a key threatening process under the TSC Act. Hollow bearing trees are a critical habitat feature for a number of threatened species (Gibbons & Lindenmayer 2002), providing breeding and/or sheltering habitat. Gibbons and Lindenmayer (2002) found that hollow bearing trees were more common in older stands, gullies, vegetation not logged and on flat terrain. Habitats with high productivity were also noted to support a higher number of hollow bearing trees.

Hollow-bearing trees are present in habitats to be cleared by the project in all habitat types and project sections. The number and location of hollow-bearing trees was not quantified for the biodiversity assessment. Reliance is on the habitat assessment (refer to Chapter 3) to identify the relative densities hollow-bearing trees for each habitat type. The highest density hollow-bearing trees recorded in the dry sclerophyll forests on clay soils followed by the floodplain eucalypt forests and dry forest on sandy soils. These three habitats account for a combined loss of 772.8 hectares (81.5 per cent of the total habitat loss). The mean number of hollow-bearing trees per habitat type was recorded over 1 hectare (calculated from 0.1 hectare survey plots). Assuming that habitat condition is homogeneous across the project this impact would equate to a loss of 18 (±8.36) hollow bearing trees per hectare for the dry sclerophyll forest on clay soils, 14.29 (±11.34) hollow-bearing trees per hectare for the floodplain eucalypt forests and 12.31 (±11.66) hollow-bearing trees per hectare for the dry forests on sandy soils.

Hollow bearing trees occur in all project sections. Loss of these is likely to be greatest where the project would deviate from the existing Pacific Highway alignment in Section 3 and in sections 9 and 10. However, the presence of hollow-bearing trees may also be high in habitats adjoining the highway, where they would be impacted by the duplicated highway.

In NSW, terrestrial vertebrate species that are reliant on tree hollows for shelter and nests include at least 46 mammals, 81 birds, 31 reptiles and 16 frogs (Gibbons and Lindenmayer 1997, Gibbons and Lindenmayer 2002). Of these, 22 are listed as threatened species (TSC Act or EPBC Act) and have either been identified in the study area or are considered likely to occur in the three dominant habitat types discussed.

C.3 Management of biodiversity impacts

Measures to manage the impact of the project on biodiversity have been developed as part of the environmental assessment for the project. Management measures for biodiversity impacts were developed following these general principles, in order of preference:

- Avoiding impacts
- Mitigating impacts
- Offsetting impacts

A summary of the key measures relevant to biodiversity impacts are outlined below. For further detail refer to the Biodiversity Assessment in the EA for the project.

Avoidance

Disturbance and clearing of vegetation as a result of the project would be unavoidable, however opportunities to minimise the loss of native vegetation and fauna habitat are to be prioritised during all aspects of the detailed design, in particular this includes the following:

- Avoiding and minimising vegetation removal wherever possible through the detailed design process
- Sensitive selection of ancillary facilities. The ancillary facilities identified present a selection of available sites, however further evaluation will be conducted prior to approval to select the minimum number of sites required with a priority to avoid native vegetation clearing if possible. A prior site inspection is required to survey and map hollow-bearing trees and check for large nests for species such as raptors, including Osprey and also Black-necked Stork at these sites
- Construction compounds and stockpile sites are to be sited in cleared or sparsely treed portions of the ancillary facility sites where feasible and reasonable, to avoid unnecessary clearing of vegetation and threatened flora species
- Water quality basins would be placed in the optimal location for treating surface runoff. During detailed design, the location of water quality treatment measures would consider the competing environmental requirement of minimising vegetation removal, particularly where there is the potential for threatened plant species, threatened fauna habitat or in identified regional wildlife corridors.
- Protective fencing would be installed to mark the limits of clearing (ie ‘no-go’ areas) surrounding the footprint to ensure that vehicles and other direct disturbances associated with the road construction, including construction compounds and stockpile sites do not enter adjacent areas of vegetation outside the footprint;
- Construction staff would be educated with regards to the status and location of protected areas during site induction and/or tool box talks and pre-clearing surveys would be undertaken to flag hollow bearing trees and identify trees where fauna may be present;
- Vegetation management strategies would be developed for retained areas of vegetation, including weed management, native plantings, and the collection of seed.

Mitigation

Mitigation measures designed to reduce impacts on biodiversity include:

- Biodiversity connectivity strategies;
- Construction measures; and
- Threatened species management.

Biodiversity connectivity strategies

This biodiversity assessment built on previous work started during the preferred route design phase to develop a whole of project Biodiversity Connectivity Strategy (refer to Appendix A). The Biodiversity Connectivity Strategy focuses both on design and management actions that may minimise the barrier effect of the project.

The goal of the strategy is to maintain connectivity in the landscape, as well as enhance connectivity where feasible and reasonable near the road corridor. Additionally, the Biodiversity Connectivity Strategy presents opportunities for protection or revegetation at key sites adjoining the project boundary to enhance connectivity. The strategy also outlines future research and adaptive monitoring needs for fauna crossing structures. The format of the strategy is presented as follows:

- Guiding principles: basis for developing whole of project connectivity goals and influence decision making
- Connectivity strategy goals: provides a focus for the strategy that is appropriate at a local and regional level
- Decision-making framework: presents a framework for meeting the connectivity goals including identification of the issues and how these have been met, outlines future monitoring needs and strategic connectivity enhancement opportunities
- Connectivity design measures: details the structures proposed, fencing requirements and further recommendations and design principles for consideration at detailed design.

The strategy outlines the measures to be adopted for the detailed design in the form of connectivity design principles. The summary of crossing structures for each project section includes dedicated and combined fauna crossing structures. This summary is based on the concept design for the project, and the locations would be subject to some refinement during detailed design. Any changes would be made in line with the design principles identified in the Strategy.

Exclusion fencing

The connectivity design measures provide recommended locations for fauna exclusion fencing. These locations are based on ensuring exclusion of fauna from known roadkill hotspots (including emu road kill research) and directing fauna to dedicated and combined crossing structures. The connectivity design principles outline measures for exclusion fencing including fence design specifications and length of fencing around dedicated and combined structures. The detailed design should refer to the connectivity design principles for final fence design.

Exclusion fencing is recommended for portions of sections 3 and 4 to exclude emus from the road corridor and to direct emus and other fauna to the bridge underpass structures. It is recognised that fencing would be problematic in low-lying areas of sections 3 and 4 subject to flooding and that fencing in these areas should be placed higher on fill embankments to reduce impacts of flooding on the fauna fence. Dense landscape plantings could be used in these locations to screen fences or if stock fencing is also required to act a natural barrier. Preferred plant species are to include those that are tolerant of occasional water logging and can be densely planted, such as *Melaleuca* spp. and *Casuarina glauca*.

Arboreal crossing structure locations

During detailed design it would be necessary to conduct tree surveys at proposed rope and glider crossing locations to determine the most appropriate location to place the structure at a site specific scale. The design should aim to place arboreal crossing structures at grade level, where average tree heights exceed 20 metres, and/ or taller trees would be naturally positioned close to the road edge. Preference would be given to riparian habitats if possible and the tree survey should aim to identify hollow-tree density.

Widened medians

Widened medians are located in the design at key areas for aerial connectivity. The design of fauna exclusion fencing and drainage or fauna underpass structures in widened medians should minimise any vegetation clearing.

Landscape plans

Landscape planning is to avoid placement of emu food plants along the road corridor in sections 3 and 4. These species include the following genus *Dianella, Gahnia, Lomandra* and *Ficus* in addition to Bangalow Palm (*Archontophoenix cunninghamiana*) and soy, oats or rye grass cover crops. Further information on diet would be obtained from a diet study of the coastal emu and would inform the detailed landscape plan. However, initial plantings of soy and / or oats would be targeted at key emu crossing locations to help with the adaptation of emus to these crossing structures.

In general, landscape plans are to avoid dense plantings of grasses and graminoids in road verge areas in sections 2 and 3 to discourage use by Rufous Bettong and minimise potential roadkill of this species. Additional planting of trees around glider crossings and widened medians would be conducted to act as a long terms replacement of these structures.

Construction measures

RMS has developed *Biodiversity Guidelines: Protecting and Managing Biodiversity on RTA projects* (RTA 2011a). These guidelines are intended for RMS project managers, staff and contractors (including ecologists and landscape designers). They are a tool to help minimise impacts on biodiversity during construction and maintenance works. Reference is to be made to the biodiversity guidelines in addition to the RMS *Vegetation Clearing and Fauna Management Practice Note: Pacific Highway Projects* (RMS 2012) when preparing environmental specifications for contracts and for the development of project specific Construction Environmental Management Plans (CEMP's), including flora and fauna management sub-plans (FFMP's). An outline of the content of the biodiversity guidelines is shown in Table C-3 and each management guide described below.

Table C-3 Content of RMS Biodiversity Guidelines for developing project CEMPs and FFMP's

Management guide	Outline of content
1. Pre-clearing process	Guidance for the pre-clearing process that should be conducted before any clearing takes place to minimise the impact on native flora and fauna.
2. Exclusion zones	Guidance for determining and establishing exclusion zones to prevent damage to native vegetation and fauna habitats and prevent the distribution of pests, weeds and disease.
3. Re-establishment of native vegetation	Guidance for the re-establishment of native vegetation through managing site conditions, material sourcing and procurement, and seed and plant stock installation and establishment.
4. Clearing of vegetation and removal of bushrock	Guidance for minimising the impact of habitat removal, such as vegetation clearing and bush rock removal, on native flora and fauna.
5. Re-use of woody debris and bushrock	Guidance for maximising the re-use of woody debris and bushrock to minimise loss and/or damage to native flora and fauna habitats.
6. Weed management	Guidance for preventing or minimising the spread of noxious and environmental weed species on all RMS project sites and during maintenance works.
7. Pathogen management	Guidance for preventing the introduction and/or spread of disease causing agents such as bacteria and fungi.
8. Nest boxes	Guidance for works that involve the removal of hollow-bearing trees. Guidance for minimising the impact of hollow loss by providing supplementary fauna habitat in the form of artificial hollows (nest boxes).
9. Fauna handling	Guidance for minimising impacts on fauna as a result of being handled by humans and prevent injury to people handling fauna.
10. Aquatic habitats and riparian zones	Guidance for limiting impacts on aquatic flora and fauna and their habitats, and to ensure the movement of fish up and downstream is maintained at all times during works in a waterway.

Management of unforeseen additional impacts

Throughout the construction period there is a possibility of design changes that may impact on additional areas of native vegetation. Where additional clearing is proposed to be undertaken outside of the construction clearing limits a consistency assessment would be undertaken against the Minster for Planning's and Commonwealth Conditions of Approval for the project.

Consistency assessment(s) would take into account the vegetation type, quality and habitat. If the design change is deemed inconsistent with the Conditions of Approval then a modification under Section 75 W of the Environmental Planning and Assessment Act 1979 would be lodged for determination by the Minster for Planning.

This process would also enable a detailed record of any additional clearing impacts outside of what was anticipated in the Biodiversity Offset Strategy. In addition a survey at the end of the construction phase of the project would be undertaken to compare the area cleared for construction against what was envisaged in the Biodiversity Offset Strategy. In the event that there is a significant increase in the area of native vegetation impacted above what was anticipated in the Biodiversity Offset Strategy then additional offset measures would be implemented. A significant increase would be determined by the quality of the habitat removed and the mitigation measures implemented to restore the disturbed areas (where this is possible). The extent of any additional measures would be determined in consultation with the OEH and Department of Planning.

Additional offset measures may include one or a combination of the following:

- Secure additional native vegetation protected through covenants (or other equivalent protection mechanism)
- Additional revegetation in strategic locations
- Investment in management research related to the rehabilitation and protection of relevant threatened species.

C.4 Biodiversity offsetting

Offset requirements (EPBC Act)

The EPBC Act Environmental Offsets Policy (Department of Sustainability, Environment, Water, Populations and Community 2012e) has five key aims, which are:

- Ensure the efficient, effective, transparent, proportionate, scientifically robust and reasonable use of offsets under the EPBC Act;
- Provide proponents, the community and other jurisdictions with greater certainty and guidance on how offsets are determined and applied under the EPBC Act;
- Deliver improved environmental outcomes by consistently applying offsets policy;
- Outline the appropriate nature and scale of offsets and how they are determined;
- Provide guidance on acceptable delivery mechanisms for offsets.

There are numerous species listed under the EPBC Act that are required to be offset including threatened flora and fauna species such as *Angophora robur,* Grey-headed Flying-fox, Spotted-tail Quoll and Lowland Rainforest of Subtropical Australia. The full list of EPBC Act matters to be included in offsets are specified in the Biodiversity Assessment for the EA and full details of how each of these are offset would be included in the Biodiversity Offset Package.

Offset requirements under the EPBC Act Environmental Offsets Policy are specified in Box 1 of the policy, and how each of these will be addressed for the project is provided below.

1. A suitable offset must deliver an overall conservation outcome that improves or maintains the viability of the aspect of the environment that is protected by national environment law and affected by the proposed development

Using the proposed methodology, indicative offset requirements will be between 3771 and 3830 hectares. The impact to compensatory habitat ratio equates to 3830 hectares to 1254 hectares, an overall ratio of around 3.05:1. This ratio takes into account 431.6 hectares of edge effects. This would result in a net improvement in biodiversity over time as the proposed offset area is greater than the potential loss resulting from the project.

One of the criteria for selecting offsets is to ensure that the land is suitable for ongoing management for conservation through an appropriate legal instrument. Offsets will not be chosen that cannot be managed in this way, to ensure the offset results in a net improvement in biodiversity over time.

2. A suitable offset must be built around direct offsets but may include other compensatory measures

The proposed methodology in this strategy takes into account both direct and indirect impacts. The impact to compensatory habitat ratio equates to 3830 hectares to an overall ratio of around 3.05:1. These offset calculations are based on a total of total of 1254 hectares of direct and indirect impacts, which includes around 432 hectares of edge effects.

3. A suitable offset must be in proportion to the level of statutory protection that applies to the protected matter

Offsets for the project will be chosen using a number of criteria to ensure biodiversity is offset on a like-for-like or better conservation outcome. Only offsets that meet these criteria will be considered for use as an offset. This ensures that impacts, particularly TECs and key threatened species habitat are offset with areas that have equal or greater conservation status than the area to be impacted.

4. A suitable offset must be of a size and scale proportionate to the residual impacts on the protected matter

A quantitative assessment has been undertaken to determine the exact area that requires offsetting. This includes construction buffers, potential ancillary areas and offsets for edge effects to ensure the true impact of the project is offset. The impact assessments conducted for the project were conducted in accordance with the relevant guidelines to ensure impacts were accurately estimated.

5. A suitable offset must effectively account for and manage the risks of the offset not succeeding

Offsets would only be chosen if they are suitable for ongoing management for conservation through an appropriate legal instrument. Additionally, offsets would be audited to ensure that the actions have been carried out, and monitored to determine that the actions are leading to positive biodiversity outcomes. Details of monitoring and auditing would be included in the Biodiversity Offset Package.

6. A suitable offset must be additional to what is already required, determined by law or planning regulations or agreed to under other schemes or programs (this does not preclude the recognition of state or territory offsets that may be suitable as offsets under the EPBC Act for the same action.

The offset package will ensure that any offsets identified for the proposed action will not include land that has already been set aside in the conservation estate. Further any proposed offsets would be additional to what has been paid for under other schemes or programs on a pro rata basis, for example conservation initiatives on private land.

7. A suitable offset must be efficient, timely, transparent, scientifically robust and reasonable

A decision making framework has been developed for the selection of offsets to ensure they include the consideration of structure, function and compositional elements of biodiversity, enhance biodiversity at a range of scales, consider the conservation status of ecological communities, and ensure the long-term viability and functionality of biodiversity. Further detail on the decision making framework is provided below.

A quantitative assessment has been undertaken to determine the exact area that requires offsetting. This includes construction buffers, potential ancillary areas and offsets for edge effects to ensure the true impact of the project is offset. The impact assessments conducted for the project were conducted in accordance with the relevant guidelines to ensure impacts were accurately estimated. The timely delivery of the offset package has been considered and is discussed in the offset strategy.

8. A suitable offset must have transparent governance arrangements including being able to be readily measured, monitoring, audited and enforced.

Offsets would be audited to ensure that the actions have been carried out, and monitored to determine that the actions are leading to positive biodiversity outcomes. Details of monitoring and auditing would be included in the Biodiversity Offset Package.

Offsetting principles (NSW)

The Office of Environment and Heritage (OEH) have developed principles for the use of biodiversity offsets in NSW, to be used as a framework for considering environmental impacts and developing offset proposals (OEH 2011). The principles have been used in the development of this Biodiversity Offset Strategy and have been addressed as follows:

Principle 1: Impacts must be avoided first by using prevention and mitigation measures

Measures to manage the impact of the project on biodiversity have been developed as part of the environmental assessment for the project. Management measures for biodiversity impacts were developed following these general principles, in order of preference:

- Avoiding impacts
- Mitigating impacts
- Offsetting impacts

Principle 2: All regulatory requirements must be met

The strategy is being implemented to address biodiversity impacts and satisfy the Minister’s Conditions of Approval as part of the project approval under Part 5.1 of the Environmental Planning and Assessment Act. This Biodiversity Offset Strategy is not being used concurrently to satisfy an assessment or approval under other legislation.

Principle 3: Offsets must never reward ongoing poor performance

Land for offsets will be chosen based on the criteria outlined in this strategy, and any land found to address these criteria would not be deliberately degraded in order to increase the value from the offset.

Principle 4: Offsets will complement other government programs

The Biodiversity Offset Strategy for the project has been developed to complement other government programs, including other offset strategies along the Pacific Highway corridor and the establishment and management of new national parks, nature reserves and state conservation areas. RMS will consult with other government departments to ensure offsets complement existing conservation areas and are of sufficient quality and are managed appropriately to ensure the offsets are secured in perpetuity.

The NSW Biodiversity Strategy and the Mid and Far North Coast Regional Conservation Plan will be consulted when identifying offset options. RMS acknowledges the NSW State plan's commitment to continue to build and establish national parks and nature reserves as the primary biodiversity conservation mechanism, and also recognises the Commonwealth Government's objective of Building the National Reserve System, through mechanisms such as supporting conservation covenants (DSEWPC, The National Reserve System Fact Sheet 1, April 2010).

Principle 5: Offsets must be underpinned by sound ecological principles

A decision making framework has been developed for the selection of offsets to ensure they include the consideration of structure, function and compositional elements of biodiversity, enhance biodiversity at a range of scales, consider the conservation status of ecological communities, and ensure the long-term viability and functionality of biodiversity. Further detail on the decision making framework is provided below.

Principle 6: Offsets should aim to result in a net improvement in biodiversity over time.

Using the proposed methodology, indicative offset requirements will be between 3771 and 3830 hectares. The impact to compensatory habitat ratio equates to 3830 hectares to 1254 hectares, an overall ratio of around 3.05:1. This ratio takes into account 431.6 hectares of edge effects. This would result in a net improvement in biodiversity over time as the proposed offset area is greater than the potential loss resulting from the project.

One of the criteria for selecting offsets is to ensure that the land is suitable for ongoing management for conservation through an appropriate legal instrument. Offsets will not be chosen that cannot be managed in this way, to ensure the offset results in a net improvement in biodiversity over time.

Principle 7: Offsets must be enduring – they must offset the impact of the development for the period that the impact occurs

Road projects generally have a long-term impact on the environment by removing areas of vegetation and fauna habitat, and reducing fauna connectivity. Therefore, all offsets for road construction projects are secured in perpetuity, to ensure the impact is offset for the period that it occurs.

The selection criteria identified in this strategy include the need for the offset to be appropriate for ongoing management for conservation through an appropriate legal instrument. This ensures any land selected under these criteria will be secured in perpetuity.

Principle 8: Offsets should be agreed prior to the impact occurring.

No construction work that would result in the disturbance of any native vegetation would commence prior to the approval of this strategy.

Principle 9: Offsets must be quantifiable – the impacts and benefits must be reliably estimated.

A quantitative assessment has been undertaken to determine the exact area that requires offsetting. This includes construction buffers, potential ancillary areas and offsets for edge effects to ensure the true impact of the project is offset. The impact assessments conducted for the project were conducted in accordance with the relevant guidelines to ensure impacts were accurately estimated.

Principle 10: Offsets must be targeted.

Offsets for the project will be chosen using a number of criteria to ensure biodiversity is offset on a like-for-like or better conservation outcome. Only offsets that meet these criteria will be considered for use as an offset. This ensures that impacts, particularly TECs and key threatened species habitat are offset with areas that have equal or greater conservation status than the area to be impacted.

Principle 11: Offsets must be located appropriately.

All offsets would be located within the NSW North Coast Bioregion to ensure that these offsets have similar characteristics and broad vegetation types of those to be impacted. Where it is not feasible to offset on a like for like basis other vegetation types of a similar conservation value that contain habitat suitable for the impacted threatened species will be considered in consultation with EPA.

The framework of the offset strategy would primarily target securing offsets that are linked into broader landscapes.

Principle 12: Offsets must be supplementary.

Offsets chosen would not be already funded or protected under another scheme. Additionally, areas that are already managed for conservation by the government, such as flora reserves, national parks and public open space would not be chosen as offsets.

Principle 13: Offsets and their actions must be enforceable through development consent conditions, licence conditions, conservation agreements or a contract.

Offsets would only be chosen if they are suitable for ongoing management for conservation through an appropriate legal instrument. Additionally, offsets would be audited to ensure that the actions have been carried out, and monitored to determine that the actions are leading to positive biodiversity outcomes. Details of monitoring and auditing would be included in the Biodiversity Offset Package.

Offsetting options

The Biodiversity Offset Strategy proposes three options for consideration. In order of priority for implementation in the Biodiversity Offset package they are:

Option A Protect land containing native vegetation communities, threatened ecological communities threatened species and threatened species habitat through an appropriate legal instrument that ensures the land is managed for conservation

Option B Undertake revegetation works in strategic locations using native vegetation species that provide habitat for threatened species

Option C Invest in management research related to the rehabilitation and protection of impacted threatened species.

Delivery of options

Option A

To deliver the biodiversity offset the RMS would engage the services of an appropriate organisation to act as a third party offset agent to negotiate with landholders to secure conservation management of the land and negotiate appropriate covenant or agreements. Third party offset agents could include conservation organisations established for this purpose. There are also a number of private companies that offer specialist services in finding biodiversity offset lands. The RMS would also consult with OEH to pursue opportunities to purchase land that may be suitable for reserve estate with the OEH.

Tools used to identify potential offset land include but not limited to include the OEH twenty five (25) year investment layer, priority areas identified in the *Northern Rivers Regional Biodiversity Management Plan* (DECCW 2010), RMS property databases and possibly through advertisements for expression of interest for the provision of land for conservation purposes.

Condition and habitat assessment of the proposed offset lands would be undertaken to ensure the potential offset land(s) consist of appropriate vegetation type(s) and of adequate condition that meet the decision-making framework outlined above. This assessment would be undertaken by suitable qualified ecologists and report prepared would be included the Biodiversity Offset Package.

Option B

In the event that offset land cannot be reasonably found through the investigation process outlined in Priority 1 or 2 above then the RMS would consult further with OEH and Commonwealth before proceeding with the delivery of Option B and Option C.

To deliver Option B, the RMS would invest in the strategic revegetation of the TECs impacted by the project adjacent to the road corridor or within the project region. Locations of revegetation would be guided by outcomes of the further investigation and specialist ecological advice. Revegetation would be focused particularly at increasing key habitat for the key populations or key sites for enhancing connectivity identified the Biodiversity Connectivity Strategy (Appendix A).

Option C

To delivery Option C, the RMS would work with OEH, Commonwealth and other relevant government agencies and stakeholders to identify some key projects aimed at threatened species management in the region that would lead to future opportunities for improving biodiversity outcomes. The amount of investment in this option would depend on outcomes of the other options above.

Delivery of Option A

Calculation of the offset targets

This Biodiversity Offset Strategy relies on the terrestrial flora and fauna and aquatic ecology field surveys and desktop assessments of the Biodiversity Assessment in the EA. Methods for the terrestrial flora and fauna assessments are detailed in the EA, and involved a number of phases which are briefly described in the Table C-4.

Table C-4 The phases for the development of the offset strategy and package

Phase	Description
Preliminary assessment	Methods for identifying a list of threatened species, populations and ecological communities known or likely to occur in the project boundary, from a review of background information relevant to the study area. The assessment also outlines the approach to consulting key stakeholders and the collation and review of existing information gathered from the previous development projects ecological surveys. Critical review of this information focuses on the adequacy of the data for informing this impact assessment with any data gaps identified as a requirement for additional targeted surveys.
Field investigations and subject species assessment	The field investigations were aimed at providing a reliable assessment of the presence or absence of threatened species, populations and ecological communities where previous surveys were undertaken for a satisfactory level, these were included. These surveys are described in detail which includes firstly an outline of all ecological surveys conducted as part of the project development and secondly a description of any supplementary surveys conducted to fill any gaps identified from the original surveys. State and nationally listed species identified from the preliminary assessment were assessed to identify their likelihood of occurrence in the project boundary based on the known habitat requirements and compared with the habitats and condition identified across the project boundary. In some cases, where the habitat present indicated the possible presence of a species even if the species had not been conclusively found within the survey area, the species was assessed as present.
Evaluation of impacts	Outlines the general principles of avoidance, mitigate and offset and describes the steps taken to avoid potential biodiversity impacts on biodiversity in particular key design measures informed by the detailed field surveys. Residual impacts are described where avoidance was not possible including direct and indirect impacts. These impacts are then assessed (significance assessment) for threatened species, populations and ecological communities in the context of Part 5.1 of the EP&A Act, the TSC Act, FM Act and EPBC Act including significance assessments and identification of key threatening processes.
Avoid, mitigate	Where impacts have been identified these form the basis of detailed mitigation

Phase	Description
and then offset	strategies. An outline for management during construction and operation of the project is provided in the form of a biodiversity connectivity strategy, a construction management strategy, and operational monitoring strategy. A strategy is presented for offsetting the residual impacts with a focus on identifying objectives and framework to achieve these objectives so that the project will maintain or improve biodiversity values.
Key thresholds	As a final step in the biodiversity assessment process, an evaluation on whether or not the impacts of the project, including measures to avoid or mitigate impacts or compensation to prevent unavoidable impacts on threatened species, populations and communities meets the key thresholds identify by the threatened species guideline.

RMS has considered the use of the Biobanking Assessment Methodology (BBAM) in calculating the offset requirements as recommended by OEH. However, the methodology is problematic for use at the concept level and for a linear project of such length where the body of ecological data for this Working Paper has been accumulated over a number of years, prior to the implementation of the process. The methodology requires condition assessment at a plot level for each patch of each vegetation type in similar condition impacted by the project and calculation of ecosystem and species credits and application of management actions for each of these patches. Over the length of this project (155 kilometres) this would involve detailed calculations for many hundreds of individual vegetation polygons. Design refinements during the development of each project may lead to minor variations in impact requiring recalculation. The benefits of early implementation and delivery of the offset strategy would not be achievable. For these reasons, it is considered unfeasible to use the BBAM at the concept stage.

It is however proposed to use the principles underlying the BBAM to guide calculation of a suitable offset target for the project area.

The following principles would apply:

- The vegetation communities and habitat types represented in the offset areas would reflect the vegetation communities and habitat types impacted by the project.
- Offset areas would contain habitat for threatened and migratory fauna (TSC Act and EPBC Act) and would contain or be suitable for re-establishing threatened flora (TSC Act and EPBC Act) affected by the project.
- A minimum ratio of 2:1 would be achieved for all remnant vegetation cleared by the project and higher ratios would apply to areas of high conservation value such as threatened ecological communities (TSC Act and EPBC Act).
- Offset properties would be managed under effective and secure long term management arrangements and could include:
- Dedication of land under the National Parks and Wildlife Act 1974
- Biobanking Agreements under the Threatened Species Conservation Act 1995
- Conservation Agreements under the National Parks and Wildlife Act 1974
- Trust Agreements under the Nature Conservation Trust Act 2001
- Property vegetation Plans registered on title under the *Native Vegetation Act 2003*
- Planning agreements under s93F of the Environmental Planning and Assessment Act 1979.

Regardless of the legal mechanism offset properties would be managed:

- With a principle objective of ongoing site management being biodiversity conservation in perpetuity
- In accordance with a resourced and implementable Plan of Management
- With a monitoring and accountability mechanism to ensure management objectives are achieved
- Offset properties would be located as close to the impact site as feasible, this is identified as a 30 km buffer from the project corridor as a first priority, where possible
- All offset properties would be located within the NSW North Coast Bioregion
- Offset properties would aim to protect larger patches of vegetation and habitat with preference given to sites that are connected to, or provide connectivity to, other core areas of habitat.

Threatened Ecological Communities (EPBC Act and TSC Act) and highly cleared vegetation communities impacted by the project (refer to Table C-7) would be offset at a ratio of 4:1 and non-listed vegetation communities impacted by the project would be offset at a ratio of 2:1. Threatened ecological communities (TEC) refer to those communities that are listed as Critically Endangered, Endangered or Vulnerable under the TSC Act and the EPBC Act. Highly cleared ecological communities are those vegetation types identified as being more than 75 per cent cleared in the catchment management area as identified in DECCW vegetation types database.

Table C-8 demonstrates how the proposed offset ratios would be applied for TEC/highly cleared vegetation communities and non-TECs impacted by the project. In the absence of quantifiable vegetation condition data the condition of the remnant vegetation being impacted is assumed to be moderate to good.

In addition to general habitat offsets there is a requirement to offset specific threatened flora and fauna species directly impacted by the project. As part of the detailed design, every effort would be made to minimise the impact on these species. However, it may not be possible to avoid impact altogether.

Where impacts are unavoidable the following offset principles would apply:

- The area impacted would be offset at a ratio of 2:1
- The offset would comprise land containing the species or land that is suitable for re-establishment of those species
- The offset would include the works necessary to protect or re-establish the species on the land.

It is feasible that these criteria may be met by the general habitat offsets outlined in Table C-8. However, the outcomes would be measured separately to ensure the species offset requirements are met.

It is proposed that the only exception to using the variable offset ratio approach as described above would be in case(s) where the potential biodiversity offset lands have the following attributes:

- Exemplary conservation value within the Woolgoolga to Ballina region (as agreed by OEH);
- Are under significant development pressure; and/or
- Due to the offset land location providing significant social and cultural values to the community.

This approach takes into consideration that such lands are likely to require significant public funds to purchase and in such case(s) the offset ratio may be less than the variable offset ratio, however, as a minimum, the area purchased would meet 2:1 requirement against direct clearing loss.

Forest Management Zones

RMS is negotiating with the Department of Primary Industries (Forests) to compensate for the loss of State Forest land. Compensation to the Department of Primary Industries (Forests) could be in the form of native vegetation or cleared land to allow for the establishment of plantations. Where native vegetation is provided as compensation it is recognised that there will be biodiversity benefits accruing from State Forest management of the land. In recognition of this RMS proposes to discount the biodiversity offset requirement for operational areas of State Forests that are impacted by the proposal.

This essentially means that in addition to providing Department of Industry and Investment (Forests) the equivalent area of land directly impacted by the project, further land would be acquired for the biodiversity offset at a 1:1 ratio on a like for like basis. This would apply only to land that is not TEC nor greater than 75 percent cleared within the catchment management areas (DECCW 2009). For areas where the project impacts on Forestry Management Zones (FMZs) which have been established for conservation purposes (Conservation FMZs) such as Wells Crossing Flora Reserve these lands will have a biodiversity offset ratio of 4:1 on a like for like basis. It is important to note that no land acquired for compensation of State Forests will be used as offset land unless there are Conservation FMZs placed on the land.

For the purposes of this assessment Conservation FMZs comprise the following forestry management zones:

- Zone 1 special protection.
- Zone 2 special management.
- Zone 3a harvesting exclusions.
- Zone 3b special prescription.

For the purposes of this assessment the remaining zones are classified as Other FMZs comprising: Zone 4 general management; Zone 5 hardwood plantations; Zone 6 softwood plantations; Zone 7 non forestry use; and Zone 8 areas for further assessment. Table C-5 specifies the proposed loss of vegetation in Conservation FMZs and Other FMZs.

Table C-5 Proposed loss of vegetation from Conservation FMZs and Other FMZs

State Forest or reserve	Total direct impact on area of state forest	Direct impact on vegetation on Conservation FMZs (hectares)
Wells Crossing Flora Reserve (Newfoundland State Forest)	27.81	27.81
Pine Brush State Forest	11.51	5.46
Mororo State Forest	2.70	0.23
Wedding Bells State Forest	5.03	1.17
Glenugie State Forest	56.9	13.18
Tabbimoble State Forest	5.99	2.83
Doubleduke State Forest	20.73	4.8
TOTAL	**130.67**	**55.48**

Table C-6 demonstrates how the proposed offset ratios would be applied for TEC/poorly conserved vegetation communities within state forest land and how the ratios would be applied to non-TECs impacted by the project across both state forest land and non-state forest land.

Table C-6 Biodiversity offset ratio for TEC and non-TEC vegetation in state forest and non state forest land

Tenure	TEC/Poorly Conserved Vegetation Community/ Conservation FMZs	Non –TEC (Native Vegetation) in Other FMZs
State Forest Land	4:1	2:1# / 1:1#
Other Lands (Non- State Forests)	4:1	2:1

Instances where it is agreed with Department of Industry and Investment (Forestry) to compensate for the loss of working State Forest by providing existing native forests a biodiversity offset ratio of 1:1 applies. If other forestry offset measures are used such as funding for establishment of plantations then the biodiversity offset ratio that is applied will be 2:1.

Table C-6 highlights that regardless of land tenure and how Department of Primary Industries –Forests (DPI Forests NSW) are compensated; if TECs, poorly conserved vegetation communities or Conservation FMZs fall within State Forests and are impacted by the project then the biodiversity offset is set at the higher ratio (4:1).

Table C-7 quantifies the biodiversity offset required as a result of the impacts of the project within State Forests. The area of Conservation FMZs that is impacted by the project is around 55.48 hectares, so would be individually offset at 4:1 along with areas of highly cleared vegetation types and TECs outside of Conservation FMZs. As derived from Table C-7 a total of 407.58 hectares of biodiversity offset would be required as a result of the project's clearing impacts within State Forest land – assuming that DPI (Forests) are compensated for the loss of 'working forests' through the provision of cleared land/funding for the establishment a forestry plantation(s). If DPI (Forests NSW) are compensated through the provision of existing native forests then the total biodiversity offset required would be 350 hectares on a like for like basis within the NSW North Coast Bioregion.

Table C-7 Indicative biodiversity offset areas required as a result of clearing impacts from the project within State Forests

Vegetation/habitat type potentially impacted	Area impacted within state forest (ha)	Offset ratio applied	Offset area required (ha)
Conservation FMZs	55.48	4:1	221.92
Subtropical Coastal Floodplain Forest (TEC) in Other FMZs	13.40	4:1	53.60
Swamp Sclerophyll Forest (TEC) in Other FMZs	3.82	4:1	15.28
Highly cleared vegetation types in Other FMZs	0.42	4:1	1.68
All other vegetation types in Other FMZs	57.55	2:1	115.10
TOTAL	**130.67**		**407.58**

A summary of the remaining (excluding state forest) offset area required has been provided in Table C-8. From Tables C-7 and C-8 the biodiversity offset areas required for the project would be 3829.26 hectares assuming DPI (Forests NSW) are compensated through plantation forestry or 3771 hectares if DPI (Forests NSW) are compensated through provision of existing native forests.

Table C-8 Direct and indirect impacts on vegetation and fauna habitat outside of State Forests and availability of habitats for offsetting in the region

Biometric vegetation association*	Vegetation formation (Keith 2004)^	Direct loss (detailed vegetation mapping)	Edge effects (based on CRAFTI and detailed mapping)	TEC / highly cleared	Offset ratio	Offset target	Area (hectares) in 30 km radius (Biometric)	Area (hectares) in 100 km radius (Keith 2004)
Black Bean - Weeping Lilly Pilly Riparian Rainforest of the North Coast	Rainforest	1.40	0.5	Highly cleared 75%	4:1	7.60	57.6	160412
Blackbutt - Bloodwood Dry Heathy Open Forest on Sandstones of the Northern North Coast	Shrubby dry sclerophyll forest	73.82	28.9	No	2:1	205.44	51812.3	214461
Blackbutt Grassy Open Forest of the Lower Clarence Valley of the North Coast	Wet sclerophyll forest	43.22	11.3	No	2:1	109.04	13765.5	270628
Coast Cypress Pine Shrubby Open Forest of the North Coast Bioregion	Shrubby dry sclerophyll forest	27.40	5	TEC	4:1	129.60	84.5	214461
Coastal Floodplain Sedgelands, Rushlands, and Forblands	Freshwater wetland	3.00	0.8	TEC	4:1	15.20	6668.3	9085
Coastal Heath on Sands of the North Coast	Heathland	0.20	2	No	2:1	4.40	14610.8	25311
Flooded Gum - Tallowwood - Brush Box Moist Open Forest of the Coastal Ranges of the North Coast	Wet sclerophyll forest	2.00	1.6	No	2:1	7.20	4095.5	270628
Forest Red Gum - Swamp Box of the Clarence Valley Lowlands of the North Coast	Grassy woodland	60.77	29.4	TEC	4:1	360.68	12998.7	74266

Biometric vegetation association*	Vegetation formation (Keith 2004)^	Direct loss (detailed vegetation mapping)	Edge effects (based on CRAFTI and detailed mapping)	TEC / highly cleared	Offset ratio	Offset target	Area (hectares) in 30 km radius (Biometric)	Area (hectares) in 100 km radius (Keith 2004)
Grey Gum - Grey Ironbark Open Forest of the Clarence Lowlands of the North Coast	Dry sclerophyll shrub/grass forest	44.97	7.1	No	2:1	104.14	2840.2	109505
Hoop Pine - Yellow Tulipwood Dry Rainforest of the North Coast	Rainforest	0.50	0.3	TEC	4:1	3.20	1210	160412
Mangrove - Grey Mangrove Low Closed Forest of the NSW Coastal Bioregions	Saline wetland	1.50	0.4	Highly cleared 75%	4:1	7.60	865.6	3227
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast	Grassy woodland	34.70	30.6	TEC	4:1	261.20	35439.7	74266
Needlebark Stringybark - Red Bloodwood Heathy Woodland on Sandstones of the Lower Clarence of the North Coast	Shrubby dry sclerophyll forest	53.34	15.4	No	2:1	137.48	25073.6	214461
Orange Gum (Eucalyptus bancroftii) Open Forest of the North Coast	Shrubby dry sclerophyll forest	2.25	6	Highly cleared 75%	4:1	33.00	5824.1	214461
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast 2004	Swamp sclerophyll forest	46.03	17.1	TEC	4:1	252.52	22199.4	38380
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast	Wet sclerophyll forest	38.75	16.7	No	2:1	110.90	1665.2	270628

Biometric vegetation association*	Vegetation formation (Keith 2004)^	Direct loss (detailed vegetation mapping)	Edge effects (based on CRAFTI and detailed mapping)	TEC / highly cleared	Offset ratio	Offset target	Area (hectares) in 30 km radius (Biometric)	Area (hectares) in 100 km radius (Keith 2004)
Scribbly Gum - Needlebark Stringybark Heathy Open Forest of Coastal Lowlands of the Northern North Coast	Shrubby dry sclerophyll forest	69.48	35.5	No	2:1	209.96	4922.7	214461
Spotted Gum - Grey Box - Grey Ironbark Dry Open Forest of the Clarence Valley Lowlands of the North Coast	Dry sclerophyll shrub/grass forest	0.02	10.3	No	2:1	20.64	16215.6	109505
Spotted Gum - Grey Ironbark - Pink Bloodwood Open Forest of the Clarence Valley Lowlands of the North Coast	Dry sclerophyll shrub/grass forest	87.13	124.2	No	2:1	422.66	113919.9	109505
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	Grassy woodland	27.16	0	TEC	4:1	108.64	80.5	74266
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	Swamp sclerophyll forest	39.16	18.4	TEC	4:1	230.24	1483.1	38380
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	Swamp sclerophyll forest	56.20	21.5	TEC	4:1	310.80	9670.1	38380
Tallowwood Dry Grassy Forest of the Far Northern Ranges of the North Coast	Dry sclerophyll shrub/grass forest	53.00	23	No	2:1	152.00	1065.3	109505

Biometric vegetation association*	Vegetation formation (Keith 2004)^	Direct loss (detailed vegetation mapping)	Edge effects (based on CRAFTI and detailed mapping)	TEC / highly cleared	Offset ratio	Offset target	Area (hectares) in 30 km radius (Biometric)	Area (hectares) in 100 km radius (Keith 2004)
Turpentine Moist Open Forest of the Coastal Hills and Ranges of the North Coast	Wet sclerophyll forest	37.97	17.6	No	2:1	111.14	2	270628
Wet Heathland and Shrubland of Coastal Lowlands of the North Coast	Freshwater wetland	10.00	3.7	Highly cleared 75%	4:1	54.80	10800.2	9085
White Booyong - Fig Subtropical Rainforest of the North Coast	Rainforest#	8.60	4.3	TEC	4:1	51.60	6776.4	160412
TOTALS		**822.59**	**431.6**		**2.73:1**	**3421.68**	**461697.2**	
Cleared and Modified	N/A	864.75						

**Vegetation classification system based on the OEH vegetation types database (Office of Environment and Heritage 2012a) used in Biometric 2.0 (Gibbons et al. 2008).*

^Keith, D. (2004). *Ocean shores to desert dunes: the native vegetation of New South Wales and the ACT*. Department of Environment and Conservation. Hurstville. NSW.
Listing under the EPBC Act and TSC Act for Lowland Rainforest of Subtropical Australia

Using the proposed methodology, indicative offset requirements will be between 3,771 and 3,830 hectares. The impact to compensatory habitat ratio equates to 3,830 hectares to 1,254 hectares, an overall ratio of around 3.05:1.

It is proposed that the only exception to using the variable offset ratio approach as described above would be in case(s) where the potential biodiversity offset lands have the following attributes:

- Exemplary conservation value within the region (as agreed by EPA);
- Are under significant development pressure; and
- Due to the offset land location provides significant social and cultural values to the community.

This approach takes into consideration that such lands are likely to require considerable public funds to purchase and in such case(s) the offset ratio may be less than the variable offset ratio.

Threatened species habitat

The proposed offset methodology would take into account the value of key threatened species habitat when determining appropriate offsets. To help address the loss of biodiversity values, the NSW Government introduced the Biodiversity Banking and Offsets Scheme (or 'Biobanking'). The Biobanking assessment methodology establishes two classes of biodiversity credits that can be used to address the loss of habitat values for threatened species: ecosystem credits and species credits.

Threatened fauna species (TSC Act and EPBC Act) known or likely to occur in the study area are not known to be associated with all vegetation types recorded in the study area, according to the Threatened Species Profile Database (TSPD) (OEH 2011). The vegetation types within the study area known or predicted to be associated with each species are outlined in Table C-9 to Table C-12 below.

Ecosystem credits

Ecosystem credits can be created or required for all impacts on biodiversity values (including threatened species that can be reliably predicted by habitat surrogates), except the threatened species or populations that require species credits. Threatened species recorded or predicted to occur in the study area that would require ecosystem credits are listed in Table C-9.

Table C-9 Threatened fauna species (TSC Act and EPBC Act) recorded or considered likely to occur in the project boundary that require ecosystem credits

Scientific name	Common name	Confirmed	Associated vegetation formations in the project boundary
SPECIES IDENTIFIED FROM SURVEYS IN THE PROJECT AREA THAT REQUIRE ECOSYSTEM CREDITS			
Birds			
Burhinus grallarius	Bush stone-curlew	Section 2	Dry Sclerophyll Forests, Wet Sclerophyll Forests, Grassy Woodlands, Forested Wetlands
Anseranas semipalmata	Magpie Goose	Section 3	Forested Wetlands, Grassy Woodlands
Calyptorhynchus lathami	Glossy-black Cockatoo	Section 1, 3, 7 and 10	Dry Sclerophyll Forests, Wet Sclerophyll Forests, Forested Wetlands, Heathlands, Grassy Woodlands
Climacteris picumnus	Brown Treecreeper	Section 2, 6 and 7	Rainforest, Forested Wetlands, Grassy Woodlands, Dry Sclerophyll Forests, Wet Sclerophyll Forests
Grus rubicundus	Brolga	Section 1-3	Forested Wetlands, Freshwater Wetlands
Melithreptus gularis gularis	Black-chinned Honeyeater (estn ssp.)	Section 2	Dry Sclerophyll Forests, Grassy Woodlands,
Ninox strenua	Powerful Owl	Section 3, 7	Rainforest, Forested Wetlands, Grassy Woodlands, Dry Sclerophyll Forests, Wet Sclerophyll Forests
Pomatostomus temporalis temporalis	Grey-crowned Babbler (estn ssp.)	Section 3, 6, 7 and 8	Rainforest, Forested Wetlands, Grassy Woodlands, Dry Sclerophyll Forests, Wet Sclerophyll Forests
Ptilinopus regina	Rose-crowned Fruit Dove	Section 10	Rainforest, Dry Sclerophyll Forests, Wet Sclerophyll Forests
Tyto longimembris	Eastern Grass Owl	Section 9	Forested Wetlands, Dry Sclerophyll Forests, Heathlands, Grassy Woodlands
Tyto novaehollandiae	Masked Owl	Section 11	Rainforest, Forested Wetlands, Grassy Woodlands, Dry Sclerophyll Forests, Wet Sclerophyll Forests
Tyto tenebricosa	Sooty Owl	Section 2	Rainforest, Forested Wetlands, Wet Sclerophyll Forests, Grassy Woodlands
Mammals			
Phascolarctos cinereus	Koala*	Section 3	Rainforest, Forested Wetlands, Grassy Woodlands, Dry Sclerophyll Forests, Wet Sclerophyll Forests
Chalinolobus nigrogriseus	Hoary Wattled Bat	Section 1-3 and 6-8	Forested Wetlands, Grassy Woodlands, Dry Sclerophyll Forests, Wet Sclerophyll Forests, Heathlands
Falsistrellus tasmaniensis	Eastern False Pipistrelle	Section 1-3	Rainforests, Forested Wetlands, Grassy Woodlands, Dry Sclerophyll Forests, Wet Sclerophyll Forests, Heathlands, Freshwater Wetlands
Mormopterus norfolkensis	Eastern Freetail-Bat	Section 6-11	Rainforests, Forested Wetlands, Grassy Woodlands, Dry Sclerophyll Forests, Wet Sclerophyll Forests, Heathlands, Freshwater Wetlands, Saline Wetlands

Scientific name	Common name	Confirmed	Associated vegetation formations in the project boundary
Syconycteris australis	Common Blossom-bat	Section 8-11	Rainforests, Forested Wetlands, Dry Sclerophyll Forests, Wet Sclerophyll Forests, Heathlands, Freshwater Wetlands
Saccolaimus flaviventris	Yellow-bellied Sheathtail Bat	Section 9-11	Rainforests, Forested Wetlands, Grassy Woodlands, Dry Sclerophyll Forests, Wet Sclerophyll Forests, Heathlands, Freshwater Wetlands, Saline Wetlands
Scoteanax rueppellii	Greater Broad-nosed Bat	Section 9-11	Rainforests, Forested Wetlands, Grassy Woodlands, Dry Sclerophyll Forests, Wet Sclerophyll Forests, Freshwater Wetlands, Saline Wetlands
Kerivoula papuensis	Golden-tipped Bat	Section 9-11	Rainforests, Forested Wetlands, Grassy Woodlands, Dry Sclerophyll Forests, Wet Sclerophyll Forests
Petaurus australis	Yellow-bellied Glider	Section 2	Forested Wetlands, Grassy Woodlands, Dry Sclerophyll Forests, Wet Sclerophyll Forests
Petaurus norfolcensis	Squirrel Glider	Section 1-11	Forested Wetlands, Grassy Woodlands, Dry Sclerophyll Forests, Wet Sclerophyll Forests, Heathlands
Reptiles			
Hoplocephalus stephensii	Stephen's' banded snake	Section 3	Rainforests, Forested Wetlands, Grassy Woodlands, Wet Sclerophyll Forests
SPECIES CONSIDERED LIKELY TO OCCUR IN PROJECT AREA THAT REQUIRE ECOSYSTEM CREDITS			
Birds			
Stictonetta naevosa	Freckled Duck	3-5	Grassy Woodlands, Forested Wetlands
Coracina lineata	Barred cuckoo-shrike	1-2, 6-11	Rainforests, Forested Wetlands, Grassy Woodlands, Dry Sclerophyll Forests, Wet Sclerophyll Forests
Rostratula australis	Australian Painted Snipe*	1-11	Forested Wetlands
Glossopsitta pusilla	Little Lorikeet	1-11	Wet Sclerophyll Forests, Forested Wetlands, Dry Sclerophyll Forests, Grassy Woodlands
Lathamus discolor	Swift Parrot*	1-11	Wet Sclerophyll Forests, Forested Wetlands, Dry Sclerophyll Forests, Grassy Woodlands
Ninox connivens	Barking Owl	1-11	Rainforests, Wet Sclerophyll Forests, Forested Wetlands, Dry Sclerophyll Forests, Heathlands, Grassy Woodlands
Ptilinopus magnificus	Wompoo fruit-Dove	1-2, 6-11	Rainforests, Wet Sclerophyll Forests
Ptilinopus superbus	Superb fruit-Dove	1-2, 8-11	Rainforests, Wet Sclerophyll Forests, Forested Wetlands, Grassy Woodlands

Scientific name	Common name	Confirmed	Associated vegetation formations in the project boundary
Xanthomyza phrygia	Regent Honeyeater*	1-11	Wet Sclerophyll Forests, Forested Wetlands, Dry Sclerophyll Forests, Grassy Woodlands
Mammals			
Mormopterus beccarii	Beccari's Freetail-Bat	1-11	Rainforests, Wet Sclerophyll Forests, Dry Sclerophyll Forests, Heathlands, Grassy Woodlands, Forested Wetlands
Cercartetus nanus	Eastern Pygmy-Possum	1-11	Rainforests, Forested Wetlands, Grassy Woodlands, Dry Sclerophyll Forests, Wet Sclerophyll Forests, Heathlands, Freshwater Wetlands
Dasyurus maculatus maculatus (SE population)	Spotted-tailed Quoll*	1-11	Rainforest, Dry Sclerophyll Forests, Wet Sclerophyll Forests, Forested Wetlands, Grassy Woodlands, Heathlands, Saline Wetlands, Freshwater Wetlands
Potorous tridactylus tridactylus	Long-Nosed Potoroo*	1-3, 6-11	Rainforests, Forested Wetlands, Grassy Woodlands, Dry Sclerophyll Forests, Wet Sclerophyll Forests, Heathlands, Freshwater Wetlands

* Listed as Matter of National Environmental Significance (EPBC Act)

Species credits

Species credits can be created or required for impacts on threatened species that cannot be reliably predicted to use an area of land based on habitat surrogates. The number of species credits will be determined from the targeted surveys and known records. (DECC 2007). Nineteen threatened fauna species (TSC Act and EPBC Act) were identified as requiring species credits. Ten of these have habitat requirements specified in the Threatened Species Characteristics by CMA database (TSCCD) (refer to Table C-10).

Table C-10 Threatened fauna species recorded or considered likely to occur in the project boundary that require species credits

Scientific name	Common name	Potential project sections	Associated vegetation formations in the project boundary	Habitat requirements specified in the TSCCD
SPECIES IDENTIFIED FROM FAUNA SURVEYS IN THE PROJECT CORRIDOR				
Birds				
Botaurus poiciloptilus	Australasian Bittern*	Section 3	Forested Wetlands, Grassy Woodlands, Saline Wetlands, Freshwater Wetlands	Land containing brackish or freshwater wetlands
Ephippiorhynchus asiaticus	Black-necked Stork	Sections 1-5	Forested Wetlands, Grassy Woodlands, Saline Wetlands, Freshwater Wetlands	Land within 40 m of freshwater or saline wetlands (eg saltmarsh, mangroves, mudflats, swamps, billabongs, floodplains, watercourse pools, wet heathland and/or farm dams)
Dromaius novaehollandiae	Coastal Emu Population	Section 3-4	Dry Sclerophyll Forests, Forested Wetlands, Grassy Woodlands, Freshwater Wetlands	Not specified
Lichenostomus fasciogulari	Mangrove Honeyeater	Section 10	Forested Wetlands, Saline Wetlands, Freshwater Wetlands	Mangrove vegetation associations of coasts, estuaries and offshore islands
Pandion haliaetus	Eastern Osprey	Section 1-11	Rainforest, Dry Sclerophyll Forests, Wet Sclerophyll Forests, Forested Wetlands, Grassy Woodlands, Heathlands, Saline Wetlands, Freshwater Wetlands	Land within 40 m of fresh/brackish/saline waters of larger rivers or creeks; estuaries, coastal lagoons, lakes and/or inshore marine waters
Mammals				
Aepyprymnus rufescens	Rufous Bettong	Section 1-3	Rainforest, Dry Sclerophyll Forests, Wet Sclerophyll Forests, Forested Wetlands, Grassy Woodlands,	Not specified
Phascogale tapoatafa	Brush-tailed Phascogale	Section 2, 4, 6, 7 and 8	Dry Sclerophyll Forests, Wet Sclerophyll Forests, Forested Wetlands, Grassy Woodlands, Freshwater Wetlands	Not specified

Scientific name	Common name	Potential project sections	Associated vegetation formations in the project boundary	Habitat requirements specified in the TSCCD
Planigale maculata	Common Planigale	Section 1-2	Rainforest, Dry Sclerophyll Forests, Wet Sclerophyll Forests, Forested Wetlands, Grassy Woodlands, Heathlands, Freshwater Wetlands	Rainforest, eucalypt forest, heathland, marshland, grassland or rocky areas
Amphibians				
Crinia tinnula	Wallum Froglet	Section 1,2 and 6-11	Freshwater Wetlands, Forested Wetlands	Land within 40 m of swamps, wet or dry heaths or sedge grasslands
Litoria brevipalmata	Green-thighed Frog	Section 1 and 6-8	Rainforest, Dry Sclerophyll Forests, Wet Sclerophyll Forests, Forested Wetlands, Grassy Woodlands, Heathlands, Saline Wetlands, Freshwater Wetlands	Land within 100 m of semi-permanent or ephemeral ponds or depressions containing leaf litter
Mixophyes iteratus	Giant Barred Frog*	Section 1	Rainforest, Wet Sclerophyll Forests, Forested Wetlands, Grassy Woodlands	Land below 1000 m in altitude and within 40 m of rainforest or eucalypt forest with deep leaf litter
Invertebrates				
Phyllodes imperialis southern subsp.	Pink Underwing Moth*	Section 10	Rainforest	land within 40 m of rainforest containing *Carronia multisepalea* or orchids
Nurus atlas	Atlas Rainforest Ground Beetle*	Section 10	Rainforest, Wet Sclerophyll Forests	Land within 40 m of low elevation rainforest/wet eucalypt forest with rainforest understorey containing leaf litter or fallen timber
SPECIES CONSIDERED LIKELY TO OCCUR IN PROJECT AREA				
Birds				
Amaurornis molucanna	Pale-vented Bush Hen	9-10	Rainforests, Forested Wetlands, Wet Sclerophyll Forests, Freshwater Wetlands, Saline Wetlands	Not specified
Cyclopsitta diophthalma coxeni	Double-Eyed Fig-Parrot*	9-11	Rainforests, Wet Sclerophyll Forests	rainforests with fig or other fleshy-fruited trees

Scientific name	Common name	Potential project sections	Associated vegetation formations in the project boundary	Habitat requirements specified in the TSCCD
Erythrotriorchis radiatus	Red Goshawk*	1-11	Forested Wetlands, Grassy Woodlands, Dry Sclerophyll Forests, Wet Sclerophyll Forests, Freshwater Wetlands	tall trees in forest or woodland, within 1 km of permanent water
Hieraaetus morphnoides	Little Eagle	1-11	Rainforests, Forested Wetlands, Grassy Woodlands, Dry Sclerophyll Forests, Wet Sclerophyll Forests, Heathlands, Freshwater Wetlands, Saline Wetlands	Not specified
Irediparra gallinacea	Comb-Crested Jacana	3-9	Freshwater Wetlands, Forested Wetlands	land within 40 m of permanent wetlands with a good surface cover of floating vegetation
Ixobrychus flavicollis	Black Bittern	1-3, 6-7, 9	Forested Wetlands, Grassy Woodlands, Saline Wetlands, Freshwater Wetlands	land within 40 m of freshwater and estuarine wetlands, in areas of permanent water and dense vegetation or emergent aquatic vegetation
Lophoictinia isura	Square-tailed Kite	1-11	Rainforests, Wet Sclerophyll Forests, Forested Wetlands, Dry Sclerophyll Forests, Heathlands, Grassy Woodlands, Saline Wetlands, Freshwater Wetlands	Not specified
Pezoporus wallicus wallicus	Ground Parrot (eastern subsp.)	8-10	Freshwater Wetlands, Forested Wetlands	land within 40 m of dense multi-layered coastal heath with patches that have been unburnt for 3 years or more
Mammals				
Chalinolobus dwyeri	Large-eared Pied Bat*	1-7	Rainforest, Dry Sclerophyll Forests, Wet Sclerophyll Forests, Forested Wetlands, Grassy Woodlands, Saline Wetlands, Freshwater Wetlands	land containing escarpments, cliffs, caves, deep crevices, old mine shafts or tunnels

Scientific name	Common name	Potential project sections	Associated vegetation formations in the project boundary	Habitat requirements specified in the TSCCD
Amphibians				
Litoria olongburensis	Olongburra Frog	1-11	Forested Wetlands, Freshwater Wetlands	land within 40 m of ephemerally wet areas, lakes, marsh or swampy areas with emergent vegetation/reeds in/adjacent to wallum
Reptiles				
Hoplocephalus bitorquatus	Pale-headed Snake	1-3, 6-8	Rainforest, Dry Sclerophyll Forests, Wet Sclerophyll Forests, Forested Wetlands, Grassy Woodlands, Heathlands	land within 40 m of watercourses, containing hollow-bearing trees, loose bark and/or fallen timber
Invertebrates				
Petalura litorea	Coastal Petaltail	7-10	Forested Wetlands, Grassy Woodlands, Freshwater Wetlands	coastal freshwater sedgelands, wetlands and peatlands

* Listed Matter of National Environmental Significance (EPBC Act)

No habitat requirements are defined in the TSCCD for the Brush-tailed Phascogale, Rufous Bettong, Pale-vented Bush Hen, Little Eagle, Square-tailed Kite and the Coastal Emu Population. Habitat requirements for these species are specified in the TSPD (OEH 2011) defines habitat for these species and these are provided below in Table C-11.

Table C-11 Threatened fauna habitat requirements specified in the TSPD (OEH 2011) for species with no habitat requirements in the TSCCD

Scientific Name	Common Name	Habitat requirements as specified in the TSPD (OEH 2011)
Mammals		
Aepyprymnus rufescens	Rufous Bettong	Prefer forests with a grassy to sparse understorey including coastal forest, tall wet sclerophyll forest and dry forests west of the Great Diving Range. It is most commonly found on sites derived from sedimentary rock and in north eastern NSW in forests characterised by Spotted Gum (*Corymbia maculata* and *C. henryi*).
Phascogale tapoatafa	Brush-tailed Phascogale	Preferred habitat is dry open forest with a sparse open understorey, however, has been located in heath, swamps and rainforest and wet sclerophyll forest. Breeding habitat for this species as ‘hollow trees, logs or stumps with entrances > 2.5 cm wide’ (OEH 2011).

Scientific Name	Common Name	Habitat requirements as specified in the TSPD (OEH 2011)
Birds		
Dromaius novaehollandiae	Coastal Emu Population	On the NSW north coast, Emus occur in a range of predominantly open lowland habitats, including grasslands, heathland, shrubland, open and shrubby woodlands, forest, and swamp and sedgeland communities, as well as the ecotones between these habitats. They also occur in plantations of tea-tree and open farmland, and occasionally in littoral rainforest. Eggs are laid on a platform of grass, twigs, leaves and bark on the ground, often at the base of some vegetation and with good views from the nest. Incubation and all parental care is by the male.
Amaurornis molucanna	Pale-vented Bush Hen	The Pale-vented Bush-hen inhabits tall dense understorey or ground-layer vegetation on the margins of freshwater streams and natural or artificial wetlands, usually within or bordering rainforest, rainforest remnants or forests. Also occur in secondary forest growth, rank grass or reeds, thickets of weeds, such as Lantana (*Lantana camara*), and pastures, crops or other farmland, such as crops of sugar cane, and grassy or weedy fields, or urban gardens where they border forest and streams or wetlands, such as farm dams. Can also occur in and around mangroves, though rarely do so, if at all, in NSW. The nest is a shallow bowl or cup of grass stems, often partly hooded, built close to water in thick ground vegetation such as dense Blady Grass (*Imperata cylindrica* or mat rush (*Lomandra spp.*) or reeds, often under or growing through shrubs or vine or beneath a tree.
Hieraaetus morphnoides	Little Eagle	Occupies open eucalypt forest, woodland or open woodland. Sheoak or Acacia woodlands and riparian woodlands of interior NSW are also used. Nests in tall living trees within a remnant patch, where pairs build a large stick nest in winter.
Lophoictinia isura	Square-tailed Kite	Found in a variety of timbered habitats including dry woodlands and open forests. Shows a particular preference for timbered watercourses. Breeding habitat requires forks or large horizontal limbs on trees and that these are close to watercourses.

Based on the habitat requirements for the 25 threatened species requiring species credits that occur or are predicted to occur within the study area, the proposed offset should contain the habitat types specified in Table C-10 and Table C-12. Expert opinion from a suitably qualified ecologist will be sought to determine whether the proposed offset land is suitable for threatened fauna species that can't be offset using vegetation type alone.

For six bat species recorded in the study area, there is no specification in the TSPD for whether they require ecosystem or species credits, as particular habitat elements, such as breeding habitat of cave-roosting bats, may require species credits whereas foraging habitat may be offset with ecosystem credits. Given that the study area represents foraging habitat only for most of these species (with the exception of the Eastern long-eared Bat and Grey-headed Flying-fox), it is likely that the habitat within the study area for these species can be offset by vegetation type. These five species and their associated breeding/sheltering habitat are outlined in Table C-12. The six species are associated with, or predicted to be associated with dry sclerophyll forests, wet sclerophyll forests, and swamp sclerophyll forests within the study area.

Table C-12 Threatened fauna recorded in the project boundary for which no credit type is defined

Scientific name	Common name	Confirmed	Associated vegetation formations in the project boundary	Breeding/shelter habitat as identified in the TSPD
Pteropus poliocephalus	Grey-headed Flying-Fox*	Sections 1-11	Rainforest, Dry Sclerophyll Forests, Wet Sclerophyll Forests, Forested Wetlands, Grassy Woodlands, Heathlands, Saline Wetlands, Freshwater Wetlands	Canopy trees associated with rainforest, or coastal scrub or riparian or estuarine communities and with sufficient forage resources available within 40 km.
Miniopterus australis	Little Bent-wing Bat	Section 1-11	Rainforest, Dry Sclerophyll Forests, Wet Sclerophyll Forests, Forested Wetlands, Grassy Woodlands, Saline Wetlands, Freshwater Wetlands	Caves, often limestone
Miniopterus schreibersii oceanensis	Eastern Bent-wing Bat	Section 1-2 and 6-11	Rainforest, Dry Sclerophyll Forests, Wet Sclerophyll Forests, Forested Wetlands, Grassy Woodlands, Saline Wetlands, Freshwater Wetlands	Caves
Myotis macropus	Southern Myotis	Section 1-2 and 6-11	Rainforest, Dry Sclerophyll Forests, Wet Sclerophyll Forests, Forested Wetlands, Grassy Woodlands, Heathlands, Saline Wetlands, Freshwater Wetlands	Live and dead hollow-bearing trees, under bridges or other artificial structures, in caves, or in dense foliage. Forage over streams and pools.
Nyctophilus bifax	Eastern Long-eared Bat	Section 6-11	Wet Sclerophyll Forests, Forested Wetlands, Rainforest	Tree hollows, the hanging foliage of palms, in dense clumps of foliage of rainforest trees, under bark and in shallow depressions on trunks and branches, among epiphytes, in the roots of strangler figs, among dead fronds of tree ferns and less often in buildings.

