UPGRADING THE PACIFIC HIGHWAY

Woolgoolga to Ballina Planning Alliance

UPGRADING THE PACIFIC HIGHWAY

Woolgoolga to Ballina Upgrade

Supplementary Biodiversity Assessment

FINAL

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6. Supplementary impact assessment

This chapter documents the supplementary assessment that was undertaken following the supplementary surveys and additional analysis of the impacts on biodiversity by the project from that provided in the EIS. The supplementary assessment also considers design refinements to the EIS design, and ancillary facility sites that were not part of the assessment for the EIS. The main areas of focus are:

- Threatened ecological communities.
- Threatened rainforest flora.
- Other threatened (non-rainforest) flora.
- Threatened fauna.
- Impacts on groundwater at embankment cutting sites.

Where this work or new information gathered from supplementary surveys has identified changes to the biodiversity impacts from what was reported in the EIS, a revised Assessment of Significance have been provided, as required. This would reflect changed impacts, including increases or decreases in impacts.

6.1. Avoidance and loss of vegetation

The clearing of native vegetation is listed as a key threatening process under the TSC Act and EPBC Act. The EIS estimated the project would result in a total clearing of native vegetation of 947.9 hectares. The combination of further targeted ground-truthing for the supplementary assessment and multiple design refinements has resulted in a reduction of this total to 931.7 hectares. A breakdown of the changed impact for individual vegetation types (BioMetric) is shown in section 5.1.3.

With the design refinements, the construction footprint would extend over about an additional 870 hectares of cleared land, some areas of which comprise small fragments of modified vegetation that is not associated with natural vegetation communities.

6.2. Summary of impacts on threatened ecological communities

The project would directly clear 261.9 hectares of threatened ecological communities. This would be around 75 hectares less than estimated in the EIS.

This reduced impact has been achieved as a result of further targeted surveys to ground-truth and refine the edges of threatened ecological communities in the project boundary, as well as the combined design refinements.

There would be a reduced impact on all but two ecological communities. The impacts on these ecological communities are detailed in sections 6.1.1 to 6.1.7 and summarised in Table 6-1. Where required, the assessment of significance has also been revised.

The notable differences in impact from those described in the EIS relate to a reduction of around 60 per cent in the direct impacts on Lowland Rainforest (EPBC Act) and Freshwater Wetlands (TSC Act), and a considerably reduced impact on Coastal Cypress Pine Forest (TSC Act) and Subtropical Coastal Floodplain Forest (TSC Act).

Table 6-1 Revised impact of the project on threatened ecological communities

Threatened ecological communities (listed status)	EIS – direct impact (hectares)	Revised – direct impact (hectares)
Lowland Rainforest in NSW North Coast and Sydney Basin Bioregions (Endangered, TSC Act) *Lowland Rainforest in Sub-tropical Australia (Critically Endangered, EPBC Act)	10.3 (5.8*)	4.2 (2.0*)
Littoral Rainforest in the New South Wales North Coast, Sydney Basin and South East Corner Bioregions (Endangered, TSC Act) *Littoral Rainforest and Coastal Vine Thickets of Eastern Australia (Critically Endangered, EPBC Act)	0.0	0.2 (0*)
Coastal Cypress Pine Forest of the NSW North Coast Bioregion (Endangered TSC Act)	27.4	3.3
Freshwater Wetlands On Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions (Endangered TSC Act)	13.0	5.1
Subtropical Coastal Floodplain Forest of the NSW North Coast Bioregion (Endangered TSC Act)	137.1	93.9
Swamp Sclerophyll Forest On Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions (Endangered TSC Act)	93.7	112.1
Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin And South East Corner Bioregions (Endangered TSC Act)	56.2	43.1
Total	**337.7**	**261.9**

6.2.1. Lowland Rainforest community

6.2.1.1. Background

A total of 81.4 hectares of Lowland Rainforest (TSC Act listed) has been identified in the study area from targeted surveys up to 400 metres from the project boundary. The EIS design would impact 10.3 hectares of Lowland Rainforest that would fit the criteria for listing on the TSC Act. Of the 10.3 hectares, 5.8 hectares would also fit the criteria of a critically endangered ecological community listing on the EPBC Act. These 5.8 hectares occur within six patches.

6.2.1.2. Direct and indirect impacts

The impact assessment for Lowland Rainforest communities has been revised from that provided in the EIS based on:

- Supplementary surveys undertaken in areas surrounding Section 10, which identified low condition rainforest patches that are not considered to fit with the criteria for listing under the EPBC Act. This was as a result of the application of new criteria under the act that outlined field-based thresholds within large patches.
- Supplementary surveys undertaken for the design refinement at the proposed Wardell interchange (refer section 3.3.16), where no additional areas of this community were recorded (refer section 3.17).

As a result of the design refinement the direct impact on Lowland Rainforest would reduce to 4.2 hectares that is TSC Act listed, occurring within seven patches. Of this, 2.0 hectares is EPBC Act listed, occurring within three patches.

The combination of additional field data and design refinement has resulted in changes to the number and proportion of patches of Lowland Rainforest that would remain following construction. Table 6-2 shows the impacts of the project on the seven Lowland Rainforest patches and the proportion of each patch that would remain, including their listed status under State and Commonwealth legislation.

Table 6-2 Impacts on Lowland Rainforest patches (TSC and EPBC Act)

Project Section	Patch number / (approximate station)	Total patch area (ha)	Area impacted (ha)	Area remaining following impact (ha)	Proportion of patch remaining
Lowland Rainforest (EPBC Act and TSC Act listed)					
10	1 (155.5 to 156.0)	1.9	0.5	1.4	73%
10	2 (157.5 to 158.0)	10.5	1.0	9.5	90%
10 & 11	3 (158.2 to 159.7)	3.0	0.5	2.5	81%
	TOTAL	15.4	2.0	13.4	87% in total
Lowland Rainforest (TSC Act listed only)					
1	4 (8.9 to 9.1)	0.4	0.3	0.1	25%
3	5 (46.7 to 46.8)	1.5	0.7	0.8	53%
3	6 (59.3 to 59.5)	2.8	0.7	2.1	75%
10	7 (156.0 to 156.2)	0.7	0.5	0.2	29%
	Total	5.4	2.2	3.2	59% in total

As shown in Table 6-2, between 73 and 90 per cent of each EPBC Act listed patch would remain following construction; in total, 87 per cent of these patches (which cover 2.0 hectares) would remain. The extent of the EPBC Act community was surveyed up to around 400 metres from the project boundary and found to occupy around 68.5 hectares. Therefore, the direct impact on these two hectares would represent around 2.9 per cent of the total in the study area.

The largest patch (patch 2) would be fragmented by the project with remnants remaining on the eastern side (1.5 hectares) and western side (8.0 hectares) of the project.

Potential indirect impacts on Lowland Rainforest could include:

- Weed invasion.
- Increased light and exposure (drying).
- Decreased humidity.
- Altered hydrology and increased nutrients, which could result in weed (and/or pathogen) invasion, particularly Camphor Laurel.
- Fragmentation.
- Polluted surface runoff.
- Increased dust during construction.

In Section 10, to the greatest extent possible, the project would avoid, areas of rainforest and be located on cleared areas. These cleared areas adjoin remnant Lowland Rainforest and, as such, the areas that could be subject to indirect impacts from the project are already subject to edge effects. Indirect impacts on previously unaffected areas would be limited to the three directly impacted patches where new edges would be created.

To manage the potential for edge effects, mitigation measures would include appropriate landscaping adjacent to impacted rainforest patches, sedimentation and erosion control and weed management. These measures are described in a Threatened Rainforest Communities and Rainforest Plants Management Plan.

Indirect impacts from surface runoff are expected to be minimal as the majority of the Lowland Rainforest patches are mostly situated on higher ground to the west of the project and the road would drain away from much of the remaining rainforest areas. However, portions of the directly impacted patches are situated downstream (or on relatively flat ground) of the highway, and appropriately designed culverts, bridges, sedimentation basins and water quality ponds would be installed to minimise alteration of the hydrological regimes and manage runoff during construction and operation.

6.2.1.3. Assessment of significance: critically endangered ecological community (EPBC Act)

The assessment of significance for Lowland Rainforest of Subtropical Australia was undertaken according to criteria for critically endangered and endangered ecological communities in the DEWHA (2009) assessment guidelines. The assessment is provided in Table 6-3.

Table 6-3 Assessment of significance: Lowland Rainforest of Subtropical Australia (EPBC Act)

Lowland Rainforest of Subtropical Australia
According to the DSEWPAC (2009) 'significant impact criteria' an action is likely to have a significant impact on a critically endangered ecological community if there is a real chance or possibility that it would:
Reduce the extent of an ecological community
The results of the targeted surveys for Lowland Rainforest confirmed the findings of the EIS that this critically endangered community is restricted to Section 10, and that the other locations surveyed in sections 1–3 were not consistent with the criteria for field identification provided under the EPBC Act. In Section 10 the condition assessments undertaken in each patch of Lowland Rainforest identified a total of three patches in the project boundary that conformed to the condition thresholds for Lowland Rainforest of Subtropical Australia. The design refinement near Coolgardie Road in Section 10 would result in the area of Lowland Rainforest of Subtropical Australia (EPBC Act) impacted being reduced by around 3.8 hectares from 5.8 hectares to two hectares. Table 6-1 shows the impacts on the three critically endangered Lowland Rainforest patches and the proportion of each patch that would remain. A relatively high proportion of each patch would remain following construction (73-90%) with an overall proportion of 87% of these patches remaining. The overall extent of the critically endangered ecological community in the study area is around 68.5 hectares with the impact to two hectares comprising around 2.9% of these identified areas of Lowland Rainforest of Subtropical Australia. The Comprehensive Regional Assessment Aerial Photographic Interpretation (CRAFTI) (NPWS 1998) has mapped about 1818 hectares of vegetation with affinities to Lowland Rainforest within about a 10 kilometre radius of the project boundary. There is also potential for indirect impacts to alter the composition and viability of the remaining area of Lowland Rainforest, particularly areas downslope of the project. The remaining areas at particular risk are estimated to comprise all of patch 1, the remaining areas of patch 2 on the eastern side and a small area of patch 3 comprising a total of around three hectares of Lowland Rainforest most at risk from indirect impacts. Considering the above information the project would result in a reduction in around 13% of the Lowland Rainforest patches impacted, and an overall reduction to the known extent of the ecological community in the proximity to the project (68.5 hectares) of less than 3%, which is further reduced when considering the potential distribution in the locality (10 kilometre radius).
Fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines
The project would further fragment Lowland Rainforest patches with reductions of between 10-27%, however impacts would be confined to one edge for two of the patches and one patch would be dissected by the project. patch 2 as

Lowland Rainforest of Subtropical Australia

identified by the above table would be dissected by the project with remnants remaining on the eastern (1.5 hectares) and western (8.0 hectares) sides of the project.

Although the project would result in further fragmentation of the ecological community, considering the high mobility of many pollinator species for the various plant species within this 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.

Adversely affect habitat critical to the survival of an ecological community

A relatively high proportion of each patch would remain following construction (73-90%) with an overall proportion of 87% of these patches remaining. The overall extent of the critically endangered ecological community in the study area is around 68.5 hectares with the impact to two hectares comprising around 2.9% of these identified areas of Lowland Rainforest of Subtropical Australia. The Comprehensive Regional Assessment Aerial Photographic Interpretation (CRAFTI) (NPWS 1998) has mapped about 1,818 hectares of vegetation with affinities to Lowland Rainforest within about a 10 kilometre radius of the project boundary.

The project would adversely affect around two hectares of habitat critical to the survival of the ecological community, and there is potential for further indirect impacts on affect some of the remaining areas (estimated at around three hectares) of these patches.

Modify or destroy abiotic factors (such as water, nutrients, or soil) necessary for an ecological communities survival, including reduction of groundwater levels, or substantial alteration of surface water 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 project. There would also be indirect impacts on 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 project are likely to minimise these indirect impacts.

Around three hectares of Lowland Rainforest that would be retained adjacent to the project has been identified as being most susceptible to indirect impacts being in close proximity and downstream of the project. Provided the mitigation measures are adequately implemented any modification to these areas of Lowland Rainforest can be avoided.

Mitigation measures include (but are not limited to):

- Water quality controls.
- Provision of exclusion zones and temporary fencing to protect Lowland Rainforest and threatened plants adjacent to the project construction area, to be clearly delineated on work plans and remain in place for the full construction period.
- Clearing of native vegetation, including Lowland Rainforest would be restricted to the minimum necessary for construction.
- Site induction of construction workers would inform and instruct them of vegetation to be retained and on the identification of threatened species.
- Weed control during construction and operation focused on in-situ populations and informed by monitoring of habitat condition.
- Revegetation of areas disturbed by construction adjacent to in-situ populations.

Create 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 and fauna harvesting

Current disturbance regimes in the identified Lowland Rainforest of Subtropical Australia adjacent to the project include weed invasion, cattle grazing and change in nutrient levels leading to reduced floristic diversity and altered structural complexity. Small fragmented patches of this community exhibit a mix of native flora and invasive weeds along edges affected zones. There is potential for further indirect impacts such as edge effects, weed invasion and altered hydrology associated with road construction and operation.

The project is likely to result in a change to the current disturbance regimes, although some would increase and others decrease 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.

Around three hectares of the 13.4 hectares of Lowland Rainforest that would be retained adjacent to the project has been identified as being most susceptible to indirect impacts being in close proximity and downstream of the project. Provided the mitigation measures are adequately implemented any substantial changes to these areas of Lowland Rainforest can be avoided.

Lowland Rainforest of Subtropical Australia
Cause a substantial reduction in the quality 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 the 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 project. There would also be indirect impacts on 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 project are likely to minimise these indirect impacts. Around three hectares of the 13.4 hectares Lowland Rainforest that would be retained adjacent to the project has been identified as being most susceptible to indirect impacts being in close proximity and downstream of the project. The proposed mitigation measures are designed to target edge effects and avoid where possible substantial changes to the quality or integrity of the Lowland Rainforest.
Interfere with the recovery of an ecological community
The project would not significantly conflict with potential recovery actions of Lowland Rainforest of Subtropical Australia. Some recovery actions have been implemented through avoidance of the community and mitigation measures implemented for areas of the community proposed to be retained surrounding the project including protective fencing, 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 the community and habitat for other threatened flora and fauna, through placing an area of private land or state forest under conservation. An offset supporting Lowland Rainforest of Subtropical Australia would contribute towards the recovery of the community.

Conclusion of the assessment

Provided the identified mitigation measures are adequately implemented, any substantial changes to quality or integrity of the residual Lowland Rainforest can be minimised and the project is unlikely to have a significant impact on this ecological community.

However, the unknown level of indirect impact on an additional 3.0 hectares of the 13.4 hectares present, and the critically endangered status of the community, suggest that a precautionary approach should be taken and a potential significant impact has been concluded.

This conclusion is consistent with the conclusion in the EIS.

6.2.1.4. Assessment of significance: endangered ecological community (TSC Act)

The assessment of significance for Lowland Rainforest was undertaken in accordance with the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-4.

Table 6-4 Assessment of significance: Lowland Rainforest (TSC Act)

Lowland Rainforest in NSW North Coast and Sydney Basin Bioregion
How is the project likely to affect the lifecycle of a threatened species and/or population?
Not applicable
How is the project likely to affect the habitat of a threatened species, population or ecological community?
A total of 81.4 hectares of Lowland Rainforest (TSC Act) has been identified within and surrounding the study area mainly in Section 10 near Coolgardie Road, of which the project would impact around 4.2 hectares (5.2 per cent) of this community in various condition states. There is potential for the project to alter the residual areas of rainforest habitat adjoining the project through indirect impacts associated with altering hydrological and nutrient conditions where runoff and ephemeral streams are relevant. There would also be potential indirect impacts from edge effects associated with increasing light into the habitat which may result in altered understorey floristics and structure and increased weeds and, altered soil conditions. 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 project have been specifically designed to target these potential indirect impacts.
Does the project affect any threatened species or populations that are at the limit of its known distribution?
Not applicable
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. The largest patch (patch 2) would be fragmented by the project with remnants remaining on the eastern (1.5 hectares) and western (8.0 hectares) sides of the project. Considering the high mobility of many pollinator species for the various plant species within Lowland Rainforest (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 Lowland Rainforest occurs on drainage lines.
How is the project likely to affect critical habitat?
No critical habitat has been identified for this community

Conclusion of the assessment

The project is unlikely to result in a significant impact on this ecological community because of the relatively small proportion of the community that would be impacted compared with residual areas, and the low condition of the impacted areas.

This conclusion differs from the conclusion presented in the EIS and is a result of the proposed measures to avoid this community.

6.2.2. Littoral Rainforest communities

The EIS and supplementary surveys identified Littoral Rainforest (endangered, TSC Act; and critically endangered, EPBC Act) in five patches in and around the project boundary, as follows:

- One small patch (0.2 hectares) is in a clearing boundary within a modified area of swamp forest in project Section 11.
- Four patches were not previously identified due to their location outside the project boundary.
- One of these five patches would be impacted by the project comprising a total of 0.03 hectares.

6.2.2.1. Direct and indirect impacts

The impact assessment for Littoral Rainforest communities has been revised from that provided in the EIS based on ssupplementary surveys and in view of the design refinement at the proposed Wardell interchange.

As noted above, five patches of Littoral Rainforest were identified in and around the project boundary. Of these, only two would be directly impacted by the project (refer to Table 6-5). The overall extent of the critically endangered ecological community in the study area is around 14.4 hectares. The project would have a direct impact on 0.23 hectares in sections 10 and 11. This is around 1.6 per cent of the known areas of Littoral Rainforest in and around the project boundary.

Table 6-5 Impacts on Littoral Rainforest patches

Patch number / (approximate station)	Total patch area (ha)	Area impacted (ha)	Area remaining following impact (ha)	Proportion of patch remaining
1 (157.5 to 157.6)	0.3	0.03	0.27	90%
2 (162.8 to 163)	0.2	0.2	0	0%
Total	**0.5**	**0.23**	**0.27**	**90% in total**

The impact would be on two patches:

- The project would directly impact 10 per cent of patch 1, with 90 per cent of the patch remaining following construction.
- The project would directly impact all of patch 2, which is completely within the project boundary and within the road reserve for the Pacific Highway.

The entire area of Littoral Rainforest retained in surrounding areas comprises greater than 97 per cent of the known distribution.

The potential for indirect impacts would be limited to the remaining area of patch 1 with other patches surrounding the alignment being unlikely to be indirectly impacted given the distance from the project boundary (refer to Figure 5-4). This patch is currently situated in the road reserve between the existing highway and Kays Road with a small power easement at the northern end. Given its current location, existing edge effects are evident, including a reduced canopy, low recruitment and abundant weeds. The project would contribute to these impacts although the actual direct contribution would be difficult to determine as edge effects are likely to be ongoing in the absence of the upgrade.

6.2.2.2. Assessment of significance: critically endangered ecological community (EPBC Act)

The assessment of significance for Littoral Rainforests and Coastal Vine Thickets of Eastern Australia was undertaken according to criteria for critically endangered and endangered ecological communities in the DEWHA (2009) assessment guidelines. The assessment is provided in Table 6-6.

Table 6-6 Assessment of significance: Littoral Rainforests and Coastal Vine Thickets of Eastern Australia (EPBC Act)

Littoral Rainforests and Coastal Vine Thickets of Eastern Australia
According to the DSEWPAC (2009) 'significant impact criteria' an action is likely to have a significant impact on a critically endangered ecological community if there is a real chance or possibility that it would:
Reduce the extent of an ecological community
A total of five patches of Littoral Rainforest were identified in Section 9, 10 and 11 of the study area as part of the supplementary surveys. These include several small patches surrounding Coolgardie Road in Section 10, a small patch at the northern end of the project in Section 11 and a large patch adjacent to the eastern side of the project in Section 9 adjacent to an existing quarry. Potential impacts to Littoral Rainforests and Coastal Vine Thickets of Eastern Australia would be limited to two of the small patches of this community, one directly south of Coolgardie Road adjacent to existing highway and Kays Road and another patch in Section11, also adjacent to the existing road and comprising a total of around 0.23 hectares in total. The overall extent of the critically endangered ecological community in the study area is around 14.4 hectares with the impact to 0.23 hectares comprising around 1.6% of these identified areas of Littoral Rainforest. The TSSC (2008afi) listing advice reports around 433 patches in NSW with a total area estimated to be about 1624 hectares and the project represents around 0.4 hectares of this regional total. Overall, the project would impact less than 3% of the known extent of the ecological community in the study area (14.4 hectares). This would be even less when considering the potential distribution of the ecological community in the locality (10 kilometre radius). Apart from the remaining area of patch 1 (0.1 hectares) other patches surrounding the alignment are unlikely to be indirectly impacted given the distance from the project boundary. Direct impacts would be limited to two of the small patches of this community, one directly south of Coolgardie Road adjacent to existing highway and another patch in Section 11, comprising a total of around 0.23 hectares. The project would result in a minor reduction to the extent of the ecological community.
Fragment or increase fragmentation of an ecological community, for example by clearing vegetation for roads or transmission lines
The impacts to Littoral Rainforests and Coastal Vine Thickets of Eastern Australia would be limited to the entire area of one small patch (0.2 hectares) in Section 11 and up to 10% of another small patch around 0.3 hectares in size. Apart from the remaining area of patch 1 (0.1 hectares) other patches surrounding the alignment are unlikely to indirect impacted given the distance from the project boundary. The further widening of the existing Pacific Highway corridor would result in further fragmentation of patches of the surrounding Lowland Rainforest of Subtropical Australia. However fragmentation of Littoral Rainforests and Coastal Vine Thickets of Eastern Australia would be limited to the removal of one patch (0.2 hectares) and partial removal (0.2 hectares) of another small patch. The project would cleared a portion at the northern end although not fragment this patch, which currently sites between two roads and is hence already fragmented.
Adversely affect habitat critical to the survival of an ecological community
Potential impacts on the Littoral Rainforests and Coastal Vine Thickets of Eastern Australia would be limited to two of the small patches of this community, one directly south of Coolgardie Road adjacent to existing highway and another patch in Section11, comprising a total of around 0.23 hectares. The overall extent of the critically endangered ecological community in the study area is around 14.4 hectares with the impact to 0.23 hectares comprising around 1.6% of these identified areas of Littoral Rainforest. The project would adversely affect around 0.23 hectares of habitat critical to the survival of the ecological community. There is potential for indirect impacts on affect some of the remaining areas (around 0.1 hectares) of these patches, however other patches of Littoral Rainforest identified in surrounding areas are unlikely to be indirectly impacted given the distance of these from the project boundary.
Modify or destroy abiotic factors (such as water, nutrients, or soil) necessary for an ecological communities survival, including reduction of groundwater levels, or substantial alteration of surface water 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 project. There would also be indirect impacts on 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.

Littoral Rainforests and Coastal Vine Thickets of Eastern Australia

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 project are likely to minimise these indirect impacts.

Around 0.1 hectares of Littoral Rainforest that would be retained adjacent to the project has been identified as being most susceptible to indirect impacts being in close proximity and downstream of the project. This areas is already identified as indirectly impacted due its position surrounded by two roads and a power easement. Despite this it has managed to survive in this location. Therefore provided the mitigation measures are adequately implemented any modification to these areas of Littoral Rainforest can be somewhat avoided, however the small patch size limits the viability of this patch.

Mitigation measures include (but are not limited to):

- Water quality controls.
- Provision of exclusion zones and temporary fencing to protect Littoral Rainforest and threatened plants adjacent to the project construction area, to be clearly delineated on work plans and remain in place for the full construction period.
- Clearing of native vegetation, including Littoral Rainforest would be restricted to the minimum necessary for construction.
- Site induction of construction workers would inform and instruct them of vegetation to be retained and on the identification of threatened species.
- Weed control during construction and operation focused on in-situ populations and informed by monitoring of habitat condition.
- Revegetation of areas disturbed by construction adjacent to in-situ populations.

A translocation strategy would be prepared for threatened plants in the construction corridor in conjunction with offset strategy.

Create a substantial change in the species composition of an occurrence of an ecologically community, including causing a decline or loss of functionally important species, for example through regular burning or flora and fauna harvesting

The potential for indirect impacts would be limited to the remaining area of patch 1 (0.1 hectares) with other patches surrounding the alignment being unlikely to be indirectly impacted given the distance from the project boundary (refer to Figure 5-4). This patch is currently situated in the road reserve between the existing highway and Kays Road with a small power easement at the northern end. As such existing edge effects here are evident and mainly reduced canopy, low recruitment and abundant weeds. The project would contribute to these impacts although would be difficult to attribute directly as likely to be ongoing in the absence of the road.

Cause a substantial reduction in the quality 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 the species in the ecological community

This relates to the one small patch retained adjacent to the project in Section 10, as the other patch is Section 11 would be removed and the patches in Section 9 are east of and outside of the likely zone of impact. As described previously this patch is currently situated in the road reserve between the existing highway and Kays Road with a small power easement at the northern end. As such existing edge effects here are evident and mainly reduced canopy, low recruitment and abundant weeds. The project would contribute to these impacts although would be difficult to attribute directly as likely to be ongoing in the absence of the road. The project would contribute to the long-term impacts on this small remnant, and it is likely that the quality of the patch would continue to decline over the long-term.

Interfere with the recovery of an ecological community

The project would not significantly conflict with potential recovery actions for the Littoral Rainforests and Coastal Vine Thickets of Eastern Australia. Some recovery actions can be implemented for areas of the community proposed to be retained around the project including protective fencing during construction, 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 Littoral Rainforests and Coastal Vine Thickets of Eastern Australia and habitat for other threatened flora and fauna, through placing an area of private land or state forest under conservation. An offset supporting Littoral Rainforests and Coastal Vine Thickets of Eastern Australia would contribute towards the recovery of the community.

6.2.2.3. Assessment of significance: endangered ecological community (TSC Act)

The assessment of significance for Littoral Rainforest was undertaken with consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-7.