Scientific name	Common name	Confirmed	Associated vegetation formations in the project boundary	Breeding/shelter habitat as identified in the TSPD
Vespadelus troughtoni	Eastern Cave Bat	Section 6-11	Rainforest, Dry Sclerophyll Forests, Wet Sclerophyll Forests, Grassy Woodlands,	Cave-roosting species that is usually found in dry open forest and woodland, near cliffs or rocky overhangs; has been recorded roosting in disused mine workings, occasionally in colonies of up to 500 individuals. Occasionally found along cliff-lines in wet eucalypt forest and rainforest.

Mitigation measures proposed for the six bat species include: pre-clearing surveys, fauna rescue protocol, avoidance of hollow-bearing trees where possible, and the inspection of large pipes beneath the existing highway prior to removal.

Potential compensatory habitat in the region

An indication of the availability of land within 30 kilometres and 100 kilometres of the project alignment supporting communities affected by the project is provided in Table C-8 and does not include lands that are within the conservation reserve system. The distribution of the available habitats within 30 kilometres of the proposal area showing biometric vegetation types are provided in Figure C-1, and availability of habitats within 100 kilometres showing broad structural vegetation types is displayed in Figure C-2. The land is under private tenure and is theoretically available to be considered as part of any offset package. Table C-8 shows that there are substantial tracts of land potentially available for consideration in a biodiversity offset package although areas greater than 30 kilometres from alignment are likely to be needed to fulfil some or all of the biodiversity offset obligations.

Biodiversity offset package

Within two years of the approval of the project the RMS would submit to the Department of Planning and Infrastructure (and the Commonwealth Government) a Biodiversity Offset Package. The package would be prepared in consultation with OEH (and the Commonwealth Government) and would include details of the final suite of measures to be implemented as a result of this strategy. The package would identify a timeline for implementation and the detail of measures, including arrangements for ongoing management of offset lands, to be undertaken under Options A, B and C.

Figure C-1
Biometric vegetation types within a 30 kilometre radius of the proposal (adapted from NPWS 1998)

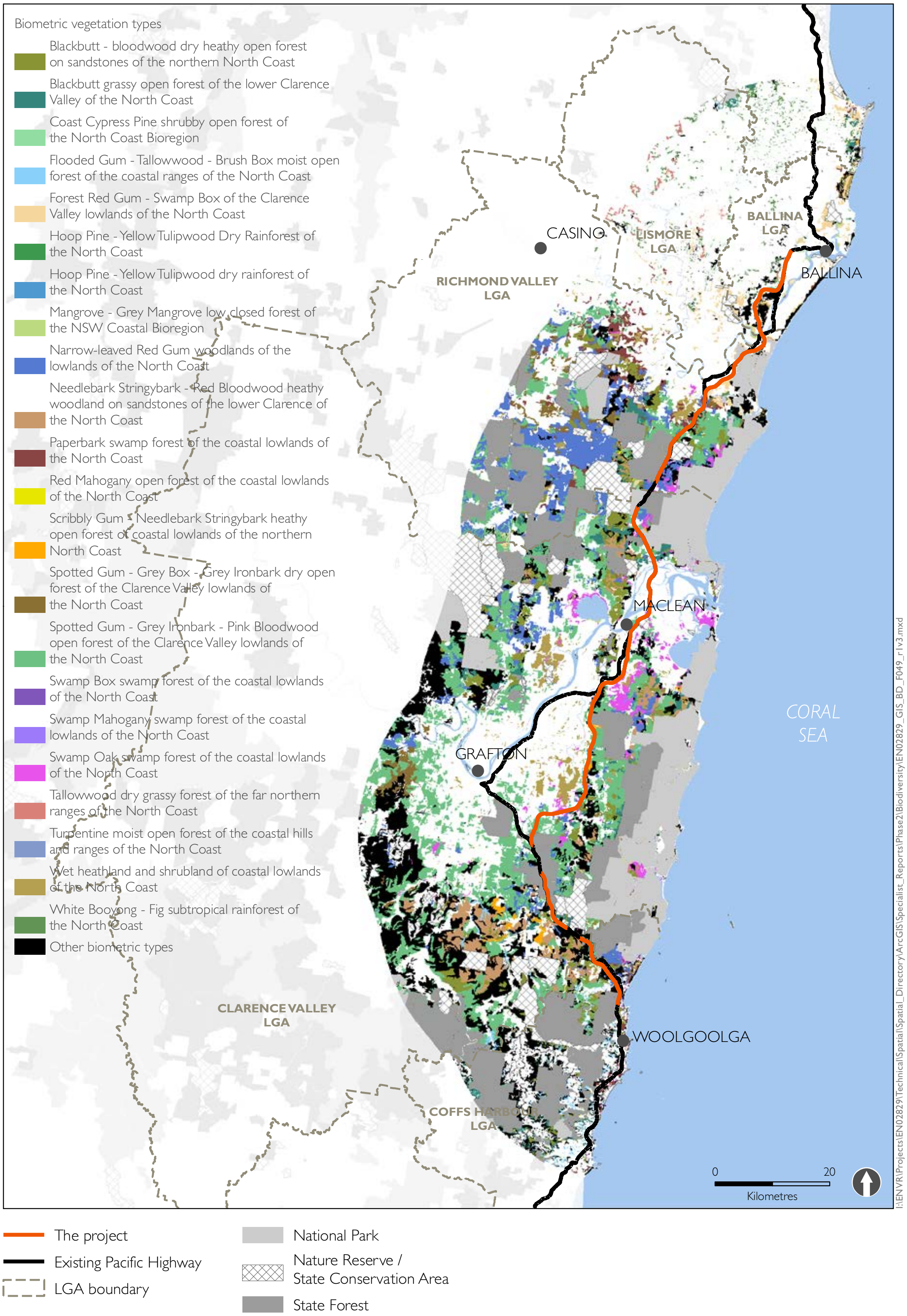
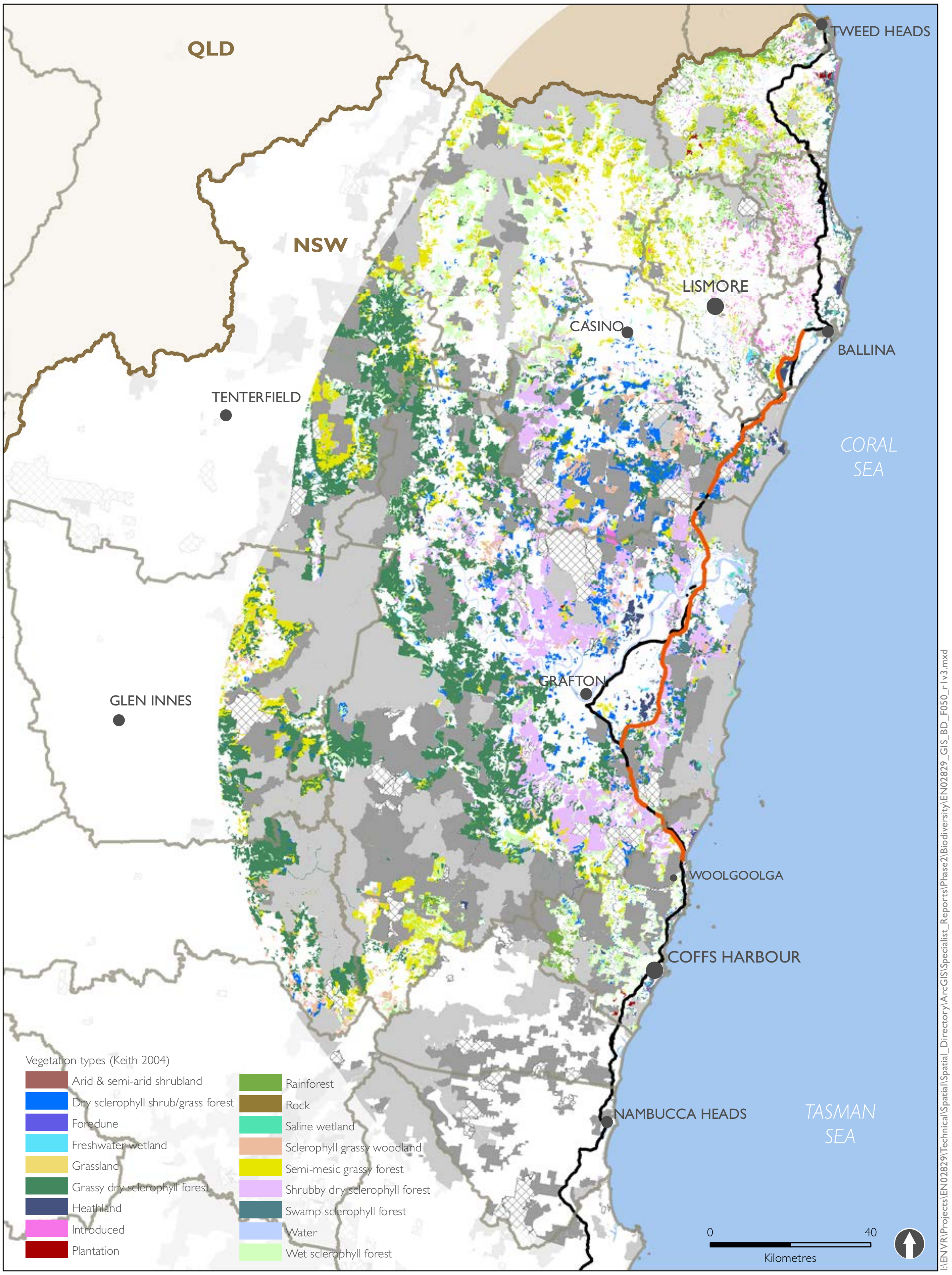


Figure C-2
Broad structural vegetation types within a 100 kilometre radius of the proposal (adapted from NPWS 1998)



The project
Existing Pacific Highway
LGA boundary
National Park
Nature Reserve / State Conservation Area
State Forest

Decision-making framework

All biodiversity offsets would be located within the NSW North Coast Bioregion with the aim of offsetting on a like for like basis based on vegetation formations/classes. Specific requirements have been identified for flora species directly impacted by the project.

It is recognised that the availability and suitability of land for inclusion in the offset package would be uncertain until the detailed investigation of suitable sites and finalisation of negotiations with landholders occurs. As a result it is necessary to have a prioritise approach to determining the suitability of sites for inclusion in the package.

Priority 1

The first priority would be to identify land that meets all the following criteria:

- Located within 30 kilometre radius of the project, but extending to a 100 kilometre radius should a suitable offset not be found closer to the proposal;
- Contains vegetation types and classes identified in Table C-8;
- Contains suitable habitat and patch sizes for threatened species potentially impacted by the project based on the OEH threatened species profile databases (including the specific requirements identified for flora species);
- Contains vegetation of at least moderate to good condition (according to OEH native vegetation benchmarks database);
- Provides connectivity to adjacent areas of vegetation; and
- Is suitable for ongoing conservation management through an appropriate legal instrument.

Priority 2

The second priority, if required, would be to:

- Identify other land that contains the required vegetation types and classes within the broader North Coast Bioregion; and
- Substitute other vegetation types or formations that consist of similar habitat features and be of similar conservation value to those in Table C-8 (for example dry sclerophyll shrubby formation with dry sclerophyll grassy formation, but not dry sclerophyll with lowland rainforest TEC).

The second priority would only be considered if the offset requirements could not reasonably be met using the Priority 1 criteria and consultation with OEH has occurred. The offset package would clearly identify where Priority 2 lands have been used to meet the objectives of the strategy.

Notwithstanding the above, the project offset package may also be part of a larger offset package where other Pacific Highway projects between Port Macquarie and Ballina may be included. The scope of this larger offset package would be determined using the same methodology as described in this Strategy and would potentially allow larger more continuous areas of land to be acquired leading to improved conservation outcomes and economies of scale. Conservation organisations have shown interest in this approach and are interested in working with RMS to identify and manage such lands.

C.5 Conclusions

Measures for managing biodiversity impacts arising from the project were developed following the general principles of avoiding, mitigating and offsetting impacts. Impacts on biodiversity values within the region have been avoided, where possible, through the route selection process and development of the concept design alignment. Management measures designed to reduce impacts on biodiversity include fauna crossing measures, revegetation measures, threatened flora protection and translocation, additional fauna mitigation measures and monitoring measures.

The project will result in direct impacts to around 948 hectares of vegetation and indirect impacts (edge effects) on an additional 431.6 hectares. Based on offset ratios of 4:1 for threatened ecological communities and 2:1 for non-TEC vegetation communities impacted by the project, indicative offset requirements for the project will be 3736 hectares.

There are substantial tracts of land potentially available for consideration for the biodiversity offset package within 30 km of the study area, which appears to represent a suitable offset for the vegetation to be cleared for the project.

Within two years of the approval of this strategy, RMS will submit to the Department of Planning and Infrastructure a Biodiversity Offset Package, to be prepared in consultation with the EPA and including details of the final suite of measures selected in accordance with this strategy.

Appendix D Likelihood of threatened species occurring in the study area

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Likelihood of threatened species occurring in the study area

Potential state and nationally listed species identified from the background review were assessed to identify their likelihood of occurrence based on the known habitat requirements and comparison with the habitats identified in each project section. The assessment has been provided in Table D1 which includes the legislative status of each species. The likelihood of occurrence was classified according to the criteria described in Table D1.

Table D1. Likelihood of occurrence includes one or more of the following criteria

Likelihood of occurrence	Criteria
Unlikely (U)	• Species highly restricted to certain geographical areas not within the study area • Specific habitat requirements were not present in the study area.
Low (L)	Species not recorded during preferred route field surveys and fit one or more of the following criteria: • Have not been recorded previously in the project study area/surrounds and for which the study area would be beyond the current distributional range • Use specific habitats or resources that have not been identified in the study area • A non-cryptic perennial flora species that was specifically targeted by surveys and not recorded.
Medium (M)	Species not recorded during the preferred route field surveys that fit one or more of the following criteria: • Have infrequently been recorded previously in the study area/surrounds on the basis of NSW Wildlife Atlas records • Use specific habitats or resources that are present in the study area but in a poor or modified condition or poorly represented • Unlikely to maintain sedentary populations, however may seasonally use resources within the study area opportunistically or during migration • Cryptic flowering flora species that were seasonally targeted by surveys and that have not been recorded.
High (H)	Species not recorded during the preferred route field surveys that fit one or more of the following criteria: • Have frequently been recorded previously in the study area/surrounds, based on a high number of NSW Wildlife Atlas records • Use habitat types or resources that were present in the study area that are abundant and/or in good condition • Known or likely to maintain resident populations surrounding the study area • Known or likely to visit the site during regular seasonal movements or migration.
Confirmed (C)	Species recorded directly from field surveys in the relevant project section.

Table D2. Subject species assessment

Scientific name	Common name	Broad habitat requirements	Records in 10 km of project	Status		Project section										
				TSC / FM Act	EPBC Act	1	2	3	4	5	6	7	8	9	10	11
Birds																
Amaurornis molucanna	Pale-vented Bush Hen	Wetlands and forest edges	18	V		L	L	L	L	L	L	L	L	M	M	M
Anseranas semipalmata	Magpie Goose	Shallow wetlands with rushes and sedges	20	V	-	L	M	C	M	M	M	L	M	M	M	M
Ardea ibis	Cattle Egret	Grasslands, woodlands and wetlands	>1000	-	Mi	C	C	C	C	C	H	H	H	C	C	C
Atrichornis rufescens	Rufous Scrub-Bird	Rainforests and wet sclerophyll forests	0	V	-	L	L	L	L	L	L	L	L	L	L	L
Burhinus grallarius	Bush Stone-curlew	Open forests and woodlands	36	E1	-	H	C	M	L	L	L	L	L	L	L	L
Botaurus poiciloptilus	Australasian Bittern	Freshwater wetlands, rivers and streams	8	E1	-	M	M	C	M	L	L	M	M	M	M	M
Burhinus grallarius	Beach Stone-Curlew	Open beaches and coastal dunes	223	E1	-	U	U	U	U	U	U	U	U	U	U	U
Calidris alba	Sanderling	Oceanic, marine and estuarine	33	V	Mi	U	U	U	U	U	U	U	U	U	U	U
Calidris tenuirostris	Great Knot	Oceanic, marine and estuarine	113	V	Mi	U	U	U	U	U	U	U	U	U	U	U
Calyptorhynchus banksii	Red-tailed Black-cockatoo	Eucalyptus forests and woodlands along watercourses	0	CE	-	U	U	U	U	U	U	U	U	U	U	U
Calyptorhynchus lathami	Glossy Black-cockatoo	Woodlands and open forest	314	V	-	C	C	C	C	C	C	C	H	H	C	H
Charadrius leschenaultii	Greater Sand plover	Oceanic, marine and estuarine	51	V	Mi	U	U	U	U	U	U	U	U	U	U	U
Charadrius mongolus	Lesser Sand Plover	Oceanic, marine and estuarine	89	V		U	U	U	U	U	U	U	U	U	U	U
Climacteris picumnus	Brown Treecreeper	Woodlands and open forests	48	V	-	C	C	C	M	M	M	M	U	U	U	U
Coracina lineata	Barred Cuckoo-shrike	Rainforests and wet sclerophyll forests	21	V	-	M	M	L	L	L	M	M	M	H	H	H

Scientific name	Common name	Broad habitat requirements	Records in 10 km of project	Status		Project section										
				TSC / FM Act	EPBC Act	1	2	3	4	5	6	7	8	9	10	11
Cyclopsitta diophthalma coxeni	Double-Eyed Fig-Parrot	Rainforests and wet sclerophyll forests	0	CE	E1	U	U	U	U	U	U	U	U	L	M	M
Dromaius novaehollandiae	Coastal Emu	Woodlands and open forests	511	E2	-	U	L	C	C	C	L	L	L	U	U	U
Egretta alba	Great Egret	Shallow wetlands and damp grasslands	248	-	Mi	H	M	H	H	H	M	M	C	H	H	H
Ephippiorhynchus asiaticus	Black-necked Stork	Open wetlands & adjoining agricultural areas	1383	E1	-	H	H	C	C	C	H	H	H	C	C	C
Erythrotriorchis radiatus	Red Goshawk	Woodlands and open forests and watercourses	15	CE	V	M	M	M	M	M	M	M	M	M	M	M
Gallinago hardwickii	Latham's Snipe	Wetlands, swamps, flooded grasslands or heathlands	73	-	Mi	M	M	C	H	H	H	H	M	H	H	H
Glossopsitta pusilla	Little Lorikeet	Woodlands and eucalypt forests	104	V	-	H	H	H	M	H	H	H	M	H	M	M
Grantiella picta	Painted Honeyeater	Woodlands and open forests	1	V	-	L	L	L	L	L	L	L	L	L	L	L
Grus rubicundus	Brolga	Open wetlands, grasslands and pasture salt flats	189	V	-	C	C	C	C	C	H	H	H	H	C	C
Haematopus fuliginosus	Sooty Oystercatcher	Oceanic, marine and estuarine	142	V	-	L	L	L	L	L	L	L	L	L	L	L
Haematopus longirostris	Pied Oystercatcher	Oceanic, marine and estuarine	634	E	-	L	L	L	L	L	L	L	L	L	L	L
Haliaeetus leucogaster	White-bellied Sea-Eagle	Oceanic, marine and estuarine	385	-	Mi	C	H	H	H	H	M	H	H	H	H	H
Hamirostra melanosternon	Black-breasted Buzzard	Woodlands and grasslands	0	V	-	L	L	L	L	L	L	L	L	L	L	L
Hieraaetus morphnoides	Little Eagle	Open woodland, grassland and arid regions,	36	V	-	M	M	M	M	M	M	M	M	M	M	M
Irediparra gallinacea	Comb-crested Jacana	Open wetlands & adjoining agricultural areas	48	V	-	L	L	M	M	M	M	M	M	M	M	M

Scientific name	Common name	Broad habitat requirements	Records in 10 km of project	Status		Project section										
				TSC / FM Act	EPBC Act	1	2	3	4	5	6	7	8	9	10	11
Ixobrychus flavicollis	Black Bittern	Streams, estuarine and swamps	15	V	-	M	M	M	L	U	M	M	L	M	L	L
Lathamus discolor	Swift Parrot	Woodlands and open forests	17	E	E, Mi	M	M	M	M	M	M	M	M	M	M	M
Lichenostomus fasciogulari	Mangrove Honeyeater	Mangroves and estuarine	62	V		U	U	U	M	M	U	U	U	H	C	H
Limicola falcinellus	Broad-billed Sandpiper	Oceanic, marine and estuarine	11	V		U	U	U	U	U	U	U	U	U	U	U
Limosa limosa	Black-tailed Godwit	Oceanic, marine and estuarine	48	V	Mi	U	U	U	U	U	U	U	U	U	U	U
Lophoictinia isura	Square-tailed Kite	Woodlands and open forests	36	V	-	M	M	M	M	M	M	M	M	M	M	M
Melanodryas cucullata	Hooded Robin	Woodlands and open forests	3	V	-	L	L	L	L	L	L	L	L	L	L	L
Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subsp.)	Woodlands and open forests	53	V	-	M	C	C	L	L	M	M	L	L	L	L
Menura alberti	Alberts Lyrebird	Rainforests and wet eucalyptus forests	30	V	-	U	U	U	U	U	U	U	U	L	L	L
Merops ornatus	Rainbow Bee-eater	Open forests, woodlands, shrublands and cleared areas.	446	-	Mi	H	H	C	H	H	H	H	H	H	H	H
Monarcha leucotis	White-eared Monarch	Littoral rainforests, wet and dry sclerophyll forests and swamp forests	0	V	-	L	L	L	L	L	L	L	L	L	L	L
Monarcha melanopsis	Black-faced Monarch	Rainforest and eucalypt forests	161	-	Mi	H	H	C	H	H	H	M	H	H	H	H
Monarcha trivirgatus	Spectacled Monarch	Rainforest and eucalypt forests	264	-	Mi	H	H	M	H	H	H	M	M	H	H	H
Myiagra cyanoleuca	Satin Flycatcher	Dry open eucalypt forests	11	-	Mi	C	C	M	M	M	C	C	C	H	H	M
Neophema pulchella	Turquoise Parrot	Woodlands and open forests	1	V	-	L	L	L	L	L	L	L	L	L	L	L
Ninox connivens	Barking Owl	Woodlands and riparian habitats	49	V	-	M	M	M	M	M	M	M	M	M	M	M

Scientific name	Common name	Broad habitat requirements	Records in 10 km of project	Status		Project section										
				TSC / FM Act	EPBC Act	1	2	3	4	5	6	7	8	9	10	11
Ninox strenua	Powerful Owl	Woodlands and open forests	117	V	-	H	H	C	H	C	H	C	H	H	C	H
Pachycephala olivacea	Olive Whistler	Rainforests and wet sclerophyll forests	0	V	-	L	L	L	L	L	L	L	L	L	L	L
Pandion haliaetus	Eastern Osprey	Estuarine, Rivers and lakes	699	V	Mi	C	M	C	C	C	M	M	M	C	C	C
Pezoporus wallicus wallicus	Ground Parrot (eastern subsp.)	Heathland and Sedgeland	57	V	-	U	U	U	U	U	U	U	M	M	M	U
Podargus ocellatus	Marbled Frogmouth	Rainforests and wet sclerophyll forests	2	V	-	L	L	L	L	L	L	L	L	L	L	L
Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subsp.)	Woodlands and open forests	166	V	-	C	C	C	M	L	C	C	C	C	C	C
Ptilinopus magnificus	Wompoo Fruit-dove	Rainforests and wet sclerophyll forests	155	V	-	H	H	L	L	L	M	M	M	H	H	M
Ptilinopus regina	Rose-crowned Fruit Dove	Rainforests and wet sclerophyll forests	124	V	-	M	M	M	M	M	M	M	M	H	C	H
Ptilinopus superbus	Superb Fruit-dove	Rainforests and wet sclerophyll forests	10	V	-	M	M	M	M	M	M	M	M	H	H	H
Pyrrholaemus sagittatus	Speckled Warbler	Woodlands and open forests	0	V	-	L	L	L	L	L	L	L	L	L	L	L
Rhipidura rufifrons	Rufous Fantail	Wet forests, open forests and woodlands	571	-	Mi	H	H	H	H	H	C	H	H	H	H	H
Rostratula australis	Australian Painted Snipe	Shallow wetlands, swamps, lakes and claypans	1	E	V, Mi	M	M	H	M	M	M	M	M	M	M	M
Stagonopleura guttata	Diamond Firetail	Open forest, grasslands and riparian areas.	10	V	-	L	L	L	L	L	L	L	L	L	L	L
Sterna albifrons	Little Tern	Oceanic, marine and estuarine	562	E1	Mi	U	U	U	U	U	U	U	U	U	U	U
Sterna fuscata	Sooty Tern	Oceanic, marine and estuarine	8	V	-	U	U	U	U	U	U	U	U	U	U	U
Stictonetta naevosa	Freckled Duck	Open wetlands & adjoining agricultural areas	3	V	-	L	L	M	L	M	L	L	L	L	L	L

Scientific name	Common name	Broad habitat requirements	Records in 10 km of project	Status		Project section										
				TSC / FM Act	EPBC Act	1	2	3	4	5	6	7	8	9	10	11
Thalassarche melanophris	Black-browed Albatross	Oceanic and marine	2	V	V, Mi	U	U	U	U	U	U	U	U	U	U	U
Todiramphus chloris	Collared Kingfisher	Woodlands, open forests and mangroves	3	V	-	L	L	L	L	L	L	L	L	L	L	L
Turnix melanogaster	Black-breasted Button-quail	Rainforests and wet sclerophyll forests	0	CE	V	U	U	U	U	U	U	U	U	U	U	U
Tyto longimembris	Grass Owl	Open wetlands and grasslands	78	V	-	M	M	H	H	M	M	M	M	H	C	H
Tyto novaehollandiae	Masked Owl	Woodlands and open forests	67	V	-	H	H	H	H	H	C	H	H	H	H	H
Tyto tenebricosa	Sooty Owl	Rainforests and wet sclerophyll forests	4	V	-	C	M	L	L	L	L	L	L	L	L	L
Xanthomyza phrygia	Regent Honeyeater	Woodlands and open forests	5	E1	E, Mi	M	M	M	M	M	M	M	M	M	M	M
Xenus cinereus	Terek Sandpiper	Oceanic, marine and estuarine	111	V	Mi	U	U	U	U	U	U	U	U	U	U	U
Invertebrates																
Thersites mitchellae	Mitchells Rainforest Snail	Subtropical rainforests and swamp forests	0	E1	CE	U	U	U	U	U	U	U	L	L	L	L
Argyreus hyperbius subsp. *inconstans*	Laced Fritillary	Coastal lowland areas and is closely associated with its host plant *Viola betonicifolia*	0	-	E	U	U	U	U	U	U	U	U	U	U	U
Phyllodes imperialis southern subsp.	Pink Underwing Moth	Undisturbed subtropical rainforest and occurs in association with host vine *Carronia multisepalea*	1	E	E	U	U	U	U	U	U	U	U	M	C	M
Nurus atlas	Atlas Rainforest Ground Beetle	Moist rainforest	1	E	-	U	U	U	U	U	U	U	U	M	C	M
Nurus brevis	Shorter Rainforest Ground Beetle	Dry rainforest	0	E	-	U	U	U	U	U	U	U	U	L	L	L
Petalura litorea	Coastal Petaltail	Wallum heathlands, swamps and wetlands and bogs	1	E	-	U	U	M	M	M	U	M	M	M	M	U

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Flying mammals																
Chalinolobus dwyeri	Large-eared Pied Bat	Woodlands, dry open forests and caves	1	V	V	M	M	M	M	M	M	M	L	L	L	L
Chalinolobus nigrogriseus	Hoary Wattled Bat	Woodlands, open forests, vine thickets & grasslands	66	V	-	H	H	H	C	C	H	C	H	M	M	M
Falsistrellus tasmaniensis	Eastern False Pipistrelle	Woodlands and moist open forests	8	V	-	H	C	H	H	H	H	H	H	H	H	H
Kerivoula papuensis	Golden-tipped Bat	Rainforests and wet, dry sclerophyll forests	15	V	-	M	M	M	M	M	M	M	M	M	C	M
Miniopterus australis	Little Bent-wing Bat	Rainforest, wet and dry sclerophyll forest, swamps and coastal scrublands and caves	221	V	-	C	C	C	C	H	H	H	C	C	H	H
Miniopterus schreibersii oceanensis	Eastern Bent-wing Bat	Caves and forests	20	V	-	H	C	H	H	H	H	H	H	H	H	H
Mormopterus beccarii	Beccari's Freetail-Bat	Open forests, woodlands and grasslands	4	V	-	M	M	M	C	M	M	M	M	M	C	M
Mormopterus norfolkensis	Eastern Freetail-Bat	Woodland, wet and dry sclerophyll forests	15	V	-	H	H	H	C	H	H	H	H	H	C	H
Myotis macropus	Southern Myotis	Woodlands, open forests near water	29	V		C	C	H	H	H	C	C	C	C	C	C
Nyctophilus bifax	Eastern Long-Eared Bat	Coastal heath, woodlands, rainforests and wet sclerophyll forests	48	V	-	H	H	H	H	H	H	H	C	C	C	H
Pteropus poliocephalus	Grey-headed Flying-fox	Diversity of natural and modified habitats	396	V	V	C	C	H	C	C	C	H	C	C	C	C
Saccolaimus flaviventris	Yellow-bellied Sheathtail-bat	Woodlands, open forests, shrubland, mallee and desert	12	V	-	H	H	H	H	H	H	H	H	C	C	C
Scoteanax rueppellii	Greater Broad-nosed Bat	Rainforests, wet and dry eucalyptus forests	35	V	-	H	H	H	H	H	H	H	H	C	C	C
Syconycteris australis	Common Blossom-bat	Rainforests and wet sclerophyll forests	29	V	-	U	U	U	U	U	U	U	H	H	C	H

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Vespadelus troughtoni	Eastern Cave Bat	Woodlands, open forests	3	V		M	M	M	M	M	C	C	C	C	C	C
Non-flying mammals																
Aepyprymnus rufescens	Rufous Bettong	Tall moist eucalyptus forests and woodlands	208	V	-	H	C	C	H	M	H	H	H	L	L	L
Cercartetus nanus	Eastern Pygmy-possum	Rainforest, sclerophyll forests, woodlands and heaths	1	V	-	M	M	M	M	M	M	M	M	M	M	M
Dasyurus maculatus maculatus (SE population)	Spotted-tailed Quoll	Rainforests, open woodlands, coastal heathlands and inland riparian forests	64	V	E1	H	H	H	H	L	M	H	H	H	M	M
Macropus parma	Parma Wallaby	Rainforests and wet sclerophyll forests	0	V		L	L	L	L	L	L	L	L	L	L	L
Petaurus australis	Yellow-bellied Glider	Woodlands, open forests	288	V	-	C	C	C	H	H	C	C	M	M	M	M
Petaurus norfolcensis	Squirrel Glider	Dry open forests and woodlands	144	V	-	C	C	C	M	C	H	H	C	C	C	H
Petrogale penicillata	Brush-tailed Rock Wallaby	Open forest on sandstone ridges	0	E1	V	U	U	U	U	U	U	U	U	U	U	U
Phascogale tapoatafa	Brush-tailed Phascogale	Dry open sclerophyll forests	117	V	-	H	H	C	H	H	H	C	H	H	H	H
Phascolarctos cinereus	Koala	Woodlands, open forests	567	V	-	H	H	C	H	H	H	H	H	C	C	H
Planigale maculata	Common Planigale	Rainforest, eucalyptus forest, heathland, marshland, grassland	35	V	-	C	H	H	L	L	H	H	H	H	C	M
Potorous tridactylus tridactylus	Long-Nosed Potoroo	Coastal heath, dry and wet sclerophyll forests	9	V	V	M	M	M	L	L	M	M	H	H	C	H
Pseudomys gracilicaudatus	Eastern Chestnut Mouse	Wet heathlands and swamps	1	V	-	L	L	L	L	L	L	L	L	L	L	L
Pseudomys novaehollandiae	New Holland Mouse	Open heathland, open woodland with heathy understorey and vegetated sand dunes.	0	-	V	L	L	L	L	L	L	L	L	L	L	L

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Pseudomys oralis	Hastings River Mouse	Woodlands and open forests	1	E1	E1	L	L	L	L	L	L	L	L	L	L	L
Thylogale stigmatica	Red-legged Pademelon	Rainforests and wet sclerophyll forests	7	V		L	L	L	L	L	L	L	L	L	L	L
Amphibians																
Assa darlingtoni	Pouched Frog	Cool rainforests and wet eucalyptus forests	1	V		L	L	L	L	L	L	L	L	L	L	L
Crinia tinnula	Wallum Froglet	Paperbark and sedge swamps	99	V	-	C	C	C	H	M	C	C	H	C	C	H
Litoria aurea	Green and Golden Bell Frog	Open water bodies, marshes and streams	32	E1	V	L	L	L	L	L	L	L	L	L	L	L
Litoria booroolongensis	Boorolong Frog	Streams and cobblebanks	0	E1	E1	L	L	L	L	L	L	L	L	L	L	L
Litoria brevipalmata	Green-thighed Frog	Rainforest, wet & dry sclerophyll forest & heaths	6	V		C	C	H	H	M	M	H	H	M	M	L
Litoria olongburensis	Olongburra Frog	Paperbark and sedge swamps and heaths	31	V	V	M	M	H	H	M	M	H	H	C	H	H
Litoria subglandulosa	Glandular Frog	Rainforests streams, wet & dry eucalyptus forests and subalpine swamps	0	V		U	U	U	U	U	U	U	U	U	U	U
Mixophyes balbus	Stuttering Frog	Rainforests and wet tall open forests	0	E1	V	U	U	U	U	U	U	U	U	U	U	U
Mixophyes fleayi	Fleay's Barred Frog	Rainforest and wet eucalyptus forests	0	E1	E1	U	U	U	U	U	U	U	U	U	U	U
Mixophyes iteratus	Giant Barred Frog	Rainforest and wet & dry eucalyptus forests	48	E1	E1	C	H	H	M	L	H	C	H	M	M	L
Philoria sphagnicola	Sphagnum Frog	Rainforest and wet eucalyptus forests	0	V		U	U	U	U	U	U	U	U	U	U	U
Reptiles																
Cacophis harriettae	White-crowned Snake	Dry eucalyptus forests and woodlands	3	V		L	L	L	L	L	L	L	L	L	L	L
Coeranoscincus reticulatus	Three-toed Snake-tooth Skink	Rainforest and wet eucalyptus forest	1	V	V	L	L	L	L	L	L	L	L	L	L	L

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Emydura macquarii (Bellinger River)	Bellinger River Emydura	Long, deep pools of upper Bellinger River	0	V	V	L	L	L	L	L	L	L	L	L	L	L
Hoplocephalus bitorquatus	Pale-headed Snake	Wet and dry eucalyptus forests and woodlands	0	V	-	M	M	M	L	U	M	M	M	U	U	U
Hoplocephalus stephensii	Stephens' banded snake	Rainforests and eucalyptus forests and rocky areas	8	V	-	M	M	C	L	U	M	M	M	U	U	U
Fish																
Nannoperca oxleyana	Oxleyan Pygmy Perch	Slow moving still waters, low pH	48	E	E	H	H	M	L	L	H	C	C	C	H	L
Mogurnda adspersa	Purple-spotted Gudgeon	Slow moving still waters rivers and creeks	2	E		H	H	L	L	L	M	H	H	H	H	M
Maccullochella ikei	Eastern Freshwater Cod	Estuaries, rivers	10	E	E	U	U	M	M	M	U	U	U	U	M	U
Epinephelus daemelii	Black Cod	Reefs and bommies	0	V		U	U	U	L	U	U	U	L	U	L	U
Pristis zijsron	Green Sawfish	Inshore areas with soft muddy bottoms	0	Ex	V	U	U	U	L	L	U	U	U	U	U	U
Trees																
Acronychia littoralis	Scented Acronychia	Littoral rainforest on sand	39	E1	E1	L	L	L	L	L	L	L	C	M	C	M
Angophora robur	Sandstone Rough Barked Apple	Dry open forest on sandstone or granite	48	V	V	L	L	C	C	L	L	L	L	L	L	L
Archidendron hendersonii	White Lace Flower	Subtropical and littoral rainforest	20	V	-	L	L	L	L	L	L	L	H	H	C	C
Baloghia marmorata	Marbled Baloghia	Subtropical rainforest on basaltic soil	33	V	V	L	L	L	L	L	L	L	L	L	L	L
Cassia brewsteri var. marksiana	Mark's Cassia	Grows in littoral and riverine rainforest	1	E1	-	L	L	L	L	L	L	L	L	L	L	L
Corynocarpus rupestris subsp. rupestris	Glenugie Karaka	Dry rainforest on basalt slopes	17	V	V	U	U	U	U	U	U	U	U	U	U	U
Cryptocarya foetida	Stinking Cryptocarya	Subtropical and littoral rainforest	47	V	V	L	L	L	L	L	L	L	H	H	C	H
Davidsonia jerseyana	Davidson's Plum	Subtropical rainforest in coastal areas	1	E1	E1	L	L	L	L	L	L	L	L	L	L	L

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Davidsonia johnsonii	Smooth Davidson's Plum	Subtropical rainforest in coastal areas	3	E1	E1	L	L	L	L	L	L	L	L	L	L	L
Diploglottis campbellii	Small-leaved Tamarind	Subtropical rainforest in coastal areas	10	E1	E1	L	L	L	L	L	L	L	L	L	L	L
Endiandra hayesii	Rusty Rose Walnut	Subtropical rainforest on alluvium or basaltic soils	10	V	V	L	L	L	L	L	L	L	H	H	C	H
Endiandra muelleri subsp. bracteata	Green-leaved Rose Walnut	Subtropical rainforest on alluvium or basaltic soils	6	E	-	L	L	L	L	L	L	L	H	H	C	H
Eucalyptus glaucina	Slaty Red Gum	Grassy woodland and dry eucalyptus forests	4	V	V	L	L	L	L	L	L	L	L	L	L	L
Eucalyptus tetrapleura	Square fruited Ironbark	Dry or wet eucalyptus forests	240	V	V	L	C	L	L	L	L	L	L	L	L	L
Floydia praealta	Ball Nut	Subtropical rainforest on alluvium or basaltic soils	13	V	V	L	L	L	L	L	L	L	L	L	L	L
Geijera paniculata	Axe Breaker	Dry subtropical rainforest	8	E1	-	L	L	L	L	L	L	L	L	L	L	L
Gossia fragrantissima	Sweet Myrtle	Dry subtropical rainforest	13	E1	E1	L	L	L	L	L	L	L	L	L	L	L
Grevillea hilliana	White Silky Oak	Subtropical rainforest, often on basic igneous substrates	1	E1	-	L	L	L	L	L	L	L	L	L	L	L
Hicksbeachia pinnatifolia	Red Bopple Nut	Subtropical rainforest	1	V	V	L	L	L	L	L	L	L	L	L	L	L
Macadamia tetraphylla	Rough-shelled Bush Nut	Subtropical rainforest	102	V	V	L	L	L	L	L	L	M	H	H	C	C
Niemeyera whitei	Rusty Plum	Rainforest and moist eucalyptus forest	118	V	-	L	L	L	L	L	L	L	L	L	L	L
Owenia cepiodora	Onionwood	Wet sclerophyll or subtropical rainforest	5	V	V	L	L	L	L	L	L	L	L	L	L	L
Syzygium hodgkinsoniae	Red Lily Pilly	Subtropical rainforest	26	V	V	L	L	L	L	L	L	L	H	H	C	H
Syzygium moorei	Durobby	Subtropical rainforest	5	V	V	L	L	L	L	L	L	L	L	L	L	L
Syzygium paniculatum	Magenta Lily Pilly	Littoral rainforest on sand	1	E	V	L	L	L	L	L	L	L	L	L	L	L

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Shrubs																
Acalypha eremorum		Subtropical and dry rainforest	1	E1	-	U	U	U	U	U	U	U	L	L	L	L
Allocasuarina defungens	Dwarf Heath Casuarina	Tall heath on coastal hills or headlands and sandplains	5	E1	E1	L	L	L	L	L	L	L	L	L	L	L
Allocasuarina simulans	Nabiac Casuarina	Heathlands on coastal sand	0	V	V	L	L	L	L	L	L	L	L	L	L	L
Boronia hapalophylla	Shannon Creek Boronia	Dry woodland on sandstone hill slopes	1	E1	-	L	L	L	L	L	L	L	L	L	L	L
Boronia umbellata	Orara boronia	Wet open forest	18	V	V	L	L	L	L	L	L	L	L	L	L	L
Caesalpinia bonduc	Nicker Bean	Grows near waterways	2	E1	-	L	L	L	L	L	L	L	L	L	L	L
Callistemon linearifolius	Netted Bottle Brush	Coastal dry sclerophyll forest	2	V	-	L	L	L	L	L	L	L	L	L	L	L
Desmodium acanthocladum	Thorny pea	Dry rainforest	4	V	V	L	L	L	L	L	L	L	C	L	L	L
Fontainea oraria	Coastal Fontainea	Littoral rainforest on basalt	1	E1	E1	L	L	L	L	L	L	L	L	L	L	L
Grevillea masonii	Mason's Grevillea	Open eucalyptus woodland	0	E1	E1	L	L	L	L	L	L	L	L	L	L	L
Grevillea quadricauda	Four-tailed Grevillea	Dry eucalyptus forest	7	V	V	L	L	C	L	L	L	L	L	L	L	L
Hibbertia marginata	Bordered Guinea Flower	Grassy or dry eucalyptus forest	28	V	V	L	L	L	L	L	L	L	L	L	L	L
Leucopogon confertus	Torrington Beard-heath	Open forest and woodland on granite	3	E1	E1	L	L	L	L	L	L	L	L	L	L	L
Melaleuca irbyana	Weeping Paperbark	Open eucalyptus forest on clay	39	E1		M	M	C	M	L	M	C	M	L	L	L
Melichrus hirsutus	Hairy Melichrus	Dry eucalyptus forest on sand	24	E1	E1	L	L	L	L	L	L	L	L	L	L	L
Melicope vitiflora	Northern Euodia	Subtropical and littoral rainforest	2	E1	-	L	L	L	L	L	L	L	L	L	L	L
Myrsine richmondensis	Ripple-leaf Muttonwood	Subtropical rainforests	4	E1	E1	L	L	L	L	L	L	L	L	L	L	L

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Ochrosia moorei	Southern Ochrosia	Subtropical rainforests	20	E1	E1	L	L	L	L	L	L	L	L	L	L	L
Olax angulata	Square-stemmed Olax	Coastal heath and woodland on sand	0	V	-	H	C	H	L	L	L	L	L	L	L	L
Pultenaea maritima	Coastal Bush-pea	Mainly in grasslands along the coast.	9	V	-	U	U	U	U	U	U	U	U	U	U	U
Quassia sp. 'Moonee Creek'	Moonee Quassia	Tall moist and dry eucalyptus forests	70	E1	E1	H	H	C	L	L	L	L	L	H	H	H
Senna acclinis	Rainforest Cassia	Subtropical and dry rainforest	5	E1	-	I	L	L	L	L	L	L	L	L	L	L
Sophora fraseri		Rainforest margins in eucalypt forests	2	V	V	L	L	L	L	L	L	L	L	L	L	L
Sophora tomentosa	Silver Bush	Grows on sea shores	1	E1	-	U	U	U	U	U	U	U	U	U	U	U
Xylosma terrae-reginae		Littoral rainforest	1	E1	-	L	L	L	L	L	L	L	L	L	L	L
Zieria prostrata	Headland Zieria	Grassy heath and shrublands	2	E1	E1	L	L	L	L	L	L	L	L	L	L	L
Herbs																
Blumea lacera		Grows in wasteland and along roadsides	2	X		L	L	L	L	L	L	L	L	L	L	L
Centranthera cochinchinensis	Swamp Foxglove	Moist sites usually open grasslands	3	E1	-	M	H	H	M	L	M	H	H	M	L	L
Chamaesyce psammogeton		Sand dunes near the sea	2	E1	-	U	U	U	U	U	U	U	U	U	U	U
Isoglossa eranthemoides	Isoglossa	Subtropical rainforests	1	E1	E1	L	L	L	L	L	L	L	L	H	C	H
Polygala linariifolia		Dry sclerophyll communities	2	E1	-	L	L	L	L	L	L	L	L	L	L	L
Prostanthera cineolifera	Singleton Mint Bush	Open woodlands on sandstone	0	V	V	M	M	M	M	M	M	C	M	M	M	M
Prostanthera palustris	Swamp Mint Bush	Wet heathland to shrubland	8	V	V	L	L	L	L	L	L	C	L	L	L	L
Rutidosis heterogama	Heath Wrinklewort	Heath and open forest	7	V	V	L	L	L	L	L	L	L	L	L	L	L
Thesium australe	Austral Toadflax	Grassland or grassy woodland	9	V	V	L	L	L	L	L	L	L	L	L	L	L

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Typhonium sp. aff. brownii		Flooded Gum *Eucalyptus grandis* forest	1	E1	-	L	L	L	L	L	L	L	L	L	L	L
Orchids																
Cryptostylis hunteriana	Leafless Tongue Orchid	Swamps, heath and woodland	1	V	V	L	L	L	L	L	L	L	L	L	L	L
Dendrobium melaleucaphilum	Spider Orchid	Epiphytic on *Melaleuca styphelioides*	3	E1	-	M	M	M	M	M	M	M	M	M	M	M
Diuris sp. aff. chrysantha	Byron Bay Diuris	Low-growing grassy heath on clay soil	1	E	-	L	L	L	L	L	L	L	L	L	L	L
Oberonia complanata	Yellow flowered King of the Faires	Rainforest, and also sclerophyll forest, coastal scrub and mangroves	1	V	V	L	L	L	L	L	L	L	L	L	L	L
Oberonia titania	Red flowered King of the Faires	Littoral and subtropical rainforests and paperbark swamps	12	V	-	M	M	M	M	M	M	C	M	M	C	M
Peristeranthus hillii		Grows on trees and woody climbers in rainforest	7	V	-	L	L	L	L	L	L	L	M	M	M	M
Phaius australis	Southern Swamp Orchid	Swamp grassland or forest	12	E1	E1	L	L	L	L	L	L	L	L	L	L	L
Grasses																
Ancistrachne maidenii	-	Dry sclerophyll forest on sandstone	0	V	-	L	L	L	L	L	L	L	L	L	L	L
Arthraxon hispidus	Hairy Joint-grass	Rainforest margins and moist open grasslands	5709	V	V	L	L	L	L	L	L	L	H	H	C	H
Bothriochloa biloba	Lobed Blue Grass	Grassland on clay	0	-	V	L	L	L	L	L	L	L	L	L	L	L
Elyonurus citreus	Lemon scented Grass	Coastal sand dunes	0	E1	-	L	L	L	L	L	L	L	L	L	L	L
Paspalidium grandispiculatum		Sclerophyll forest	9	V	V	L	L	L	L	L	L	L	L	L	L	L
Aquatic																
Aldrovanda vesiculosa	Waterwheel Plant	Shallow fresh water	2	E1	-	L	L	L	L	L	L	L	L	L	L	L
Cyperus aquatilis	Water Nutgrass	Open ephemerally wet situations	5	E1	-	L	L	L	L	L	C	C	L	L	L	L

Scientific name	Common name	Broad habitat requirements	Records in 10 km of project	Status		Project section										
				TSC / FM Act	EPBC Act	1	2	3	4	5	6	7	8	9	10	11
Maundia triglochinoides	-	Swamps and creeks on clay	4	V	-	H	C	C	M	M	M	C	M	M	M	M
Persicaria elatior	Tall Knotweed	Streams, lakes and swamp forest	3	V	-	L	L	L	L	L	L	L	L	L	L	L
Ferns																
Belvisia mucronata		Epiphytic on all kinds of trees or on rocks	7	E1	-	L	L	L	L	L	L	L	L	L	L	L
Drynaria rigidula	Basket Fern	Moist eucalyptus and Swamp Oak forests	2	E1	-	L	L	L	L	L	L	L	L	L	L	L
Grammitis stenophylla	Narrow-leaf Finger Fern	Rainforest and wet eucalyptus forests	4	E1	-	L	L	L	L	L	L	L	L	L	L	L
Hypolepis elegans		Open places on forest margins	1	X	-	L	L	L	L	L	L	L	L	L	L	L
Lindsaea brachypoda		Banks and rocks in subtropical rainforest	1	E1	-	L	L	L	L	L	L	L	L	L	L	L
Lindsaea fraseri	Fraser’s Screw Fern	Swamp and open eucalyptus forest	0	E1	-	L	L	L	L	L	L	L	L	L	L	L
Lindsaea incisa	*Slender Screw Fern*	Wet and dry eucalyptus forests on sandstone	13	E1	-	M	C	C	L	L	C	M	M	M	M	M
Psilotum complanatum	Flat Fork Fern	Epiphyte in rainforest	2	E1	-	L	L	L	L	L	L	L	L	L	L	L
Climbers																
Marsdenia longiloba	Slender Marsdenia	Subtropical rainforests and wet eucalyptus forest with rocky outcrops	14	E1	V	M	M	M	M	M	M	M	M	M	C	M
Parsonsia dorrigoensis	Milky Silkpod	Subtropical rainforests and wet eucalyptus forest	3	V	E1	L	L	L	L	L	L	L	L	L	L	L
Tinospora tinosporoides	Arrow Head Vine	Rainforest on basalt	51	V	V	L	L	L	L	L	L	L	L	L	C	L
Tylophora woollsii		Wet sclerophyll forest and rainforest	0	E	E	L	L	L	L	L	L	L	L	L	L	L

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Appendix E Significance assessments

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Significance assessments

Significance assessments have been conducted for species, populations and communities that were identified as having a moderate or high potential to occur in the study area, or were confirmed as present from the route studies. These 'subject species' are listed in Table E-1 to Table E-3.

Significance assessments have been divided into:

- State listed species (under the *Threatened Species Conservation Act 1995* or the *Fisheries Management Act 1994*) (refer to Appendix E.1)
- Commonwealth listed species (under the *Environmental Protection and Biodiversity Assessment Act 1999*) (refer to Appendix E.2).

For threatened biodiversity listed under the *Threatened Species Conservation Act* 1995, the assessment considered the heads of consideration for Threatened species assessment as suggested in the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The guidelines present methods to consider the impacts on biodiversity of projects, including presenting heads of consideration for determining the significance of impacts.

For threatened biodiversity listed under the *Environment Protection and Biodiversity Conservation Act* 1999 significance assessment have been completed in accordance with the *Matters of National Environmental Significance Significant Impact Guidelines 1.1* (Department of the Environment, Water, Heritage and the Arts 2009).

Species with similar taxonomy or ecological requirements have been assessed together, for example tree-roosting microchiropteran bats.

Table E-1 Threatened fauna

Species	Common name	Records in 10 km of project	TSC Act	EPBC Act	project section
Wetland birds					
Anseranas semipalmata	Magpie Goose	20	V	-	2-6, 8-11
Botaurus poiciloptilus	Australasian bittern	8	E1	E	1-4, 7-11
Ephippiorhynchus asiaticus	Black-necked stork	1383	E1	-	1-11
Grus rubicundus	Brolga	189	V	-	1-11
Irediparra gallinacea	Comb-Crested Jacana	48	V	-	3-9
Ixobrychus flavicollis	Black Bittern	15	V	-	1-3, 6-7, 9
Amaurornis molucanna	Pale-vented Bush Hen	18	V	-	9-10
Stictonetta naevosa	Freckled Duck	3	V	-	3-5
Rostratula australis	Australian Painted Snipe	11	V	V	1-11
Large forest owls					
Ninox strenua	Powerful Owl	117	V	-	1-11
Ninox connivens	Barking Owl	49	V	-	1-11
Tyto novaehollandiae	Masked Owl	67	V	-	1-11
Tyto tenebricosa	Sooty Owl	4	V	-	1-2
Frugivorous rainforest birds					
Cyclopsitta diophthalma coxeni	Double-Eyed Fig-Parrot	0	CE	E1	9-11
Ptilinopus magnificus	Wompoo fruit-Dove	155	V	-	1-2, 6-11
Ptilinopus regina	Rose-crowned Fruit Dove	124	V	-	1-2, 8-11
Ptilinopus superbus	Superb fruit-Dove	10	V	-	1-2, 8-11
Coracina lineata	Barred cuckoo-shrike	21	V	-	1-2, 6-11

Species	Common name	Records in 10 km of project	TSC Act	EPBC Act	project section
Cave-roosting microbats					
Chalinolobus dwyeri	Large-eared Pied Bat	1	V	V	1-7
Miniopterus australis	Little Bent-wing Bat	221	V	-	1-11
Miniopterus schreibersii oceanensis	Eastern Bent-wing Bat	20	V	-	1-11
Myotis macropus	Southern Myotis	29	V	-	1-11
Vespadelus troughtoni	Eastern Cave Bat	3	V	-	1-11
Tree-roosting microbats					
Chalinolobus nigrogriseus	Hoary Wattled Bat	66	V	-	1-11
Falsistrellus tasmaniensis	Eastern False Pipistrelle	8	V	-	1-11
Kerivoula papuensis	Golden-tipped Bat	15	V	-	1-11
Mormopterus beccarii	Beccari's Freetail-Bat	4	V	-	1-11
Mormopterus norfolkensis	Eastern Freetail-Bat	15	V	-	1-11
Nyctophilus bifax	Eastern Long-Eared Bat	48	V	-	1-11
Saccolaimus flaviventris	Yellow-bellied Sheathtail-Bat	12	V	-	1-11
Scoteanax rueppellii	Greater Broad-nosed Bat	35	V	-	1-11
Gliders					
Petaurus australis	Yellow-bellied Glider	288	V	-	1-9
Petaurus norfolcensis	Squirrel Glider	144	V	-	1-11
Arboreal snakes					
Hoplocephalus bitorquatus	Pale-headed Snake	0	V	-	1-3, 6-8
Hoplocephalus stephensii	Stephens' banded snake	8	V	-	1-3, 6-8
Diurnal raptors					
Hieraaetus morphnoides	Little Eagle	36	V	-	1-11
Erythrotriorchis radiatus	Red Goshawk	15	CE	V	1-11
Lophoictinia isura	Square-tailed Kite	36	V	-	1-11
Other fauna species					
Calyptorhynchus lathami	Glossy black-cockatoo	314	V	-	1-7
Dromaius novaehollandiae	Coastal Emu	511	E2	-	3-5
Glossopsitta pusilla	Little Lorikeet	104	V	-	1-11
Lathamus discolor	Swift Parrot	17	E	E, M1	1-11
Lichenostomus fasciogulari	Mangrove Honeyeater	62	V		4-5, 8-10
Pandion haliaetus	Eastern Osprey	699	V	Mi	1-11
Pezoporus wallicus wallicus	Ground Parrot (eastern subsp.)	57	V	-	8-10
Tyto capensis	Eastern Grass Owl	78	V	-	1-11
Xanthomyza phrygia	Regent Honeyeater	5	E1	E, Mi	1-11
Petalura litorea	Coastal Petaltail	1	E		7-10
Pteropus poliocephalus	Grey-headed Flying-Fox	396	V	V	1-11
Syconycteris australis	Common Blossom-Bat	29	V	-	8-11
Aepyprymnus rufescens	Rufous Bettong	208	V	-	1-8
Cercartetus nanus	Eastern Pygmy-Possum	1	V	-	1-11
Dasyurus maculatus maculatus (SE population)	Spotted-tailed Quoll	64	V	E1	1-11
Phascogale tapoatafa	Brush-tailed Phascogale	117	V	-	1-9
Phascolarctos cinereus	Koala	567	V	V	1-11
Planigale maculata	Common Planigale	35	V	-	1-11
Potorous tridactylus tridactylus	Long-nosed Potoroo	9	V	V	1-3, 6-11
Crinia tinnula	Wallum Froglet	99	V	-	1-11
Litoria brevipalmata	Green-thighed Frog	6	V		1-10
Litoria olongburensis	Olongburra Frog	31	V	V	1-11
Mixophyes iteratus	Giant Barred Frog	48	E1	E1	1-4, 6-10

Species	Common name	Records in 10 km of project	TSC Act	EPBC Act	project section
Climacteris picumnus	Brown Treecreeper	48	V	-	1-7
Melithreptus gularis gularis	Black-chinned Honeyeater (eastern subsp.)	53	V	-	1-3, 6-7
Burhinus grallarius	Bush stone-curlew	36	E1	-	1-3
Pomatostomus temporalis temporalis	Grey-crowned Babbler (eastern subsp.)	166	V	-	1-4, 6-10
Phyllodes imperialis southern subsp.	Pink Underwing Moth	1	E	E	9-11
Nurus atlas	Atlas Rainforest Ground Beetle	1	E		9-11

Table E-2 Threatened Flora

Species	Common name	Records in 10 km of project	TSC Act	EPBC Act	Project section
Acronychia littoralis	Scented Acronychia	39	V	E	9-11
Angophora robur	Sandstone Rough Barked Apple	48	V	V	3-4
Archidendron hendersonii	White Lace Flower	20	V	-	8-11
Arthraxon hispidus	Hairy Joint-grass	5709	V	V	8-11
Centranthera cochinchinensis	Swamp Foxglove	3	E	-	1-11
Cryptocarya foetida	Stinking Cryptocarya	47	V	V	8-11
Cyperus aquatilis	Water Nutgrass	5	E	-	6-7
Dendrobium melaleucaphilum	Spider Orchid	3	E	-	1-11
Desmodium acanthocladum	Thorny Pea	4	V	V	8
Endiandra hayesii	Rusty Rose Walnut	10	V	V	8-11
Endiandra muelleri subsp. bracteata	Green-leaved Rose Walnut	6	E	-	8-11
Eucalyptus tetrapleura	Square fruited Ironbark	240	V	V	2
Grevillea quadricauda	Four-tailed Grevillea	7	V	V	3
Isoglossa eranthemoides	Isoglossa	1	E	E	9-11
Lindsaea incisa	Slender Screw Fern	13	E	-	1-3, 6-11
Macadamia tetraphylla	Rough-shelled Bush Nut	102	V	V	7-11
Marsdenia longiloba	Slender Marsdenia	14	E	V	1-11
Maundia triglochinoides	-	4	V	-	1-11
Melaleuca irbyana	Weeping Paperbark	39	E	-	1-4, 6-8
Olax angulata	Square-stemmed Olax	0	V	-	1-3
Oberonia titania	Red flowered King of the Faires	12	V	-	1-11
Peristeranthus hillii		7	V	-	9-11
Prostanthera cineolifera	Singleton Mint Bush	0	V	V	7
Prostanthera palustris	*Swamp Mint Bush*	8	V	V	7
Quassia sp. 'Moonee Creek'	Moonie Quassia	70	E	E	1-3, 9-11
Syzygium hodgkinsoniae	Red Lily Pilly	26	V	V	8-11
Tinospora tinosporoides	Arrow Head Vine	51	V	V	10

Table E-3 Threatened fish species

Scientific Name	Common Name	No. of records within 10 km of project	FM Act	EPBC Act	Section
Nannoperca oxleyana	Oxleyan Pygmy Perch	48	E	E	1-2, 6-11
Mogurnda adspersa	Purple-spotted Gudgeon	2	E		1-2, 6-11
Maccullochella ikei	Eastern Freshwater Cod	10	E	E	3-5

Table E-4 Threatened Ecological Communities

Threatened Ecological Communities	Status (TSC Act)	Status (EPBC Act)
Subtropical Coastal Floodplain Forest	Endangered	
Swamp Sclerophyll Forest	Endangered	
Swamp Oak Floodplain Forest	Endangered	
Freshwater Wetlands	Endangered	
Lowland Rainforest	Endangered	Critically Endangered
Coastal Cypress Pine Forest	Endangered	

E.1 *Environmental Planning & Assessment Act, 1979*

Significance assessments for species listed under the *Threatened Species Conservation Act 1995* and the *Fisheries Management Act 1994* have been prepared in accordance with heads of consideration under the *Guidelines for Threatened Species Assessment* (Department of Environment and Conservation and Department of Primary Industries 2005). These are aimed at identifying potential effects of the project on threatened species, populations, or ecological communities. The heads of considerations are identified below.

How is the project likely to affect the lifecycle of a threatened species and/or population?
a) Displaces or disturbs threatened species and /or populations b) Disrupts the breeding cycle c) Disturbs the dormancy period d) Disrupts roosting behaviour e) Changes forages behaviour f) Affects migration and dispersal ability g) Disrupts pollination cycle h) Disturbs seed banks i) Disrupts recruitment (ie germination and establishment of plants) j) Affects the interaction between threatened species and other species in the community (eg pollinators, host species, mycorrhizal associations)
How is the project likely to affect the habitat of a threatened species, population or ecological community?
a) Disturbs any permanent, semi-permanent or ephemeral waterbodies b) Degrades soil quality c) Clears or modifies native vegetation d) Introduces weeds, vermin or feral species or provides conditions for them to increase and/or spread e) Removes or disturbs key habitat features such as trees with hollows, caves and rock crevices, foraging habitat. f) Affects natural revegetation and recolonisation of existing species following disturbance
Does the project affect any threatened species or populations that are at the limit of its known distribution?
How is the project likely to affect current disturbance regimes?
a) Modifies the intensity and frequency of fires b) Modifies flooding regimes
How is the project likely to affect habitat connectivity?
a) Creates barrier to fauna movement b) Removes remnant vegetation or wildlife corridors c) Modifies remnant vegetation or wildlife corridors
How is the project likely to affect critical habitat?
a) Removes or modifies key habitat features b) Affects natural revegetation or recolonisation or existing species following disturbance c) Introduces weeds, vermin or feral species d) Generates or disposes of solid, liquid or gaseous waste e) Uses pesticides, herbicides or other chemicals

Wetland birds

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

As the project traverses a portion of the floodplain of the Clarence and Richmond rivers in addition to the Corindi River north of Woolgoolga, this would result in direct impacts to around three hectares of wetland habitats in addition to crossing numerous tributaries which also provide known and potential habitat for these species.

Potential indirect impacts were identified for eight Nationally Important Wetlands and 15 SEPP 14 listed wetlands outside the project boundary. Most of these wetlands are recharged or fed by the Clarence River and Richmond River catchments.

Historically there has been a dramatic decline in the diversity and abundance of waterbirds and wetland birds on the Clarence River floodplain (Smith 2011). This is a trend which is likely to have also been experienced on the Richmond River floodplain, and a result of the long history of wetland change associated with floodplain mitigation and agriculture. Magpie Goose, Black-necked Stork, Brolga, Freckled Duck and Comb-crested Jacana are typically associated with open water wetland habitats, while Australasian Bittern, Black Bittern, Australian Painted Snipe and Pale vented Bush-hen may also use these habitats there is also a dependence on tall densely vegetated wetlands and potentially creeks above the floodplain. Some of these species have adapted to using modified or degraded wetlands in farmland including artificially constructed environments including Black-necked Stork (Clancy 2011), Brolga, Australian Painted Snipe and Pale-vented Bush-hen

The project may directly and indirectly affect the life-cycle of localised populations by displacing or disturbing individuals or established pairs. This may include nesting, foraging and roosting life-cycle activities within the home range of established pairs. These species are not restricted to the study area and extend across other states and territories.

There are known populations of Black-necked Stork across all project sections (Clancy 2010), with several known nesting locations near project sections 2 to 5. No nest sites have been identified directly within the project boundary. In a study of nesting locations in northern NSW, Clancy (2011) identified 86.2 per cent of nests were located in cleared or modified farmland (beef cattle) and 14 per cent were within 200 metres of a road including highways with the closest nest reported at 50 metres.

Nesting locations for the remaining threatened wetland birds are not published, however there is data suggesting an historical decline in the south-eastern (NSW) distribution of Magpie Goose (Nye *et al* 2007) and assumed reduction in breeding success in the study area. Brolga are commonly recorded but patchily distributed across the study area, in particular the Clarence River wetlands (Smith 2011) and have been observed near the project boundary in Section 1 on the Corindi River floodplain, and Section 2 near Halfway Creek, and Section 3, at Ellis Swamp near Sandy Crossing.

Potential habitat for these wetland bird species' is widespread throughout the study area including dense vegetation on the margins of freshwater creeks, rivers and natural or artificial wetlands. In particular species such as Black-necked Stork and Brolga and Bush-hen which frequent disturbed and modified farmland including forest regrowth, rank grass or reeds, thickets of weeds and farmland (eg sugar cane, grassy or weedy fallow or abandoned fields).

There are fewer records of Black Bittern and Australasian Bittern in the study and more patchily distributed across the region, which may be a result of the secretive behaviour of the species in addition to low density. There is no quantifiable data on direct impacts for the life-cycle of these species.

The distribution of the Bush-hen is largely confined to north of the Richmond river, while the Australian Painted Snipe is widespread with a greater density around the lower Clarence River floodplain.

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

Black-necked Storks, Brolga, Australian Painted Snipe and Bush-hen are mainly found on shallow, permanent, freshwater terrestrial wetlands, and surrounding marginal vegetation, including swamps, floodplains, watercourses and billabongs, freshwater meadows, wet heathland, farm dams and shallow floodwaters, as well as extending into adjacent grasslands, and paddocks. They also forage within or around estuaries and along intertidal shorelines, such as saltmarshes, mudflats and sandflats, and mangrove vegetation. Magpie Geese and Freckled Duck are mainly found in shallow wetlands (less than 1 m deep) with dense growth of rushes or sedges and can occur in aquatic or terrestrial habitats.

Australasian Bittern and Black Bittern favour permanent freshwater wetlands and riparian vegetation with tall, dense vegetation, particularly bulrushes (*Typha* spp.) and spikerushes (*Eleocharis* spp.).

As the project traverses a portion of the floodplain of the Clarence and Richmond rivers in addition to the Corindi River north of Woolgoolga, these habitat types are common and widespread across the major floodplains of the study area. The project would result in direct impacts to around thirteen hectares of wetland habitats in addition to crossing numerous tributaries which have not been quantified, and these also provide known and potential habitat for these subject species. Potential indirect impacts were identified for eight Nationally Important Wetlands and 15 SEPP 14 listed wetlands outside the project boundary. Most of these wetlands are recharged or fed by the Clarence River and Richmond River catchments.

The review of habitat availability and records of these species suggest that potential habitat for these wetland bird species' is widespread throughout the study area and adjacent to the project footprint including dense vegetation on the margins of freshwater creeks, rivers and natural or artificial wetlands. In particular there are widespread opportunities for species such as Black-necked Stork and Brolga, Painted Snipe and Bush-hen which frequent disturbed and modified farmland including forest regrowth, rank grass or reeds, thickets of weeds and farmland (eg sugar cane, grassy or weedy fallow or abandoned fields).

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

In Australia, Black-necked Storks (Satin Stork) are widespread in coastal and subcoastal northern and eastern Australia, south to central-eastern NSW and with vagrants recorded at scattered sites well away from the coast (for example, near Moree, north-east of Hay and in Victoria). In NSW, the species becomes increasingly uncommon south of the Northern Rivers region, and rarely occurs south of Sydney. The species *Ephippiorhynchus asiaticus* comprises two subspecies, *E. a. asiaticus* in India and south-eastern Asia, and *E. a. australis* in Australia and New Guinea. These are eventually likely to be treated as two separate species, with the Australian and New Guinea birds known as the Satin Stork *Ephippiorhynchus australis.*

Australasian Bitterns and Freckled Duck are widespread but uncommon over south-eastern Australia. In NSW they may be found over most of the state except for the far north-west.

The Black Bittern has a wide distribution, from southern NSW north to Cape York and along the north coast to the Kimberley region. The species also occurs in the south-west of Western Australia. In NSW, records of the species are scattered along the east coast, with individuals rarely being recorded south of Sydney or inland.

The Brolga was formerly found across Australia, except for the south-east corner, Tasmania and the south-western third of the country. It is still abundant in the northern tropics, but very sparse across the southern part of its range.

In Australia, the Pale-vented Bush-hen occurs mainly in coastal and subcoastal regions from the Top End of the Northern Territory and Cape York Peninsula south through eastern Queensland to north-eastern NSW. There are a few records in the Kimberley Division of northern Western Australia. In NSW, Bush-hens are an apparently uncommon resident from the Queensland border south to the Clarence River, though the species appears to be expanding its range southwards with recent records as far south as the Nambucca River.

The Australian Painted Snipe is restricted to Australia. Most records are from the south east, particularly the Murray Darling Basin, with scattered records across northern Australia and historical records from around the Perth region in Western Australia. In NSW many records are from the Murray-Darling Basin including the Paroo wetlands, Lake Cowal, Macquarie Marshes, Fivebough Swamp and more recently, swamps near Balldale and Wanganella. Other important locations with recent records include wetlands on the Hawkesbury River and the Clarence and lower Hunter Valleys.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime. Similarly, frog species adapted to the current flooding regime have potential to be negatively impacted by a change in the movements of floodwaters. The development of basins for holding water has potential to favour introduced species such as Plague Minnow (*Gambusia holbrooki*) and Cane Toad (*Bufo marinus*).

The potential increase in fires adjacent to the road or change in disturbance associated with increased pollutants or sediments into waterways may have a short to medium term impact the condition and structure of the habitat. Much of the habitat of these species throughout Yuraygir National Park and adjacent areas is fire adapted and evolved with relatively short intervals between fires associated with natural events and also fuel reduction burning and burning of cane fields and grazing paddocks. Any changes in fire regime associated with the project are not expected to have a significant long term impact on the habitat of these species.

Similarly, the reliance of wetland habitats of the Clarence River floodplain has evolved over a long period in conjunction with historical change in the structure and function of these wetlands associated with anthropogenic disturbances. The potential increase in pollutants or sediments into waterways and wetlands may have a short to medium term impact the condition and structure of the habitat. Measures to mitigate this disturbance have been incorporated into the project.

How is the project likely to affect habitat connectivity?

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of some species and fauna groups more than others for example small ground-dwelling mammals, reptiles and amphibians with smaller home range and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10). These project sections occur within the important range of habitats for wetland birds associated with the Clarence River and Richmond River floodplains.

There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River. These highly mobile species are capable of and adapted to moving between wetland habitats in response to changed and local hydrological regimes and are unlikely to be significantly impacted by the barrier effect of the road.

How is the project 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.

Large forest owls

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

The assessment refers to Powerful Owl, Masked Owl, Sooty Owl and Barking Owl. There are over 1000 records for each of Powerful Owl and Masked Owl in the Northern Rivers CMA region on the NSW Atlas of wildlife, around 600 records of Sooty Owl and less than 200 records of Barking Owl.

Powerful Owl and Masked Owl are widespread throughout the region recorded in a range of habitats including the wet and dry open forests and riparian habitats typical of the study area. The species were reported in Section 3 and 11 and a Sooty Owl was reported in Section 2. There were no confirmed records of Barking Owl from the project boundary however the species is predicted to occur. There is no quantifiable data on the distribution of established breeding pairs or individual home range for these species across the study area and no published data on nest sites.

The project could be expected to impact on a portion of the regional population for all four species and may directly impact on the breeding territory of a number of pairs, in particular the Powerful Owl and Masked Owl which are widespread. The clearing of vegetation, in particular large hollow-bearing trees would result in displacement and disturbance and potential direct impacts on breeding cycles and roosting behaviour.

Whilst Powerful Owl and Barking Owl are known to roost by day in dense thickets of vegetation or foliage, the *Tyto* spp. (Sooty and Masked Owl) are more specialised hollow roosting species. The nesting requirements for all four species are also 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 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 and sooty owl ranging from swamp forest to wet and dry sclerophyll, preferably in wet gullies for roosting and the masked owl and barking owl favouring the more open forest and woodland types for foraging, particularly on the edge of open lands such as agricultural lands.

Prey species for the Powerful Owl and Sooty Owl (typically arboreal mammals) are common and represented by a range of species across a wide distribution including sugar glider, greater glider, squirrel glider, common brushtail and ringtail possum. These species are expected to be common within the low elevation dry and wet sclerophyll habitats in the study area. Similarly common prey species for masked owl (ground-dwelling mammals) and barking owl (birds and mammals) are also common and widespread, and masked owls are known to preferentially hunt over disturbed areas in search of rodents which include introduced species (Kavanagh and Murray 1996).

The widespread distribution of habitat and prey species for these forest owls is reflected in the widespread distribution in the northern rivers region (Kavanagh et al 1995). This factor combined with the typically large home of the forest owls (eg Kavanagh and Murray 1995; Soderquist and Gibbons 2007), suggest that the affect of the project on the hunting activities and prey abundance across the range of the pairs is unlikely to be significant in the context of a reduction in local or regional populations. A temporary change in foraging behaviour could occur for pairs that have a home range that is intersected by the project.

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

In a study of the distribution of nocturnal birds in north-eastern NSW Kavanagh et al (1995) identified a widespread distribution throughout the region for three large forest owls, Powerful Owl, Masked Owl and Sooty Owl, with no strong associations to altitude or longitude. However, these large owls appeared to respond differently to a gradient in forest type from wet to dry and in understorey characteristics from dense to sparse. The Sooty Owl was strongly associated with the wetter forest types, rainforest and wet sclerophyll forest, and those containing a dense understorey.

The Masked Owl appeared to be most associated to dry open forest with a sparse understorey, one that is possibly maintained by fire. The Masked Owl was more likely to be associated with unlogged sites and sites with many old hollow trees. The powerful owl showed little association with any of the environmental gradients considered by these authors as demonstrated by its widespread and relatively even distribution throughout north-eastern NSW. There has been no assessment of Barking Owl in the region.

The distribution of habitat is difficult to predict and the combination of all four species is linked to over 50 different vegetation classes, from wet and dry sclerophyll forests, to grassy woodlands and rainforest over a range of altitudes. The project would remove a total of 443 hectares of dry sclerophyll forest and 329 hectares of wet/moist sclerophyll forest including riparian vegetation. In addition this clearing of habitat is associated with a significant reduction in hollow-bearing trees, a portion of which would be suited to these species for roosting and breeding, and a portion of which would be suited as potential shelter for prey species.

The home range of the Powerful Owl has been estimated at 1000 to 5000 hectares (Soderquist and Gibbons 2007) and the Masked Owl greater than 1000 hectares. It is evident that these species exhibit very large home ranges, although there distribution is dependent on the presence of prey species and suitably large habitat trees. There is no quantifiable data to assess the number of birds or pairs that may be impacted by the loss of habitat associated with the project, however based on distributional data for the species and their prey and the extent of similar habitat types in the region, it is likely that only a minor portion of the regional populations would be directly impacted. Habitats adjoining the project boundary or within proximity may be expected to continue to provide habitat for displaced birds, although this would be dependent on other impacts associated with increased lights and traffic noise.

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

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

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime. Similarly, frog species adapted to the current flooding regime have potential to be negatively impacted by a change in the movements of floodwaters. The development of basins for holding water has potential to favour introduced species such as Plague Minnow (*Gambusia holbrooki*) and Cane Toad (*Bufo marinus*).

The dominant owl prey species include ground-dwelling and arboreal mammals and to a lesser extent birds. The prey species have adapted to the current disturbance regimes, in particular fire regimes and altered nutrient cycling resulting in the current structure of the habitat. The construction and operation of the project has potential to affect these current disturbance regimes as discussed, potentially leading to a change in prey abundance and reduction in breeding success of owls over a short to medium-term.

Disturbance is considered a natural process that occurs at different spatial and temporal scales (eg Pickett and White 1985). The ability of a community or species to adapt to disturbance is related to its life-cycle history, including life span (Lytle 2000). Life histories of organisms that have fast growth and mature quickly do not respond to disturbances as strongly as slow-growing, long-lived organisms.

Large forest owls are a long-lived species and a high order predatory species and have very large home ranges. Any disturbance that affects their prey species or sheltering and nesting habitat, has potential to negatively impact on the species in proximity to the road environment. They have greater potential for adaptation to disturbance then shorter lived species and given the larger home range, may be less affected by the scale of the impact associated with altered disturbance regimes in proximity to the project.

How is the project likely to affect habitat connectivity?

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of some species and fauna groups more than others for example small ground-dwelling mammals, reptiles and amphibians with smaller home range and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10). These project sections occur within a range of habitats suitable for these species.

There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River. These highly mobile species have large home ranges that would likely include a mosaic of forested and cleared landscapes and are adapted to moving across forest clearings such as roads and are unlikely to be significantly impacted by the barrier effect of the road.

How is the project 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.

Frugivorous rainforest birds

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

The assessment refers to the fruit-doves (Wompoo and Rose-crowned and Superb) as well as Barred-cuckoo Shrike and Double-eyed Fig Parrot (Coxen's Fig Parrot). These species frequent rainforest, low elevation moist eucalypt forest and brush-box forest feeding on a diverse range of tree and vine fruits. The birds are locally nomadic, travelling large distances to access seasonally available ripening fruit which may be available in large remnants or across a network of smaller fragmented remnants in floodplain areas such as the study area. The preference is for larger mature fruit-bearing trees. The exception is the Coxens Fig Parrot which is associated with five discrete populations that are outside the study area, mainly north and west of Ballina and is less likely to be reliant on smaller fragments.

The clearing of habitat for the project in particular, lowland rainforest (10 hectares) and wet/moist sclerophyll forest (329 hectares) would affect the current availability of food resources and therefore affect the foraging and roosting activities of birds in the study area. The distribution of the fruit-doves and barred cuckoo-shrike is very widespread across the region reflecting their nomadic movements in relation to spatially and temporally separated food resources. There is no published data on nesting, breeding territories in the study area, and any impacts from the loss of habitat along the project boundary is more than likely affecting foraging resources rather than a significant breeding/nesting area.

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

The project would see the clearing of 10 hectares of lowland rainforest and 329 hectares of moist forest habitat containing potential fruiting resources. The proportion of fruit-bearing trees or known and favoured food resources within the habitats to be cleared has not been identified and as such the entire clearing of 339 hectares is considered to remove potential habitat for the fruit-dove species and the barred cuckoo-shrike. These areas may only provide marginal or occasional resources for Double-eyed Fig Parrot, as the distribution of the population is outside of the study area.

Potential for increased fire events near roadside environments may have an indirect impact on adjacent retained habitats as would run-off from the road.

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

The study area does not represent the limit of distribution for any of these species, which typically occur along the coast and coastal ranges from the Hunter River in NSW to Cape York Peninsula, although they are rare south of Coffs Harbour. The distribution of the Double-eyed Fig Parrot is outside of the study area.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime. Similarly, frog species adapted to the current flooding regime have potential to be negatively impacted by a change in the movements of floodwaters. The development of basins for holding water has potential to favour introduced species such as Plague Minnow (*Gambusia holbrooki*) and Cane Toad (*Bufo marinus*).

The preferred rainforest habitat for frugivorous rainforest birds in the study area has been extensively cleared and fragmented. Remaining areas occur along road reserves, protected riparian areas or small fragments of regrowth in formerly cleared farmland. These habitats would be less reliant on fire related disturbance than the dry sclerophyll habitats. Impacts would be associated with loss of potential foraging habitat and the degradation of adjacent areas, in many cases this may be associated with riparian areas in moist or dry sclerophyll habitats. The potential increase in fires adjacent to the road or change in disturbance associated with increased pollutants or sediments into waterways may have a longer term impact on riparian vegetation, altering the structure and suitability for important food plant species.

Frugivorous rainforest birds are wide-ranging adapted to moving across fragmented landscapes to access spatially and temporally separated food resources. Any impacts from changed of habitat condition associated with altering disturbance regimes in proximity to the road may be offset by their ability to move widely throughout the landscape and access disturbed and fragmented habitats.

How is the project likely to affect habitat connectivity?

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of some species and fauna groups more than others for example small ground-dwelling mammals, reptiles and amphibians with smaller home range and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10). These project sections occur within a range of habitats suitable for these species.

There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River. These highly mobile species have large home ranges that would likely include a mosaic of forested and cleared landscapes and are adapted to moving across forest clearings such as roads to access spatially separated food resources and nesting habitats and are unlikely to be significantly impacted by the barrier effect of the road.

How is the project 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.

Cave-roosting microbats

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

The study area provides known and potential foraging habitat for the assessed species. The Little Bent-wing Bat in particular was commonly recorded from trapping and call recording surveys at a number of locations widely dispersed along the project boundary. These species are predominantly cave-roosting bats, although a small colony of the Little Bent-wing Bat has been observed roosting in a hollowed tree trunk (Schulz 1997) and Southern Myotis have been recorded roosting under old timber and concrete bridges. An assessment of bridges to be removed from the project did not detect any roosting bats. There is potential for smaller roosting sites to occur in existing culverts under the Pacific Highway, which have not been identified.

Similarly no caves or abandoned mine shafts have been recorded in the project boundary and the project is not expected to impact on the roosting life-cycle activities of these species. The location of any roost sites for these species in the regional area is not known.

The loss of forest habitat, in particular swamp forest (149 hectares) and wetlands (thirteen hectares) would impact on the potential breeding habitat for prey species (invertebrates) and therefore potentially lead to reduction of populations associated with increased pressure on a local scale. However comparable habitats are well represented throughout the locality and regional area and predation by bats would account for only a very small proportion of the prey availability. Therefore impacts on foraging habitat and prey abundance would result from the project however the overall magnitude of impact is small relative to the extent of insect breeding resources in the study area.

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

Impacts on known roosting habitat or a roosting colony have not been identified. The project would remove about 948 hectares of habitat comprising a combination of wet and dry sclerophyll forest and heath which provides known and potential foraging habitat for the assessed insectivorous bat species. The affect of the removal of this habitat is to remove breeding and shelter opportunities for insect prey and hunting habitat for bats, potentially leading to a reduction in population size or range. Southern Myotis hunt over water bodies for small fish and invertebrates and may frequent the creek and wetland habitats. Impacts on foraging habitat for this species would result from the project however the overall magnitude of impact is relatively small.

Does the project 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 project study area.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime. Similarly, frog species adapted to the current flooding regime have potential to be negatively impacted by a change in the movements of floodwaters. The development of basins for holding water has potential to favour introduced species such as Plague Minnow (*Gambusia holbrooki*) and Cane Toad (*Bufo marinus*).

These species are all insectivorous bats which hunt in forested and cleared landscapes and are reliant on caves or artificial structures for roosting and breeding life-cycle events. The current prey base has adapted to the current disturbance regimes many exhibiting life-cycles that revolve around accessing standing around water for breeding. The potential increase in fires adjacent to the road or change in disturbance associated with increased pollutants or sediments into waterways may have a short term impact on prey breeding sites.

Insectivorous bats are wide-ranging species adapted to moving across fragmented landscapes to find prey. Any impacts from change of habitat condition associated with altering disturbance regimes in proximity to the road may be offset by their ability to move widely throughout the landscape and access disturbed and fragmented habitats.

How is the project likely to affect habitat connectivity?

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of some species and fauna groups more than others for example small ground-dwelling mammals, reptiles and amphibians with smaller home range and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10). These project sections occur within a range of habitats suitable for these species.

There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River. These highly mobile species are adapted to moving across forest clearings such as roads to access foraging and roosting habitat and are unlikely to be significantly impacted by the barrier effect of the road.

How is the project 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.

Tree-roosting microbats

How is the project 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. 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 both are typically associated with tree hollows as well as foraging for insect prey which occurs in a variety of habitat types. Breeding habitat for insect prey includes a very diverse range of wetlands, swamps and open modified and artificial landscapes.

The size of local populations is not known, although expected to be moderately large given the expanses of suitable habitat and tree hollow densities across the large project study area. The loss of forest habitat, in particular swamp forest (149 hectares) and wetlands (thirteen hectares) would impact on the potential breeding habitat for prey species (invertebrates) and therefore potentially lead to reduction of populations associated with increased competition and energy use on a local scale. However comparable insect breeding habitats are well represented throughout the locality and regional area and predation by bats would account for only a very small proportion of the prey availability. Therefore while impacts on foraging habitat and prey abundance would result from the project however the overall magnitude of impact is small relative to the extent of insect breeding resources in the study area.

The project would remove about 948 hectares of habitat comprising a combination of wet and dry sclerophyll forest and heath which provides known and potential foraging and roosting / breeding habitat (tree hollows) for the assessed insectivorous bat species. The affect of this loss on the life-cycle activities of bats relates to disruption of breeding activities and shelter or dormancy activities and leading to increased competition for hollows.

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

The project would remove about 948 hectares of habitat comprising a combination of wet and dry sclerophyll forest and heath which provides known and potential foraging and roosting / breeding habitat (tree hollows) for the assessed insectivorous bat species. The magnitude of this loss from a regional perspective represents a very large scale. The highest densities of hollow-bearing trees were recorded in dry sclerophyll forests and moist floodplain forests (range between 28 and 76 trees per hectare) which account for 81 per cent of the total habitat loss. The affect of this loss on the life-cycle activities of bats relates to disruption of breeding activities and shelter or dormancy activities and increased competition for hollows.

Does the project 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 project study area. Dry and moist sclerophyll forest habitats are very common and widespread throughout the region particularly further west of the study area.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime. Similarly, frog species adapted to the current flooding regime have potential to be negatively impacted by a change in the movements of floodwaters. The development of basins for holding water has potential to favour introduced species such as Plague Minnow (*Gambusia holbrooki*) and Cane Toad (*Bufo marinus*).

These species are all insectivorous bats which hunt in forested and cleared landscapes and are reliant on caves or artificial structures for roosting and breeding life-cycle events. The current prey base has adapted to the current disturbance regimes many exhibiting life-cycles that revolve around accessing standing around water for breeding. The potential increase in fires adjacent to the road or change in disturbance associated with increased pollutants or sediments into waterways may have a short term impact on prey breeding sites.

Insectivorous bats are wide-ranging species adapted to moving across fragmented landscapes to find prey. Any impacts from change of habitat condition associated with altering disturbance regimes in proximity to the road may be offset by their ability to move widely throughout the landscape and access disturbed and fragmented habitats.

How is the project likely to affect habitat connectivity?

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of some species and fauna groups more than others for example small ground-dwelling mammals, reptiles and amphibians with smaller home range and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10). These project sections occur within a range of habitats suitable for these species.

There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River. These highly mobile species are adapted to moving across forest clearings such as roads to access foraging and roosting habitat and are unlikely to be significantly impacted by the barrier effect of the road.

How is the project 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.

Arboreal snakes

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

Vegetation in the study area provides potential hunting and sheltering habitat for the assessed species (Stephens Banded Snake and Pale-headed Snake). These snakes inhabit a variety of habitat types ranging from dry sclerophyll forests and woodlands to wet sclerophyll forest, particularly where exposed rock crevices occur or tree hollows and standing dead trees.

Important life-cycle activities include hunting, sheltering, breeding and dispersal and both species are typically associated with habitats containing tree hollows and standing dead trees. Prey species includes frogs, lizards, small mammals and birds. Stephens Banded Snake feeds predominantly on mammalian prey such as Bush Rats (*Rattus fuscipes*) and Pygmy-possums (*Cercartetus nanus*); but juveniles also take lizards (Fitzgerald 2012).

The greatest potential impact on lifecycle activities associated with the loss of habitat the ability to find adequate shelter and the increased competition for hollows. A study on diet on Stephens Banded Snake identified that gape-limitation prevents snakes from ingesting adult rodents and therefore the species specialises on sub-adult rats which are only seasonally available (Fitzgerald et al 2012). Further, low feeding rates result in snakes in being thin, growing slowly and reproducing infrequently. These life-history traits correlate with a high adult survival rate and a low reproductive rate. These traits suggest the species is susceptible during habitat change associated with clearing of habitat trees and temporary reduction in prey and that recovery is very slow.

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

The project would remove about 948 hectares of habitat comprising a combination of wet and dry sclerophyll forest and heath which provides known and potential hunting and sheltering habitat (habitat trees). The magnitude of this loss from a regional perspective represents a very large scale. The highest densities of hollow-bearing trees were recorded in dry sclerophyll forests and moist floodplain forests (range between 28 and 76 trees per hectare) which account for 81 per cent of the total habitat loss. The major threat to these species is associated with the clearing and fragmentation of habitat particularly habitat containing old or dead trees.

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

Both species extend from the central coast of NSW to south-east Queensland with the Pale-headed Snake having a wider distribution into central western regions along the Great Dividing Range where Stephens Banded Snake is confined to coastal areas. The study area is not the distributional limit.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime. Similarly, frog species adapted to the current flooding regime have potential to be negatively impacted by a change in the movements of floodwaters. The development of basins for holding water has potential to favour introduced species such as Plague Minnow (*Gambusia holbrooki*) and Cane Toad (*Bufo marinus*).

The greatest potential impact may be from changed fire frequency or fire spread, as this would impact on the availability of tree hollows and the structure of the habitats and abundance of prey species. Stephens Banded Snake feeds predominantly on mammalian prey such as Bush Rats (*Rattus fuscipes*) and Pygmy-possums (*Cercartetus nanus*); but juveniles also take lizards (Fitzgerald 2012). Similar prey items are expected for the Pale-headed Snake. These prey species are adapted to inhabiting fire prone environments.

It is difficult to predict the degree of change in fire regimes or spatial and temporal scale. It is unlikely that the project would significantly alter fire spread on a landscape level as the project traverses a largely fragmented landscape or duplicates the existing highway in densely vegetated areas such as Tabbimoble and Doubleduke State Forest and Broadwater National Park. There is no data on the fire regime across the study area.

How is the project likely to affect habitat connectivity?

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of some species and fauna groups more than others for example small ground-dwelling mammals, reptiles and amphibians with smaller home range and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10). These project sections occur within a range of habitats suitable for these species.

Roads act as a barrier or filter to the movement of vertebrates (eg Mansergh and Scotts 1989; Alexander and Waters 2000; van der Ree 2006). Animal movement may involve daily travel through a home range, seasonal migration associated with changes in habitat use or breeding events, or the dispersal of individuals from their natal areas (Taylor and Goldingay 2011). A barrier effect may result from a behavioural aversion to a road. There have been limited results for reptiles.

As part of the response to mitigate and minimise this barrier effect for these species, RMS has developed a strategy with the aim of providing connectivity structures and enhancing landscape connectivity where feasible and reasonable in strategic locations. The Biodiversity Connectivity Strategy is detailed in Chapter 5 and Appendix A.

How is the project 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.

Glossy Black-cockatoo

How is the project 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.*

The species occurrence in the region is widespread but uncommon. Black She-oak (Allocasuarina littoralis) represents the dominant food resource and is a moderately common component of the dry sclerophyll open forests which make up the majority of the study area. The size of local populations and importance of particularly areas is not known. Large tree hollows are used for nesting and these features are present although in low abundance along the project boundary.

A hollow limb or hole, often is a tall dead tree in a forest clearing, is typically used for roosting (Forshaw and Cooper 1978). This species requires large cavities for nesting and breeding. The abundance of food resources and distributional range of the regional population together with the high mobility of the species suggests there are potentially multiple family groups in the region and that these are adapted to moving across modified landscapes to access spatially separated food resources. The project is unlikely to significantly impact on the availability of food resources which are common.

The loss of large hollow-bearing trees, which may currently or potentially provide nest sites would impact on the breeding and recruitment of populations. These are an uncommon feature in the landscape as a result of the historical land uses.

How is the project 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 littoralis* which is a common component of the extensive dry open forest communities. The project would clear up to 443 hectares of potential foraging and nesting habitat for this species.

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. There is no published data on the location of breeding territories for Glossy Black-cockatoo.

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

The species is not at the limit of its distribution in the project study are, it occurs throughout coastal eastern Australia through Queensland to the Victoria border.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime. Similarly, frog species adapted to the current flooding regime have potential to be negatively impacted by a change in the movements of floodwaters. The development of basins for holding water has potential to favour introduced species such as Plague Minnow (*Gambusia holbrooki*) and Cane Toad (*Bufo marinus*).

Altered fire regimes would impact on the availability and recruitment of food resources for this species and presence of nesting sites (large tree hollows). The food tree species (*Allocasuarina* spp.) currently exist in a fire adapted landscape and are a pioneer species in early successional regeneration following fire.

The Glossy Black-cockatoo is a wide-ranging species adapted to moving across fragmented landscapes to find scattered food resources. Any impacts from change of habitat condition associated with altering disturbance regimes in proximity to the road may be offset by their ability to move widely throughout the landscape and access disturbed and fragmented habitats.

How is the project likely to affect habitat connectivity?

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of some species and fauna groups more than others for example small ground-dwelling mammals, reptiles and amphibians with smaller home range and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10). These project sections occur within a range of habitats suitable for this species.

There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River. This highly mobile species is adapted to moving across forest clearings such as roads to access foraging and roosting and nesting habitat and is unlikely to be significantly impacted by the barrier effect of the road.

How is the project 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.

Coastal Emu

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

This assessment focuses on the larger Yuraygir sub-population which occupies much of the coastal strip of Yuraygir National Park to the east of the project boundary (project sections 3 and 4) as well as surrounding contiguous areas in the Sandon and Brooms Head area in the north and Wooli Road and Pillar Valley in the south as far as Red Rock.

To support the life-cycle activities of feeding and drinking, breeding and nesting, the emus appear to depend on a mosaic of vegetation types including both natural and modified habitats. This includes open forest, heath, woodland, agricultural land (grazing and cropping land), grasslands and wetland fringes.

At all times the birds are semi-nomadic, keeping in touch with variation in availability of food (Davies 1978; 1984). Emus are omnivorous relying on insects, seeds, fruits and succulent vegetation (Dawson et al 1983) which may include both native and exotic plant species in coastal areas (McGrath and Bass 1999). In any locality in a particular time of year emus exhibit clear food preferences (Davies 1976) a factor which is associated with the typical sporadic and seasonal occurrences of fruits and seeds and this may partly explain their semi-nomadic behaviour and need to travel long distances to access available food sources.

The full extent of areas used for breeding is not known, as breeding localities have been identified on the basis of family groups with striped chicks in July-September, and predictably these observations correlate to coastal villages, public lands and roads. Based on this current knowledge, there are no breeding sites west of the proposed highway, all breeding sites occur to the east of the project boundary. There is some evidence to suggest that nesting occurs well above the floodline further east of the project boundary, for example Chaffin Hill and may extend east to the foothills of the Sommervale Range.

As discussed emus are semi-nomadic moving in response to the availability of food and water resources (Davies 1978; Dawson et al 1983). However, seasonal access to frequented habitats may be via regular but broad movement pathways across the landscape. There has been no study on the movements of the emu population in the Clarence Valley and data on movements is based on observations as discussed. Several main emu movement areas are assumed based on regular sightings at the same locations and include:

- Pillar Valley across Wooli Road at Whites Bridge (Pillar Valley Creek) and also south towards Coldstream Wetlands
- Brooms Head / Sandon River - Tucabia (via northern Yuraygir National Park / Pine Brush State Forest and includes Red Root Road, Sommervale Road, down to Champion Creek and Bostock Road
- Sommervale Flats and Tyndale Swamp north to Shark Creek and Byrons Lane area
- Brooms Head to Green Hill and McIntyres Lane.

The current challenge entails dealing with small numbers of emus that occupy a broad landscape mosaic of both natural and modified habitats. Being predominantly nomadic, non-breeding birds move from place to place without regard to season or direction and depend on resources that occur rarely at the same site. A continuity of supply can be ensured only if birds are able to locate successive favourable areas which are often spatially separated. Successful behaviour is therefore linked to success in locating resources that are widely separated in space (Davies 2007). In areas where environmental conditions are regular, the movements of emus can appear regular but the birds are still influenced by the same suite of behaviour patterns as are birds in environments that are less consistent (Davies 2007).

Based on the distribution of emu records for the Pillar Valley to Shark Creek group (project section 3 and 4), the evidence suggests that the relatively stable environmental conditions associated with the floodplain wetlands and swamps of the Coldstream River, Chaffin Swamp, Champions Creek, Tyndale Swamp and Shark Creek including the associated agricultural land support reliable food and water resources, both spatially and temporally. These habitats account for observed movements in the pre and post breeding life-cycle periods of birds. The wetlands are currently contiguous with the forest and heath communities to the east of the floodplain via relatively natural and modified habitats, albeit for a network of smaller roads, such as the Tyndale-Tucabia Road, continuing to the coastal lands of Yuraygir National Park and surrounds.

Project section 3 and the southern end of section 4 would traverse the eastern extent of the lower Clarence floodplain effectively skirting around the Coldstream wetlands eventually crossing Pillar Valley Creek, Chaffin Creek, Champions Creek and Shark Creek and therefore potentially introduce a physical barrier for emus accessing the wetlands from the east. Therefore the impact to the population from the project would include the direct removal, fragmentation and isolation of important habitat. This factor combined with the increased risk of vehicle strike associated with the project has potential to have a significant long-term impact associated with a cumulative reduction in the population leading to loss of viability.

The project would have the greatest impact on the group ranging the Pillar Valley to Tyndale area. The degree of relatedness and interaction of this group to the other identified groups in the study area is not known.

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

Knowledge on emu groups and their range are based on interpretation and discussion of the annual survey results from NPWS land managers (Gina Hart NPWS and Matt Clarke formerly NPWS) and interviews with property owners in the Pillar Valley to Tyndale area. These data suggest that the subject population is divided by a number of groups which show fidelity to particular areas and habitat that support important pre and post-breeding life cycle events.

The majority of the population is centred on Yuraygir National Park at a considerable distance from the project boundary and includes:

- Southern Yuraygir (Station Creek to Red Rock River)
- Central Yuraygir (Wooli - Diggers Camp - Minnie Water - Sandon [village])
- Northern Yuraygir (Sandon River - Brooms Head - Wooloweyah - James Creek – Taloumbi).

At least two separate groups to these are predicted to be impacted by the project, this includes:

- A group ranging within the area south of Tucabia from the Coldstream River wetlands in the west to Pillar Valley and Yuraygir National Park in the east
- A second group is largely found on the agricultural land and woodland between Pine Brush and Candole State Forest in the south, Tyndale Swamp and north to Shark Creek and Green Hill and cane farms around Byrons Lane and McIntyres Lane at Tyndale.

These latter two groups are typically active around the floodplain and creek areas including agricultural lands during pre- and post-breeding activities in spring and summer with the cane fields being frequented by adult males raising young.

The project would involve removal of potential habitat, although given the widespread occurrence of suitable habitat and the diversity of habitat types including natural and modified habitats that used by the species, the direct loss of habitat associated with the project is not expected to place significant pressure on the population. The potential impacts to the population lie in the fragmentation of known important habitats to the east of the corridor around the wetlands of the Coldstream and Tyndale and cane growing country north of Tyndale.

Providing continued access to the floodplain wetlands is considered critical to the survival of the population as is preventing road fatalities on the future highway. In theory access can be provided via appropriately placed and adequately sized crossing structures (ie bridges and culverts) in addition to exclusion fencing, which should also act as directional fencing leading to the crossing structures. However there is a risk in this approach in that it relies on efficacy of these mitigation measures when there is no current scientific evidence to indicate that wild emus are capable of finding and using crossing structures or can be directed by fencing. In the absence of scientific certainty the benefit of providing crossing structures remains to be proven.

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

The endangered coastal emu population comprises three sub-populations, the largest centred on Yuraygir National Park and surrounds on the southern side of the Clarence River estimated at between 80-120 individuals. The remaining sub-populations occur north of the river centred on Bundjalung National Park and Bungawalbin Nature Reserve (Main Camp). The table below describes the current status of the three sub-populations and their proximity to the project boundary.

Sub-population and range	Predicted population size (2011)	Intersection with project boundary
Yuraygir sub-population: Yuraygir National Park and surrounds, including Clarence River floodplain north to Gulmarrad-Maclean, and south to Red Rock.	Largest group has remained stable at between 80-120 individuals for last 10 years.	Intersects with project sections 3 and 4
Bundjalung sub population: Bundjalung National Park from Iluka to Evans Head	Smallest population, only 20 birds estimated in 2006. No emus counted in 2010-11 census, current population unknown and considered possibly extinct.	Not directly affected
Bungawalbin sub-population: Bungawalbin Nature Reserve and National Park, main camp	Estimated at < 60 birds.	Not directly affected

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime. Similarly, frog species adapted to the current flooding regime have potential to be negatively impacted by a change in the movements of floodwaters. The development of basins for holding water has potential to favour introduced species such as Plague Minnow (*Gambusia holbrooki*) and Cane Toad (*Bufo marinus*).

The potential increase in fires adjacent to the road or change in disturbance associated with increased pollutants or sediments into waterways may have a short to medium term impact the condition and structure of the habitat. Much of the habitat of the coastal emu throughout Yuraygir National Park is fire adapted and evolved with relatively short intervals between fires associated with natural events and also fuel reduction burning and burning of cane fields. Any changes in fire regime associated with the project are not expected to have a significant long term impact on the habitat of this species.

Similarly, the reliance of wetland habitats of the Clarence River floodplain has evolved over a long period in conjunction with historical change in the structure and function of these wetlands associated with anthropogenic disturbances. The potential increase in pollutants or sediments into waterways and wetlands may have a short to medium term impact the condition and structure of the habitat. Measures to mitigate this disturbance have been incorporated into the project.

How is the project likely to affect habitat connectivity?

Providing continued access to the floodplain wetlands is considered critical to the survival of the population as is preventing road fatalities on the future highway. In theory access can be provided via appropriately placed and adequately sized crossing structures (ie bridges and culverts) in addition to exclusion fencing, which should also act as directional fencing leading to the crossing structures. However there is a risk in this approach in that it relies on efficacy of these mitigation measures when there is no current scientific evidence to indicate that wild emus are capable of finding and using crossing structures or can be directed by fencing. In the absence of scientific certainty the benefit of providing crossing structures remains to be proven.

How is the project 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.

Diurnal raptors (Little Eagle, Square-tailed Kite and Red Goshawk)

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

These species occur across most of NSW and cover a broad area of the coastal and sub-coastal region, frequented open forest and woodlands on fertile soils with abundant prey species (Debus et al. 1993; Marchant and Higgins 1993). On the coast, these species appear 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 appear to be associated with the extensive dry sclerophyll forest habitats on low hills.

No nest sites were located along the project boundary during the route surveys nor have been reported in the vicinity of the route in the local State Forests. There are no published accounts of nesting by these species in the vicinity of the project. Further surveys are recommended prior to construction. The project is unlikely to have a significant impact on breeding activities of local populations, however the clearing of vegetation could impact on the habitat of prey species and roosting habitat. Similar and suitable habitats for prey species are common and widespread in the region and the impacts on this life-cycle activity are expected to be minimal.

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

The project would remove around 948 hectares of forest habitat comprising wet and dry sclerophyll forests and heathlands. Of this around 550 hectares (58 per cent) consists of open dry sclerophyll forests and woodlands that could potentially be used by these raptor species. In theory this would result in the loss of foraging and breeding habitat and may have a short term impact on food resources. However the habitats suited to these species are particularly well represented in the region, particularly to the east and south of the study area. The overall reduction of habitat is considered a small proportion of the available potential habitat. Populations are considered to persist following development of the project.

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

The Little Eagle and Square-tailed Kite have a patchy distribution across all mainland states. The Red Goshawk occurs across northern and eastern Australia as far south as the lower north coast.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime.

The potential increase in fires adjacent to the road or change in disturbance associated with increased pollutants or sediments into waterways may have a short to medium term impact on the condition and structure of the habitat.

Disturbance is considered a natural process that occurs at different spatial and temporal scales (eg Pickett and White 1985). The ability of a community or species to adapt to disturbance is related to its life-cycle history, including life span (Lytle 2000). Life histories of organisms that have fast growth and mature quickly do not respond to disturbances as strongly as slow-growing, long-lived organisms.

These diurnal raptors are long-lived species and a high order predatory species and have very large home ranges. Any disturbance that affects their prey species or sheltering and nesting habitat, has potential to negatively impact on the species near the road environment. They have greater potential for adaptation to disturbance then shorter lived species and given the larger home range, may be less affected by the scale of the impact associated with altered disturbance regimes in proximity to the project.

How is the project likely to affect habitat connectivity?

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of some species and fauna groups more than others for example small ground-dwelling mammals, reptiles and amphibians with smaller home range and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10). These project sections occur within a range of habitats suitable for these species.

There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River. These highly mobile species are adapted to moving across forest clearings such as roads to access foraging, roosting and nesting habitat and are unlikely to be significantly impacted by the barrier effect of the road.

How is the project 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.

Mangrove Honeyeater

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

The primary habitat of the species is mangrove woodlands and shrublands adjacent forests, woodlands and shrublands, including casuarina and paperbark swamp forests and associations dominated by eucalypts or banksias. They occasionally forage in parks and gardens of coastal towns and villages. Mangrove Honeyeaters eat nectar, from flowers, and invertebrates, including marine snails and crabs. They generally forage in mangroves, mainly taking food from among the foliage but also feeding at flowers, and from the trunks and roots. They also sometimes forage among flowering trees and shrubs in adjacent habitats.

The distribution of this species in the study area is closely aligned to coastal forests and estuaries to the east of the project boundary. There is a minor impact on mangroves and estuarine wetlands associated with the project of around 1.5 hectares. Impacts on foraging and breeding life-cycle activities may occur in small localised areas, although this is not expected to be a significant impact to this species.

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

The primary habitat of the species is mangrove woodlands and shrublands, of which around 1.5 hectares of marginal habitat would be cleared around the proposed major bridge locations only. This is a minor impact in relation to the extent of the regional population and distribution of known habitat types.

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

The Mangrove Honeyeater is confined to the coastal fringe and offshore islands of eastern Australia, from Townsville, Queensland, south to the northern coast of NSW, where it may be expanding its range. It is common in Queensland but rare in NSW, where birds are found at several scattered localities. In NSW, most observations occur south to the Clarence River: around Tweed Heads, near Broken Head, and in the estuary of the Clarence River, near Iluka and Yamba. South of the Clarence, individuals or small numbers have been recorded around the mouth of the Macleay River between Stuarts Point and South West Rocks, and at Wauchope on the lower Hastings River. The study area is not the limit of its distribution.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime.

The potential increase in fires adjacent to the road or change in disturbance associated with increased pollutants or sediments into waterways may have a short to medium term impact the condition and structure of the habitat although is unlikely to be of significance for this species. The potential change in flooding regime on floodplain areas is not associated with mangrove or estuarine habitats favoured by this species.

How is the project likely to affect habitat connectivity?

The impacts on habitat connectivity for this species would be associated with crossing of the major rivers of the Clarence and Richmond River and other smaller streams where mangroves and adjacent swamp forest occur such as the Serpentine Channel north of Harwood. Connectivity would be maintained below the bridge at these locations and the project is not expected to impact on the movements of this species.

How is the project 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.

Eastern Osprey

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

The eastern osprey is moderately common and widespread across the coastal regions of the study area and larger rivers and estuaries. Nesting is commonly reported in the Clarence River valley and Richmond River valley. The species favours coastal areas, especially the mouths of large rivers, lagoons and lakes, where it feeds on fish over clear, open water.

No known nest sites have been reported in the project boundary or would be directly impacted. The nearest nest is reported on the western side of Harwood Bridge (on an artificially created purpose built structure) along the Clarence River, which is on the opposite side of Harwood Bridge to the project boundary. Further surveys for nesting sites are recommended prior to construction. The project would have minimal impact on the riverine habitats for prey species.

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

Through the removal of large trees that could be used as nest sites, in particular large dead trees in paddocks or emergent trees in swamp forest habitat. Also through disturbances to water quality, such as from runoff during construction, that increases turbidity in feeding areas. Other impacts to habitat include the potential contamination of waterways during road operation.

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

The Osprey has a global distribution with four subspecies previously recognised throughout its range. However, recent studies have identified that there are two species of Osprey - the Western Osprey (*P. haliaetus*) with three subspecies occurring in Europe, Asia and the Americas and the Eastern Osprey (*P. cristatus*) occurring between Sulawesi (in Indonesia), Australia and New Caledonia. Eastern Ospreys are found right around the Australian coast line, except for Victoria and Tasmania. They are common around the northern coast, especially on rocky shorelines, islands and reefs. The species is uncommon to rare or absent from closely settled parts of south-eastern Australia. There are a handful of records from inland areas.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime.

The potential increase in fires adjacent to the road or change in disturbance associated with increased pollutants or sediments into waterways may have a short to medium term impact the condition and structure of the habitat although is unlikely to be of significance for this species as most nesting occurs in open landscapes, swamp vegetation or riparian vegetation. The potential change in flooding regime on floodplain areas is not associated with the prey species or nesting habitat of the species.

How is the project likely to affect habitat connectivity?

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of some species and fauna groups more than others for example small ground-dwelling mammals, reptiles and amphibians with smaller home range and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10). These project sections occur within a range of habitats suitable for these species.

There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River. This highly mobile species is adapted to moving across forest clearings such as roads to access foraging, roosting and nesting habitat and is unlikely to be significantly impacted by the barrier effect of the road.

How is the project 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.

Ground Parrot

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

The Ground Parrot occurs in high rainfall coastal and near coastal low heathlands and sedgelands, generally below one metre in height and very dense (up to 90 per cent projected foliage cover). These habitats provide a high abundance and diversity of food, adequate cover and suitable roosting and nesting opportunities for the Ground Parrot, which spends most of its time on or near the ground.

The large majority of records of this species are associated with the extensive areas of coastal heath conserved in Yuraygir, Bundjalung and Broadwater National Park to the east of the project. Much of the habitat of the species in the region is conserved. There are no records around the project boundary. There are scattered records near the heath at Wardell and Broadwater National Park. The project boundary would have minimal impact on the lifecycle of this species.

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

The coastal and subcoastal heathland and sedgeland habitats of the Ground Parrot are particularly fire-prone. Ground Parrots can re-colonise burnt habitat after one to two years and reach maximum densities after 15 to 20 years without fire. The project could potentially increase the incidence of fire in the study area through opening up to traffic. However the project would involve duplication of the existing highway in locations that provide potential habitat for this species and therefore this risk is low.

Up to 10 hectares of wet and dry heath along the edges of the existing highway would be removed for the project, this provides potential habitat for this species, however there are no recent accounts of populations present near the highway.

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

The eastern subspecies (wallicus) inhabits south-eastern Australia from southern Queensland through NSW to western Victoria. It formerly occurred in South Australia, but was last recorded in 1945. In NSW populations have declined and contracted to islands of coastal or subcoastal heathland and sedgeland habitats. The species is found in small numbers on the north coast (Broadwater, Bundjalung, Yuraygir NPs) and Myall Lakes on the central coast. The largest populations occur on the NSW south coast, particularly Barren Grounds Nature Reserve, Budderoo National Park, the Jervis Bay area and Nadgee Nature Reserve. Small numbers are recorded at Morton and Ben Boyd National Park and other areas on the south coast. Estimated population size is about 2000 birds.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime.

The potential increase in fires adjacent to the road or change in disturbance associated with increased pollutants or sediments into waterways may have a short to medium term impact the condition and structure of the habitat. The large majority of records of this species are associated with the extensive areas of coastal heath conserved in Yuraygir, Bundjalung and Broadwater national parks to the east of the project. Much of the habitat of the species is fire adapted and evolved with relatively short intervals between fires associated with natural events and also fuel reduction burning. Any changes in fire regime associated with the project are not expected to have a significant long term impact on the habitat of this species.

How is the project likely to affect habitat connectivity?

The potential habitats for this species in Broadwater National Park are currently fragmented by the existing highway and the Wardell heath is isolated to the eastern side of the existing highway. The project would improve connectivity in these areas through the provision of purpose built fauna crossing overpasses to link the heath type habitats.

How is the project 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.

Eastern Grass Owl

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

Eastern Grass Owls are found in areas of tall grass, including grass tussocks, in swampy areas, grassy plains, swampy heath, and in cane grass or sedges on flood plains. This species was not confirmed from targeted surveys along the project boundary, but is predicted to occur in the larger swamp habitats in floodplain areas of sections 3 to 5 and sections 9 to 11. Indeed the highest densities in NSW occur in the coastal regions between Lennox Head and Brunswick Heads (Sections 9 to 11) including the perimeters of Ballina.

Birds nest on the ground in trodden grass and feed and specialises on a limited range of small mammal prey predominantly rodents, including introduced species. The project would clear potential habitat from open and adjacent paddocks or tall grass areas predominantly on the floodplain of the Clarence and Richmond rivers. The there is no published data inferring the home range or territory of pairs in the region. The species may be nomadic moving to new territories in response the changes in prey abundance, or may be resident in areas of reliable prey abundance. Clearing of habitat and disturbance associated with the project may interfere with prey abundance of remove potential breeding habitat and reproductive potential.

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

As the habitat of this species includes both natural and modified habitats it is difficult to identify the full extent of available habitat to be affected by the project. However, suitable habitat is common and widespread and any loss would be a fraction of the habitat available to this species.

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

Eastern Grass Owls have been recorded occasionally in all mainland states of Australia but are most common in northern and north-eastern Australia. In NSW they are more likely to be resident in the north-east. Eastern Grass Owl numbers can fluctuate greatly, increasing especially during rodent plagues.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime.

The potential increase in fires adjacent to the road or change in disturbance associated with increased pollutants or sediments into waterways may have a short to medium term impact the condition and structure of the habitat. Much of the habitat of this species throughout Yuraygir, Broadwater and Bundjalung national parks and adjacent areas is fire adapted and evolved with relatively short intervals between fires associated with natural events and also fuel reduction burning and burning of cane fields and grazing paddocks. Any changes in fire regime associated with the project are not expected to have a significant long term impact on the habitat of this species.

Similarly, the reliance on wetland habitats of the Clarence River and Richmond River floodplains has evolved over a long period in conjunction with historical change in the structure and function of these wetlands associated with anthropogenic disturbances. The potential increase in pollutants or sediments into waterways and wetlands may have a short to medium term impact the condition and structure of the habitat. Measures to mitigate this disturbance have been incorporated into the project.

How is the project likely to affect habitat connectivity?

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of some species and fauna groups more than others for example small ground-dwelling mammals, reptiles and amphibians with smaller home range and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10). These project sections occur within a range of habitats suitable for these species.

There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River. This highly mobile species is adapted to moving across forest clearings such as roads to access foraging and roosting habitat and are unlikely to be significantly impacted by the barrier effect of the road.

How is the project 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.

Long-nosed Potoroo

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

The Long-nosed Potoroo occurs in high rainfall coastal and near coastal low heathlands and sedgelands on sandy soils. These habitats provide a high abundance and diversity of food, adequate cover and suitable shelter.

The large majority of records of this species are associated with the extensive areas of coastal heath conserved in Yuraygir, Bundjalung and Broadwater national parks to the east of the project. Much of the habitat of the species in the region is conserved. There are no records around the project boundary. There are scattered records near the heath at Wardell and Broadwater National Park. The project boundary would have minimal impact on the lifecycle of this species.

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

The coastal and subcoastal heathland and sedgeland habitats of the species are particularly fire-prone. The project could potentially increase the incidence of fire in the study area through opening up to traffic. However the project would involve duplication of the existing highway in locations that provide potential habitat for this species and therefore this risk is low.

Up to 10 hectares of wet and dry heath along the edges of the existing highway would be removed for the project, this provides potential habitat for this species, however there are no recent accounts of populations present near the highway.

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

The Long-nosed Potoroo is found on the south-eastern coast of Australia, from Queensland to eastern Victoria and Tasmania, including some of the Bass Strait islands. There are geographically isolated populations in western Victoria. In NSW it is generally restricted to coastal heaths and forests east of the Great Dividing Range, with an annual rainfall exceeding 760 millimetres.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime.

The potential increase in fires adjacent to the road or change in disturbance associated with increased pollutants or sediments into waterways may have a short to medium term impact the condition and structure of the habitat. The large majority of records of this species are associated with the extensive areas of coastal heath conserved in Yuraygir, Bundjalung and Broadwater national parks to the east of the project. Much of the habitat of the species is fire adapted and evolved with relatively short intervals between fires associated with natural events and also fuel reduction burning. Any changes in fire regime associated with the project are not expected to have a significant long term impact on the habitat of this species.

How is the project likely to affect habitat connectivity?

The potential habitats for this species in Broadwater National Park are currently fragmented by the existing highway and the Wardell heath is isolated to the eastern side of the existing highway. The project would improve connectivity in these areas through the provision of purpose built fauna crossing overpasses to link the heath type habitats.

How is the project 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.

Pink Underwing Moth

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

The Pink Underwing Moth was recorded at the northern end of project in section 10 in a rainforest / moist forest remnant within and adjacent to the project boundary. This observation consisted of several Pink Underwing Moth larvae at two sites (refer Appendix L for specialist report). The potential habitat for this species includes lowland rainforest and low elevation moist floodplain forest with high species diversity. These habitat types were found in the northern end of the project (Section 10 and 11). Potential breeding habitat is restricted to areas where the caterpillar's food plant, a native rainforest vine, *Carronia multisepalea*. Adult Pink Underwing Moths require the darkness supplied by the vine and the canopy of other rainforest vegetation in order to breed. This host plant was identified at only a few locations in and adjacent to the corridor and the project would likely remove a portion of the known and potential host plant population from the study area. There is only one other record of this moth species in NSW which reflects the large scale removal of potential habitat.

The project would clear up to 10 hectares of lowland rainforest including the removal of likely breeding habitat as determined by the presence of larvae and the host plant Carronia multisepalea. The project would likely have a significant impact on the burrowing / sheltering and breeding, and foraging life-cycle activities for the local population of this species. The records in the study area represent the first records for the region around Ballina and only the second record in NSW. There is no data on the size or distribution of the population, however as a precautionary measure this is likely to be restricted to a small number of fragmented floodplain rainforest remnants.

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

Potential habitat for the Butterfly was identified in the study area (Section 10-11) as determined by the presence of the host plant species. The Pink Underwing Moth has potential to occur and breed within the study as its host plant is present from within the alignment (Section 11) to a little beyond the edge of the western buffer zone. The clearing of this habitat for the project in particular, lowland rainforest (10 hectares) would affect the current availability of food resources and affect the foraging and breeding activities of the species in the study area.

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

The southern subspecies of the Pink Underwing Moth is distributed from Nambour, south-eastern Queensland to near Dorrigo and Bellingen, in northern NSW, but is only known from 5 or 6 locations across its range. There is only one other record in northern NSW from Atlas of NSW wildlife and population sizes in NSW appear to be very small.

The species distribution in the study area is likely restricted to small patches of rainforest remnants occurring across the Richmond River floodplain.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime.

The existing network of small rainforest remnants across the Richmond River floodplain is threatened by weed invasion, in particularly Lantana and Camphor Laurel. The clearing, reduction and increased fragmentation resulting from the project would likely increase the potential for weed invasion.

How is the project likely to affect habitat connectivity?

There is currently a high degree of habitat fragmentation of the lowland rainforest habitat in the study area and indeed across the floodplain of the lower Richmond River. This is due to the broad-scale clearing for agriculture and development including construction of the existing Pacific Highway and network of roads. These species are unlikely to move large distances to access scattered remnants and in the case of the moth, its distribution is tied to the presence of the host plant and intact canopy.

The project would fragment the potential and known habitat identified at this location, resulting in reduced connectivity.

How is the project 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. However, Lowland Rainforest of Subtropical Australia is listed nationally as critically endangered under the EPBC Act.

Atlas Rainforest Ground Beetle

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

The species was recorded at the northern end of project in section 10 with a rainforest remnant located within and adjacent to the project boundary. This observation comprised a single adult Atlas Rainforest Ground Beetle encountered in a burrow positioned under a large protruding root of a White Cedar (Melia azedarach) in soil derived from basalt. The potential habitat for this species includes lowland rainforest in the northern end of the project (Section 10 and 11).

The project would clear up to 10 hectares of lowland rainforest and this would have a significant impact on the burrowing / sheltering and breeding, and foraging life-cycle activities for these species. The records in the study area represent the first records for the region around Ballina. There is only one previous record of the ground beetle between Alstonville and Coraki.

These species frequent rainforest and low elevation moist eucalypt forest. There is little known of the life-cycle requirements of associated habitat characteristics. The survival of this species is threatened by an extremely restricted distribution, clearing of rainforest remnants, removal of fallen timber and ground cover.

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

The Atlas rainforest ground beetle also occurs in lowland rainforest habitat. The species distribution in the project area is likely restricted to small patches of rainforest remnants occurring across the Richmond River floodplain which are heavily reduced and fragmented. The survival of this species is threatened by an extremely restricted distribution, clearing of rainforest remnants, removal of fallen timber and ground cover. The clearing of this habitat for the project in particular, lowland rainforest (10 hectares) would affect the current availability of habitat, and food resources and therefore affect the foraging and breeding activities of the species in the study area. This is potentially a significant loss of habitat for this highly restricted species.

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

The ground beetle was historically widespread in heavily timbered high rainfall areas east of the Great Dividing Range on the north coast of NSW. Presently it is only known from this location and a few other sites in the Lismore-Alstonville area. The study area represents the southern limit of the species distribution and a significant find in terms of regional population.

Further, the species distribution in the project area is likely restricted to small patches of rainforest remnants occurring across the Richmond River floodplain which are heavily reduced and fragmented. The survival of this species is threatened by an extremely restricted distribution, clearing of rainforest remnants, removal of fallen timber and ground cover.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or rainforest vegetation that have adapted to the current flooding regime.

The existing network of small rainforest remnants across the Richmond River floodplain is threatened by weed invasion, in particularly Lantana and Camphor Laurel. The clearing, reduction and increased fragmentation resulting from the project would likely increase the potential for weed invasion.

How is the project likely to affect habitat connectivity?

There is currently a high degree of habitat fragmentation of the lowland rainforest habitat in the study area and indeed across the floodplain of the lower Richmond River. This is due to the broad-scale clearing for agriculture and development including construction of the existing Pacific Highway and network of roads. These species are unlikely to move large distances to access scattered remnants due to its small size and low dispersal ability.

The project would fragment the potential and known habitat identified at this location, resulting in reduced connectivity.

How is the project 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. However, Lowland Rainforest of Subtropical Australia is listed nationally as critically endangered under the EPBC Act.

Coastal Petaltail

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

The direct loss of up to 3 hectares of wetland habitats and direct impacts to adjoining wetlands may impact on the habitat of this species. However the distribution of populations is not known and there is no published data on the minimum condition of the habitat that supports this species.

If present in wetlands cleared by this project, the project may affect the larval stage of the species. The larval stage is unusually long, from at least 10 to 30 years. The larvae occupy permanent long chambered burrows, built under swamps.

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

As the project traverses a portion of the floodplain of the Clarence and Richmond rivers in addition to the Corindi River north of Woolgoolga, these habitat types are common and widespread across the major floodplains of the study area. The project would result in direct impacts to around 3 hectares of wetland habitats provide known and potential habitat for this species. Potential indirect impacts were identified for eight Nationally Important Wetlands and 15 SEPP 14 listed wetlands outside the project boundary. Most of these wetlands are recharged or fed by the Clarence River and Richmond River catchments. A review of habitat available for this species suggest that potential habitat is widespread throughout the study area including dense vegetation on the margins of freshwater creeks, rivers and natural or artificial wetlands.

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

The coastal petaltail has been recorded from permanent wetlands, both coastal and upland, from Moss Vale near Sydney northwards to southern Queensland, and is not at the limit of its distribution in the study area.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime.

The potential increase in fires adjacent to the road or change in disturbance associated with increased pollutants or sediments into waterways may have a short to medium term impact the condition and structure of the habitat. The reliance on wetland habitats has evolved over a long period in conjunction with historical change in the structure and function of these wetlands associated with anthropogenic disturbances. The potential increase in pollutants or sediments into waterways and wetlands may have a short to medium term impact the condition and structure of the habitat. Measures to mitigate this disturbance have been incorporated into the project.

How is the project likely to affect habitat connectivity?

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of some species and fauna groups more than others for example small ground-dwelling mammals, reptiles and amphibians with smaller home range and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10).

While the current distribution of the species is unknown, the dispersal opportunities of the Coastal Petaltail would not be significantly impacted by the project.

How is the project 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.

Common Blossom Bat

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

The species occurs in high rainfall coastal and near coastal low heathlands and occupies adjacent littoral rainforests for roosting. These habitats provide a high abundance and diversity of food in the form of nectar (blossom) and suitable shelter.

The large majority of records of this species are associated with the extensive areas of coastal habitats conserved in Yuraygir, Bundjalung and Broadwater national parks to the east of the project. Much of the habitat of the species in the region is conserved. There are very few records around the project boundary. There are scattered records near the heath at Wardell and Broadwater National Park. The project boundary would have minimal impact on the lifecycle of this species.

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

Common Blossom-bats often roost in littoral rainforest and feed on nectar and pollen from flowers in adjacent heathland and paperbark swamps. They have also been recorded in a range of subtropical forest types, rainforest, wet sclerophyll forest and coastal Eucalypt forest. They generally roost individually in dense foliage and vine thickets of the sub-canopy, staying in the same general area for a season. They change roost sites daily, but each roost site is generally only 50 metres or so away from other recent roosts.

Favoured feeding sites are repeatedly visited on consecutive nights within a flowering season and returned to over several years. They require a year round supply of nectar and pollen which is gathered from a mosaic of coastal complex vegetation types. When these vegetation types are in short supply of nectar and pollen (November / December in northern NSW) Common Blossom-bats have been known to use riverine areas containing Black Bean, Silky Oak and Weeping Bottlebrush.

Up to 10 hectares of wet and dry heath would be removed from habitat currently lying adjacent to the existing road corridor and up to 10 hectares of lowland rainforest. There is no quantifiable data on the extent of populations and the suitability of the habitats for this species along the project boundary. Rainforest roosting habitats need to be within proximity (2 to 4 kilometres from foraging habitat). The clearing of heath habitat has potential to remove a portion of the foraging habitat available to this species. Impacts to roosting habitat are not expected.

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

The species is not at the limit of distribution in the study area and occurs along coastal south-eastern Australia from the tip of Cape York Queensland to about Kempsey in NSW.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime. Similarly, frog species adapted to the current flooding regime have potential to be negatively impacted by a change in the movements of floodwaters. The development of basins for holding water has potential to favour introduced species such as Plague Minnow (*Gambusia holbrooki*) and Cane Toad (*Bufo marinus*).

Altered fire regimes would impact on the availability and recruitment of food resources for this species and presence of potential roost sites in rainforest habitats. The food tree species (*Banksia*, *Melaleuca* spp. and other heath flora) currently exist in a fire adapted landscape and may be pioneer species in early successional regeneration following fire.

The Common Blossom Bat is a wide-ranging species adapted to moving across fragmented landscapes to find food resources that are seasonally and spatially separated. Any impacts from change of habitat condition associated with altering disturbance regimes near the road may be offset by their ability to move widely throughout the landscape and access broad areas.

How is the project likely to affect habitat connectivity?

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of some species and fauna groups more than others for example small ground-dwelling mammals, reptiles and amphibians with smaller home range and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10).

The highly mobile Blossom Bat is adapted to moving across the landscape to access seasonally available food resources and move between roost and foraging habitat. Much of the habitat for this species in the region is continuous and associated with the larger national parks.

How is the project 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.

Rufous Bettong

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

A population of Rufous Bettong has been identified from north of Woolgoolga through to Halfway Creek, Wells Crossing, Glenugie and Pillar Valley. The population occupies habitat in Glenugie State Forest, Wells Crossing Flora Reserve, Yuraygir State Conservation Area and National Park. The regional population is widespread in relation to the distribution of dry sclerophyll forests and grassy woodlands. Forestry ecologists from Department of Infrastructure and Industry have recorded this species widely in Glenugie State Forest and from a wide variety of habitats (Brian Tolhurst; *pers comm*.).

The species is recorded in sparsely grassed, lightly timbered open forest and woodland and particular favours open grassy understorey and a high diversity of groundcover flora associated with its dietary needs. The association with riparian areas in the study area may be related to the groundcover flora diversity and density of logs or Blady Grass (*Imperata cylindrica*) for shelter and nesting. Individuals have been observed in the study area in cleared paddocks along the edge of open forest areas.

The removal of known and potential habitat would impact on foraging, breeding and sheltering life-cycle activities. The loss would likely impact on the home range territory of a number of individuals, remove a percentage of the shelter and foraging resources for these animals and potentially disrupt a breeding season. The number of animals affected in relation to the size of local population is not known. Given the widespread occurrence of records of the species (Department of Infrastructure and Industry and Office of Environment and Heritage Atlas of NSW Wildlife) in the locality it could be reasonably expected the proportion the population impacted would be minor and not lead to a significant impact on the population as a whole. The project also has potential to impacts on dispersal and movements of individuals within the population leading to genetic isolation.