Table 6-7 Assessment of significance: Littoral Rainforest (TSC Act)

Littoral Rainforest
How is the project likely to affect the lifecycle of a threatened species and/or population?
Not applicable
How is the project likely to affect the habitat of a threatened species, population or ecological community?
A total of five patches of Littoral Rainforest were identified adjacent to the project in sections 9, 10 and 11. These include several small patches surrounding Coolgardie Road in Section 10, a small patch at the northern end of the project in Section 11 and a large patch adjacent to the eastern side of the project in Section 9 adjacent to an existing quarry. Potential impacts on Littoral Rainforest would be limited to two of the small patches of this community, one directly south of Coolgardie Road adjacent to existing highway and another patch in Section 11, comprising a total of around 0.23 hectares. The overall extent of the ecological community in the study area is around 14.4 hectares with the impact to 0.23 hectares comprising around 1.6 per cent of these identified areas of Littoral Rainforest. The TSSC (2008afi) listing advice reports around 433 patches in NSW with a total area estimated to be about 1624 hectares and the project represents around 0.23 hectares of this regional total. Overall, the project would impact less than 3% of the known extent of the ecological community in the study area (14.4 hectares). This would be even less when considering the potential distribution of the ecological community in the locality (10 kilometre radius). Other patches surrounding the alignment are unlikely to be indirectly impacted given the distance from the project boundary. Direct impacts would be limited to two of the small patches of this community, one directly south of Coolgardie Road adjacent to existing highway and another patch in Section 11, comprising a total of around 0.23 hectares. As described previously the patch south of Coolgardie Road is currently situated in the road reserve between the existing highway and Kays Road with a small power easement at the northern end. As such existing edge effects here are evident and mainly include reduced canopy, low recruitment and abundant weeds. The project would contribute to these impacts although this would be difficult to attribute directly as likely to be ongoing in the absence of the upgrade. The project would contribute to the long-term impacts on this small remnant, and it is likely that the quality of the patch would continue to decline over the long-term.
Does the project affect any threatened species or populations that are at the limit of its known distribution?
Not applicable
How is the project likely to affect current disturbance regimes?
It would contribute to the current disturbance regimes for the residual patch south of Coolgardie Road. The project would contribute to these impacts although would be difficult to attribute directly as likely to be ongoing in the absence of the road. The project would contribute to the long-term impacts on this small remnant, and it is likely that the quality of the patch would continue to decline over the long-term.
How is the project likely to affect habitat connectivity?
Clearing of Littoral Rainforests and Coastal Vine Thickets of Eastern Australia would involve the complete removal of one patch (0.2 hectares) and partial removal (0.03 hectares) of another small patch. The project would clear a portion of this second patch at the northern end although not fragment this patch, which currently sites between two roads and is hence already fragmented.
How is the project likely to affect critical habitat?
No critical habitat has been identified for this community

Conclusion of the assessment

The project would not have a significant impact on this ecological community, under Commonwealth and State assessment criteria as it would directly impact and potentially indirectly impact only a small area of this community (0.23 hectares occurring in two patches) relative to the known extent in the study area (14.4

hectares). In addition, these patches are already in a modified condition due to high levels of indirect impacts from existing infrastructure.

The EIS did not distinguish this community from Lowland Rainforest and further work has modified the community classification, although this does not alter the conclusions of the impact assessment.

6.2.3. Coastal Cypress Pine Forest community

The impact assessment for Coastal Cypress Pine Forest (Endangered TSC Act) has been revised from the assessment provided in the EIS to incorporate the results from additional ground-truthing of vegetation communities in selected areas within the project boundary (as detailed in section 5.1.3).

6.2.3.1. Direct and indirect impacts

The EIS assessed that the project would have a total (direct) impact on 27.4 hectares of Coastal Cypress Pine Forest, which was based on the BioMetric vegetation layer and surveys conducted for the preferred route assessment. The critical review identified this as potentially inaccurate and, consequently, additional surveys were undertaken, which involved ground-truthing all locations and re-mapping the communities. These surveys found 26.6 hectares of Coastal Cypress Pine Forest within and surrounding the project, occurring in a number of patches. The project would directly impact around 3.3 hectares of this community in various conditions of quality.

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 a 10-kilometre radius of the project. However, CRAFTI provides only broadscale vegetation mapping, with limited ground-truthing, and therefore provides only a rough estimate. The NSW Scientific Committee final determination for Coastal Cypress Pine Forest in the North Coast Bioregion (OEH, 2011) states that the total distribution of Coastal Cypress Pine Forest covers around 150 hectares and is certainly less than 200 hectares.

The project would therefore result in impacts on up to 2.2 per cent of the estimated extent (150 hectares) and around 1.7 per cent of the upper estimated extent (200 hectares) of this ecological community in the North Coast Bioregion.

There is also potential for the project to alter the 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 on adjacent areas of vegetation as a result of edge effects, such as increased 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, which would potentially result in changes to understorey floristics and die-back in the canopy. Mitigation measures during construction and the incorporation of specific design features into the proposed development are likely to minimise these indirect impacts.

Many of the patches that would be impacted by the project comprise small fragmented patches that are already highly edge affected. Although the project would create around 270 metres of newly affected edge, it is unlikely to result in substantial further modification to these habitats.

Assuming edge effects could potentially extend up to 30 metres in from the edge of the construction project boundary an additional 0.8 hectares of this community would potentially be indirectly impacted.

6.2.3.2. Assessment of significance: endangered ecological community (TSC Act)

The assessment of significance for this community was undertaken with consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft Guidelines for Threatened Species Assessment. The assessment is provided in Table 6-8.

Table 6-8 Assessment of significance: Coastal Cypress Pine Forest (TSC Act)

Coastal Cypress Pine Forest
How is the project likely to affect the lifecycle of a threatened species and/or population?
Not applicable
How is the project likely to affect the habitat of a threatened species, population or ecological community?
A total of 26.6 hectares of Coastal Cypress Pine Forest has been identified within and surrounding the study area, of which the project would impact around 3.3 hectares of this community in various condition states. CRAFTI mapping indicates about 38 hectares of vegetation with affinities to Coastal Cypress Pine Forest within a 10 kilometre radius of the project boundary. However, this is only broadscale vegetation mapping, with limited ground-truthing. The final determination states the total distribution of Coastal Cypress Pine Forest covers around 150 hectares and is certainly less than 200 hectares. The project would result in impacts on up to 2.2 per cent of the estimated extent (150 hectares) and around 1.7 per cent of the upper estimated extent (200 hectares). 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 or downslope of the project. There would also be indirect impacts on 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 project are likely to minimise these indirect impacts. Many of the patches impacted by the project comprise small fragmented patches which are currently highly edge effected and the project is unlikely to result in further substantial modification to these areas. The project would result in impacts on several relatively intact patches which would potentially be subject to indirect impacts, comprising around 270 metres of new edges. Assuming indirect impacts could potentially extend up to 30 metres in from the edge of the construction project boundary an additional 0.8 hectares of this community would potentially be indirectly impacted
Does the project affect any threatened species or populations that are at the limit of its known distribution?
Not applicable
How is the project likely to affect current disturbance regimes?
Many of the patches impacted by the project comprise small fragmented patches which are currently highly edge affected and the project would contribute to but is unlikely to result in substantial further modification to these habitats. This contribution through indirect impact would comprise around 270 metres of new edges. Assuming indirect impacts could potentially extend up to 30 metres in from the edge of the construction project boundary an additional 0.8 hectares of this community would potentially be indirectly impacted.
How is the project likely to affect habitat connectivity?
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 traversed creating fragmentation either side of the highway.. Considering the high mobility of many pollinator species for the various plant species within this 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.
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.

Conclusion of the assessment

The project would potentially have a significant impact on the Coastal Cypress Pine Forest community because of the moderate level of direct impacts, the limited known extent of the community, and the potential for indirect impacts.

This conclusion is consistent with the conclusion in the EIS.

6.2.4. Freshwater Wetlands community

The impact assessment for Freshwater Wetlands (Endangered TSC Act) has been revised from the assessment provided in the EIS to incorporate the results from additional ground-truthing of vegetation communities in selected areas within the project boundary (as detailed in section 5.1.3).

6.2.4.1. Direct and indirect impacts

A total of 46.5 hectares of Freshwater Wetlands has been identified within and surrounding the study area. The project would directly impact around 5.1 hectares of this community in various conditions of quality. (The majority of Freshwater Wetlands within the project boundary are in a low condition comprising depressions and drainage lines within cleared paddocks open to grazing livestock.)

The CRAFTI mapping (NPWS, 1998) has mapped about 3051 hectares of vegetation with affinities to Freshwater Wetlands within a 10-kilometre radius of the project boundary. The project would potentially result in the removal of 0.2 per cent of this estimated local distribution of this community.

There is also 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 project. 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 project are likely to minimise these indirect impacts.

Indirect impacts on Freshwater Wetlands from altered hydrology regimes are difficult to quantify for the project as they may result in areas downstream remote from the project boundary. As the majority of Freshwater Wetlands within the project boundary are in a low condition, any potential indirect impacts that would result in weed invasion, altered vegetation structure and loss of native diversity are unlikely to substantially exacerbate existing conditions.

Potential indirect impacts on Freshwater Wetlands would be in Section 3 in tributaries and billabongs of the Coldstream River (station 42.7 to 43.5). Here, around three hectares of Freshwater Wetlands are susceptible to indirect impacts.

6.2.4.2. Assessment of significance: endangered ecological community (TSC Act)

The assessment of significance for this community was undertaken with consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft Guidelines for Threatened Species Assessment. The assessment is provided in Table 6-9.

Table 6-9 Assessment of significance: Freshwater Wetlands (TSC Act)

Freshwater Wetlands
How is the project likely to affect the lifecycle of a threatened species and/or population?
Not applicable
How is the project likely to affect the habitat of a threatened species, population or ecological community?
A total of 46.5 hectares of Freshwater Wetlands has been identified within and surrounding the study area, of which the project would impact around 5.1 hectares of this community in various condition states. Some of areas of Freshwater Wetlands in the project boundary are in a low condition comprising depressions and drainage lines within cleared paddocks open to grazing livestock. CRAFTI mapping has mapped about 3051 hectares of vegetation with affinities to Freshwater Wetlands within a 10 kilometre radius of the project boundary. The project would potentially result in the removal of 0.2 per cent of this estimated 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 project. 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 project are likely to minimise these indirect impacts. The majority of Freshwater Wetlands in the project boundary are in a low condition comprising depressions and drainage lines within cleared paddocks open to grazing livestock, and therefore any potential indirect impacts that would result in weed invasion, altered vegetation structure and loss of native diversity are unlikely to be substantially exacerbated in comparison to existing conditions. The largest potential for indirect impacts on Freshwater Wetlands is considered to be in Section 3 in tributaries and billabongs of the Coldstream River (chainage 42.7 to 43.5), with around three hectares of Freshwater Wetlands identified as being susceptible to indirect impacts.
Does the project affect any threatened species or populations that are at the limit of its known distribution?
Not applicable
How is the project likely to affect current disturbance regimes?
Current disturbance regimes in Freshwater Wetlands mainly comprise weed invasion, cattle grazing, cropping 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. The majority of Freshwater Wetlands in the project boundary are in an altered condition comprising depressions and drainage lines within cleared paddocks open to grazing livestock, and therefore any potential indirect impacts that would result in weed invasion, altered vegetation structure and loss of native diversity are unlikely to be substantially exacerbated in comparison to existing conditions. The largest potential for indirect impacts on Freshwater Wetlands is considered to be in Section 3 in tributaries and billabongs of the Coldstream River (chainage 42.7 to 43.5), with around three hectares of Freshwater Wetlands identified as being susceptible to indirect impacts.
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 that are located away 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 Freshwater Wetlands, (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 and bridges where Freshwater Wetlands 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.

Conclusions of the assessment

The project is unlikely to have a significant impact on Freshwater Wetlands because it would affect a relatively small proportion of the ecological community in the locality, because of the low condition of many areas of the community, and provided mitigation measures are adequately implemented and maintained.

This conclusion is consistent with the conclusion in the EIS.

6.2.5. Subtropical Coastal Floodplain Forest community

The impact assessment for Subtropical Coastal Floodplain Forest (Endangered TSC Act) has been revised from the assessment provided in the EIS to incorporate the results from additional ground-truthing of vegetation communities in selected areas within the project boundary (as detailed in section 5.1.3) and the reduced impacts resulting from the design refinements.

6.2.5.1. Direct and indirect impacts

A total of 1158 hectares of Subtropical Coastal Floodplain Forest has been identified within and surrounding the study area. The project would remove 93.9 hectares of this community.

The condition of this community varies, but a large majority is likely to be in a moderate condition including various remnants within agricultural landscapes open to grazing and thin strips of riparian vegetation.

CRAFTI mapping (NPWS, 1998) has broadly mapped about 14,287 hectares of vegetation with affinities to Subtropical Coastal Floodplain Forest within a 10-kilometre radius of the project boundary. However, CRAFTI provides broadscale vegetation mapping; much of the vegetation mapped as part of this project has not been ground truthed. The project would result in the removal of about 0.6 per cent of the local distribution of this community.

There is also potential for the project to alter habitat attributes of surrounding areas through indirect impacts such as altering hydrological and nutrient regimes in habitats downstream or downslope of the project. There would also be indirect impacts on adjacent areas of vegetation as a result of edge effects, such as increased 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 incorporation of specific design features into the proposed development are likely to minimise these indirect impacts.

A total of 40.2 hectares of this community (occurring close to the project or in downslope areas adjoining the project) has been identified as being susceptible to indirect impacts,.

6.2.5.2. Assessment of significance: endangered ecological community (TSC Act)

The assessment of significance for this community was undertaken with consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft Guidelines for Threatened Species Assessment. The assessment is provided in Table 6-10.

Table 6-10 Assessment of significance: Subtropical Coastal Floodplain Forest (TSC Act)

Subtropical Coastal Floodplain Forest
How is the project likely to affect the lifecycle of a threatened species and/or population?
Not applicable
How is the project likely to affect the habitat of a threatened species, population or ecological community?
A total of 1158 hectares of Subtropical Coastal Floodplain Forest has been identified within and surrounding the study area, of which the project would directly remove 93.9 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. CRAFTI mapping indicates about 14,287 hectares of vegetation with affinities to Subtropical Coastal Floodplain Forest within a 10 kilometre radius of the project boundary. The project would result in the removal of about 0.6 per cent of the local distribution of this community. There is potential for the project to alter habitat attributes of surrounding areas leading to indirect impacts such as altering the surface hydrological and nutrient regimes in habitats downstream or downslope of the project. There would also be indirect impacts on adjacent areas of vegetation from edge effects increasing light availability which may result in altered understorey floristics and structure leading to decreased condition and increases in weed abundance, altered soil condition. 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 project are likely to minimise these indirect impacts. A total of 40.2 hectares of this community has been identified as being susceptible to indirect impacts.
Does the project affect any threatened species or populations that are at the limit of its known distribution?
Not applicable
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. A total of 40.2 hectares of this community has been identified as being susceptible to indirect impacts.
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. In addition, 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 and bridges 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.

Conclusion of the assessment

The project would remove 93.9 hectares of Subtropical Coastal Floodplain Forest (about 0.6 per cent of the local distribution within a 10-kilometre radius of the project boundary), and have potential to indirectly impact another 40.2 hectares.

The project is unlikely to result in a significant impact on this community because of the relatively small proportion of the community that would be impacted.

This conclusion is consistent with the conclusion in the EIS.

6.2.6. Swamp Sclerophyll Forest community

The impact assessment for Swamp Sclerophyll Forest (Endangered TSC Act) has been revised from the assessment provided in the EIS to incorporate the results from additional ground-truthing of vegetation communities in selected areas within the project boundary (as detailed in section 5.1.3).

6.2.6.1. Direct and indirect impacts

A total of 1254 hectares of Swamp Sclerophyll Forest has been identified within and surrounding the study area. The project would remove around 112.1 hectares of this community in various condition states.

CRAFTI mapping (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 breakdown in area of both communities is not known.

There is also 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 project. There would also be indirect impacts on adjacent areas of vegetation from altered surface and groundwater conditions and edge effects such as increasing light and exposure which may result in altered understorey floristics and general condition leading to potential increases in weed abundance, and altered soil conditions and changing the structure of the community to a more disturbed state. An additional 44.2 hectares of this community is potentially vulnerable to indirect impacts. Hence, the project has potential to impact on around 156 hectares in total, or around 12 per cent of this community within and surrounding the project area.

Indirect impacts could result from changes to local hydrological conditions, which 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 project may minimise these indirect impacts.

Areas of this community outside of the project boundary may also potentially be affected by indirect impacts. Several identified areas of this community surrounding the project are designated areas of SEPP 14 coastal wetlands.

6.2.6.2. Assessment of significance: endangered ecological community (TSC Act)

The assessment of significance for this community was undertaken with consideration the Department of Environment and Conservation/ Department of Primary Industries (2005) draft Guidelines for Threatened Species Assessment. The assessment is provided in Table 6-11.

Table 6-11 Assessment of significance: Swamp Sclerophyll Forest (TSC Act)

Swamp Sclerophyll Forest
How is the project likely to affect the lifecycle of a threatened species and/or population?
Not applicable
How is the project likely to affect the habitat of a threatened species, population or ecological community?
A total of 1254 hectares of Swamp Sclerophyll Forest has been identified within and surrounding the study area, of which the project would directly clear around 112.1 hectares (nine per cent) of this community in various condition states. A further 44 hectares may also be indirectly impacted due to its presence adjoining the corridor increasing this impact to 12 per cent. Indirect impacts may be associated with changed surface and groundwater regimes, increase exposure in edge areas, particularly wind, dust and sunlight and weed abundance. Residual areas may continue to decline in ecosystem function, species diversity and condition, particularly fragmented patches. Within 10 kilometres of the project, there is about 20,465 hectares of vegetation with affinities to Swamp Sclerophyll Forest and Swamp Oak Floodplain Forest and the community is widespread across the floodplains on the Clarence and Richmond River, Corindi River and Coldstream River beyond the project corridor. 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. The areas of direct and indirect impact are widespread across multiple remnant patches on a local and regional scale and include loss of habitat, reduced condition and increased fragmentation of residual habitats.
Does the project affect any threatened species or populations that are at the limit of its known distribution?
Not applicable
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 would result in further fragmentation of the community adjacent to the existing highway. Several patches of Swamp Sclerophyll Forest located away 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 and bridges 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.

Conclusion of the assessment

The project would impact around 156 hectares (12 per cent) of the total of 1254 hectares of Swamp Sclerophyll Forest within and surrounding the study area.

The project has potential to significantly impact on this ecological community because the scale and magnitude of the impact would be across all project sections, and because of the high potential for indirect impacts on habitats adjoining the project. This conclusion is consistent with the conclusion in the EIS.

6.2.7. Swamp Oak Floodplain Forest community

The impact assessment for Swamp Oak Floodplain Forest (Endangered TSC Act) has been revised from the assessment provided in the EIS to incorporate the results from additional ground-truthing of vegetation communities in selected areas within the project boundary (as detailed in section 5.1.3).

6.2.7.1. Direct and indirect impacts

A total of 426.8 hectares of Swamp Oak Floodplain Forest has been identified within and surrounding the study area. The project would directly clear around 43.1 hectares of this community (10.1 per cent) in various condition states.

CRAFTI mapping (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 breakdown in the area of both communities is not known.

There is also potential for the project to alter habitat attributes of surrounding areas through indirect impacts such as altering hydrological and nutrient regimes in habitats adjoining the project. There would also be indirect impacts on adjacent areas of vegetation from altered surface and groundwater conditions and edge effects such as increasing light and exposure which may result in altered understorey floristics and general condition leading to potential increases in weed abundance, and altered soil conditions. These indirect impacts could change the structure of the community to a more disturbed state. An additional 16.6 hectares of this community is potentially vulnerable to indirect impacts.

Changes to local hydrological conditions 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 project may minimise these indirect impacts.

Areas of this community outside of the project boundary may potentially be affected by indirect impacts. Several areas of this community surrounding the project are also designated areas of SEPP 14 coastal wetlands.

All swamp oak forest communities within and near the project boundary already show evidence of degradation from indirect impacts – mainly through draining the land for agriculture, altered surface and groundwater regimes, weeds and fragmentation.

Mitigation measures during construction and the implementation of specific design features would minimise these indirect impacts but may only have short-term success.

6.2.7.2. Assessment of significance: endangered ecological community (TSC Act)

The assessment of significance for this community was undertaken in consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft Guidelines for Threatened Species Assessment. The assessment is provided in Table 6-12.

Table 6-12 Assessment of significance: Swamp Oak Floodplain Forest (TSC Act)

Swamp Oak Floodplain Forest
How is the project likely to affect the lifecycle of a threatened species and/or population?
Not applicable
How is the project likely to affect the habitat of a threatened species, population or ecological community?
A total of 426.8 hectares of Swamp Oak Floodplain Forest has been identified within and surrounding the study area, of which the project would impact around 43.1 hectares (11 per cent). A further 16 hectares may be subject to indirect impacts increasing this impact to 14 per cent. Within a 10 kilometre radius of the project, there is about 20,465 hectares of vegetation with affinities to Swamp Sclerophyll Forest and Swamp Oak Floodplain Forest and this community is widespread but heavily fragmented across the floodplains of the Richmond River, Clarence River, Coldstream River and Corindi River. 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. The areas of direct and indirect impact are widespread across multiple remnant patches on a local and regional scale and include loss of habitat, reduced condition and increased fragmentation of residual habitats.
Does the project affect any threatened species or populations that are at the limit of its known distribution?
Not applicable
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 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. A total of 16.6 hectares of this community has been identified as being susceptible to indirect impacts. Changes to local hydrological regimes are likely in proximity to the project and may result in water being contained for longer periods of time in vegetation patches adjacent to the project or lowering the water table potentially resulting in changes to understorey floristics, drying of the forest and eventual die-back in the canopy. All swamp forest communities noted already show evidence of indirect impacts mainly through draining the land for agricultural and altered surface and groundwater regimes and the project will contribute to this as well as fragmentation.
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 located away 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 and bridges 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.

Conclusions of the assessment

The project would remove 43.1 hectares of Swamp Oak Floodplain Forest and indirectly impact an additional 16.6 hectares, which is 14 per cent of this community within and surrounding the study area.

The project has potential to significantly impact on this ecological community because the scale and magnitude of the impact would be across all project sections and because of the high potential for indirect impacts on habitats adjoining the project. This conclusion is consistent with the conclusion in the EIS.

6.3. Threatened rainforest flora

The impact assessment for threatened rainforest flora was revised from the EIS to incorporate further surveys undertaken in areas inside and outside of the project boundary (as detailed in section 5.2).

The supplementary surveys confirmed the results and assessment of impacts from the EIS biodiversity working paper. As expected, the widening of the search area beyond the project boundary revealed several threatened species not previously identified and increased the known population size for several other species, as shown in Table 6-13.

Table 6-13 Results of rainforest plant surveys in Section 10

Species	Status		Directly impacted		No. potentially indirectly impacted	Total known population in study area (Supp)
	EPBC Act	TSC Act	No. in project boundary (EIS)	No. in project boundary (Supp)		
Acalypha eremorum (Acalypha)	V	E	0	0	0	71
Acronychia littoralis (Scented Acronychia)	E	E	0	1 (125 stems)	0	2 (1 x125 stems)
Archidendron hendersonii (White Lace Flower)	-	V	6	0	10	20
Belvisia mucronata (Needle-leaf Fern)	-	E	0	0	0	53
Cryptocarya foetida (Stinking Cryptocarya)	V	V	13	13	0	88
Davidsonia johnsonii (Smooth Davidson's Plum)	E	E	0	0	0	1 (25 stems)
Endiandra hayesii (Rusty Rose Walnut)	V	V	5	3	4	30
Endiandra muelleri subsp. bracteata (Green-leaved Rose Walnut)	-	E	6	0	2	44
Geijera paniculata (Axe-breaker)	-	E	0	0	0	25
Macadamia tetraphylla (Rough-shelled Bush Nut)	V	V	37	1	0	99
Ochrosia moorei (Southern Ochrosia)	E	E	0	0	0	1
Streblus pendulinus syn. S. brunonianus (Whalebone Tree)	E	-	0 (not listed at time)	8	1	43
Syzygium hodgkinsoniae (Red Lilly Pilly)	V	V	1	0	1	8
Tinospora tinosporoides (Arrow-head Vine)	V	V	0	0	0	60

Surveys undertaken for rainforest plants in a wider search area have provided additional insight into the degree of impact on these local threatened rainforest plant populations and resulted in a revision of the impacts identified in the EIS. Specifically, for several species, the proportion of the population that would be impacted by the project is now known to be lower than reported in the EIS, as shown in Table 6-13. In addition, impacts were further reduced through the design refinement at the interchange at Wardell (refer to Chapter 3). There remains the potential for indirect impacts on individuals near the project boundary and these are identified in Table 6-13. These individuals are generally in habitats where new edges would be created and/or are downstream of the project boundary.

The following species were reported as not being impacted in the EIS and although the total number in the population estimates has been revised (refer Table 6-13) the impact from the project is unchanged:

- Acalypha eremorum (Acalypha)
- Belvisia mucronata (Needle-leaf Fern)
- Ochrosia moorei (Southern Ochrosia)
- Geijera paniculata (Axe-breaker)
- Tinospora tinosporoides (Arrow-head Vine)

The design refinement has reduced the impact to around 4.2 hectares of subtropical rainforest habitat and 0.23 hectares of Littoral Rainforest that provides potential habitat for threatened rainforest flora species. There would be direct impacts on five threatened flora species and indirect impacts on five species (refer to Table 6-13).

An assessment of significance is required for species where there has been a change from the impacts reported in the EIS, resulting in either an increase or decrease in the level of impact or there is an additional or increased population size determined by the targeted surveys. Accordingly, an assessment of significance has been prepared for the following plant species:

- *Acronychia littoralis.*
- *Archidendron hendersonii.*
- *Cryptocarya foetida.*
- *Endiandra hayesii.*
- *Endiandra muelleri subsp bracteata.*
- *Macadamia tetraphylla.*
- *Streblus pendulinus.*
- *Syzygium hodgkinsoniae.*

With regard to the remaining species reported in the EIS, the project would not have a changed impact on these populations, and the supplementary surveys do not change the conclusions in the EIS. Therefore, a revised assessment of significance is not required.

6.3.1. Acronychia littoralis

Acronychia littoralis is a shrub or small tree that grows to around eight metres. This species was not assessed in the EIS. However, a design refinement at the proposed interchange at Wardell necessitated a site survey, which identified this species.

6.3.1.1. Direct and indirect impacts

Supplementary surveys identified a stand of *Acronychia sp.* within a drainage line on the edge of the existing highway, north of Coolgardie Road. This stand appeared entirely clonal (with an estimated 125 stems). As a precautionary approach, this plant is considered to be *A. littoralis*.

The project would require removal of a single individual. It would also remove 0.23 hectares of preferred Littoral Rainforest habitat and around four hectares of marginal habitat for this species, including Littoral Rainforest, Lowland Rainforest and swamp forest.

6.3.1.2. Assessment of significance: endangered species (EPBC Act)

The assessment of significance was undertaken according to criteria for endangered species in the DEWHA (2009) assessment guidelines. The assessment is provided in Table 6-14.

Table 6-14 Assessment of significance: *Acronychia littoralis* (EPBC Act)

Acronychia littoralis
According to the DSEWPAC (2009) 'significant impact criteria' an action is likely to have a significant impact on an endangered species if there is a real chance or possibility that it would:
Lead to a long-term decrease in the size of a population
This species was recorded in Section 8 and 10, in section 8 this includes one individual outside of the project boundary (around 130 metres to the west) and in section 10 there is one individual within the design refinement area that would be directly impacted. A small area within a drainage line on the edge of the existing highway, north of Coolgardie Road was dominated by a stand of Acronychia sp. that appears entirely clonal (estimated 125 stems) and is therefore considered one individual and not a population. The individuals identified in the study area potentially part of a larger population of this species occurring in rainforest habitats surrounding the corridor in Section 10, although this has not been confirmed and there is no evidence of a population within the 400 metre radius search area of the project. This individual is likely to be a sterile plant which is vegetatively reproducing from suckers, although this is not known. This species is potentially insect/bird pollinated and it is reasonable to expect that a potential population would include all individuals within 500 metres of individuals in the study area, however this would have no bearing on the sterile individual and has not been confirmed. In either case, the project would remove the individual from section 10. Translocation is not a mitigation measure, however it should be noted that this species has been successfully translocated. Clonal forms of A. littoralis have a high translocation survival due to their extensive root systems and free suckering nature, as learned from the Chinderah Bypass (RTA 1996). The feasibility of this measure is further addressed in the threatened rainforest species management plan. Specific mitigation measures for this species would focus on maintaining existing biotic and abiotic conditions in potential rainforest habitats where the remaining stems (if any) of this species occur close to the project boundary. Surveys of all stem locations would be undertaken prior to construction to determine if any stems can be retained adjacent to or within the project boundary. If stems can be retained, specific measures include the establishment of an exclusion zone including installation of barrier fencing, adequate sediment and erosion controls during construction, sediment retention basins upstream and the installation of a bridge structure over Randles Creek feeding into this patch which would maintain existing hydrological conditions. Considering the proposed impacts on single clonal individual and the absence of data and knowledge regarding the local population size, the project should be considered to potentially lead to a long term decrease in the local population.