Measures to mitigate the effects of fragmentation have been considered in the design and placement of fauna underpass structures aimed at facilitating crossing of the highway to access available habitat and allow genetic exchange. Suitable habitat is widespread and common providing continued habitat for local populations.

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

The species is recorded in sparsely grassed, lightly timbered open forest and woodland and particularly favours open grassy understorey and a high diversity of groundcover flora associated with its dietary needs. The association with riparian areas in the study area may be related to the groundcover flora diversity and density of logs or Blady Grass (*Imperata cylindrica*) for shelter and nesting. Individuals have been observed in the study area in cleared paddocks along the edge of open forest areas.

The project would remove up to 443 hectares of open forest and woodland vegetation, this would include the loss of foraging resources and habitat connectivity particularly in the area around Nine Mile Creek and Eight Mile Lane which is frequented by this species.. The overall reduction of habitat is a small proportion of the available potential habitat. Populations are considered to persist following construction of the project. Measures to mitigate the barrier effect of the road have been considered in the design and placement of underpass structures to maintain connectivity.

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

The project study area is not the limit of the species distribution. The Rufous Bettong is known from coastal and sub-coastal NSW and Queensland from north of Newcastle to Cooktown, Queensland.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime. Similarly, frog species adapted to the current flooding regime have potential to be negatively impacted by a change in the movements of floodwaters. The development of basins for holding water has potential to favour introduced species such as Plague Minnow (*Gambusia holbrooki*) and Cane Toad (*Bufo marinus*).

The greatest potential impact may be from changed fire frequency or fire spread, as this would impact on the availability of food resources and the structure of the habitats.

It is difficult to predict the degree of change in fire regimes or spatial and temporal scale. It is unlikely that the project would significantly alter fire spread on a landscape level as the project traverses a largely fragmented landscape or duplicates the existing highway in densely vegetated areas such as Tabbimoble and Doubleduke state forests and Broadwater National Park. There is no data on the fire regime across the study area. This species is common in simplified forest and woodland habitats of Glenugie State Forest (SKM 2009) and agricultural lands from Pillar Valley to Glenugie suggesting a tolerance of modified landscapes or habitats subject to frequent fire regimes.

How is the project likely to affect habitat connectivity?

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of small ground-dwelling mammals, reptiles and amphibians and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10).

The project has potential to create an east-west barrier the identified population of Rufous Bettong from north of Woolgoolga through to Halfway Creek, Wells Crossing, Glenugie and Pillar Valley. The population occupies habitat in Glenugie State Forest, Wells Crossing Flora Reserve, Yuraygir State Conservation Area and National Park. Much of the habitat of the species is already fragmented by the existing highway.

How is the project 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.

Eastern Pygmy Possum

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

Found in a broad range of habitats from rainforest through sclerophyll (including Box-Ironbark) forest and woodland to heath, but in most areas woodlands and heath appear to be preferred, except in north-eastern NSW where they are most frequently encountered in rainforest.

Feeds largely on nectar and pollen collected from banksias, eucalypts and bottlebrushes; an important pollinator of heathland plants such as banksias; soft fruits are eaten when flowers are unavailable. Also feeds on insects throughout the year; this feed source may be more important in habitats where flowers are less abundant such as wet forests.

Shelters in tree hollows, rotten stumps, holes in the ground, abandoned bird-nests, Ringtail Possum dreys or thickets of vegetation, (eg grass-tree skirts); nest-building appears to be restricted to breeding females; tree hollows are favoured but spherical nests have been found under the bark of eucalypts and in shredded bark in tree forks.

Removal of potential habitat would displace and disrupt individuals and affect breeding success. The species was not recorded from the project boundary surveys and there is no data on the population distribution and abundance. As habitat types for this species are broad, the project is likely to affect foraging, sheltering and breeding life-cycle events for this species. The species is widespread but uncommon throughout the northern rivers region and has been recorded in a diversity of wet forest and rainforest habitats including sites dominated by Camphor Laurel.

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

The project would see the clearing of 10 hectares of lowland rainforest and 329 hectares of moist forest habitat containing potential habitat. Due to the high degree of fragmentation of this habitat in the study area it is likely that only a fraction of this habitat is occupied by this species. These areas may only provide marginal or occasional resources. Potential for increased fire events near roadside environments may have an indirect impact on adjacent retained habitats as would run-off from the road.

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

Western slopes and coastal plains of the Great Dividing Range from south-east Queensland to south-east South Australia.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime. Similarly, frog species adapted to the current flooding regime have potential to be negatively impacted by a change in the movements of floodwaters. The development of basins for holding water has potential to favour introduced species such as Plague Minnow (*Gambusia holbrooki*) and Cane Toad (*Bufo marinus*).

The greatest potential impact may be from changed fire frequency or fire spread, as this would impact on the availability of food resources and the structure of the habitats for this species. This species is linked to over 60 different vegetation classes including rainforests, wet and dry sclerophyll forest, and heath.

It is difficult to predict the degree of change in fire regimes or spatial and temporal scale. It is unlikely that the project would significantly alter fire spread on a landscape level as the project traverses a largely fragmented landscape or duplicates the existing highway in densely vegetated areas such as Tabbimoble and Doubleduke state forests and Broadwater National Park. There is no data on the fire regime across the study area.

How is the project likely to affect habitat connectivity?

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of small ground-dwelling mammals, reptiles and amphibians and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10).

There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River.

The widening of the existing Pacific Highway in some areas would exacerbate the current barrier effect of the highway on regional and local populations of fauna, including the eastern pygmy possum.

As part of the response to mitigate and minimise this barrier effect for these species, RMS has developed a strategy with the aim of providing connectivity structures and enhancing landscape connectivity where feasible and reasonable in strategic locations. The Biodiversity Connectivity Strategy is detailed in Chapter 5 and Appendix A.

How is the project 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.

Gliders (Yellow-bellied Glider and Squirrel Glider)

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

The distribution of the Yellow-bellied Glider in the North Coast Bioregion is widespread across slopes, ranges and coastal areas being largely restricted to the large key habitats and corridors. It is generally absent from the heavily fragmented alluvial floodplains, wetlands and north of the Richmond River in the coastal heath and floodplains.

There are two main locations of Yellow-bellied Glider population intersected by the project:

- Woolgoolga to Glenugie including Halfway Creek, Wells Crossing and Glenugie State Forest (Sections 1 and 2)
- Bundjalung National Park to Devils Pulpit, Tabbimoble State Forest and Doubleduke State Forest (Sections 6 and 7).

These populations are largely associated with the taller, mature dry and moist sclerophyll forests on nutrient rich soils. They rely primarily on plant and insect exudates, including nectar, sap, honeydew and manna with pollen and insects providing protein and are dependent of tree hollows for shelter and breeding.

The species is very mobile and occupy large home ranges between 20 to 85 hectares to encompass dispersed and seasonally variable food resources (Goldingay and Kavanagh 1991).

The distribution of the Squirrel Glider throughout the North Coast Bioregion is widespread within a range of habitats, dominated by coastal sclerophyll forests and swamp forests, but extends into drier forests and woodlands of the tablelands in the northern regions. They frequent habitats with an abundant and varied supply of nectar and arthropods (Kavanagh 1984).

There are three broad locations of Squirrel Glider population intersected by the project:

- Woolgoolga to Glenugie including Halfway Creek, Wells Crossing and Glenugie State Forest (Sections 1 and 2)
- The slopes of the Summervale Range from Pillar Valley to Pine Brush State Forest and Gulmarrad (Section 3)
- Bundjalung National Park to Devils Pulpit, Tabbimoble State Forest and Doubleduke State Forest (Sections 6 and 7).

These populations are largely associated with the mature dry and moist sclerophyll forests on both sandy and clay soils. They rely primarily on a diversity of eucalypt species in the canopy and in some locations, Banksia and Melaleuca to supply the nectar supply. They are also dependent on tree hollows for shelter and breeding which limits their distribution to older growth remnants. However, Squirrel Gliders have also been recorded denning in isolated paddock trees, so they are capable of traversing partially cleared land.

Potential impacts for both species are associated with the loss of habitat including potential den sites, fragmentation and the barrier effect of the high leading to increased isolation of family groups and reduced genetic diversity. The severity of the impact on a regional scale is low as the species is widespread over a large portion of the bioregion, although localised impacts in areas discussed may be more moderate. The impacts of the barrier effect and fragmentation have been addressed via a focus on this species in the Biodiversity

Connectivity Strategy (Appendix A). Large areas of habitat would remain in state forests and reserved habitats for the longer-terms viability of these species.

The lifecycle activities affected by clearing of habitat for the project include displacement and disruption to breeding and foraging, particularly through the removal of den trees and hollow-bearing trees. This impact would also affect social interaction and the maintenance of family territories. It is likely that populations would remain stable in these locations given the extent of suitable habitat however it would be desirable to mitigate the effect of fragmentation from the project on these species through the addition of canopy crossing and widened medians at this has been addressed in the fauna mitigation strategy for the project.

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

The project is likely to remove a portion of the home range territory of several family groups for each species in the identified important population areas. There is no specific data on the home range of these group or known den trees, so the extent of this impact on the local populations is not known, although data on the species suggest home ranges can extend as large as 60 hectares (Goldingay and Kavanagh 1991). The groups identified near the road corridor would be part of a larger population which extends into the surrounding state forests, private lands and national park to the east and west.

The long-term persistence of gliders requires a landscape mosaic of old growth trees and tree diversity which meets both their foraging and sheltering needs. Such habitat is present throughout adjoining habitats in the larger state forests particularly in riparian areas. Clearing of riparian forest would be minimised during construction and hollow trees marked prior to clearing to protect these features wherever possible.

Yellow-bellied gliders need to occupy large home ranges as their 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.

Does the project 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 and is not at the limit of its distribution in the study area.

The Squirrel Glider occurs along Great Dividing Range from central Cape York to near Stanwell in western Victoria, the species is not at the limit of its distribution in the study area.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime.

The greatest potential impact may be from changed fire frequency or fire spread, as this would impact on the availability of food resources and the structure of the habitats for these species including the presence of den trees (hollows). It is difficult to predict the degree of change in fire regimes or spatial and temporal scale. It is unlikely that the project would significantly alter fire spread on a landscape level as the project traverses a largely fragmented landscape or duplicates the existing highway in densely vegetated areas such as Tabbimoble and Doubleduke state forests and Broadwater National Park. There is no data on the fire regime across the study area.

How is the project likely to affect habitat connectivity?

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of small ground-dwelling mammals, reptiles and amphibians and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the upgrade would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10).

There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River.

The widening of the existing Pacific Highway in some areas would exacerbate the current barrier effect of the highway on regional and local populations of fauna, including these glider species.

As part of the response to mitigate and minimise this barrier effect for these species, RMS has developed a strategy with the aim of providing connectivity structures and enhancing landscape connectivity where feasible and reasonable in strategic locations. The Biodiversity Connectivity Strategy is detailed in Chapter 5 and Appendix A.

How is the project 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.

Brush-tailed Phascogale

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

The Brush-tailed Phascogale is largely arboreal and occupies intact and fragmented dry open sclerophyll forests and woodlands with an open ground layer and moderate density of trees and shrubs in the mid-stratum. The species is dependent on tree hollows for shelter and breeding, using many different hollows within its range over a short time span (Trail and Coates 1993). Individuals forage preferentially in rough-barked trees of 25 centimetres or greater.

There are three broad locations where known populations are affected by the project:

- Woolgoolga to Glenugie including Halfway Creek, Wells Crossing and Glenugie State Forest (Section1-2).
- Pillar Valley to Harwood (Section 3 and 4) in the foot slopes of the Summervale Range extending to intact and fragmented habitats on lower undulating lands near Bostock Road, Sommervale Road to Tyndale and Gulmarrad and upper Shark Creek.
- Bundjalung National Park to Devils Pulpit, Tabbimoble State Forest and Doubleduke State Forest (Sections 6 and 7).

Potential impacts are associated with loss of habitat, in particular those containing hollow-bearing trees and the barrier effect of the highway as well as potential for increased predation associated with fragmentation and degradation of habitat adjoining the project. These impacts would temporarily affect dispersal, foraging, sheltering and breeding events. The severity of the impact on a regional scale is low, as the species is widespread over a large portion of the bioregion.

The impacts of the barrier effect and fragmentation have been addressed via a focus on these species in the Biodiversity Connectivity Strategy (Appendix A). The species is tolerant of modified and fragmented habitats as evidenced by the size of the populations and habitats used in Glenugie State Forest and adjacent grazed and slashed habitats in the Pillar Valley to Tyndale area.

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

The species distribution in the NSW North Coast Bioregion largely extends on the eastern slopes and ranges of the Great Dividing Range from Port Macquarie to the Queensland border and coming to the coast between Coffs Harbour and Woodburn. Records are generally widespread however there are known hotspots in the area from Halfway Creek (Section 2) to Eight Mile Lane including Glenugie State Forest, Nine Mile Creek and Pillar Valley to Tucabia (Section 3). This population is associated with dry sclerophyll forest on sandy and clay soils and includes the lower undulating lands and slopes of the Sommervale Range.

The species is recorded in sparsely grassed, lightly timbered open forest and woodland and particularly favours open grassy understorey. Individuals have been observed in the study area in clearings along the edge of open forest areas and the species is tolerant of logging, given its wide distribution in a number of state forests as determined by the distribution of records.

The project would remove up to 443 hectares of open forest and woodland vegetation; this would include the loss of foraging resources and habitat connectivity. The overall reduction of habitat is a small proportion of the available potential habitat. Populations are considered to persist following construction of the project. Measures to mitigate the barrier effect of the road have been considered in the design and placement of underpass structures to maintain connectivity.

Does the project 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 and the study area is not the limit of distribution for this species.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime.

The greatest potential impact may be from changed fire frequency or fire spread, as this would impact on the availability of food resources and the structure of the habitats for these species including the presence of den trees (hollows). It is difficult to predict the degree of change in fire regimes or spatial and temporal scale. It is unlikely that the project would significantly alter fire spread on a landscape level as the project traverses a largely fragmented landscape or duplicates the existing highway in densely vegetated areas such as Tabbimoble and Doubleduke state forests and Broadwater National Park. There is no data on the fire regime across the study area.

How is the project likely to affect habitat connectivity?

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of small ground-dwelling mammals, reptiles and amphibians and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to- 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10).

There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River.

The widening of the existing Pacific Highway in some areas would exacerbate the current barrier effect of the highway on regional and local populations of fauna, including the brush-tailed phascogale.

As part of the response to mitigate and minimise this barrier effect for these species, RMS has developed a strategy with the aim of providing connectivity structures and enhancing landscape connectivity where feasible and reasonable in strategic locations. The Biodiversity Connectivity Strategy is detailed in Chapter 5 and Appendix A.

How is the project 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.

Common Planigale

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

Common Planigale inhabit rainforest, eucalypt forest, heathland, marshland, grassland and rocky areas where there is surface cover, and usually close to water. They shelter in saucer-shaped nests built in crevices, hollow logs, beneath bark or under rocks, preying on insects and small vertebrates,

Removal of potential habitat would displace and disrupt individuals and affect breeding success. The species was recorded from Section 1 of the project boundary surveys and there is no data on the population distribution and abundance. As habitat types for this species are broad, the project is likely to affect foraging, sheltering and breeding life-cycle events for this species. The species is widespread but uncommon throughout the northern rivers region and has been recorded in a diversity of habitat conditions.

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

Common Planigale inhabit rainforest, eucalypt forest, heathland, marshland, grassland and rocky areas where there is surface cover, and usually close to water. The association with riparian areas may be related to the groundcover flora diversity and density of logs for shelter and nesting.

The project would remove up to 948 hectares of combined potential habitat for this species this would include the loss of foraging resources and habitat connectivity. The overall reduction of habitat is a small proportion of the available potential habitat for this species generalist species. Populations are considered to persist following construction of the project. Measures to mitigate the barrier effect of the road have been considered in the design and placement of underpass structures to maintain connectivity.

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

Occurs from the Hunter Valley in NSW across eastern and northern Australia in Northern Territory and Western Australia and is not at the limit of distribution into the study area.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime. Similarly, frog species adapted to the current flooding regime have potential to be negatively impacted by a change in the movements of floodwaters. The development of basins for holding water has potential to favour introduced species such as Plague Minnow (*Gambusia holbrooki*) and Cane Toad (*Bufo marinus*).

The greatest potential impact may be from changed fire frequency or fire spread, as this would impact on the availability of food resources and the structure of the habitats.

It is difficult to predict the degree of change in fire regimes or spatial and temporal scale. It is unlikely that the project would significantly alter fire spread on a landscape level as the project traverses a largely fragmented landscape or duplicates the existing highway in densely vegetated areas such as Tabbimoble and Doubleduke state forests and Broadwater National Park. There is no data on the fire regime across the study area. This species is common in simplified forest and woodland habitats suggesting a tolerance of modified landscapes or habitats subject to frequent fire regimes.

How is the project likely to affect habitat connectivity?

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of small ground-dwelling mammals, reptiles and amphibians and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10).

There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River.

The widening of the existing Pacific Highway in some areas would exacerbate the current barrier effect of the highway on regional and local populations of fauna, including the common planigale.

As part of the response to mitigate and minimise this barrier effect for these species, RMS has developed a strategy with the aim of providing connectivity structures and enhancing landscape connectivity where feasible and reasonable in strategic locations. The Biodiversity Connectivity Strategy is detailed in Chapter 5 and Appendix A.

How is the project 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.

Wallum Froglet

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

Wallum Froglets are found only in acid paperbark swamps and sedge swamps of the coastal 'wallum' country. The species is a late winter breeder. Populations of Wallum Froglet are abundant across the study area in appropriate habitat, in particular in the coastal areas of Yuraygir, Bundjalung and Broadwater national parks where populations are well conserved. The species occurs in a range of habitat conditions and disturbance regimes and is tolerant of cleared vegetation areas provided that the surface water conditions remain the same.

The longer-term viability of local populations of Wallum Froglet is not expected to be significantly impacted given the widespread distribution and abundance.

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

Wallum Froglets are found only in acid paperbark swamps and sedge swamps of the coastal 'wallum' country. The species is a late winter breeder. Males call in choruses from within sedge tussocks or at the water edge.

The coastal and subcoastal heathland and sedgeland habitats of the species are particularly fire-prone. The project could potentially increase the incidence of fire in the study area through opening up to traffic. However the project would involve duplication of the existing highway in locations that provide potential habitat for this species and therefore this risk is low.

Up to 10 hectares of wet and dry heath along the edges of the existing highway would be removed for the project, this provides potential habitat for this species, however there are no recent accounts of populations present near the highway.

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

The Wallum Froglet is not at the limit of its distribution in the study area, the species distribution extends from the NSW central coast to south-east Queensland.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime. Similarly, frog species adapted to the current flooding regime have potential to be negatively impacted by a change in the movements of floodwaters. The development of basins for holding water has potential to favour introduced species such as Plague Minnow (*Gambusia holbrooki*) and Cane Toad (*Bufo marinus*).

The potential increase in pollutants or sediments into waterways and wetlands may have a short to medium term impact the condition and structure of the habitat. Measures to mitigate this disturbance have been incorporated into the project.

How is the project likely to affect habitat connectivity?

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of small ground-dwelling mammals, reptiles and amphibians and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10).

There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River.

The widening of the existing Pacific Highway in some areas would exacerbate the current barrier effect of the highway on regional and local populations of fauna, including the wallum froglet.

As part of the response to mitigate and minimise this barrier effect for these species, RMS has developed a strategy with the aim of providing connectivity structures and enhancing landscape connectivity where feasible and reasonable in strategic locations. The Biodiversity Connectivity Strategy is detailed in Chapter 5 and Appendix A.

How is the project 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.

Green-thighed Frog

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

Green-thighed Frogs occur in a range of habitats from rainforest and moist eucalypt forest to dry eucalypt forest and heath, typically in areas where surface water gathers after rain. Breeding occurs following heavy rainfall in late spring and summer, with frogs aggregating around grassy semi-permanent ponds and flood-prone grassy areas. The frogs are thought to forage in leaf-litter.

The clearing of riparian habitat along drainage lines and the disruption to local hydrological conditions has the potential to affect the life-cycle of the species by changing the natural drainage patterns which reduce periodic local flooding. The species is reliant on these flooding events for breeding. This may happen along the project boundary and indirectly within adjacent potential habitats for this species.

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

The species has a widespread distribution that includes coastal habitat to the eastern slopes of the range, occurring in wet forests and moist sclerophyll forests including swamp and riparian habitats adjoining drier open forest types. The two main locations intersected by the project are:

- Woolgoolga to Glenugie including Halfway Creek, Wells Crossing and Glenugie State Forest (Section 1-2)
- Bundjalung National Park to Devils Pulpit, Tabbimoble State Forest and Doubleduke State Forest (Sections 6 and 7).

These populations are largely associated with the taller, mature moist sclerophyll forests and riparian habitats on nutrient rich soils.

Impacts would include direct loss of habitat over small discrete areas through crossing drainage and creek habitats and the indirect edge effects on remaining areas adjacent to the road. There is potential for detrimental changes to drainage patterns in important habitats if present in small and local scale in addition to altered water quality associated with polluted water from runoff and overflow of sediment basins in drainage areas.

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

The species occurs from the NSW central coast to south-east Queensland and is not at the limit of its distribution in the study area.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime. Similarly, frog species adapted to the current flooding regime have potential to be negatively impacted by a change in the movements of floodwaters. The development of basins for holding water has potential to favour introduced species such as Plague Minnow (*Gambusia holbrooki*) and Cane Toad (*Bufo marinus*).

The potential increase in pollutants or sediments into waterways and wetlands may have a short to medium term impact the condition and structure of the habitat. Measures to mitigate this disturbance have been incorporated into the project.

How is the project likely to affect habitat connectivity?

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of small ground-dwelling mammals, reptiles and amphibians and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10).

There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River.

The widening of the existing Pacific Highway in some areas would exacerbate the current barrier effect of the highway on regional and local populations of fauna, including the green-thighed frog.

As part of the response to mitigate and minimise this barrier effect for these species, RMS has developed a strategy with the aim of providing connectivity structures and enhancing landscape connectivity where feasible and reasonable in strategic locations. The Biodiversity Connectivity Strategy is detailed in Chapter 5 and Appendix A.

How is the project 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.

Giant Barred Frog

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

Giant Barred Frogs forage and live amongst deep, damp leaf litter in rainforests, moist eucalypt forest and nearby dry eucalypt forest. They breed around shallow, flowing rocky streams from late spring to summer. Due to the paucity of records of this species in the project boundary 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 project would impact on potential habitat via direct traverse of several small streams and gullies. The impact would be localised, restricted to the construction footprint and may impact on the breeding, dispersal and foraging activities of the species. Design measures have been incorporated to minimise the direct and indirect impact.

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

Giant Barred Frog was identified in Section 1 (Wedding Bells State Forest) and also identified in Yuraygir State Conservation Area near Section 2 and an unnamed creek in Section 9. Local populations are assumed to occur at these locations and are supported by atlas records of the species in these project sections. The large majority of regional records of this species occur in the wetter forests between Grafton and Coffs Harbour on the western side of the highway. These potential habitats would extend around the project through Section 2 and the southern and central parts of Section 3.

The project would impact on this potential habitat via the direct traverse of several small streams and gullies. The impact would be localised 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.

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

The species occurs from the NSW central coast to south-east Queensland and is not at the limit of its distribution in the study area.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime. Similarly, frog species adapted to the current flooding regime have potential to be negatively impacted by a change in the movements of floodwaters. The development of basins for holding water has potential to favour introduced species such as Plague Minnow (*Gambusia holbrooki*) and Cane Toad (*Bufo marinus*).

The potential increase in pollutants or sediments into waterways and wetlands may have a short to medium term impact the condition and structure of the habitat. Measures to mitigate this disturbance have been incorporated into the project.

How is the project likely to affect habitat connectivity?

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of small ground-dwelling mammals, reptiles and amphibians and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10).

There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River.

The widening of the existing Pacific Highway in some areas would exacerbate the current barrier effect of the highway on regional and local populations of fauna, including the giant barred frog.

As part of the response to mitigate and minimise this barrier effect for these species, RMS has developed a strategy with the aim of providing connectivity structures and enhancing landscape connectivity where feasible and reasonable in strategic locations. The Biodiversity Connectivity Strategy is detailed in Chapter 5 and Appendix A.

How is the project 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.

Olongburra Frog

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

The Olongburra Frog occurs in high rainfall coastal and near coastal low heathlands and sedgelands. The large majority of records of this species are associated with the extensive areas of coastal heath conserved in Yuraygir, Bundjalung and Broadwater national parks to the east of the project. Much of the habitat of the species in the region is conserved. There are no records around the project boundary, although there is potential for the species to occur in Broadwater National Park either side of the project. In this location, the project would duplicate the existing highway and have little direct impact on habitat. Indirect impacts may result through edge effects such as weeds and altered hydrological regimes including polluted run-off and the movements of frogs across the highway.

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

The coastal and subcoastal heathland and sedgeland habitats of the species are particularly fire-prone. The project could potentially increase the incidence of fire in the study area through opening up to traffic. However the project would involve duplication of the existing highway in locations that provide potential habitat for this species and therefore this risk is low.

Up to 10 hectares of wet and dry heath along the edges of the existing highway would be removed for the project, this provides potential habitat for this species.

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

The Olongburra Frog is not at the limit of its distribution in the study area, the species distribution extends from the NSW mid north coast to south-east Queensland.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime. Similarly, frog species adapted to the current flooding regime have potential to be negatively impacted by a change in the movements of floodwaters. The development of basins for holding water has potential to favour introduced species such as Plague Minnow (*Gambusia holbrooki*) and Cane Toad (*Bufo marinus*).

The potential increase in pollutants or sediments into waterways and wetlands may have a short to medium term impact the condition and structure of the habitat. Measures to mitigate this disturbance have been incorporated into the project.

How is the project likely to affect habitat connectivity?

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of small ground-dwelling mammals, reptiles and amphibians and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10).

There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River.

The widening of the existing Pacific Highway in some areas would exacerbate the current barrier effect of the highway on regional and local populations of fauna, including the Olongburra Frog; this would be most evident at Broadwater National Park.

As part of the response to mitigate and minimise this barrier effect for these species, RMS has developed a strategy with the aim of providing connectivity structures and enhancing landscape connectivity where possible in strategic locations. The Biodiversity Connectivity Strategy is detailed in Chapter 5 and Appendix A.

How is the project 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.

Koala

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

In coastal northern NSW, populations have been estimated to range from one animal every 45 hectares to one every 4.5 hectares (average one every 20 to 25 hectares) (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 population, while the extent of potential habitat to be removed by the project has been estimated at 550 hectares. The project would remove potential habitat for the koala through the clearing of vegetation communities containing the identified food tree species. The impact of this activity on the life-cycle of the species would include displacement from home range areas (foraging habitat), competition for resources and disruption to breeding activities. Suitable food resources are common and widespread in the region and not restricted to the project boundary. Further the provision of dedicated crossing structures is designed to prevent the isolation of potential habitat for local populations such that the broader area of occupancy of the population would not be reduced.

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

There are over 11,000 recorded koala sightings in the NSW Atlas for the NSW North Coast Bioregion, spread over all local government areas in a wide range of topographies and habitats. This suggests that koalas could occur in all project sections in a range of habitats that would be impacted by the project. The two main centres of high density of koala records occur around Coffs Harbour, south of Woolgoolga (outside of the project), and in Richmond Valley LGA between Woodburn and Ballina (Sections 9, 10 and 11).

Important koala populations in the study are have been identified from Ashby, Iluka and Woombah (Clarence Valley Council 2010) to the east of the project boundary, also the western regions of the Clarence Valley LGA (Clarence Valley Council 2010), northern regions of the Coffs Harbour LGA (Coffs Harbour City Council 1999) and the west of Woodburn in the larger state forests of the Richmond LGA (AKF 2008). The project would not impact on these populations.

Impacts on koala relate primarily to the clearing of around 580 hectares of habitat containing the primary koala feed tree species Forest Red Gum (*E. tereticornis*), Swamp Mahogany (*E. robusta*) and Tallowwood (*E.microcorys*). The species could also be negatively affected by fragmentation and the barrier effect of the highway and is regularly struck by cars where high-density populations occur in fragmented urban habitats. The impacts of the barrier effect and fragmentation have been addressed via a focus on this species in the Biodiversity Connectivity Strategy (Appendix A). Large areas of habitat would remain in the landscape including state forests and reserved habitats for the longer-term viability of this species.

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

The species occurs from the NSW central coast to south-east Queensland and is not at the limit of its distribution in the study area.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime. Similarly, frog species adapted to the current flooding regime have potential to be negatively impacted by a change in the movements of floodwaters. The development of basins for holding water has potential to favour introduced species such as Plague Minnow (*Gambusia holbrooki*) and Cane Toad (*Bufo marinus*).

The potential increase in pollutants or sediments into waterways and wetlands may have a short to medium term impact the condition and structure of the habitat. Measures to mitigate this disturbance have been incorporated into the project.

How is the project likely to affect habitat connectivity?

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of small ground-dwelling mammals, reptiles and amphibians and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10).

There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River.

The widening of the existing Pacific Highway in some areas would exacerbate the current barrier effect of the highway on regional and local populations of fauna, including the koala.

As part of the response to mitigate and minimise this barrier effect for these species, RMS has developed a strategy with the aim of providing connectivity structures and enhancing landscape connectivity where feasible and reasonable in strategic locations. The Biodiversity Connectivity Strategy is detailed in Chapter 5 and Appendix A.

How is the project 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.

Grey-headed Flying-fox

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

There have been no roost camps identified in the project boundary to date and at the time of the EIS the project would not directly impact on any known breeding / maternity site. The nearest known camp is at Maclean around 500 metres west of the route.

Therefore it is likely that the impacts of construction and operation of the project would be confined to loss of feeding habitat caused by 1) direct clearing or damage to native vegetation during the construction phase and 2) edge effects during operation related to degradation of habitat at the interface with cleared land and altered feeding behaviours of flying foxes.

The project would directly remove around 948 hectares of vegetation with additional indirect impacts expected through edge effects. This area of habitat may be defined as a portion of the potential area of occupancy for feeding life-cycle attributes of the population. However as stated, the affected area of foraging habitat would represent a small percentage of the total extent of important foraging vegetation types present within a 50 kilometre radius of the project boundary. Given the widespread nature and abundance of potential foraging habitat within the feeding range of regional populations, the project is not expected to significantly reduce the area of occupancy of an important population.

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

The project would remove about 948 hectares of vegetation comprising a diversity of dry open forests, most forests, rainforests and heath. Ongoing habitat removal, particularly in coastal areas is a continual threat to this species. Other threats include disturbance and modification of habitat near roosting camps and electrocution from contacting overhead wires. The nearest known roost camps for this species are at Maclean (500 metres west) and Susan Island in Grafton (15 kilometres west) and there are no roost camps within the project boundary at the time of the EIS.

Foraging resources for the Grey-headed Flying-fox occur throughout all naturally vegetated areas of the study area and it is likely that the vegetation to be cleared provides a portion of the foraging range of local populations of Grey-headed Flying-foxes given the proximity of the roost camps and the known foraging range of this species. The project boundary is within the range of several roost camps in northern NSW located between Coffs Harbour and Ballina.

The project removal of 948 hectares is considered a sustainable loss of potential foraging habitat in the context of available habitat in the surrounding region, including several state forests and conservation reserves and considering the broad foraging requirements of the species. The proposed action would not result in a decrease in the size of a local population and would not impact on a known roost site.

Life-cycle characteristics of the species at threat from habitat clearing relate to the loss of critical foraging habitat within a 50 kilometre radius of known camps (DECCW 2009). This is the expected maximum foraging distance of the species from a roost site (Eby 1996).

Given the absence of a roost camp in the project boundary, the impacts of construction and operation of the project relate to loss of feeding habitat caused by 1) direct clearing or damage to native vegetation during the construction phase and 2) edge effects during operation related to degradation of habitat at the interface with cleared land and altered feeding behaviours of flying foxes. It is likely that flying foxes would avoid feeding near the highway once it is operational, causing loss of feeding opportunities in those areas.

Construction and operation of the project would result in the loss of around 948 hectares of native vegetation from 57 vegetation types. Additional flying fox foraging habitat would be impacted through edge effects. The affected foraging dry open forest habitats contain a diversity of highly productive plants in the blossom diet of flying foxes including *Corymbia intermedia, Eucalyptus pilularis, Eucalyptus. robusta, Eucalyptus siderophloia* and *Melaleuca quinquenervia* (Eby and Law 2008). A diverse range of fruit-producing diet species dominate the lowland rainforest and moist floodplain forest habitats.

The affected area of foraging habitat would represent a small percentage of the total extent of these vegetation types within a 50 kilometre radius of the project boundary. Similarly, vegetation types containing known diet species as dominants or subdominants are widespread in the study area and the overall impact of loss of these species would be ameliorated by their prevalence in a broad range of vegetation types such that this project is unlikely to lead to a long-term decrease in the size of the population.

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

The species occurs from the NSW central coast to south-east Queensland and is not at the limit of its distribution in the study area.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime. Similarly, frog species adapted to the current flooding regime have potential to be negatively impacted by a change in the movements of floodwaters. The development of basins for holding water has potential to favour introduced species such as Plague Minnow (*Gambusia holbrooki*) and Cane Toad (*Bufo marinus*).

The potential increase in pollutants or sediments into waterways and wetlands may have a short to medium term impact the condition and structure of the habitat. Measures to mitigate this disturbance have been incorporated into the project.

How is the project likely to affect habitat connectivity?

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of small ground-dwelling mammals, reptiles and amphibians and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10).

There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River.

The widening of the existing Pacific Highway in some areas would exacerbate the current barrier effect of the highway on regional and local populations of fauna, including the Grey-Headed Flying-fox.

As part of the response to mitigate and minimise this barrier effect for these species, RMS has developed a strategy with the aim of providing connectivity structures and enhancing landscape connectivity where feasible and reasonable in strategic locations. The Biodiversity Connectivity Strategy is detailed in Chapter 5 and Appendix A.

How is the project 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.

Spotted-tailed Quoll

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

Potential impacts for the species are associated with the loss of habitat including potential den sites, fragmentation and the barrier effect of the highway potentially leading to increased genetic isolation and decreased dispersal ability. The species is known to frequent roadsides feeding on roadkill and where would be threatened by vehicle strike. The severity of the impact on a regional scale is low as the species is very widespread over a large portion of the bioregion, although localised may be more moderate. The impacts of the barrier effect and fragmentation have been addressed via a focus on this species in the Biodiversity Connectivity Strategy (Appendix A).

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 and may include adjacent modified patches of forest on farmland. Suitable habitat is well represented in the larger fragments of forest in the study area, particularly state forests and adjoining private properties and national park estate. The project would remove potential habitat for the species however the overall reduction of habitat is a small proportion of the available potential habitat.

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

The species is very widespread throughout all areas and habitats of the North Coast Bioregion. There are no records of particular clusters near the project that would suggest an important population exists. However based on the habitats present, in particular the larger state forests and conservation reserves, two main areas exist which may represent important habitat for regional populations. These are the areas from Woolgoolga to Glenugie including Halfway Creek, Wells Crossing and Glenugie State Forest (Sections1 and 2) and Bundjalung National Park to Devils Pulpit, Tabbimoble State Forest and Doubleduke State Forest (Sections 6 and 7). These habitats are largely associated with the mature dry and moist sclerophyll forests on both sandy and clay soils. Large areas of habitat would remain in state forests and reserved habitats for the longer-terms viability of this species.

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

The species occurs from the NSW central coast to south-east Queensland and is not at the limit of its distribution in the study area.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime. Similarly, frog species adapted to the current flooding regime have potential to be negatively impacted by a change in the movements of floodwaters. The development of basins for holding water has potential to favour introduced species such as Plague Minnow (*Gambusia holbrooki*) and Cane Toad (*Bufo marinus*).

The potential increase in pollutants or sediments into waterways and wetlands may have a short to medium term impact the condition and structure of the habitat. Measures to mitigate this disturbance have been incorporated into the project.

How is the project likely to affect habitat connectivity?

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of small ground-dwelling mammals, reptiles and amphibians and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10).

There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River.

The widening of the existing Pacific Highway in some areas would exacerbate the current barrier effect of the highway on regional and local populations of fauna, including the spotted-tailed quoll.

As part of the response to mitigate and minimise this barrier effect for these species, RMS has developed a strategy with the aim of providing connectivity structures and enhancing landscape connectivity where feasible and reasonable in strategic locations. The Biodiversity Connectivity Strategy is detailed in Chapter 5 and Appendix A.

How is the project 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.

Regent Honeyeater

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

The species is an occasional visitor to the region during peak flowering events of the dominant trees, particularly the winter flowering Large-leaved Spotted Gum (*Corymbia henryi*) and Swamp Mahogany (*E.robusta*). There are no breeding records in the study area and the extent of habitat remaining in the study area would provide sufficient resources to sustain future visitation.

The project would contribute to the loss of potential foraging habitat throughout the distributional range of the Regent Honeyeater and therefore potentially impact on the foraging and movement life-cycle.

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

The species is an occasional visitor to the region during peak flowering events of the dominant trees, particularly the winter flowering Large-leaved Spotted Gum (*Corymbia henryi*) and Swamp Mahogany (*E.robusta*). The project would remove around 146.9 hectares of habitat containing Spotted Gum and around 44 hectares of habitat dominated by Swamp Mahogany.

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

No, the species is an occasional visitor to the region and its distribution extends across Victoria and NSW.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease.

Further, retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime.

How is the project likely to affect habitat connectivity?

The species is an occasional visitor to the region and there are no known permanent populations within the study area. This species is wide-ranging and capable of moving widely through the landscape to access spatially and temporally separated food resources.

How is the project 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.

Swift Parrot

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

The species is an occasional visitor to the region during peak flowering events of the dominant trees, particularly the winter flowering Large-leaved Spotted Gum (*Corymbia henryi*) and Swamp Mahogany (*E.robusta*). There are no breeding records in the study area and the extent of habitat remaining in the study area would provide sufficient resources to sustain future visitation. The project would contribute to the loss of potential foraging habitat throughout the distributional range of the Swift Parrot and therefore potentially impact on the foraging and movement life-cycle.

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

The species is an occasional visitor to the region during peak flowering events of the dominant trees, particularly the winter flowering Large-leaved Spotted Gum (*Corymbia henryi*) and Swamp Mahogany (*E.robusta*). The project would remove around 146.9 hectares of habitat containing Spotted Gum and around 44 hectares of habitat dominated by Swamp Mahogany.

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

No, the species is an occasional visitor to the region and its distribution extends from Tasmania to south-eat Queensland.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime.

How is the project likely to affect habitat connectivity?

The species is an occasional visitor to the region and there are no known permanent populations within the study area. This species is wide-ranging and capable of moving widely through the landscape to access spatially and temporally separated food resources.

How is the project 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.

Little Lorikeet

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

Little lorikeets are known to occupy a diversity of forest and woodland habitats, including old-growth and logged forests, and remnant woodland patches and roadside vegetation (Pizzey & Knight 1997, DECC 2008). The species is generally considered to be nomadic, with irregular large or small influxes of individuals occurring at any time of year, apparently related to food availability (DECC 2008). However, they do exhibit some site fidelity, with breeding pairs resident from April to December, and even during their non-resident period some individuals will return to the nest area for short periods if there is some tree-flowering in the vicinity.

They feed in small flocks, often with other species of lorikeet, primarily on nectar and pollen in the tree canopy. They prefer profusely flowering eucalypts but will also feed in other species such as melaleucas and mistletoes. The species breeds in tree hollows in living trees, during May to September, raising clutches of three to five eggs (DECC 2008). They likely commence breeding at one year, and live for around 10 years in the wild.

Major threats to little lorikeets are loss of breeding sites and food resources from ongoing land clearing. Loss of nest trees from road-side verges, often associated with road works, remains an ongoing threat (DECC 2008).

The study area would constitute breeding and non-breeding habitat for the little lorikeet in New South Wales. The loss of hollow-bearing and feed trees would directly affect the species opportunity to feed and breed in the area. However the study area is not considered a critical area for the little lorikeet as extensive areas of suitable habitat occur elsewhere in the region. The current potential for the species to occur based on the presence of potential foraging and breeding habitat is expected to remain after completion of the project such that foraging, movement and other life-cycle attributes would not be impacted.

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

The project would remove about 948 hectares of vegetation comprising a diversity of dry open forests, most forests, rainforests and heath. In considering the potential habitat for the species in the study area, it is likely that all the open forest habitats present at the study area, provide opportunities for foraging and breeding. The project would remove up to 443 hectares of dry open forest and woodland. This loss is considered moderate but only a relatively low portion of the habitat used by and available to this species in the bioregion. Large areas of high quality habitat are represented outside the road corridor in several regional State Forests, conservation reserves and rural properties. The potential for continued visitation to the region is expected following construction of the project.

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

The distribution of the little lorikeet extends from just north of Cairns, around the east of Australia, to Adelaide (DECC 2008). In NSW the species is distributed in forests and woodlands from the coast to the western slopes of the Great Dividing Range. Hence the study area is not at the limit of the species known distribution.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime.. Measures to mitigate this disturbance have been incorporated into the project.

How is the project likely to affect habitat connectivity?

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of small ground-dwelling mammals, reptiles and amphibians and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10).

There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River.

The widening of the existing Pacific Highway in some areas would exacerbate the current barrier effect of the highway on regional and local populations of fauna, however this is not expected to negatively impact on the wide-ranging nomadic movements of this species.

As part of the response to mitigate and minimise this barrier effect for these species, RMS has developed a strategy with the aim of providing connectivity structures and enhancing landscape connectivity where feasible and reasonable in strategic locations. The Biodiversity Connectivity Strategy is detailed in Chapter 5 and Appendix A.

How is the project 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.

Brown Treecreeper

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

Potential habitat for the species is common but restricted the central parts of the study area (Sections 2 to 7) and largely absent from the wetter forests of the southern and northern ends of the project. Brown Treecreeper was found to be associated with the Grey Box / Spotted Gum habitat types and particularly grassy woodlands. The Brown Treecreeper is an obligate hollow nesting species and the clearing of woodland and dry sclerophyll forest containing tree hollows would impact on the breeding resources and lifecycle of the Brown Treecreeper. However not all dry open forest habitats are suitable and the species mainly inhabits woodlands dominated by stringybarks or other rough-barked eucalypts, usually with an open grassy understorey. These habitat types are well represented beyond the project boundary and only moderately present across the project area.

Other life-cycle activities potentially affected by the project include breeding and roosting as a direct result of habitat loss and foraging activities due to a reduction in insect prey abundance. The clearing of habitat is unlikely to significantly alter dispersal activities as many woodland bird species, in particular Brown Treecreeper, are adapted to moving across gaps in woodland and forest and cleared habitats for dispersal and foraging forays (Doerr *et al* 2011). The number of birds affected in relation to the size of local populations is not known, however records are widespread and it could be reasonably expected the proportion of the population impacted would be minor and not lead to a significant impact on the population as a whole.

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

The project would remove around 948 hectares of forest habitat comprising wet and dry sclerophyll forests and heathlands. Of this around 550 hectares (58 per cent) consists of open dry sclerophyll forests and woodlands that could potentially be used by this species. This would result in the loss of foraging and breeding habitat and may have a short term impact on food resources. However the habitats suited to this species are particularly well represented in the region, particularly to the east and south of the study area. The overall reduction of habitat is considered a small proportion of the available potential habitat. Populations are considered to persist following development of the project. In addition observations of these species in Grey Box woodland in Glenugie State Forest (SKM 2009) indicates a presence in simplified habitats that are subject to frequent fire regimes and disturbances associated with selective logging.

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

The project study area is not at the limit of distribution for the Brown Treecreeper which approaches the coast in northern NSW and southern Queensland, elsewhere their distribution is inland.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime. Similarly, frog species adapted to the current flooding regime have potential to be negatively impacted by a change in the movements of floodwaters. The development of basins for holding water has potential to favour introduced species such as Plague Minnow (*Gambusia holbrooki*) and Cane Toad (*Bufo marinus*).

The potential increase in fires adjacent to the road or change in disturbance associated with increased pollutants or sediments into waterways may have a short to medium term impact the condition and structure of the habitat. Observations of this species in Grey Box woodland in Glenugie State Forest (SKM 2009) indicates a presence in simplified habitats that are subject to frequent fire regimes and disturbances associated with selective logging.

How is the project likely to affect habitat connectivity?

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of some species and fauna groups more than others for example small ground-dwelling mammals, reptiles and amphibians with smaller home range and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10). These project sections occur within a range of habitats suitable for these species.

There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River.

These mobile species are adapted to moving across forest clearings such as roads to access foraging, roosting and nesting habitat. Woodland bird species typically use a foray-based search strategy to move through fragmented landscapes, making exploratory movements but returning to an established home range area (Doerr *et al* 2011). The interruptions to connectivity in the landscape may be more associated with dispersal ability in addition to foraging movements between fragmented habitats. In their study of gap crossing by five woodland birds species Doerr *et al* (2011) determined that birds were able to cross gaps between habitat patches of up to 100 metres.

How is the project 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.

Black-chinned Honeyeater

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

Habitat for this species is common but restricted the central parts of the study area (Sections 2 to 7) and largely absent from the wetter forests of the southern and northern ends of the project. Black-chinned Honeyeater was found to be associated with the Grey Box / Spotted Gum habitat types and particularly grassy woodlands. The clearing of woodland and dry sclerophyll forest would impact on the breeding resources and lifecycle of the species, however not all dry open forest habitat are suitable and the species mainly inhabits woodlands dominated by stringybarks or other rough-barked ironbark eucalypts, usually with an open grassy understorey. These habitat types are well represented beyond the project boundary.

Other life-cycle activities potentially affected by the project include breeding and roosting as a direct result of habitat loss and foraging activities due to a reduction in insect prey abundance. The clearing of habitat is unlikely to significantly alter dispersal activities. The number of birds affected in relation to the size of local populations is not known, however records are widespread and it could be reasonably expected the proportion of the population impacted would be minor and not lead to a significant impact on the population as a whole.

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

The project would remove around 550 hectares of open dry sclerophyll forests and woodlands that could potentially be used by this species. This would result in the loss of foraging and breeding habitat and may have a short term impact on food resources. However the habitats suited to these species are particularly well represented in the region, particularly to the east and south of the study area. The overall reduction of habitat is considered a small proportion of the available potential habitat. Populations are considered to persist following development of the project. In addition observations of these species in Grey Box woodland in Glenugie State Forest (SKM 2009) indicates a presence in simplified habitats that are subject to frequent fire regimes and disturbances associated with selective logging.

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

The project study area is not at the limit of distribution for this species which approaches the coast in northern NSW and southern Queensland, elsewhere their distribution is inland.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime.

The potential increase in fires adjacent to the road or change in disturbance associated with increased pollutants or sediments into waterways may have a short to medium term impact the condition and structure of the habitat. Observations of this species in Grey Box woodland in Glenugie State Forest (SKM 2009) indicates a presence in simplified habitats that are subject to frequent fire regimes and disturbances associated with selective logging.

How is the project likely to affect habitat connectivity?

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of some species and fauna groups more than others for example small ground-dwelling mammals, reptiles and amphibians with smaller home range and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10). These project sections occur within a range of habitats suitable for these species.

There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River.

These mobile species are adapted to moving across forest clearings such as roads to access foraging, roosting and nesting habitat. Woodland bird species typically use a foray-based search strategy to move through fragmented landscapes, making exploratory movements but returning to an established home range area (Doerr *et al* 2011). The interruptions to connectivity in the landscape may be more associated with dispersal ability in addition to foraging movements between fragmented habitats. In their study of gap crossing by five woodland birds species Doerr *et al* (2011) determined that birds were able to cross gaps between habitat patches of up to 100 metres. However data is not presented on the Black-chinned Honeyeater.

How is the project 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.

Bush Stone-curlew

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

Habitat for this species is common but restricted the central parts of the study area (Sections 2 to 7) and largely absent from the wetter forests of the southern and northern ends of the project. The species was identified in the southern end of Section 2 near Wells Crossing. The clearing of woodland and dry sclerophyll forest containing tree hollows would impact on the breeding resources and lifecycle of the species, however not all dry open forest habitat are suitable and the species is typically associated with an open grassy understorey. These habitat types are well represented beyond the project boundary.

Other life-cycle activities potentially affected by the project include breeding and roosting as a direct result of habitat loss and foraging activities due to a reduction in insect prey abundance. The clearing of habitat may also alter dispersal activity however is expected to be adapted to moving across gaps in woodland and forest and cleared habitats for dispersal. The number of birds affected in relation to the size of local populations is not known, however records are widespread across the region, particularly in coastal areas and it could be reasonably expected the proportion of the population impacted would not lead to a significant impact on the population as a whole.

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

The project would remove around 550 hectares of open dry sclerophyll forests and woodlands that could potentially be used by this species. This would result in the loss of foraging and breeding habitat and may have a short term impact on food resources. However the habitats suited to these species are particularly well represented in the region, particularly to the east and south of the study area. The overall reduction of habitat is considered a small proportion of the available potential habitat. Populations are considered to persist following development of the project.

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

The Bush Stone-curlew is found throughout Australia except for the central southern coast and inland, the far south-east corner, and Tasmania. Only in northern Australia is it still common however and in the south-east it is either rare or extinct throughout its former range.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime.

The potential increase in fires adjacent to the road or change in disturbance associated with increased pollutants or sediments into waterways may have a short to medium term impact the condition and structure of the habitat. Observations of this species in Grey Box woodland in Glenugie State Forest (SKM 2009) indicates a presence in simplified habitats that are subject to frequent fire regimes and disturbances associated with selective logging.

How is the project likely to affect habitat connectivity?

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of some species and fauna groups more than others for example small ground-dwelling mammals, reptiles and amphibians with smaller home range and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10). These project sections occur within a range of habitats suitable for these species.

There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River which are not likely to be important habitat for this species.

The interruptions to connectivity in the landscape may be more associated with dispersal ability in addition to foraging movements between fragmented habitats. There is no data on the species ability to cross gaps or roads.

How is the project 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.

Grey-crowned Babbler

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

The habitat for this species is common but restricted the central parts of the study area (Sections 2-3 and 7). The species has a preference for open woodland or forest with open grassy understorey including cleared rural and residential land around woodland habitats. This is evident in Section 3 where the species was observed in residential yards foraging on mown lawns in Tucabia, demonstrating an adaptation to modified habitats.

Dense open forest, moist forest, rainforest and denser swamp habitats are not suitable. The clearing of woodland and dry sclerophyll forest with open understorey would impact on the breeding resources and lifecycle of the species where family territories intersect with the project corridor and may impact on the colonisation of new territories for dispersing family groups. However not all dry open forest habitats being impacted by the project are likely to be suitable habitat and the species mainly inhabits woodlands with open understorey which is patchy.

Other life-cycle activities potentially affected by the project include temporary disruption to breeding and roosting activities as a direct result of habitat loss within the home range of established family groups and interruption to foraging activities due to a possible reduction in insect prey abundance. The clearing of habitat is unlikely to significantly alter dispersal activities as the species is adapted to moving across cleared landscapes. The loss of habitat for insect prey is unlikely to be a significant loss in terms of the local or regional distribution of habitat. Overall the proportion of the Grey-crowned Babbler population across the region being impacted would be minor and not lead to a significant impact on the regional population as a whole. There may be a greater impact on a relatively small number of local sub-groups.

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

The project would remove around 550 hectares of open dry sclerophyll forests and woodlands that could potentially be used by this species. This does not take into account the variation in habitat types used by Grey-crowned Babbler, which includes paperbark and swamp forest margins and cleared lands which are very widespread.

This would result in the loss of foraging and breeding habitat for established family group territories and may have a short term impact on food resources. The distribution and abundance of family groups in the study is not known, but on the basis of records of the species is predicted to be widespread and common. Furthermore, the habitats suited to this species are particularly well represented in the region, particularly to the east and south of the study area. The overall reduction of habitat is considered a small proportion of the available potential habitat and local populations are considered to persist following development of the project which the exception of some expected losses or adjustment of family territories.

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

The eastern subspecies of Grey-crowned Babbler (*temporalis)* occurs from Cape York south through Queensland, NSW and Victoria and formerly to the south east of South Australia. In NSW, the eastern sub-species occurs on the western slopes of the Great Dividing Range, and on the western plains reaching as far as Louth and Balranald. It also occurs in woodlands in the Hunter Valley and in several locations on the north coast of NSW. It may be extinct in the southern, central and New England tablelands.

How is the project likely to affect current disturbance regimes?

The range of disturbance regimes that currently exists in the study area, and the evolutionary adaption of species to these disturbances, has been influenced by the historical and current land-uses. For example processes such as seasonal weed invasions, fire regimes influenced by human interaction, interruption to surface and groundwater flow through dam construction and draining of swamps, nutrient inputs into aquatic systems exacerbated by land-clearing and farming and predator-prey relationships altered by the introduction of predators and creation of favourable habitat for these species.

The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease. Further retention and channelling of surface flows may have a negative impact on existing riparian or floodplain vegetation that have adapted to the current flooding regime. Similarly, frog species adapted to the current flooding regime have potential to be negatively impacted by a change in the movements of floodwaters.

The potential increase in fires adjacent to the road or change in disturbance associated with increased pollutants or sediments into waterways may have a short to medium term impact on the condition and structure of the habitat for this species. Observations of these species in cleared residential properties in Tucabia (SKM 2009) indicate a presence in simplified habitats that are subject to anthropogenic disturbances.

How is the project likely to affect habitat connectivity?

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of some species and fauna groups more than others for example small ground-dwelling mammals, reptiles and amphibians with smaller home range and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10). These project sections occur within a range of habitats suitable for these species.

There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River.

The Grey-crowned Babbler is adapted to moving across forest clearings such as roads to access foraging, roosting and nesting habitat as observed in the study area. The interruptions to connectivity in the landscape may be more associated with dispersal ability for establishment of new family groups.

How is the project 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.

Threatened fish

Oxleyan Pygmy Perch

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

The NSW DPI Recovery Plan for the Oxleyan Pygmy Perch identifies significant gaps in the life history, population dynamics, dispersal patterns and genetics of this species. Despite this limited knowledge, the Project has the potential to impact on the lifecycles of Oxleyan Pygmy Perch during its construction and operation in the following ways:

- Disturbance and loss of habitat and creation of habitats conducive for noxious aquatic flora and fauna species
- Changes to hydraulic regime and creation of temporary and permanent instream barriers
- Reduction in water quality

Measures to avoid and mitigate impacts to this species include:

- Implementation of water quality control measures
- Design to prevent and/or minimise in-stream barriers
- Management of stockpiles
- Management of riparian and aquatic habitats; and
- Management of sedimentation and erosion;
- Management of in-stream woody debris.

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

Oxleyan Pygmy Perch are known to be associated with swamps, streams and dune lakes that lie in the coastal lowland 'wallum' ecosystems with little or no flow (Arthington 1996; Pusey *et al.* 2004; Knight & Arthington 2008). The species is restricted to aquatic habitats with suitable physicochemical water quality conditions, specifically acidic waters (pH 4.4-6.8) with low conductivity (90 to 830μS/cm). Waters can either be clear or tannin stained. Previous studies (Knight & Arthington 2008) have correlated the presence of Oxleyan Pygmy Perch with an abundance of structural microhabitat in the form of dense aquatic vegetation and/or steep undercut banks fringed with woody debris root overhang from riparian vegetation.

A total of twenty-six Oxleyan Pygmy Perch individuals have been recorded from several studies in Section 6, 7 and 8 of the study area. In Section 6, three individuals were found at a small dam situated at Tabbimoble Floodway 2, and three individuals were found downstream of the confluence of Tabbimoble 2 and 3. In Section 7, 17 individuals were recorded within an unnamed ephemeral stream near station 114.0. In Section 8, two individuals were recorded at Broadwater National Park/McDonalds Creek, and one individual was found at the upstream extent of an unnamed ephemeral stream near station 134.7.

- In section 6 of the project boundary, three individuals were recorded in a small dam located adjacent to Tabbimoble Floodway 2. Habitat conditions where the sightings were recorded are consistent with conditions for which these species favour including dense emergent macrophytes, clear tannin stained waters with low pH and electrical conductivity.
- Another three individuals were also recorded in Section 6, 1.2 kilometres downstream of the confluence of Tabbimoble Floodway 2 and 3. Habitat conditions at the location of the sightings did not exhibit the typical habitat characteristics for the Oxleyan Pygmy Perch, being highly modified with unfavourable water quality conditions (HYDER 2005). Therefore it is highly unlikely that this site is a critical habitat of the species and most probable the individuals have become isolated during movement between habitats in periods of high flow.
- Two individuals were recorded in Section 8 at Broadwater National Park/McDonalds Creek. The permanent, semi permanent and intermittent tributaries of McDonalds Creek form important connection habitat during floods and important local breeding habitat during non-drought periods. An additional Oxleyan Pygmy Perch was found at the most upstream extent of an ephemeral drainage line near station 134.7.
- Seventeen individuals were recorded within an unnamed ephemeral stream near station 114.0. The site had ideal Oxleyan Pygmy Perch habitat and water quality conditions a neutral pH (6.99), and low conductivity of (100µs/cm).

Direct impacts are not expected on downstream habitats, and mitigation measures (eg water quality control measures) would be implemented to prevent impacts to downstream habitat. Additionally, measures to mitigate impacts to in-stream connectivity have been considered during construction and operational phases to allow suitable movement of fauna between upstream and downstream environments.

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

No, the project, and its impacts, is not geographically situated near the known limit of Oxleyan Pygmy Perch distribution. Known populations of Oxleyan Pygmy Perch range over around 530 kilometres of coastline from Coongul Creek on Fraser Island in south-east Queensland to Tick Gate Swamp near Wooli in northern New South Wales (Knight & Arthington 2008). Within the study area, populations have been recorded at Tabbimoble Floodways 2 and 3 and Broadwater National Park/McDonalds Creek and an ephemeral drainage line near station 114.0.

How is the Proposal likely to affect current disturbance regimes?

There are a number of disturbance regimes associated with road construction and related drainage, many of which already exist in the project area due to historical and current landuses. These regimes include disturbing or destroying habitat, fragmenting habitat, increasing pollutant loading, mobilising acid sulphate soils and increase volume, velocity and peaks of stormwater. Known disturbances around the key areas of Oxleyan Pygmy Perch habitat particularly the Tabbimoble Floodways 2 and 3 and within Broadwater National Park includes loss of riparian vegetation through land clearing, severe modification of stream channel profile, a reduction in water quality through an increase in sediment loads and stream bed and bank disturbance.

The construction and operational phases of the project have potential to further impact on aquatic habitats through further degradation of water quality values, reduction of current riparian vegetation, introduction of pest species and the disruption of hydrological regimes by temporary and permanent instream barriers. Best management practices can be applied in areas where OPP and/or habitat may be present and include:

- Install sediment and pollution controls
- Provide adequate fish passage
- Minimise impacts on stream flows and maintain flow regimes
- Minimise impacts on habitat connectivity
- Minimise impacts on aquatic and riparian vegetation and soils
- Avoid maintenance during wet season when the impacts of soil and vegetation disturbance would be greater
- Only undertake works between May and September to minimise impacts during the OPP breeding season

Provided best management practices are abided by, it is considered unlikely that aquatic habitats would be disturbed beyond their current condition.

How is the Proposal likely to affect habitat connectivity?

The construction and operation of the project has the potential to restrict the movement of aquatic fauna through the creation of temporary and permanent instream barriers if inappropriately designed. Other impacts that can affect habitat connectivity, particularly during construction include instream habitat disturbance, water quality degradation and the introduction of pest aquatic species. There is semi-permanent habitat that represents important linkages between upstream and downstream at Tabbimoble Floodways 2 and 3. Mitigation measures such as suitable design of temporary and permanent waterway crossings have been designed to minimise the occurrence of impacts to habitat connectivity and to ensure that connectivity is maintained during construction and operation. Other mitigation measures include water quality control measures, aquatic habitat management measures and the creation of sediment and erosion control plans.

How is the Proposal likely to affect critical habitat?

A submission has been prepared by DPI (2010) to list all known areas of the Oxleyan Pygmy perch that occur on public land (national parks and conservation reserves) as critical habitat. This declaration has not been adopted at present. Eight locations along the project corridor have known populations of the Oxleyan Pygmy Perch within the alignment foot print and there are several other areas of potential habitat within the project area. This includes a crossing of Broadwater National Park, which is part of the submission for critical habitat. At present the legislative requirements under Part 3 of the EP&A Act relating to activities in critical habitat do not apply.

Removal of in stream vegetation, woody debris and riparian root overhang are the key impacts that can critically affect Oxleyan Pygmy Perch habitat. Specific habitat management measures as detailed in Chapter 5 would be employed so that the likelihood of the proposal affecting critical habitat of the Oxleyan Pygmy Perch is minimal and short lived.

Purple-spotted Gudgeon

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

A key threatening process under the FM Act includes the removal of large woody debris. Woody debris, together with trailing roots, undercut banks and instream vegetation represents important structural microhabitats for the Purple-spotted Gudgeon. Despite no recordings of the Purple-spotted Gudgeon within the study area, there are a number of waterways in the project area which have habitats that may support the Purple-spotted Gudgeon. Therefore assuming the possible presence of Purple-spotted Gudgeon within the study area, the project has the potential to impact on this species lifecycle during its construction and operation in the following ways:

- Reduce the availability of shelter and aquatic habitat available for foraging through removal of structural habitat and modification of instream areas
- Increase predation of Plague Minnow and other noxious aquatic species.

Measures have been recommended to minimise impacts to instream habitat and riparian condition, minimise removal of instream woody debris and manage incursion of noxious species including Plague Minnow as detailed in Chapter 5. As such the project is unlikely to impact considerably on the lifecycle of the Purple-spotted Gudgeon.

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

The Purple-spotted Gudgeon are often found in slow moving or still waters of rivers, creeks and billabongs, often amongst weeds, rocks or large woody debris. The species is restricted to aquatic habitats with suitable physiochemical water quality conditions, specifically waters with a pH ranging from 5.6 to 8.8, conductivity of 72 to 4,295µS/cm, dissolved oxygen between 0.6 and 12.8mg/L and low turbidity. Considering these habitat requirements it is possible that the species resides in a number in a number of aquatic habitats, most likely in Sections 1, 2 and 5. Whilst there is the potential for the project to involve temporary modification to areas of suitable habitats within the alignment, mitigation measures have been developed to minimise impacts.

Therefore, due to the proposed mitigation measures and no recordings of Purple-spotted Gudgeon within the study area, impact to key habitat is considered unlikely.

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

No, the project, and its impacts, is not geographically sited near the limit of Purple-spotted Gudgeon known distribution. Populations of the Purple-spotted Gudgeon occur in inland drainages of the Murray-Darling Basin and coastal drainage systems of the east coast from Cape York Peninsula south to the Clarence River.

How is the Proposal likely to affect current disturbance regimes?

There are a number of disturbance regimes that currently exist within the project area as a result of current and historical landuse activities. Disturbance to waterways and drainage pathways include loss of riparian vegetation through land clearing, modification of stream channel profile, reduction in water quality due to increased sediment loads and stream bank erosion. The construction and operation of the project has the potential to further disturb aquatic habitats through removal of riparian vegetation, introduction of pest species, degraded water quality and disruption of hydrological regimes. Implementation of mitigation measures outlined in Chapter 5 would ensure that potential aquatic habitats for the Purple-spotted Gudgeon are not disturbed beyond their current condition.

How is the Proposal likely to affect habitat connectivity?

There is limited semi-permanent and permanent habitat suitable for Purple-spotted Gudgeon, particularly upstream of the alignment. However, the construction and operation of the project has the potential to impede on the movement of Purple-spotted Gudgeon through the creation of temporary and permanent instream barriers. Waterway crossings have therefore been designed to limit impact to habitat connectivity, with bridges being constructed over the majority of waterway crossings. Other measures to maintain habitat connectivity include water quality control measures, aquatic habitat management measures and the creation of sediment and erosion control plans.

It is therefore considered unlikely that the project would significantly affect the habitat connectivity for the Purple-spotted Gudgeon.

How is the Proposal likely to affect critical habitat?

The Purple-spotted Gudgeon has not previously been recorded in the study area or immediate surrounds, however sections of the study area are within the species range and suitable habitat is present. Mitigation measures have been developed to minimise impacts to potential areas of habitat through management of riparian and aquatic habitats. As such it is highly unlikely that the project would adversely affect critical habitat of the Purple-spotted Gudgeon.

Eastern Freshwater Cod

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

Research into the life history of the Eastern (Freshwater) Cod has been extremely limited (NSW Fisheries 2004). Despite this limited knowledge, there are a number of key threatening processes under the FM Act which can affect the lifecycle of this species. These processes may occur during the construction and operation of the project and include:

- Habitat degradation through a reduction or removal of in-stream woody debris and aquatic vegetation and sedimentation of deeper holes
- Barriers such as road crossings
- Loss of riparian vegetation and reduce water quality
- Introduced species.

Measures have been recommended to avoid and mitigate impacts to this species including the implementation of water quality control measures, management of riparian and aquatic habitats, management of sedimentation and erosion, management of in-stream woody debris and design to prevent and/or minimise in-stream barriers. As such the project is unlikely to impact considerably on the lifecycle of the Eastern (Freshwater) Cod.

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

The Eastern (Freshwater) Cod are often found in clear flowing streams with rocky beds and deep holes. They are generally associated with areas that have plenty of boulders or large woody debris (snags). Riparian vegetation, boulders and snags provide habitat for the Eastern Freshwater Cod through various stages of its lifecycle and influence the quality and quantity of food and shelter (NSW Fisheries 2004). Considering these requirements, there are potential areas of habitat in the Coldstream River, Chaffin Creek and Pillar Valley Creek in Section 3. Whilst there is the potential for the project to involve temporary modification to areas of suitable habitat, mitigation measures have been developed to minimise impacts.

Therefore, due to the proposed mitigation measures and no recordings of Eastern (Freshwater) Cod within the study are, impact to key habitat is considered unlikely.

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

No, the project, and its impacts, is not geographically sited near the limit of the Eastern (Freshwater) Cod known distribution. Wild populations of the species are considered extinct in the Richmond River system and very rare or absent in the major northern tributaries of the Clarence River systems (NSW Fisheries 2004). Recordings of the Eastern (Freshwater) Cod have been from tributaries such as the Nymboida, Guy Fawkes, Boyd and Mann rivers. Whilst restocking has talking place throughout the Clarence and Richmond river systems this has occurred outside the project boundary.

How is the Proposal likely to affect current disturbance regimes?

There are a number of disturbance regimes associated with road construction and related drainage, many of which already exist in the project area and are known to be key threatening processes to the Eastern (Freshwater) Cod. Disturbance includes loss of riparian vegetation through land clearing, modification of stream channel profile, reduction in water quality due to increased sediment loads and stream bank erosion. The construction and operation of the project has the potential to further disturb aquatic habitats through removal of riparian vegetation, introduction of pest species, degraded water quality and disruption of hydrological regimes and barriers.

Implementation and management of mitigation measures would ensure that any suitable areas of potential aquatic habitat for the Eastern (Freshwater) Cod are not disturbed beyond their current condition.

How is the Proposal likely to affect habitat connectivity?

There are limited areas of habitat suitable for the Eastern (Freshwater) Cod within the project area, and the species does not undergo distinct upstream or downstream migrations. Despite this, the construction and operation of the project has the potential to impact habitat through the creation of temporary and in-stream barriers and removal of in-stream woody debris. Waterway crossings have therefore been designed to limit impact to habitat connectivity, with bridges being constructed over the majority of waterway crossings. Other measures to maintain habitat connectivity include water quality control measures, aquatic habitat management measures and the creation of sediment and erosion control plans.

It is therefore considered unlikely that the project would significantly affect the habitat connectivity for the Eastern (Freshwater) Cod.

How is the Proposal likely to affect critical habitat?

The Eastern (Freshwater) Cod has not been recorded in the study area or immediate surrounds, however areas of suitable habitat have been identified in the midstream sections of the Coldstream River, Chaffin Creel and Pillar Valley Creek. Mitigation measures have been developed to minimise impacts to potential areas of habitat through management of riparian and aquatic habitats. As such it is highly unlikely that the project would adversely affect critical habitat of the Eastern (Freshwater) Cod.

Threatened flora

Acronychia littoralis (vulnerable species, TSC Act)

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

This species was recorded in Section 8, comprising one individual outside of the project boundary in subtropical rainforest which will not be impacted by the proposal. This individual occurs around 130 metres to the west of the proposed footprint and is considered unlikely to be indirectly impacted. There is a low possibility this species is present in rainforest and wet sclerophyll forests within the project boundary, however these habitats are marginal and targeted surveys have not identified any populations within the project boundary.

Considering the relatively extensive targeted searches undertaken for this species in areas of suitable habitat, it is unlikely to be present in the study area. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

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

The preferred habitat for this species is littoral rainforest on sand which does not occur in the study area; however it is known to also occur in subtropical rainforest which is present in the study area. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

Does the project 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. The occurrence adjacent to the project boundary is not the limit of the known distribution for this species.

How is the project likely to affect current disturbance regimes?

Indirect impacts from edge effects and altered hydrology may impact the habitat of this species affecting life-cycle attributes of the known single individual.

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

How is the project likely to affect habitat connectivity?

The project would result in the dissection of habitat for this species, however the population would not be dissected. Habitat for this species is currently highly fragmented in the locality and the project would result in further fragmentation of habitats with around 10.33 hectares of the 94.62 hectares of potential rainforest habitat for this species potentially being impacted.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this species.

Angophora robur (vulnerable species, TSC Act)

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

A large population of *Angophora robur* has been identified in the local area growing on Kangaroo Creek Sandstone geology between the Pillar Valley and the Maclean area as part of the ecological surveys for the Wells Crossing to Iluka Road project boundary (SKM 2009), and supplementary surveys undertaken for this project in February 2011 and December 2011.

The life cycle of *Angophora robur* is likely to be linked to a large range of factors, but several important components include:

- A wide range of potential pollinator species including insects, birds, bats and arboreal mammals
- Fire regime including fire intensity, frequency and season
- Available gene pool
- Hybridisation with *Angophora woodsiana*
- Other disturbance regimes such as forestry activities and grazing.

There is estimated to be around 6,893 individuals of *Angophora robur* in the project boundary occurring over 82.06 hectares. Based on calculations from the detailed surveys the average number of individuals per hectare is 84. This average was extrapolated across the known and predicted regional distribution for this species and the results are provided below in Table E-4. The entire current known extent of *Angophora robur* includes three main clusters comprising:

- The eastern population within and surrounding the study area between Pillar Valley and Tyndale
- North-west of Coffs Harbour in the Coutts Crossing and Nymboida regions
- North-west of Grafton in the Copmanhurst and Coaldale regions.

Table E-4 *Angophora robur* population clusters in the project boundary and the populations from the wider region

Subpopulation location	Area of habitat occupied (hectares)	Predicted population number	Number of individuals in project boundary	Area of occupied habitat in project boundary (proportion)
Eastern Population (Pillar Valley, Tucabia, Tyndale including Pine Brush SF and Newfoundland SF)				
Population Cluster 1 – Pillar Valley	*451.5*	*37928*	*1516*	*18 hectares (4%)*
Population Cluster 2 – Firth Heinz Rd	*14.7*	*1237*	*148*	*1.8 hectares (11.9%)*
Population Cluster 3 – Bostock Road	*15.8*	*1328*	*293*	*3.5 hectares (22.1%)*
Population Cluster 4 – Sommervale Road to Tallowwood Lane	*189*	*15876*	*1294*	*15.4 hectares (8.1%)*

Subpopulation location	Area of habitat occupied (hectares)	Predicted population number	Number of individuals in project boundary	Area of occupied habitat in project boundary (proportion)
Population Cluster 5 – Tucabia Road	*14.1*	*1183*	*142*	*1.7 hectares (12%)*
Population Cluster 6 – Tyndale	*684.2*	*57476*	*3500*	*41.7 hectares (6.1%)*
Eastern Population (total)	Known: 1,471.4	Known: 123,601	Known: 6893	**82.1 hectares (5.6% of known local population)**
Northwest Population*(*Copmanhurst, Coaldale including Fortis Creek NP))	Known: 457 Predicted 7,368	Known: 38,388 Predicted 619,912	0	0
Southwest Population *(*Glenreagh, Kangaroo Creek, Chambigne NR)	Unknown	500 known from records	0	0
Total *(*including known and predicted and records from southwest population)	9,296 hectares	782,401	6893	82 hectares from total 9,296 hectares (0.9% of known regional population)

The known regional distribution including the eastern population and northwest population is estimated to comprise 161,989 individuals occurring over 1,928 hectares and the predicted distribution including the northwest population only is estimated to consist of an additional 619,912 individuals over 7,368 hectares.

The population in the corridor represents the known eastern distribution of the species. A total of 11 population clusters within the larger eastern subpopulation have been mapped within and surrounding the project boundary occurring over a total of 1,471 hectares with individual clusters ranging from 1.3 to 684 hectares in area. All known locations within 500 metres of each other have been regarded as being part of the same population cluster based on the likely maximum dispersal distance of pollinators between subpopulations. A total of six of the 11 known population clusters occur in the project boundary and these are described in Table E-4.

The 11 subpopulations also includes four smaller outlying populations to the north in Woodford Island State Forest and to the south in Newfoundland State Forest, however these clusters include a high abundance of *Angophora woodsiana* and a low abundance of *Angophora robur* as well as intergrades between the two species. There is also a low abundance of *Angophora robur (*around one per hectare) occurring with *Angophora woodsiana* over an additional 445 hectares on the more skeletal ridges and upper slopes *(*excluded from calculations).

The project would potentially impact up to 6,893 individual *Angophora robur* including 82.06 hectares of known habitat. This impact represents a significant proportion of the known extent of the eastern subpopulation comprising around 5.6 per cent of the population and area of habitat. It is highly likely that there are additional population clusters of *Angophora robur* within the eastern population in areas not surveyed during the study, including private property, state forests and national park estates. The total known population consisting of the northwest and eastern subpopulations comprises 161,989 individuals occurring over 1,928 hectares, of which the potential impact represents around 4.25 per cent of the population and area of habitat.

The predicted population size of the northwest population is estimated to consist of an additional 618,912 individuals over 7,368 hectares. When added to the known extent of the population and records from the southwest population, the total of the known and predicted extent comprises 782,401 individuals occurring over 9,296 hectares of habitat *(*refer to Table E-4). The potential impact of the project represents around 1% of the total known and predicted population and area of habitat. These figures are likely to be further reduced when including known and predicted estimates for the southwest population which have not been undertaken for this project.

The project would potentially have a significant impact to the eastern population of *Angophora robur* considering that potentially up to 5 per cent of the local population would be impacted. The local gene pool would be reduced from the project however this impact can be mitigated somewhat through a seed collection and propagation strategy. Considering the large proportion of the population that would remain in the local area and the high mobility of pollinator species the project is unlikely to lead to inbreeding depressions due to fragmentation. Habitat for pollinator species would be removed, however sufficient habitat for large populations of potential pollinator species would remain in surrounding areas.

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

The project would result in the removal of up to 105 hectares of known occupied habitat for *Angophora robur*. This are of potentially impacted habitat comprises around:

- Seven per cent of the known occupied habitat of the eastern subpopulation.
- 5.5 per cent of the known extant of the eastern population and northwest subpopulation
- 1.2 per cent of the known and predicted extent of the eastern and northwest subpopulations and records from the southwest subpopulation (500 individuals).

Impacts to the eastern subpopulation *(*7per cent) are relatively significant considering this population represents the eastern extent of the species, there is limited known representation in conservation reserves and this area would be subject to increasing development pressure in the future. It is highly likely that there are additional population clusters of *Angophora robur* within the eastern population in areas not surveyed during the study, including private property, state forests and national park estates.

The potential impacts to habitat for *Angophora robur* are likely to represent a significantly smaller proportion when including the entire extent of the species, including the southwest subpopulation and additional locations of the eastern and northwest subpopulations not surveyed during this project.

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

Angophora robur is endemic to sandstone ridges and slopes from around Glenreagh to the Coaldale area north-west of Grafton, and along the Somervale Range east of Grafton between Pillar Valley and Maclean. Within this range, the current known distribution is patchy, however the species has not been extensively surveyed and the full extent of the population is unknown.

The population within the project boundary is at the north-eastern extent of known distribution of *Angophora robur* and may potentially represent the distributional limit of the species. There are known populations extending along the Somervale Range consist of around 11 population clusters containing an estimated 123,564 individuals. Several small population clusters occur to the north, south and east of the population in the project boundary including a very small population 7.5 kilometres to the north in Woodford Island North State Forest, several small clusters 7.5 to 9.5 kilometres to the south in Newfoundland State Forest and on private property 2.5 kilometres to the east. Several of these smaller population clusters include intergrades with *Angophora woodsiana*.

How is the project likely to affect current disturbance regimes?

The project is unlikely to significantly alter disturbance regimes. The project would result in a larger fire break to wildfire approaching from the west potentially resulting in the frequency of wildfire to be reduced in population clusters to the east of the project boundary.

Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability. Considering that the majority of the population adjacent to the project boundary occurs upslope of the project, impacts from some of the potential indirect impacts such as stormwater run-off and altered hydrology would not affect the remaining individuals of *Angophora robur*.

How is the project likely to affect habitat connectivity?

Several of the population clusters would be dissected by the project impacting habitat connectivity for *Angophora robur*. Considering the high mobility of some pollinator species such as insects, birds and bats, and wind dispersal of pollen, gene flow is expected to continue across the width of the project.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this species.

Arthraxon hispidus (vulnerable species, TSC Act)

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

Several large populations of *Arthraxon hispidus* have been recorded in Section 10 between Coolgardie Road and Lumley's Lane during the supplementary surveys (BAAM 2012). The project would potentially impact around 47 per cent of the known extent of the species within and surrounding the project boundary. Three distinct subpopulations have been identified based on their spatial distribution with all occupied habitats within 150 metres each other regarded as being part of the same subpopulation. Pollen from wind pollinated grass species have been observed to travel up to 150 metres in favourable conditions (Wang et al 2003). The potential impacts to each subpopulation is summarised in Table E-5.

Table E-5 *Arthraxon hispidus* population clusters in the study area and potential impacts

Subpopulation Name/Location	Population dissected by project boundary	Distance from nearest subpopulation (m)	Area of occupied habitat (ha)	Area of occupied habitat (ha) in project boundary	Proportion of occupied habitat in project boundary
Subpopulation 1 – Lumley's Lane	No	995	4.17	2.9	70%
Subpopulation 2 - Central	Yes	450	4.85	3.43	71%
Subpopulation 3 – Pacific Highway 1	Yes	450	2.86	1.94	68%
Subpopulation 4 – Pacific Highway 2	No	200	8.9	1.54	17%
Total			**20.79**	**9.81**	**47%**

A relatively significant proportion of occupied habitat would be potentially impacted from the project, particularly for subpopulations 1, 2 and 3 with up to 68 to 71 per cent of these subpopulations being impacted. Only 17 per cent of the largest population would be potentially impacted by the project.

There is potential for the genetic diversity of these subpopulations to be depleted particularly for subpopulations 1, 2 and 3 which could lead to an inbreeding depression. There are potential opportunities to mitigate potential impacts to this species through the maintenance, restoration and management of the remaining population which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

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

Arthraxon hispidus occurs in moist, shady positions and is usually found in or on the edges of rainforest and in wet eucalypt forest, often near creeks or swamps.

The known area of occupation of the species is 20.79 hectares of which, 9.81 hectares (47 per cent) is within the project boundary. The area of unoccupied potential habitat is relatively extensive in the locality comprising wet areas in open paddocks and the edges of moist vegetation. However the potential occurrence of *Arthraxon hispidus* is likely to be dependent on numerous factors including grazing and maintenance regimes, hydrology and soils.

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

This species is a cosmopolitan species which is relatively widespread but uncommon throughout southeast Queensland and the NSW North Coast and Northern Tablelands, as well as occurring from Japan to central Eurasia. This species occurs within the Border River–Gwydir, Northern Rivers (NSW), Fitzroy, Border Rivers–Maranoa Balonne, Condamine, South East, Burnett Mary and Wet Tropics (Queensland) Natural Resource Management Regions.

Hairy-joint Grass is known to be reserved in Carnarvon Cooloola National Park, Noosa National Park (Briggs & Leigh, 1996), Carnarvon National Park (Queensland CRA/RFA Steering Committee, 1998), and Daintree National Park (Queensland Herbarium, 2008).

The occurrence in the study area is towards the southern limit of the species in Australia, however there are records for this species around 180 kilometres south of the occurrence in Section 10.

How is the project likely to affect current disturbance regimes?

Considering that the majority of the population adjacent to the project boundary occurs in low elevation areas subject to flooding, remaining locations surrounding the project would be potentially indirectly impacted from stormwater run-off and altered hydrology.

Considering the majority f the population surrounding the corridor occurs in open paddock areas there is unlikely to be significant indirect impacts from edge effects such as increased sunlight. There is potential for weed invasion to impact remaining individuals however weed management measure would be implemented.

How is the project likely to affect habitat connectivity?

The project would result in further fragmentation of individuals. Table E-5 identifies the subpopulations which would be dissected by the project. Subpopulations 2 and 3 would be dissected by the project, with individuals being retained on either side of the project. Impacts to subpopulations 1 and 4 would be restricted to one edge of the populations.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this species.

Archidendron hendersonii (vulnerable species, TSC Act)

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

This species was recorded in Section 10, comprising 11 individuals in subtropical rainforest north of Coolgardie Road (BAAM 2012). Of these 11 individuals, six are within the project boundary. The remaining 5 individuals outside of the project could potentially be impacted by indirect impacts from edge effects and altered hydrology.

The individuals identified during recent field surveys are potentially part of a larger population of this species occurring in rainforest habitats surrounding the corridor in Section 10. *Archidendron hendersonii* is insect/bird pollinated and so it is reasonable to expect the potential population to include all individuals within 500 metres of individuals surrounding corridor.

There is potential for the genetic diversity of the local population of *Archidendron hendersonii* to be depleted. There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

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

It is found on a variety of soils including coastal sands and those derived from basalt and metasediments. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

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

This species occurs from north Queensland south to the Richmond River in north-east NSW. The occurrence in the project boundary potentially represents the current southern distributional limit for the species. There is one record around 150 kilometres to the south, however this record is from 1914 with no recent records present in this area.

How is the project likely to affect current disturbance regimes?

Indirect impacts from edge effects and altered hydrology may impact the habitat of this species affecting life-cycle attributes of the remaining six individuals.

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

How is the project likely to affect habitat connectivity?

The project would result in the dissection of habitat for this species with, individuals being present on the eastern and western side of the project. Habitat for this species is currently highly fragmented in the locality and the project would result in further fragmentation of habitats with around 10.33 hectares of the 94.62 hectares of potential rainforest habitat for this species potentially being impacted.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this species.

Centranthera cochinchinensis (endangered species, TSC Act)

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

No individuals have been recorded in the project boundary. There is a possibility this species is present in suitable habitats within the project boundary which are widespread comprising moist paddocks and other open moist sites. Although targeted surveys have not identified any populations within the project boundary, the cryptic nature of the species and the large areas of potential habitat suggest there is potential for the species to be present.

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

Habitats for this species are widespread comprising moist paddocks and other open moist sites. There would be impacts to large areas of cleared paddocks and other open sites which would contain pockets of suitable habitat such as moist grassland/herbland. This species has been recorded in the Glenugie area growing in moister areas of open, cleared paddocks

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

This species has a widespread distribution, but is limited to the north coast region of NSW north of Wooli. It also occurs in northern Australia and south-east Asia. Any potential populations at the southern end of the proposal would be at the known southern distribution.

How is the project likely to affect current disturbance regimes?

The project is unlikely to significantly alter disturbance regimes. The project would result in a larger fire break to wildfire approaching from the west potentially resulting in the frequency of wildfire to be reduced in population clusters to the east of the project boundary. Vegetation clearing would potentially contribute to further invasion of Lantana camara and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability.

How is the project likely to affect habitat connectivity?

As no individuals have been identified adjacent to or within the project boundary, the project would not result in further fragmentation of individuals, however there would be further fragmentation of potential habitat.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this species.

Cryptocarya foetida (vulnerable species, TSC Act)

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

A total of 17 individuals were recorded within and surrounding the project boundary during supplementary surveys in Section 10 north of Coolgardie Road *(*BAAM 2012). Of these 17 identified individuals, up to 13 occur within the project boundary. Indirect impacts from edge effects and altered hydrology may alter the habitat of the remaining individuals of this species affecting life-cycle attributes.

The individuals identified during recent field surveys are potentially part of a larger population of this species occurring in rainforest habitats surrounding the corridor in Section 10. *Cryptocarya foetida* is presumed to be insect/bird pollinated and so it is reasonable to expect the potential population to include all individuals within 500 metres of individuals surrounding corridor. The seeds are readily distributed by fruit-eating bird species.

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

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

Found in littoral rainforest, usually on sandy soils, but mature trees are also known on basalt soils. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

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

Cryptocarya foetida is known from Iluka, NSW, to Fraser Island and east of Gympie, southern Queensland. This species is conserved within the Cooloola National Park, Noosa National Park, Burleigh Heads National Park, Lamington National Park, Broken Head Nature Reserve, Brunswick Heads Nature Reserve, Ukerebagh Nature Reserve and Tyagarah Nature Reserve (Briggs & Leigh, 1996). *Cryptocarya foetida* grows in littoral rainforest, usually on sandy soils, with mature trees also growing on basalt soils. This species occurs within the Northern Rivers (NSW), Burnett Mary and South East Queensland Natural Resource Management Regions.

The individuals in the project boundary are around 52 kilometres north of Iluka the known southern distributional limit.

How is the project likely to affect current disturbance regimes?

Indirect impacts from edge effects and altered hydrology may impact the habitat of the remaining individuals of this species affecting life-cycle attributes.

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

How is the project likely to affect habitat connectivity?

The project would result in the dissection of habitat for this species with, individuals being present on the eastern and western side of the project. Habitat for this species is currently highly fragmented in the locality and the project would result in further fragmentation of habitats with around 10.33 hectares of the 94.62 hectares of potential rainforest habitat for this species potentially being impacted.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this species.

Cyperus aquatilis (endangered species, TSC Act)

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

The known distribution of this species in the study area from past and present surveys is detailed in Table E-6. It was previously recorded at six locations in Sections 6 and 7 (Ecos Environmental 2007) in low to moderate abundance. During supplementary surveys (January 2012), it could only be relocated at one of these locations (Mororo State Forest) where a relatively large population (around 80 plants) was previously recorded. Similarly locations of this species recorded in winter 2005 where not relocated during summer 2006, suggesting the distribution and abundance of the species is highly variable and dependant on numerous factors such as habitat disturbance, flooding events, seed dispersal and climatic conditions.

Other records in the study include a grazed paddock area south of Jacky Bulbin Road (c. 18 plants), a disturbed drainage line north of Glencoe Road (9 plants) and several locations where only 1 to 3 individuals were recorded including Tabbimoble Floodway No. 2. Most of the occurrences recorded during summer 2006 were associated with boggy access tracks that had recently been disturbed by tractors or other vehicles (Ecos Environmental 2007). During the supplementary surveys there was little evidence of recent disturbance in the locations previous surveyed by Ecos Environmental (2007) and growth of other *Cyperus* spp. and grasses may have limited the germination of *Cyperus aquatilis* in these areas.

Table E-6 Known and potential locations of *Cyperus aquatilis* in the project boundary

Location description	When recorded	Approximate area of suitable habitat (based on 2012 surveys)	Approximate area of suitable habitat within project boundary (proportion)	Population size
Mororo State Forest, on western side of highway in a grassed easement along property boundary	Summer 2006 Summer 2012	1683 metres^2	1683 metres^2 (100%)	Summer 2006 – 80 individuals Summer 2012 – 10 individuals
South of Jacky Bulbin Road on the eastside of the highway in a grazed paddock	Summer 2006	2279 metres^2	480 metres^2 (20%)	Summer 2006 – 18 individuals Summer 2012 - None
Tabbimoble Floodway No. 2 on the westside of the highway	Winter 2005	78 metres^2	0	Winter 2005 – 3 senescent individuals Summer 2006 – None Summer 2012 – None
Adjacent to Tabbimoble State Forest on the eastside of the highway	Winter 2005	5231 metres^2	531 metres^2 (10%)	Winter 2005 – 3 senescent individuals Summer 2006 - None Summer 2012 – None

Location description	When recorded	Approximate area of suitable habitat (based on 2012 surveys)	Approximate area of suitable habitat within project boundary (proportion)	Population size
South of Serendipity Road on the eastside of Road	Summer 2006	1042 metres^2	0	Summer 2006 – 1 individual Summer 2012 – None
North of Glencoe Road on both sides of the highway on disturbed trails	Summer 2006	1019 metres^2	917 metres^2 (90%)	Summer 2006 – 9 individuals (2 on western side of highway and 7 on eastern side) Summer 2012 - None
Trustums Hill there is a roadside drain which potentially provides suitable habitat with other *Cyperus* spp. present	n/a	400 metres^2	400 metres^2 (100%)	None recorded in this area to date, but suitable habitat observed along edge of existing highway in roadside drain.
TOTAL		**11,732 metres^2**	**4011 metres^2 (34%)**	

The population of *Cyperus aquatilis* in the study area appears to be part of a larger population extending north east into Tabbimoble Swamp Nature Reserve and Bundjalung National Park (Geolyse 2005).

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

In the study area this species occurs in disturbed, boggy sites in floodplain open forest or pastureland. *Cyperus aquatilis* appears during the wet summer period in ephemerally wet sites then dies off in early spring as the habitat dries out. Records from the coastal floodplain are nearly all from track ruts on recently disturbed, muddy access trails (Ecos Environmental 2007). It also occurs in seepage areas from small sandstone cliffs.

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

This species is a cosmopolitan species which is relatively widespread throughout the northern states of Australia including Queensland, Western Australia and the Northern Territory, as well as occurring in New Guinea.

Only known from a small number of records north of Grafton in NSW, mainly between the Pacific Highway in the east and Summerland Way to the west (OEH 2011), including records the project boundary. This species has been observed at numerous locations throughout the project boundary between 2005 and 2010.

How is the project likely to affect current disturbance regimes?

Indirect impacts from edge effects and altered hydrology may impact the habitat of the remaining individuals of this species affecting life-cycle attributes.

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

How is the project likely to affect habitat connectivity?

As the existing populations are currently fragmented by the existing highway, the project would result in further fragmentation of individuals, with individuals being retained on either side of the project.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this species.

Dendrobium melaleucaphilum (endangered species, TSC Act)

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

No individuals have been recorded in the project boundary. There is a possibility this species is present in suitable habitats within the project boundary which are relatively widespread comprising the trunks of Prickly-leaved paperbark (*Melaleuca styphelioides*) in sheltered forests. Prickly-leaved paperbark trees are relatively common along the length of the project, mainly occurring in gullies and along drainage lines. Although targeted surveys have not identified any populations within the project boundary, the cryptic nature of the species and the widespread areas of potential habitat suggest there is potential for the species to be present.

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

Habitats for this species are widespread comprising the trunks of Prickly-leaved paperbark (Melaleuca styphelioides) in sheltered forests. There are records for this species surrounding the project boundary at various locations.

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

Occurs in coastal districts and nearby ranges, extending from Queensland south to its distributional limit in the lower Blue Mountains. The study area doesn't represent the distributional limit of the species.

How is the project likely to affect current disturbance regimes?

The project is unlikely to significantly alter disturbance regimes. The project would result in a larger fire break to wildfire approaching from the west potentially resulting in the frequency of wildfire to be reduced in population clusters to the east of the project boundary. Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability.

How is the project likely to affect habitat connectivity?

As no individuals have been identified adjacent to or within the project boundary, the project would not result in further fragmentation of individuals, however there would be further fragmentation of potential habitat.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this species.

Desmodium acanthocladum (vulnerable species, TSC Act)

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

This species was recorded in Section 8, comprising around 15 individuals outside of the project boundary in subtropical rainforest derived vegetation along a drainage line.

The preferred habitat for this species is dry rainforest and edges of subtropical rainforest on basalt derived soils which is present in the study area. There is a low possibility this species is present in rainforest habitats within the project boundary, however targeted surveys have not identified any populations within the project boundary.

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. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

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

This species is known to also occur in dry rainforest and edges of subtropical rainforest on basalt derived soils which is present in the study area. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

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

The distribution of the species is only in north-east NSW, in the Lismore area, and there are also records from near Grafton, Coraki, Casino and the Mount Warning area. The occurrence adjacent to the project boundary is not the limit of the known distribution for this species, but is likely be relatively near to known distributional limit considering the small area of potential occurrence.

How is the project likely to affect current disturbance regimes?

Indirect impacts from edge effects and altered hydrology may impact the habitat of this species affecting life-cycle attributes of the known population.

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

How is the project likely to affect habitat connectivity?

The project would result in the dissection of habitat for this species, however a population would not be dissected. Habitat for this species is currently highly fragmented in the locality and the project would result in further fragmentation of habitats with around 10.33 hectares of the 94.62 hectares of potential rainforest habitat for this species potentially being impacted.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this species.

Endiandra hayesii (endangered species, TSC Act)

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

Endiandra hayesii was recently recorded in supplementary surveys in a patch of subtropical rainforest north of Coolgardie Road *(*BAAM 2012) comprising a total of five larger individuals and three juveniles. Of these eight individuals, two larger individuals and three juveniles are within the project boundary, comprising around 62.5 per cent of the known population.

The individuals identified during recent field surveys are potentially part of a larger population of this species occurring in rainforest habitats surrounding the corridor in Section 10. *Endiandra hayesii* is presumed to be insect/bird pollinated and so it is reasonable to expect the potential population to include all individuals within 500 metres of individuals surrounding corridor. The seeds are readily distributed by fruit-eating bird species.

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

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

Endiandra hayesii occurs on poorer soils derived from sedimentary, metamorphic, or acid volcanic rocks. Vegetation includes subtropical and warm temperate rainforests, and Brush Box (Lophostemon confertus) forests, including regrowth and highly modified forms of these habitats. The altitude varies from near sea level to 800 metres. Rusty Rose Walnut occurs within the Northern Rivers (NSW) and South East Queensland Natural Resource Management Regions.

Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

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

Endiandra hayesii is known from a restricted distribution in northern NSW and southern Queensland (Hyland, 1989). Records of this species are clustered in the Border Ranges and Nightcap Ranges area, and at a few scattered near-coastal locations. Harden (1990) gives the Clarence River as the southern limit. In NSW, it is also conserved in Mooball National Park and Billinudgel Nature Reserve. In Queensland, the species is rare, with locations reported by Barry and Thomas (1994) only at Burleigh Heads, Tallebudgera and Springbrook National Park (DEC, 2004).

Endiandra hayesii has been previously recorded in the local area (10 kilometre radius) to the south east of the subject population near Iluka and there is also a record from 1997 near Coffs Harbour. The individuals recorded in the project boundary are around 55 kilometres north of the southern distribution specified in Harden (1990) at the Clarence River near Iluka.

How is the project likely to affect current disturbance regimes?

Indirect impacts from edge effects and altered hydrology may impact the habitat of this species affecting life-cycle attributes for remaining individuals.

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

How is the project likely to affect habitat connectivity?

The project would result in the dissection of potential rainforest habitat for this species however individuals would not be dissected with individuals being retained on the western side of the project boundary only. Habitat for this species is currently highly fragmented in the locality and the project would result in further fragmentation of habitats with around 10.33 hectares of the 94.62 hectares of potential rainforest habitat for this species potentially being impacted.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this species.

Endiandra muelleri subsp. bracteata (endangered species, TSC Act)

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

Endiandra muelleri subsp. *bracteata* was recently recorded in supplementary surveys in a patch of subtropical rainforest north of Coolgardie Road (BAAM 2012) comprising a total of five larger individuals and three juveniles. Of these eight individuals, three larger individuals and three smaller individuals are within the project boundary, comprising around 75 per cent of the known population.

The individuals identified during recent field surveys are potentially part of a larger population of this species occurring in rainforest habitats surrounding the corridor in Section 10. *Endiandra muelleri* subsp. *bracteata* is presumed to be insect/bird pollinated and so it is reasonable to expect the potential population to include all individuals within 500 metres of individuals surrounding corridor. The seeds are readily distributed by fruit-eating bird species.

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

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

Endiandra muelleri subsp. *bracteata* occurs in subtropical rainforest or wet eucalypt forest, chiefly at lower altitudes. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

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

This species occurs in Queensland and in north-east NSW south to Maclean. It is sparsely distributed within this range. This species has been previously recorded in the local area (10 kilometre radius) to the west of the project boundary at Maclean (Section 5) and at Section 10. The individuals recorded in the project boundary are around 65 kilometres north of the known southern distribution at Maclean.

How is the project likely to affect current disturbance regimes?

Indirect impacts from edge effects and altered hydrology may impact the habitat of this species affecting life-cycle attributes for remaining individuals.

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

How is the project likely to affect habitat connectivity?

The project would result in the dissection of habitat for this species with, individuals being present on the eastern and western side of the project. Habitat for this species is currently highly fragmented in the locality and the project would result in further fragmentation of habitats with around 10.33 hectares of the 94.62 hectares of potential rainforest habitat for this species potentially being impacted.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this species.

Eucalyptus tetrapleura (vulnerable species, TSC Act)

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

The life cycle of Eucalyptus tetrapleura is likely to be linked to a large range of factors, but several important components include:

- A wide range of potential pollinator species including insects, birds, bats and arboreal mammals.
- Fire regime including fire intensity, frequency and season.
- Available gene pool.
- Other disturbance regimes such as forestry activities and grazing.

The major populations for *Eucalyptus tetrapleura* were recorded in the Glenugie area some of which has been impacted by the Glenugie Pacific Highway upgrade. Large populations are predicted to be present to the east and west of Glenugie State Forest on private property and additional populations are potentially present in Yuraygir State Conservation Area.

Eucalyptus tetrapleura was also surveyed in several locations remote from the project boundary, including areas along Rockview Road at Chambigne. *Eucalyptus tetrapleura* was observed to extend into areas of private property surrounding Rockview Road, and although no population assessments were carried out in this area *Eucalyptus tetrapleura* is expected to be relatively abundant in this area.

The local abundance of the species varied considerably within each of the different populations and so separate densities were calculated for each population. The average density is calculated as around 100 individuals per hectare. The density of individuals was often dependant on the degree of recruitment, with some areas supporting a large number of juvenile trees and smaller saplings, whilst other areas supported more mature trees with fewer juveniles. The abundance of juveniles is dependent on several factors including fire history, understorey structure and other disturbances such as logging activities. Many of the State Forest areas supported a large number of juveniles possibly due to past disturbance from logging activities and wildfire providing bare soil for germination. Certain fire regimes are likely to favour recruitment, such as fire during the major fruiting period for *Eucalyptus tetrapleura*, providing bare surface substrates for germination of plant-stored seed.

Population estimates were established for several locations surrounding the project with several other locations including State Forests and National Park estates also assessed. The population estimates for each of the areas assessed is detailed below in Table E-7.

Table E-7 Known and predicted *Eucalyptus tetrapleura* populations and potential impacts

Location	Survey status	Area of population (hectares)	Estimated population (no.)	Area of pop in project boundary (hectares)	Estimated number in project boundary
Glenugie State Forest	Surveyed	638.8	103,826	4.14	612
Pine Brush State Forest	Surveyed	139.31	10,336	0	0
Newfoundland State Forest	Surveyed	53.51	5510	0	0
Subtotal - State Forests		**831.62**	**119,672**	**4.14**	**612**
Chambigne Nature Reserve	Surveyed	13.28	1010	0	0
Yuraygir State Conservation Area	Surveyed	18.7	1023	0	0
Wells Crossing Flora Reserve	Surveyed	86.62	4218	10.36	495

Location	Survey status	Area of population (hectares)	Estimated population (no.)	Area of pop in project boundary (hectares)	Estimated number in project boundary
Subtotal - Conservation Reserves		**118.6**	**6251**	**10.36**	**495**
Private property - Glenugie	Surveyed	40.73	6540	0.06	12
Private property - Rockview	Confirmed Records	28.18	1409	0	0
Private property – Glenugie Offset	Surveyed	354.83	22,960	0	0
Private property – Dirty Creek	Surveyed	1.52	94	1.52	94
Private property - Predicted	Predicted	168.54	19,664	0	0
Subtotal – Private Property		**593.8**	**50,667**	**1.58**	**106**
Shannon Creek Dam (Crown Land)	Atlas Records	170	3173	0	0
Total (with impacts from Glenugie Upgrade project subtracted)		**1,714.02**	**179,763**	**16.08**	**1,213**
Total area local population impacted by the project (occurrences within 500 metres of each other)	Surveyed	**1,289.24**	**159,629**	**16.08**	**1,213**
Glenugie Upgrade	Surveyed	**34.52**	**6,061**	**0**	**0**

The data presented above provides a population estimate for 12 sites. However the total population number is estimated to be significantly larger than indicated in Table E-7 as many additional records (DECC Atlas) occur on private lands to the west of Glenugie State Forest (ie At least 30 records) that have not been assessed in detail. Additionally the species is also known to occur in the following state forest and national park estates:

- Whipore State Forest
- Gibberagee State Forest
- Candole State Forest
- Southgate State Forest
- Camira State Forest
- Fullers State Forest
- Mt Neville Nature Reserve
- Sherwood Nature Reserve
- Ramorning National Park.

The total regional population based on recorded locations to date is therefore considered to comprise in the order of 50 different sub-groups with a conservative estimate of between 170,000 to 250,000 individuals.

The local population within the project boundary comprises all occurrences within 500 metres radius of each other considering the high mobility of some pollinator species such as insects, birds and bats, as well as wind dispersal of pollen. This local population is estimated to consist of around 159,629 individuals including occurrences in Glenugie State Forest, Wells Crossing Flora Reserve, private property including the Glenugie offset property and Yuraygir State Conservation Area. The potential impact from the project and the Glenugie upgrade represents around 0.76 per cent of the local population and around 1.25 per cent of the area of occupancy (1,289.24 hectares). This project would have impacts to the local distribution of the species, removing part of the local gene pool and 16.08 hectares of known habitat for *Eucalyptus tetrapleura*.

Including cumulative impacts from the Glenugie upgrade and the current project, the combined impacts to the local population comprise around 7,274 individuals occurring over 50.6 hectares of habitat representing 4.6 per cent of the local population and up to 3.9 per cent of the occupied habitat. The project would result in the removal of habitat for pollinator species, however sufficient habitat for large populations of potential pollinator species would remain in surrounding areas. The cumulative impacts of the project and the Glenugie upgrade, while reducing the local gene pool, however it is considered that there would be significant genetic diversity in the remaining 95 per cent of the population and sufficient habitat for pollinator species to avoid inbreeding depressions or impacts from stochastic events.

When considering the cumulative impacts of the project and the Glenugie Upgrade there would be a significant reduction to the local gene pool, however it is considered that there would be significant genetic diversity in the remaining 95 per cent of the population and sufficient habitat for pollinator species to avoid inbreeding depressions. To mitigate the ecological impacts from the project an offset strategy is proposed to provide greater protection of *Eucalyptus tetrapleura* and habitat for other threatened flora and fauna.

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

Habitat for *Eucalyptus tetrapleura* is not well defined and is not restricted to one particular vegetation association, landform, soil type or geology. Its occurrence was observed to be more associated with a number of physical features influencing soil moisture and groundwater levels, including soil texture, soil depth, slope, bedrock geology and subsoil permeability. Overall, *Eucalyptus tetrapleura* seems to occupy a niche where it is able to out-compete other *Eucalyptus* species where soils are moist but not too wet, where drainage is not significantly impeded and in some circumstances where soils are not too shallow but shallow enough for the bedrock to influence groundwater levels.

The project would result in the removal of up to 16.08 hectares of known habitat for *Eucalyptus tetrapleura*. This constitutes about 0.93 per cent of the total known habitat for *Eucalyptus tetrapleura* identified in the field surveys for this project (refer to **Table E-7**) and significantly less than the total area of habitat occupied by and potentially available to the species. The proportion of the local population habitat being potentially impacted comprises 1.25 per cent; however when considering cumulative impacts from the Glenugie Upgrade this proportion significantly increases to 3.9 per cent of the known habitat.

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

Eucalyptus tetrapleura is endemic to coastal lowlands and foothills from near Glenreagh in the south to Casino in the north, occurring within a range of about 100 km north-south and 50 km east-west. Within this range, the current known distribution is patchy, however the species has not been extensively surveyed and the full extent of the population is unknown.

The population with the project boundary is towards the southern end of known distribution of *Eucalyptus tetrapleura*. There are known populations assessed in the field surveys about 12.5 kilometres to the east and 32 kilometres to the west of the local population within the project boundary. There are records of *Eucalyptus tetrapleura* (DECC 2009) about 8.6 kilometres to the south and 70 kilometres to the north of the population in the project boundary, however the extent and abundance of these populations were not assessed during the field surveys.

How is the project likely to affect current disturbance regimes?

The project would result in a larger fire break to wildfire approaching from the west of the existing highway, potentially resulting in the frequency of wildfire to be reduced in populations to the east. However state forest areas are likely to be fire-managed with control burns implemented in areas during cooler months. Although there is potential for fire regimes to change following the project it is considered unlikely to significantly impact the life cycle of populations of *Eucalyptus tetrapleura*.

Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability. Other indirect impacts from vegetation clearing would include stormwater run-off potentially increasing water and nutrient loads entering adjacent bushland areas, leading to the increased growth and spread of exotic species.

How is the project likely to affect habitat connectivity?

The population is currently fragmented by the existing highway and the project would widen the disturbance width further fragmenting habitats on the western side of the existing highway from populations to the east. However, considering the high mobility of some pollinator species such as insects, birds and bats, and wind dispersal of pollen, gene flow is expected to continue across the existing highway and the width of the project. There are estimated to be about 7,100 individuals on the western side of the existing highway, and this is likely to be a large enough gene pool to continue to successfully reproduce without inbreeding depressions.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this species.

Grevillea quadricauda (vulnerable species, TSC Act)

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

Grevillea quadricauda was recorded in the project boundary at two different locations in Section 3. It occurs in moderate abundance in the project boundary comprising two subpopulations around 1.4 kilometres apart. One of these subpopulations is very small occurring in partially cleared disturbed habitats consisting of eight individuals and a larger population consisting of at least 200 individuals extending to the east of the project boundary. The population number and are of occupancy of these subpopulations are summarised in Table E-8.

Table E-8 *Grevillea quadricauda* populations and potential impacts

Subpopulation name/location	Area of habitat occupied (ha)	Total population number	Number of individuals in project boundary	Area of occupied habitat in project boundary
Northern Population	0.013	8	5	0.012
Southern Population	0.632	200	3	0.008
Total	**0.646**	**208**	**8**	**0.02**

The potential impacts of the project would result in the removal of a high proportion of individuals (62.5 per cent) from the northern population with only three individuals occurring outside of the project boundary. The viability of the northern population is likely to currently be low considering a total population number of eight individuals, and the population is currently threatened from clearing and agricultural activities. It is unlikely that cross-pollination would occur between the two known populations, however there is potential for other occurrences of this species in habitats adjacent to the study area which would improve the potential viability of this population. In the absence of any additional occurrences of *Grevillea quadricauda* within 500 metres of the northern population the project is likely to significantly reduce the viability of this population.

The southern population represents a relatively large abundance of individuals occurring in intact habitats on sandy slopes surrounding the project boundary. The occurrence of this population in the footprint is on the edge of an existing trail near a major creek line, evidence of selective logging was observed in areas of this population. This population is largely avoided by the project and impacts would be limited to three individuals representing around 1.5 per cent of the known population in this area. The removal of three individuals from this population is considered unlikely to significantly reduce the genetic diversity within this population. However there is potential for indirect impacts to alter the habitat of the remaining individuals and mitigation measures are required to minimise indirect impacts.

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

This species grows in gravely loam, in the understorey of dry eucalypt forest, usually along or near creeks. Only a small area of known habitat for the species would be impacted comprising a total of around 0.02 hectares from both populations representing around 3 per cent of the known area of habitat for both populations.

The known habitat removal for the northern population represents around 92 per cent of the total area of known occupied habitat. This population is growing in partially cleared forested areas high on the bank of a major creek line. The known habitat removal for the southern population represents around 1.26 per cent of the total area of known occupied habitat.

Considering this species was recorded on dry sandy slopes and areas surrounding creeks and drainage lines there is a relatively substantial area of potential habitat for the species in the local area including areas of the project boundary.

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

In NSW it is found to the north-west of Whiporie in Mount Belmore State Forest and Mount Neville Nature Reserve, and at Tucabia east of Grafton. It also occurs near Toowoomba in south-east Queensland.

The populations in the project boundary are towards the southern and eastern known distributional limits for *Grevillea quadricauda*. There is a record from 1993 around 5.3 kilometres to the southwest of the subject population however this record appears to occur in a cleared area near Tucabia and is unlikely to be correct. There are records near Whiporie are around 55 kilometres to the northwest. There are no records of *Grevillea quadricauda* to the east of the subject population.

The subject population is likely to represent the eastern and southern distribution limit of the species.

How is the project likely to affect current disturbance regimes?

The project is unlikely to significantly alter disturbance regimes. The project would result in a larger fire break to wildfire approaching from the west potentially resulting in the frequency of wildfire to be reduced in population clusters to the east of the project boundary.

Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability. Considering that the majority of the population adjacent to the project boundary occurs upslope of the project, impacts from some of the potential indirect impacts such as stormwater run-off and altered hydrology would not impact the remaining individuals.

How is the project likely to affect habitat connectivity?

As the majority of the population occurs to the east of the project boundary areas of known habitat would not be fragmented from the project. However habitat connectivity would be affected including potential habitat for *Grevillea quadricauda* and pollinator species.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this species.

Isoglossa eranthemoides (endangered species, TSC Act)

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

This species was recorded in the project boundary in Section 10, comprising 1 individual outside of the project boundary in subtropical rainforest.

The preferred habitat for this species is the understorey of lowland subtropical rainforest, in moist situations on floodplains and slopes. There is a possibility this species is present in rainforest and wet sclerophyll forests within the project boundary, however targeted surveys have not identified any populations within the project boundary.

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. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

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

The preferred habitat for this species is the understorey of lowland subtropical rainforest, in moist situations on floodplains and slopes. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

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

This species has a very restricted distribution in north-east NSW from the Tweed to the Lismore area, with a single uncertain historical report from south-east Queensland. The occurrence in Section 10 would be at the southern distributional limit for the species.

How is the project likely to affect current disturbance regimes?

Indirect impacts from edge effects and altered hydrology may impact the habitat of this species affecting life-cycle attributes of the known single individual.

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

How is the project likely to affect habitat connectivity?

The project would result in the dissection of habitat for this species; however the population would not be dissected. Habitat for this species is currently highly fragmented in the locality and the project would result in further fragmentation of habitats with around 10.33 hectares of the 94.62 hectares of potential rainforest habitat for this species potentially being impacted.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this species.

Lindsaea incisa (endangered species, TSC Act)

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

This species was recorded in or directly adjacent to the project boundary at four locations in Sections 1, 2, 3 and 6. Populations were found along the edges of drainage swales with sandy soils. The four populations are described below and the total area of each population and the area within the project boundary are provided in Table E-9. The populations comprise:

- Population 1: A large population extending into the corridor on the western side of the highway opposite Lemon Tree Road in Section 1. This population occurs in dense shrubs and sedges along the edges of drainage line in a disturbed area of swamp forest
- Population 2: A small patch 12 metres upstream to the east of the project boundary on an elevated area in the centre of Halfway Creek, Section 2
- Population 3: A large population 20 metres downstream to the west of the project boundary near Tucabia in Section 3. This population occurs among dense shrubs and sedges on the edges of a broad drainage swale through partially disturbed swamp forest habitats
- Population 4: A large population extending into the project boundary in Mororo State Forest in Section 6. This population occurs in pockets along the edges of a broad drainage swale in sclerophyll forest grading into swamp forest, extending into disturbed habitats within the road reserve. This population is the largest population occurring over around two hectares of habitat.

Table E-9 *Lindsaea incisa* populations and potential impacts

Subpopulation Name/Location	Area of habitat occupied (ha)	Area of occupied habitat in project boundary (ha)	Proportion of occupied habitat in project boundary
Population 1 – Section 1	0.045	0.024	53.3%
Population 2 – Section 2	0.01	0	0%
Population 3 – Section 3	0.637	0	0%
Population 4 – Section 6	1.974	0.355	18%
Total	**2.666**	**0.379**	**14.2%**

Two of the four populations would potentially be impacted from the project, comprising Population 1 and Population 4 (refer to **Table E-9**). The population number could not be accurately estimated during field surveys considering fronds grow from a spreading rhizome and the high abundance of fronds growing within dense understorey vegetation, therefore the area of occupancy was mapped and is used as the basis for the impact assessment.

Around 53 per cent of Population 1 would potentially be impacted representing a significant proportion of the available gene pool and occupied habitat. There are potentially other locations of this species in adjacent areas of habitat not surveyed which would reduce the proportion of the population being impacted. The proposed impact boundary is relatively broad in this area (up to 215 metres wide) and should be reduced to avoid significantly impacting this population.

Around 18 per cent of Population 2 would potentially be impacted representing a relatively significant proportion of the available gene pool, however it is likely that there are other locations of *Lindsaea incisa* in adjacent areas of habitat not surveyed which would reduce the proportion of the population being impacted. The proposed impact boundary in this area includes several large sediment basins which increases the impact on *Lindsaea incisa*. These sediment basins should be relocated to avoid impacts to *Lindsaea incisa.*

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

Lindsaea incisa grows in damp sandy places in dry eucalypt forest on sandstone and moist shrubby eucalypt forest on metasediments. It is usually found in waterlogged or poorly drained sites along creeks, where ferns, sedges and shrubs grow thickly.

In the study area *Lindsaea incisa* was associated with the edges of drainage swales on sandy soils within and on the edges of swamp forest communities and moist sclerophyll forest. Numerous locations were within previously disturbed areas with an open canopy including the two impacted populations.

The area of occupied habitat impacted is summarised in **Table E-9**. Habitat at Population 1 comprises a narrow band of moist habitat along a creek line with dense sedges, ferns and shrubs in a partially disturbed ecotonal area between swamp forest and dry sclerophyll forests. Habitats at Population 4 include a broad drainage swale in areas of intact moist forest and swamp forest as well as more open habitats along the edges of a maintained easement and also within disturbed habitats in the road easement.

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

In NSW it is known only from a few locations between Woombah and just south of Coffs Harbour around 45 kilometres south of the nearest subject population in the project boundary. It also occurs in north and south-east Queensland, however there are only a couple of records 20 kilometres north of Population 4 near Doubleduke State Forest. The subject populations in the project boundary are not at the southern or northern distributional limit of *Lindsaea incisa*, however there are limited records to the east and west of the subject populations and therefore the subject populations may be at the western and eastern distributional limit for *Lindsaea incisa*.

How is the project likely to affect current disturbance regimes?

The project is unlikely to significantly alter disturbance regimes. The project would result in a larger fire break to wildfire approaching from the west potentially resulting in the frequency of wildfire to be reduced in population clusters to the east of the project boundary.

Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability. Considering that the majority of the population adjacent to the project boundary occurs downslope of the project, impacts from some of the potential indirect impacts such as stormwater run-off and altered hydrology would potentially impact the remaining individuals of *Lindsaea incisa.*

How is the project likely to affect habitat connectivity?

Impacts to Population 1 and Population 4 would not result in the dissection of any population clusters with impacts being limited to one side of the known extant of the population. However potential habitat for the species would be further fragmented by the project removal of known and potential habitat.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this species.

Macadamia tetraphylla (vulnerable species, TSC Act)

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

Macadamia tetraphylla was recently recorded in supplementary surveys in patches of subtropical rainforest north of Coolgardie Road *(*BAAM 2012) comprising a total of 68 individuals. Of these 68 individuals, 37 individuals are within the project boundary, comprising over half of the known population.

Total population size is estimated to be between 1000 and 2000 mature individuals with around 75 key populations with around 5 to 20 mature specimens at each locality (Costello et al 2009). Therefore the population in the study area could be regarded as a relatively large population and potentially represents up to 6.8 to 13.6 per cent of the entire population of which over half would potentially be impacted. The potential impacts to 37 individuals represents a significant proportion of the entire known population of between 1000 and 2000 mature individuals (Costello et al 2009) comprising up to 3.7 to 7.4 per cent of the entire estimated population.

The individuals identified during recent field surveys are potentially part of a larger population of this species occurring in rainforest habitats surrounding the corridor in Section 10. *Macadamia tetraphylla* is pollinated by both introduced European Honey Bee (*Apis mellifera*) and native bees (*Trigona* spp.) with native bees being the superior pollinators (Costello et al 2009). There is evidence indicating considerable pollination occurs between populations even in highly fragmented landscape (Neal 2007). These data indicate that the species may survive small population size if there is a network of small populations within a region, however larger distances between populations are not conducive to gene flow by pollen sufficient to maintain the genetic integrity of populations (Costello et al 2009).

Investigations into the reproduction of *Macadamia tetraphylla* suggest a pollen source from at least a two kilometres distance is an optimal outbreeding distance (Pisanu et al 2008). However, many wild populations do not have neighbouring populations at optimal distances owing to habitat fragmentation which may be the case with the population in the project boundary. Highly disturbed populations have been observed to produce seed and are important as stepping stones for genetic flow between larger populations (Pisanu et al 2008).

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

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

Macadamia tetraphylla is found in several regional ecosystems from complex notophyll vine forest to littoral rainforest to wet sclerophyll communities. In NSW habitat for *Macadamia tetraphylla* includes various rainforest communities. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

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

Macadamia tetraphylla is endemic to eastern Australia, with a known national distribution of scattered populations extending from the Coomera River south of Brisbane to the Richmond River in northern New South Wales, and an altitudinal range of 100 to 800 metres. *Macadamia tetraphylla* is found within the Big Scrub, which has been extensively cleared, substantially altering the original distribution. There are several records in the local area including to the west of the project boundary at Maclean (Section 5), surrounding the corridor at Section 10 and 11 and to the south of the corridor at Section 1.

The population in the study area is towards the southern distributional limit for the species and is part of the southern group identified in the Southern Macadamia Species Recovery Plan (Costello et al 2009) which has a high priority for recovery actions.

How is the project likely to affect current disturbance regimes?

Indirect impacts from edge effects and altered hydrology may impact the habitat of this species affecting life-cycle attributes of the remaining individuals. There is potential for weed invasion to be exacerbated in remaining habitats.

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

How is the project likely to affect habitat connectivity?

The project would result in the dissection of potential rainforest habitat for this species however individuals would not be dissected with individuals being retained on the western side of the project boundary only. Habitat for this species is currently highly fragmented in the locality and the project would result in further fragmentation of habitats with around 10.33 hectares of the 94.62 hectares of potential rainforest habitat for this species potentially being impacted.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this species.

Marsdenia longiloba (endangered species, TSC Act)

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

This species was recorded in Section 10, comprising 1-3 individuals outside of the project boundary in moist forest on the edge of swamp forest with rainforest elements.

The preferred habitat for this species is the understorey of moist forest on floodplains and slopes. There is a possibility this species is present in habitats within the project boundary, however targeted surveys have not identified any populations within the project boundary.

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

The preferred habitat for this species is the understorey of moist forest on floodplains and slopes. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted. There are also more extensive areas of potential habitat along the edges of swamp forests and moist drainage lines in dry sclerophyll forest.

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

Occurs at scattered sites on the north coast of NSW north from Barrington Tops. Also occurs in south-east Queensland. The occurrence in Section 10 would not be at the distributional limit for the species.

How is the project likely to affect current disturbance regimes?

Indirect impacts from edge effects and altered hydrology may impact the habitat of this species affecting life-cycle attributes of the known single individual.

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

How is the project likely to affect habitat connectivity?

The project would result in the dissection of habitat for this species, however a known population would not be dissected.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this species.

Maundia triglochinoides (vulnerable species, TSC Act)

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

Maundia triglochinoides has been recorded at 13 locations in close proximity to the project boundary during the supplementary surveys in 2011 and 2012, of which eight are within the project boundary. *Maundia triglochinoides* is suspected to be wind pollinated and therefore all occurrences within 150 metres of each other have been regarded as a single population, based on evidence of pollen from wind pollinated grass species have been observed to travel up to 150 metres in favourable conditions (Wang et al 2003).

The 13 population clusters are detailed below in Table E-10, including the approximate area occupied by the population, are of population within project boundary, the density of plant clumps within each clump and proportion of population potentially impacted.

Table E-10 Known locations of *Maundia triglochinoides*

Location description	Population dissected by project boundary	Population density	Total known area occupied by population	Total known area within project boundary	Proportion of population within project boundary
Population 1 - Halfway Creek	No	Very high	10,322 metres^2	250 metres^2	2%
Population 2 - Wells Crossing	Yes	Very high	1,324 metres^2	288 metres^2	22%
Population 3 - Coldstream River	Potentially	Very High	1,183 metres^2	0 metres^2	0%
Population 4 - Chaffin Creek	No	Very high	3,818 metres^2	0 metres^2	20%
Population 5 - Un-named creek south of Bostock Road	No	Moderate	175 metres^2	0 metres^2	0%
Population 6 - Several lagoons associated with un-named drainage lines east of Tallowwood Lane	Yes	Low to very high	6,828 metres^2	497 metres^2	7%
Population 7 - Un-named creek east of Tucabia Road	No	Low	155 metres^2	0 metres^2	0%
Population 8 - Swamp Forest south of Tabbimoble Floodway No.2	No	Low	106 metres^2	106 metres^2	100%
Population 9 - Tabbimoble Floodway No.2	No	Very high	419 metres^2	34 metres^2	8%
Population 10 - Tabbimoble Floodway No.1	No	High	314 metres^2	154 metres^2	49%
Population 11 - Un-named creek 1 north of New Italy	No	Moderate	594 metres^2	28 metres^2	6%
Population 12 - Un-named creek 2 north of New Italy	No	Moderate	49 metres^2	49 metres^2	100%
Population 13 - Lagoon east of Tucabia Road	No	Very high	4,340 metres^2	0 metres^2	0%
TOTAL			**29,628 metres^2**	**2,183 metres^2**	**7%**

Other locations remote from the project boundary include two locations east of the project boundary in Section 10 adjacent to Thurgates Lane and Old Bagotville Road.

The project would potentially result in the total removal of the entire area of two populations (Population 8 and 12), a large proportion (10 to 50 per cent) of three populations (Population 2, 4 and 10), moderate impacts (five to 10 per cent) to three populations (Population 6, 9 and 11) and low level impacts (two per cent) to Population 1. Additional to these direct impacts there would potentially be large scale indirect impacts to populations downstream of the project boundary from altered hydrology, sedimentation and erosion.

The proposed impact boundary at Population 4 and 12 includes large sediment basins which increases the impact on *Maundia triglochinoides*. These sediment basins should be relocated to avoid impacts to *Maundia triglochinoides.*

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

Maundia triglochinoides grows in swamps, creeks or shallow freshwater 30 to 60 centimetres deep on heavy clay with low nutrients. In the study area it was observed growing in major creeks and rivers or lagoons associated with these such as Halfway Creek, Wells Crossing, Coldstream River and Chaffin Creek. It was also associated with smaller drainage lines and areas of swamp forest at several locations. Several of the locations appeared to have sandy soils rather than heavy clay.

There is around 2,183 metres squared of occupied habitat for *Maundia triglochinoides* in the project boundary, representing around seven per cent of the total area of occupied habitat identified during recent surveys. There would be a substantial proportion of potential habitat unoccupied by *Maundia triglochinoides* impacted from the project including creek lines and other areas of standing water such as lagoons, wetlands, swamp forest and dams.

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

It is restricted to coastal NSW and extending into southern Queensland. The current southern limit is Wyong; former sites around Sydney are now considered to be extinct. The populations in the study area are within the central areas of the distribution of the species.

How is the project likely to affect current disturbance regimes?

Considering that the species occurs in drainage lines and other low elevation areas subject to flooding, remaining locations surrounding the project would be potentially indirectly impacted from stormwater run-off, sedimentation and altered hydrology.

How is the project likely to affect habitat connectivity?

Habitat connectivity would be somewhat impacted from the project with individuals being present on both sides of the project boundary at some locations (Population 2, 3 and 6). Some connectivity would be maintained along drainage lines beneath road through culverts and bridges. For Population 6, the distance is 150 metres between existing populations that would potentially be retained on either side of the project boundary. Areas of Population 2 would be retained within a protected, vegetated median which would provide a link between occurrences retained either side of the project boundary.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this species.

Melaleuca irbyana (endangered species, TSC Act)

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

A large population of *Melaleuca irbyana* was recorded in the project boundary at New Italy. The population consists of around 800 individuals comprising 250 trees (greater than three metres high) and 550 saplings and suckers, occurring over an area that extends north-south for around 200 metres and east-west for 100 metres (Ecos Environmental 2007) occupying a total of around 2 hectares. Of these 800 individuals recorded up to 530 would potentially be impacted from the project including around 1.16 hectares of occupied habitat. The population included both seedlings, juvenile and adult plants.

The life cycle of *Melaleuca irbyana* is likely to be linked to a large range of factors, but several important components include:

- A wide range of potential pollinator species including insects, birds, bats and arboreal mammals
- Fire regime including fire intensity, frequency and season
- Available gene pool
- Other disturbance regimes such as forestry activities and grazing.

To the west of the project boundary there are several populations of *Melaleuca irbyana* recorded on the OEH Atlas of NSW Wildlife (2011), with at least 114 individuals recorded. Several relatively large populations area also known from the southern end of the project including a large population of about 4,200 individuals occurring over a 3 hectare area adjacent to the western side of the existing highway at Glenugie in Glenugie State Forest and another population about 2.5 kilometres northeast of the Pacific Highway in Glenugie State Forest and freehold land (Glenugie Upgrade Offset property). Small population clusters were also recorded on freehold lands surrounding the project boundary in the Pillar Valley area (Section 3).

The local population for *Melaleuca irbyana* at New Italy is considered to include only the plants within and directly adjacent to the project boundary, with no other populations recorded in surrounding areas to date. Considering the high mobility of potential pollinator species and wind dispersal of pollen the local population may also include other yet to be identified population clusters on freehold lands surrounding the project boundary at New Italy.

The total population size is estimated to be 800 individuals occurring over two hectares of which 530 individuals occurring over 1.16 hectares would be impacted from the project. Therefore the individuals potentially impacted from the project comprise around 66per cent of the local population and 58 per cent of the area of occupied habitat.

To mitigate the loss of individuals within the project boundary and prevent significant losses to the local gene pool, it is proposed that seed collection and propagation program be implemented for *Melaleuca irbyana* in close proximity to the project boundary. There is up to three hectares of disturbed areas of potential *Melaleuca irbyana* habitat adjacent to the western side of the project boundary which could be rehabilitated for translocation of *Melaleuca irbyana* from the project boundary as well as direct seeding and planting of tubestock.

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

Melaleuca irbyana occurs in open eucalypt forest on poorly drained clay soils. Populations within and surrounding the project boundary were observed in ecotonal areas between Spotted Gum – Ironbark forest and swamp forest/floodplain forest communities. Populations observed in and surrounding the project boundary are co-located with Prickly-leaved Paperbark *(Melaleuca nodosa*).

The project would result in the removal of about 1.16 hectares of known *Melaleuca irbyana* habitat, from the two hectares of habitat estimated to be present in close proximity to the project boundary. There is up to three hectares of disturbed areas of potential *Melaleuca irbyana* habitat adjacent to the western side of the project boundary which could be rehabilitated for translocation of *Melaleuca irbyana* from the project boundary as well as direct seeding and planting of tubestock.

To the west of the project boundary at New Italy there are several populations of *Melaleuca irbyana* recorded on the OEH Atlas of NSW Wildlife *(*2011) 13 and 35 kilometres from the project boundary, with at least 114 individuals recorded. More investigations would be required to accurately determine the total area of habitat occupied by *Melaleuca irbyana* in the locality.

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

Melaleuca irbyana is found in only a few places in north-east NSW, including near Coraki, Casino, Coutts Crossing south of Grafton, and also near Ipswich south-east Queensland. The study area is towards the known southern extent of the species; however there are populations in Glenugie State Forest about 82 kilometres to the south of New Italy. Additionally there are also several populations between 13 and 35 kilometres to the west of the project boundary. There are no records to the east of the project boundary at New Italy and therefore the population at New Italy may represent the eastern extent of *Melaleuca irbyana* in this area.