Acronychia littoralis
Reduce the area of occupancy of the species
This species was recorded in the project boundary in Section 10, comprising one clonal individual (125 stems). Around 14.4 hectares of potential Littoral Rainforest habitat for this species has been identified within and surrounding the project boundary in addition to marginal habitat types including Lowland Rainforest (81.4 hectares) and swamp sclerophyll forest (1,254 hectares). There is potential for further individuals to occur beyond the 400 metre search around the project, although this is not known. The project would result in the area of current and potential occupancy for the species being reduced. Although the project would result in further fragmentation of rainforest and swamp forest communities.
Fragment an existing population into two or more populations
Considering the known population being impacted consists of a single individual which would be removed (or translocated) the project would not fragment an existing population into two or more populations.
Adversely affect habitat critical to the survival of a species
This species was recorded in the project boundary in Section 10, comprising one clonal individual (125 stems). Around 14.4 hectares of potential Littoral Rainforest habitat for this species has been identified within and surrounding the project boundary in addition to marginal habitat types including Lowland Rainforest (81.4 hectares) and swamp sclerophyll forest (1254 hectares). The project would result in a small reduction in habitat critical to the survival of the species generally being limited to areas of Littoral Rainforest (0.23 hectares).
Disrupt the breeding cycle of a population
Considering the clonal nature of the species in the project boundary comprising 125 stems believed to be part of the same individual, it is unlikely cross-pollination (breeding) is occurring with this individual. However this individual could be within pollination distance of other individuals in surrounding habitats, however there is no evidence of this.
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 recorded in the project boundary in Section 10, comprising one clonal individual (125 stems). Around 14.4 hectares of potential Littoral Rainforest habitat for this species has been identified within and surrounding the project boundary in addition to marginal habitat types including Lowland Rainforest (81.4 hectares) and swamp sclerophyll forest (1,254 hectares). Around 0.23 hectares of preferred habitat would be impacted and additionally around 112.1 hectares of swamp forest and 4.2 hectares of Lowland Rainforest habitat would be impacted comprising marginal habitat for the species. Considering the entire known local population would be directly impacted including removal of 0.2 hectares of Littoral Rainforest habitat from the project and there is a relatively high potential for the remaining areas of habitat to be indirectly impacted (modified), the project would potentially lead to a decline in the species. It is likely that the species has already declined in the locality
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 which would limit the potential for invasive species to be spread and become established in adjacent areas.
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 Roads and Maritime (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. There are no priority sites for conservation of this species within the project boundary.

Conclusion of the assessment

The project would result in the removal of a single clonal individual of *Acronychia littoralis* comprising 125 stems, 0.23 hectares of preferred Littoral Rainforest habitat and around four hectares of marginal habitat.

The project is likely to have a significant impact on the local population of *Acronychia littoralis* based on the existing population data.

This conclusion differs from the conclusion in the EIS, and has occurred following a design refinement that necessitated an additional survey.

6.3.1.3. Assessment of significance: endangered species (TSC Act)

The assessment of significance for this species was undertaken with consideration the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-15.

Table 6-15 Assessment of significance: *Acronychia littoralis* (TSC Act)

Acronychia littoralis
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 on the eastern side of the existing highway north of Coolgardie Road. A stand of Acronychia sp was identified in a drainage line on the edge of the existing highway, north of Coolgardie Road, that appears entirely clonal (estimated 125 stems). As a precautionary assessment this plant is considered as potentially *A. littoralis* and the total impact is considered to comprise a single individual. The individuals identified in the study are potentially part of a larger population of this species occurring in rainforest habitats surrounding the corridor in Section 10. This individual is likely to be a sterile plant which is vegetatively reproducing. This species is potentially insect/bird pollinated and it is reasonable to expect the potential population to include all individuals within 500 metres of individuals in the study area, however this would have no bearing on a sterile individual. Specific mitigation measures for this species would focus on maintaining existing biotic and abiotic conditions in potential rainforest habitats where the remaining stems (if any) of this species occur in close proximity to the project boundary. Specific measures include the establishment of an exclusion zone including installation of barrier fencing, adequate sediment and erosion controls during construction, sediment retention basins up stream and the installation of a bridge structure over Randles Creek feeding into this patch which would maintain existing hydrological conditions. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. Translocation of rainforest flora would be undertaken as part of the management plan for the project. Notably, clonal forms of A. littoralis have a high translocation survival due to their complex root systems and free suckering nature, as learned from the Chinderah Bypass (RTA 1996).
How is the project likely to affect the habitat of a threatened species, population or ecological community?
This species was recorded in the project boundary in Section 10, comprising one clonal individual (125 stems). Around 14.4 hectares of potential Littoral Rainforest habitat for this species has been identified within and surrounding the project boundary in addition to marginal habitat types including Lowland Rainforest (81.4 hectares) and swamp sclerophyll forest (1,254 hectares). Around 0.23 hectares of the preferred habitat (Littoral Rainforest) would be impacted by the project.
Does the project affect any threatened species or populations that are at the limit of its known distribution?
Acronychia littoralis is found between Fraser Island in Queensland and Port Macquarie on the north coast of NSW. The occurrence of the species in the study area is not at the limit of its known distribution, however record for the species are all east of the project and the study area may be at the western limit for the species which is generally associated with

Acronychia littoralis
Littoral Rainforest which generally occurs close to the coastline.
How is the project likely to affect current disturbance regimes?
There are several current disturbance regimes operating in the study area which include edge effects from habitat fragmentation, weed invasion and agricultural activities. There is potential for the project to result in indirect impacts from edge effects and altered hydrology which may impact the potential habitat for this species. Specific mitigation measures for this species would focus on maintaining existing biotic and abiotic conditions in potential rainforest habitats where the remaining stems (if any) of this species occur close to the project boundary. Surveys of all stem locations would be undertaken prior to construction to determine if any stems can be retained adjacent to or within the project boundary. If stems can be retained, specific measures include the establishment of an exclusion zone including installation of barrier fencing, adequate sediment and erosion controls during construction, sediment retention basins upstream and the installation of a bridge structure over Randles Creek feeding into this patch which would maintain existing hydrological conditions. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. Considering the proposed mitigation measures including minimising indirect impacts, habitat restoration, weed management and monitoring, current disturbance regimes are unlikely to be exacerbated and there is potential to improve habitat condition.
How is the project likely to affect habitat connectivity?
The project would result in the dissection of Lowland Rainforest habitat for this species, however a population would not be dissected and the referred habitat type (Littoral Rainforest) would not be dissected by 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 4.2 hectares of Lowland Rainforest being impacted and 0.23 hectares of Littoral Rainforest habitats of the total 95.8 hectares of potential rainforest habitat for this species in the study area.
How is the project likely to affect critical habitat?
No critical habitat has been identified for this species according to the TSC Act

Conclusion of the assessment

The project would result in removal of a single clonal individual of *Acronychia littoralis* with 125 stems, and 0.23 hectares of preferred Littoral Rainforest habitat.

The extent of the local population is unknown and has been assumed to constitute this single individual. Therefore, the project is likely to have a significant impact on the local population based on the existing population data.

This conclusion differs from the conclusion in the EIS, and is due to a design refinement that necessitated an additional survey.

6.3.2. Archidendron hendersonii

Archidendron hendersonii is a tree that grows up to 18 metres tall. This species was re-assessed due to a design refinement to the proposed interchange at Wardell.

6.3.2.1. Direct and indirect impacts

The EIS assessed that the EIS design would require removal of six *Archidendron hendersonii* individuals. However, a design refinement to the proposed interchange at Wardell has resulted in the project avoiding direct impact on all individuals. The design refinement would also reduce the impact on the potential habitat for the species (Lowland Rainforest).

The project would also result in the removal of 4.2 hectares of potential habitat for this species.

Supplementary surveys undertaken further afield from the project boundary revised the number of known individuals in the local population from 11 to 20. There is potential for indirect impacts on 10 of these individuals (within 25 metres of the project) due to edge effects from habitat removal and changes to hydrology regimes. Two individuals are within four metres of the project construction footprint with the remaining eight individuals within 25 metres. The remainder of the population are situated over 50 metres from the project and would not be impacted.

6.3.2.2. Assessment of significance: vulnerable species (TSC Act)

The assessment of significance for this species was undertaken with consideration of Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-16.

Table 6-16 Assessment of significance: *Archidendron hendersonii* (TSC Act)

Archidendron hendersonii
How is the project likely to affect the lifecycle of a threatened species and/or population?
This species was recorded in Section 10, comprising 20 individuals in subtropical rainforest north and south of Coolgardie Road. Of these 20 individuals, none are within the project boundary, however 10 individuals are in close proximity to the project boundary and would potentially be indirectly impacted by edge effects and altered hydrology. The remaining 10 individuals are greater than 50 metres up slope of the project boundary and are unlikely to be impacted by indirect impacts from edge effects and altered hydrology. The individuals identified in the study 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 in the study area. Specific mitigation measures for this species would focus on maintaining existing biotic and abiotic conditions in the patch of rainforest where the remaining 10 individuals of this species occur in close proximity to the project boundary. Specific measures for this patch include the establishment of an exclusion zone including installation of barrier fencing, adequate sediment and erosion controls during construction, sediment retention basins up stream of this patch and the installation of a bridge structure over Randles Creek feeding into this patch which would maintain existing hydrological conditions as close as possible. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring.
How is the project likely to affect the habitat of a threatened species, population or ecological community?
The species is found on a variety of soils including coastal sands and those derived from basalt and metasediments. Around 95.8 hectares of potential Lowland and Littoral Rainforest habitat within the distributional range of this species has been identified within and surrounding the project boundary, of which around three hectares would be impacted. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and 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?
There are several current disturbance regimes operating in the study area which include edge effects from habitat fragmentation, weed invasion and agricultural activities. There is potential for the project to result in indirect impacts from edge effects and altered hydrology which may impact the habitat for this species affecting life-cycle attributes of the remaining 10 individuals in close proximity to the project boundary. Specific mitigation measures for this species would focus on maintaining existing biotic and abiotic conditions in the patch of rainforest where the remaining 10 individuals of this species occur in close proximity to the project boundary. Specific measures for this patch include the establishment of an exclusion zone including installation of barrier fencing, adequate sediment and erosion controls during construction, sediment retention basins up stream of this patch and the installation of a bridge structure over Randles Creek feeding into this patch which would maintain existing hydrological conditions as close as possible. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. Considering the proposed mitigation measures including minimising indirect impacts, habitat restoration, weed management and monitoring, current disturbance regimes are unlikely to be exacerbated and there is potential to improve habitat condition.

Archidendron hendersonii
How is the project likely to affect habitat connectivity?
The project would result in the dissection of habitat for this species. Remaining individuals would be 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 with around three hectares of the 95.8 hectares of potential rainforest habitat potentially being impacted. There is some potential for habitat connectivity to be improved through habitat restoration in currently cleared/disturbed areas.
How is the project likely to affect critical habitat?
No critical habitat has been identified for this species

Conclusion of the assessment

The project could result in indirect impacts on around 50 per cent of the known population in the study area. However, provided proposed mitigation measures identified in section 7.1.1 are adequately implemented, indirect impacts would be minimised, with the project not having a significant impact on this species.

This conclusion differs from the conclusion in the EIS, and is due to a design refinement and impact avoidance measures.

6.3.3. Cryptocarya foetida

Cryptocarya foetida is a tree that grows up to 20 metres tall. This species was re-assessed due to the significant impact of the EIS design.

6.3.3.1. Direct and indirect impacts

The project would require removal of 13 individuals of this species north of Coolgardie Road. Surveys for the EIS only identified 17 individuals in the local population, resulting in an impact on 76 per cent of the population.

Additional surveys undertaken further afield of the project boundary revised the known extent of the local population to 88 individuals. This has revised the project impact down to only 15 per cent of the local population. The results of the additional surveys suggest the local population is likely to include additional individuals outside of the study area that have not been identified.

The project (including design refinements) would result in the removal of 0.23 hectares of Littoral Rainforest which is considered the preferred habitat for this species and around 5.7 hectares of other potential habitat for this species, including Lowland Rainforest (4.2 hectares) and adjacent swamp sclerophyll habitats (1.5 hectares). This represents a reduction on the amount of clearing assessed in the EIS (namely, 7.6 hectares).

The remaining individuals of the species that would not be directly impacted by the project are located in a fragmented rainforest patch that shows evidence of edge effects. As such, indirect impacts on this species from further edge effects are not anticipated. As these individuals are located upslope of the project, indirect impacts from altered hydrology regimes are also not anticipated.

The 13 individuals within the project boundary north of Coolgardie Road are separated by around 1.3 kilometres from other known locations of this species south of Coolgardie Road. These individuals could be regarded as a sub-population within the local population. Removal of these individuals would potentially remove an existing 'stepping stone' for genetic exchange between sub-populations. Therefore, there may be

impacts on the exchange of genetic material within the local population which may lead to a decrease in genetic diversity, potentially decreasing the health and vigour of the population.

6.3.3.2. Assessment of significance: vulnerable species (EPBC Act)

The assessment of significance was undertaken according to criteria for vulnerable species in the DEWHA (2009) assessment guidelines. The assessment is provided in Table 6-17.

Table 6-17 Assessment of significance: *Cryptocarya foetida* (EPBC Act)

Cryptocarya foetida
According to the DSEWPAC (2009) 'significant impact criteria' an action is likely to have a significant impact on an vulnerable species if there is a real chance or possibility that it would:
Lead to a long-term decrease in the size of an important population
A total of 88 individuals were recorded within and surrounding the project boundary during supplementary surveys in Section 10 north of Coolgardie Road (BAAM 2012). Of these 88 identified individuals up to 13 occur within the project boundary comprising around 15 per cent of the known population in the study area. The 13 individuals within the project boundary north of Coolgardie Road are separated by around 1.3 kilometres from other known locations of this species south of Coolgardie Road. These individuals could be regarded as a sub-population within the local population. Removal of these individuals would potentially remove an existing 'stepping stone' for genetic exchange between sub-populations. Therefore there may be some impacts on the exchange of genetic material within the local population which may lead to a decrease in genetic diversity potentially decreasing the health and vigour of the population. All remaining individuals occur greater than 44 metres up slope of the project boundary and therefore indirect impacts from altered hydrology regimes are not anticipated for the remaining individuals of this species. The project would not result in further clearing of the patch of rainforest habitat where the remaining individuals of this species are present; therefore indirect impacts on this species from edge effects are not anticipated to be exacerbated by the project. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, translocation, appropriate landscaping for the project, weed management and monitoring. Considering the project would potentially remove an entire sub-population of the species which may be important for genetic exchange between sub-populations of the species, the project would potentially lead to a long-term decrease in the local population.
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 in Lowland Rainforest or occasionally adjacent swamp sclerophyll. Around 95.8 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary although some areas outside the natural distribution of the species, of which around 4.4 hectares would be impacted. Reductions to the area of occupancy of this species would be limited to around 0.1 hectares of habitat where this species occurs within the project boundary. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. These measures have the potential to increase the area of occupancy for this species.
Fragment an existing 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 4.4 hectares of the 95.8 hectares of potential rainforest habitat for this species potentially being impacted.
Adversely affect habitat critical to the survival of a species
Around 95.8 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around three hectares would be impacted. The occupied area of habitat for this species within the project boundary comprises less than 0.1 hectares of rainforest. Rainforest habitats within and surrounding the project boundary are regarded as being critical to the survival of this species and around 3 per cent is proposed to be directly

Cryptocarya foetida
impacted. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. This is likely to have a positive effect on habitat critical to the survival of the species.
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. • Seed dispersal. • Other disturbance regimes such as forestry activities and grazing. The individuals identified in the study 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 would include all individuals within 500 metres. The seeds are readily distributed by fruit-eating bird species. The 13 individuals within the project boundary north of Coolgardie Road are separated by around 1.3 kilometres from other known locations of this species south of Coolgardie Road. These individuals could be regarded as a sub-population within the local population. Removal of these individuals would potentially remove an existing 'stepping stone' for genetic exchange between sub-populations. Therefore there may be some impacts on the exchange of genetic material within the local population which may lead to a decrease in genetic diversity potentially decreasing the health and vigour of the population.
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 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 4.4 hectares of the 95.8 hectares of potential rainforest habitat for this species potentially being impacted. Around 85 per cent of the population would be retained in surrounding areas of rainforest habitat and are considered unlikely to be indirectly impacted. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. This is likely to have a positive effect on habitat critical to the survival of 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;
All remaining individuals occur greater than 44 metres upstream of the project and therefore indirect impacts from altered hydrology regimes are not anticipated for the remaining individuals of this species. The project would not result in further clearing of the patch of rainforest habitat where the remaining individuals of this species are present, therefore indirect impacts on this species from edge effects are not anticipated to be exacerbated by the project. It is unlikely that the project would exacerbate existing threats posed by invasive species considering indirect impacts from edge effects and altered hydrology regimes are unlikely.
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, potential for impacts from plant pathogens would be minimised. Monitoring and management actions for the retained populations as part of the mitigation measures of the project would be carried out in a way that minimises the risk of the spread of disease from plant pathogens.

Cryptocarya foetida
Interfere 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 would be retained on elevated lands west of the project boundary including monitoring of populations and weed control within habitat areas. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. This is likely to have a positive effect on habitat critical to the survival of the species.

6.3.3.3. Assessment of significance: vulnerable species (TSC Act)

The assessment of significance for this species was undertaken in consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-18.

Table 6-18 Assessment of significance: *Cryptocarya foetida* (TSC Act)

Cryptocarya foetida
How is the project likely to affect the lifecycle of a threatened species and/or population?
A total of 88 individuals were recorded within and surrounding the project boundary during supplementary surveys in Section 10 north of Coolgardie Road. Of these 88 identified individuals, 13 occur within the project boundary comprising around 15 per cent of the known population in the study area. All remaining individuals occur greater than 44 metres upstream of the project boundary and therefore indirect impacts from altered hydrology regimes are not anticipated for the remaining individuals of this species. The project would not result in further clearing of the patch of rainforest habitat where the remaining individuals of this species are present, therefore indirect impacts on this species from edge effects are not anticipated to be exacerbated by the project. The individuals identified in the study 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. The 13 individuals within the project boundary north of Coolgardie Road are separated by around 1.3 kilometres from other known locations of this species south of Coolgardie Road. These individuals could be regarded as a sub-population within the local population. Removal of these individuals would potentially remove an existing 'stepping stone' for genetic exchange between sub-populations. Therefore there may be some impacts on the exchange of genetic material within the local population which may lead to a decrease in genetic diversity potentially decreasing the health and vigour of the population. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and 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 95.8 hectares of potential lowland and Littoral Rainforest habitat within the distributional range of this species has been identified within and surrounding the project boundary, of which around 4.4 hectares would be impacted. No indirect impacts on remaining individuals surrounding the project boundary are anticipated. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring.

Cryptocarya foetida
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?
There are several current disturbance regimes operating in the study area include edge effects from habitat fragmentation, weed invasion and agricultural activities. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. No indirect impacts on remaining individuals surrounding the project boundary are anticipated. Considering the proposed mitigation measures including minimising indirect impacts, habitat restoration, weed management and monitoring, current disturbance regimes are unlikely to be exacerbated and there is potential to improve habitat condition.
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 with around 4.4 hectares of the 95.8 hectares of potential rainforest habitat being impacted. There is some potential for habitat connectivity to be improved through habitat restoration in currently cleared/disturbed areas.
How is the project likely to affect critical habitat?
No critical habitat has been identified for this species

Conclusion of the assessment

The project would potentially result in a significant impact on the *Cryptocarya foetida* species under Commonwealth and State assessment criteria. This is because it would remove an entire sub-population of this species that constitutes around 15 per cent of the wider population in the study area.

This conclusion is consistent with the conclusion in the EIS.

6.3.4. Endiandra hayesii

Endiandra hayesii is a small tree. This species was re-assessed due to a design refinement to the proposed interchange at Wardell, which necessitated supplementary surveys.

6.3.4.1. Direct and indirect impacts

Surveys undertaken for the EIS identified eight individuals of *Endiandra hayesii*. Of these, five would be removed under the EIS design. Supplementary surveys increased the known number of individuals in the local population of *Endiandra hayesii* to 30.

In addition, the design refinement at the interchange at Wardell reduced the number of individuals that would be removed from five down to three.

As such, the project would directly impact three out of 30 individuals, or 10 per cent of the known population in the study area. The local population is likely to include additional individuals outside of the study area. The project would also result in the removal of two hectares of potential habitat for this species, including a vegetation patch that contains individuals.

The project would also have indirect impacts from edge effects on four individuals up to 25 metres away. These individuals occur on relatively flat terrain and therefore are vulnerable to changes to hydrology regimes as a result of the project.

The remaining 23 individuals are greater than 80 metres upstream of the project and there would be no further clearing of the patch of rainforest habitat where they are present. Therefore, the project is not expected to exacerbate indirect impacts on these individuals.

6.3.4.2. Assessment of significance: vulnerable species (EPBC Act)

The assessment of significance was undertaken according to criteria for vulnerable species in the DEWHA (2009) assessment guidelines. The assessment is provided in Table 6-19.

Table 6-19 Assessment of significance: *Endiandra hayesii* (EPBC Act)

Endiandra hayesii
According to the DSEWPAC (2009) 'significant impact criteria' an action is likely to have a significant impact on an vulnerable species if there is a real chance or possibility that it would:
Lead to a long-term decrease in the size of an important population
A total of 30 individuals have been recorded in the study area, of which three would potentially be directly impacted from the project. This impact constitutes around 10 per cent of the known population in the study area, however the local population is likely to include additional individuals outside of the study area. 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 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 likely to be readily distributed by fruit-eating bird species. The project would not result in the further isolation of individuals of this species from one another, with all known individuals being within 500 metres of another individual, however habitat connectivity would be fragmented. The modified concept design would result in the removal of 4.2 hectares of potential habitat for this species and there is potential for edge effects from habitat removal to indirectly impact four of the remaining individuals in close proximity to the project boundary. The project boundary is around 7 metres from one individual and 22 metres from three individuals which would potentially impacted from edge effects with the removal of part of the rainforest patch where these individuals occur. These individuals also occur on relatively flat terrain and therefore are vulnerable to changes to hydrology regimes as a result of the project. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. The project has the potential to lead to a long-term decrease with four of the remaining individuals being vulnerable to indirect impacts. The proposed mitigation measures would minimise the potential or indirect impacts on remaining individuals
Reduce the area of occupancy of an important population
Around 81.4 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 4.2 hectares would be impacted. Reductions to the area of occupancy of this species would be limited to less than 0.1 hectares of habitat where this species occurs within the project boundary. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. These measures have the potential to increase the area

Endiandra hayesii
of occupancy for this species. Although there would be a small reduction to the area of occupancy for this species proposed mitigation measures including restoration of rainforest habitats have the potential to increase the area of occupancy for this species.
Fragment an existing 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 4.2 hectares of the 81.4 hectares of potential rainforest habitat for this species potentially being impacted. Although the population would be fragmented by the project, potential flying insect pollinators are likely to cross the project boundary between individuals continuing genetic exchange between individuals. Similarly dispersal of seed by birds is unlikely to be substantially impacted from the project.
Adversely affect habitat critical to the survival of a species
Around 81.4 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 4.2 hectares would be impacted. The occupied area of habitat for this species within the project boundary comprises less than 0.1 hectares of rainforest. Rainforest habitats within and surrounding the project boundary are regarded as being critical to the survival of this species and around 3 per cent is proposed to be directly impacted. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. These measures have the potential to increase the area of habitat critical to the survival of this species. Considering the minor proportion of habitat being impacted in the study area (3%) and the proposed restoration, management and monitoring proposed as part of the mitigation measures the project is unlikely to adversely affect habitat critical to the survival of the species.
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. • Seed dispersal • 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 likely to be readily distributed by fruit-eating bird species. The project would not result in the further isolation of individuals of this species from one another, with all known individuals being within 500 metres of another individual. There is potential for the breeding cycle to be disrupted from the removal of around 10 per cent of the known available gene pool, however considering that the project would not result in the further isolation of individuals, genetic exchange between individuals is expected to continue. There are several current disturbance regimes operating in the study area including edge effects from habitat fragmentation, weed invasion and agricultural activities. Considering the proposed mitigation measures including minimising indirect impacts, habitat restoration, weed management and monitoring, current disturbance regimes are unlikely to be exacerbated and there is potential to improve habitat condition.
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 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 4.2 hectares of the 81.4 hectares of potential rainforest habitat for this species potentially being impacted comprising around 3 per cent of the available habitat. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road

Endiandra hayesii
boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. These measures have the potential to increase the area of occupancy for this species. Considering the minor proportion of habitat being impacted in the study area (3 per cent) and the proposed restoration, management and monitoring proposed as part of the mitigation measures the project is unlikely to 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 critically endangered or endangered species becoming established in the endangered or critically endangered 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. 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. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. These measures have the potential to increase the area of occupancy for this species. Considering the proposed habitat restoration and weed management mitigation measures and the current levels of weed invasion and other disturbances the project is unlikely to result in further invasive species becoming established and resulting in further impacts on the species.
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. Considering the proposed mitigation measures to limit the spread and introduction of disease, the project is unlikely to result in harm to the species from disease.
Interfere 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 project including protective fencing, monitoring of populations and weed control within habitat areas. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring.

Conclusion of the assessment

The project would result in a significant impact on *Endiandra hayesii* under Commonwealth assessment criteria. This is because it would require removal of 10 per cent of the known population in the study area and have potential for indirect impacts on an additional 13 per cent of the known population in the study area.

This conclusion is consistent with the conclusion in the EIS.

6.3.4.3. Assessment of significance: vulnerable species (TSC Act)

The assessment of significance for this species was undertaken in consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-20.