How is the project likely to affect current disturbance regimes?

The project is unlikely to significantly alter disturbance regimes. The project would result in a larger fire break to wildfire approaching from the west potentially resulting in the frequency of wildfire. Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability. Considering that the majority of the population adjacent to the project boundary occurs downslope of the project, impacts from some of the potential indirect impacts such as stormwater run-off and altered hydrology would potentially impact the remaining individuals of *Melaleuca irbyana*.

How is the project likely to affect habitat connectivity?

As the existing population is currently fragmented by the existing highway, the project would result in further fragmentation of individuals, however individuals would only be retained on the western side of the project boundary.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this species.

Oberonia titania (vulnerable species, TSC Act)

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

A small population of *Oberonia titania* was recorded to the east of the construction footprint in Section 10 during 2010 and it was also recorded east of the corridor in Section 7 but could not be relocated during surveys in 2012. In Section 10, it was mainly recorded growing on the small rainforest tree (*Trochocarpa laurina*) and several plants were also recorded growing on moss and lichens on Bangalow Palm (*Archontophoenix cunninghamiana*) and Brush Kurrajong (*Commersonia fraseri*) in an area of swamp sclerophyll forest with rainforest elements. The population was restricted to two small areas growing on three trees in one area around 100 to 120 metres from the construction footprint consisting of up to 370 individuals, and up to 10 plants growing on two trees around 12 metres from the edge of the construction footprint. No individuals would be directly impacted, although there is potential for indirect impacts from edge effects to impact the 10 individuals closest to the proposed cut area.

There is potential for populations of this species to be present at other sites where suitable swamp forest, rainforest and mangrove habitats are present. Although targeted searches were conducted in most areas of suitable habitat there is potential for the species to be present considering the epiphytic nature of the species, the potential for the species to be high in the canopy and the small and cryptic habit of the species.

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

The total area of potential habitat for this species impacted by the project comprises over 100 hectares of rainforest and swamp sclerophyll forest, and there is an additional 100 hectares of floodplain forest of which some areas may have suitable habitat attributes for *Oberonia titania*. There would be impacts to potential habitat for the species in the local area. The distribution of *Oberonia titania* in the local area may have included other patches of swamp forest in the study area, however some of these areas have been impacted from wildfire with significant scorch marks noted on paperbarks in several swamp forest areas.

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

Oberonia titania occurs on the NSW north coast north from Kendall, and also in Queensland and Norfolk Island. It is known from 10 locations in NSW, two of which occur within Dorrigo National Park and Washpool National Park. The population in the study area is not at the distributional limit for the species.

How is the project likely to affect current disturbance regimes?

Vegetation clearing for the project would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability. Considering that the species is epiphytic and grows on tree branches and trunks the main impacts would be from increased sunlight and other disturbances such as weed invasion as well as indirect impacts such as stormwater run-off. However, these are unlikely to impact the majority of the remaining individuals.

How is the project likely to affect habitat connectivity?

There would be some impacts to connectivity with impacts significant areas of potential habitat for *Oberonia titania*. However, impacts are mostly limited to edges of these habitats and there would not be significant amounts of fragmentation of existing larger vegetation patches.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this species.

Olax angulata (vulnerable species, TSC Act)

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

One individual has been recorded in the project boundary north of Halfway Creek at Section 2, during surveys in September 2010 for this project. Further supplementary surveys during December 2011 failed to locate any additional individuals. The main population near Minnie Waters is estimated to consist of around 5500 individuals with the nearest record around 20 kilometres to the east of the project boundary. There is likely to be other occurrences of the species closer to the project boundary from where the individual in the corridor has been recruited.

The fleshy fruit of this species is potentially attractive to fruit-eating bird species and is likely to have been carried into the project boundary from surrounding populations.

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

Olax angulata was identified growing in dry sclerophyll forest dominated by Needlebark (*Eucalyptus planchoniana*). This vegetation type is widespread in the project boundary with around 60 hectares of similar habitat potentially being impacted.

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

Olax angulata is known only from a small area east of Grafton, on the NSW north coast, near Minnie Waters and Wooli. It occurs mainly within Yuraygir National Park and on nearby Crown leasehold land (Quinn et al. 1995). The species is locally common in these areas, with the main population near Minnie Waters comprising about 5500 individuals. A disjunct population in Banyabba Nature Reserve was discovered in 2006, which contains about ten plants.

The single plant in the project boundary is likely to represent the south-western distributional limit of the *Olax angulata*.

How is the project likely to affect current disturbance regimes?

The project is unlikely to significantly alter disturbance regimes. The project would result in a larger fire break to wildfire approaching from the west potentially resulting in the frequency of wildfire to be reduced in population clusters to the east of the project boundary. Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability.

How is the project likely to affect habitat connectivity?

As only one individual has been identified in the project boundary the project would not result in further fragmentation of individuals, however there would be further fragmentation of potential habitat.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this species.

Quassia sp. 'Moonee Creek' (endangered species, TSC Act)

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

One individual has been recorded in Section 3 outside of the project boundary and will not be directly or indirectly impacted from the proposal. Potential habitat for this species is widespread in the locality, and there is likely to be a viable population in the locality, with around 70 records in the locality. This individual occurs around 230 metres to the east of the proposed footprint and is considered unlikely to be indirectly impacted.

There is a low possibility this species is present in habitats within the project boundary, however targeted surveys have not identified any populations within the project boundary. 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.

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

This species was identified growing in dry sclerophyll forest dominated by Needlebark (*Eucalyptus planchoniana*) and Smudgy Apple (*Angophora woodsiana*). This vegetation type is widespread in the project boundary with around 60 hectares of similar habitat potentially being impacted.

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

This species has a scattered distribution from the Moonee Creek area north of Coffs Harbour to north-east of Grafton. There are also records to the north of this known distribution surrounding Section 10 and 11. The occurrence of this species adjacent to the project boundary in section 3 is not the limit of the known distribution for this species.

How is the project likely to affect current disturbance regimes?

The project is unlikely to significantly alter disturbance regimes. The project would result in a larger fire break to wildfire approaching from the west potentially resulting in the frequency of wildfire to be reduced in population clusters to the east of the project boundary. Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability.

How is the project likely to affect habitat connectivity?

As only one individual has been identified adjacent to the project boundary and the project would not result in further fragmentation of individuals, however there would be further fragmentation of potential habitat.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this species.

Peristeranthus hillii (vulnerable species, TSC Act)

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

No individuals have been recorded in the project boundary. There is a possibility this species is present in suitable habitats within the project boundary comprising coastal and near-coastal environments, particularly in Lowland Rainforest. Although targeted surveys have not identified any populations within the project boundary. There is a possibility of moderate likelihood for this species to occur throughout the project boundary in suitable habitats of sandstone sclerophyll forests however targeted surveys have not identified this species at any additional locations in the corridor.

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

This species is an epiphyte, growing in clumps on tree trunks and thick vines in lowland rainforest. There are records for this species surrounding the project boundary at various locations. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

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

Found in north-eastern NSW, north from Port Macquarie. The study area doesn't represent the distributional limit of the species.

How is the project likely to affect current disturbance regimes?

The project is unlikely to significantly alter disturbance regimes. The project would result in a larger fire break to wildfire approaching from the west potentially resulting in the frequency of wildfire to be reduced in population clusters to the east of the project boundary. Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability.

How is the project likely to affect habitat connectivity?

As no individuals have been identified adjacent to or within the project boundary, the project would not result in further fragmentation of individuals; however there would be further fragmentation of potential habitat.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this species.

Prostanthera cineolifera (vulnerable species, TSC Act)

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

This species is known from one locations, one on the Tabbimoble Creek south of Tullymorgan Road, inhabiting a narrow belt of deep, sandy soil along Tabbimoble Creek. This area was surveyed again during January 2012 to estimate the number of individuals in and surrounding the project boundary. There is a possibility of moderate likelihood for this species to occur throughout the project boundary in suitable habitats of sandstone sclerophyll forests.

The entire population in the known location is very large with the majority of the population occurring to the west of the project boundary in some areas forming a dense thicket of understory vegetation along Tabbimoble Creek. The population number is conservatively estimated to comprise 5000 to 8000 individuals occurring over 2.22 hectares. The population may extend further to the west along Tabbimoble Creek.

The number of plants in the project boundary is estimated to comprise up to 250 individuals occurring over 0.41 hectares, with mainly the population on the western side of the existing highway potentially being impacted. The proportion of the population potentially being impacted comprises around three to five per cent of the local population and around 18.5 per cent of the known area of occupied habitat.

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

Prostanthera cineolifera occurs in sclerophyll forests (Harden, 2002) and open woodlands on exposed sandstone ridges and is often found in association with shallow or skeletal sands. Of the 2.22 hectares of identified occupied habitat around 0.41 hectares (18.5 per cent) would potentially be impacted.

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

The population in the project boundary represents the most northerly occurrence of *Prostanthera cineolifera* and is widely disjunct from its known distribution previously regarded as being restricted to only a few localities near Walcha, Scone and St Albans. Therefore the population in the project boundary is important in terms of the overall distribution and genetic diversity of the species.

How is the project likely to affect current disturbance regimes?

The project is unlikely to significantly alter disturbance regimes. The project would result in a larger fire break to wildfire approaching from the west potentially resulting in the frequency of wildfire to be reduced in population clusters to the east of the project boundary.

Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability. Considering that the majority of the population adjacent to the project boundary occurs downslope of the project, impacts from some of the potential indirect impacts such as stormwater run-off and altered hydrology would potentially impact the remaining individuals of *Prostanthera cineolifera*.

How is the project likely to affect habitat connectivity?

As the existing population is currently fragmented by the existing highway, the project would result in further fragmentation of individuals, with individuals being retained on either side of the project.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this species.

Prostanthera palustris (vulnerable species, TSC Act)

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

This species was recorded in Section 7, comprising an unknown number of individuals outside of the project boundary growing in wet heath and swamp forest.

The preferred habitat for this species is poorly drained sandy soils, subject to extended water logging, in wet shrubland to heathland. There is a possibility this species is present in these habitats within the project boundary, however targeted surveys have not identified any populations within the project boundary.

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

The preferred habitat for this species is poorly drained sandy soils, subject to extended waterlogging, in wet shrubland to heathland. There is around 10 hectares of wet heathland in project boundary which provides potential habitat for this species.

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

This species is only known from the Jerusalem Creek area in the north of Bundjalung National Park, near Evans Head. Therefore the occurrence in Section 7 would represent the known distributional limit of the species.

How is the project likely to affect current disturbance regimes?

The project is unlikely to significantly alter disturbance regimes. The project would result in a larger fire break to wildfire approaching from the west potentially resulting in the frequency of wildfire to be reduced in population clusters to the east of the project boundary.

Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability. Considering that the majority of the population adjacent to the project boundary occurs downslope of the project, impacts from some of the potential indirect impacts such as stormwater run-off and altered hydrology would potentially impact the remaining individuals of *Prostanthera cineolifera*.

How is the project likely to affect habitat connectivity?

The project would result in the dissection of habitat for this species, however a population would not be fragmented.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this species.

Syzygium hodgkinsoniae (vulnerable species, TSC Act)

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

This species was recorded in Section 10, comprising a single individual in subtropical rainforest north of Coolgardie Road (BAAM 2012) within the project boundary. There are no known individuals adjacent to the construction footprint and the size of the local population is largely unknown. Any individuals present in areas surrounding the construction footprint could potentially be impacted by indirect impacts from edge effects and altered hydrology.

The individuals identified during recent field surveys are potentially part of a larger population of this species occurring in rainforest habitats surrounding the corridor in Section 10. *Syzygium hodgkinsoniae* is insect/bird pollinated and so it is reasonable to expect the potential population to include all individuals within 500 metres of individuals surrounding corridor.

There is some potential for the genetic diversity of the local population of *Syzygium hodgkinsoniae* to be depleted. There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

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

It is found on deep rich alluvial and basalt soils. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

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

Occurs in a geographically disjunct distribution from the Richmond River in north-east New South Wales (NSW) to Maleny and Kin Kin in south-east Queensland, with disjunct populations in Kuranda and Gordonvale, north-east Queensland. The occurrence in the project boundary is near the southern distributional limit for the species. There are three records in the local area including around two kilometres west of the corridor in Section 8.

How is the project likely to affect current disturbance regimes?

Indirect impacts from edge effects and altered hydrology may impact the habitat of this species affecting life-cycle attributes of any remaining individuals which could potentially be present.

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

How is the project likely to affect habitat connectivity?

The project would result in the dissection of habitat for this species with, individuals being present on the eastern and western side of the project. Habitat for this species is currently highly fragmented in the locality and the project would result in further fragmentation of habitats with around 10.33 hectares of the 94.62 hectares of potential rainforest habitat for this species potentially being impacted.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this species.

Tinospora tinosporoides (vulnerable species, TSC Act)

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

No individuals have been recorded in the project boundary. There is a possibility this species is present in suitable habitats within the project boundary comprising wetter subtropical rainforest, including littoral rainforest, on fertile, basalt-derived soils. Although targeted surveys have not identified any populations within the project boundary, the cryptic nature of the species suggests there is potential for the species to be present.

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

The preferred habitat for this species is the understorey of moist rainforest on floodplains and slopes. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

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

North from the Richmond River in north-east NSW, it is locally common in some parts of its range. It is also recorded from a single location in south-east Queensland. Any occurrences south of the Richmond River would be regarded to be at the distributional limit for the species.

How is the project likely to affect current disturbance regimes?

Indirect impacts from edge effects and altered hydrology may impact the habitat of this species affecting life-cycle attributes of the known single individual.

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

How is the project likely to affect habitat connectivity?

The project would result in the dissection of habitat for this species, however a known population would not be dissected.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this species.

Endangered Ecological Communities

Subtropical Coastal Floodplain Forest

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

Subtropical Coastal Floodplain Forest is not a threatened species or a population.

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

A total of 1483 hectares of Subtropical Coastal Floodplain Forest has been identified within and surrounding the study area, of which the project would directly remove 130 hectares. The condition of this community varies throughout the project boundary, however a large majority of the community is likely to be in a moderate condition including various remnants within agricultural landscapes open to grazing and thin strips of riparian vegetation.

The Comprehensive Regional Assessment Aerial Photographic Interpretation (CRAFTI) (NPWS 1998) has broadly mapped about 14,287 hectares of vegetation with affinities to Subtropical Coastal Floodplain Forest within around a 10 kilometre radius of the project boundary, however CRAFTI provide broad-scale vegetation mapping, with much of the vegetation mapped as part of has not been ground truthed and therefore this is regarded as a rough estimate. Based on the interpretation of the CRAFTI data the project would result in the removal of about one per cent of the local distribution of this community.

There is potential for the project 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 water table 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.

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

Subtropical Coastal Floodplain Forest is not a threatened species or a population.

How is the project likely to affect current disturbance regimes?

Current disturbance regimes in Subtropical Coastal Floodplain Forest mainly comprise weed invasion, grazing and edge effects. The project is unlikely to significantly alter any of the current disturbance regimes, however there is potential weed invasion to be exacerbated. Impacts from grazing may be minimised in some areas where grazing would be excluded from areas, however weed management may be required in some of these previously grazed sites.

How is the project likely to affect habitat connectivity?

Much of this community in the project boundary is currently highly fragmented however several larger intact patches are present which would be further fragmented where the project boundary adjoins the existing highway and several patches of Subtropical Coastal Floodplain Forest remote from the existing highway would be dissected creating new edge effects through intact patches.

Considering the high mobility of many pollinator species for the various plant species within this Threatened Ecological Community (such as insects, birds and bats, and also wind and water dispersal of genetic material) some gene flow is expected to continue across the existing highway and the width of the project boundary. Some connectivity would be maintained beneath the project through culverts, pipes etc where this Threatened Ecological Community occurs on drainage lines.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this community.

Swamp Sclerophyll Forest

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

Swamp Sclerophyll Forest is not a threatened species or a population.

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

A total of 1249 hectares of Swamp Sclerophyll Forest has been identified within and surrounding the study area, of which the project would impact around 93 hectares of this community in various condition states. The Comprehensive Regional Assessment Aerial Photographic Interpretation (CRAFTI) (NPWS 1998) has mapped about 20,465 hectares of vegetation with affinities to Swamp Sclerophyll Forest and Swamp Oak Floodplain Forest within about a 10 kilometre radius of the project boundary. The project would potentially result in the removal of 0.45 per cent of the local distribution of these communities, however this is likely to be a greater proportion when considering only the Swamp Sclerophyll Forest component of this area interpreted from the CRAFTI dataset.

There is potential for the project 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 water table 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.

Areas of this community outside of the project boundary which may potentially be impacted from indirect impacts include numerous areas throughout the study area. There are also several identified areas of SEPP 14 coastal wetlands surrounding the project area which include areas of this community.

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

Swamp Sclerophyll Forest is not a threatened species or a population.

How is the project 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 weed species such as *Lantana camara* and where under-scrubbing has been implemented for grazing purposes some pasture grasses and other weed species are present.

The project is likely to contribute to further invasion of *Lantana camara* particularly along the edges where removal of vegetation is required and there would be increased sunlight availability. Other indirect impacts such as altered water and nutrient regimes may also aid the growth of weed species. The project 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 project would retain most of the current disturbance regimes.

How is the project likely to affect habitat connectivity?

Habitat connectivity for Swamp Sclerophyll Forest would be impacted in several locations along the project area. The further widening of the existing Pacific Highway corridor would result in further fragmentation of the community adjacent to the existing highway. Several patches of Swamp Sclerophyll Forest remote from the existing highway would be dissected creating new edge effects through intact patches.

Considering the high mobility of many pollinator species for the various plant species within this Threatened Ecological Community (such as insects, birds and bats, and also wind and water dispersal of genetic material) some gene flow is expected to continue across the existing highway and the width of the project boundary. Some connectivity would be maintained beneath the project through culverts, pipes etc where this Threatened Ecological Community occurs on drainage lines.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this community.

Swamp Oak Floodplain Forest

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

Swamp Oak Floodplain Forest is not a threatened species or a population.

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

A total of 524 hectares of Swamp Oak Floodplain Forest has been identified within and surrounding the study area, of which the project would impact around 56 hectares of this community in various condition states. The Comprehensive Regional Assessment Aerial Photographic Interpretation (CRAFTI) (NPWS 1998) has mapped about 20,465 hectares of vegetation with affinities to Swamp Sclerophyll Forest and Swamp Oak Floodplain Forest within about a 10 kilometre radius of the project boundary. The project would potentially result in the removal of 0.27 per cent of the local distribution of these communities, however this is likely to be a greater proportion when considering only the Swamp Oak Floodplain Forest component of this area interpreted from the CRAFTI dataset.

There is potential for the project 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 water table 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.

Areas of this community outside of the project boundary which may potentially be impacted from indirect impacts include numerous areas throughout the study area. There are also several identified areas of SEPP 14 coastal wetlands surrounding the project area which include areas of this community.

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

Swamp Oak Floodplain Forest is not a threatened species or a population.

How is the project likely to affect current disturbance regimes?

Current disturbance regimes in Swamp Oak Floodplain Forest mainly comprise weed invasion and cattle grazing. Some drier patches of this community support low-moderate abundances of weed species such as *Lantana camara* and where under-scrubbing has been implemented for grazing purposes some pasture grasses and other weed species are present.

The project is likely to contribute to further invasion of *Lantana camara* particularly along the edges where removal of vegetation is required and there would be increased sunlight availability. Other indirect impacts such as altered water and nutrient regimes may also aid the growth of weed species. 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 project would retain most of the current disturbance regimes.

How is the project likely to affect habitat connectivity?

Habitat connectivity for Swamp Oak Floodplain Forest would be impacted in several locations along the project area. The further widening of the existing Pacific Highway corridor would result in further fragmentation of the community adjacent to the existing highway. Several patches of Swamp Oak Floodplain Forest remote from the existing highway would be dissected creating new edge effects through intact patches.

Considering the high mobility of many pollinator species for the various plant species within this Threatened Ecological Community (such as insects, birds and bats, and also wind and water dispersal of genetic material) some gene flow is expected to continue across the existing highway and the width of the project boundary. Some connectivity would be maintained beneath the project through culverts, pipes etc where this Threatened Ecological Community occurs on drainage lines.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this community.

Freshwater Wetlands

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

Freshwater wetland is not a threatened species or a population.

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

A total of 125 hectares of Freshwater Wetlands has been identified within and surrounding the study area, of which the project would impact around 13 hectares of this community in various condition states. The Comprehensive Regional Assessment Aerial Photographic Interpretation (CRAFTI) (NPWS 1998) has mapped about 3051 hectares of vegetation with affinities to Freshwater Wetlands within about a 10 kilometre radius of the project boundary. The project would potentially result in the removal of 0.42 per cent of the local distribution of this community.

There is potential for the project to alter habitat attributes of surrounding areas through indirect impacts such as altering hydrological and nutrient regimes in habitats downstream of the proposed development. 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 water table. Mitigation measures during construction and the implementation of specific design features into the proposed development are likely to minimise these indirect impacts.

Areas of this community outside of the project boundary may potentially be impacted from indirect impacts. There are also several identified areas of SEPP 14 coastal wetlands surrounding the project area which include areas of this community.

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

Freshwater wetland is not a threatened species or a population.

How is the project 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. There is potential for indirect impacts such as altered hydrology and sedimentation levels.

How is the project likely to affect habitat connectivity?

Habitat connectivity for Freshwater Wetlands would be impacted in several locations along the project area. The further widening of the existing Pacific Highway corridor would result in further fragmentation of the community adjacent to the existing highway. Several patches of Freshwater Wetlands remote from the existing highway would be dissected creating new edge effects through intact patches.

Considering the high mobility of many pollinator species for the various plant species within this Threatened Ecological Community (such as insects, birds and bats, and also wind and water dispersal of genetic material) some gene flow is expected to continue across the existing highway and the width of the project boundary. Some connectivity would be maintained beneath the project through culverts, pipes etc where this Threatened Ecological Community occurs on drainage lines.

How is the project 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.

Lowland Rainforest

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

Lowland Rainforest is not a threatened species or a population.

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

A total of 95 hectares of Lowland Rainforest has been identified within and surrounding the study area mainly in Section 10 near Coolgardie Road, of which the project would impact around 10 hectares of this community in various condition states. The Comprehensive Regional Assessment Aerial Photographic Interpretation (CRAFTI) (NPWS 1998) has mapped about 1817.75 hectares of vegetation with affinities to Lowland Rainforest within about a 10 kilometre radius of the project boundary. The project would potentially result in the removal of 0.57 per cent of the local distribution of this community.

There is potential for the project 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 water table 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.

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

Lowland Rainforest is not a threatened species or a population.

How is the project likely to affect current disturbance regimes?

Current disturbance regimes in Lowland Rainforest 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. There is potential for indirect impacts such as altered hydrology and sedimentation levels.

How is the project likely to affect habitat connectivity?

Habitat connectivity for Lowland Rainforest would be impacted in several locations along the project area. The further widening of the existing Pacific Highway corridor would result in further fragmentation of the community adjacent to the existing highway.

Considering the high mobility of many pollinator species for the various plant species within this Threatened Ecological Community (such as insects, birds and bats, and also wind and water dispersal of genetic material) some gene flow is expected to continue across the existing highway and the width of the project boundary. Some connectivity would be maintained beneath the project through culverts, pipes etc where this Threatened Ecological Community occurs on drainage lines.

How is the project 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.

Coastal Cypress Pine Forest

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

Coastal Cypress Pine Forest is not a threatened species or a population.

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

The affinities of Coastal Cypress Pine Forest in the study area to the description of this ecological community in the final determination have not been assessed, and therefore there are likely to areas which are not consistent with the threatened ecological community. The final determination states the total distribution of Coastal Cypress Pine Forest covers around 150 hectares and is certainly less than 200 hectares.

A total of 306 hectares of Coastal Cypress Pine Forest has been identified within and surrounding the study area, of which the project would impact around 27 hectares of this community in various condition states. The Comprehensive Regional Assessment Aerial Photographic Interpretation (CRAFTI) (NPWS 1998) has mapped about 38 hectares of vegetation with affinities to Coastal Cypress Pine Forest within about a 10 kilometre radius of the project boundary.

There is potential for the project 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 water table 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.

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

Coastal Cypress Pine Forest is not a threatened species or a population.

How is the project likely to affect current disturbance regimes?

Current disturbance regimes in this community 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. There is potential for indirect impacts such as altered hydrology and sedimentation levels.

How is the project likely to affect habitat connectivity?

Habitat connectivity for Coastal Cypress Pine Forest would be impacted in several locations along the project area. The further widening of the existing Pacific Highway corridor would result in further fragmentation of the community adjacent to the existing highway. Several patches of Coastal Cypress Pine Forest remote from the existing highway would be dissected creating new edge effects through intact patches.

Considering the high mobility of many pollinator species for the various plant species within this Threatened Ecological Community (such as insects, birds and bats, and also wind and water dispersal of genetic material) some gene flow is expected to continue across the existing highway and the width of the project boundary. Some connectivity would be maintained beneath the project through culverts, pipes etc where this Threatened Ecological Community occurs on drainage lines.

How is the project 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.

E.2 *Environment Protection and Biodiversity Conservation Act, 1999*

Under the Environment Protection and Biodiversity Conservation Act 1999, important populations are:

- likely to be key source populations either for breeding or dispersal
- likely to be necessary for maintaining genetic diversity
- at or near the limit of the species range.

The heads of consideration for critically endangered and endangered species under the EPBC Act, are as follows:

An action is likely to have a significant impact on a critically endangered or endangered species if there is a real chance or possibility that it will:

- lead to a long-term decrease in the size of a population
- reduce the area of occupancy of the species
- fragment an existing population into two or more populations
- adversely affect habitat critical to the survival of a species
- disrupt the breeding cycle of a population
- modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
- result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat
- introduce disease that may cause the species to decline, or
- interfere with the recovery of the species.

Endangered fauna

Australasian Bittern

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

As the project traverses a portion of the floodplain of the Clarence and Richmond rivers in addition to the Corindi River north of Woolgoolga, this would result in direct impacts to around thirteen hectares of wetland habitats in addition to crossing numerous tributaries which also provide known and potential habitat for this species.

Potential indirect impacts were identified for eight Nationally Important Wetlands and 15 SEPP 14 listed wetlands outside the project boundary. Most of these wetlands are recharged or fed by the Clarence River and Richmond River catchments. This species is linked to several vegetation types that would be impacted by the project as outlined below.

Vegetation / habitat types linked to Australasian Bittern and impacted by the project	Area in project boundar y	Project Section (extent in hectares)
Coastal floodplain sedgelands, rushlands, and forblands	3.0 ha	3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha)
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	73.9 ha	1(4.7 ha), 2 (0.8 ha),3 (38.4 ha),4 (0.8 ha), 5 (2.3 ha),6 (18.7 ha) ,7 (0.1 ha),10 (5.6 ha),11 (1.8 ha)
Mangrove - Grey Mangrove low closed forest of the NSW Coastal Bioregions	1.5 ha	5 (1.3ha), 10 (0.2ha)
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	34.7 ha	6 (7.3ha), 7 (12.5ha), 8 (8.1ha)
Paperbark swamp forest of the coastal lowlands of the North Coast	49.5 ha	1 (10.4ha), 2 (3.4ha), 3 (1.1ha), 4 (0.2ha), 6 (1.8ha), 7 (20.5ha), 8 (11.1ha), 10 (0.2ha)
Swamp Box swamp forest of the coastal lowlands of the North Coast	28.5 ha	1 (23.3ha), 2(5.2ha)
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	44.2 ha	1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha)
Swamp Oak swamp forest of the coastal lowlands of the North Coast	56.2 ha	1 (0.9 ha), 3 (12.8 ha), 4(1.6 ha), 5(11.7 ha), 8(12.2 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
Wet heathland and shrubland of coastal lowlands of the North Coast	10 ha	6 (10ha)

Historically there has been a dramatic decline in the diversity and abundance of waterbirds on the Clarence River floodplain (Smith 2011). This is a trend which is likely to have also been experienced on the Richmond River floodplain, and a result of the long history of wetland change associated with floodplain mitigation and agriculture. Australasian Bittern is dependent on tall densely vegetated wetlands and creeks above the floodplain and have adapted to using modified or degraded wetlands including artificially constructed environments.

The project may directly and indirectly affect the life-cycle of populations by displacing or disturbing individuals or established pairs. This may include nesting, foraging and roosting life-cycle activities. Nesting locations for this species are not published and their location in relation to the study area is not known. However potential habitats for the species as identified above are widespread throughout the study area and region including dense vegetation on the margins of freshwater creeks, rivers and natural or artificial wetlands.

Although there are few records of Australasian Bittern in the study area and these are patchily distributed across the region, which may be a result of the secretive behaviour of the species in addition to low density.

Indirect impacts would be associated with edge effects, light and noise, these would be localised in relation to home range and territory. The number of pairs potentially affected is not known. There is expected to be several pairs in the floodplain areas of the Clarence River.

Reduce the area of occupancy of the species

Australasian Bittern favour permanent freshwater wetlands and riparian vegetation with tall, dense vegetation, particularly bulrushes (*Typha* spp.) and spikerushes (*Eleocharis* spp.).

As the project traverses a portion of the floodplain of the Clarence and Richmond Rivers in addition to the Corindi River north of Woolgoolga, these habitat types are common and widespread across the major floodplains of the study area. The project would result in direct impacts to around 3 hectares of wetland habitats in addition to crossing numerous tributaries which have not been quantified, and these also provide known and potential habitat for these subject species. Potential indirect impacts were identified for eight Nationally Important Wetlands and 15 SEPP 14 listed wetlands outside the project boundary. Most of these wetlands are recharged or fed by the Clarence River and Richmond River catchments.

The review of habitat availability and records of this species suggest that potential habitat is widespread throughout the study area including dense vegetation on the margins of freshwater creeks, rivers and natural or artificial wetlands.

Fragment an existing population into two or more populations

The project has potential to isolate remnant vegetation patches and create barriers to the movement of this species on both a patch and landscape scale. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg Sections 3 to 4 and 9 to 10), these occur in areas of known and potential habitat for the Australasian Bittern.

Within the floodplain areas that are preferred by this species there is currently a high degree of habitat fragmentation. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River.

There is limited data on the distribution of local and regional populations to identify if a population would be fragmented, however potential habitat would be traversed. This species is capable of dispersing across fragmented habitats including roads and cleared land.

Adversely affect habitat critical to the survival of a species

The project would result in direct impacts to around thirteen hectares of wetland habitats in addition to crossing numerous tributaries which have not been quantified, and these also provide known and potential habitat for this species. This impact is likely to affect life-cycle activities for localised populations. However, the distribution and abundance of populations over this scale is not known.

There are eight Nationally Important Wetlands and 15 SEPP 14 listed wetlands outside the project boundary. Most of these wetlands are recharged or fed by the Clarence River and Richmond River catchments in addition to numerous non-listed wetlands in the region. It is assumed that these habitats also contribute to the long-term maintenance of the species including maintaining genetic diversity and the long term evolutionary development of the species.

Portions of at least nine other habitat types as described previously would be impacted, and it is likely that some of these areas provide critical habitat for established pairs. However the distribution of known pairs is not known.

Disrupt the breeding cycle of a population

On the basis that the project construction would extend over two to five years, there is reasonable potential for the activity to disrupt the breeding cycle of a breeding pair or a number of pairs across the scale of the project. Measures to minimise impacts on waterways during construction have been implemented as part of the construction environmental management plan.

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

The project would result in a decrease of around thirteen hectares of wetland habitats in addition to small section of bridge crossings over numerous tributaries which provide known and potential habitat for this species.

While the distribution and abundance of populations over this scale is not known there are eight Nationally Important Wetlands and 15 SEPP 14 listed wetlands outside the project boundary. Most of these wetlands are recharged or fed by the Clarence River and Richmond River catchments in addition to numerous non-listed wetlands in the region. It is assumed that these habitats also contribute to the long-term maintenance of the species and recruitment into other habitats.

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

The potential for weed invasion has been considered possible with a project of this nature and appropriate controls have been provided 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 construction environmental management plan and during operation of the highway.

Introduce disease that may cause the species to decline

Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. This water-borne fungus infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction for the project has the potential to transmit the fungus to remaining native vegetation remnants of the species. This is a potential indirect impact to the species through the transmission of pathogens into retained habitat near the road. This can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols as detailed in RTA (2011) on this project as part of the CEMP to prevent the introduction or spread of pathogens.

The project mitigation strategy and environmental management procedures would include guidance for preventing the introduction and/or spread of disease causing agents such as bacteria and fungi.

Interfere with the recovery of the species.

The project 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, and mitigation and offset measures would target threatened fauna. There are no priority sites for conservation of this species within the project boundary.

Double-eyed Fig Parrot (Coxen's Fig Parrot)

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

The assessment refers to the Double-eyed Fig Parrot also known as Coxen's Fig Parrot. This species frequents rainforest and occasionally low elevation moist eucalypt forest feeding on a diverse range of tree and vine fruits.

The total population of Coxen's Fig-Parrot is estimated at 100 breeding birds and expected to occur in four subpopulations: greater Bundaberg region, Maleny/Imbil/Kin Kin Creek area, the Qld/NSW border area (Lamington National Park, Whian Whian State Forest, Alstonville plateau), and the upper Hastings River catchment. These locations are outside the study area, mainly north and west of Ballina and the species is unlikely to be resident or heavily dependent on smaller fragments of rainforest around the project boundary. Any use of the study area would be transient or sporadic.

Reduce the area of occupancy of the species

The clearing of habitat for the project in particular, lowland rainforest (10 hectares) and wet/moist sclerophyll forest (329 hectares) would affect the current availability of food resources and therefore affect the foraging and roosting activities of the species in the study area. There is no published data on nesting, breeding territories for this species in the study area, and any impacts from the loss of habitat along the project boundary is more than likely affecting foraging resources rather than a significant breeding/nesting area.

The project would see the clearing of 10 hectares of lowland rainforest and 329 hectares of moist forest habitat containing potential fruiting resources. These areas may only provide marginal or occasional resources for Double-eyed Fig Parrot, as the distribution of the population is outside of the study area. The remaining habitats may be indirectly impacted through edge effects such as light and wind.

Fragment an existing population into two or more populations

The species is associated with four discrete populations, all of which occur outside the study area, mainly north and west of Ballina and is unlikely to be resident or heavily dependent on smaller fragments of rainforest around the project boundary.

Adversely affect habitat critical to the survival of a species

The species is associated with four discrete populations, all of which occur outside the study area, mainly north and west of Ballina and is unlikely to be resident or heavily dependent on smaller fragments of rainforest around the project boundary. Any presence would be from transient of dispersing individuals and the habitats present and not critical for the population.

Disrupt the breeding cycle of a population

There is no published data on nesting, breeding territories in the study area, and any impacts from the loss of habitat along the project boundary is more than likely affecting foraging resources rather than a significant breeding/nesting area.

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

The species is associated with five discrete populations, all of which occur outside the study area, mainly north and west of Ballina and is unlikely to be resident or heavily dependent on smaller fragments of rainforest around the project boundary. Any presence would be from transient of dispersing individuals and the habitats present and not critical for the population.

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

The potential for weed invasion has been considered possible with a project of this nature and appropriate controls have been provided 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 construction environmental management plan and during operation of the highway.

Introduce disease that may cause the species to decline

Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. This water-borne fungus infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction for the project has the potential to transmit the fungus to remaining native vegetation remnants of the species. This is a potential indirect impact to the species through the transmission of pathogens into retained habitat near the road. This can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols as detailed in RTA (2011) on this project as part of the CEMP to prevent the introduction or spread of pathogens.

The project mitigation strategy and environmental management procedures would include guidance for preventing the introduction and/or spread of disease causing agents such as bacteria and fungi.

Interfere with the recovery of the species.

The project 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, and mitigation and offset measures would target threatened fauna. There are no priority sites for conservation of this species within the project boundary.

Swift Parrot

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

The Swift Parrot is an occasional visitor to the North coast bioregion during peak flowering events of the dominant trees, particularly the winter flowering Large-leaved Spotted Gum (*Corymbia henryi*) and Swamp Mahogany (*E.robusta*). There are no breeding records in the study area as the species is known to only breed in Tasmania and travels to the region during non-breeding periods. The extent of habitat remaining in the bioregion would provide sufficient foraging and shelter resources to sustain future visitation, particularly as the populations range extends to other bioregions north and south of the project.

The project would contribute to the loss of known and potential foraging habitat throughout the distributional range of the Swift Parrot. The habitat types that are linked to this species and will be removed by the project are described below.

Vegetation / habitat types linked to Swift Parrot and Regent Honeyeater	Area in project boundary (ha)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	79.7
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	46.2
Coast Cypress Pine shrubby open forest of the North Coast Bioregion	27.4
Coastal floodplain sedgelands, rushlands, and forblands	3.0
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	2.0
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	73.9
Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast	48.2
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	34.7
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast	58.2
Orange Gum (Eucalyptus bancroftii) open forest of the North Coast	11.5
Paperbark swamp forest of the coastal lowlands of the North Coast	49.5
Red Mahogany open forest of the coastal lowlands of the North Coast	46.2
Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast	71.9
Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast	2.1
Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast	144.8
Swamp Box swamp forest of the coastal lowlands of the North Coast	28.5
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	44.2
Swamp Oak swamp forest of the coastal lowlands of the North Coast	56.2
Tallowwood dry grassy forest of the far northern ranges of the North Coast	53
Turpentine moist open forest of the coastal hills and ranges of the North Coast	44.5

Reduce the area of occupancy of the species

The species is an occasional visitor to the region and there are no known permanent populations. The project would contribute to the loss of potential foraging habitat throughout the distributional range of the Swift Parrot and therefore reduce the area of habitat available.

Fragment an existing population into two or more populations

The species is an occasional visitor to the region and there are no known permanent populations within the study area. The foraging range of the Swift parrot population occurs across Victoria, NSW and southern Queensland and the species has evolved to disperse over great distances.

Adversely affect habitat critical to the survival of a species

Any use of the site habitats by this migratory and nomadic bird is likely to be sporadic and during peak flowering events of the dominant mature trees. The habitat within the project boundary is not recognised as a critical breeding area for this species however the project would contribute to the loss of suitable foraging habitat throughout the distributional range of the Swift Parrot. In particularly the loss of habitat that is dominated by winter flowering eucalyptus species is considered critical for this species. In this instance the project will remove critical foraging habitat. Indirect impacts on adjacent areas of critical habitat may results from edge effects.

Disrupt the breeding cycle of a population

There are no breeding records of Swift Parrot in the study area.

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

There are no permanent populations in the region although the study area is known to contain important winter foraging habitat for this species. The project would contribute to the loss of potential foraging habitat including critical habitat throughout the distributional range of the Swift Parrot in NSW. This loss is a recognised threat to the species.

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

The potential for weed invasion has been considered possible with a project of this nature and appropriate controls have been provided 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 construction environmental management plan and during operation of the highway.

Introduce disease that may cause the species to decline

Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. This water-borne fungus infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction for the project has the potential to transmit the fungus to remaining native vegetation remnants of the species. This is a potential indirect impact to the species through the transmission of pathogens into retained habitat near the road. This can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols as detailed in RTA (2011) on this project as part of the CEMP to prevent the introduction or spread of pathogens.

The project mitigation strategy and environmental management procedures would include guidance for preventing the introduction and/or spread of disease causing agents such as bacteria and fungi.

Interfere with the recovery of the species.

The project 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, and mitigation and offset measures would target threatened fauna. There are no priority sites for conservation of this species within the project boundary.

Regent Honeyeater

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

The species is an occasional visitor to the region during peak flowering events of the dominant trees, particularly the winter flowering Large-leaved Spotted Gum (*Corymbia henryi*) and Swamp Mahogany (*E.robusta*). There are no breeding records in the study area and the extent of habitat remaining in the study area would provide sufficient resources to sustain future visitation.

The project would contribute to the loss of known and potential foraging habitat throughout the distributional range of the Regent Honeyeater. The habitat types that are linked to this species and will be removed by the project are described below.

Vegetation / habitat types linked to Swift Parrot and Regent Honeyeater	Area in project boundary (ha)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	79.7
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	46.2
Coast Cypress Pine shrubby open forest of the North Coast Bioregion	27.4
Coastal floodplain sedgelands, rushlands, and forblands	3.0
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	2.0
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	73.9
Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast	48.2
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	34.7
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast	58.2
Orange Gum (Eucalyptus bancroftii) open forest of the North Coast	11.5
Paperbark swamp forest of the coastal lowlands of the North Coast	49.5
Red Mahogany open forest of the coastal lowlands of the North Coast	46.2
Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast	71.9
Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast	2.1
Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast	144.8
Swamp Box swamp forest of the coastal lowlands of the North Coast	28.5
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	44.2
Swamp Oak swamp forest of the coastal lowlands of the North Coast	56.2
Tallowwood dry grassy forest of the far northern ranges of the North Coast	53
Turpentine moist open forest of the coastal hills and ranges of the North Coast	44.5

Reduce the area of occupancy of the species

The species is an occasional visitor to the region and there are no known permanent populations. The project would contribute to the loss of potential foraging habitat throughout the distributional range of the Regent Honeyeater.

Fragment an existing population into two or more populations

The species is an occasional visitor to the region and there are no known permanent populations within the study area.

Adversely affect habitat critical to the survival of a species

Any use of the site habitats by this migratory and nomadic bird is likely to be sporadic and during peak flowering events of the dominant mature trees. The habitat within the project boundary is not recognised as a critical breeding area for this species however the project would contribute to the loss of suitable foraging habitat throughout the distributional range of the Regent Honeyeater. In particularly the loss of habitat that is dominated by winter flowering eucalyptus species is considered critical for this species. In this instance the project will remove critical foraging habitat. Indirect impacts may results on adjacent habitats through edge effects.

Disrupt the breeding cycle of a population

There are no recent breeding records of Regent Honeyeater in the study area.

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

There are no permanent populations in the region although the study area is known to contain important winter foraging habitat for this species. The project would contribute to the loss of potential foraging habitat including critical habitat throughout the distributional range of the Regent Honeyeater in NSW. This loss is a recognised threat to the species.

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

The potential for weed invasion has been considered possible with a project of this nature and appropriate controls have been provided 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 construction environmental management plan and during operation of the highway.

Introduce disease that may cause the species to decline

Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. This water-borne fungus infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction for the project has the potential to transmit the fungus to remaining native vegetation remnants of the species. This is a potential indirect impact to the species through the transmission of pathogens into retained habitat near the road. This can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols as detailed in RTA (2011) on this project as part of the CMP to prevent the introduction or spread of pathogens.

The project mitigation strategy and environmental management procedures would include guidance for preventing the introduction and/or spread of disease causing agents such as bacteria and fungi.

Interfere with the recovery of the species.

The project 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, and mitigation and offset measures would target threatened fauna. There are no priority sites for conservation of this species within the project boundary.

Pink Underwing Moth

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

This species was encountered at the northern end of section 10 in rainforest / moist forest remnants within an adjacent to the project boundary. This comprised several Pink Underwing Moth larvae at two sites (refer 0). This species frequents rainforest and low elevation moist eucalypt forest. The Pink Underwing Moth is found in subtropical rainforest below about 600 metres elevation. Potential breeding habitat is restricted to areas where the caterpillar's food plant, a native rainforest vine, *Carronia multisepalea*, occurs in subtropical rainforest. Adult Pink Underwing Moths require the darkness supplied by the vine and other rainforest vegetation in order to breed. This host plant was identified at these locations (refer 0), and the project would likely remove portion of the host plant from the study area. The clearing of this habitat for the project in particular, lowland rainforest (10 hectares) would affect the current availability of food resources and therefore affect the foraging and breeding activities of the species in the study area and likely to lead to a decline in the population. There is only one previous record of this species in NSW, near Dorrigo.

The habitat for this species in the study area is already impacted to a large degree by edge effects due to the fragmented nature of the habitat. Further indirect impacts are also likely

Reduce the area of occupancy of the species

The clearing of this habitat for the project in particular, lowland rainforest (10 hectares) would affect the current availability of the species host plant and significantly reduce important areas of habitat that are already greatly reduced and fragmented. There are no other records of this species in the study area and only one previous record of this species in NSW, near Dorrigo.

Fragment an existing population into two or more populations

The rainforest habitat for this species occurs on the floodplain of the Richmond River in Section 9-11 and is heavily fragmented and currently exist as many smaller patches across the landscape. The project has potential to further isolate remnant rainforest patches and create barriers to the movement of the species. There is little known of the dispersal capability of the species, however it is presumed to disperse across open landscapes in search of food resources and therefore may be able to access fragments of habitat.

Adversely affect habitat critical to the survival of a species

Potential breeding habitat is restricted to areas where the caterpillar's food plant, a native rainforest vine, *Carronia multisepalea*, occurs in subtropical rainforest. Adult Pink Underwing Moths require the darkness supplied by the vine and other rainforest vegetation in order to breed. This host pant and the species was recorded together at two sites in Section 10 and the project will remove critical habitat for this species. Further indirect impacts may be expected through edge effects.

Disrupt the breeding cycle of a population

On the basis that the project construction would extend over two to five years, there is reasonable potential for the activity to disrupt the breeding cycle of the local population residing in the study area. Measures to minimise impacts on vegetation during construction have been implemented as part of the construction environmental management plan.

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

Potential breeding habitat is restricted to areas where the caterpillar's food plant, a native rainforest vine, *Carronia multisepalea*, occurs in subtropical rainforest. Adult Pink Underwing Moths require the darkness supplied by the vine and other rainforest vegetation in order to breed. This host pant and the species was recorded together at two sites in Section 10. The removal of 10 hectares of lowland rainforest from the study area including a portion of the host plant population has a high likelihood of contributing to the decline of this species.

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

The potential for weed invasion has been considered possible with a project of this nature and appropriate controls have been provided 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 construction environmental management plan and during operation of the highway.

Introduce disease that may cause the species to decline; or

Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. This water-borne fungus infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction for the project has the potential to transmit the fungus to remaining native vegetation remnants of the species. This is a potential indirect impact to the species through the transmission of pathogens into retained habitat near the road. This can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols as detailed in RTA (2011) on this project as part of the CEMP to prevent the introduction or spread of pathogens.

The project mitigation strategy and environmental management procedures would include guidance for preventing the introduction and/or spread of disease causing agents such as bacteria and fungi.

Interfere with the recovery of the species.

The project 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, and mitigation and offset measures would target habitat for this species.

Spotted-tailed Quoll

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

The species is very widespread throughout all areas and habitats of the North Coast Bioregion. There are no records of particular clusters near the project that would suggest an important population exists, rather records are widespread and scattered.

However based on the habitats present, in particular the larger state forests and conservation reserves, two main areas exist which may represent important habitat for regional populations. These are the areas from Woolgoolga to Glenugie including Halfway Creek, Wells Crossing and Glenugie State Forest (Sections1 and 2) and Bundjalung National Park to Devils Pulpit, Tabbimoble State Forest and Doubleduke State Forest (Sections 6 and 7). These habitats are largely associated with the mature dry and moist sclerophyll forests on both sandy and clay soils. Large areas of habitat would remain in state forests and reserved habitats for the longer-terms viability of this species.

Reduce the area of occupancy of the species;

Potential impacts for both species are associated with the loss of habitat including potential den sites, fragmentation and the barrier effect of the highway potentially leading to increased genetic isolation. The species is known to frequent roadsides feeding on roadkill and where would be threatened by vehicle strike. The severity of the impact on a regional scale is low as the species is very widespread over a large portion of the bioregion, although localised impacts in areas discussed may be more moderate. The impacts of the barrier effect and fragmentation have been addressed via a focus on this species in the Biodiversity Connectivity Strategy (Appendix A).

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 and may include adjacent modified patches of forest on farmland. Suitable habitat is well represented in the larger fragments of forest in the study area, particularly state forests and adjoining private properties and national park estate. The project 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 population into two or more populations;

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of small ground-dwelling mammals, reptiles and amphibians and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10).

There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River.

The widening of the existing Pacific Highway in some areas would exacerbate the current barrier effect of the highway on regional and local populations of fauna, including the Spotted-tailed Quoll. There is limited data on the distribution of local and regional populations to identify if a population would be fragmented, however potential habitat would be traversed and it is assumed that the population would persist on either side of the highway.

As part of the response to mitigate and minimise this barrier effect for these species, RMS has developed a strategy with the aim of providing connectivity structures and enhancing landscape connectivity where feasible and reasonable in strategic locations. The Biodiversity Connectivity Strategy is detailed in Chapter 5 and Appendix A.

Adversely affect habitat critical to the survival of a 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. Given that up to 950 hectares of suitable habitat for this species would be removed, it is likely that a portion of this is critical habitat for local and regional quoll populations.

Disrupt the breeding cycle of a population;

Given the typically large home range 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 particularly given the project construction timeframe (two to five years).

Measures to minimise impacts on vegetation during construction have been implemented as part of the construction environmental management plan.

Modify, destroy, remove, 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 range of this species, potentially only a small number of individuals may be present in the lands surrounding the study area.

The project 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 project.

The spotted-tailed Quoll is a generalist that is linked to a large number of habitat types. Those within the project corridor that would be directly impacted are described below.

Vegetation / habitat types linked to target species	Area in project boundary (ha)	Project Section (extent in hectares)
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast	1.4	3 (1.4ha)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	79.7	1 (33.1ha), 2 (6.7ha), 3 (11.3ha), 6 (4.3ha), 7 (22.3ha)
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	46.2	1 (22.1ha), 9 (1.2ha), 10 (22.8ha)
Coast Cypress Pine shrubby open forest of the North Coast Bioregion	27.4	3 (0.9ha), 4 (0.1ha), 8 (1.1ha), 9 (0.9ha)
Coastal floodplain sedgelands, rushlands, and forblands	3.0	3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha)
Coastal heath on sands of the North Coast	0.2	9 (0.2 ha)
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	2.0	4 (2.0ha)
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	73.9	1(4.7 ha), 2 (0.8 ha),3 (38.4 ha),4 (0.8 ha), 5 (2.3 ha),6 (18.7 ha) ,7 (0.1 ha),10 (5.6 ha),11 (1.8 ha)
Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast	48.2	3 (9.8ha), 4 (17.8ha), 6 (7.9ha), 7 (1.4ha), 8 (11.1ha)
Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast	0.5	10 (0.5ha)
Mangrove - Grey Mangrove low closed forest of the NSW Coastal Bioregions	1.5	5 (1.3ha), 10 (0.2ha)
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	34.7	6 (7.3ha), 7 (12.5ha), 8 (8.1ha)
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast	58.2	1 (16.9ha), 2 (26.3ha), 3 (14.9ha), 7 (1.0ha)
Orange Gum (Eucalyptus bancroftii) open forest of the North Coast	11.5	2 (11.5ha)
Paperbark swamp forest of the coastal lowlands of the North Coast	49.5	1 (10.4ha), 2 (3.4ha), 3 (1.1ha), 4 (0.2ha), 6 (1.8ha), 7 (20.5ha), 8 (11.1ha), 10 (0.2ha)
Red Mahogany open forest of the coastal lowlands of the North Coast	46.2	6 (8.9ha), 7 (35.7ha), 8 (1.6ha)
Scribbly Gum - Needlebark Stringybark heathy	71.9	3 (48.8ha), 7 (21.5 ha)

Vegetation / habitat types linked to target species	Area in project boundary (ha)	Project Section (extent in hectares)
open forest of coastal lowlands of the northern North Coast		
Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast	2.1	2 (2.11ha)
Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast	144.8	1(17.8ha), 2 (37.5ha), 3 (66.96ha), 4 (6.7ha), 6 (1.9ha), 7 (12.1ha)
Swamp Box swamp forest of the coastal lowlands of the North Coast	28.5	1 (23.3ha), 2(5.2ha)
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	44.2	1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha)
Swamp Oak swamp forest of the coastal lowlands of the North Coast	56.2	1 (0.9 ha), 3 (12.8 ha), 4(1.6 ha), 5(11.7 ha), 8(12.2 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
Tallowwood dry grassy forest of the far northern ranges of the North Coast	53	3 (36.8ha), 4 (3.5ha), 5(11.2ha), 6 (1.5ha)
Turpentine moist open forest of the coastal hills and ranges of the North Coast	44.5	3 (44.5ha)
Wet heathland and shrubland of coastal lowlands of the North Coast	10	6 (10ha)
White Booyong - Fig subtropical rainforest of the North Coast	8.6	10 (7.9ha), 11 (0.7ha)

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

The potential for weed invasion has been considered possible with a project of this nature and appropriate controls have been provided 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 construction environmental management plan and during operation of the highway.

Introduce disease that may cause the species to decline

Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. This water-borne fungus infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction for the project has the potential to transmit the fungus to remaining native vegetation remnants of the species. This is a potential indirect impact to the species through the transmission of pathogens into retained habitat near the road. This can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols as detailed in RTA (2011) on this project as part of the CEMP to prevent the introduction or spread of pathogens.

The project mitigation strategy and environmental management procedures would include guidance for preventing the introduction and/or spread of disease causing agents such as bacteria and fungi.

Interfere with the recovery of the species.

The project 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, and mitigation and offset measures would target threatened fauna. There are no priority sites for conservation of this species within the project boundary.

Giant Barred Frog

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

Giant Barred Frog was identified in Section 1 (Wedding Bells State Forest) and also identified in Yuraygir State Conservation Area near Section 2 and an unnamed creek in Section 9. Local populations are assumed to occur at these locations and are supported by atlas records of the species in these project sections. The large majority of regional records of this species occur in the wetter forests between Grafton and Coffs Harbour on the western side of the highway. These potential habitats would extend around the project through Section 2 and the southern and central parts of Section 3.

The project would impact on this potential habitat via the direct traverse of several small streams and gullies. The impact would be localised 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;

Giant Barred Frogs forage and live amongst deep, damp leaf litter in rainforests, moist eucalypt forest and nearby dry eucalypt forest. They breed around shallow, flowing rocky streams from late spring to summer. Due to the paucity of records of this species in the project boundary 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 project would impact on potential habitat via direct traverse of several small streams and gullies. The impact would be localised, 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 project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of small ground-dwelling mammals, reptiles and amphibians and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg project sections 3 to 4 and 9 to 10).

There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River.

The widening of the existing Pacific Highway in some areas would exacerbate the current barrier effect of the highway on regional and local populations of fauna, including the Giant Barred Frog. There is limited data on the distribution of local and regional populations to identify if a population would be fragmented, however potential habitat would be traversed and it is assumed that the population would persist on either side of the highway.

As part of the response to mitigate and minimise this barrier effect for these species, RMS has developed a strategy with the aim of providing connectivity structures and enhancing landscape connectivity where feasible and reasonable in strategic locations. The Biodiversity Connectivity Strategy is detailed in Chapter 5 and Appendix A.

Adversely affect habitat critical to the survival of a species;

The large majority of regional records of this species occur in the wetter forests between Grafton and Coffs Harbour on the western side of the highway. Several creeks and drainage lines in the project boundary, particularly Sections 1 and 2 were identified as potential habitat for this species.

The project would impact on potential habitat via direct traverse of several small streams and gullies and may impact on critical habitat for localised populations in this area.

Disrupt the breeding cycle of a population;

The species breeds at shallow, flowing rocky streams from late spring to summer. On the basis that the project construction would extend over two to five years, there is the potential for the activity to disrupt the breeding cycle of a population. Measures to minimise impacts on waterways during construction have been implemented as part of the construction environmental management plan.

Modify, destroy, remove, isolate or decrease the availability or quality of 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. Several creeks and drainage lines in the project boundary, particularly Sections 1 and 2 were identified as potential habitat for this species.

The large majority of regional records of this species occur in the wetter forests between Grafton and Coffs Harbour on the western side of the highway. These potential habitats would extend around the project through Section 2 and the southern and central parts of Section 3. The removal of habitat along the duplication in sections 1 and 2 is unlikely to lead to a significant decline in the regional population.

The project would impact on potential habitat via direct traverse of several small streams and gullies. The impact would be restricted to the construction footprint. Design measures have been incorporated to provide fauna passage and protection of waterways during construction and operation to ensure potential habitat would not be further affected. The following habitat types that are linked to this species would be impacted by the project.

Vegetation / habitat types linked to target species	Area in project boundary (ha)	Project Section (extent in hectares)
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast	1.4	3 (1.4ha)
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	46.2	1 (22.1ha), 9 (1.2ha), 10 (22.8ha)
Coastal floodplain sedgelands, rushlands, and forblands	3.0	3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha)
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	2.0	4 (2.0ha)
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	73.9	1(4.7 ha), 2 (0.8 ha),3 (38.4 ha),4 (0.8 ha), 5 (2.3 ha),6 (18.7 ha) ,7 (0.1 ha),10 (5.6 ha),11 (1.8 ha)
Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast	0.5	10 (0.5ha)
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	34.7	6 (7.3ha), 7 (12.5ha), 8 (8.1ha)
Paperbark swamp forest of the coastal lowlands of the North Coast	49.5	1 (10.4ha), 2 (3.4ha), 3 (1.1ha), 4 (0.2ha), 6 (1.8ha), 7 (20.5ha), 8 (11.1ha), 10 (0.2ha)
Red Mahogany open forest of the coastal lowlands of the North Coast	46.2	6 (8.9ha), 7 (35.7ha), 8 (1.6ha)
Swamp Box swamp forest of the coastal lowlands of the North Coast	28.5	1 (23.3ha), 2(5.2ha)
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	44.2	1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha)
Swamp Oak swamp forest of the coastal lowlands of the North Coast	56.2	1 (0.9 ha), 3 (12.8 ha), 4(1.6 ha), 5(11.7 ha), 8(12.2 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
Tallowwood dry grassy forest of the far northern ranges of the North Coast	53	3 (36.8ha), 4 (3.5ha), 5(11.2ha), 6 (1.5ha)
Turpentine moist open forest of the coastal hills and ranges of the North Coast	44.5	3 (44.5ha)
White Booyong - Fig subtropical rainforest of the North Coast	8.6	10 (7.9ha), 11 (0.7ha)

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

The potential for weed invasion has been considered possible with a project of this nature and appropriate controls have been provided 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 construction environmental management plan and during operation of the highway.

Introduce disease that may cause the species to decline; or

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

Interfere with the recovery of the species.

The project 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, and mitigation and offset measures would target threatened fauna. There are no priority sites for conservation of this species within the project boundary.

Endangered flora

Acronychia littoralis

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

This species was recorded in the project boundary in Section 8, comprising one individual outside of the project boundary in subtropical rainforest.

The preferred habitat for this species is littoral rainforest on sand which does not occur in the study area, however it is known to also occur in subtropical rainforest which is present in the study area. There is a low possibility this species is present in rainforest and wet sclerophyll forests within the project boundary, however these habitats are marginal and targeted surveys have not identified any populations within the project boundary.

Considering the relatively extensive targeted searches undertaken for this species in areas of suitable habitat, it is unlikely to be present in the study area and the project would result in a long-term decrease. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

Reduce the area of occupancy of the species

This species was recorded in the project boundary in Section 8, comprising one individual outside of the project boundary in subtropical rainforest. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted. As there are no known individuals in the project boundary the project would not reduce the area of occupancy.

Fragment an existing population into two or more populations

The project would result in the dissection of habitat for this species, however a population would not be dissected. Habitat for this species is currently highly fragmented in the locality and the project would result in further fragmentation of habitats with around 10.33 hectares of the 94.62 hectares of potential rainforest habitat for this species potentially being impacted.

Adversely affect habitat critical to the survival of a species

No critical habitat has been identified for this species, and habitats in the study area are generally marginal for this species.

Disrupt the breeding cycle of a population

Considering the relatively extensive targeted searches undertaken for this species in areas of suitable habitat, it is unlikely to be present in the study area and the project would result in a disruption to the breeding cycle. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

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

Considering the relatively extensive targeted searches undertaken for this species in areas of suitable habitat, it is unlikely to be present in the study area and the project would result in a long-term decrease in habitat availability. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

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

The potential for weed invasion has been considered possible with a project of this nature and appropriate controls have been provided 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 construction environmental management plan and during operation of the highway.

Introduce disease that may cause the species to decline

Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. This water-borne fungus infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction for the project has the potential to transmit the fungus to remaining native vegetation remnants of the species. This is a potential indirect impact to the species through the transmission of pathogens into retained habitat near the road. This can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols as detailed in RMS (2011) on this project as part of the CEMP to prevent the introduction or spread of pathogens.

The project mitigation strategy and environmental management procedures would include guidance for preventing the introduction and/or spread of disease causing agents such as bacteria and fungi.

Interfere with the recovery of the species.

The project 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, and mitigation and offset measures would target threatened flora. There are no priority sites for conservation of this species within the project boundary.

Isoglossa eranthemoides

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

This species was recorded in Section 10, comprising one individual outside of the project boundary in subtropical rainforest.

The preferred habitat for this species is the understorey of lowland subtropical rainforest, in moist situations on floodplains and slopes. There is a possibility this species is present in rainforest and wet sclerophyll forests within the project boundary, however targeted surveys have not identified any populations within the project boundary.

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. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

Reduce the area of occupancy of the species

Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted. As there are no known individuals in the project boundary the project would not reduce the area of occupancy.

Fragment an existing population into two or more populations

The project would result in the dissection of habitat for this species, however a population would not be dissected. Habitat for this species is currently highly fragmented in the locality and the project would result in further fragmentation of habitats with around 10.33 hectares of the 94.62 hectares of potential rainforest habitat for this species potentially being impacted.

Adversely affect habitat critical to the survival of a species

No critical habitat has been identified for this species.

Disrupt the breeding cycle of a population

Considering the relatively extensive targeted searches undertaken for this species in areas of suitable habitat, it is unlikely to be present in the study area and the proposal would result in a disruption to the breeding cycle. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

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

Considering the relatively extensive targeted searches undertaken for this species in areas of suitable habitat, it is unlikely to be present in the study area and the project would result in a long-term decrease. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

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

The potential for weed invasion has been considered possible with a project of this nature and appropriate controls have been provided 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 construction environmental management plan and during operation of the highway.

Introduce disease that may cause the species to decline

Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. This water-borne fungus infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction for the project has the potential to transmit the fungus to remaining native vegetation remnants of the species. This is a potential indirect impact to the species through the transmission of pathogens into retained habitat near the road. This can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols as detailed in RMS (2011) on this project as part of the CEMP to prevent the introduction or spread of pathogens.

Quassia sp. 'Moonee Creek'

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

One individual has been recorded in Section 3 outside of the project boundary. Potential habitat for this species is widespread in the locality, and there is likely to be a viable population in the locality, with around 70 records in the locality.

There is a low possibility this species is present in habitats within the project boundary, however targeted surveys have not identified any populations within the project boundary. Considering the relatively extensive targeted searches undertaken for this species in areas of suitable habitat, it is unlikely to be present in the study area.

Reduce the area of occupancy of the species

This species was identified growing in dry sclerophyll forest dominated by Needlebark (*Eucalyptus planchoniana*) and Smudgy Apple (*Angophora woodsiana*). This vegetation type is widespread in the project boundary with around 60 hectares of similar habitat potentially being impacted.

Fragment an existing population into two or more populations

Only one individual has been identified adjacent to the project boundary and the project would not result in further fragmentation of individuals. However there would be further fragmentation of potential habitat for this species.

Adversely affect habitat critical to the survival of a species

No critical habitat has been identified for this species.

Disrupt the breeding cycle of a population

There is a low possibility this species is present in habitats within the project boundary, however targeted surveys have not identified any populations within the project boundary. Considering the relatively extensive targeted searches undertaken for this species in areas of suitable habitat, it is unlikely to be present in the study area.

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

This species was identified growing in dry sclerophyll forest dominated by Needlebark (*Eucalyptus planchoniana*) and Smudgy Apple (*Angophora woodsiana*). This vegetation type is widespread in the project boundary with around 60 hectares of similar habitat potentially being impacted.

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

The potential for weed invasion has been considered possible with a project of this nature and appropriate controls have been provided 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 construction environmental management plan and during operation of the highway.

Introduce disease that may cause the species to decline

Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. This water-borne fungus infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction for the project has the potential to transmit the fungus to remaining native vegetation remnants of the species. This is a potential indirect impact to the species through the transmission of pathogens into retained habitat near the road. This can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols as detailed in RTA (2011) on this project as part of the CEMP to prevent the introduction or spread of pathogens.

Critical endangered ecological community

Lowland Rainforest of Subtropical Australia

Reduce the extent of an ecological community

A total of 95 hectares of Lowland Rainforest has been identified within and surrounding the study area mainly in Section 10 near Coolgardie Road, of which the project would impact around 10 hectares of this community in various condition states. Of this 10 hectares around 5.8 hectares has been identified as conforming to the condition thresholds identified for the federally listed community. The Comprehensive Regional Assessment Aerial Photographic Interpretation (CRAFTI) (NPWS 1998) has mapped about 1817.75 hectares of vegetation with affinities to Lowland Rainforest within about a 10 kilometre radius of the project boundary. The project would potentially result in the removal of 0.3 per cent of the local distribution of this community.

The proposal will impact six patches of this ecological community and these are detailed below.

Patch number	Total patch area (ha)	Area impacted (ha)	Area remaining following impact (ha)	Proportion of patch remaining
1	2.27	0.37	1.90	84%
2	30.38	0.47	29.91	98%
3	5.95	0.68	5.27	89%
4	4.93	0.54	4.39	89%
5	5.49	2.21	3.28	60%
6	3.38	1.53	1.84	55%
TOTAL	52.4	5.8	46.6	

Of the six patches potentially impacted, four of these will be reduced in extent by 2 to16%, and the remaining two will be reduced in extent by 40 to 45%. The overall reduction in extent for the ecological community is 11%, with 89% of the ecological community remaining in surrounding areas.

Fragment or increase fragmentation of an ecological community

Habitat connectivity for Lowland Rainforest would be impacted in several locations along the project area. The further widening of the existing Pacific Highway corridor would result in further fragmentation of patches of the community adjacent to the existing highway. These patches are currently highly fragmented and subject to edge effects. The proposal will contribute to this fragmentation and modification due to edge effects particularly for the two patches being reduced in extent by 40 to 45%.

Considering the high mobility of many pollinator species for the various plant species within this Threatened Ecological Community (such as insects, birds and bats, and also wind and water dispersal of genetic material) some gene flow is expected to continue across the existing highway and the width of the project boundary. Some connectivity would be maintained beneath the project through culverts, pipes etc where this community occurs on drainage lines.

Adversely affect habitat critical to the survival of an ecological community

A total of 95 hectares of Lowland Rainforest has been identified within and surrounding the study area mainly in Section 10 near Coolgardie Road, of which the project would impact around 5.8 hectares conforms to the condition thresholds of this community. The Comprehensive Regional Assessment Aerial Photographic Interpretation (CRAFTI) (NPWS 1998) has mapped about 1817.75 hectares of vegetation with affinities to Lowland Rainforest within about a 10 kilometre radius of the project boundary. The project would potentially result in the removal of 0.3 per cent of the local distribution of this community.

Modify or destroy biotic (non-living) factors (such as water, nutrients, or soil) necessary for an ecological community's survival, including reduction of groundwater levels, or substantial alteration of surface water drainage patterns

There is potential for the project 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 water table 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.

Cause a substantial change in the species composition of an occurrence of an ecological community, including causing a decline or loss of functionally important species, for example through regular burning or flora or fauna harvesting

Current disturbance regimes in Lowland Rainforest mainly comprise weed invasion, cattle grazing and high nutrient levels. Areas of this community in paddock areas support a mix of native flora and invasive weeds on the edges of these areas. There is potential for indirect impacts such as edge effects, weed invasion and altered hydrology.

The project is unlikely to result in an increase in current disturbance regimes, and would potentially limit some disturbances in the non-impacted areas retained within the road boundary such as exclusion of grazing and through weed management actions.

Cause a substantial reduction in the quality or integrity of an occurrence of an ecological community, including, but not limited to: *-- assisting invasive species, that are harmful to the listed ecological community, to become established, or* *-- causing regular mobilisation of fertilisers, herbicides or other chemicals or pollutants into the ecological community which kill or inhibit the growth of species in the ecological community.*

There is potential for the project 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 water table 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.

Interfere with the recovery of an ecological community.

The project would not significantly conflict with potential recovery actions for Lowland Rainforest. Some recovery actions can be implemented for areas of the community proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

To mitigate the ecological impacts from the project an offset strategy is proposed to provide greater protection of Lowland Rainforest and habitat for other threatened flora and fauna, through placing an area of private land or state forest under conservation. There are several potential options for the offset strategy. An offset supporting Lowland Rainforest would contribute towards the recovery of the species.

Endangered fish

Oxleyan Pygmy Perch (Nannoperca oxleyana)

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

Oxleyan Pygmy Perch are known to be associated with swamps, streams and dune lakes that lie in the coastal lowland 'wallum' ecosystems with little or no flow (Arthington 1996; Pusey et al. 2004; Knight & Arthington 2008). The species is restricted to aquatic habitats with suitable physicochemical water quality conditions, specifically acidic waters (pH 4.4-6.8) with low conductivity (90 to 830μS/cm). Waters can either be clear or tannin stained. Previous studies (Knight & Arthington 2008) have correlated the presence of Oxleyan Pygmy Perch with an abundance of structural microhabitat in the form of dense aquatic vegetation and/or steep undercut banks fringed with woody debris root overhang from riparian vegetation.

A total of twenty-six Oxleyan Pygmy Perch individuals have been recorded from several studies in sections 6, 7 and 8 of the study area. In Section 6, three individuals were found at a small dam situated at Tabbimoble Floodway 2, and three individuals were found downstream of the confluence of Tabbimoble 2 and 3. In Section 7, 17 individuals were recorded within an unnamed ephemeral stream near station 114.0. In Section 8, two individuals were recorded at Broadwater National Park/McDonalds Creek, and one individual was found at the upstream extent of an unnamed ephemeral stream near station 134.7.

There are also several locations within the study area where aquatic habitat are considered suitable to sustain populations of Oxleyan Pygmy Perch. These habitats are located in:

- Section 1: Corindi River, Cassons Creek and Redbank Creek
- Section 2: Halfway Creek and Glenugie Creek
- Section 3: Low lying swamps and wallum creek of the Coldstream River, south of Tucabia
- Section 6: Tabbimoble Floodway 2 and 3, Bundjalung National Park (around seven kilometres downstream of project boundary), ephemeral streams in region
- Section 7: Ephemeral streams
- Section 8: Broadwater National Park, McDonalds Creek and vicinity of Rileys Hill
- Section 9: Tuckean Broadwater.

Other aquatic habitats in the adjacent study area appeared to be outside the range that Oxleyan Pygmy Perch typically occurs as a result of either unfavourable water quality and or lack of suitable habitat.

The project would result in changes to aquatic habitat within the project boundary and study area. Construction of the project would result in short term impacts on immediate downstream reaches. Mitigation measures have been considered to minimise potential in stream habitat disturbance, water quality degradation, in stream barriers and the introduction of pest aquatic species to aquatic habitats within and adjacent to the study area. These mitigation measures are outlined in Section 5 of this report. As a result of these mitigation measures, it is considered unlikely that the project would impact on long term habitat values and therefore the local populations of Oxleyan Pygmy Perch.

Other known populations outside the footprint of the project within Broadwater National Park would likely be beyond the extent of any assumed impacts associated with this project.

Reduce the area of occupancy of the species

The occurrence of Oxleyan Pygmy Perch is restricted to aquatic habitats with suitable physicochemical water quality conditions and the presence of suitable microhabitat (aquatic vegetation and overhanging riparian root vegetation). As such, potential habitats which meet Oxleyan Pygmy Perch requirements are restricted to the following locations:

- Section 1: Corindi River, Cassons Creek and Redbank Creek
- Section 2: Halfway Creek and Glenugie Creek
- Section 3: Low lying swamps and wallum creek of the Coldstream River, south of Tucabia
- Section 6: Tabbimoble Floodway 2 and 3, Bundjalung National Park (around seven kilometres downstream of project boundary), ephemeral streams in region
- Section 7: Ephemeral streams
- Section 8: Broadwater National Park, McDonalds Creek and vicinity of Rileys Hill
- Section 9: Tuckean Broadwater.

Aquatic habitats outside these locations generally represent unfavourable conditions to support Oxleyan Pygmy Perch.

The construction and operation of the project has the potential to restrict the movement of aquatic fauna through the creation of temporary and permanent instream barriers. Marginal habitat may be further reduced due to the introduction of pest species, removal of in stream habitat and impacts to water quality conditions. Mitigation measures such as suitable design of temporary and permanent waterway crossings have been developed to minimise the occurrence of impacts to habitat connectivity. Other mitigation measures include water quality control measures, aquatic habitat management measures and the creation of sediment and erosion control plans.

The project has the potential to reduce the availability and/or quality of both temporary and known environments for the Oxleyan Pygmy Perch, however assumed management and mitigation measures have been developed to minimise the likelihood of these impacts.

Fragment an existing population into two or more populations

The project has the potential to isolate upstream areas of Oxleyan Pygmy Perch habitat through the construction of temporary and permanent in stream barriers. It is important to note however, that areas of key habitat for the Oxleyan Pygmy Perch have already been fragmented by the existing Pacific Highway and through in stream modifications and land clearing practices. Assumed impacts of the project would include instream barriers which would prevent the dispersal of Oxleyan Pygmy Perch. Provided appropriate waterway crossings were implemented, impacts to the movement and dispersal of Oxleyan Pygmy Perch is not expected.

Populations of Oxleyan Pygmy Perch are likely to move and interbreed within catchment and may be dispersed during periods of flooding over low lying coastal plains. Areas to the east of the study area become intermittently connected during periods of high rainfall and may reduce fragmentation and allow for dispersal of Oxleyan Pygmy Perch.

Mitigation measures have been considered to ensure current connectivity is maintained during construction and operation through suitable design of waterway crossings (with preferential use of Bridge crossings where feasible and reasonable) and suitable timing of construction to avoid the spring-summer seasons that are representative of a typical high rainfall period when aquatic habitats are most likely flowing.

Provided mitigation measures are followed, it is considered unlikely that further fragmentation of Oxleyan Pygmy Perch populations would occur.

Adversely affect habitat critical to the survival of the species

Four locations have known populations of the Oxleyan Pygmy Perch within the alignment foot print. Potential impacts to critical Oxleyan Pygmy Perch habitat associated with the project include the removal of instream vegetation and riparian root overhang. Specific habitat management measures have been employed to minimise the likelihood of impacts to Oxleyan Pygmy Perch habitat, and as such any disruption to the Oxleyan Pygmy Perch habitat is likely to be short term (Section 5).

The habitat affected by the project represents a small fraction of known habitat for Oxleyan Pygmy Perch in the region, on both a local and regional scale and is not considered critical for the survival of this species.

The prevalence of Oxleyan Pygmy Perch on coastal floodplains may be attributed to intermittent connection between waterbodies during high rainfall or flooding events (emanating from the Richmond and Clarence Rivers). These could facilitate dispersal, thereby allowing the species to colonise new systems and/or recolonise previously disturbed areas (Knight *et al* 2009).

Floods may help to distribute Oxleyan Pygmy Perch, although fragmented habitats and other barriers to fish movement would reduce the ability of the species to recolonise areas from which it is lost.

Disrupt the breeding cycle of a population

The Oxleyan Pygmy Perch Recovery Plan (NSW DPI 2005) identified knowledge gaps regarding the life history of this species, population dynamics, dispersal patterns and genetics of the Oxleyan Pygmy Perch. The breeding season is extended, beginning in October and continuing into May, although spawning takes place primarily between October and December (NSW DPI 2005).

Stockpiling of materials for bridge construction at known Oxleyan Pygmy Perch locations and habitat including Cassons Creek, Redbank Creek, Tabbimoble Creek, McDonalds Creek, Randals Creek and other areas should be undertaken, where feasible and reasonable, after April to avoid the October to March breeding season for the OPP.

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

The project would result in the modification of small sections of potential and/or known Oxleyan Pygmy Perch aquatic habitat. For the majority of the alignment, the existing habitat conditions are generally unfavourable to Oxleyan Pygmy Perch and represent only temporary habitat and potential movement corridors.

Mitigation measures have been considered to prevent the destruction, removal or isolation of aquatic habitats and have been designed to ensure habitat connectivity is maintained through these movement corridors in the construction and operational phases. These measures are listed below and expanded on in Section 5:

- Management and implementation of water quality control measures
- Prevention/minimisation of in-stream barriers
- Timing of in-stream construction works to avoid the critical spring-summer period, as this represents the typical high rainfall periods when aquatic habitats are most likely to be flowing
- Management of stockpiles to avoid breeding season
- Management of riparian and aquatic habitats
- Management of sedimentation and erosion
- Management of in-stream woody debris.

Assuming that mitigation measures are implemented and effectively managed and monitored, it is considered unlikely the project would lead to decline in the local population of Oxleyan Pygmy Perch.

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

There is potential for exotic species such as Plague Minnow (*Gambusia holbrooki*) to become established within areas of potential Oxleyan Pygmy Perch habitat. There is little information regarding the impacts of Plague Minnow on Oxleyan Pygmy Perch however, their aggression and ability to survive and compete for food in Oxleyan Pygmy Perch habitats suggest their presence may be detrimental to Oxleyan Pygmy Perch (NSW DPI 2005). Plague Minnow is known to be present within many of watercourses within the study area, however, since Plague Minnow are known to be distributed by floods, their presence in other creeks within the Oxleyan Pygmy Perch geographic range is also an important consideration .

Few options exist to control Plague Minnow in water bodies occupied by Oxleyan Pygmy Perch (NSW DPI 2005), however mitigations measures have been designed for this project to prevent the introduction of noxious flora and fauna as provided in Section 5. These measures include: management of riparian and aquatic habitats, including management of aquatic weeds by restricting the development of weeds in the understorey and within the stream so that habitats do not become favourable for the highly aggressive and predatory Plague Minnow.

At present, the aquatic habitats where Oxleyan Pygmy Perch has been recorded often have no permanent water, and therefore does not provide suitable habitat for Plague Minnow to breed.

Introduce disease that may cause the species to decline

Acid sulfate soils which are widespread on the NSW estuarine floodplains and coastal lowlands, if exposed can result in outbreaks of fish disease. The location of works involving ASS does not impact on known habitats or locations of Oxleyan Pygmy Perch. Therefore the project would not introduce any disease that may cause the species to decline.

Interferes substantially with the recovery of the species

Known populations of Oxleyan Pygmy Perch range over around 530 kilometres of coastline from Consul Creek on Fraser Island in south-east Queensland to Tick Gate Swamp near Wooli in northern New South Wales (Knight & Arthington 2008). The areas of suitable aquatic habitat identified to support Oxleyan Pygmy Perch within the study areas represents a small fraction of both the regional and total population. Provided mitigation measures are abided by, the project is considered unlikely to interfere substantially with the recovery of Oxleyan Pygmy Perch.

Eastern (Freshwater) Cod

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

Eastern (Freshwater) Cod are large, predatory, freshwater fish native to the Clarence and Richmond River in northern New South Wales. They are a territorial fish that does not undergo distinct upstream or downstream migrations, although limited movement may occur before and during the breeding season.

Eastern (freshwater) Cod are often found in clear flowing streams with rocky beds and deep holes. They are generally associated with areas that have plenty of boulders or large woody debris (snags). Riparian vegetation, boulders and snags provide habitat for the Eastern Freshwater Cod through various stages of its lifecycle and influence the quality and quantity of food and shelter (NSW Fisheries 2004).

Although once considered prolific in the Clarence and Richmond Rivers, Eastern Cod are now only found naturally in a couple of well isolated tributaries of the Clarence River and there are no natural populations remaining in the Richmond River system (NSW Fisheries 2004).

Whilst the Eastern (Freshwater) Cod have not been observed in the study are during any field surveys, suitable habitat which have the potential to support the species was observed in the middle section of Coldstream River, Chaffin Creek and Pillar Valley Creek in Section 3 of the project (The Ecology Lab 2009).

Other aquatic habitats within the study area appear to be outside the range that Eastern (Freshwater) Cod would typically occur due to lack of clear flowing water, with rock beds and deep holes, low dissolved oxygen levels and tidal influences of some streams. Due to the lack of suitable habitat, the knowledge that the Eastern Freshwater Cod prefer deeper parts of the river near cover and that the streams affected by the potential project are not within the current known natural distribution of the Eastern Cod, indicates it is highly unlikely that the waterways with the potential to be impacted by the project present potential habitat for this species.

The project would result in changes to aquatic habitat within the project boundary and study area. Construction of the project would result in short term impacts on immediate downstream reaches. Mitigation measures have been considered to minimise potential in stream habitat disturbance, water quality degradation, in stream barriers and the introduction of pest aquatic species to aquatic habitats within and adjacent to the study area. These mitigation measures are outlined in Section5 of this report. As a result of these mitigation measures, it is considered unlikely that the project would impact on long term habitat values and therefore the local populations of the Eastern (Freshwater) Cod.

Reduce the area of occupancy of a population

The Eastern (Freshwater) Cod has not previously been recorded in the study area, and much of the proposed project is outside the known historic distribution of the Eastern (Freshwater) Cod. However, there is the presence of favourable habitat in the Coldstream River, Chaffin Creek and Pillar Valley Creek (Section 3).

The project has the potential to reduce the availability and/or quality of potential environments for the Eastern (Freshwater) Cod. Mitigation measures have been developed to minimise potential project impacts through management of riparian and aquatic habitats, management of in-stream woody debris and management of aquatic weeds. Considering these mitigation measures, assumed impacts on the occupancy of the Eastern (Freshwater) Cod are considered minimal.

Fragment an existing population into two or more populations

Potential habitats of the Eastern (Freshwater) Cod have already been degraded or fragmented due to removal of in-stream woody debris and aquatic vegetation, sedimentation of deeper holes and barriers such as weirs, dams and road crossings and a reduction in water quality.

Mitigation measures have been considered to ensure current connectivity is maintained during construction and operation through suitable design of waterway crossings (with preferential use of Bridge crossings where feasible and reasonable) and suitable timing of construction to avoid the spring-summer seasons that are representative of a typical high rainfall period when aquatic habitats are most likely flowing. Provided mitigation measures are followed, it is considered unlikely that fragmentation of populations of this species would occur.

Adversely affect habitat critical to the survival of the species

The Eastern (Freshwater) Cod has not previously been recorded in the study area, although since the 1960s small numbers of cod have been caught from outside the study area in the Nymboida, Little Nymboida, Guy Fawkes, Boyd and Mann Rivers where pristine habitat still exists (NSW Fisheries 2004). Whilst re-stocking of artificially bred juveniles have been undertaken at numerous freshwater locations throughout the Clarence and Richmond River systems, this restocking appears to have not occurred within the project boundary (Butler 2009), however, sections of the study are within the species range and suitable habitat is present. Mitigation measures have been developed to minimise potential impacts through management of riparian and aquatic habitats. As such it is highly unlikely that the project would adversely affect habitat critical to the survival of Eastern (Freshwater) Cod.

Disrupt the breeding cycle of a population

The life history of the Eastern (Freshwater) Cod is extremely limited (NSW Fisheries 2004). The Eastern (Freshwater) Cod breeding season is in spring, with spawning starting when the water temperatures rise above 16°C (NSW Fisheries 2004). Whilst the Eastern (Freshwater) Cod does not undergo distinct upstream or downstream migrations, limited movement may occur before and during the breeding season. Where feasible and reasonable, works including the stockpiling of materials should occur outside these times to avoid any disruption to the species breeding cycle.

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

Whilst there are no recordings of the Eastern (Freshwater) Cod within the study area, but there are suitable areas of habitat in the midstream Coldstream River, Chaffin Creek and Pillar Valley Creek (Section 3), mitigation measures have been considered to prevent the destruction, removal or isolation of aquatic habitats and have been designed to ensure habitat connectivity is maintained through these movement corridors in the construction and operational phases. These measures include:

- Management and implementation of water quality control measures
- Prevention/minimisation of in-stream barriers
- Timing of in-stream construction works to avoid the critical spring-summer period, as this represents the typical high rainfall periods when aquatic habitats are most likely to be flowing.
- Management of stockpiles to avoid breeding season
- Management of riparian and aquatic habitats
- Management of sedimentation and erosion
- Management of in-stream woody debris
- Assuming that mitigation measures are implemented and effectively managed and monitored, it is considered unlikely the project would lead to decline in the Eastern (Freshwater) Cod.

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

Several introduced species already exist in the project area, carp (*Cyprinus carpio*), goldfish (*Carassius auratus*) and banded grunter (*Amniataba percoides*) which pose threats from disease, competition, predation and habitat degradation (Butler 2009). There is the potential for the exotic species Plague Minnow (*Gambusia holbrooki*) to become established within areas of suitable habitat, particularly as it is already present in the Clarence and Richmond Rivers, however, its effects on the Eastern Cod are unknown (NSW Fisheries 2004)).

Mitigation measures have been designed to prevent the introduction of noxious species including the management of riparian and aquatic habitat, by restricting the development of weeds in the understory and within the stream so that habitats do not become favourable for invasive species.

Introduce disease that may cause the species to decline

The project would not introduce any disease that may cause the species to decline.

Interferes substantially with the recovery of the species

Re-stocking of artificially bred juveniles have been undertaken at numerous freshwater locations throughout the Clarence and Richmond River systems, however data provided in Butler (2009) indicates that restocking has not occurred within the freshwater tributaries located within the project boundary. As such it is considered unlikely that the project would interfere with the recovery of the Eastern (Freshwater) Cod.

Vulnerable Species

Under the Environment Protection and Biodiversity Conservation Act 1999, important populations are:

- likely to be key source populations either for breeding or dispersal
- likely to be necessary for maintaining genetic diversity, and/or
- at or near the limit of the species range.

The heads of consideration for vulnerable species under the EPBC Act, are as follows:

An action is likely to have a significant impact on a vulnerable species if there is a real chance or possibility that it will:

- lead to a long-term decrease in the size of an important population of a species
- reduce the area of occupancy of an important population
- fragment an existing important population into two or more populations
- adversely affect habitat critical to the survival of a species
- disrupt the breeding cycle of an important population
- modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
- result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat
- introduce disease that may cause the species to decline, or
- interfere substantially with the recovery of the species.

An 'important population' is a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:

- key source populations either for breeding or dispersal
- populations that are necessary for maintaining genetic diversity, and/or
- populations that are near the limit of the species range.

Vulnerable fauna

Grey-headed Flying-fox

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

The project would remove about 948 hectares of vegetation comprising a diversity of dry open forests, most forests, rainforests and heath. Ongoing habitat removal, particularly in coastal areas is a continual threat to this species. Other threats include disturbance and modification of habitat near roosting camps and electrocution from contacting overhead wires. The nearest known roost camps for this species are at Maclean (500 metres west) and Susan Island in Grafton (15 kilometres west) and there are no roost camps within the project boundary at the time of the EIS.

Foraging resources for the Grey-headed Flying-fox occur throughout all naturally vegetated areas of the study area and it is likely that the vegetation to be cleared provides a portion of the foraging range of local populations of Grey-headed Flying-foxes given the proximity of the roost camps and the known foraging range of this species. The project boundary is within the range of several roost camps in northern NSW located between Coffs Harbour and Ballina.

The range of habitats linked to this species and being impacted by the project are described below.

Vegetation / habitat types linked to target species	Area in project boundary (ha)	Project Section (extent in hectares)
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast	1.4	3 (1.4ha)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	79.7	1 (33.1ha), 2 (6.7ha), 3 (11.3ha), 6 (4.3ha), 7 (22.3ha)
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	46.2	1 (22.1ha), 9 (1.2ha), 10 (22.8ha)
Coast Cypress Pine shrubby open forest of the North Coast Bioregion	27.4	3 (0.9ha), 4 (0.1ha), 8 (1.1ha), 9 (0.9ha)
Coastal floodplain sedgelands, rushlands, and forblands	3.0	3 (0.9 ha), 4 (0.1 ha), 8 (1.1 ha), 9 (0.9 ha)
Coastal heath on sands of the North Coast	0.2	9 (0.2 ha)
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	2.0	4 (2.0ha)
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	73.9	1(4.7 ha), 2 (0.8 ha),3 (38.4 ha),4 (0.8 ha), 5 (2.3 ha),6 (18.7 ha) ,7 (0.1 ha),10 (5.6 ha),11 (1.8 ha)
Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast	48.2	3 (9.8ha), 4 (17.8ha), 6 (7.9ha), 7 (1.4ha), 8 (11.1ha)
Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast	0.5	10 (0.5ha)
Mangrove - Grey Mangrove low closed forest of the NSW Coastal Bioregions	1.5	5 (1.3ha), 10 (0.2ha)
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	34.7	6 (7.3ha), 7 (12.5ha), 8 (8.1ha)
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast	58.2	1 (16.9ha), 2 (26.3ha), 3 (14.9ha), 7 (1.0ha)
Orange Gum (Eucalyptus bancroftii) open forest of the North Coast	11.5	2 (11.5ha)

Vegetation / habitat types linked to target species	Area in project boundary (ha)	Project Section (extent in hectares)
Paperbark swamp forest of the coastal lowlands of the North Coast	49.5	1 (10.4ha), 2 (3.4ha), 3 (1.1ha), 4 (0.2ha), 6 (1.8ha), 7 (20.5ha), 8 (11.1ha), 10 (0.2ha)
Red Mahogany open forest of the coastal lowlands of the North Coast	46.2	6 (8.9ha), 7 (35.7ha), 8 (1.6ha)
Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast	71.9	3 (48.8ha), 7 (21.5 ha)
Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast	2.1	2 (2.11ha)
Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast	144.8	1(17.8ha), 2 (37.5ha), 3 (66.96ha), 4 (6.7ha), 6 (1.9ha), 7 (12.1ha)
Swamp Box swamp forest of the coastal lowlands of the North Coast	28.5	1 (23.3ha), 2(5.2ha)
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	44.2	1 (9.9ha), 2 (7.8ha), 3 (16.6ha), 5 (1.3ha), 8 (0.5ha), 9 (7.8ha), 10, (0.3ha)
Swamp Oak swamp forest of the coastal lowlands of the North Coast	56.2	1 (0.9 ha), 3 (12.8 ha), 4(1.6 ha), 5(11.7 ha), 8(12.2 ha), 9(3.1 ha). 10 (5.8 ha). 11(7.8 ha)
Tallowwood dry grassy forest of the far northern ranges of the North Coast	53	3 (36.8ha), 4 (3.5ha), 5(11.2ha), 6 (1.5ha)
Turpentine moist open forest of the coastal hills and ranges of the North Coast	44.5	3 (44.5ha)
Wet heathland and shrubland of coastal lowlands of the North Coast	10	6 (10ha)
White Booyong - Fig subtropical rainforest of the North Coast	8.6	10 (7.9ha), 11 (0.7ha)

The project removal of 948 hectares is considered a sustainable loss of potential foraging habitat in the context of available habitat in the surrounding region, including several state forests and conservation reserves and considering the broad foraging requirements of the species. The proposed action would not result in a decrease in the size of a local population and would not impact on a known roost site.

Life-cycle characteristics of the species at threat from habitat clearing relate to the loss of critical foraging habitat within a 50 kilometre radius of known camps (DECCW 2009). This is the expected maximum foraging distance of the species from a roost site (Eby 1996).

Given the absence of a roost camp in the project boundary, the impacts of construction and operation of the project relate to loss of feeding habitat caused by 1) direct clearing or damage to native vegetation during the construction phase and 2) edge effects during operation related to degradation of habitat at the interface with cleared land and altered feeding behaviours of flying foxes. It is likely that flying foxes would avoid feeding in close proximity to the highway once it is operational, causing loss of feeding opportunities in those areas.

Construction and operation of the upgrade would result in the loss of around 948 hectares of native vegetation from 57 vegetation types. Additional flying fox foraging habitat would be impacted through edge effects. The affected foraging dry open forest habitats contain a diversity of highly productive plants in the blossom diet of flying foxes including *Corymbia intermedia, Eucalyptus pilularis, Eucalyptus. robusta, Eucalyptus siderophloia* and *Melaleuca quinquenervia* (Eby and Law 2008). A diverse range of fruit-producing diet species dominate the lowland rainforest and moist floodplain forest habitats.

The affected area of foraging habitat would represent a small percentage of the total extent of these vegetation types within a 50 kilometre radius of the project boundary. Similarly, vegetation types containing known diet species as dominants or subdominants are widespread in the study area and the overall impact of loss of these species would be ameliorated by their prevalence in a broad range of vegetation types such that this project is unlikely to lead to a long-term decrease in the size of the population.

Reduce the area of occupancy of an important population

There have been no roost camps identified in the project boundary to date and at the time of the EIS the project would not directly impact on an identified roost camp. The nearest known camp is at Maclean around 500 metres west of the route. Therefore it is likely that the impacts of construction and operation of the project would be confined to loss of feeding habitat caused by 1) direct clearing or damage to native vegetation during the construction phase and 2) edge effects during operation related to degradation of habitat at the interface with cleared land and altered feeding behaviours of flying foxes.

The project would directly remove around 948 hectares of vegetation with additional indirect impacts expected through edge effects. This area of habitat may be defined as a portion of the potential area of occupancy for feeding life-cycle attributes of the population. However as stated, the affected area of foraging habitat would represent a small percentage of the total extent of important foraging vegetation types present within a 50 kilometre radius of the project boundary. Given the widespread nature and abundance of potential foraging habitat within the feeding range of regional populations, the project is not expected to significantly reduce the area of occupancy of an important population.

Fragment an existing important population into two or more populations

The project would increase the fragmentation of habitat in the landscape by impacting on contiguous forest areas including forestry and private lands, and conservation reserves. It is important to note however that all areas of habitat affected by the project have already been fragmented in the past by roads, and clearing for forestry operations. The project would be contributing to this cumulative fragmentation of habitat in the landscape.

Highly mobile species such as bats 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 project 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 habitat loss represents a small percentage of the potential foraging habitat for the Grey-headed Flying-fox within a 50 kilometre radius of the project boundary and know roost camps in the region. This species typically exhibits very large home ranges and Grey-headed Flying-fox are known to travel distances of at least 50 kilometres from roost sites to access seasonal foraging resources (Eby 1996). No evidence of a camp site has been identified from the footprint of the upgrade.

The draft recovery plan for the Grey-headed Flying-fox (DECCW 2009) identifies critical foraging habitat for this species as:

- Productive during winter and spring, when food bottlenecks have been identified
- Known to support populations of >30,000 individuals, within an area of 50 kilometre radius
- Productive during the final weeks of gestation, and during the weeks of birth, lactation and conception (Sept-May)
- Productive during the final stages of fruit development and ripening in commercial crops affected by Grey-headed Flying-foxes
- Known to be continuously occupied as a camp site.

Construction and operation of the upgrade would result in the loss of around 948 hectares of native vegetation from 57 vegetation types. Additional flying fox foraging habitat would be indirectly impacted through edge effects.

The affected foraging dry open forest habitats contain a diversity of highly productive plants in the blossom diet of flying foxes including *Corymbia intermedia, Eucalyptus pilularis, Eucalyptus. robusta, Eucalyptus siderophloia* and *Melaleuca quinquenervia* (Eby and Law 2008). A diverse range of fruit-producing diet species dominate the lowland rainforest and moist floodplain forest habitats. Many of these habitats are considered critical habitat for the species according to the definitions in DECCW (2009).

The affected area of foraging habitat would represent a small percentage of the total extent of these vegetation types within a 50 km radius of the project boundary. Similarly, vegetation types containing known diet species as dominants or subdominants are widespread in the study area and the overall impact of loss of these species would be ameliorated by their prevalence in a broad range of vegetation types such that this project is unlikely to lead to a long-term decrease in the size of the population.

Disrupt the breeding cycle of an important population

As stated above there would be a minor impact on critical habitat identified as important during the breeding cycle of the species. The upgrade would not directly impact on a known roost camp / breeding or maternity site.

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

No evidence of a roost camp has been identified from the footprint of the upgrade. Further there would be a relatively minor impact on critical foraging habitat associated with the upgrade and contained with a 50 kilometre radius of known camp sites. This impact is not expected to lead to a decline in the species in this region.

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

The potential for weed invasion was considered possible with a project of this nature and appropriate controls are required during 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 diversity of flora and would be unlikely to be dependent on roadside verges where most degradation from invasive species would occur. The management of invasive species would be managed under the construction environmental management plan and during operation of the highway using best practice methods as outlined in RTA (2011).

Introduce disease that may cause the species to decline

There are no known disease issues affecting this species in relation to the project. The project would be unlikely to increase feral animal abundance or the potential for significant disease vectors to affect local populations.

Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. This water-borne fungus infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction for the project has the potential to transmit the fungus to remaining native vegetation remnants of the species. This is a potential indirect impact to the species through the transmission of pathogens into retained habitat near the road. This can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols as detailed in RTA (2011) on this project as part of the CMP to prevent the introduction or spread of pathogens.

Interferes substantially with the recovery of the species

The route has been selected on the basis of avoiding high quality habitats for threatened fauna and impacts to critical foraging habitat have been identified as minimal. However the loss of potential foraging habitat for this project is considered a substantial loss and proposed offset measures are required.

Koala

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

There are over 11,000 recorded koala sightings in the NSW Atlas for the NSW North Coast Bioregion, spread over all local government areas in a wide range of topographies and habitats. This suggests that koalas could occur in all project sections in a range of habitats that would be impacted by the project. The two main centres of high density of koala records occur around Coffs Harbour, south of Woolgoolga (outside of the project), and in Richmond Valley LGA between Woodburn and Ballina (Sections 9, 10 and 11). Refer Figure 4-1 to Figure 4-5.

Important koala populations in the study are have been identified from Ashby, Iluka and Woombah (Clarence Valley Council 2010) to the east of the project boundary, also the western regions of the Clarence Valley LGA (Clarence Valley Council 2010), northern regions of the Coffs Harbour LGA (Coffs Harbour City Council 1999) and the west of Woodburn in the larger State Forests of the Richmond LGA (AKF 2008). The project would not impact on these populations.

Impacts on koala relate primarily to the clearing of around 580 hectares of habitat containing the primary koala feed tree species Forest Red Gum (*E. tereticornis*), Swamp Mahogany (*E. robusta*) and Tallowwood (*E.microcorys*). The species could also be negatively affected indirectly by increased fragmentation and the barrier effect of the highway and is regularly struck by cars where high-density populations occur in fragmented urban habitats. The impacts of the barrier effect and fragmentation have been addressed via a focus on this species in the Biodiversity Connectivity Strategy (Appendix A). Large areas of habitat would remain in the landscape including state forests and reserved habitats for the longer-term viability of this species.

Reduce the area of occupancy of an important population

In coastal northern NSW, populations have been estimated to range from one animal every 45 hectares to one every 4.5 hectares (average one every 20 to 25 hectares) (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 however the extent of potential habitat for this species is known and has been identified on Figure 4-1 to Figure 4-5 in addition to the distribution of known records. The project would remove potential habitat for the koala through the clearing of vegetation communities containing the identified primary and secondary koala 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. Further the provision of dedicated crossing structures is designed to prevent the isolation of potential habitat for local populations such that the broader area of occupancy of the population would not be reduced.

Fragment an existing important population into two or more populations

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of koalas on a both a patch and landscape scale.

The widening of the existing Pacific Highway in some areas would exacerbate the current barrier effect of the highway on regional and local Koala populations. There is limited data on the distribution of local and regional populations to identify if a population would be fragmented, however potential habitat would be traversed and it is assumed that the population would persist on either side of the highway.

As part of the response to mitigate and minimise this barrier effect for these species, RMS has developed a strategy with the aim of providing connectivity structures and enhancing landscape connectivity where feasible and reasonable in strategic locations. The Biodiversity Connectivity Strategy is detailed in Chapter 5 and Appendix A

The highest density of koala records occur in Section 9-11 in the Richmond Valley area (refer Figure 4-5). A range of dedicated and combined fauna crossing structures have been specifically located in the north of the project to target this species (refer Table A-5) and Appendix A for discussion. Both underpasses and overpasses are known to be effective in facilitating movements of koalas across roads (refer Section 0 for discussion).

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 project would remove potential habitat for the species through the clearing of vegetation communities containing identified food tree species known to preferred by koalas in the region including Forest Red Gum (*Eucalyptus tereticornis*), Swamp Mahogany (*Eucalyptus robusta*) and Tallowwood (*E.microcorys*) and Grey Gum (*E.propinqua* and *E.punctata*). The impact of habitat loss on this scale represents a moderately large loss, although not all areas containing potential feed trees are actually occupied by koalas and the loss of known habitat is difficult to quantify. The habitat types identified below contain known primary, secondary and supplementary food tree species and will be impacted by the project. however not all of this habitat would be occupied by koala populations.

BioMetric vegetation type containing food trees as dominant or sub-dominant	Koala food tree species			Area to be cleared (hectares)
	Primary	Secondary	Supplementary	
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	Tallowwood (*E. microcorys*)			79.7
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	Tallowwood (*E. microcorys*)		White stringybark (*E. globoidea*)	46.2
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	Tallowwood (*E. microcorys*)	Small-fruited grey gum (*E. propinqua*)		2.0
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	Forest red gum (*E. tereticornis*)	Small-fruited grey gum (*E. propinqua*) Grey box (*E. moluccana*)		73.9
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	Tallowwood (*E. microcorys*) Forest red gum (*E. tereticornis*) Orange gum (*E. bancroftii*)	Narrow-leaved red gum (*E. seeana*) Red mahogany (*E. resinifera*) Small-fruited grey gum (*E. propinqua*)		34.7
Orange Gum (Eucalyptus bancroftii) open forest of the North Coast	Orange gum (*E. bancroftii*)			11.5
Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast	Orange gum (*E. bancroftii*)			71.9
Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast	Forest red gum (*E. tereticornis*) Orange gum (*E. bancroftii*)	Grey box (*E. moluccana*) Small-fruited grey gum (*E. propinqua*)	Thin-leaved stringybark (*E. eugenioides*)	2.1
Swamp Box swamp forest of the coastal lowlands of the North Coast	Swamp mahogany (*E. robusta*)			28.5
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	Swamp mahogany (*E. robusta*) Forest red gum (*E. tereticornis*)	Red mahogany (*E. resinifera*)		44.2
Swamp Oak swamp forest of the coastal lowlands of the North Coast	Forest red gum (*E. tereticornis*)			56.2
Tallowwood dry grassy forest of the far northern ranges of the North Coast	Forest red gum (*E. tereticornis*	Small-fruited grey gum (*E. propinqua*)		53.0

BioMetric vegetation type containing food trees as dominant or sub-dominant	Koala food tree species			Area to be cleared (hectares)
	Primary	Secondary	Supplementary	
Turpentine moist open forest of the coastal hills and ranges of the North Coast	Tallowwood (*E.microcorys*)	Red mahogany (*E. resinifera*) Small-fruited grey gum (*E. propinqua*)		44.5
Total habitat containing primary koala food trees				**548.4**
Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast		Small-fruited grey gum (*E. propinqua*)		48.2
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast		Red mahogany (*E. resinifera*)	Stringybark (*E. tindaliae*)	58.2
Red Mahogany open forest of the coastal lowlands of the North Coast		Red mahogany (*E. resinifera*)		46.2
Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast		Small-fruited grey gum (*E. propinqua*) Grey box (*E. moluccana*)	Stringybark (*E. tindaliae*)	144.8
Total area containing secondary and supplementary koala food trees				**297.4**

Appropriate measures have been incorporated into the design of the road to minimise the impacts of fragmentation on this species and allow continued access to potential habitat for foraging, breeding and dispersal.

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, tallowood. 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).

Disrupt the breeding cycle of an important population

The evidence indicates that habitat within a number of project sections, particular from the Coffs Harbour region up to Glenugie and the Richmond River valley may be used by important koala populations which extends beyond the corridor several kilometres to the east and west. There is no data on the genetic relatedness between local populations and there are other larger populations in the region, particularly south into Coffs Harbour and around the Richmond.

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 project would remove potential habitat for the species through the clearing of vegetation communities containing identified food tree species within the actual corridor. The timing for clearing of vegetation is not known. A Construction Environmental Management Plan would be prepared to avoid, minimise and mitigate, to the extent practicable, the impact of vegetation clearing on fauna which includes this species. The CEMP would include appropriate procedures for clearing habitat such as pre-clearance surveys and a two stage clearing process which includes having an ecologist present at all times. This produced is designed to avoid direct injury and death to fauna including koalas and would avoid impacts to pregnant females or females carrying young.

Further appropriate measures have been incorporated into the design of the road to minimise the impacts of fragmentation on this species and allow continued access to potential habitat for foraging, breeding and dispersal. This includes purpose design underpass structures and fauna exclusion fencing for koalas, targeted in identified habitat areas.

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

A number of factors have been considered in assessing the importance of the habitat for Koalas. This includes:

- The quality of the habitat present
- The distribution of local populations
- The long-term security of the habitat adjoining the project.

The habitat within a number of state forests and across private land in Section 1-3 and 7-11 is considered likely to support viable breeding populations of Koalas on the basis of historical and current records of the species. Likely koala food trees in the region include primary browse trees such as forest red gum, swamp mahogany, grey gum, and tallowood. Occasional browse trees such as blackbutt, broad-leaved paperbark, and red mahogany are also common in the region (NPWS 2003).

The proposed clearing would remove preferred and supplementary habitat for local koala populations. The total area of preferred habitat for this species in the study area region is not known however the impact of habitat loss on this scale is considered only a portion of the habitat resources available in the region particularly to the north and west of the project as identified from regional vegetation mapping.

Appropriate measures have been incorporated into the design of the road to minimise the impacts of fragmentation on this species and allow continued access to potential habitat for foraging, breeding and dispersal. . This includes purpose design underpass structures and fauna exclusion fencing for koalas, targeted in identified habitat areas.

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

The clearing of habitat is recognised as a major factor contributing to the loss of habitat of the Koala. The associated impacts of this key threatening process are well documented and include increased potential for invasive species. The project would include the removal of potential habitat from a potentially important population. Measures to minimise invasion of weeds during construction and operation would be included in the CEMP. With these measures in place, this removal is not considered likely to result in an increase of invasive species precluding the koala from its habitat.

Introduce disease that may cause the species to decline

The clearing of habitat is recognised as a major factor contributing to the loss of habitat of the Koala. The associated impacts of this key threatening process are well documented and potentially include the introduction of disease. The project would include the removal of potential habitat. This removal is not considered a significant loss of habitat on a local or regional scale.

Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. This water-borne fungus infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction for the project has the potential to transmit the fungus to remaining native vegetation remnants of the species. This is a potential indirect impact to the species where key koala feed trees (all eucalypts) can be infected and die. This can be suitably mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols as detailed in RTA (2011) on this project as part of the CEMP to prevent the introduction or spread of pathogens.

Interferes substantially with the recovery of the species

The route has been selected on the basis of avoiding high quality habitats for threatened fauna and impacts to critical foraging habitat have been identified as minimal. However the loss of potential foraging habitat for this project is considered a substantial loss and proposed offset measures are required.

Long-nosed Potoroo

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

The Long-nosed Potoroo occurs in high rainfall coastal and near coastal low heathlands and sedgelands on sandy soils. These habitats provide a high abundance and diversity of food, adequate cover and suitable shelter.

The large majority of records of this species are associated with the extensive areas of coastal heath conserved in Yuraygir, Bundjalung and Broadwater National Park to the east of the project. Much of the habitat of the species in the region is conserved. There are no records around the project boundary. There are scattered records near the heath at Wardell and Broadwater National Park. The project boundary would have minimal impact on known populations and an important population would not be impacted.

Reduce the area of occupancy of an important population

The coastal and subcoastal heathland and sedgeland habitats of the species are particularly fire-prone. The project could potentially increase the incidence of fire in the study area through opening up to traffic. However the project would involve duplication of the existing highway in locations that provide potential habitat for this species and therefore this risk is low.

Up to 10 hectares of wet and dry heath along the edges of the existing highway would be removed for the project, this provides potential habitat for this species, however there are no recent accounts of populations present near the highway.

Fragment an existing important population into two or more populations

The potential habitats for this species in Broadwater National Park are currently fragmented by the existing highway and the Wardell heath is isolated to the eastern side of the existing highway. The project would improve connectivity in these areas through the provision of purpose built fauna crossing overpasses to link the heath type habitats.

Adversely affect habitat critical to the survival of the species

The large majority of records of this species are associated with the extensive areas of coastal heath conserved in Yuraygir, Bundjalung and Broadwater national parks to the east of the project. Much of the habitat of the species in the region is conserved. There are no records around the project boundary. There are scattered records near the heath at Wardell and Broadwater National Park. The project boundary would have minimal impact on known populations.

Disrupt the breeding cycle of an important population

Impacts on an important population of Long-nosed Potoroo are not expected. The existing area of potential habitat for this species occurs outside the project boundary. Up to 10 hectares of wet and dry heath along the edges of the existing highway would be removed for the project, this provides potential habitat for this species, however there are no recent accounts of populations present near the highway.

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

The large majority of records of this species are associated with the extensive areas of coastal heath conserved in Yuraygir, Bundjalung and Broadwater national parks to the east of the project. Much of the habitat of the species in the region is conserved. There are no records around the project boundary. There are scattered records near the heath at Wardell and Broadwater National Park. The project boundary would have minimal impact on known populations and an important population would not be impacted.

Up to 10 hectares of wet and dry heath along the edges of the existing highway would be removed for the project, this provides potential habitat for this species, however there are no recent accounts of populations present near the highway.

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

The potential for weed invasion has been considered possible with a project of this nature and appropriate controls have been provided 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 construction environmental management plan and during operation of the highway.

Introduce disease that may cause the species to decline

Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. This water-borne fungus infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction for the project has the potential to transmit the fungus to remaining native vegetation remnants of the species. This is a potential indirect impact to the species through the transmission of pathogens into retained habitat near the road. This can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols as detailed in RTA (2011) on this project as part of the CMP to prevent the introduction or spread of pathogens.

The project mitigation strategy and environmental management procedures would include guidance for preventing the introduction and/or spread of disease causing agents such as bacteria and fungi.

Interferes substantially with the recovery of the species

The project 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, and mitigation and offset measures would target threatened fauna. There are no priority sites for conservation of this species within the project boundary.

Olongburra Frog

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

The species occupies paperbark swamps and sedge swamps in coastal banksia dominated lowland heath ecosystem characterised by acidic waterbodies. The large majority of records of this species are associated with the extensive areas of coastal heath conserved in Yuraygir, Bundjalung and Broadwater national parks to the east of the project. Much of the habitat of this species in the region is conserved (ie in national parks or conservation areas). There are no records around the project boundary. There are scattered records near the heath at Wardell and Broadwater National Park. The project boundary would have minimal impact on known populations but an important population would not be impacted.

Reduce the area of occupancy of an important population

The coastal and subcoastal heathland and sedgeland habitats of the species are particularly fire-prone. The project could potentially increase the incidence of fire in the study area through opening up to traffic. However the project would involve duplication of the existing highway in locations that provide potential habitat for this species and therefore this risk is low.

Up to 10 hectares of wet and dry heath along the edges of the existing highway would be removed for the project, this provides potential habitat for this species, however there are no recent accounts of populations present near the highway.

Fragment an existing important population into two or more populations

The potential habitat for this species in the project boundary (Broadwater National Park) is currently fragmented by the existing highway and the Wardell heath is isolated to the eastern side of the existing highway. The project would improve connectivity in these areas through the provision of purpose built fauna crossing overpasses and underpasses to link the heath type habitats.

Adversely affect habitat critical to the survival of the species

The large majority of records of this species are associated with the extensive areas of coastal heath conserved in Yuraygir, Bundjalung and Broadwater national parks to the east of the project. Much of the habitat of the species in the region is conserved (ie in national parks or conservation areas). There are few records around the project boundary. There are scattered records near the heath at Wardell and Broadwater National Park. The project boundary would have minimal impact on known populations.

Disrupt the breeding cycle of an important population

On the basis that the project construction would extend over two to five years, there is reasonable potential for the activity to disrupt the breeding cycle of localised populations of this species in the study area. Measures to minimise impacts on waterways during construction would be implemented as part of the construction environmental management plan.

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

The large majority of records of this species are associated with the extensive areas of coastal heath conserved in Yuraygir, Bundjalung and Broadwater national parks to the east of the project. Much of the habitat of the species in the region is conserved. There are few records around the project boundary. There are scattered records near the heath at Wardell and Broadwater National Park. The project boundary would have minimal impact on known populations and an important population would not be impacted.

Up to 10 hectares of wet and dry heath along the edges of the existing highway would be removed for the project, this provides potential habitat for this species, however there are no recent accounts of populations present near the highway.

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

The potential for weed invasion has been considered possible with a project of this nature and appropriate controls have been provided 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, particularly aquatic weeds which would impact on the habitat of this species. The management of invasive species would be managed under the construction environmental management plan and during operation of the highway.

Introduce disease that may cause the species to decline

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

Interferes substantially with the recovery of the species

The project 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, and mitigation and offset measures would target threatened fauna. There are no priority sites for conservation of this species within the project boundary.

Large-eared Pied Bat

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

The study area provides potential foraging habitat for this species which is a cave-roosting bat. No caves or abandoned mine shafts have been recorded in the project boundary and the project is not expected to impact on the roosting life-cycle activities of this species. The location of any roost sites for these species in the regional area is not known.

The loss of forest habitat, in particular swamp forest (149 hectares) and wetlands (thirteen hectares) would impact on the potential breeding habitat for prey species (invertebrates) and therefore potentially lead to reduction of populations associated with increased pressure on a local scale. However comparable habitats are well represented throughout the locality and regional area and predation by bats would account for only a very small proportion of the prey availability. Therefore impacts on foraging habitat and prey abundance would result from the project however the overall magnitude of impact is small relative to the extent of insect breeding resources in the study area.

Reduce the area of occupancy of an important population

Impacts on known roosting habitat or a roosting colony have not been identified. The project would remove about 948 hectares of habitat comprising a combination of wet and dry sclerophyll forest and heath which provides known and potential foraging habitat for this insectivorous bat species. The effect of the removal of this habitat would be to remove breeding and shelter opportunities for insect prey and hunting habitat for bats, potentially leading to a reduction in population size or range.

Fragment an existing important population into two or more populations

The project would increase the fragmentation of habitat in the landscape by impacting on a number of contiguous forest areas. It is important to note however that all areas of habitat affected by the project have already been fragmented in the past by roads, and clearing for forestry operations. The project 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.

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 large-eared pied bat. As the species is a cave-roosting bat and there are no caves in the study area, there would be no impact on potential roosting habitat.

Disrupt the breeding cycle of an important population

No evidence of a roosting colony of the large-eared pied bat occurs in proximity to the study area and the project would not impact on breeding cycles or potential breeding habitat.

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

The project would remove about 948 hectares of habitat comprising a combination of wet and dry sclerophyll forest and heath which provides known and potential foraging habitat for this insectivorous bat species. The effect of the removal of this habitat would be to remove potential breeding and shelter opportunities for insect prey and hunting habitat for the bat species, potentially leading to a reduction in population size or range over a short to medium term.

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

The potential for weed invasion has been considered possible with a project of this nature and appropriate controls have been provided 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 construction environmental management plan and during operation of the highway.

Introduce disease that may cause the species to decline

Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. This water-borne fungus infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction for the project has the potential to transmit the fungus to remaining native vegetation remnants of the species. This is a potential indirect impact to the species through the transmission of pathogens into retained habitat near the road. This can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols as detailed in RTA (2011) on this project as part of the CMP to prevent the introduction or spread of pathogens.

The project mitigation strategy and environmental management procedures would include guidance for preventing the introduction and/or spread of disease causing agents such as bacteria and fungi.

Interferes substantially with the recovery of the species

The project 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, and mitigation and offset measures would target threatened fauna. There are no priority sites for conservation of this species within the project boundary.

Red Goshawk

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

The species occurs across most of NSW and covers a broad area of the coastal and sub-coastal region, frequenting open forest and woodlands on fertile soils with abundant prey species (Debus et al. 1993; Marchant and Higgins 1993). On the coast, the species appears to prefer the drier forest types on the foothills and coastal plains, which is consistent with the records occurring in the study area.

No nest sites were located along the project boundary during the route surveys nor have been reported in the vicinity of the route in the local state forests. There are no published accounts of nesting by this species in the vicinity of the project. Further surveys are recommended prior to construction. The project is unlikely to have a significant impact on breeding activities of a regional population however the clearing of vegetation could impact on the habitat of prey species and roosting habitat. Similar and suitable habitats for prey species are common and widespread in the region and the impacts on the population is expected to be minimal. There is no direct evidence of an important population occurring in the study area.

Reduce the area of occupancy of an important population

There is no direct evidence of an important population occurring in the study area. The species occurs across most of NSW and covers a broad area of the coastal and sub-coastal region, frequenting open forest and woodlands on fertile soils. As there are no established breeding pairs in the study area, the project would not reduce the area of occupancy of an important population.

Fragment an existing important population into two or more populations

The Red Goshawk occurs across northern and eastern Australia as far south as the lower north coast, given the large range and potential movements of the species, this is considered the entire population.

Adversely affect habitat critical to the survival of the species

As stated, the Red Goshawk population extends over a large area over northern Australia. The species occurs across most of NSW and covers a broad area of the coastal and sub-coastal region, frequenting open forest and woodlands on fertile soils with abundant prey species (Debus et al. 1993; Marchant and Higgins 1993). The project would not affect any unique habitat types that are critical to the species.

Disrupt the breeding cycle of an important population

No evidence of a breeding population or nest site has been identified in the project boundary and the project would not impact on breeding cycles or potential breeding habitat.

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

The project would remove around 948 hectares of forest habitat comprising wet and dry sclerophyll forests and heathlands. Of this around 550 hectares (58 per cent) consists of open dry sclerophyll forests and woodlands that could potentially be used by this species. In theory this would result in the loss of potential foraging and breeding habitat and may have a short term impact on prey abundance. However the habitats suited to this species are particularly well represented in the region, particularly to the east and south of the study area and the overall reduction of habitat is considered a small proportion of the available potential habitat. Populations are considered to persist following development of the project.

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

The potential for weed invasion has been considered possible with a project of this nature and appropriate controls have been provided 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 construction environmental management plan and during operation of the highway.

Introduce disease that may cause the species to decline

Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. This water-borne fungus infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction for the project has the potential to transmit the fungus to remaining native vegetation remnants of the species. This is a potential indirect impact to the species through the transmission of pathogens into retained habitat near the road. This can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols as detailed in RTA (2011) on this project as part of the CMP to prevent the introduction or spread of pathogens.

The project mitigation strategy and environmental management procedures would include guidance for preventing the introduction and/or spread of disease causing agents such as bacteria and fungi.

Interferes substantially with the recovery of the species

The project 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, and mitigation and offset measures would target threatened fauna. There are no priority sites for conservation of this species within the project boundary.

Australian Painted Snipe

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

As the project traverses a portion of the floodplain of the Clarence and Richmond rivers in addition to the Corindi River north of Woolgoolga, this would result in direct impacts to around thirteen hectares of wetland habitats in addition to crossing numerous tributaries and cleared floodplain areas which also provide known and potential habitat for this species.

Potential indirect impacts were identified for eight Nationally Important Wetlands and 15 SEPP 14 listed wetlands outside the project boundary. Most of these wetlands are recharged or fed by the Clarence River and Richmond River catchments.

Populations of Painted Snipe are known to occur in the Clarence River floodplain and frequently on floodplain habitats transcending movements across their range. Historically there has been a dramatic decline in the diversity and abundance of waterbirds on the Clarence River floodplain (Smith 2011) although there is no published data on the distribution and abundance of this species. This is a trend which is likely to have also been experienced on the Richmond River floodplain, and a result of the long history of wetland change associated with floodplain mitigation and agriculture. Australian Panted Snipe have adapted to using modified or degraded wetlands including artificially constructed environments.

The project may directly and indirectly affect the life-cycle of populations by temporarily displacing or disturbing individuals or established pairs. This may include nesting, foraging and roosting life-cycle activities. Nesting locations for this species in the study are not published, however potential habitat for the species is widespread throughout the study area including dense vegetation on the margins of freshwater creeks, rivers and natural or artificial wetlands that would not be impacted.

Reduce the area of occupancy of the species

The Painted Snipe prefers fringes of swamps, dams and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber. As the project traverses a portion of the floodplain of the Clarence and Richmond Rivers in addition to the Corindi River north of Woolgoolga, these habitat types are common and widespread across the major floodplains of the study area. The project would result in direct impacts to around 3 hectares of wetland habitats in addition to crossing numerous tributaries which have not been quantified, and these also provide known and potential habitat for this species. Potential indirect impacts were identified for eight Nationally Important Wetlands and 15 SEPP 14 listed wetlands outside the project boundary. Most of these wetlands are recharged or fed by the Clarence River and Richmond River catchments.

The review of habitat availability and records of this species suggest that potential habitat is widespread throughout the study area including dense vegetation on the margins of freshwater creeks, rivers and natural or artificial wetlands.

Fragment an existing population into two or more populations

The project traverses diverse landscapes across a large geographic area and would likely impact on landscape connectivity and fauna movements over a range of temporal and spatial scales. The project has potential to isolate remnant vegetation patches and create barriers to the movement of small ground-dwelling mammals, reptiles and amphibians and potentially discrete arboreal mammal populations on a both a patch and landscape scale.

The project design includes a four-lane divided carriageway, with space in the median for upgrade to a six-lane carriageway, if required. The width of the project boundary would vary considerably according to the location, elevation and proximity of service roads and interchanges. Generally, the project width is within a range of 50 to 200 metres. Large sections of the project would occur adjacent to the existing highway. The upgrade and widening of the road would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (eg Sections 3 to 4 and 9 to 10).

There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broad-scale clearing of native vegetation for agriculture and development including construction of the existing Pacific Highway and network of roads. This fragmentation of habitat is evident in the floodplain regions of the Corindi River, Clarence River and Richmond River.

The widening of the existing Pacific Highway in some areas would exacerbate the current barrier effect of the highway on regional and local populations of fauna, including the Australian Painted Snipe. There is limited data on the distribution of local and regional populations to identify if a population would be fragmented, however potential habitat would be traversed.

As part of the response to mitigate and minimise this barrier effect for these species, RMS has developed a strategy with the aim of providing connectivity structures and enhancing landscape connectivity where feasible and reasonable in strategic locations. The Biodiversity Connectivity Strategy is detailed in Chapter 5 and Appendix A .

Adversely affect habitat critical to the survival of a species

The project would result in direct impacts to around thirteen hectares of wetland habitats in addition to crossing numerous tributaries which have not been quantified, and these also provide known and potential habitat for this species. This impact is likely to affect life-cycle activities for localised populations. However, the distribution and abundance of populations over this scale is not known.

There are eight Nationally Important Wetlands and 15 SEPP 14 listed wetlands outside the project boundary. Most of these wetlands are recharged or fed by the Clarence River and Richmond River catchments in addition to numerous non-listed wetlands in the region. It is assumed that these habitats also contribute to the long-term maintenance of the species including maintaining genetic diversity and the long term evolutionary development of the species.

Disrupt the breeding cycle of a population

On the basis that the project construction would extend over two to five years, there is reasonable potential for the activity to disrupt the breeding cycle of a breeding pair or a number of pairs across the scale of the project. Measures to minimise impacts on waterways during construction have been implemented as part of the construction environmental management plan.

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

The project would result in a decrease of around thirteen hectares of wetland habitats in addition to small section of bridge crossings over numerous tributaries which provide known and potential habitat for this species.

While the distribution and abundance of populations over this scale is not known there are eight Nationally Important Wetlands and 15 SEPP 14 listed wetlands outside the project boundary. Most of these wetlands are recharged or fed by the Clarence River and Richmond River catchments in addition to numerous non-listed wetlands in the region. It is assumed that these habitats also contribute to the long-term maintenance of the species and recruitment into other habitats.

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

The potential for weed invasion has been considered possible with a project of this nature and appropriate controls have been provided 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 construction environmental management plan and during operation of the highway.

Introduce disease that may cause the species to decline

Infection of native plants by *Phytophthora cinnamomi* has been identified as being spread by construction machinery. This water-borne fungus infects the roots of plants and has the potential to cause dieback. Machinery associated with vegetation clearance and subsequent construction for the project has the potential to transmit the fungus to remaining native vegetation remnants of the species. This is a potential indirect impact to the species through the transmission of pathogens into retained habitat near the road. This can be mitigated through the development and implementation of suitable control measures for vehicle and plant hygiene and is unlikely to have a significant impact. It is the intention to use current best practice hygiene protocols as detailed in RTA (2011) on this project as part of the CEMP to prevent the introduction or spread of pathogens.

The project mitigation strategy and environmental management procedures would include guidance for preventing the introduction and/or spread of disease causing agents such as bacteria and fungi.

Interfere with the recovery of the species.

The project 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, and mitigation and offset measures would target threatened fauna. There are no priority sites for conservation of this species within the project boundary.

Migratory Fauna

The list of known and potential migratory species includes the following:

Species	Preferred habitat	Confirmed
Osprey (*Pandion haliaetus*)	Occur in littoral and coastal habitats and terrestrial wetlands of tropical and temperate Australia and offshore islands. They are mostly found in coastal areas but occasionally travel inland along major rivers	May occur across the entire study area, was confirmed in Sections 1-6 and 9-11.
Great Egret (*Egretta alba*)	Prefer shallow water, particularly when flowing, but may be seen on any watered area, including damp grasslands.	May occur across the entire study area, was confirmed in section 8.Commonly reported in the Clarence Valley wetlands (Smith 2011).
Cattle Egret (*Ardea ibis*)	Is found in grasslands, woodlands and wetlands particularly in coastal areas. It also uses pastures and croplands, especially where drainage is poor. Is often seen with cattle and other stock.	May occur across the entire study area, was confirmed in Section 1-5 and 9-11. Commonly reported in the Clarence valley wetlands (Smith 2011).
White-bellied Sea-Eagle (*Haliaeetus leucogaster*)	Forages over large open fresh or saline waterbodies, coastal seas and open terrestrial areas (Higgins 1999; Simpson & Day 1999). Breeding habitat consists of tall trees, mangroves, cliffs, rocky outcrops, silts, caves and crevices and is located along the coast or major rivers. Breeding habitat is usually in or close to water, but may occur up to a kilometre away (Marchant & Higgins 1999).	May occur along the length of the study area mostly in floodplain, wetland, riverine or estuarine habitats. Reported in Section 1 near Corindi River.
Satin Flycatcher (*Myiagra cyanoleuca*)	Associated with drier eucalypt forests, absent from rainforests (Blakers et al. 1984), open forests, often at height (Simpson & Day 1999).	May occur throughout the study area in all forested habitats. Recorded in Sections 1-2 and 6-8.
White Throated Needletail (*Hirundapus caudacutus*)	Forages aerially over a variety of habitats usually over coastal and mountain areas, most likely with a preference for wooded areas (Higgins 1999; Simpson & Day 1999). Has been observed roosting in dense foliage of canopy trees, and may seek refuge in tree hollows in inclement weather (Higgins 1999).	May occur throughout the study area in all forested habitats, reported near Shark Creek Section 4
Rainbow Bee-eater (*Merops ornatus*)	Occurs mainly in open forests and woodlands, shrublands, and in various cleared or semi-cleared habitats, including farmland and areas of human habitation (Higgins 1999). Usually occurs in open, cleared or lightly-timbered areas, especially in arid or semi-arid areas, in riparian, floodplain or wetland vegetation assemblages (Woinarski et al. 1988).	May occur throughout the study area in all forested habitats, typically prefers more open landscapes. Recorded near Tucabia in Section 3.
Black-faced Monarch (*Monarcha melanopsis*)	Occurs in rainforest and eucalypt forests, feeding in tangled understorey (Blakers et al. 1984).	May occur throughout the study area in all forested habitats. Recorded in dry forest near Tucabia in Section 4.
Rufous Fantail (*Rhipidura rufifrons*)	Frequents wet forests, less often open forests and woodlands (Simpson & Day 1999). May occur in open woodland and forest habitats throughout the north coast region.	May occur throughout the study area in all forested habitats. Recorded in Section 6 in Doubleduke State Forest.