Table 6-20 Assessment of significance: *Endiandra hayesii* (TSC Act)

Endiandra hayesii
How is the project likely to affect the lifecycle of a threatened species and/or population?
A total of 30 individuals have been recorded in the study area, of which three individuals would potentially be directly impacted from the project. This impact constitutes around 10 per cent of the known population in the study area, however the local population is likely to include additional individuals outside of the study area. 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 likely to be readily distributed by fruit-eating bird species. The project would not result in the further isolation of individuals of this species from one another, with all known individuals being within 500 metres of another individual. The modified concept design would result in the removal of 4.2 hectares of potential habitat for this species and there is potential for edge effects from habitat removal to indirectly impact four of the remaining individuals in close proximity to the project boundary. The project boundary is around 7 metres from one individual and 22 metres from three individuals which would potentially impacted from edge effects with the removal of part of the rainforest patch where these individuals occur. These individuals also occur on relatively flat terrain and therefore are vulnerable to changes to hydrology regimes as a result of the project. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and 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. Around 81.4 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 4.2 hectares would be impacted. There is potential for edge effects from habitat removal to indirectly impact four of the remaining individuals in close proximity to the project boundary. The project boundary is around 7 metres from one individual and 22 metres from three individuals which would potentially impacted from edge effects with the removal of part of the rainforest patch where these individuals occur. These individuals also occur on relatively flat terrain and therefore are vulnerable to changes to hydrology regimes as a result of the project. The mitigation measures outlined in the working paper and species-specific management plans are directly applicable to both the concept design and the design refinement around rainforest patches in Section 10. Specific mitigation measures for this species would focus on maintaining existing biotic and abiotic conditions in the patch of rainforest where the remaining four individuals of this species occur in close proximity to the project boundary along with three other threatened rainforest species. Specific measures for this patch include the establishment of an exclusion zone including installation of barrier fencing during construction, adequate sediment and erosion controls during construction, sediment retention basins upstream of this patch and the installation of a bridge structure over Randles Creek feeding into this patch which would maintain existing hydrological conditions as close as possible. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and 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.

Endiandra hayesii
How is the project likely to affect current disturbance regimes?
There are several current disturbance regimes operating in the study area include edge effects from habitat fragmentation, weed invasion and agricultural activities. The modified concept design would result in the removal of 4.2 hectares of potential habitat for this species and there is potential for edge effects from habitat removal to indirectly impact four of the remaining individuals in close proximity to the project boundary. The project boundary is around 7 metres from one individual and 22 metres from three individuals which would potentially impacted from edge effects with the removal of part of the rainforest patch where these individuals occur. These individuals also occur on relatively flat terrain and therefore are vulnerable to changes to hydrology regimes as a result of the project. Specific mitigation measures for this species would focus on maintaining existing biotic and abiotic conditions in the patch of rainforest where the remaining four individuals of this species occur in close proximity to the project boundary. Specific measures for this patch include the establishment of an exclusion zone including installation of barrier fencing, adequate sediment and erosion controls during construction, sediment retention basins up stream of this patch and the installation of a bridge structure over Randles Creek feeding into this patch which would maintain existing hydrological conditions as close as possible. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. Considering the proposed mitigation measures including minimising indirect impacts, habitat restoration, weed management and monitoring, current disturbance regimes are unlikely to be exacerbated and there is potential to improve habitat condition.
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 4.2 hectares of the 84.1 hectares of potential rainforest habitat for this species potentially being impacted. There is some potential for habitat connectivity to be improved through habitat restoration in currently cleared/disturbed areas. Although the population would be fragmented by the project, potential flying insect pollinators are likely to cross the project boundary between individuals continuing genetic exchange between individuals.
How is the project likely to affect critical habitat?
No critical habitat has been identified for this species

Conclusion of the assessment

The project would potentially result in a significant impact on this species under State assessment criteria. This is because it would require removal of 10 per cent of the known population in the study area and have potential for indirect impacts on an additional 13 per cent of the known population in the study area

This conclusion is consistent with the conclusion in the EIS.

6.3.5. Endiandra muelleri subsp. bracteata

Endiandra muelleri subsp. bracteata is a large tree that is a sub-species of *Endiandra muelleri*. This species was re-assessed due to a design refinement to the proposed interchange at Wardell, which necessitated supplementary surveys.

6.3.5.1. Direct and indirect impacts

Surveys undertaken for the EIS identified eight individuals of *Endiandra muelleri subsp. bracteata.* Supplementary surveys undertaken further afield of the project have increased the number of known individuals in the local population to 44 individuals.

The design refinement at the interchange at Wardell would avoid impacting on any individuals. However, the project would result in the removal of two hectares of potential habitat for this species and could indirectly impact two individuals within 25 metres of the project. These two individuals are potentially vulnerable to new edge effects from clearing of the rainforest patch where these individuals occur, as well as potential changes to hydrology regimes. The remaining 42 individuals are greater than 70 metres upstream of the project and would not be subject to indirect impacts.

6.3.5.2. Assessment of significance: endangered species (TSC Act)

The assessment of significance for this species was undertaken in consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-21.

Table 6-21 Assessment of significance: *Endiandra muelleri subsp. bracteata* (TSC Act)

Endiandra muelleri subsp. bracteata
How is the project likely to affect the lifecycle of a threatened species and/or population?
This species was recorded in Section 10, comprising 44 individuals in subtropical rainforest north and south of Coolgardie Road. Of these 44 individuals, none are within the project boundary, however 2 individuals are in 25 metres of the project and would potentially be indirectly impacted by edge effects and altered hydrology. The remaining 42 individuals are greater than 70 metres upstream of the project and are unlikely to be impacted by indirect impacts from edge effects and altered hydrology. Specific mitigation measures for this species would focus on maintaining existing biotic and abiotic conditions in the patch of rainforest where two individuals occur in close proximity to the project boundary. Specific measures for this patch include the establishment of an exclusion zone including installation of barrier fencing during construction, adequate sediment and erosion controls during construction, sediment retention basins up stream of this patch and the installation of a bridge structure over Randles Creek feeding into this patch which would maintain existing hydrological conditions as close as possible. 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. The project would not result in the further isolation of individuals of this species from one another, with all known individuals being within 500 metres of another individual. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and 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 84.1 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 4.2 hectares would be impacted. Specific mitigation measures for this species would focus on maintaining existing biotic and abiotic conditions in the patch of rainforest where two individuals of this species occur in close proximity to the project boundary. Specific measures for this patch include the establishment of an exclusion zone including installation of barrier fencing, adequate sediment and erosion controls during construction, sediment retention basins up stream of this patch and the installation of a bridge structure over Randles Creek feeding into this patch which would maintain existing hydrological conditions as close as possible. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring.

Endiandra muelleri subsp. bracteata
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?
There are several current disturbance regimes operating in the study area include edge effects from habitat fragmentation, weed invasion and agricultural activities. Indirect impacts from edge effects and altered hydrology may impact the habitat of this species affecting life-cycle attributes for two of the remaining individuals in close proximity to the project boundary. Specific mitigation measures for this species would focus on maintaining existing biotic and abiotic conditions in the patch of rainforest where two individuals of this species occur in close proximity to the project boundary. Specific measures for this patch include the establishment of an exclusion zone including installation of barrier fencing during construction, adequate sediment and erosion controls during construction, sediment retention basins up stream of this patch and the installation of a bridge structure over Randles Creek feeding into this patch which would maintain existing hydrological conditions as close as possible. There are potential opportunities to mitigate potential impacts on 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 monitoring. Considering the proposed mitigation measures including minimising indirect impacts, habitat restoration, weed management and monitoring, current disturbance regimes are unlikely to be exacerbated and there is potential to improve habitat condition.
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 4.2 hectares of the 84.1 hectares of potential rainforest habitat for this species potentially being impacted. There is some potential for habitat connectivity to be improved through habitat restoration in currently cleared/disturbed areas.
How is the project likely to affect critical habitat?
No critical habitat has been identified for this species

Conclusion of the assessment

The project is unlikely to result in a significant impact on *Endiandra muelleri subsp. bracteata* under State assessment criteria. This is because the design refinement at the proposed interchange at Wardell would avoid removal of individuals of this species, and only around five per cent of the known population in the study area could potentially be indirectly impacted.

This conclusion differs from the conclusion presented in the EIS and is due to a design refinement and impact avoidance measures.

6.3.6. Macadamia tetraphylla

Macadamia tetraphylla is a tree that grows to 18 metres tall. This species was re-assessed due to a design refinement to the proposed interchange at Wardell, which necessitated supplementary surveys.

6.3.6.1. Direct and indirect impacts

Surveys undertaken for the EIS identified 68 individuals of *Macadamia tetraphylla.* Of these, 37 would be removed under the EIS design. Supplementary surveys undertaken beyond the project boundary increased the number of individuals in the local population to 99 individuals.

The design refinement at the interchange at Wardell would reduce the impacts from 37 individuals to one individual and reduce the impacts on the Lowland Rainforest potential habitat of the species down to 4.2 hectares. The project would therefore impact on only one per cent of the local population.

The remaining 98 individuals in the local population are located in habitat patches 24 metres upslope of the project and would not be directly impacted by the project. The subject habitat patch is subject to existing edge effects and the project would not create any new edges in these habitats. In addition, hydrology regimes are unlikely to be modified as a result of the project.

6.3.6.2. Assessment of significance: vulnerable species (EPBC Act)

The assessment of significance was undertaken according to criteria for vulnerable species in the DEWHA (2009) assessment guidelines. The assessment is provided in Table 6-22.

Table 6-22 Assessment of significance: *Macadamia tetraphylla* (EPBC Act)

Macadamia tetraphylla
According to the DSEWPAC (2009) 'significant impact criteria' an action is likely to have a significant impact on an vulnerable species if there is a real chance or possibility that it would:
Lead to a long-term decrease in the size of an important population
A total of 99 individuals have been recorded in the study area, of which one individual would potentially be directly impacted from the project. This impact constitutes around 1 per cent of the known population in the study area, however the local population is likely to include additional individuals outside of the study area. The total population size of *Macadamia tetraphylla* is estimated to be between 1000 and 2000 mature individuals with around 75 key populations consisting of 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 10 per cent of the entire population of *Macadamia tetraphylla*. The potential impacts on one individual represents a minor proportion of the entire known population of between 1000 and 2000 mature individuals (Costello et al 2009) comprising up to 0.1 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). The project would not result in the further isolation of individuals of this species from one another, with all known individuals being within 500 metres of another individual. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and 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 81.4 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 4.2 hectares would be impacted. Reductions to the area of occupancy of this species would be limited to less than 0.1 hectares of habitat where this species occurs within the project boundary. Although there would be a small reduction to the area of occupancy for this species proposed mitigation measures including restoration of rainforest habitats have the potential to increase the area of occupancy for this species.

Macadamia tetraphylla

Fragment an existing 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 4.2 hectares of the 81.4 hectares of potential rainforest habitat for this species potentially being impacted.

Adversely affect habitat critical to the survival of a species

Around 81.4 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 4.2 hectares would be impacted. The occupied area of habitat for this species within the project boundary comprises less than 0.1 hectares of rainforest. Rainforest habitats within and surrounding the project boundary are regarded as being critical to the survival of this species and around 3 per cent is proposed to be directly impacted.

Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. These measures have the potential to increase the area of habitat critical to the survival of this species.

Considering the minor proportion of habitat being impacted in the study area (3 per cent) and the proposed restoration, management and monitoring proposed as part of the mitigation measures the project is unlikely to adversely affect habitat critical to the survival of the species.

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.

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).

Considering that the project would not result in the further isolation of individuals, genetic exchange between individuals is expected to continue. There are several current disturbance regimes operating in the study area including edge effects from habitat fragmentation, weed invasion and agricultural activities. Considering the proposed mitigation measures including minimising indirect impacts, habitat restoration, weed management and monitoring, current disturbance regimes are unlikely to be exacerbated and there is potential to improve habitat condition. The breeding cycle of this species is unlikely to be significant impacted considering the minor direct impact, limited habitat fragmentation and low potential for indirect impacts on remaining individuals.

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 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 4.2 hectares of the 81.4 hectares of potential rainforest habitat for this species potentially being impacted.

Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. These measures have the potential to increase the area of occupancy for this species.

Macadamia tetraphylla
Considering the minor proportion of habitat being impacted in the study area (1%) and the proposed restoration, management and monitoring proposed as part of the mitigation measures the project is unlikely to 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 critically endangered or endangered species becoming established in the endangered or critically endangered 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. 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. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. These measures have the potential to increase the area of occupancy for this species. Considering the proposed habitat restoration and weed management mitigation measures and the current levels of weed invasion and other disturbances the project is unlikely to result in further invasive species becoming established and resulting in further impacts on the species.
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. Considering the proposed mitigation measures to limit the spread and introduction of disease, the project is unlikely to result in harm to the species from disease.
Interfere 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 project including protective fencing, monitoring of populations and weed control within habitat areas. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring.

6.3.6.3. Assessment of significance: vulnerable species (TSC Act)

The assessment of significance for this species was undertaken in consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-23.

Table 6-23 Assessment of significance: *Macadamia tetraphylla* (TSC Act)

Macadamia tetraphylla
How is the project likely to affect the lifecycle of a threatened species and/or population?
A total of 99 individuals have been recorded in the study area, of which one individual would potentially be directly impacted from the project. This impact constitutes around 1 per cent of the known population in the study area, however the local population is likely to include additional individuals outside of the study area. The total population size of *Macadamia tetraphylla* is estimated to be between 1000 and 2000 mature individuals with around 75 key populations consisting of 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 10 per cent of the entire population of *Macadamia tetraphylla*. The potential impacts on one individual represents a minor proportion of the entire known population of between 1000 and 2000 mature individuals (Costello et al 2009) comprising

Macadamia tetraphylla
up to 0.1 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). The project would not result in the further isolation of individuals of this species from one another, with all known individuals being within 500 metres of another individual. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and 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 81.4 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 4.2 hectares would be impacted. Reductions to the area of occupancy of this species would be limited to less than 0.1 hectares of habitat where this species occurs within the project boundary. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. These measures have the potential to increase the area of occupancy for this species.
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?
There are several current disturbance regimes operating in the study area include edge effects from habitat fragmentation, weed invasion and agricultural activities. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. No indirect impacts on remaining individuals surrounding the project boundary are anticipated. Considering the proposed mitigation measures including minimising indirect impacts, habitat restoration, weed management and monitoring, current disturbance regimes are unlikely to be exacerbated and there is potential to improve habitat condition.
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 4.2 hectares of the 81.4 hectares of potential rainforest habitat for this species potentially being impacted.

Macadamia tetraphylla
How is the project likely to affect critical habitat?
No critical habitat has been identified for this species

Conclusion of the assessment

Considering the direct impact on only one per cent of the known population in the study area and the potential for indirect impacts unlikely for the remaining individuals, the project is unlikely to result in a significant impact on this species under Commonwealth and State assessment criteria. Proposed mitigation measures are likely to result in a positive ecological outcome for this population relative to existing disturbance regimes.

This conclusion differs from the conclusion presented in the EIS and is due to a design refinement and impact avoidance measures.

6.3.7. Streblus pendulinus

Streblus pendulinus is a small tree or shrub that grows to 12 metres tall.

This species was not considered in the EIS and has been included as a result of the revised status of the species under the EPBC Act. The listing under the EPBC Act for *Streblus pendulinus* treated the species as endemic to Norfolk Island and islands of the Pacific Ocean. However, recent taxonomic changes have resulted in the mainland species *Streblus brunonianus* being included with *Streblus pendulinus*. The mainland distribution of this species on the east coast of Australia between Milton in NSW to northern Queensland has therefore been listed under the EPBC Act.

Previous surveys for rainforest plants in the study area were conducted prior to these changes taking effect and therefore the species was not identified as a threatened species. As such, the EIS did not assess this species.

Supplementary surveys were therefore undertaken to target this species in the study area. These surveys recorded 43 individuals.

6.3.7.1. Direct and indirect impacts

Under the EIS design, the project would require removal of seven individuals. The design refinement at the interchange at Wardell would increase this impact to eight. This is around 19 per cent of the known population in the study area, but the local population is likely to include additional individuals outside the study area. The project would also result in the removal of 4.2 hectares of potential habitat for this species.

The project would also create new edge effects due to the partial removal of a vegetation patch that could indirectly impact one of the remaining individuals that is 3.5 metres from the project boundary. This individual would potentially be impacted by edge effects due to removal of part of the rainforest patch where it occurs and as a result of altered hydrology regimes.

The remaining 34 individuals are greater than 50 metres up slope of the project footprint and the project would not result in further clearing of the patch of rainforest habitat where they occur. Indirect impacts from altered hydrological regimes and edge effects are therefore not anticipated to be exacerbated by the project.

6.3.7.2. Assessment of significance: endangered species (EPBC Act)

The assessment of significance was undertaken according to criteria for endangered species in the DEWHA (2009) assessment guidelines. The assessment is provided in Table 6-24.

Table 6-24 Assessment of significance: *Streblus pendulinus* (EPBC Act)

Streblus pendulinus
According to the DSEWPAC (2009) 'significant impact criteria' an action is likely to have a significant impact on an endangered species if there is a real chance or possibility that it would:
Lead to a long-term decrease in the size of a population
Recent targeted surveys for *Streblus pendulinus* have recorded a total of 43 individuals in and surrounding the project area. Of these 43 individuals, impacts would be limited to eight individuals that occur in the project boundary and there is potential for indirect impacts on one individual, comprising a potential impact on 19-21% of the known population in the study area. 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. *Streblus pendulinus* is likely to be insect and wind 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. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. The project has the potential to lead to a long-term decrease with up to 21% of the known population being potentially impacted (direct and indirectly), however the local population is likely to comprise a substantially larger number of individuals in surrounding habitats. The proposed mitigation measures would minimise the potential or indirect impacts on remaining individuals. Considering the widespread nature of this species on mainland Australia and the potential for a large population to be present in the locality, direct and indirect impacts on nine individuals is unlikely to lead to long-term decrease in the size of the local population.
Reduce the area of occupancy of the species
Streblus pendulinus occurs from Cape York Peninsula in northern Qld to Milton in south-east NSW, as well as Norfolk Island (The Royal Botanic Gardens and Domain Trust 2012). Outside of Australia, the species is found in Papua New Guinea, Micronesia, Vanuatu, New Caledonia, Fiji, Rapa and Hawaii. Around 95.8 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 4.2 hectares would be impacted. Reductions to the area of occupancy of this species would be limited to less than 0.1 hectares of habitat where this species occurs within the project boundary. Although there would be a small reduction to the area of occupancy for this species, the proposed mitigation measures including restoration of rainforest habitats have the potential to increase the area of occupancy for this species.
Fragment an existing 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 4.2 hectares of the 95.8 hectares of potential rainforest habitat for this species potentially being impacted. Although the population would be fragmented by the project, potential flying insect pollinators are likely to cross the project boundary between individuals continuing genetic exchange between individuals.
Adversely affect habitat critical to the survival of a species
Around 95.8 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around three hectares would be impacted. The occupied area of habitat for this species within the project boundary comprises less than 0.1 hectares of rainforest. Rainforest habitats within and surrounding the project boundary are regarded as being critical to the survival of this species and around 19-21% is proposed to be directly impacted. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. These measures have the potential to increase the area

Streblus pendulinus
of habitat critical to the survival of this species. Considering the minor proportion of habitat being impacted in the study area (19-21% and the proposed restoration, management and monitoring proposed as part of the mitigation measures the project is unlikely to adversely affect habitat critical to the survival of the species.
Disrupt the breeding cycle of a population
The life cycle of *Streblus pendulinus* 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. *Streblus pendulinus* is likely to be insect and wind 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. The project would not result in the further isolation of individuals of this species from one another, with all known individuals being within 500 metres of another individual. There is some potential for the genetic diversity of the local population of *Streblus pendulinus* to be depleted, however considering the widespread distribution of the species and the relatively small proportion being impacted by the project, depletion of the genetic diversity in the species is considered unlikely. There is potential for the breeding cycle to be disrupted from the removal of up to 21% of the known available gene pool, however considering that the project would not result in the further isolation of individuals, genetic exchange between individuals is expected to continue for the remaining individuals and it is unlikely that the project would result in disruption of the breeding cycle.
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 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 three hectares of the 95.8 hectares of potential rainforest habitat for this species potentially being impacted comprising around 19-21% of the available habitat. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. These measures have the potential to increase the area of occupancy for this species. Considering the minor proportion of habitat being impacted in the study area (19-21%) and the proposed restoration, management and monitoring proposed as part of the mitigation measures the project is unlikely to 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 critically endangered or endangered species becoming established in the endangered or critically endangered 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. 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. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. These measures have the potential to increase the area of occupancy for this species. Considering the proposed habitat restoration and weed management mitigation measures and the current levels of weed invasion and other disturbances the project is unlikely to result in further invasive species becoming established and resulting in further impacts on the species.

Streblus pendulinus
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. Considering the proposed mitigation measures to limit the spread and introduction of disease, the project is unlikely to result in harm to the species from disease.
Interfere 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 project including protective fencing, 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 on this species 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 *Streblus pendulinus* would contribute towards the recovery of the species.

Conclusion of the assessment

Overall, the project would have a potential impact on 19–21 per cent of the known population of Streblus pendulinus in the study area. Eight individuals would be removed and one individual would be indirectly impacted.

However, the project is unlikely to result in a significant impact on the local population because the local population is likely to comprise a substantially larger number of individuals. The individuals identified during recent field surveys are likely to be part of a much larger population of this species occurring in rainforest habitats surrounding the corridor in Section 10. In addition, the species is widespread on the mainland, and there are large areas of habitat surrounding the project that are likely to support a relatively large population.

This species was not considered in the EIS and has been included as a result of the revised status of the species under the EPBC Act.

6.3.8. Syzygium hodgkinsoniae

Syzygium hodgkinsoniae is a small tree that grows to 11 metres tall on. This species has been re-assessed because of the proposed design refinement at the interchange at Wardell.

Surveys undertaken for the EIS identified one individual of *Syzygium hodgkinsoniae* in the area. However, supplementary surveys undertaken beyond the project boundary identified a total of eight individuals.

6.3.8.1. Direct and indirect impacts

The design refinement at the proposed interchange at Wardell would avoid direct impacts on this species. However, one individual occurs less than one metre from the project boundary and is likely to be indirectly impacted. Indirect impacts could consist of edge effects and altered hydrology regimes.

An additional eight individuals occur around 4.5 kilometres to the north of this single individual on the edge of the project boundary and are likely to be part of a separate sub-population of this species. These eight individuals occur around 175 metres upstream of the project, so indirect impacts on these individuals are not anticipated.

The one individual of *Syzygium hodgkinsoniae* constitutes around 11 per cent of the known population in the study area, but the local population is likely to include additional individuals outside the study area.

The design refinement would also result in the removal of 4.2 hectares of potential habitat for this species.

6.3.8.2. Assessment of significance: vulnerable species (EPBC Act)

The assessment of significance was undertaken according to criteria for vulnerable species in the DEWHA (2009) assessment guidelines. The assessment is provided in Table 6-25.

Table 6-25 Assessment of significance: *Syzygium hodgkinsoniae* (EPBC Act)

Syzygium hodgkinsoniae
According to the DSEWPAC (2009) 'significant impact criteria' an action is likely to have a significant impact on an vulnerable species if there is a real chance or possibility that it would:
Lead to a long-term decrease in the size of an important population
A total of 9 individuals have been recorded in the study area, of which 1 individual is within one metre of the project boundary and would potentially be indirectly impacted from edge effects by the project. This impact constitutes around 11% of the known population in the study area, however the local population is likely to include additional individuals outside of the study area. The modified concept design would result in the removal of 4.2 hectares of potential habitat for this species. This species 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 likely to be readily distributed by fruit-eating bird species. The project would not result in the further isolation of individuals of this species from one another, with all known individuals being within 500 metres of another individual. The project would result in the removal of 4.2 hectares of potential habitat for this species and there is potential for edge effects from habitat removal to indirectly impact one individual in close proximity to the project boundary. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. The project is unlikely to lead to a long-term decrease in the population with only one of the nine remaining individuals being vulnerable to indirect impacts. The proposed mitigation measures would minimise the potential for indirect impacts on individuals.
Reduce the area of occupancy of an important population
In NSW habitat for *Syzygium hodgkinsoniae* includes various rainforest communities. Around 81.4 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 4.2 hectares would be impacted. Reductions to the area of occupancy of this species would be limited to less than 0.1 hectares of habitat where this species occurs within the project boundary. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of remaining rainforest habitat within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. These measures have the potential to increase the area of occupancy for this species. Although there would be a small reduction to the area of occupancy for this species proposed mitigation measures including restoration of rainforest habitats have the potential to increase the area of occupancy for this species.
Fragment an existing population into two or more populations
The project would result in the dissection of 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 4.2 hectares of the 81.4 hectares of potential rainforest habitat for this species potentially being impacted.

Syzygium hodgkinsoniae

Although the population would be potentially fragmented by the project, potential flying insect pollinators are likely to cross the project boundary between individuals continuing genetic exchange between individuals.

Adversely affect habitat critical to the survival of a species

Around 81.4 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 4.2 hectares would be impacted. The occupied area of habitat for this species within the project boundary comprises less than 0.1 hectares of rainforest. Rainforest habitats within and surrounding the project boundary are regarded as being critical to the survival of this species and around 3 per cent is proposed to be directly impacted.

Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. These measures have the potential to increase the area of habitat critical to the survival of this species.

The project would result in the removal of around 4.2 hectares of habitat critical to the survival of the species.

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.
- Seed dispersal
- 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. The seeds are likely to be readily distributed by fruit-eating bird species. The project would not result in the further isolation of individuals of this species from one another.

There are several current disturbance regimes operating in the study area including edge effects from habitat fragmentation, weed invasion and agricultural activities. Considering the proposed mitigation measures including minimising indirect impacts, habitat restoration, weed management and monitoring, current disturbance regimes are unlikely to be exacerbated and there is potential to improve habitat condition.

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 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 4.2 hectares of the 81.4 hectares of potential rainforest habitat for this species potentially being impacted comprising around 3 per cent of the available habitat.

Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. These measures have the potential to increase the area of occupancy for this species.

Considering the minor proportion of habitat being impacted in the study area (3 per cent) and the proposed restoration, management and monitoring proposed as part of the mitigation measures the project is unlikely to 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 critically endangered or endangered species becoming established in the endangered or critically endangered 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. 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.

Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through

Syzygium hodgkinsoniae
restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. These measures have the potential to increase the area of occupancy for this species. Considering the proposed habitat restoration and weed management mitigation measures and the current levels of weed invasion and other disturbances the project is unlikely to result in further invasive species becoming established and resulting in further impacts on the species.
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 construction 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. Considering the proposed mitigation measures to limit the spread and introduction of disease, the project is unlikely to result in harm to the species from disease.
Interfere 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 project including protective fencing, monitoring of populations and weed control within habitat areas. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring.

6.3.8.3. Assessment of significance: vulnerable species (TSC Act)

The assessment of significance for this species was undertaken in consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-26.

Table 6-26 Assessment of significance: *Syzygium hodgkinsoniae* (TSC Act)

Syzygium hodgkinsoniae
How is the project likely to affect the lifecycle of a threatened species and/or population?
All known locations of this species have been avoided, however one individual occurs less than one metre from the project boundary and is likely to be indirectly impacted. An additional eight individuals occur around 4.5 kilometres to the north of this single individual on the edge of the project boundary and are likely to be part of a separate sub-population of this species. Remaining individuals occur around 175 metres up slope of the project and there is not anticipated to be any indirect impacts on these individuals. There is anticipated to indirect impacts on the single individual in close proximity to the project boundary from edge effects and altered hydrology regimes considering the very close proximity (less than one metre) to the project boundary. 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. The project would not result in the further isolation of individuals of this species from one another, with all known remaining individuals being within 500 metres of another individual. The modified concept design would result in the removal of 4.2 hectares of potential habitat for this species and there is potential for edge effects from habitat removal to indirectly impact four of the remaining individuals in close proximity to the project boundary. The project boundary is around 7 metres from one individual and 22 metres from three individuals which would potentially impacted from edge effects with the removal of part of the rainforest patch where these individuals occur. These individuals also occur on relatively flat terrain and therefore are vulnerable to changes to hydrology regimes as a result of the project.

Syzygium hodgkinsoniae
Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and 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 81.4 hectares of potential rainforest habitat for this species has been identified within and surrounding the project boundary, of which around 4.2 hectares would be impacted. There is potential for edge effects from habitat removal to indirectly impact four of the remaining individuals in close proximity to the project boundary. The project boundary is around 7 metres from one individual and 22 metres from three individuals which would potentially impacted from edge effects with the removal of part of the rainforest patch where these individuals occur. These individuals also occur on relatively flat terrain and therefore are vulnerable to changes to hydrology regimes as a result of the project. The mitigation measures outlined in the working paper and species-specific management plans are directly applicable to both the concept design and the design refinement around rainforest patches in Section 10. Specific mitigation measures for this species would focus on maintaining existing biotic and abiotic conditions in the patch of rainforest where the remaining four individuals of this species occur in close proximity to the project boundary along with three other threatened rainforest species. Specific measures for this patch include the establishment of an exclusion zone including installation of barrier fencing during construction, adequate sediment and erosion controls during construction, sediment retention basins up stream of this patch and the installation of a bridge structure over Randles Creek feeding into this patch which would maintain existing hydrological conditions as close as possible. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and 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?
There are several current disturbance regimes operating in the study area including edge effects from habitat fragmentation, weed invasion and agricultural activities. The project would result in the removal of 4.2 hectares of potential habitat for this species and there is potential for edge effects from habitat removal to indirectly impact a single individual close proximity (less than one metre) to the project. Specific mitigation measures for this species would focus on maintaining existing biotic and abiotic conditions in the patch of rainforest where the individual of this species occurs in close proximity to the project boundary. Specific measures for this patch include the establishment of an exclusion zone including installation of barrier fencing during construction, adequate sediment and erosion controls during construction, sediment retention basins up stream of this patch and the installation of a bridge structure over Randles Creek feeding into this patch which would maintain existing hydrological conditions as close as possible. Potential impacts on this species, rainforest habitats and other threatened rainforest flora would be mitigated through restoration and management of the remaining areas of rainforest habitat which would be retained within the road boundary and proposed offset sites. Potential restoration and management measures are detailed in a specific management plan for threatened rainforest flora species and may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. Considering the proposed mitigation measures including minimising indirect impacts, habitat restoration, weed management and monitoring, current disturbance regimes are unlikely to be exacerbated and there is potential to improve habitat condition.
How is the project likely to affect habitat connectivity?
The project would result in the dissection of habitat for this species, however habitat for this species is currently highly fragmented in the locality and the project would result in further fragmentation of habitats with around 4.2 hectares of the 81.4 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

Conclusion of the assessment

The project would result in a significant impact on *Syzygium hodgkinsoniae* under Commonwealth and State assessment criteria, as it would have a potential indirect impact on 11 per cent of the known population in the study area (one individual). Proposed mitigation measures would minimise the potential for a significant impact on this species.

This conclusion is consistent with the conclusion in the EIS.

6.3.9. Summary of assessment of significance for threatened rainforest plants

The assessment of significance for threatened rainforest plants is summarised in Table 6-27.

Table 6-27 Conclusion of the impact assessment for rainforest plants

Species	Status		Significant impact
	EPBC Act	TSC Act	
Acronychia littoralis (Scented Acronychia)	E	E	Yes
Archidendron hendersonii (White Lace Flower)	-	V	No
Cryptocarya foetida (Stinking Cryptocarya)	V	V	Yes
Endiandra hayesii (Rusty Rose Walnut)	V	V	Yes
Endiandra muelleri subsp. bracteata (Green-leaved Rose Walnut)	-	E	No
Macadamia tetraphylla (Rough-shelled Bush Nut)	V	V	No
Streblus pendulinus syn. S. brunonianus (Whalebone Tree)	E	-	No
Syzygium hodgkinsoniae (Red Lilly Pilly)	V	V	Yes

6.4. Other threatened (non-rainforest) flora

The supplementary surveys confirmed the results and assessment of impacts from the EIS biodiversity working paper. The surveys also recorded new threatened species not previously identified, and changed threatened species population size for several other species, as shown in Table 6-28.

Table 6-28 Results of threatened plant surveys and adjusted impacts

Species	Status		Project Section	No. impacted (EIS)	Adjusted No. impacted	Total subject population
	EPBC	TSC				
Angophora robur (Sandstone Rough-barked Apple)	V	V	3	6893	7056	125,076
Arthraxon hispidus (Hairy Joint-grass)	V	V	10	9.8 ha	8.4 ha	21.3 ha
Eleocharis tetraquetra (Square-stemmed Spike-rush)	-	E	1	0	6 population clusters	11 population clusters
Eucalyptus tetrapleura (Square-fruited Ironbark)	V	V	2	1213	760	159,629
Grevillea quadricauda Four-tailed Grevillea	V	V	3	8	8	218
Lindsaea incisa (Slender Screw Fern)		E	3	0.4	0.4	2.7 ha

Species	Status		Project Section	No. impacted (EIS)	Adjusted No. impacted	Total subject population
	EPBC	TSC				
Marsdenia longiloba (Slender Marsdenia)	V	E	10	0	0	6
Maundia triglochinoides		V	1	0.21 ha	0.23 ha	3.15 ha
Phaius australis (Southern Swamp Orchid)	E	E	9	0	0	68
Quassia sp. Mooney Creek (Moonee Quassia)	E	E	1	0	35	899

An assessment of significance is required for species where there has been a change from the impacts reported in the EIS, resulting in either an increase or decrease in the level of impact or there is a reported increase in population size determined by the targeted surveys. Accordingly, a revised assessment of significance was undertaken for the following species:

- *Angophora robur.*
- *Arthraxon hispidus.*
- *Eleocharis tetraquetra.*
- *Eucalyptus tetrapleura.*
- *Maundia triglochinoides.*
- *Olax angulata.*
- *Quassia sp. Moonee Creek.*

With regard to the remaining species, the following applies:

- *Marsdenia longiloba*: In the EIS, it was assessed that the project would not impact on any individuals of the species. Supplementary surveys identified an additional small population of *Marsdenia longiloba* outside the Section 10 project corridor that are not expected to be indirectly impacted by the project. Therefore, there is no change in potential impact to the species, and a revised assessment of significance is not required.
- *Lindsaea incisa*: The EIS identified an impact on 0.4 hectares of this species, out of a known 2.7 hectares population. Through supplementary surveys, an additional small population of *Lindsaea incisa* was identified in the study area along an access track to a proposed ancillary site and well outside the project corridor in Section 3. The plants could be avoided through management measures and would not be impacted by the project. Therefore, there is no change in potential impact to the species, and a revised assessment of significance is not required.
- *Phaius australis*: In the EIS, it was reported that the project would not impact this species, so it was not assessed. Supplementary surveys have identified a new population of the *Phaius australis* in Broadwater National Park to the east of the project in Section 9. This conserved population is at a suitable distance from the project where indirect impacts are not expected. Therefore, an assessment of significance is not required.
- *Grevillea quadricauda*: The EIS identified 208 individuals of this species in two subpopulations. Supplementary surveys of the species have increased this number to 218 individuals. These 10 newly identified plants would not be impacted by the project, and the impact on the species remains as identified in Table 10-15 of the EIS, with only eight individuals within the project boundary.

6.4.1. Angophora robur

6.4.1.1. Direct and indirect impacts

Angophora robur is a species of Eucalypt tree known from dry-forests in the Clarence Valley. The EIS design would require removal of 6893 *Angophora robur* individuals. The design refinements would increase the impact to 7056 individuals (an additional 163 individuals). This impact represents 5.6 per cent of the local population (125,076 individuals). The increased loss of individuals would result from:

- Design refinements at Firth Heinz Road (loss of an additional 181 individuals).
- Design refinements at Crowleys Road (loss of an additional 11 individuals).
- Design refinements at the rest area at Tucabia (avoidance of 408 individuals).
- The confirmed recording of 379 additional individuals in the corridor during the supplementary surveys.

Indirect impacts on the remaining individuals of *Angophora robur* adjacent to the project boundary may involve weed and disease invasion and contaminated surface runoff. These effects are not anticipated to be substantial and mitigation measures would manage the potential impacts. The project would be downstream of the majority of the retained individuals, so indirect impacts from altered hydrological and soil conditions would be limited. Considering *Angophora robur* has been observed growing in edge-affected habitats throughout the study area including roadsides, impacts from edge effects are not anticipated to significantly affect the growth or health of individuals.

The project would create around 20 kilometres of new edges through *Angophora robur* habitat. Indirect impacts on habitat for the species may extend up to 30 metres from the edge of the project, resulting in potential impacts on up to 60 hectares of habitat for *Angophora robur*. However, much of this area of habitat would be upslope of the project and substantial indirect impacts are unlikely to occur.

The population clusters and potential impacts from the project on *Angophora robur* are detailed in Table 6-29.

Table 6-29 *Angophora robur* populations and impacts from the project

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	*452*	*37,988*	*1529*	*18.2 hectares (4%)*
Population Cluster 2 – Firth Heinz Rd	*23*	*1,971*	*301*	*3.6 hectares (15.2%)*
Population Cluster 3 – Bostock Road	*21*	*1,734*	*492*	*5.9 hectares (28.3%)*
Population Cluster 4 – Sommervale Road to Tallowwood Lane	*190*	*15,963*	*1,362*	*16.2 hectares (8.5%)*
Population Cluster 5 – Tucabia Road	*14*	*1183*	*142*	*1.7 hectares (12%)*

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 6 – Tyndale	*686*	*57,625*	*3230*	*38.5 hectares (5.6%)*
Eastern Population (total including additional population clusters not impacted by the project)	Known: 1489	Known: 125,076	Known: 7056	**84.1 hectares (5.6% of known local population)**
Northwest Population (Copmanhurst, Coaldale including Fortis Creek NP)	Known: 457 Predicted 7,368	Known: 38,388 Predicted 618,912	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)	9,314 hectares	782,376	7056	84.1 hectares from total 9,314 hectares (0.9% of known regional population)

Because of the additional impacts on *Angophora robur,* assessments of significance have been revised. These are provided below.

6.4.1.2. Assessment of significance: vulnerable species (EPBC Act)

The assessment of significance was undertaken according to criteria for vulnerable species in the DEWHA (2009) assessment guidelines. The assessment is provided in Table 6-30.

Table 6-30 Assessment of significance: *Angophora robur* (EPBC Act)

Angophora robur
According to the DSEWPAC (2009) 'significant impact criteria' an action is likely to have a significant impact on an vulnerable species if there is a real chance or possibility that it would:
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, December 2011 and January 2013. There is estimated to be around 7,056 individuals of *Angophora robur* affected by the project occurring over 84.1 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 above in Table 6-28. 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 163,464 individuals occurring over 1,946 hectares, whilst the predicted distribution includes a far larger area with the northwest population estimated to consist of 618,912 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 sub-population have been mapped within and surrounding the project boundary occurring over 1,489 hectares with individual clusters ranging from 14 to 686 hectares in area. All known locations within 500 metres of

Angophora robur

each other have been regarded as being part of the same population cluster based on the likely maximum dispersal distance of pollinators between sub-populations. A total of six of the 11 known population clusters occur in the project boundary.

The project would potentially impact up to 7,056 individual *Angophora robur* including 84.1 hectares of known habitat. This impact represents a significant proportion of the known extent of the eastern sub-population 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.

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. Indirect impacts on habitat for the species may extend up to 30 metres from the edge of the project, with around 20 kilometres of new edges being created through *Angophora robur* populations resulting in potential impacts on up to 60 hectares of habitat for *Angophora robur*. However much of this area of habitat is up slope of the project and is unlikely to substantially indirectly impacted.

The project would potentially have a significant impact to the eastern population of *Angophora robur* considering that potentially up to 5.6 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 degree of impact on this species the project would potentially to lead to a long-term decrease in the size of this important population, however this could be somewhat offset through the restoration of potential habitat for the species in modified lands and protection of habitat for the species.

Reduce the area of occupancy of an important population

The project would result in the removal of up to 84.1 hectares of known occupied habitat for *Angophora robur*. This area of potentially impacted habitat comprises around:

- 5.6 per cent of the known occupied habitat of the eastern sub-population.
- 4.3 per cent of the known extent of the eastern population and northwest sub-population.
- 0.9 per cent of the known and predicted extent of the eastern and northwest sub-populations and records from the southwest sub-population (500 individuals).

Impacts to the eastern sub-population (5.6 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 on habitat for *Angophora robur* are likely to represent a significantly smaller proportion when including the entire extent of the species, including the southwest sub-population and additional locations of the eastern and northwest sub-populations not surveyed during this project.

Considering the large degree of impact to this important population the extent would be reduced through direct impacts from the project.

Fragment an existing 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 a species

The project would potentially impact up to 7,056 individual *Angophora robur* including 84.1 hectares of known habitat. This impact represents a significant proportion of the known extent of the eastern sub-population 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 sub-populations comprises 163,464 individuals occurring over 1,946 hectares, of which the potential impact represents around 4.3 per cent of the population and area of habitat. The project would adversely affect around 84.1 hectares of habitat critical to the survival of the species.

Angophora robur

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:

- 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 population in the corridor represents the known eastern distribution of the species. A total of 11 population clusters within the larger eastern sub-population have been mapped within and surrounding the project boundary occurring over a total of 1,489 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 sub-populations.

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. The project has the potential to disrupt the breeding cycle of this important population through depletion of genetic diversity, however pollination is expected to continue within the remaining proportion of the population.

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 potentially impact up to 7,056 individual *Angophora robur* including 84.1 hectares of known habitat. This impact represents a significant proportion of the known extent of the eastern sub-population 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 sub-populations comprises 163,464 individuals occurring over 1,946 hectares, of which the potential impact represents around 4.3 per cent of the population and area of habitat. The project would remove up to 84.1 hectares of habitat for the species which would result in declines 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;

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 runoff 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 construction 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.

Interfere 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 project including protective fencing, 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.

6.4.1.3. Assessment of significance: vulnerable species (TSC Act)

The assessment of significance for *Angophora robur* was undertaken in consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-31.

Table 6-31 Assessment of significance: *Angophora robur* (TSC Act)

Angophora robur
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, December 2011 and January 2013. 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. The project would potentially impact up to 7,056 individual *Angophora robur* including 84.1 hectares of known habitat. This impact represents a significant proportion of the known extent of the eastern sub-population comprising around 5.6 per cent of the population and area of habitat. The project would potentially have a significant impact to the eastern population of *Angophora robur* considering that potentially up to 5.6 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. The life cycle of the species is unlikely to be substantially modified by the project provided mitigation measures are adequately implemented.
How is the project likely to affect the habitat of a threatened species, population or ecological community?
There is estimated to be around 7,056 individuals of *Angophora robur* in the project boundary occurring over 84.1 hectares. The entire current known extent of *Angophora robur* includes three main clusters as detailed in the table below, 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 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 runoff and altered hydrology would not affect the remaining individuals of *Angophora robur*. Indirect impacts on habitat for the species may extend up to 30 metres from the edge of the project, with around 20 kilometres of new edges being created through *Angophora robur* populations resulting in potential impacts on up to 60 hectares of habitat for *Angophora robur*. However as mentioned much of this area of habitat is up slope of the project and is unlikely to substantially indirectly impacted. A total of six of the 11 known population clusters occur in the project boundary and these are described in Table 6-28. Around 5.6 per cent of the known area of habitat occupied by the local population would be impacted by the project. The potential impacts on habitat for *Angophora robur* is likely to represent a relative small proportion of the available habitat in the locality when considering additional areas of habitat are likely to be present in unsurveyed areas, and this is further reduced when considering the entire extent of the species, including the southwest and northwest sub-populations.

Angophora robur
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 125,076 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 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 runoff 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

Conclusion of the assessment

The project would have a significant impact on the local population of *Angophora robur* as it would remove an estimated 7056 individuals within the project boundary, which occur over 84.1 hectares and comprise up to 5.6 per cent of the local population.

This conclusion is consistent with the conclusion in the EIS.

6.4.2. Arthraxon hispidus

6.4.2.1. Direct and indirect impacts

Arthraxon hispidus is a species of grass with habitat preference for cleared wet pasture land and paddocks. Surveys for the EIS recorded several large populations of *Arthraxon hispidus* in Section 10 between Lumleys Lane and Coolgardie Road (station 154.9 to 157.6). No additional populations were identified from the supplementary surveys.

The impacts on this species are calculated in terms of area of habitat, rather than individual plants, as individuals are very difficult to distinguish and quantify in the field. The EIS assessed that the EIS design would require removal of 9.8 hectares of this species. The design refinement at the interchange at Wardell would avoid direct impacts on 1.4 hectares; as a result, 8.4 hectares would be removed.

The total area of occupied habitat identified in the study area comprises 20.9 hectares. Hence, the project would directly clear around 40 per cent of the local population. Additional areas may be indirectly impacted as well, but this species favours disturbed and modified habitats and has potential to colonise areas

disturbed by the project. The spatial extent of the population is large with a potential population size suggesting that the risk of local extinction from removal of 40 per cent of this population would still be low. However, there is a risk of increased weed abundance adjoining the road and this would increase competition with remaining areas of *Arthraxon hispidus* in addition to runoff impacts.

Some drying out of land around the population may result from the collection of surface water and diversion to drains and basins away from the low-lying areas, but it is expected that the site's low-lying topographic position on the floodplain will mean that soil moisture conditions remain damp enough for germination and growth of *Arthraxon hispidus*.

This local population is divided into four sub-populations with all occupied habitats within 150 metres of each other regarded as being part of the same sub-population. The potential impacts on each sub-population and the total local population are summarised in Table 6-32. Studies on seed dispersal by *Arthraxon hispidus* (Benwell, 2004) showed the species has low dispersal capabilities and propagation generally occurs close to parent plants. The distance between these sub-populations may suggest they are separate population clusters.

Table 6-32 *Arthraxon hispidus* sub-populations and impacts

Sub-population Name/Location	Population dissected by project	Distance from nearest sub-population (metres)	Area of occupied habitat	Area of impacted occupied habitat	% of impact on population
1 – Lumley's Lane	No	995	4.2 ha	2.9 ha	69%
2 - Central	Yes	415	4.9 ha	3.0 ha	61%
3 – Coolgardie Road	Yes	180	2.9 ha	1.1 ha	37%
4 – Northern	Yes	180	8.9 ha	1.4 ha	16%
Total			**20.9 ha**	**8.4 ha**	**40%**

The project would impact a relatively significant proportion of occupied habitat, particularly for sub-populations 1, 2 and 3. While only 16 per cent of the largest sub-population (4) would be potentially impacted by the project it would be bisected and become fragmented into two smaller populations.

There is potential for the genetic diversity of these sub-populations to be depleted (particularly sub-populations 1, 2 and 3), which could lead to an inbreeding depression particularly as the species has low dispersal capabilities. There are opportunities to mitigate impacts through the maintenance, restoration and management of the remaining population within the road boundary, and translocation of plants or soil-stored seed bank within the project boundary. Potential restoration and management measures may include seed collection and propagation, landscaping, weed management and monitoring.

There is also potential for indirect impacts on at least five hectares of the remaining areas of occupied habitat. These indirect impacts could modify the habitat attributes of the remaining areas of habitat that adjoin the project footprint. Mitigation measures would be implemented to minimise indirect impacts as far as practicable. These measures would include provision of drainage via bridges and culverts, water quality controls, weed control and habitat restoration.

In total, the project would have a combined direct and potential indirect impact on 13.4 hectares of *Arthraxon hispidus*.

The following assessments of significance were prepared to assess the reduced impacts on *Arthraxon hispidus* resulting from the design refinement.

6.4.2.2. Assessment of significance: vulnerable species (EPBC Act)

The assessment of significance was undertaken according to criteria for vulnerable species in the DEWHA (2009) assessment guidelines. The assessment is provided in Table 6-33.

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.

The *Arthraxon hispidus* populations in the study area are not at the limit of the species range, which is known to occur through south-east Queensland and on the northern tablelands and northern NSW. The species was shown to have a very restricted range in the study area and was only found in Section 10 near remnant rainforest patches; suitable habitat is not widespread. It is possible that the subject populations are a key source for dispersal in the study area and are therefore important populations.

Table 6-33 Assessment of significance: *Arthraxon hispidus* (EPBC Act)

Arthraxon hispidus
According to the DSEWPAC (2009) 'significant impact criteria' an action is likely to have a significant impact on an vulnerable species if there is a real chance or possibility that it would:
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. The project would directly impact around 40 per cent of the total population within and surrounding the project boundary. Four distinct sub-populations have been identified based on their spatial distribution with all occupied habitats within 150 metres each other regarded as being part of the same sub-population. This is based on 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 on each sub-population is summarised in Table 6-32. The area of known habitat for *Arthraxon hispidus* being impacted has been decreased by around 1.4 hectares from 9.8 hectares to 8.4 hectares compared with the EIS concept design. The total area of occupied habitat identified in the study area comprises 20.9 hectares of which the project would potentially impact around 40 per cent. A relatively significant proportion of occupied habitat would be potentially impacted from the project, particularly for sub-populations 1, 2 and 3 with up to 37 to 69 per cent of these sub-populations being impacted. Only 16 per cent of the largest population would be potentially impacted by the project although this population would be dissected by the highway leaving two smaller fragments adjoining the project and subject to further indirect impacts, suggesting total impacts may be around 65 per cent. There is potential for the genetic diversity of these sub-populations to be depleted particularly for sub-populations 1, 2 and 3 which could lead to an inbreeding depression. There are potential opportunities to mitigate potential impacts on this species through the maintenance, restoration and management of the remaining population which would be retained within the road boundary, and translocation of plants or soil-stored seed bank within the project boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. There is potential for indirect impacts to modify the habitat attributes of the remaining areas of habitat adjoining the project boundary. Mitigation measures would be implemented to minimise indirect impacts as much as possible including sufficient drainage structures including bridges and culverts, water quality controls, weed control and habitat restoration. There is potential for indirect impacts on at least five hectares of the remaining areas of occupied habitat. The total direct impact and potential indirect impact comprises 13.4 hectares. Considering up to 65 per cent of this important population would be impacted and the fragmentation of remaining areas, the project has the potential to lead to a long-term decrease in the size of this important population.

Arthraxon hispidus
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 20.9 hectares of which 8.4 hectares (40 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. There is potential for indirect impacts on at least five hectares of the remaining areas of occupied habitat. The total direct impact and potential indirect impact comprises 13.4 hectares representing 64 per cent of the known local population. Considering up to 65 per cent of the local population would potentially be impacted this will reduce the areas of occupancy. There were no other populations reported in the project area.
Fragment an existing population into two or more populations
The project would result in further fragmentation of individuals. The sub-populations which would be dissected by the project are identified in the Table 6-31. Subpopulations 2, 3 and 4 would be dissected by the project, with individuals being retained on either side of the project. Impacts to sub-population 1 would be restricted to one edge of the populations.
Adversely affect habitat critical to the survival of a species
A relatively significant proportion of occupied habitat would be potentially impacted from the project, particularly for sub-populations 1, 2 and 3 with up to 37 to 69 per cent of these sub-populations being impacted. Only 16 per cent of the largest population would be potentially impacted by the project. The overall impact to the area of known habitat comprises 40 per cent. There is potential for indirect impacts to modify the habitat attributes of the remaining areas of habitat adjoining the project boundary. Mitigation measures would be implemented to minimise indirect impacts as much as possible including sufficient drainage structures including bridges and culverts, water quality controls, weed control and habitat restoration. Considering up to 40 per cent of the local population would potentially be impacted and the potential for indirect impacts to impact the remaining areas of habitat the project would adversely affect habitat critical to the survival of the species.
Disrupt the breeding cycle of an important population
Four distinct sub-populations have been identified based on their spatial distribution with all occupied habitats within 150 metres each other regarded as being part of the same sub-population. 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 sub-populations to be depleted particularly for sub-populations 1, 2 and 3 which could lead to an inbreeding depression. There are potential opportunities to mitigate potential impacts on 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 monitoring. There is potential for genetic diversity to be depleted which may affect the breeding cycle for the species, however pollination within the remaining population is likely to continue.
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 potentially impact around 40 per cent of the known extent 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 sub-populations 1, 2 and 3 with up to 37 to 69 per cent of these sub-populations being impacted. Only 16 per cent of the largest population would be potentially impacted by the project although would be dissected by the project. The total direct impact and potential indirect impact comprises 13.4 hectares representing 64 per cent of the known local population. Considering the relatively large proportion of the occupied habitat being impacted and the potential for indirect impacts to modify remaining habitats the project has a high potential to modify, destroy, remove, or isolate or decrease the availability or quality of habitat to the extent that the species may decline in this localised area.
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 species is threatened by competition with invasive grasses such as Setaria, and such weeds have potential to increase in abundance in adjoining areas along the project, particularly in the location preferred by Arthraxon which is damp and low-lying.

Arthraxon hispidus
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.
Interfere 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, 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.

Conclusion of the assessment

The project would have significant impacts on the local population of *Arthraxon hispidus*. This is because:

- The project would require removal of 20.9 hectares (around 40 per cent) of the total area of occupied habitat in the study area.
- There is potential for indirect impacts on at least five hectares of the remaining areas of occupied habitat. Impacts could result from invasive grasses that compete with *Arthraxon* and changes hydrology and sub-surface water regimes.
- The total direct impact and potential indirect impact would total 13.4 hectares, which is 64 per cent of the known local population. The reduction in impacts that would result from the design refinement would not substantially reduce the proportion of the local population of *Arthraxon hispidus* that would be impacted.

This conclusion is consistent with the conclusion in the EIS.

6.4.2.3. Assessment of significance: vulnerable species (TSC Act)

The assessment of significance for this species was undertaken with consideration of 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 assessment is provided in Table 6-34.

Table 6-34 Assessment of significance (TSC Act) Arthraxon hispidus

Arthraxon hispidus
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. The project would potentially impact around 40 per cent of the known extent of the species within and surrounding the project boundary. Four distinct sub-populations have been identified based on their spatial distribution with all occupied habitats within 150 metres each other regarded as being part of the same sub-population. This is based on 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 on each sub-population is summarised in Table 6-31. The area of known habitat for *Arthraxon hispidus* being impacted has been decreased by around 1.4 hectares from 9.8 hectares to 8.4 hectares compared with the EIS concept design. The total area of occupied habitat identified in the study area comprises 20.9 hectares of which the project would potentially impact around 40 per cent.