Species	Preferred habitat	Confirmed
Lathams Snipe (*Gallinago hardwickii*)	Occurs in permanent and ephemeral wetlands, usually inhabiting open, freshwater wetlands with low, dense vegetation (eg swamps, flooded grasslands or heathlands, around bogs and other water bodies) (Frith et. al. 1977). However, they can also occur in habitats with saline or brackish water, in modified or artificial habitats, and in habitats located close to humans or human activity (Frith et al. 1977)	May occur throughout the study area particularly in floodplain areas of the Richmond River, Clarence River and Corindi River. Recorded in Section 3 in wetlands near the Pillar Valley.
Australian Painted Snipe (*Rostratula australis*)	Generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans. They also use inundated or waterlogged grassland or saltmarsh, dams, rice crops, sewage treatment plants and bore drains. Typical sites include those with rank emergent tussocks of grass, sedges, rushes or reeds, or samphire; often with scattered clumps of lignum Muehlenbeckia or canegrass or sometimes tea-tree (Melaleuca).	May occur throughout the study area particularly in floodplain areas of the Richmond River, Clarence River and Corindi River. Not observed during field surveys.
Spectacled Monarch (*Monarcha trivirgatus*)	Occurs in rainforest and eucalypt forests, feeding in tangled understorey (Blakers et al. 1984).	May occur throughout the study area in all forested habitats. Not observed during field surveys.

An area of 'important habitat' for a migratory species is:

- habitat used by a migratory species occasionally or periodically within a region that supports an ecologically significant proportion of the population of the species, and/or
- habitat that is of critical importance to the species at particular life-cycle stages, and/or
- habitat used by a migratory species which is at the limit of the species range, and/or
- habitat within an area where the species is declining.

Listed migratory species cover a broad range of species with different life cycles and population sizes. Therefore, what is an 'ecologically significant proportion' of the population varies with the species. Some factors that should be considered include the species' population status, genetic distinctiveness and species specific behavioural patterns (for example, site fidelity and dispersal rates). These factors have been considered in the following assessment.

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

As discussed above potential habitat for these migratory species may occur widely throughout the study area particularly in floodplain areas of the Richmond River, Clarence River and Corindi River. However, there is limited data on the size and distribution of local populations. Records from the atlas of NSW wildlife show that sightings are very widespread across the region in particular along the eastern foothills of the Great Dividing Range and low flat coastal regions. Many records are associated Nationally Important Wetlands which are not within the project boundary. There is no evidence to suggest that an ecologically significant proportion of the population of any identified migratory species exists within the project boundary.

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

The potential for weed invasion has been considered highly likely with a project of this nature and appropriate controls have been provided 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 construction environmental management plan and during operation of the highway.

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

As discussed there is no evidence to suggest that an ecologically significant proportion of the population of a migratory species exists within the project boundary.

Vulnerable flora

Sandstone Rough-barked Apple (Angophora robur)

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

A large population of *Angophora robur* has been identified in the local area growing on Kangaroo Creek Sandstone geology between the Pillar Valley and the Maclean area as part of the ecological surveys for the Wells Crossing to Iluka Road project boundary (SKM 2009), and supplementary surveys undertaken for this project in February 2011 and December 2011.

The life cycle of *Angophora robur* is likely to be linked to a large range of factors, but several important components include:

- A wide range of potential pollinator species including insects, birds, bats and arboreal mammals
- Fire regime including fire intensity, frequency and season
- Available gene pool
- Hybridisation with *Angophora woodsiana*
- Other disturbance regimes such as forestry activities and grazing.

There is estimated to be around 6,893 individuals of *Angophora robur* in the project boundary occurring over 82.06 hectares. Based on calculations from the detailed surveys the average number of individuals per hectare is 84. This average was extrapolated across the known and predicted regional distribution for this species and the results are provided below in Table E-11. The entire current known extent of *Angophora robur* includes three main clusters comprising:

- The eastern population within and surrounding the study area between Pillar Valley and Tyndale
- North-west of Coffs Harbour in the Coutts Crossing and Nymboida regions
- North-west of Grafton in the Copmanhurst and Coaldale regions.

Table E-11 *Angophora robur* population clusters in the project boundary and the populations from the wider region

Subpopulation name/location	Area of habitat occupied (ha)	Total population number	Number of individuals in project boundary	Area of occupied habitat in project boundary (proportion)
Eastern Population (Pillar Valley, Tucabia, Tyndale including Pine Brush SF and Newfoundland SF)	Known: 1,471.44	Known: 123,601	Known: 6893	82.06 (5.6%)
Population Cluster 1 – Pillar Valley	451.53	37928	1516	18.04 (4%)
Population Cluster 2 – Firth Heinz Road	14.73	1237	148	1.76 (11.9%)
Population Cluster 3 – Bostock Road	15.82	1328	293	3.5 (22.1%)
Population Cluster 4 – Summervale Road to Tallowwood Lane	189	15876	1294	15.4 (8.1%)
Population Cluster 5 – Tucabia Road	14.08	1183	142	1.69 (12%)
Population Cluster 6 – Tyndale	684.24	57476	3500	41.67 (6.1%)
Northwest Population *(*Copmanhurst, Coaldale including Fortis Creek NP))	Known: 457 Predicted 7,368	Known: 38,388 Predicted 619,912	0	0
Southwest Population *(*Glenreagh, Kangaroo Creek, Chambigne NR)	Unknown	500 known from records	0	0
Total *(*including known and predicted and records from southwest population)	9296	782,401	6893	82.06 (5.6%)

The known regional distribution including the eastern population and northwest population is estimated to comprise 161,989 individuals occurring over 1928 hectares and the predicted distribution including the northwest population only is estimated to consist of an additional 619,912 individuals over 7368 hectares.

The population in the corridor represents the known eastern distribution of the species. A total of 11 population clusters within the larger eastern subpopulation have been mapped within and surrounding the project boundary occurring over a total of 1471 hectares with individual clusters ranging from 1.3 to 684 hectares in area. All known locations within 500 metres of each other have been regarded as being part of the same population cluster based on the likely maximum dispersal distance of pollinators between subpopulations. A total of six of the 11 known population clusters occur in the project boundary and these are described in Table E-11.

The 11 subpopulations also includes four smaller outlying populations to the north in Woodford Island State Forest and to the south in Newfoundland State Forest, however these clusters include a high abundance of *Angophora woodsiana* and a low abundance of *Angophora robur* as well as intergrades between the two species. There is also a low abundance of *Angophora robur (*c. 1/ha) occurring with *Angophora woodsiana* over an additional 445 hectares on the more skeletal ridges and upper slopes *(*excluded from calculations).

The project would potentially impact up to 6893 individual *Angophora robur* including 82.06 hectares of known habitat. This impact represents a significant proportion of the known extent of the eastern subpopulation comprising around 5.6 per cent of the population and area of habitat. It is highly likely that there are additional population clusters of *Angophora robur* within the eastern population in areas not surveyed during the study, including private property, state forests and national park estates. The total known population consisting of the northwest and eastern subpopulations comprises 161,989 individuals occurring over 1928 hectares, of which the potential impact represents around 4.25 per cent of the population and area of habitat.

The predicted population size of the northwest population is estimated to consist of an additional 618,912 individuals over 7368 hectares. When added to the known extent of the population and records from the southwest population, the total of the known and predicted extent comprises 782,401 individuals occurring over 9296 hectares of habitat *(*refer to Table E-11). The potential impact of the project represents around one per cent of the total known and predicted population and area of habitat. These figures are likely to be further reduced when including known and predicted estimates for the southwest population which have not been undertaken for this project.

There would also potentially be indirect impacts from edge effects and habitat fragmentation. *Angophora robur* was recorded in currently edge affected habitats in the study area including open paddocks. Therefore *Angophora robur* is likely to be somewhat tolerant of edge effects and indirect impacts are not expected to significantly impact the life cycle attributes of *Angophora robur*, particularly with appropriate mitigation to reduce these edge effects such as weed treatment, water quality controls and native landscaping.

The project would potentially have a significant impact to the eastern population of *Angophora robur* considering that potentially up to five per cent of the local population would be impacted. The local gene pool would be reduced from the project however this impact can be mitigated somewhat through a seed collection and propagation strategy. Considering the large proportion of the population that would remain in the local area and the high mobility of pollinator species the project is unlikely to lead to inbreeding depressions due to fragmentation. Habitat for pollinator species would be removed, however sufficient habitat for large populations of potential pollinator species would remain in surrounding areas.

Reduce the area of occupancy of an important population

The project would result in the removal of up to 105 hectares of known occupied habitat for *Angophora robur*. This are of potentially impacted habitat comprises around:

- Seven per cent of the known occupied habitat of the eastern subpopulation
- 5.5 per cent of the known extant of the eastern population and northwest subpopulation
- 1.2 per cent of the known and predicted extent of the eastern and northwest subpopulations and records from the southwest subpopulation (500 individuals).

Impacts to the eastern subpopulation *(*seven per cent) are relatively significant considering this population represents the eastern extent of the species, there is limited known representation in conservation reserves and this area would be subject to increasing development pressure in the future. It is highly likely that there are additional population clusters of *Angophora robur* within the eastern population in areas not surveyed during the study, including private property, state forests and national park estates.

The potential impacts to habitat for *Angophora robur* are likely to represent a significantly smaller proportion when including the entire extent of the species, including the southwest subpopulation and additional locations of the eastern and northwest subpopulations not surveyed during this project.

Fragment an existing important population into two or more populations

Several of the population clusters would be dissected by the project impacting habitat connectivity for *Angophora robur*. Considering the high mobility of some pollinator species such as insects, birds and bats, and wind dispersal of pollen, gene flow is expected to continue across the width of the project.

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 project would potentially impact up to 6893 individual *Angophora robur* including 82.06 hectares of known habitat. This impact represents a significant proportion of the known extent of the eastern subpopulation comprising around 5.6 per cent of the population and area of habitat. It is highly likely that there are additional population clusters of *Angophora robur* within the eastern population in areas not surveyed during the study, including private property, state forests and national park estates. The total known population consisting of the northwest and eastern subpopulations comprises 161,989 individuals occurring over 1928 hectares, of which the potential impact represents around 4.25 per cent of the population and area of habitat.

Disrupt the breeding cycle of an important population

The life cycle of Angophora robur is likely to be linked to a large range of factors, but several important components include:

- A wide range of potential pollinator species including insects, birds, bats and arboreal mammals
- Fire regime including fire intensity, frequency and season
- Available gene pool
- Hybridisation with *Angophora woodsiana*
- Other disturbance regimes such as forestry activities and grazing.

There is estimated to be around 6,893 individuals of *Angophora robur* in the project boundary occurring over 82.06 hectares. Based on calculations from the detailed surveys the average number of individuals per hectare is 84. This average was extrapolated across the known and predicted regional distribution for this species and the results are provided below in Table E-11. The entire current known extent of *Angophora robur* includes three main clusters comprising:

- The eastern population within and surrounding the study area between Pillar Valley and Tyndale
- North-west of Coffs Harbour in the Coutts Crossing and Nymboida regions
- North-west of Grafton in the Copmanhurst and Coaldale regions.

The known regional distribution including the eastern population and northwest population is estimated to comprise 161,989 individuals occurring over 1928 hectares and the predicted distribution including the northwest population only is estimated to consist of an additional 619,912 individuals over 7368 hectares.

The population in the corridor represents the known eastern distribution of the species. A total of 11 population clusters within the larger eastern subpopulation have been mapped within and surrounding the project boundary occurring over a total of 1471 hectares with individual clusters ranging from 1.3 to 684 hectares in area. All known locations within 500 metres of each other have been regarded as being part of the same population cluster based on the likely maximum dispersal distance of pollinators between subpopulations. A total of six of the 11 known population clusters occur in the project boundary and these are described in Table E-11.

The 11 subpopulations also includes four smaller outlying populations to the north in Woodford Island State Forest and to the south in Newfoundland State Forest, however these clusters include a high abundance of *Angophora woodsiana* and a low abundance of *Angophora robur* as well as intergrades between the two species. There is also a low abundance of *Angophora robur (*around one per hectare) occurring with *Angophora woodsiana* over an additional 445 ha on the more skeletal ridges and upper slopes *(*excluded from calculations).

The project would potentially impact up to 6893 individual *Angophora robur* including 82.06 hectares of known habitat. This impact represents a significant proportion of the known extent of the eastern subpopulation comprising around 5.6 per cent of the population and area of habitat. It is highly likely that there are additional population clusters of *Angophora robur* within the eastern population in areas not surveyed during the study, including private property, state forests and national park estates. The total known population consisting of the northwest and eastern subpopulations comprises 161,989 individuals occurring over 1928 hectares, of which the potential impact represents around 4.25 per cent of the population and area of habitat.

The predicted population size of the northwest population is estimated to consist of an additional 618,912 individuals over 7368 hectares. When added to the known extent of the population and records from the southwest population, the total of the known and predicted extent comprises 782,401 individuals occurring over 9296 hectares of habitat (refer to Table E-11). The potential impact of the project represents around 1% of the total known and predicted population and area of habitat. These figures are likely to be further reduced when including known and predicted estimates for the southwest population which have not been undertaken for this project.

The project would potentially have a significant impact to the eastern population of *Angophora robur* considering that potentially up to five per cent of the local population would be impacted. The local gene pool would be reduced from the project however this impact can be mitigated somewhat through a seed collection and propagation strategy. Considering the large proportion of the population that would remain in the local area and the high mobility of pollinator species the project is unlikely to lead to inbreeding depressions due to fragmentation. Habitat for pollinator species would be removed, however sufficient habitat for large populations of potential pollinator species would remain in surrounding areas.

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

The project would potentially impact up to 6893 individual *Angophora robur* including 82.06 hectares of known habitat. This impact represents a significant proportion of the known extent of the eastern subpopulation comprising around 5.6 per cent of the population and area of habitat. It is highly likely that there are additional population clusters of *Angophora robur* within the eastern population in areas not surveyed during the study, including private property, state forests and national park estates. The total known population consisting of the northwest and eastern subpopulations comprises 161,989 individuals occurring over 1928 hectares, of which the potential impact represents around 4.25per cent of the population and area of habitat.

The predicted population size of the northwest population is estimated to consist of an additional 618,912 individuals over 7368 hectares. When added to the known extent of the population and records from the southwest population, the total of the known and predicted extent comprises 782,401 individuals occurring over 9296 hectares of habitat (refer to Table E-11). The potential impact of the project represents around one per cent of the total known and predicted population and area of habitat. These figures are likely to be further reduced when including known and predicted estimates for the southwest population which have not been undertaken for this project.

The project would potentially have a significant impact to the eastern population of *Angophora robur* considering that potentially up to five per cent of the local population would be impacted. The local gene pool would be reduced from the project however this impact can be mitigated somewhat through a seed collection and propagation strategy. Considering the large proportion of the population that would remain in the local area and the high mobility of pollinator species the project is unlikely to lead to inbreeding depressions due to fragmentation. Habitat for pollinator species would be removed, however sufficient habitat for large populations of potential pollinator species would remain in surrounding areas.

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

Vegetation clearing would potentially contribute to further invasion of Lantana camara and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability. Other indirect impacts are likely to be minor due to remaining individuals being present upslope of the project. Therefore impacts from stormwater run-off such as increased water and nutrient loads would not be a significant impact.

Weed management would be implemented during the construction phase of the project 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 *Angophora robur* include the introduction of Root Rot Fungus (*Phytophthora cinnamomi*) and other plant pathogens. Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the project, impacts from plant pathogens would be minimised. Monitoring and management actions for the retained populations as part of the mitigation measures of the project 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 project would not significantly conflict with the recovery actions proposed for Angophora robur. Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

To mitigate the ecological impacts from the project an offset strategy is proposed to provide greater protection of Angophora robur and habitat for other threatened flora and fauna, through placing an area of private land or state forest under conservation. There are several potential options for the offset strategy. An offset supporting a large number of *Angophora robur* would contribute towards the recovery of the species.

Arthraxon hispidus

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

Several large populations of *Arthraxon hispidus* have been recorded in Section 10 between Coolgardie Road and Lumley's Lane during the supplementary surveys (BAAM 2012). The project would potentially impact around 47 per cent of the known extant of the species within and surrounding the project boundary. Three distinct subpopulations have been identified based on their spatial distribution with all occupied habitats within 150 metres each other regarded as being part of the same subpopulation. Pollen from wind pollinated grass species have been observed to travel up to 150 metres in favourable conditions (Wang et al 2003). The potential impacts to each subpopulation is summarised in Table E-12.

Table E-12 *Arthraxon hispidus* population clusters in the study area and potential impacts

Subpopulation name/location	Population dissected by project boundary	Distance from nearest subpopulation (m)	Area of occupied habitat (ha)	Area of occupied habitat (ha) in project boundary	Proportion of occupied habitat in project boundary
Subpopulation 1 – Lumley's Lane	No	995	4.17	2.9	70%
Subpopulation 2 - Central	Yes	450	4.85	3.43	71%
Subpopulation 3 – Pacific Highway 1	Yes	450	2.86	1.94	68%
Subpopulation 4 – Pacific Highway 2	No	200	8.9	1.54	17%
Total			**20.79**	**9.81**	**47%**

A relatively significant proportion of occupied habitat would be potentially impacted from the project, particularly for subpopulations 1, 2 and 3 with up to 68 to 71 per cent of these subpopulations being impacted. Only 17 per cent of the largest population would be potentially impacted by the project.

There is potential for the genetic diversity of these subpopulations to be depleted particularly for subpopulations 1, 2 and 3 which could lead to an inbreeding depression. There are potential opportunities to mitigate potential impacts to this species through the maintenance, restoration and management of the remaining population which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

There is potential for indirect impacts to alter the existing habitat attributes such as hydrology regimes and weed invasion which may increase the overall proportion of occupied habitat impacted.

Reduce the area of occupancy of an important population

Arthraxon hispidus occurs in moist, shady positions and is usually found in or on the edges of rainforest and in wet eucalypt forest, often near creeks or swamps.

The known area of occupation of the species is 20.79 hectares of which 9.81 hectares (47 per cent) are within the project boundary. The area of unoccupied potential habitat is relatively extensive in the locality comprising wet areas in open paddocks and the edges of moist vegetation. However the potential occurrence of *Arthraxon hispidus* is likely to be dependent on numerous factors including grazing and maintenance regimes, hydrology and soils.

Fragment an existing important population into two or more populations

The project would result in further fragmentation of individuals. **Table E-12** identifies the subpopulations which would be dissected by the project. Subpopulations 2 and 3 would be dissected by the project, with individuals being retained on either side of the project. Impacts to subpopulations 1 and 4 would be restricted to one edge of the populations.

Adversely affect habitat critical to the survival of the species

This species is a cosmopolitan species which is relatively widespread but uncommon throughout southeast Queensland and the NSW North Coast and Northern Tablelands, as well as occurring from Japan to central Eurasia. This species occurs within the Border River–Gwydir, Northern Rivers (NSW), Fitzroy, Border Rivers–Maranoa Balonne, Condamine, South East, Burnett Mary and Wet Tropics (Queensland) Natural Resource Management Regions.

Hairy-joint Grass is known to be reserved in Carnarvon Cooloola National Park, Noosa National Park (Briggs & Leigh, 1996), Carnarvon National Park (Queensland CRA/RFA Steering Committee, 1998), and Daintree National Park (Queensland Herbarium, 2008).

The occurrence in the study area is towards the southern limit of the species in Australia, however there are records for this species around 180 kilometres south of the occurrence in Section 10.

Disrupt the breeding cycle of an important population

Three distinct subpopulations have been identified based on their spatial distribution with all occupied habitats within 150 metres each other regarded as being part of the same subpopulation. Pollen from wind pollinated grass species have been observed to travel up to 150 metres in favourable conditions (Wang et al 2003).

There is potential for the genetic diversity of these subpopulations to be depleted particularly for subpopulations 1, 2 and 3 which could lead to an inbreeding depression. There are potential opportunities to mitigate potential impacts to this species through the maintenance, restoration and management of the remaining population which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

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

The project would potentially impact around 47 per cent of the known extant of the species within and surrounding the project boundary. A relatively significant proportion of occupied habitat would be potentially impacted from the project, particularly for subpopulations 1, 2 and 3 with up to 68 to 71 per cent of these subpopulations being impacted. Only 17per cent of the largest population would be potentially impacted by the project.

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

Considering that the majority of the population adjacent to the project boundary occurs in low elevation areas subject to flooding, remaining locations surrounding the project would be potentially indirectly impacted from stormwater run-off and altered hydrology.

Considering the majority of the population surrounding the corridor occurs in open paddock areas there is unlikely to be significant indirect impacts from edge effects such as increased sunlight. There is potential for weed invasion to impact remaining individuals however weed management measure would be implemented.

Introduce disease that may cause the species to decline

Diseases which may impact Hairy-joint Grass include the introduction of Root Rot Fungus (*Phytophthora cinnamomi*) and other plant pathogens. Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the project, impacts from plant pathogens would be minimised. Monitoring and management actions for the retained populations as part of the mitigation measures of the project 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 project would not significantly conflict with the recovery actions proposed for Hairy-joint Grass. Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

To mitigate the ecological impacts from the project an offset strategy is proposed to provide greater protection of Hairy-joint Grass and habitat for other threatened flora and fauna, through placing an area of private land or state forest under conservation. There are several potential options for the offset strategy. An offset supporting a large number of Hairy-joint Grass would contribute towards the recovery of the species.

Cryptocarya foetida

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

A total of 17 individuals were recorded within and surrounding the project boundary during supplementary surveys in Section 10 north of Coolgardie Road (BAAM 2012). Of these 17 identified individuals up to 13 occur within the project boundary. Indirect impacts from edge effects and altered hydrology may alter the habitat of the remaining individuals of this species affecting life-cycle attributes.

The individuals identified during recent field surveys are potentially part of a larger population of this species occurring in rainforest habitats surrounding the corridor in Section 10. *Cryptocarya foetida* is presumed to be insect/bird pollinated and so it is reasonable to expect the potential population to include all individuals within 500 metres of individuals surrounding corridor. The seeds are readily distributed by fruit-eating bird species.

There is also potential for indirect impacts to alter the existing habitat attributes of remaining patches such as hydrology regimes and weed invasion.

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

Reduce the area of occupancy of an important population

Found in littoral rainforest, usually on sandy soils, but mature trees are also known on basalt soils. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

Fragment an existing important population into two or more populations

The project would result in the dissection of habitat for this species with, individuals being present on the eastern and western side of the project. Habitat for this species is currently highly fragmented in the locality and the project would result in further fragmentation of habitats with around 10.33 hectares of the 94.62 hectares of potential rainforest habitat for this species potentially being 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.*

Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted. There is some potential for the genetic diversity of the local population of *Cryptocarya foetida* to be depleted. There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring. The individuals in the project boundary are around 52 kilometres north of Iluka the known southern distributional limit.

Disrupt the breeding cycle of an important population

The life cycle of *Cryptocarya foetida* is likely to be linked to a large range of factors, but several important components include:

- Potential pollinator species are known to be native bees and other invertebrates
- Fire regime including fire intensity, frequency and season
- Available gene pool
- Hybridisation
- Other disturbance regimes such as forestry activities and grazing.

The individuals identified during recent field surveys are potentially part of a larger population of this species occurring in rainforest habitats surrounding the corridor in Section 10. *Cryptocarya foetida* is presumed to be insect/bird pollinated and so it is reasonable to expect the potential population to include all individuals within 500 metres of individuals surrounding corridor. The seeds are readily distributed by fruit-eating bird species.

There is some potential for the genetic diversity of the local population of *Cryptocarya foetida* to be depleted. There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

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

The project would result in the dissection of potential rainforest habitat for this species. Habitat for this species is currently highly fragmented in the locality and the project would result in further fragmentation of habitats with around 10.33 hectares of the 94.62 hectares of potential rainforest habitat for this species potentially being impacted.

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

Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability. Other indirect impacts are likely to be minor due to remaining individuals being present upslope of the project. Therefore impacts from stormwater run-off such as increased water and nutrient loads would not be a significant impact. Weed management would be implemented during the construction phase of the project 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 *Cryptocarya foetida* include the introduction of Root Rot Fungus (*Phytophthora cinnamomi*) and other plant pathogens. Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the project, impacts from plant pathogens would be minimised. Monitoring and management actions for the retained populations as part of the mitigation measures of the project 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 project would not significantly conflict with the recovery actions proposed for *Cryptocarya foetida.* Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

To mitigate the ecological impacts from the project an offset strategy is proposed to provide greater protection of *Cryptocarya foetida* and habitat for other threatened flora and fauna, through placing an area of private land or state forest under conservation. There are several potential options for the offset strategy. An offset supporting *Cryptocarya foetida* would contribute towards the recovery of the species.

Desmodium acanthocladum

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

This species was recorded in Section 8, comprising around 15 individuals outside of the project boundary in subtropical rainforest derived vegetation along a drainage line. This location is around 1 kilometre to the west of the proposal area and will not be directly impacted by the proposal and indirect impacts are unlikely to extend this far from the proposal area.

The preferred habitat for this species is dry rainforest and edges of subtropical rainforest on basalt derived soils which is present in the study area. There is a low possibility this species is present in rainforest habitats within the project boundary, however targeted surveys have not identified any populations within the project boundary.

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. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

Reduce the area of occupancy of an important population

Considering the relatively extensive targeted searches undertaken for this species in areas of suitable habitat, it is unlikely to be present in the study area. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

Fragment an existing important population into two or more populations

The project would result in the dissection of habitat for this species; however a population would not be dissected. Habitat for this species is currently highly fragmented in the locality and the project would result in further fragmentation of habitats with around 10.33 hectares of the 94.62 hectares of potential rainforest habitat for this species potentially being 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.*

No critical habitat has been identified for the species.

Disrupt the breeding cycle of an important population

This species was recorded in Section 8, comprising around 15 individuals outside of the project boundary in subtropical rainforest derived vegetation along a drainage line. However, there is no evidence of an important population being impacted by the proposal and therefore it is unlikely that there would be any disruption to the breeding cycle.

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

The project would result in the dissection of potential rainforest habitat for this species. Habitat for this species is currently highly fragmented in the locality and the project would result in further fragmentation of habitats with around 10.33 hectares of the 94.62 hectares of potential rainforest habitat for this species potentially being impacted.

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

Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability. Other indirect impacts are likely to be minor due to remaining individuals being present upslope of the project. Therefore impacts from stormwater run-off such as increased water and nutrient loads would not be a significant impact. Weed management would be implemented during the construction phase of the project 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 the species include the introduction of Root Rot Fungus (*Phytophthora cinnamomi*) and other plant pathogens. Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the project, impacts from plant pathogens would be minimised. Monitoring and management actions for the retained populations as part of the mitigation measures of the project 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 project would not significantly conflict with the recovery actions proposed for this species. Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

Endiandra hayesii

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

Endiandra hayesii was recently recorded in supplementary surveys in a patch of subtropical rainforest north of Coolgardie Road *(*BAAM 2012) comprising a total of five larger individuals and three juveniles. Of these eight individuals, two larger individuals and three juveniles are within the project boundary, comprising around 62.5 per cent of the known population.

The individuals identified during recent field surveys are potentially part of a larger population of this species occurring in rainforest habitats surrounding the corridor in Section 10. *Endiandra hayesii* is presumed to be insect/bird pollinated and so it is reasonable to expect the potential population to include all individuals within 500 metres of individuals surrounding corridor. The seeds are readily distributed by fruit-eating bird species.

There is also potential for indirect impacts to alter the existing habitat attributes of remaining patches such as hydrology regimes and weed invasion. There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

Reduce the area of occupancy of an important population

Endiandra hayesii occurs on poorer soils derived from sedimentary, metamorphic, or acid volcanic rocks. Vegetation includes subtropical and warm temperate rainforests, and Brush Box (Lophostemon confertus) forests, including regrowth and highly modified forms of these habitats. The altitude varies from near sea level to 800 metres. Rusty Rose Walnut occurs within the Northern Rivers (NSW) and South East Queensland Natural Resource Management Regions.

Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

Fragment an existing important population into two or more populations

The project would result in the dissection of potential rainforest habitat for this species however individuals would not be dissected with individuals being retained on the western side of the project boundary only. Habitat for this species is currently highly fragmented in the locality and the project would result in further fragmentation of habitats with around 10.33 hectares of the 94.62 hectares of potential rainforest habitat for this species potentially being 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.*

Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted. There is some potential for the genetic diversity of the local population of *Endiandra hayesii* to be depleted. There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

Endiandra hayesii has been previously recorded in the local area (10 kilometre radius) to the south east of the subject population near Iluka and also recorded in 1997 near Coffs Harbour. The individuals recorded in the project boundary are around 55 kilometres north of the southern distribution specified in Harden (1990) at the Clarence River near Iluka.

Disrupt the breeding cycle of an important population

The life cycle of *Endiandra hayesii* is likely to be linked to a large range of factors, but several important components include:

- Potential pollinator species are known to be native bees and other invertebrates
- Fire regime including fire intensity, frequency and season
- Available gene pool
- Hybridisation
- Other disturbance regimes such as forestry activities and grazing.

The individuals identified during recent field surveys are potentially part of a larger population of this species occurring in rainforest habitats surrounding the corridor in Section 10. *Endiandra hayesii* is presumed to be insect/bird pollinated and so it is reasonable to expect the potential population to include all individuals within 500 metres of individuals surrounding corridor. The seeds are readily distributed by fruit-eating bird species.

There is some potential for the genetic diversity of the local population of *Endiandra hayesii* to be depleted. There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

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

The project would result in the dissection of potential rainforest habitat for this species. Habitat for this species is currently highly fragmented in the locality and the project would result in further fragmentation of habitats with around 10.33 hectares of the 94.62 hectares of potential rainforest habitat for this species potentially being impacted.

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

Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability. Other indirect impacts are likely to be minor due to remaining individuals being present upslope of the project. Therefore impacts from stormwater run-off such as increased water and nutrient loads would not be a significant impact. Weed management would be implemented during the construction phase of the project 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 *Endiandra hayesii* include the introduction of Root Rot Fungus (*Phytophthora cinnamomi*) and other plant pathogens. Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the project, impacts from plant pathogens would be minimised. Monitoring and management actions for the retained populations as part of the mitigation measures of the project 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 project would not significantly conflict with the recovery actions proposed for *Endiandra hayesii.* Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

To mitigate the ecological impacts from the project an offset strategy is proposed to provide greater protection of *Endiandra hayesii* and habitat for other threatened flora and fauna, through placing an area of private land or state forest under conservation. There are several potential options for the offset strategy. An offset supporting *Endiandra hayesii* would contribute towards the recovery of the species.

Eucalyptus tetrapleura

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

Population estimates were established for several locations surrounding the project with several other locations including state forests and national park estates also assessed. The population estimates for each of the areas assessed is detailed below in Table E-13.

Table E-13 Known and predicted *Eucalyptus tetrapleura* populations and potential impacts

Location	Survey status	Area of population (hectares)	Estimated population (no.)	Area of pop in project boundary (hectares)	Estimated number in project boundary
Glenugie State Forest	Surveyed	638.8	103,826	4.14	612
Pine Brush State Forest	Surveyed	139.31	10,336	0	0
Newfoundland State Forest	Surveyed	53.51	5510	0	0
Subtotal - State Forests		**831.62**	**119,672**	**4.14**	**612**
Chambigne Nature Reserve	Surveyed	13.28	1010	0	0
Yuraygir State Conservation Area	Surveyed	18.7	1023	0	0
Wells Crossing Flora Reserve	Surveyed	86.62	4218	10.36	495
Subtotal - Conservation Reserves		**118.6**	**6251**	**10.36**	**495**
Private property - Glenugie	Surveyed	40.73	6540	0.06	12
Private property - Rockview	Confirmed Records	28.18	1409	0	0
Private property – Glenugie Offset	Surveyed	354.83	22,960	0	0
Private property – Dirty Creek	Surveyed	1.52	94	1.52	94
Private property - Predicted	Predicted	168.54	19,664	0	0
Subtotal – Private Property		**593.8**	**50,667**	**1.58**	**106**
Shannon Creek Dam (Crown Land)	Atlas Records	170	3173	0	0
Total (with impacts from Glenugie Upgrade project subtracted)		**1,714.02**	**179,763**	**16.08**	**1,213**
Total area local population impacted by the project (occurrences within 500 metres of each other)	Surveyed	**1,289.24**	**159,629**	**16.08**	**1,213**
Glenugie Upgrade	Surveyed	**34.52**	**6,061**	**0**	**0**

However the total population number is estimated to be significantly larger than indicated as many additional NSW Atlas records occur on private lands to the west of Glenugie State Forest (ie at least around 30 records) that have not been assessed in detail. Additionally the species is also known to occur in the following state forest and national park estates:

- Whipore State Forest
- Gibberagee State Forest
- Candole State Forest
- Southgate State Forest
- Camira State Forest
- Fullers State Forest
- Mt Neville Nature Reserve
- Sherwood Nature Reserve
- Ramorning National Park.

The total regional population based on recorded locations to date is therefore considered to comprise in the order of 50 different sub-groups with a conservative estimate of between 170,000 to 250,000 individuals.

The local population within the project boundary comprises all occurrences within 500 metres radius of each other considering the high mobility of some pollinator species such as insects, birds and bats, as well as wind dispersal of pollen. This local population is estimated to consist of around 159,629 individuals including occurrences in Glenugie State Forest, Wells Crossing Flora Reserve, private property including the Glenugie offset property and Yuraygir State Conservation Area. The potential impact from the project and the Glenugie upgrade represents around 0.76 per cent of the local population and around 1.25 per cent of the area of occupancy (1,289.24 hectares). This project would have impacts to the local distribution of the species, removing part of the local gene pool and 16.08 hectares of known habitat for *Eucalyptus tetrapleura*.

When considering cumulative impacts from the Glenugie upgrade and the current project, the combined impacts to the local population comprise around 7,274 individuals occurring over 50.6 hectares of habitat representing 4.6 per cent of the local population and up to 3.9 per cent of the occupied habitat. The project would result in the removal of habitat for pollinator species, however sufficient habitat for large populations of potential pollinator species would remain in surrounding areas. The cumulative impacts of the project and the Glenugie upgrade, while reducing the local gene pool, however it is considered that there would be significant genetic diversity in the remaining 95 per cent of the population and sufficient habitat for pollinator species to avoid inbreeding depressions or impacts from stochastic events.

Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability. Other indirect impacts from vegetation clearing would include stormwater run-off potentially increasing water and nutrient loads entering adjacent bushland areas, leading to the increased growth and spread of exotic species.

Reduce the area of occupancy of an important population

The major populations for *Eucalyptus tetrapleura* were recorded in the Glenugie area some of which has been impacted by the Glenugie Pacific Highway upgrade. Large populations are predicted to be present to the east and west of Glenugie State Forest on private property and additional populations are potentially present in Yuraygir State Conservation Area.

Eucalyptus tetrapleura was also surveyed in several locations remote from the project boundary, including areas along Rockview Road at Chambigne. *Eucalyptus tetrapleura* was observed to extend into areas of private property surrounding Rockview Road, and although no population assessments were carried out in this area *Eucalyptus tetrapleura* is expected to be relatively abundant in this area.

The total regional population based on recorded locations to date is therefore considered to comprise in the order of 50 different sub-groups with a conservative estimate of between 170,000 to 250,000 individuals.

This local population is estimated to consist of around 159,629 individuals including occurrences in Glenugie State Forest, Wells Crossing Flora Reserve, private property including the Glenugie offset property and Yuraygir State Conservation Area. The potential impact from the project represents around 0.76 per cent of the local population and around 1.25 per cent of the area of occupancy (1289.24 hectares). This project would have impacts to the local distribution of the species, removing part of the local gene pool and 16.08 hectares of known habitat for *Eucalyptus tetrapleura*. When considering cumulative impacts from the Glenugie Upgrade and the current project, the combined impacts to the local population comprise around 7,274 individuals occurring over 50.57 hectares of habitat representing 4.6 per cent of the local population and up to 3.9 per cent of the occupied habitat.

Fragment an existing important population into two or more populations

The population is currently fragmented by the existing highway and the project would widen the disturbance width further fragmenting habitats on the western side of the existing highway from populations to the east. However, considering the high mobility of some pollinator species such as insects, birds and bats, and wind dispersal of pollen, gene flow is expected to continue across the existing highway and the width of the project. There are estimated to be about 7100 individuals on the western side of the existing highway, and this is likely to be a large enough gene pool to continue to successfully reproduce without inbreeding depressions.

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.*

This local population is estimated to consist of around 159,629 individuals including occurrences in Glenugie State Forest, Wells Crossing Flora Reserve, private property including the Glenugie offset property and Yuraygir State Conservation Area. The potential impact from the proposed upgrades represents around 0.76 per cent of the local population and around 1.25 per cent of the area of occupancy (1289.24 hectares). This project would have impacts to the local distribution of the species, removing part of the local gene pool and 14.57 hectares of known habitat for *Eucalyptus tetrapleura*. When considering cumulative impacts from the Glenugie Upgrade and the current project, the combined impacts to the local population comprise around 7274 individuals occurring over 50.57 hectares of habitat representing 4.6 per cent of the local population and up to 3.9 per cent of the occupied habitat. The project would result in the removal of habitat for pollinator species; however sufficient habitat for large populations of potential pollinator species would remain in surrounding areas.

The local abundance of the species varied considerably within each of the different populations and so separate densities were calculated for each population. The average density is calculated as around 100 individuals per hectare. The density of individuals was often dependant on the degree of recruitment, with some areas supporting a large number of juvenile trees and smaller saplings, whilst other areas supported more mature trees with fewer juveniles. The abundance of juveniles is dependent on several factors including fire history, understorey structure and other disturbances such as logging activities. Many of the State Forest areas supported a large number of juveniles possibly due to past disturbance from logging activities and wildfire providing bare soil for germination. Certain fire regimes are likely to favour recruitment, such as fire during the major fruiting period for *Eucalyptus tetrapleura*, providing bare surface substrates for germination of plant-stored seed.

Disrupt the breeding cycle of an important population

The life cycle of *Eucalyptus tetrapleura* is likely to be linked to a large range of factors, but several important components include:

- Potential pollinator species are known to be native bees and other invertebrates
- Fire regime including fire intensity, frequency and season
- Available gene pool
- Hybridisation
- Other disturbance regimes such as forestry activities and grazing.

The local population within the project boundary comprises all occurrences within 500 metres radius of each other considering the high mobility of some pollinator species such as insects, birds and bats, as well as wind dispersal of pollen. When considering the cumulative impacts of the project and the Glenugie Upgrade there would be a significant reduction to the local gene pool, however it is considered that there would be significant genetic diversity in the remaining 95 per cent of the population and sufficient habitat for pollinator species to avoid inbreeding depressions. To mitigate the ecological impacts from the project an offset strategy is proposed to provide greater protection of *Eucalyptus tetrapleura* and habitat for other threatened flora and fauna. The project would result in the removal of habitat for pollinator species; however sufficient habitat for large populations of potential pollinator species would remain in surrounding areas.

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

This local population is estimated to consist of around 159,629 individuals including occurrences in Glenugie State Forest, Wells Crossing Flora Reserve, private property including the Glenugie offset property and Yuraygir State Conservation Area. The potential impact from the proposed upgrades represents around 0.76 per cent of the local population and around 1.25 per cent of the area of occupancy (1289.24 hectares). This project would have impacts to the local distribution of the species, removing part of the local gene pool and 16.08 hectares of known habitat for *Eucalyptus tetrapleura*. When considering cumulative impacts from the Glenugie Upgrade and the current project, the combined impacts to the local population comprise around 7,274 individuals occurring over 50.57 hectares of habitat representing 4.6 per cent of the local population and up to 3.9 per cent of the occupied habitat.

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

The project would result in a larger fire break to wildfire approaching from the west of the existing highway, potentially resulting in the frequency of wildfire to be reduced in populations to the east. However state forest areas are likely to be fire-managed with control burns implemented in areas during cooler months. Although there is potential for fire regimes to change following the project it is considered unlikely to significantly impact the life cycle of populations of *Eucalyptus tetrapleura*.

Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability. Other indirect impacts from vegetation clearing including stormwater run-off could potentially increase water and nutrient loads entering adjacent bushland areas, leading to the increased growth and spread of exotic species.

Introduce disease that may cause the species to decline

Diseases which may impact *Eucalyptus tetrapleura* include the introduction of Root Rot Fungus (*Phytophthora cinnamomi*) and other plant pathogens such as Myrtle Rust (*Puccini psidii* s.l.). Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the project, impacts from plant pathogens would be minimised. Monitoring and management actions for the retained populations as part of the mitigation measures of the project 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 project would not significantly conflict with the recovery actions proposed for *Eucalyptus tetrapleura.* Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

To mitigate the ecological impacts from the project an offset strategy is proposed to provide greater protection of *Eucalyptus tetrapleura* and habitat for other threatened flora and fauna, through placing an area of private land or state forest under conservation. There are several potential options for the offset strategy. An offset supporting *Eucalyptus tetrapleura* would contribute towards the recovery of the species.

Grevillea quadricauda

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

Grevillea quadricauda was recorded in the project boundary at two different locations in Section 3. It occurs in moderate abundance in the project boundary comprising two subpopulations around 1.4 kilometres apart. One of these subpopulations is very small occurring in partially cleared disturbed habitats consisting of eight individuals and a larger population consisting of at least 200 individuals extending to the east of the project boundary. The population number and are of occupancy of these subpopulations are summarised in Table E-14.

Table E-14 *Grevillea quadricauda* populations and potential impacts

Subpopulation Name/Location	Area of habitat occupied (ha)	Total population number	Number of individuals in project boundary	Area of occupied habitat in project boundary
Northern Population	0.013	8	5	0.012
Southern Population	0.632	200	3	0.008
Total	**0.646**	**208**	**8**	**0.02**

The potential impacts of the project would result in the removal of a high proportion of individuals (62.5per cent) from the northern population with only three individuals occurring outside of the project boundary. The viability of the northern population is likely to currently be low considering a total population number of eight individuals, and the population is currently threatened from clearing and agricultural activities. It is unlikely that cross-pollination would occur between the two known populations, however there is potential for other occurrences of this species in habitats adjacent to the study area which would improve the potential viability of this population. In the absence of any additional occurrences of *Grevillea quadricauda* within 500 metres of the northern population the project is likely to significantly reduce the viability of this population.

The southern population represents a relatively large abundance of individuals occurring in intact habitats on sandy slopes surrounding the project boundary. The occurrence of this population in the footprint is on the edge of an existing trail near a major creek line, evidence of selective logging was observed in areas of this population. This population is largely avoided by the project and impacts would be limited to three individuals representing around 1.5per cent of the known population in this area. The removal of three individuals from this population is considered unlikely to significantly reduce the genetic diversity within this population. However there is potential for indirect impacts to alter the habitat of the remaining individuals and mitigation measures are required to minimise indirect impacts.

Reduce the area of occupancy of an important population

The potential impacts of the project would result in the removal of a high proportion of individuals (62.5 per cent) from the northern population with only three individuals occurring outside of the project boundary. The viability of the northern population is likely to currently be low considering a total population number of eight individuals, and the population is currently threatened from clearing and agricultural activities. It is unlikely that cross-pollination would occur between the two known populations, however there is potential for other occurrences of this species in habitats adjacent to the study area which would improve the potential viability of this population. In the absence of any additional occurrences of *Grevillea quadricauda* within 500 metres of the northern population the project is likely to significantly reduce the viability of this population and therefore reduce the area of occupancy.

The southern population is largely avoided by the project and impacts would be limited to three individuals representing around 1.5 per cent of the known population in this area. The removal of three individuals from this population is considered unlikely to significantly reduce the genetic diversity within this population. However there is potential for indirect impacts to alter the habitat of the remaining individuals and mitigation measures are required to minimise indirect impacts.

Fragment an existing important population into two or more populations

As the majority of the population occurs to the east of the project boundary areas of known habitat would not be fragmented from the project. However habitat connectivity would be affected including potential habitat for *Grevillea quadricauda* and pollinator species.

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 potential impacts of the project would result in the removal of a high proportion of individuals (62.5 per cent) from the northern population with only three individuals occurring outside of the project boundary. The viability of the northern population is likely to currently be low considering a total population number of eight individuals, and the population is currently threatened from clearing and agricultural activities. It is unlikely that cross-pollination would occur between the two known populations, however there is potential for other occurrences of this species in habitats adjacent to the study area which would improve the potential viability of this population. In the absence of any additional occurrences of *Grevillea quadricauda* within 500 metres of the northern population the project is likely to significantly reduce the viability of this population and therefore potentially affect habitat critical to the survival of this subpopulation.

The southern population is largely avoided by the project and impacts would be limited to three individuals representing around 1.5 per cent of the known population in this area. The removal of three individuals from this population is considered unlikely to significantly reduce the genetic diversity within this population. However there is potential for indirect impacts to alter the habitat of the remaining individuals and mitigation measures are required to minimise indirect impacts.

Disrupt the breeding cycle of an important population

The life cycle of *Grevillea quadricauda* is likely to be linked to a large range of factors, but several important components include:

- Potential pollinator species are known to be native bees and other invertebrates
- Fire regime including fire intensity, frequency and season
- Available gene pool
- Hybridisation
- Other disturbance regimes such as forestry activities and grazing.

The viability of the northern population is likely to currently be low considering a total population number of eight individuals, and the population is currently threatened from clearing and agricultural activities. It is unlikely that cross-pollination would occur between the two known populations, however there is potential for other occurrences of this species in habitats adjacent to the study area which would improve the potential viability of this population. In the absence of any additional occurrences of *Grevillea quadricauda* within 500 metres of the northern population the project is likely to significantly reduce the viability of this population and therefore disrupt the breeding cycle.

The southern population is largely avoided by the project and impacts would be limited to three individuals representing around 1.5 per cent of the known population in this area. The removal of three individuals from this population is considered unlikely to significantly reduce the genetic diversity within this population. However there is potential for indirect impacts to alter the habitat of the remaining individuals and mitigation measures are required to minimise indirect impacts. The breeding cycle of the southern population is unlikely to be impacted.

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

The project would result in the dissection of potential rainforest habitat for this species. Habitat for this species is currently highly fragmented in the locality and the project would result in further fragmentation of habitats with around 10.33 hectares of the 94.62 hectares of potential rainforest habitat for this species potentially being impacted.

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

Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability. Other indirect impacts are likely to be minor due to remaining individuals being present upslope of the project. Therefore impacts from stormwater run-off such as increased water and nutrient loads would not be a significant impact. Weed management would be implemented during the construction phase of the project 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 *Grevillea quadricauda* include the introduction of Root Rot Fungus (*Phytophthora cinnamomi*) and other plant pathogens. Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the project, impacts from plant pathogens would be minimised. Monitoring and management actions for the retained populations as part of the mitigation measures of the project 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

Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

To mitigate the ecological impacts from the project an offset strategy is proposed to provide greater protection of *Grevillea quadricauda* and habitat for other threatened flora and fauna, through placing an area of private land or state forest under conservation. There are several potential options for the offset strategy. An offset supporting *Grevillea quadricauda* would contribute towards the recovery of the species.

Macadamia tetraphylla

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

Macadamia tetraphylla was recently recorded in supplementary surveys in patches of subtropical rainforest north of Coolgardie Road (BAAM 2012) comprising a total of 68 individuals. Of these 68 individuals, 37 individuals are within the project boundary, comprising over half of the known population.

Total population size is estimated to be between 1000 and 2000 mature individuals with around 75 key populations with around 5 to 20 mature specimens at each locality (Costello et al 2009). Therefore the population in the study area could be regarded as a relatively large population and potentially represents up to 6.8 to 13.6 per cent of the entire population of which over half would potentially be impacted. The potential impacts to 37 individuals represents a significant proportion of the entire known population of between 1000 and 2000 mature individuals (Costello et al 2009) comprising up to 3.7 to 7.4 per cent of the entire estimated population.

The individuals identified during recent field surveys are potentially part of a larger population of this species occurring in rainforest habitats surrounding the corridor in Section 10. *Macadamia tetraphylla* is pollinated by both introduced European Honey Bee (Apis mellifera) and native bees (Trigona spp.) with native bees being the superior pollinators (Costello et al 2009). There is evidence indicating considerable pollination occurs between populations even in highly fragmented landscape (Neal 2007). These data indicate that the species may survive small population size if there is a network of small populations within a region; however larger distances between populations are not conducive to gene flow by pollen sufficient to maintain the genetic integrity of populations (Costello et al 2009).

Investigations into the reproduction of *Macadamia tetraphylla* suggest a pollen source from at least a two kilometres distance is an optimal outbreeding distance (Pisanu et al 2008). However, many wild populations do not have neighbouring populations at optimal distances owing to habitat fragmentation which may be the case with the population in the project boundary. Highly disturbed populations have been observed to produce seed and are important as stepping stones for genetic flow between larger populations (Pisanu et al 2008).

There is also potential for indirect impacts to alter the existing habitat attributes of remaining patches such as hydrology regimes and weed invasion. There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

Reduce the area of occupancy of an important population

Macadamia tetraphylla is found in several regional ecosystems from complex notophyll vine forest to littoral rainforest to wet sclerophyll communities. In NSW habitat for *Macadamia tetraphylla* includes various rainforest communities. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

Fragment an existing important population into two or more populations

The project would result in the dissection of potential rainforest habitat for this species however individuals would not be dissected with individuals being retained on the western side of the project boundary only. Habitat for this species is currently highly fragmented in the locality and the project would result in further fragmentation of habitats with around 10.33 hectares of the 94.62 hectares of potential rainforest habitat for this species potentially being 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 project would result in the dissection of potential rainforest habitat for this species. Habitat for this species is currently highly fragmented in the locality and the project would result in further fragmentation of habitats with around 10.33 hectares of the 94.62 hectares of potential rainforest habitat for this species potentially being impacted.

Investigations into the reproduction of *Macadamia tetraphylla* suggest a pollen source from at least a two kilometres distance is an optimal outbreeding distance (Pisanu et al 2008). However, many wild populations do not have neighbouring populations at optimal distances owing to habitat fragmentation which may be the case with the population in the project boundary. Highly disturbed populations have been observed to produce seed and are important as stepping stones for genetic flow between larger populations (Pisanu et al 2008).

Disrupt the breeding cycle of an important population

The life cycle of *Macadamia tetraphylla* is likely to be linked to a large range of factors, but several important components include:

- Potential pollinator species are known to be native bees and other invertebrates
- Fire regime including fire intensity, frequency and season
- Available gene pool
- Hybridisation
- Other disturbance regimes such as forestry activities and grazing.

The individuals identified during recent field surveys are potentially part of a larger population of this species occurring in rainforest habitats surrounding the corridor in Section 10. *Macadamia tetraphylla* is pollinated by both introduced European Honey Bee (*Apis mellifera*) and native bees (*Trigona* spp.) with native bees being the superior pollinators (Costello et al 2009). There is evidence indicating considerable pollination occurs between populations even in highly fragmented landscape (Neal 2007). These data indicate that the species may survive small population size if there is a network of small populations within a region; however larger distances between populations are not conducive to gene flow by pollen sufficient to maintain the genetic integrity of populations (Costello et al 2009).

Investigations into the reproduction of *Macadamia tetraphylla* suggest a pollen source from at least a two kilometres distance is an optimal outbreeding distance (Pisanu et al 2008). However, many wild populations do not have neighbouring populations at optimal distances owing to habitat fragmentation which may be the case with the population in the project boundary. Highly disturbed populations have been observed to produce seed and are important as stepping stones for genetic flow between larger populations (Pisanu et al 2008).

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

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

The project would result in the dissection of potential rainforest habitat for this species. Habitat for this species is currently highly fragmented in the locality and the project would result in further fragmentation of habitats with around 10.33 hectares of the 94.62 hectares of potential rainforest habitat for this species potentially being impacted.

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

Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability. Other indirect impacts are likely to be minor due to remaining individuals being present upslope of the project. Therefore impacts from stormwater run-off such as increased water and nutrient loads would not be a significant impact. Weed management would be implemented during the construction phase of the project 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 *Macadamia tetraphylla* include the introduction of Root Rot Fungus (*Phytophthora cinnamomi*) and other plant pathogens. Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the project, impacts from plant pathogens would be minimised. Monitoring and management actions for the retained populations as part of the mitigation measures of the project 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

There is a recovery plan for the southern Macadamia species (Costello et al 2009), which includes *Macadamia tetraphylla*. The project would not significantly conflict with the recovery actions specified in this recovery plan. Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

To mitigate the ecological impacts from the project an offset strategy is proposed to provide greater protection of *Macadamia tetraphylla* and habitat for other threatened flora and fauna, through placing an area of private land or state forest under conservation. There are several potential options for the offset strategy. An offset supporting *Macadamia tetraphylla* would contribute towards the recovery of the species.

Marsdenia longiloba

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

This species was recorded in Section 10, comprising one to three individuals outside of the project boundary in moist forest on the edge of swamp forest with rainforest elements.

The preferred habitat for this species is the understorey of moist forest on floodplains and slopes. There is a possibility this species is present in habitats within the project boundary, however targeted surveys have not identified any populations within the project boundary.

Reduce the area of occupancy of an important population

The preferred habitat for this species is the understorey of moist forest on floodplains and slopes. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted. There are also more extensive areas of potential habitat along the edges of swamp forests and moist drainage lines in dry sclerophyll forest.

There is also potential for indirect impacts to alter the existing habitat attributes of remaining patches such as hydrology regimes and weed invasion. There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

Fragment an existing important population into two or more populations

The project would result in the dissection of habitat for this species, however a known population would not be dissected.

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.*

No critical habitat has been identified for the species.

Disrupt the breeding cycle of an important population

There is no evidence of an important population being impacted by the proposal and therefore it is unlikely there would be any disruption to the breeding cycle.

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

The preferred habitat for this species is the understorey of moist forest on floodplains and slopes. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted. There are also more extensive areas of potential habitat along the edges of swamp forests and moist drainage lines in dry sclerophyll forest.

There are opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

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

Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability. Other indirect impacts are likely to be minor due to remaining individuals being present upslope of the project. Therefore impacts from stormwater run-off such as increased water and nutrient loads would not be a significant impact. Weed management would be implemented during the construction phase of the project 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 the species include the introduction of Root Rot Fungus (*Phytophthora cinnamomi*) and other plant pathogens. Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the project, impacts from plant pathogens would be minimised. Monitoring and management actions for the retained populations as part of the mitigation measures of the project 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 project would not significantly conflict with the recovery actions proposed for this species. Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

Prostanthera cineolifera

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

This species occurs at a single location on Tabbimoble Creek south of Tullymorgan Road and inhabits a narrow belt of deep, sandy soil along Tabbimoble Creek. This area was surveyed again during January 2012 to estimate the number of individuals in and surrounding the project boundary.

The entire population in this area is very large with the majority of the population occurring to the west of the project boundary in some areas forming a dense thicket of understory vegetation along Tabbimoble Creek. The population number is conservatively estimated to comprise 5,000 to 8,000 individuals occurring over 2.22 hectares. The population may extend further to the west along Tabbimoble Creek.

The number of plants in the project boundary is estimated to comprise up to 250 individuals occurring over 0.41 hectares, with mainly the population on the western side of the existing highway potentially being impacted. The proportion of the population potentially being impacted comprises around three to five per cent of the local population and around 18.5 per cent of the known area of occupied habitat.

Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability. Other indirect impacts from vegetation clearing would include stormwater run-off potentially increasing water and nutrient loads entering adjacent bushland areas, leading to the increased growth and spread of exotic species.

Reduce the area of occupancy of an important population

The number of plants in the project boundary is estimated to comprise up to 250 individuals occurring over 0.41 hectares, with mainly the population on the western side of the existing highway potentially being impacted. The proportion of the population potentially being impacted comprises around three to five per cent of the local population. The area of occupancy would be reduced by around 18.5 per cent based on the known area of occupied habitat in the local area.

Fragment an existing important population into two or more populations

As the existing population is currently fragmented by the existing highway, the project would result in further fragmentation of individuals, with individuals being retained on either side of the project.

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 population in the project boundary represents the most northerly occurrence of *Prostanthera cineolifera* and is widely disjunct from its known distribution previously regarded as being restricted to only a few localities near Walcha, Scone and St Albans. Therefore the population in the project boundary is important in terms of the overall distribution and genetic diversity of the species.

Disrupt the breeding cycle of an important population

The life cycle of *Prostanthera cineolifera* is likely to be linked to a large range of factors, but several important components include:

- Potential pollinator species are known to be native bees and other invertebrates
- Fire regime including fire intensity, frequency and season
- Available gene pool
- Hybridisation
- Other disturbance regimes such as forestry activities and grazing.

The number of plants in the project boundary is estimated to comprise up to 250 individuals occurring over 0.41 hectares, with mainly the population on the western side of the existing highway potentially being impacted. The proportion of the population potentially being impacted comprises around three to five per cent of the local population and around 18.5 per cent of the known area of occupied habitat.

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

The project is unlikely to significantly alter disturbance regimes. The project would result in a larger fire break to wildfire approaching from the west potentially resulting in the frequency of wildfire to be reduced in population clusters to the east of the project boundary.

Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability. Considering that the majority of the population adjacent to the project boundary occurs downslope of the project, impacts from some of the potential indirect impacts such as stormwater run-off and altered hydrology would potentially impact the remaining individuals of *Prostanthera cineolifera*.

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

Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability. Other indirect impacts are likely to be minor due to remaining individuals being present upslope of the project. Therefore impacts from stormwater run-off such as increased water and nutrient loads would not be a significant impact. Weed management would be implemented during the construction phase of the project 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 *Prostanthera cineolifera* include the introduction of Root Rot Fungus (*Phytophthora cinnamomi*) and other plant pathogens. Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the project, impacts from plant pathogens would be minimised. Monitoring and management actions for the retained populations as part of the mitigation measures of the project 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

Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

To mitigate the ecological impacts from the project an offset strategy is proposed to provide greater protection of *Prostanthera cineolifera* and habitat for other threatened flora and fauna, through placing an area of private land or state forest under conservation. There are several potential options for the offset strategy. An offset supporting *Prostanthera cineolifera* would contribute towards the recovery of the species.

Prostanthera palustris

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

This species was recorded in Section 7, comprising an unknown number of individuals outside of the project boundary growing in wet heath and swamp forest. . These individuals are around 450 metres to the east of the proposal area and are unlikely to be affected by indirect impacts from the proposal.

The preferred habitat for this species is poorly drained sandy soils, subject to extended water logging, in wet shrubland to heathland. There is a possibility this species is present in these habitats within the project boundary, however targeted surveys have not identified any populations within the project boundary.

Reduce the area of occupancy of an important population

The preferred habitat for this species is poorly drained sandy soils, subject to extended water logging, in wet shrubland to heathland. There is around 10 hectares of wet heathland in project boundary which provides potential habitat for this species.

Fragment an existing important population into two or more populations

The project would result in the dissection of habitat for this species, however a known population would not be fragmented.

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.*

No critical habitat has been identified for the species.

Disrupt the breeding cycle of an important population

There is no evidence of an important population being impacted by the proposal and therefore it is unlikely there would be any disruption to the breeding cycle.

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

This species was recorded in Section 7, comprising an unknown number of individuals outside of the project boundary growing in wet heath and swamp forest.

The preferred habitat for this species is poorly drained sandy soils, subject to extended water logging, in wet shrubland to heathland. There is a possibility this species is present in these habitats within the project boundary, however targeted surveys have not identified any populations within the project boundary.

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

Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability. Other indirect impacts are likely to be minor due to remaining individuals being present upslope of the project. Therefore impacts from stormwater run-off such as increased water and nutrient loads would not be a significant impact. Weed management would be implemented during the construction phase of the project 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 the species include the introduction of Root Rot Fungus (*Phytophthora cinnamomi*) and other plant pathogens. Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the project, impacts from plant pathogens would be minimised. Monitoring and management actions for the retained populations as part of the mitigation measures of the project 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 project would not significantly conflict with the recovery actions proposed for this species. Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

Tinospora tinosporoides

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

No individuals have been recorded in the project boundary. There is a possibility this species is present in suitable habitats within the project boundary comprising wetter subtropical rainforest, including littoral rainforest, on fertile, basalt-derived soils. Although targeted surveys have not identified any populations within the project boundary, the cryptic nature of the species suggests there is potential for the species to be present.

Reduce the area of occupancy of an important population

The preferred habitat for this species is the understorey of moist rainforest on floodplains and slopes. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

There is also potential for indirect impacts to alter the existing habitat attributes of remaining patches such as hydrology regimes and weed invasion. There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

Fragment an existing important population into two or more populations

The project would result in the dissection of habitat for this species, however a known population would not be dissected.

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.*

No critical habitat has been identified for the species.

Disrupt the breeding cycle of an important population

There is no evidence of an important population being impacted by the proposal and therefore it is unlikely there would be any disruption to the breeding cycle.

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

The preferred habitat for this species is the understorey of moist rainforest on floodplains and slopes. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

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

Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability. Other indirect impacts are likely to be minor due to remaining individuals being present upslope of the project. Therefore impacts from stormwater run-off such as increased water and nutrient loads would not be a significant impact. Weed management would be implemented during the construction phase of the project 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 the species include the introduction of Root Rot Fungus (*Phytophthora cinnamomi*) and other plant pathogens. Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the project, impacts from plant pathogens would be minimised. Monitoring and management actions for the retained populations as part of the mitigation measures of the project 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 project would not significantly conflict with the recovery actions proposed for this species. Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

Syzygium hodgkinsoniae

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

This species was recorded in Section 10, comprising a single individual in subtropical rainforest north of Coolgardie Road *(*BAAM 2012) within the project boundary. There are no known individuals adjacent to the construction footprint and the size of the local population is largely unknown, apart from the single individual recorded during targeted surveys in the project corridor. Any individuals potentially present in areas outside of the construction footprint could potentially be impacted by indirect impacts from edge effects and altered hydrology.

Reduce the area of occupancy of an important population

In NSW habitat for *Syzygium hodgkinsoniae* includes various rainforest communities. Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted.

Fragment an existing important population into two or more populations

The project would result in the dissection of habitat for this species with, individuals being present on the eastern and western side of the project. Habitat for this species is currently highly fragmented in the locality and the project would result in further fragmentation of habitats with around 10.33 hectares of the 94.62 hectares of potential rainforest habitat for this species potentially being 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.*

Around 94.62 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 10.33 hectares would be impacted. There is some potential for the genetic diversity of the local population of *Syzygium hodgkinsoniae* to be depleted. There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

Disrupt the breeding cycle of an important population

The life cycle of *Syzygium hodgkinsoniae* is likely to be linked to a large range of factors, but several important components include:

- Potential pollinator species are known to be native bees and other invertebrates
- Fire regime including fire intensity, frequency and season
- Available gene pool
- Hybridisation
- Other disturbance regimes such as forestry activities and grazing.

The individuals identified during recent field surveys are potentially part of a larger population of this species occurring in rainforest habitats surrounding the corridor in Section 10. *Syzygium hodgkinsoniae* is insect/bird pollinated and so it is reasonable to expect the potential population to include all individuals within 500 metres of individuals surrounding corridor.

There is some potential for the genetic diversity of the local population of *Syzygium hodgkinsoniae* to be depleted. There are potential opportunities to mitigate potential impacts to this species and other rainforest flora through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and ongoing monitoring.

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

The project would result in the dissection of potential rainforest habitat for this species. Habitat for this species is currently highly fragmented in the locality and the project would result in further fragmentation of habitats with around 10.33 hectares of the 94.62 hectares of potential rainforest habitat for this species potentially being impacted.

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

Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project boundary where there would be increased sunlight availability. Other indirect impacts are likely to be minor due to remaining individuals being present upslope of the project. Therefore impacts from stormwater run-off such as increased water and nutrient loads would not be a significant impact. Weed management would be implemented during the construction phase of the project 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 *Syzygium hodgkinsoniae* include the introduction of Root Rot Fungus (*Phytophthora cinnamomi*) and other plant pathogens such as Myrtle Rust (*Puccinia psidii* s.l.). Provided machinery and personnel are excluded from areas where this species would be retained adjacent to the project, impacts from plant pathogens would be minimised. Monitoring and management actions for the retained populations as part of the mitigation measures of the project 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 project would not significantly conflict with the recovery actions proposed for *Syzygium hodgkinsoniae*. Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protective fencing, ongoing monitoring of populations and weed control within habitat areas.

To mitigate the ecological impacts from the project an offset strategy is proposed to provide greater protection of *Syzygium hodgkinsoniae* and habitat for other threatened flora and fauna, through placing an area of private land or state forest under conservation. There are several potential options for the offset strategy. An offset supporting *Syzygium hodgkinsoniae* would contribute towards the recovery of the species.

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