Arthraxon hispidus
A relatively significant proportion of occupied habitat would be potentially impacted from the project, particularly for sub-populations 1, 2 and 3 with up to 37 to 69 per cent of these sub-populations being impacted. Only 16 per cent of the largest population would be potentially impacted by the project. The overall impact to the area of known habitat comprises 40 per cent. There is potential for the genetic diversity of these sub-populations to be depleted particularly for sub-populations 1, 2 and 3 which could lead to an inbreeding depression. There are potential opportunities to mitigate potential impacts on this species through the maintenance, restoration and management of the remaining population which would be retained within the road boundary, and translocation of plants or soil-stored seed bank within the project boundary. Potential restoration and management measures may include seed collection and propagation, appropriate landscaping for the project, weed management and monitoring. There is potential for indirect impacts to modify the habitat attributes of the remaining areas of habitat adjoin the project boundary. Mitigation measures would be implemented to minimise indirect impacts as much as possible including sufficient drainage structures including bridges and culverts, water quality controls, weed control and habitat restoration. There is potential for indirect impacts on at least five hectares of the remaining areas of occupied habitat. The total direct impact and potential indirect impact comprises 13.4 hectares representing 64 per cent of the known local population.
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 20.9 hectares of which, 8.4 hectares (40 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. There is potential for indirect impacts to modify the habitat attributes of the remaining areas of habitat adjoin the project boundary. Mitigation measures would be implemented to minimise indirect impacts as much as possible including sufficient drainage structures including bridges and culverts, water quality controls, weed control and habitat restoration. There is potential for indirect impacts on at least five hectares of the remaining areas of occupied habitat. The total direct impact and potential indirect impact comprises 13.4 hectares representing 64% of the known local population.
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 runoff 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, however there is potential for altered hydrology regimes and weed invasion to impact habitat where the remaining individuals occur. Mitigation measures would be implemented to limit the spread and establishment of weeds design features including bridges and culverts over drainage lines to minimise alteration of hydrological regimes.
How is the project likely to affect habitat connectivity?
The project would result in further fragmentation of individuals. Table 6-31 above identifies the sub-populations which would be dissected by the project. Subpopulations 2, 3 and 4 would be dissected by the project, with individuals being retained on either side of the project. Impacts to sub-population 1 would be restricted to one edge of the population.
How is the project likely to affect critical habitat?
No critical habitat has been identified for this species

Conclusion of the assessment

The project would potentially result in a significant impact on *Arthraxon hispidus* due to the indirect impacts on around 40 to 64 per cent of the known population in the study area and the potential for indirect impacts on the remaining areas of habitat.

6.4.3. Eleocharis tetraquetra

A population of the sedge species *Eleocharis tetraquetra* was recorded in Section 1 during the supplementary surveys along tributaries of Redbank Creek. It had not been detected during earlier surveys and thus was not assessed in the EIS.

6.4.3.1. Direct and indirect impacts

Eleocharis tetraquetra occurs on edges of ponds and in riffle habitats between ponds along two creeklines including Redbank Creek and a tributary of Redbank Creek at Corindi Creek. It occurs in two different populations. (The population number was difficult to determine due to the growth habit of this species.) The species was recorded in moderate to high abundance.

The two populations comprise:

- Five sub-population clusters along the edges of Redbank Creek. This population is completely within the project footprint.
- Six sub-population clusters along a tributary of Redbank Creek. One cluster is within the project footprint and the remaining five clusters are downstream of the project.

(There are potentially other locations of this species upstream and downstream of the project boundary outside of the study area that are part of these populations.)

Therefore, six of the 11 sub-population clusters would be within the project footprint and would be directly impacted by the project, and there is potential for indirect impacts on the remaining individuals.

Plants would be retained within the project footprint where practicable. However, assuming all plants within the project boundary would be directly impacted, the project would result in the removal of 100 per cent of the population on Redbank Creek and 17 per cent of the population on the tributary of Redbank Creek.

The remaining clusters – downstream of the project on a tributary of Redbank Creek – would also be susceptible to indirect impacts. Potential indirect impacts would mainly comprise altered hydrological conditions along drainage lines and pools where the remaining individuals occur. There are several drainage lines crossing the project in this area and a mix of bridge and culvert structures would be used. Swamp forest habitats upstream of the remaining individuals feed water into the creek line where this species occurs, and a culvert structure is proposed in this area. This is likely to alter the hydrological regimes of this creekline, altering habitat conditions. The indirect impacts on the remaining five clusters are largely unknown as the potential changes in microhabitat features are not able to be accurately predicted as a result of altered hydrological regimes.

6.4.3.2. Assessment of significance: vulnerable species (TSC Act)

The assessment of significance for this species was undertaken with consideration of 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 assessment is provided in Table 6-35.

Table 6-35 Assessment of significance: *Eleocharis tetraquetra* (TSC Act)

Eleocharis tetraquetra
How is the project likely to affect the lifecycle of a threatened species and/or population?
There is limited information regarding the life cycle of *Eleocharis tetraquetra*. It is known to spread through vegetative reproduction making counting individuals difficult. It is thought vegetation reproduction may be an essential strategy for the maintenance of local populations following initial establishment from seed (NPWS 1999). One population of this species was recorded along Redbank Creek and associated tributaries at 11 locations. The species occurred in discrete areas of habitat mostly within swampy swale areas between pools. The recovery plan for *Eleocharis tetraquetra* states that the most likely habitat for the species is on tributary creeks with lower water volumes and velocity with low gradient banks and swales that are weakly incised with a constant water flow to maintain swampy conditions (NPWS 1999). These habitat conditions are consistent with observations of habitats in the study area. Of the 11 locations *Eleocharis tetraquetra* was recorded, six of these are within the project boundary and would be directly impacted. There is potential for the remaining five locations to be indirectly impacted from altered hydrology as a result of the project with all of the remaining individuals occurring downstream of the project area on the eastern side.
How is the project likely to affect the habitat of a threatened species, population or ecological community?
The recovery plan for *Eleocharis tetraquetra* states that the most likely habitat for the species is on tributary creeks with lower water volumes and velocity with low gradient banks and swales that are weakly incised with a constant water flow to maintain swampy conditions (NPWS 1999). These habitat conditions are consistent with observations of habitats in the study area. Habitat for the species is therefore limited to discrete areas where hydrological conditions are suitable. Of the 11 locations *Eleocharis tetraquetra* was recorded six of these are within the project boundary and would be directly impacted including removal of habitat. There is potential for the remaining five locations to be indirectly impacted from altered hydrology as a result of the project with all of the remaining individuals occurring downstream of the project area on the eastern side. Indirect impacts on the limited areas of suitable habitat are likely considering the drainage lines are being dissected by the alignment and filling of swampy habitats altering hydrology regimes.
Does the project affect any threatened species or populations that are at the limit of its known distribution?
This species is known from Boambee near Coffs Harbour as well as other north coast localities near Grafton and Murwillumbah. The species also occurs in south-east Queensland. The population in the Corindi Beach area is about 43 kilometres from the most southern population at Boambee.
How is the project likely to affect current disturbance regimes?
There would potentially be indirect impacts on habitat for this species considering the riparian habitat it occurs in is downstream of the project, increasing the potential for altered hydrology regimes changing flows along the creek and increasing nutrient loads potentially facilitating weed invasion. Additionally the project would require the filling of the swampy habitats and the installation of culverts which would potentially alter the habitat attributes for the remaining individuals. 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?
The project would not result in the dissection of the population however connectivity to potentially suitable upstream habitats is limited by the installation of culverts.
How is the project likely to affect critical habitat?
No critical habitat has been identified for this species.

Conclusion of the assessment

The project would potentially have a significant impact on *Eleocharis tetraquetra*. Of the 11 locations *Eleocharis tetraquetra* was recorded, six are within the project boundary and would be directly impacted (removed). There is potential for the remaining five locations to be indirectly impacted from altered hydrology as a result of the project as the remaining individuals occur downstream of the project area on the eastern side.

6.4.4. *Eucalyptus tetrapleura*

6.4.4.1. Direct and indirect impacts

Eucalyptus tetrapleura is a species of Eucalypt tree known from dry-forests in the Clarence Valley. The EIS estimated that c.1213 *Eucalyptus tetrapleura* individuals would be cleared by the project. A survey of the population number in Wells Crossing Flora Reserve was undertaken at the time of the EIS to supplement the previous data from the preferred route investigations. It estimated that of the 1213 trees cleared, around 495 individuals occur in the Wells Crossing Flora Reserve, with all of these individuals assessed as being directly impacted. The population in the reserve was based on an estimate and a more systematic survey was conducted in the flora reserve for the supplementary work. This systematic survey confirmed the population in the reserve was only around 272 individuals and a direct impact on only 137 was determined.

Therefore, the total number of *Eucalyptus tetrapleura* estimated to be impacted by the project has been reduced by 358 individuals to 855 trees from the original estimate of 1213 trees.

6.4.4.2. Assessment of significance: vulnerable species (EPBC Act)

The assessment of significance was undertaken according to criteria for vulnerable species in the DEWHA (2009) assessment guidelines. The assessment is provided in Table 6-36.

Table 6-36 Assessment of significance: *Eucalyptus tetrapleura* (EPBC Act)

Eucalyptus tetrapleura
According to the DSEWPAC (2009) 'significant impact criteria' an action is likely to have a significant impact on an vulnerable species if there is a real chance or possibility that it would:
Lead to a long-term decrease in the size of an important population
The project would impact on 855 individuals. The total population size of the local population is estimated to comprise 159,629 individuals, with an estimated proportion of the population impacted being 0.5 per cent of the local population. Considering the small proportion of the population being impacted by the project, relatively to local population, the project is unlikely to lead to a long-term decrease to this important population. However the cumulative impacts from the Glenugie project and the project would result in a significant decrease in the local population as a result of Pacific Highway projects in the study area. Vegetation clearing would potentially contribute to further invasion of *Lantana camara* and other exotic species particularly along the edges of the project where there would be increased sunlight. Other indirect impacts from vegetation clearing would include stormwater runoff potentially increasing water and nutrient loads entering adjacent bushland areas, leading to the increased growth and spread of exotic species. Considering the persistence of the species in edge effected habitats, indirect impacts from the project area not envisaged to be substantial particularly with the implementation of the proposed mitigation measures.
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 project. 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. 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 0.5 per cent of the local population and

Eucalyptus tetrapleura

around 1.7 per cent of the area of occupancy (1,289 hectares). This project would have impacts on the local distribution of the species, removing part of the local gene pool and 22.2 hectares of known habitat for *Eucalyptus tetrapleura*.

The project would reduce the area of occupancy for this important population of *Eucalyptus tetrapleura*.

Fragment an existing 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 larger 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, and additionally populations are likely to be larger than estimated on the western side of the road which was not intensively surveyed.

Adversely affect habitat critical to the survival of a 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 project represents around 0.5 per cent of the local population and around 1.7 per cent of the area of occupancy (1,289 hectares). This project would have impacts on the local distribution of the species, removing part of the local gene pool and 22.2 hectares of known habitat for *Eucalyptus tetrapleura*.

The habitat in the study area is considered to be critical to the survival of the species considering the relatively large populations recorded in these habitats. With ongoing removal of habitat including cumulative impacts from Pacific Highway projects, agricultural and forestry activities, occupied habitat for the species is becoming increasingly threatened. Considering the persistence of the species in edge effected habitats, indirect impacts from the project area not envisaged to be substantial particularly with the implementation of the proposed mitigation measures.

This project would adversely affect 22.2 hectares of habitat critical to the survival of *Eucalyptus tetrapleura*.

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, 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 project represents around 0.5 per cent of the local population and around 1.7 per cent of the area of occupancy (1,289 hectares). This project would have impacts on the local distribution of the species, removing part of the local gene pool and 22.2 hectares of known habitat for *Eucalyptus tetrapleura*. 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. Considering the persistence of the species in edge effected habitats, indirect impacts from the project area not envisaged to be substantial particularly with the implementation of the proposed mitigation measures.

Considering the small proportion of occupied habitat impacted and the limited potential for indirect impacts on areas of habitat the project is considered unlikely to modify, destroy, remove, or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline.

Eucalyptus tetrapleura
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered 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 from vegetation clearing including stormwater runoff could potentially increase water and nutrient loads entering adjacent bushland areas, leading to the increased growth and spread of exotic species. Considering the persistence of the species in edge effected habitats, indirect impacts from the project area not envisaged to be substantial particularly with the implementation of the proposed mitigation measures
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 construction 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.
Interfere 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 project including protective fencing, 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.

6.4.4.3. Assessment of significance: vulnerable species (TSC Act)

The assessment of significance for this species was undertaken in consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-37.

Table 6-37 Assessment of significance: *Eucalyptus tetrapleura* (TSC Act)

Eucalyptus tetrapleura
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: • 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.

Eucalyptus tetrapleura
How is the project likely to affect the habitat of a threatened species, population or ecological community?
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 0.5 per cent of the local population and around 1.7 per cent of the area of occupancy (1,289 hectares). This project would have impacts on the local distribution of the species, removing part of the local gene pool and 22.2 hectares of known habitat for *Eucalyptus tetrapleura*. The habitat in the study area is considered to be critical to the survival of the species considering the relatively large populations recorded in these habitats. With ongoing removal of habitat including cumulative impacts from Pacific Highway projects, agricultural and forestry activities, occupied habitat for the species is becoming increasingly threatened. Considering the persistence of the species in edge effected habitats, indirect impacts from the project area not envisaged to be substantial particularly with the implementation of the proposed mitigation measures. This project would directly impact 22.2 hectares of habitat for *Eucalyptus tetrapleura*.
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) outside of the project area 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 runoff 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

Conclusion of the assessment

The project is unlikely to result in a significant impact on *Eucalyptus tetrapleura*. This is because the local population is estimated to comprise 159,629 individuals, and the project would remove 855 individuals. This is about 0.5 per cent of the local population, which is a small proportion of the population that would be impacted.

However, when considering the cumulative impacts from the Glenugie upgrade and the project, there would be a significant decrease in the local population as a result of Pacific Highway upgrades in the study area.

This conclusion is consistent with the conclusion in the EIS.

6.4.5. *Maundia triglochinoides*

6.4.5.1. Direct and indirect impacts

Maundia triglochinoides has been recorded at in 16 population clusters close to the project boundary during the EIS field surveys in 2011 and the supplementary surveys in 2012 and 2013; 10 clusters are within the project boundary.

The supplementary surveys identified additional populations of *Maundia triglochinoides* in Section 1 along tributaries of Redbank Creek and Cassons Creek and associated areas of swamp forest. This resulted in a small increase to the known population area of occupied habitat comprising an additional 1843 square metres, and hence an increased direct impact on around 98 square metres.

The design refinement at Firth Heinz Road would avoid a known population. However, there is potential for indirect impacts from altered hydrological regimes in drainage lines and associated areas of swamp forest and billabongs where this species occurs.

The project would involve direct impacts on around seven per cent of the known extent of the species in the study area. Ten of the 16 population clusters would be directly impacted. Of these, two would be 100 per cent directly impacted (removed) and the remaining clusters would be partially impacted (between two and 60 per cent of the cluster impacted). The 16 population clusters are detailed in Table 6-38.

Table 6-38 Known locations of *Maundia triglochinoides*

Location description	Population dissected by project boundary	Population density	Total known area occupied by population	Total known area in project boundary	% of population in project boundary
Population 1 - Halfway Creek	No	Very high	10,322 m^2	250 m^2	2%
Population 2 - Wells Crossing	Yes	Very high	1324 m^2	288 m^2	22%
Population 3 - Coldstream River	Potentially	Very high	1183 m^2	0 m^2	0%
Population 4 - Chaffin Creek	No	Very high	3818 m^2	0 m^2	0%
Population 5 - Un-named creek south of Bostock Road	No	Moderate	175 m^2	0 m^2	0%
Population 6 - Several lagoons associated with un-named drainage lines east of Tallowwood Lane	Yes	Low to very high	6828 m^2	497 m^2	7%
Population 7 - Un-named creek east of Tucabia Road	No	Low	155 m^2	0 m^2	0%
Population 8 - Swamp Forest south of Tabbimoble Floodway No.2	No	Low	106 m^2	106 m^2	100%
Population 9 - Tabbimoble Floodway No.2	No	Very high	419 m^2	34 m^2	8%
Population 10 - Tabbimoble Floodway No.1	No	High	314 m^2	154 m^2	49%
Population 11 - Un-named creek 1 north of New Italy	No	Moderate	594 m^2	33 m^2	6%
Population 12 - Un-named creek 2 north of New Italy	No	Moderate	49 m^2	49 m^2	100%

Location description	Population dissected by project boundary	Population density	Total known area occupied by population	Total known area in project boundary	% of population in project boundary
Population 13 - Lagoon east of Tucabia Road	No	Very high	4340 m^2	0 m^2	0%
Population 14 – Redbank Creek	No	Moderate to high	326 m^2	48 m^2	15%
Population 15 – west of Post Office Lane	No	Very high	1350 m^2	822 m^2	60%
Population 16 – Cassons Creek	No	Moderate	168 m^2	0 m^2	0%
TOTAL			**31,471 m^2**	**2281 m^2**	**7%**

There is also potential for indirect impacts from altered hydrological regimes in drainage lines and associated areas of swamp forest and billabongs where this species occurs. The indirect impacts on the remaining individuals are largely unknown as the potential changes in microhabitat features are not able to be accurately predicted as a result of altered hydrological regimes. Some of the populations not directly impacted occur downstream of the project and would potentially be indirectly impacted. The remaining area of occupied habitat (an additional 9322 square metres) is downstream of the project and therefore at greatest risk of indirect impact.

In total, the project would have direct impacts and potential indirect impacts on 11,603 square metres, which is around 37 per cent of the known population in the study area.

6.4.5.2. Assessment of significance: vulnerable species (TSC Act)

The assessment of significance for this species was undertaken in consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-39.

Table 6-39 Assessment of significance: *Maundia triglochinoides* (TSC Act)

Maundia triglochinoides
How is the project likely to affect the lifecycle of a threatened species and/or population?
Maundia triglochinoides has been recorded at 16 locations in close proximity to the project boundary during the EIS field surveys in 2011 and the supplementary surveys in 2012 and 2013, of which 10 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. This is 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 16 population clusters are detailed above in Table 6-35. Other locations located away 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 four populations (Population 2, 10, 14 and 15), moderate impacts (five to 10 per cent) to four populations (Population 6, 9, 11) and low level impacts (two per cent) to Population 1. Additional to these direct impacts there would potentially be large scale indirect impacts on populations downstream of the project boundary from altered hydrology, sedimentation and erosion. The remaining area of occupied habitat which is downstream of the project and therefore at greatest risk of indirect impacts comprises an additional 9,322 square metres. The total impact including direct impacts and potential indirect impacts comprises 11,603 square metres representing around 37 per cent of the known population in the study area. The proposed impact boundary at Population 12 includes large sediment basins which increases the impact on *Maundia triglochinoides*. These sediment basins should be relocated to avoid impacts on the species. Population 14 is located in an area proposed for an access road which should be considered for relocation to avoid impacts on this population. Design refinements in these two areas should be investigated during detailed design in order to avoid or minimise impacts.

Maundia triglochinoides
However, population 4 occupying 3,818 square metres in the Chaffin Creek would now be avoided by the project with the proposed design changes in this area.
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 2281m² 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 suitable habitat unoccupied by the species impacted from the project including creeklines 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?
The species 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 runoff, 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

Conclusion of the assessment

The project would potentially result in a significant impact on *Maundia triglochinoides*. A high proportion of the population would be directly impacted and there is potential for indirect impacts to affect the viability of the remaining individuals.

This conclusion is consistent with the conclusion in the EIS.

The following design refinements should be investigated during detailed design in order to avoid or minimise impacts on *Maundia triglochinoides:*

- The proposed large sediment basins in Section 7 should be relocated to avoid impacts, particularly on population 12.
- The proposed access road in Section 1 should be considered for relocation (the current proposal is to relocate population 14 to make way for the road).

6.4.6. Olax angulata

The EIS assessed the potential impacts of the project on the Square-stemmed Olax (*Olax angulata)* considering the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The critical review identified that an assessment of

significance was not undertaken for this species under the EPBC Act according to the DEWHA (2009) assessment guidelines. The assessment is provided in Table 6-39.

6.4.6.1. Direct and indirect impacts

The species favours low-lying coastal heath and woodland on sandy soils, often in association with Wallum Banksia.

One individual plant was identified in the construction boundary north of Halfway Creek at Section 2, in woodland on sandy soils. Intensive general traverses were undertaken in areas radiating out from this single location in all directions to identify the spatial distribution and abundance. These surveys confirmed that this is an isolated individual and not part of an important population. The fleshy fruit of this species is potentially attractive to fruit-eating bird species and it is likely that the individual has established from dispersal of seed from a nearby population although none are identified in the study area.

The project would directly remove the individual identified. Clearing for the project would also remove up to 60 hectares of potential habitat for future recruitment. The extent of comparable habitat outside the project corridor has not been identified but is considered extensive and well represented. Other potential habitat would occur throughout large portions of Broadwater National Park, Bundjalung National Park and Yuraygir National Park.

A large population of *Olax angulata* (5500 plants) exists in a small area east of Grafton, near Minnie Water and Wooli, mainly in Yuraygir National Park and on nearby leasehold land. It has also been recorded in an area north of Grafton in Ban Yabba Nature Reserve, in Fortis Creek National Park and in adjoining freehold land.

6.4.6.2. Assessment of significance: vulnerable species (EPBC Act)

The assessment of significance was undertaken according to criteria for vulnerable species in the DEWHA (2009) assessment guidelines. The assessment is provided in Table 6-40.

Table 6-40 Assessment of significance: *Olax angulata* (EPBC Act)

Olax angulata
According to the DEWHA (2009) 'significant impact criteria' an action is likely to have a significant impact on an vulnerable species if there is a real chance or possibility that it would:
Lead to a long-term decrease in the size of an important population
The project will remove one individual and a local population has not been identified from targeted surveys. 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, although the location of this local population is not known and was not located with a 400 m radius of the project.
Reduce the area of occupancy of an important population
The project will remove one individual which is an isolated plant and there is no evidence of an important population in the construction corridor. Clearing for the project would also remove up to 60 hectares of potential habitat for future recruitment, although this habitat type is not restricted to the project corridor and is well represented in surrounding areas.
Fragment an existing population into two or more populations
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.
Adversely affect habitat critical to the survival of a species
Olax angulata was identified growing in dry sclerophyll forest dominated by Needlebark (*Eucalyptus planchoniana*). This

Olax angulata
vegetation type is widespread in the project boundary with around 60 hectares of similar habitat potentially being impacted.
Disrupt the breeding cycle of an important population
Yes, this isolated plant will be removed.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
Unlikely, this is an isolated individual and there is likely to be a local population within dispersal distance of the plant. The species and suitable habitat is also well represented in a number of conservation reserves in the region.
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 assessment considered the potential impact on surrounding areas of suitable habitat. There is potential for increased weed invasion in edge-affected habitats, although this species grows on sandy soils which exhibit low fertility and are not vulnerable to high risk invasion of noxious weeds.
Introduce disease that may cause the species to decline
The individual isolated plant will be removed; there will be no residual plants subject to indirect impacts.
Interfere with the recovery of the species.
The isolated individual identified in this location is not part of an important population that would be targeted in recovery strategies for the species.

Conclusion of the assessment

The project would remove one individual, which is not considered a significant impact. This is an isolated plant and there is no evidence of an important population in the construction corridor. Clearing for the project would also remove up to 60 hectares of potential habitat for future recruitment, but this habitat type is not restricted to the project corridor and is well represented in surrounding areas.

This conclusion is consistent with the conclusion in the EIS.

6.4.7. Quassia sp. Moonee Creek

The species was identified in surveys of Section 3 of the project and assessed in the EIS. Supplementary surveys identified a new population of *Quassia sp.* Moonee Creek within Section 1. The species was detected at about station 8.40. As a result of finding the new population in Section 1, the detailed design at Range Road was refined to reduce the impact on the population.

6.4.7.1. Direct and indirect impacts

The total population consists of two clusters around 250 metres apart, which are considered to constitute a single population. These clusters comprise:

- Cluster 1: 899 stems that were recorded by the survey for the EIS.
- Cluster 2: A smaller cluster that was recorded by the survey for the design refinement. This cluster is further south and upslope of the first cluster, and outside the impact area. The total number of plants has not been quantified.

The EIS design would require removal of 35 of the stems in cluster 1 (3.9 per cent of this cluster). The remaining individuals in this cluster are within 50 metres of the project boundary, with up to 167 stems within 10 metres of the construction edge. There is potential for the project to indirectly impact plants within 10

metres of the project. Indirect impacts could result from altered exposure and light levels, changed hydrological conditions and increased potential for competition from weeds and other flora due to the altered conditions. Therefore, the project would potentially result in impacts on 202 stems in cluster 1 (35 directly impacted and 167 indirectly impacted), which is around 22 per cent of cluster 1 and an even smaller proportion of the local population.

6.4.7.2. Assessment of significance: endangered species (EPBC Act)

The assessment of significance was undertaken according to criteria for endangered species in the DEWHA (2009) assessment guidelines. The assessment is provided in Table 6-41.

Table 6-41 Assessment of significance: *Quassia sp.* Moonee Creek (EPBC Act)

Quassia sp. Moonee Creek
According to the DEWHA (2009) 'significant impact criteria' an action is likely to have a significant impact on an endangered species if there is a real chance or possibility that it would:
Lead to a long-term decrease in the size of a population
A total of 899 stems were recorded along a rocky drainage line and surrounding rocky slopes in Section 1. This number is from the larger of two clusters. Potential habitat for this species is relatively widespread in the locality, and there is likely to be several additional populations in surrounding areas with around 70 records in the locality. One individual was also recorded previously on a rocky slope in Section 3 outside of the project boundary (230 metres away) and would not be directly or indirectly impacted from the project. Of the 899 stems recorded around 35 would potentially be directly impacted by the project, comprising about 3.9 per cent of this cluster. There are 167 individuals within 10 metres of the project, which could be affected by indirect impacts, and therefore impacts on up to 202 individuals could be expected representing around 22 per cent of this cluster and even smaller proportion of the local population. Most plants occur along a drainage line downslope of the project which is vulnerable to changes to hydrology and nutrient loads and associated weed invasion. Other indirect impacts could result from altered exposure and light levels and increased potential for competition from other flora due to the altered conditions Considering 3.9 to 22 per cent of cluster 1 would be directly impacted from the project and there is potential for the remaining individuals to be indirectly impacted, the project would potentially lead to a long-term decrease in the local population.
Reduce the area of occupancy of the species
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 in the Dirty Creek area is about 30 kilometres to the north of the southernmost population at Moonee Creek. Although the wider distribution of the species is unlikely to be significantly reduced, the subject population occurs over about 0.8 hectares of occupied habitat of which up to 0.2 hectares would potentially be directly impacted and the remaining areas potentially impacted from indirect impacts altering habitat attributes. The project would reduce the area of occupancy for the species.
Fragment an existing population into two or more populations
The project would not result in the dissection of the population however connectivity to potentially suitable downstream habitats is limited by the installation of culverts. However the absence of the species in these downstream habitats suggests these areas are potentially unsuitable for the species.
Adversely affect habitat critical to the survival of a species
The population in section 1 was recorded along a rocky drainage line dominated by Blackbutt (*Eucalyptus pilularis*). Although this vegetation type may be relatively widespread in the locality, the specific habitat attributes for this species are likely to be restricted discrete areas. There is limited literature detailing the specific habitat conditions and associated life-cycle attributes for this species, particularly in regard to fire tolerance, seed dispersal, germination and pollination. The subject population occurs over around 0.8 hectares of habitat of which up to 0.2 hectares would be directly impacted and the remaining areas of habitat would potentially be impacted from indirect impacts altering habitat attributes. Areas within 10 metres of the project have been identified as most susceptible to indirect impacts, comprising a total of 202 individuals where direct and indirect impacts could be expected representing around 22 per cent of cluster 1 and an even smaller proportion of the local population. The single individual recorded in Section 3 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

Quassia sp. Moonee Creek
boundary with around 60 hectares of similar habitat potentially being impacted, however much of this area may not have particular microhabitat features required by the species such as rocky outcrops. The project would adversely affect habitat critical to the survival of the species.
Disrupt the breeding cycle of a population
The life cycle 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. • Seed dispersal • Other disturbance regimes such as forestry activities and grazing. There is limited literature detailing the specific habitat conditions and associated life-cycle attributes for this species, particularly in regard to fire tolerance, seed dispersal, germination and pollination. The main known disruption to the life cycle of the species would be from the removal and modification of habitat, potentially resulting in the significant impacts on this local population. Considering the potential for impacts on 3.9 to 22 per cent of cluster 1 there is potential for genetic diversity to be depleted which may affect the breeding cycle for the species, however pollination within the remaining population is likely to continue.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
The subject population occurs over about 0.8 hectares of habitat of which up to 0.2 hectares would potentially be directly impacted and the remaining areas potentially impacted from indirect impacts altering habitat attributes. Areas within 10 metres of the project have been identified as most susceptible to indirect impacts, comprising a total of 202 individuals where direct and indirect impacts could be expected representing around 22 per cent of cluster 1 and an even smaller proportion of the local population Considering up to 22 per cent of cluster 1 would be directly impacted including removal of habitat from the project and there is a relatively high potential for the remaining individuals and areas of habitat to be indirectly impacted (modified), the project would potentially lead to a decline in 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;
There would potentially be indirect impacts on habitat for this species considering the riparian habitat it occurs in is downstream of the project, increasing the potential for altered hydrology regimes changing flows along the creek and increasing nutrient loads potentially facilitating weed invasion. Additionally the project would require the installation of culverts which would potentially alter the hydrology and habitat attributes for the remaining individuals. 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.
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 would not significantly conflict with the recovery actions proposed for this species. While removal of part of a population is in conflict with the objectives of the recovery plan (DEC 2005), some recovery actions could potentially be implemented. This would include protective fencing during construction, 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 on this species and habitat. There are several potential options for the offset strategy. An offset supporting *Quassia sp. Moonee Creek* would contribute towards the recovery of the species.

6.4.7.3. Assessment of significance: endangered species (TSC Act)

The assessment of significance for this species was undertaken in consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-42.

Table 6-42 Assessment of significance: *Quassia sp.* Moonee Creek (TSC Act)

Quassia sp. Moonee Creek
How is the project likely to affect the lifecycle of a threatened species and/or population?
A total of 899 stems were recorded along a rocky drainage line and surrounding rocky slopes in Section 1. Potential habitat for this species is relatively widespread in the locality, and there is likely to be several additional populations in surrounding areas with around 70 records in the locality. Of the 899 stems recorded around 35 stems would potentially be directly impacted by the project, comprising about 3.9 per cent of the population. There is a high potential for indirect impacts on the remaining species considering the majority occur along a drainage line downslope of the project which is vulnerable to changes to hydrology and nutrient loads. Areas within 10 metres of the project have been identified as most susceptible to indirect impacts, comprising a total of 202 individuals where direct and indirect impacts could be expected representing around 22 per cent of cluster 1 and an even smaller proportion of the local population. One individual was also recorded previously on a rocky slope in Section 3 outside of the project boundary and would not be directly or indirectly impacted from the project. This individual occurs around 230 metres to the east of the proposed project boundary and is considered unlikely to be indirectly impacted.
How is the project likely to affect the habitat of a threatened species, population or ecological community?
The population was recorded along a rocky drainage line dominated by Blackbutt (Eucalyptus pilularis). Although this vegetation type may be relatively widespread in the locality the specific habitat attributes for this species are likely to be restricted discrete areas. There is limited literature detailing the specific habitat conditions and associated life-cycle attributes for this species, particularly in regard to fire tolerance, seed dispersal, germination and pollination. Of the 899 stems recorded around 35 would potentially be directly impacted by the project, comprising about 3.9 per cent of cluster 1. There are 167 individuals within 10 metres of the project, which could be affected by indirect impacts, and therefore impacts on up to 202 individuals could be expected representing around 22 per cent of cluster 1 and an even smaller proportion of the local population. The subject population occurs over around 0.2 hectares of habitat of which up to half would potentially be directly impacted and the remaining areas potentially impacted from indirect impacts altering habitat attributes. The single individual recorded in Section 3 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 in the Dirty Creek area is about 30 kilometres to the north of the southernmost population at Moonee Creek.
How is the project likely to affect current disturbance regimes?
There would potentially be indirect impacts on habitat for this species considering the riparian habitat it occurs in is downstream of the project, increasing the potential for altered hydrology regimes changing flows along the creek and increasing nutrient loads potentially facilitating weed invasion. Additionally the project would require the installation of culverts which would potentially alter the habitat attributes for the remaining individuals. 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?
The project would not result in the dissection of the population however connectivity to potentially suitable downstream habitats is limited by the installation of culverts.
How is the project likely to affect critical habitat?
No critical habitat has been identified for this species

Conclusion of the assessment

The project would potentially result in a significant impact on this population as it would require removal of 35 stems and the indirect impacts could lead to the loss of up to 167 stems. Together, this loss of 202 stems is around 22 per cent of a cluster that represents more than half of the local population within the study area.

This conclusion differs from that in the EIS and reflects the additional population identified outside the impact area and the expected indirect impacts.

6.4.8. Conclusions of the assessment of significance for threatened plants

The conclusion of the assessment of significance for threatened rainforest plants is presented in Table 6-43.

Table 6-43 Conclusions of the impact assessment for threatened plants

Species	Status		Significant impact
	EPBC Act	TSC Act	
Quassia sp. Moonee Creek (Moonee Quassia)	E	E	Yes
Angophora robur (Sandstone Rough-barked Apple)	V	V	Yes
Arthraxon hispidus (Hairy Joint-grass)	V	V	Yes
Eucalyptus tetrapleura (Square-fruited Ironbark)	V	V	No
Olax angulata (Square-stemmed Olax)	V	V	No
Eleocharis tetraquetra (Square-stemmed Spike-rush)		E	Yes
Maundia triglochinoides		V	Yes

6.5. Threatened fauna

6.5.1. Pink Underwing Moth (Phyllodes imperialis smithersi)

This impact assessment in the EIS was updated to incorporate the findings of the supplementary investigations undertaken for the design refinement at the proposed Wardell interchange in sections 10 and 11 of the project.

6.5.1.1. Direct and indirect impacts

The EIS design would require removal of 6.4 hectares of known and potential habitat for the Pink Underwing Moth (*Phyllodes imperialis*). Known and preferred habitat is restricted to sections 10 and 11 of the project.

As shown in Table 6-44, the design refinement at the proposed Wardell interchange would:

- Avoid direct impact on known occupied habitat and potential breeding habitat, which would include avoiding direct impacts on areas known to have the host plant of the moth (*Carronia multisepalea*).
- Reduce the direct impact on potential non-breeding habitat from 4.7 hectares to 2.5 hectares.

Table 6-44 Comparison of direct impacts between EIS design and design refinement

Habitat for Pink Underwing Moth	EIS design	Design refinement
Known habitat (moth larvae confirmed)	1.2 ha	0.0 ha
Potential habitat (breeding; host plant present)	0.5 ha	0.0 ha
Potential habitat (non-breeding; no host plant present)	4.7 ha	2.5 ha
Total	**6.4 ha**	**2.5 ha**

The road alignment between station 154.0 and 158.0 is positioned to follow the base of the foothills of a low basalt escarpment. Vegetation to the west of the road within the escarpment and foothills is dominated by rainforest while to the east of the project the vegetation is low-lying and mostly dominated by Eucalypt or Melaleuca forests. The road design assessed in the EIS aimed to traverse the cleared land as much as possible with the rainforest habitat of the Pink Underwing Moth positioned upslope and to the west. The design refinement would move the project east, thereby affecting more of the low-lying vegetation.

Due to the presence of the cleared habitat there is an existing edge-affected zone along the rainforest habitat occupied by the moth outside the project boundary. The edge-affected zone appears in the form of a denser understorey, more open canopy in parts and higher density of weeds – mostly Camphor Laurel and Lantana – although these weeds also occur throughout the rainforest patches. There are no indirect impacts from runoff at the site as the rainforest patches are uphill from the cleared areas. Grazing impacts are evident in part of the rainforest inhabited by the moth, which are not part of the project. Despite the existing edge effects, the host plant (*Carronia multisepalea*), and the eggs and larvae of the Pink Underwing Moth were located within the edge zones.

The presence of the highway would contribute to indirect impacts at the current edge-affected zone although it may be difficult to distinguish these from the existing impacts particularly where weed invasion is concerned. Also, dust created during construction and during operation from vehicle emissions may settle on habitat areas and inhibit egg and/or larvae viability. Any changed structure of the habitat, canopy and shade in edge areas could also lead to competition with the host plant and decreased suitability of the habitat for breeding and feeding.

In addition, the project would introduce new indirect impacts from altered vehicle and street lighting and noise, which may negatively impact on the species. There is no published research on the effects of lights on the Pink Underwing Moth. While any kind of illumination is likely to disrupt normal adult moth activity for a range of common species, lights are not particularly attractive to species of *Phyllodes* moths (Dr Don Sands, *pers. comm.*). However, vehicle headlights are not expected to pose a significant threat to the moth, as these are transient rather than fixed. In addition, potential impacts would be lessened by:

- The design refinement, which would locate the alignment further east near Coolgardie Road to minimise potential impacts from lighting on the habitat of the Pink Underwing Moth.
- The redesign of ramps for the proposed interchange at Wardell to reduce the need for extensive lighting.

Another aspect to consider is dispersal. Dispersal is likely to occur to the north and west of the project and may be associated with Randles Creek (Dr Don Sands, *pers.comm.*).

However, there is limited potential for dispersal of the species. The moth favours densely shaded canopy and, given its large size, is susceptible to air movements (wind), thus restricting its dispersal capability over

cleared land. Given that the majority of the habitat of the moth occurs to the west of the project, impacts from habitat fragmentation and loss of connectivity are not expected. While the presence of the road corridor and traffic would inhibit movements of the moth, the environment currently has limited opportunities for dispersal to the east, largely due to the absence of preferred habitat.

One small exception to this is a patch of potential habitat (non-breeding) to the east of the highway on the northern side of the proposed Wardell Interchange (station 157.0) that would become fragmented. This patch would provide only marginal non-breeding habitat for the moth and a possible temporary refuge area during dispersal.

6.5.1.2. Assessment of significance: endangered species (EPBC Act)

The assessment of significance was undertaken according to criteria for endangered species in the DEWHA (2009) assessment guidelines. The assessment is provided in Table 6-45.

Table 6-45 Assessment of significance: Pink Underwing Moth (EPBC Act)

Pink Underwing Moth
According to the DEWHA (2009) 'significant impact criteria' an action is likely to have a significant impact on an endangered species if there is a real chance or possibility that it would:
Lead to a long-term decrease in the size of a population
Known and preferred habitat of the species was only identified in sections 10 and 11 of the project and consists of subtropical rainforest below about 600 metres elevation. Around 6.4 hectares of habitat for the species was identified from a 400 metre radius of the project. Potential breeding habitat is restricted to areas where the caterpillar's food plant, a native rainforest vine, *Carronia multisepalea*, occurs in subtropical rainforest. The survey targeted the identification of known (occupied) habitat, potential breeding habitat (host plant present) and potential non-breeding habitat (no host plant present). The project would impact on 2.5 hectares of habitat consisting entirely of potential non-breeding habitat (no host plant present) and no *Carronia multisepalea* would be directly impacted. The extent of potential habitat for the species beyond the 400 metres radius of the project has not been surveyed or modelled and it is likely that additional populations occur in this area. The clearing of habitat for this project would not remove current occupied habitat or breeding habitat although would remove an area of habitat that comprises known food plants (soft fruiting shrubs and trees) for the species and should be considered potential habitat. Indirect impacts would be associated with the fragmentation of the area of potential habitat and contribution to degradation along the edges of known and potential habitat associate d with increase weeds or dust and changed structure of the habitat (canopy and shade) which could lead to competition with the host plant and decreased potential for breeding and feeding. These indirect impacts can be mitigated and are proposed as part of the targeted management strategy. Impacts on dispersal of juveniles is not expected at the preferred habitat is mostly to the west and continues in this direction in adjoining areas beyond the project. The following would suggest that the project would not lead to a long-term decline in this population • Identified populations of the host plant would remain in situ • Currently occupied areas of habitat would not be directly impacted • Indirect impacts may occur along currently disturbed edge zones which are being used by the moth for breeding and these indirect impacts could be managed • Lights are not particularly attractive to species of Phyllodes moths (Dr Don Sands, *pers.comm*)
Reduce the area of occupancy of the species
The project would impact on 2.5 hectares of habitat consisting entirely of potential non-breeding habitat (no host plant present) and no *Carronia multisepalea* would be directly impacted. The extent of potential habitat for the species beyond the 400 metres radius of the project has not been surveyed or modelled and it is likely that additional populations occur in this area. The clearing of habitat for this project would not remove current occupied habitat or breeding habitat although would remove an area of habitat that comprises known food plants (soft fruiting shrubs and trees) for the species that is considered potential habitat.

Pink Underwing Moth

Fragment an existing population into two or more populations

The known population adjacent to the project currently resides over an area of known (occupied) habitat and potential breeding habitat occurring to the west of the project and associated with undulating and elevated land over basalt soils. There is no evidence of a population to the east of this location or east of the proposed highway corridor.

Along the project boundary itself and to the east of the proposed highway the soils are dominated by alluvial soils and there are a number of small patches of rainforest, in a more degraded condition. This includes the patch north of the Wardell Interchange that has been identified as a potential foraging area only and this patch would be fragmented by the road.

Currently there is limited potential for dispersal of the species in this area, which favours dense shaded canopy and given its large size, it is susceptible to air movements (wind) restricting its dispersal capability over cleared land (Dr Don Sands *pers comm*). Given that the majority of the habitat of the moth occurs to the west of the project, impacts from habitat fragmentation and loss of connectivity are not expected. While the presence of the road corridor and traffic would inhibit movements of the moth, there are currently limited opportunities for dispersal to the east, due to the absence of preferred habitat, with the exception of a patch of potential habitat (non-breeding) that would become fragmented to the east of the highway on the northern side of the Wardell interchange (Station 157.0) as discussed.

Adversely affect habitat critical to the survival of a species

Critical breeding habitat for this species is reliant on the presence of a host plant (*Carronia multisepalea*) from which the adult moth lays eggs on the leaves and the moth larvae is dependent on the leaves for food. Potential breeding habitat for the species was identified in the field and mapped and the design refinement positioned to avoid this habitat. The breeding habitat is currently flanked by cleared land and there is evidence of edge effects (weed abundance and altered habitat structure). Of interest is the fact that the host plant and moth larvae was found in this edge-affected areas. The project would contribute to these edge effects in an area identified as critical habitat, although the types of indirect impacts associated with weeds and daylight can be mitigated.

Other critical habitat would include foraging habitat (associated with fleshy fruiting species of rainforest plants) and an area of around 2.5 hectares would be cleared and further indirect impacts on the remaining patches could be expected.

Dispersal habitat has been identified to the north and west of the project, including the western portions of Randles Creek and the escarpment to the west. These habitats would not be impacted directly or indirectly.

Disrupt the breeding cycle of a population

Not expected, the project avoids known and potential breeding habitat for the species and the species management plan stipulates that clearing works would occur outside of the breeding period of the species to avoid potential indirect impacts from dust and wind.

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

Known and preferred habitat of the species was only identified in sections 10 and 11 of the project. Around 6.4 hectares of habitat for the species was identified from a 400 metre radius of the project. Potential breeding habitat is restricted to areas where the caterpillar's food plant, occurs in subtropical rainforest. The survey targeted the identification of known (occupied) habitat, potential breeding habitat (host plant present) and potential non-breeding habitat (no host plant present). The project would impact on 2.5 hectares of habitat consisting entirely of potential non-breeding habitat (no host plant present) and no *Carronia multisepalea* would be directly impacted. The extent of potential habitat for the species beyond the 400 metres radius of the project has not been surveyed or modelled and it is likely that additional populations occur in this area. Detail on meta-populations is not known.

The clearing of habitat for this project would not remove current occupied habitat or breeding habitat although would remove an area of habitat that comprises known food plants (soft fruiting shrubs and trees) for the species and should be considered potential habitat.

Indirect impacts would be associated with the fragmentation of the area of potential habitat and contribution to degradation along the edges of known and potential habitat associate d with increase weeds or dust and changed structure of the habitat (canopy and shade) which could lead to competition with the host plant and decreased potential for breeding and feeding. These indirect impacts can be mitigated and are proposed as part of the targeted management strategy. Impacts on dispersal of juveniles is not expected at the preferred habitat is mostly to the west and continues in this direction in adjoining areas beyond the project.

The following would suggest that the project would not lead to a long-term decline in this population

- Identified populations of the host plant would remain *in situ*
- Currently occupied areas of habitat would not be directly impacted
- Indirect impacts may occur along currently disturbed edge zones which are being used by the moth for breeding and these indirect impacts could be managed.
- Lights are not particularly attractive to species of Phyllodes moths (Dr Don Sands, *pers.comm*)

Pink Underwing Moth
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat;
Invasive species in this context may include Camphor Laurel and Lantana both of which are currently present and have the potential to alter the structure and floristic diversity of the habitat for this species. Due to the presence of the existing cleared habitat there is an existing edge-affected zone along the edge of the rainforest habitat occupied by the moth. This is appears in the form of a denser understorey, more open canopy in parts and presence of weeds, including Camphor Laurel and Lantana, although these weeds also occur throughout the rainforest patches and are not restricted to edge areas. Despite the existing edge impacts the host plant and eggs and larvae of the Pink Underwing Moth were located within the edge zones. Given the presence of an existing edge effected zone along the majority of the known habitat for this species and the fact that the project would not be creating a new edge it would be difficult to determine if new weed invasions are attributed to the project, particularly as runoff would be directed to the east and not within the rainforest habitat. As a precautionary approach and considering that further weed invasion could be expected in the area of potential habitat being intersected by the project, it is considered reasonable to expect that the project would contribute to the presence of these invasive species adjoining the project.
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. However the pathogen has not been identified in the area of interest and it is currently only a low risk that could be mitigated if found to occur.
Interfere with the recovery of the species.
The project and proposed highway construction would not conflict with the recovery of this species. The design refinement has been selected on the basis of avoiding high quality habitat for this species and as such is consistent with recognising the importance of habitat. There is potential that future offsets for this project would contribute to the recovery of the species.

6.5.1.3. Assessment of significance: endangered species (TSC Act)

The assessment of significance for this species was undertaken in consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-46.

Table 6-46 Assessment of significance: Pink Underwing Moth (TSC Act)

Pink Underwing Moth
How is the project likely to affect the lifecycle of a threatened species and/or population?
The clearing of habitat for this project would not remove current occupied habitat or breeding habitat although would remove an area of habitat that comprises known food plants for the species and should be considered potential foraging habitat. Indirect impacts are likely and would be associated with the fragmentation of the area of potential foraging habitat and contribution to degradation along the edges of known and potential breeding habitat. These would be associated with increased weeds or dust and potentially a changed structure of the habitat (canopy and shade) in edge areas which could lead to competition with the host plant and decreased potential for breeding and feeding. These indirect impacts can be mitigated and are proposed as part of the targeted management strategy. Disruptions to breeding life-cycle events are not expected, the project avoids known and potential breeding habitat for the species and the species management plan stipulates that clearing works would occur outside of the breeding period of the species to avoid potential indirect impacts from dust and wind.
How is the project likely to affect the habitat of a threatened species, population or ecological community?
Known and preferred habitat of the species was only identified in sections 10 and 11 of the project. Around 6.4 hectares of habitat for the species was identified from a 400 metre radius of the project. Potential breeding habitat is restricted to areas where the caterpillar's food plant, occurs in subtropical rainforest. The survey targeted the identification of known (occupied) habitat, potential breeding habitat (host plant present) and potential non-breeding habitat (no host plant present). The project would impact on 2.5 hectares of habitat consisting entirely of potential non-breeding habitat (no host plant present) and no *Carronia multisepalea* would be directly impacted. The extent of potential habitat for the species beyond the 400 metres radius of the project has not been surveyed or modelled and it is likely that additional

Pink Underwing Moth

populations occur in this area. Detail on meta-populations is not known.

The clearing of habitat for this project would not remove current occupied habitat or breeding habitat although would remove an area of habitat that comprises known food plants (soft fruiting shrubs and trees) for the species and should be considered potential habitat.

Indirect impacts would be associated with the fragmentation of the area of potential habitat and contribution to degradation along the edges of known and potential habitat associate d with increase weeds or dust and changed structure of the habitat (canopy and shade) which could lead to competition with the host plant and decreased potential for breeding and feeding. These indirect impacts can be mitigated and are proposed as part of the targeted management strategy. Impacts on dispersal of juveniles is not expected at the preferred habitat is mostly to the west and continues in this direction in adjoining areas beyond the project.

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

Yes on a local scale the sub-population is limited to Lowland Rainforest which is very patchily distributed and does not appear east of this location. There is no data on meta-populations. The following is provided for regional populations

Pink Underwing Moth (Phyllodes imperialis) is known from Papua New Guinea, the Solomon Islands, Vanuatu, New Britain, New Ireland, New Caledonia and eastern Australia (Sands 2012). The southern subspecies (P. i. smithersi) is restricted to subtropical eastern Australia from near Gympie in Queensland south to near Urunga in New South Wales (Sands 2012). Breeding (i.e. records of the larval form) has been recorded from Mary Cairncross (Sands 2012) and Witta (Herbison-Evans et al. 2011) in south-east Queensland, and from Middle Pocket (Herbison-Evans et al.2011) and near Ballina (refer to Section 2.2.2) in northern NSW. Whilst this project has revealed the second only breeding record of the species in NSW, it should be noted that Sands (2012) also states that "larvae or adults have been photographed or collected" at several additional locations. These include Border Ranges, Richmond Range, Richmond River, Billinudgel, Dorrigo, Rosewood River, Bellingen, Huonville and Bellinger Island (Sands 2012). This suggests that one or more of these locations also contain breeding records. Nevertheless, it is acknowledged that the revelation of a breeding record in association with the area of this project is a significant finding.

How is the project likely to affect current disturbance regimes?

Invasive species in this context may include Camphor Laurel and Lantana both of which are currently present and have the potential to alter the structure and floristic diversity of the habitat for this species. Due to the presence of the existing cleared habitat there is an existing edge-affected zone along the edge of the rainforest habitat occupied by the moth. This is appears in the form of a denser understorey, more open canopy in parts and presence of weeds, including Camphor Laurel and Lantana, although these weeds also occur throughout the rainforest patches and are not restricted to edge areas. Despite the existing edge impacts the host plant and eggs and larvae of the Pink Underwing Moth were located within the edge zones.

Given the presence of an existing edge effected zone along the majority of the known habitat for this species and the fact that the project would not be creating a new edge it would be difficult to determine if new weed invasions are attributed to the project, particularly as runoff would be directed to the east and not within the rainforest habitat. As a precautionary approach and considering that further weed invasion could be expected in the area of potential habitat being intersected by the project, it is considered reasonable to expect that the project would contribute to the presence of these invasive species adjoining the project

How is the project likely to affect habitat connectivity?

The known population adjacent to the project currently resides over an area of known (occupied) habitat and potential breeding habitat occurring to the west of the project and associated with undulating and elevated land over basalt soils. There is no evidence of a population to the east of this location or east of the proposed highway corridor.

Along the project boundary itself and to the east of the proposed highway the soils are dominated by alluvial soils and there are a number of small patches of rainforest, in a more degraded condition. This includes the patch north of the Wardell interchange that has been identified as a potential foraging area only and this patch would be fragmented by the road.

Currently there is limited potential for dispersal of the species in this area, which favours dense shaded canopy and given its large size, it is susceptible to air movements (wind) restricting its dispersal capability over cleared land (Dr Don Sands *pers comm*). Given that the majority of the habitat of the moth occurs to the west of the project, impacts from habitat fragmentation and loss of connectivity are not expected. While the presence of the road corridor and traffic would inhibit movements of the moth, there are currently limited opportunities for dispersal to the east, due to the absence of preferred habitat, with the exception of a patch of potential habitat (non-breeding) that would become fragmented to the east of the highway on the northern side of the Wardell interchange (Station 157.0) as discussed.

How is the project likely to affect critical habitat?

No critical habitat has been identified for this species under the TSC Act.

Conclusion of the assessment

Applying a precautionary approach, a significant impact on the Pink Underwing Moth has been concluded. The assessment concludes that a long-term decrease in the population at this location is not expected nor is impact on the dispersal movements of the species.

This is because the project would not remove current *occupied* habitat or *breeding* habitat although would remove an area of habitat that comprises known food plants (fruit trees) for the species and should be considered potential habitat. Indirect impacts are also likely and would be associated with the fragmentation of the area of potential foraging habitat and contribution to degradation along the edges of known and potential habitat. These would be associated with increased weeds or dust and potentially a changed structure of the habitat (canopy and shade) in edge areas, which could lead to competition with the host plant and decreased potential for breeding and feeding. These indirect impacts can be mitigated and are proposed as part of the targeted management strategy.

There is also potential for areas of foraging habitat (Lowland Rainforest) that are considered critical for the species to be directly and indirectly impacted over the long term.

This conclusion is consistent with the conclusion in the EIS.

6.5.2. Atlas Rainforest Ground Beetle (*Nurus atlas*)

6.5.2.1. Direct and indirect impacts

The EIS design would require removal of 6.4 hectares of known and potential habitat for the Atlas Rainforest Ground Beetle (*Nurus atlas*). Known and preferred habitat is restricted to sections 10 and 11 of the project.

The design refinement at the proposed Wardell interchange has reduced the direct impact to potential habitat only, with the removal of 2.5 hectares (refer Table 6-41).

The project would also have indirect impacts on Atlas Rainforest Ground Beetle. These may involve disruption of movement corridors or general disorientation due to artificial lighting, as well as the potential compromise of areas of known habitat adjacent to the project through a variety of indirect edge effects (including artificial lighting, road noise, dust and weeds).

The road alignment between station 154.0 and 158.0 would follow the base of the foothills of a low basalt escarpment. Vegetation to the west of the road within the escarpment and foothills is dominated by rainforest while to the east the vegetation is low-lying and mostly dominated by Eucalypt or Melaleuca forests. The road design assessed in the EIS aimed to traverse the cleared land as much as possible with the rainforest habitat of the beetle positioned upslope and to the west. The design refinement would move to the east and affect more of the low-lying vegetation.

There would be a residual impact on around 2.5 hectares of rainforest between stations 158.4 and 159.4. This habitat occurs on floodplain alluvial soils and not basalt soils and therefore is not consistent with the known habitat site further south and may be marginal. In addition to the direct impact, the alignment would fragment a patch of rainforest to the east of the road (1.5 hectares) and isolate this patch of potential habitat for this flightless beetle, although it was not recorded at this location.

The total impacts may then equate to around four hectares (2.5 hectares of rainforest between stations 158.4 and 159.4 and 1.5 hectares of rainforest to the east of the project), with further indirect impacts on the western patch of vegetation remaining adjacent to the project.

This impact may remove potential habitat for breeding and shelter and foraging and affect dispersal opportunities for a portion of the population. Similar impacts are not expected at the known sites on the basalt soils, which the project would avoid. This confirmed site is expected to be one of only two or possibly three known populations in NSW and therefore is an important population.

6.5.2.2. Assessment of significance: vulnerable species (TSC Act)

The assessment of significance for this species was undertaken in consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-47.

Table 6-47 Assessment of significance (TSC Act) Atlas Rainforest Ground Beetle

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 within a large patch of remnant rainforest located adjacent to and upslope of the project on the western side within undulating land on basalt soils. This same habitat is also occupied by the Pink Underwing Moth as described previously. The potential habitat for this species is considered low-elevation Lowland Rainforest with a well-developed rainforest understorey and this habitat type is present. It is restricted to the northern end of the project and not expected elsewhere. The species exhibits an extremely restricted distribution, and its survival is threatened by clearing of rainforest remnants, removal of fallen timber and groundcover. The road alignment between station 154.0 and 158.0 is positioned to bend around the foothills of the low basalt escarpment which contains the habitat for the species and mainly avoid direct impacts. Vegetation to the west of the road within the escarpment and foothills is dominated by rainforest while to the east of the project the vegetation is low-lying and mostly dominated by Eucalypt or Melaleuca forests. The road design assessed in the EIS had been positioned to traverse the cleared land as much as possible with the rainforest habitat of the beetle positioned upslope and to the west. This is also the case with the design refinement. There would be a residual impact of around 2.5 hectares of rainforest between stations 158.4 and 159.4. This habitat occurs on floodplain alluvial soils and not basalt soils and therefore is not consistent with the known habitat site further south and may be marginal. In addition to the direct impact the traverse of this habitat would fragment a patch of rainforest to the east of the road (1.5 ha) and isolate this patch for this flightless beetle. The total impacts may then equate to around 4 hectares with further indirect impact on the western patch remaining adjacent to the project. This impact may remove potential habitat for breeding and shelter and foraging and affect dispersal opportunities for a portion of the population. Similar impacts are not expected at the known sites on the basalt soils which have been avoided. This confirmed site is expected to be one of only two or possibly three known populations in NSW and is therefore significant given the species has a very restricted distribution. Any loss of habitat from a known population and the subsequent impacts on lifecycle activities is considered significant.
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 direct and indirect impact of this habitat equates to removal of around 2.5 hectares of potential habitat and further indirect impacts on around 1.5 to 2.0 hectares. At least 1.5 hectares is expected to be isolated and unlikely to be viable for the population, nor accessible. Remaining edge effects may occur along a 650 metre edge and be associated with potential changed structure of the vegetation the edge zone through weeds and altered light that may impact on the suitability of the habitat for this species which requires well-developed understorey vegetation. 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 two other sites in the Lismore-Alstonville area. The study area represents the southern and eastern limit of the species distribution and a significant find in terms of the regional population.

Atlas Rainforest Ground Beetle
How is the project likely to affect current disturbance regimes?
The known and potential habitats for this species in the project areas exhibit current disturbances associated with weeds and edge effects, particularly invasion of Camphor Laurel and Lantana and altered structure and floristics in the ground layer of the rainforest. The latter is attributed to the weeds and edge zones but also historical clearing and grazing particularly in the floodplain locations north of Wardell Road, which are only marginal. The placement of the road adjacent to the habitat would increase opportunities for weeds to colonise edge areas and may result in further weed invasion and altered habitat structures. Run-off impacts are not expected in known or potential areas as these would remain upslope of the project, with the exception of the small patch isolated to the east at station 158.4.
How is the project likely to affect habitat connectivity?
The project would fragment a patch of rainforest at station 158.4 to 159.4 (1.5 ha) and isolate this patch on the eastern side. This is considered to reduce accessibility to this patch for this flightless beetle. This patch is identified as potential although marginal habitat for the species. All other areas of known and potential habitat would remain on the western side of the project. These species are unlikely to move large distances to access scattered remnants due to its small size and low dispersal ability, although known habitat would remain to the west that is accessible.
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.

Conclusion of the assessment

The project would have a significant impact on this population of Atlas Rainforest Ground Beetle. This is because the project may remove potential habitat for breeding, sheltering, foraging and affect dispersal opportunities for a portion of the population. Although the project is likely to impact on only marginal habitat for the species, any loss of habitat from a known population for this species and the subsequent impacts on lifecycle activities is considered significant. The impact would be restricted to lower condition areas of potential habitat on the floodplain.

These impacts are not expected at the known beetle sites, which are located in rainforest on basalt soils to the west of the project, which would be avoided.

This conclusion is consistent with the conclusion in the EIS.

6.5.3. Koala (Phascolarctos cinereus)

6.5.3.1. Background

Surveys were undertaken for Koala (*Phascolarctos cinereus*) for the EIS and during supplementary field work (as described in Section 5.5) and the results combined. These results were analysed in accordance with the *Interim Koala Referral Advice for Proponents* in June 2012 (DSEWPaC, 2012). The analysis was also used to critically review the mitigation measures proposed for the Koala, resulting in some changes to fauna connectivity structures in the project design. In addition, design refinements addressed in Chapter 3 of this report would result in changes to impacts on Koala habitat. A revised assessment of significance was prepared to account for these changes and the additional data from the supplementary survey.

6.5.3.2. Direct and indirect impacts

Koala presence was confirmed and mapped at the following 18 sites across the project (Table 5-7, and Figure 5-20 to Figure 5-30):

- Section 1 – one site.
- Section 3 – three sites.
- Section 5 – one site.
- Section 7 – one site.
- Section 9 – four sites.
- Section 10 – eight sites.

Based on data from the NSW Atlas for the NSW North Coast Bioregion and the vegetation community mapping for the project, it is evident that koalas could occur in all project sections and in a range of habitats that would be impacted by the project. With the exception of project sections 9 and 10, the other records are associated with low-density Koala populations across multiple areas. In sections 9 and 10, high-density Koala populations occur between Woodburn and Wardell, particularly around Wardell to Coolgardie and Bagotville (Section 10) and south of the river from Rileys Hill to Broadwater National Park (Section 9). These populations are consistent with the definition of an 'important population' according to the *Interim Koala Referral Advice for Proponents*.

The Koala populations noted in the EIS that occur north and south of the river (sections 9 and 10) are considered separate sub-populations. The northern sub-population is constrained by the river to the east but there is contiguous habitat to the west towards Tuckean Nature Reserve and north to Alstonville where there are other known Koala populations. It is recognised that the highway would remove areas of known and potential foraging habitat in Section 10 and create a barrier for movements to the east and west near Coolgardie.

The connectivity strategy includes multiple crossing structures for koalas in sections 9 and 10. These include dedicated overpasses and underpasses, exclusion fencing, and strategic revegetation to mitigate the indirect impacts on movements, fragmentation and isolation. Crossing structures have been proven effective for Koala provided they are long enough and combined with fencing and revegetation.

A further important population occurs in Section 7 to the east of the project and may use habitat near the highway south of Bundjalung National Park (Clarence Valley Council, 2010). The distribution of Koala activity for the Woombah sub-population shows an area of habitat with low Koala use around 500 metres east of the Pacific Highway at this location. The Koala observed for the supplementary study on the western side of the highway in Mororo Creek Nature Reserve may be part of the Woombah sub-population. The current highway is a barrier to movements of koalas east and west in this location, and this barrier would be widened by the project with limited opportunities for crossing. The additional impact of habitat loss may occur on the western side of the highway, but would be minimal.

Several Koala food tree species listed for the NSW North Coast (DECC, 2008) were identified from the habitat assessment plots, including the primary species Swamp Mahogany (*Eucalyptus robusta*), Forest Red Gum (*E.tereticornis*), Tallowwood (*E.microcorys*), and Orange Gum (*E.bancrofti*). Secondary food tree species are represented by Red Mahogany (*E.resinfera*), Small-fruited Grey Gum gum (*E.propinqua),* and Narrow-leaved Red Gum (*E.seena*). Supplementary tree species include stringybarks (*E.tindaliae* and *E.globodiaea*).

The revised total area of Koala habitat impacted by the project is shown in Table 5-9 and includes 375 hectares of primary and secondary habitat. This calculation takes into account vegetation along all project sections where high- and low-density populations occur and are not specific to important Koala populations. In addition to the direct loss of feed trees and habitats, further adverse indirect impacts within a portion of the areas could be anticipated associated with edge effects (mainly weeds and runoff and altered microclimate conditions) leading to small-scale dieback or reduced recruitment of new feed trees.

6.5.3.3. Assessment of significance: vulnerable species (EPBC Act)

The assessment of significance was undertaken according to criteria for vulnerable species in the DEWHA (2009) assessment guidelines. The assessment is provided in Table 6-48.

Table 6-48 Assessment of significance (EPBC Act) Koala

Koala (*Phascolarctos cinereus*)
According to the DEWHA (2009) 'significant impact criteria' an action is likely to have a significant impact on an vulnerable species if there is a real chance or possibility that it would:
Lead to a long-term decrease in the size of an important population
Important populations were identified at three locations along the project as described above. Section 7 (Woombah population), Section 9 (Broadwater population) and Section 10 (Coolgardie-Bagotville population). Woombah is a low density population with a core habitat area identified to the east of the highway in private land and could potentially extend over a large area including Bundjalung National Park and Devils Pulpit State Forest to the north and east to the coast in contiguous habitats. The current highway provides a potential barrier to dispersal to the west where there are extensive areas of potential habitat. It is unknown if the individual sighted in Mororo Nature Reserve in the supplementary survey is from another population to the west of the highway or has dispersed from the Woombah population and established a home range. The project would increase the barrier effect for dispersal to the west, although this would not necessarily lead to the long-tern decrease in the population given the large expanses of habitat available on the east and north. The project may remove small areas of habitat along the highway associated with the duplication which may include the home range of an individual however this small direct impact is not expected to lead to a long-term increase in the population. The Broadwater population is constrained by the river to the north and west and also the existing highway through the town and separating the national park. The project duplication in this area would involve minimal direct removal of habitat as has been narrowed and duplicated through the reserve and other areas traverse largely cleared land. Targeted crossing structures have been included to mitigate the barrier effect of the highway. The long-term viability of the population may be constrained by the existing barriers and the additional highway which may contribute to a continued reduction in use of habitat to the west. Considering the potential loss of habitat to the west of the highway the project may result in isolation of some individuals and ultimately lead to a decrease over in the population over the medium term. Evidence from recent radio-tracking work on the Pacific Highway at Bonville (AMBS 2011) indicates that koalas eventually alter their home range and continue to use habitats adjacent to the road. Over the long-term, there is sufficient habitat to the east of the road within Broadwater National Park and considering the known effectiveness of crossing structures which are proposed, the project is not expected to lead to a long term decrease in the Broadwater population. The Coolgardie-Bagotville sub-population is not constrained by the river and could potentially be part of a larger meta-population extending across to Tuckean Nature Reserve and north across the plateau to Alstonville where other populations are known to occur. The project would directly remove around 60 hectares of critical habitat between the Richmond River and Bagotville Road extending between stations 146.0 to 150.0. By flanking around the Wardell heath to the west the project would also potentially create a barrier in this important movement area over a distance of up to 13 kilometres between the Richmond River and Laws Road. As the review in Section 7.1.3 outlines, there has been considerable effort into the placement of multiple connectivity mitigation measures targeted at this population, which may successfully mitigate the barrier effect. The long-term viability of this population is dependent on dispersal and recruitment of individuals across the highway and on this basis as a precaution the project could be expected to have a significant impact on the Coolgardie-Bagotville sub-population and potential other populations to the west which may also be reliant on this dispersal.

Koala (*Phascolarctos cinereus*)

Reduce the area of occupancy of an important population

Details on direct and indirect impacts for the Woombah population indicate that there is a low potential to reduce the areas of occupancy of this important population.

For the Coolgardie-Bagotville population the project has potential to create a barrier to the west and north and thereby reduce the area of occupancy. The evidence from the supplementary surveys indicate that the project would potentially cross the home range area of one or more koalas between station 146.0 to 150.0, thereby reducing the current occupancy of an important population

Similarly for the Broadwater population an establish home range for at least one Koala is expected to occur across habitat intersected between station 144.0 and 145.0 and the project may therefore reduce the area of occupancy for this population. Evidence of koalas was reported in Broadwater National Park to the east and west of the highway, although the project includes two overpasses in this location which would improve the current poor connectivity here.

Fragment an existing population into two or more populations

Details on direct and indirect impacts for the Woombah population indicate that this is a low potential for fragmentation.

For the Broadwater population this is also unlikely given the existing barriers and constraints to this population and the fact that the project would substantially improve this situation.

For the Coolgardie-Bagotville population the project has potential to fragment the population, given the location of the road in relation to the known and potential habitat for the population and the fact that Koala evidence was reported from both sides of the project boundary.

Adversely affect habitat critical to the survival of a species

Several Koala food tree species listed for the NSW North Coast (DECC 2008) were identified in eucalypt forests along the project including the primary species Swamp Mahogany (Eucalyptus robusta), Forest Red Gum (E.tereticornis), Tallowwood (E.microcorys), and Orange Gum (E.bancrofti). Secondary food tree species are represented by Red Mahogany (E.resinfera), Small fruited Grey-Gum (E.propinqua), and Narrow-leaved Red Gum (E.seena). Supplementary tree species included the stringybarks (E.tindaliae and E.globodiaea). The EIS provides a comprehensive account of the Koala feed tree species recorded in each of the BioMetric Vegetation Types along the project. The proportion of each of these tree species in the canopy was used to assign habitat critical to the survival of koalas to the different vegetation types reported in the study area and quantify the direct impacts on these primary and secondary habitats. This loss equates to 375 hectares. Further adverse indirect impacts may also occur to a portion of this habitat associated with edge effects, mainly weeds and runoff and altered microclimate conditions leading to small-scale dieback or reduced recruitment of new feed trees.

Disrupt the breeding cycle of an important population

Breeding is seasonal with mating taking place during October to February and most births occurring between November and late March. As the project would remove known and potential habitat including habitat critical to the survival of koalas there is potential for this clearing to impact on the breeding cycle of a portion of three populations. The number of individuals is not known or the longer-term impacts on the population as a whole.

Modify, destroy, remove, 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 5-10 is considered likely to support viable breeding populations of koalas on the basis of historical and current records of the species and three important populations have been identified within proximity to the project.

The proposed clearing of vegetation would include up to 375 hectares of primary and secondary Koala habitat (critical habitat). This factor, in addition to the locations of important population was considered in the design of dedicated and combination crossing structures for koalas and exclusion fencing. For the identified low density populations, these were identified in habitat that is contiguous with several large state forests and national parks suggesting that there would be sufficiently large areas of habitat available to maintain the viability of these populations.

For the high density population in section 9 there are constraints to the north and west by the presence of the river, however not to the south and east within Broadwater National Park. The duplication of the project here and improvement on connectivity, and small area of habitat removal may contribute to the long-term decline of the population, however in theory there are considerable large areas of habitat that could sustain the long-term viability.

For the high density population north of the Richmond River, the potential barrier effect of the highway could isolate habitat and individuals to the east leading to the long-term decline in this population.

Koala (*Phascolarctos cinereus*)
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 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 important populations. 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
koalas are vulnerable to Chlamydia and infertility and death can be outcomes. In a study of roadside Koala populations at Bonville the prevalence of Chlamydia was high (AMBS 2011). Its incidence apparently doubled over two decades with a climb in the average from 15.2 incidents per year during the decade of 1991 to 2000 to 32.75 incidents per year during the decade of 2001 to 2010. It is unknown if this prevalence was related to the location of the population adjacent to the road. Chlamydia affects the fecundity of koalas. While the disease seemed virulent in the Bonville study area, the rates of infection were similar to other areas in northern NSW and southern Queensland. The clearing of habitat for the project would not directly introduce the disease, however fragmentation of habitat has potential to isolate individuals, particularly at Wardell. If Chlamydia is present in the local population, further fragmentation and isolation may have mixed effects, such as reduce the spread of the disease or may exacerbate the spread of the disease in roadside areas. The plan to provide targeted connectivity strategies for the Koala as part of the project is aimed at facilitating the natural movements of koalas across the project boundary.
Interfere with the recovery of the species.
The route has been selected on the basis of avoiding high quality habitats for threatened fauna and impacts on 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.

6.5.3.4. Assessment of significance: vulnerable species (TSC Act)

The assessment of significance for this species was undertaken in consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-49.

Table 6-49 Assessment of significance: Koala (TSC Act)

Koala (*Phascolarctos cinereus*)
How is the project likely to affect the lifecycle of a threatened species and/or population?
Breeding is seasonal with mating taking place during October to February and most births occurring between November and late March. As the project would remove known and potential habitat including habitat critical to the survival of koalas there is potential for this clearing to impact on the breeding cycle of a portion of three populations. The number of individuals is not known or the longer-term impacts on the population as a whole. The project may also affect dispersal from populations and recruitment by creating a barrier effect. Known primary and secondary Koala habitat would be removed from areas known to be occupied by koalas and therefore have an impact on the availability of food resources which could have longer-term impacts on competition for resources, breeding success and stress.
How is the project likely to affect the habitat of a threatened species, population or ecological community?
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 5-10 is considered likely to support viable breeding populations of koalas on the basis of historical and current records of the species and three important populations have been identified within proximity to the project. The proposed clearing of vegetation would include up to 375 hectares of primary and secondary Koala habitat (critical habitat). This factor, in addition to the locations of important population was considered in the design of dedicated and combination crossing structures for koalas and exclusion fencing. For the identified low density populations, these were

Koala (*Phascolarctos cinereus*)
identified in habitat that is contiguous with several large state forests and national parks suggesting that there would be sufficiently large areas of habitat available to maintain the viability of these populations. For the high density population in section 9 there are constraints to the north and west by the presence of the river, however not to the south and east within Broadwater National Park. The duplication of the project here and improvement on connectivity, and small area of habitat removal may contribute to the long-term decline of the population, however in theory there are considerable large areas of habitat that could sustain the long-term viability. For the high density population north of the Richmond River, the potential barrier effect of the highway could isolate habitat and individuals to the east leading to the long-term decline in this population.
Does the project affect any threatened species or populations that are at the limit of its known distribution?
The species distribution extends over eastern Australia. The Coolgardie-Bagotville sub-population could potentially be part of a larger meta-population extending across to Tuckean nature Reserve and north across the plateau to Alstonville with other populations are known to occur. For the high density population in section 9 there are constraints to the north and west by the presence of the river, however not to the south and east within Broadwater National Park. The duplication of the project here and improvement on connectivity, and small area of habitat removal may contribute to the long-term decline of the population, however in theory there are considerable large areas of habitat that could sustain the long-term viability. Woombah is a low density population with a core habitat area identified to the east of the highway in private land and could potentially extend over a large area including Bundjalung National Park and Devils Pulpit State Forest to the north and east to the coast in contiguous habitats
How is the project likely to affect current disturbance regimes?
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 a large area of potential habitat. 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.
How is the project likely to affect habitat connectivity?
Details on direct and indirect impacts for the Woombah population indicate that there is a low potential to affect habitat connectivity. For the Broadwater population this is also unlikely given the existing barriers and constraints to this population and the fact that the project would substantially improve this situation. For the Coolgardie-Bagotville population the project has potential to fragment the population, given the location of the road in relation to the known and potential habitat for the population and the fact that Koala evidence was reported from both sides of the project boundary. For other low density populations, the project also has the potential to create a barrier for movements, particularly in sections 1–2 and 5–7, however a targeted mitigation strategy has been proposed and the species is crossing structures and exclusion fencing is known to be successful for maintain dispersal and breeding movements for 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.

Conclusion of the assessment

The project has potential to significantly impact on an important Koala population in the Coolgardie-Bagotville area in project Section 10. This is largely because it would lead to the loss of primary and secondary habitat. In total, there would be a loss of 375 hectares of Koala habitat.

There would also be adverse indirect impacts on Koala feed trees associated with edge effects. The project would also widen the barrier formed by the highway, which would have impacts on connectivity.

This conclusion is consistent with the conclusion in the EIS.

6.5.4. Giant Barred Frog (*Mixophyes iterates*)

6.5.4.1. Background

Surveys undertaken during the preferred route studies identified the Giant Barred Frog (*Mixophyes iterates*) in sections 3, 6, 7 and 8. This species was confirmed during targeted surveys for the detailed design in sections 1 and 2 (Lewis Ecological Services, 2013a and 2013b; refer Appendix E).

There are three confirmed populations in project sections 1 and 2 where a population of Giant Barred Frog could occur:

- In Corindi River (Section 1 - near station 3.6): The results of the targeted surveys confirmed the previous recording of this species by Ecotone (2007) and confirm the importance of this site for the species. Seven individuals were reported in 2007 and 10 individuals in 2013.
- In Dirty Creek (Section 1) and Halfway Creek (Section 2): The EIS identified and assessed potential habitat for this species and the species has now been confirmed at both sites from the targeted survey (Lewis Ecological Services, 2013a and 2013b).

The surveys also report a moderate likelihood of the species occurring in a tributary of Arrawarra Creek (station 0.3) and at Boney Creek (station 13.3), both in Section 1.

The remaining areas of Section 1 and 2 were confirmed as low potential, as predicted in the EIS.

The species was not identified in Section 3, but marginal habitat was identified on Chaffin Creek (station 52.5). There are previous records of this species on the Coldstream River further upstream of the proposed highway crossing, but the habitat at the crossing of the Coldstream River within Section 3 appeared marginal for the species and lacked specific habitat attributes.

The species was not identified in sections 6, 7 and 8 and was considered to have a low likelihood due to the near absence of important habitat characteristics. However, Tabbimoble Creek (station 101.6) and Sawpit Creek (station 125.5) may provide some of these habitat attributes, although their highly disturbed state as a result of cattle grazing, clearing and logging suggest very low quality conditions for the Giant Barred Frog and it probably does not occur at these locations.

6.5.4.2. Direct and indirect impacts

The project would cross over three waterways (Corindi River, Dirty Creek and Halfway Creek) known to contain populations of the species and six other waterways that have suitable although only marginal habitat. These crossings would involve the removal of riparian vegetation across the project boundary and therefore reduce the potential area of occupancy for the population.

There may also be indirect impacts, including:

- Increased noise near the roadway, affecting the calling of breeding males and a temporary or even permanent disruption to breeding success.
- Runoff of pollutants from the road surface and entering known habitats.
- Sediment entering known habitats.

- The barrier effect of the highway, which may negatively affect dispersal of individuals between home range areas.

6.5.4.3. Assessment of significance: endangered species (EPBC Act)

The assessment of significance was undertaken according to criteria for endangered species in the DEWHA (2009) assessment guidelines. The assessment is provided in Table 6-50.

Table 6-50 Assessment of significance: Giant Barred Frog (EPBC Act)

Giant Barred Frog (*Mixophyes iteratus*)
According to the DEWHA (2009) 'significant impact criteria' an action is likely to have a significant impact on an endangered species if there is a real chance or possibility that it would:
Lead to a long-term decrease in the size of a population
The project would impact on potentially four-five populations via the direct traverse of known and potential habitat in section 1, 2 and 3. The direct impacts would be localised and restricted to the narrow construction zone and this loss of habitat is not expected to contribute to a long-term decrease to three populations, particularly as the three known populations already occur on waterways that are crossed by the existing Pacific Highway and continue to persist at these locations. The indirect impacts associated with potential pollution to the waterway and barrier effect of the highway is likely to be mitigated by the proposed construction and operation mitigation measures, including water quality detention and treatment and the provision of bridge structures on each of the waterways currently considered as known or potential habitat for the species.
Reduce the area of occupancy of the species
The project would directly cross three waterways known to contain populations of the species and two more waterways which have suitable habitat. The direct crossing of the waterway would involve the permanent removal of riparian vegetation across the project boundary and therefore reduce the potential area of occupancy of these populations. Indirect impacts may be associated with increased noise near the roadway, affecting the calling of breeding males and a temporary or permanent disruption to breeding success. Other indirect impacts may be associated with road-runoff of pollutants or sediment entering known habitats and the barrier effect of the highway negatively affecting dispersal of individuals between home range areas and reducing the current or potential area of occupancy.
Fragment an existing population into two or more populations
There are three existing populations, all identified on waterways that are currently crossed by the existing Pacific Highway. The distribution extent of these population along the waterway is not known These streams would be crossed again for the new highway and a bridge structure built on each. There is limited evidence to confirm if the Giant Barred Frog is capable of crossing under a bridge to access habitat either side of the road, for home range, breeding movements or dispersal. In the absence of this information as a precaution the project is considered to potentially fragment three existing populations.
Adversely affect habitat critical to the survival of a species
The project would directly cross three waterways known contain populations of the species and two more waterways which have suitable habitat. The direct crossing of the waterway would involve the permanent removal of riparian vegetation across the project boundary, including additional edge effects and therefore adversely affect habitat critical to the survival of a portion of these populations.
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 the identified populations. Measures to minimise impacts on waterways during construction would be 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 direct crossing of waterways containing known or potential habitat as discussed would involve the permanent removal of riparian vegetation across the project boundary and therefore reduce the potential area of potential habitat for the population. Indirect impacts may modify the quality of the habitat downstream, or adjacent to the bridge associated with potential pollution of the waterway or increased weeds in riparian areas, changing the structure of the habitat.

Giant Barred Frog (*Mixophyes iteratus*)
The existing populations have been identified in waterways where the habitat conditions in the catchment have been significantly altered by clearing of land, particularly the Corindi River and the existing network of roads including the highway and the associated changes in sediment loading, water quality and weed invasion in riparian areas. This would suggest resilience to some change in habit quality such that further declines associated with the project may be unlikely.
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 in riparian areas 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 the 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. It is likely that chytrid fungus is already widespread throughout the project area and that 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 would 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.

6.5.4.4. Assessment of significance: endangered species (TSC Act)

The assessment of significance for this species was undertaken in consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-51.

Table 6-51 Assessment of significance: Giant Barred Frog (TSC Act)

Giant Barred Frog (*Mixophyes iteratus*)
How is the project likely to affect the lifecycle of a threatened species and/or population?
Impacts to life-cycle may include potential disruption the breeding success of established individuals within the populations, through loss of habitat and change of habitat structures and also related to increased noise from traffic and the impact on call behaviour. Foraging areas would be directly impacted over the short to medium term, although this is unlikely to have a long-term impact on the population., there may be a potential barrier to the dispersal of juveniles associated with the crossing structures placed over the stream and there is currently limited evidence to suggest that the Giant Barred Frog would cross under roads.
How is the project likely to affect the habitat of a threatened species, population or ecological community?
The direct crossing of waterways containing known or potential habitat as discussed would involve the permanent removal of riparian vegetation across the project boundary and therefore reduce the potential area of potential habitat for the population. Indirect impacts may modify the quality of the habitat downstream, or adjacent to the bridge associated with potential pollution of the waterway or increased weeds in riparian areas, changing the structure of the habitat. The existing populations have been identified in waterways where the habitat conditions in the catchment have been significantly altered by clearing of land, particularly the Corindi River and the existing network of roads including the highway and the associated changes in sediment loading, water quality and weed invasion in riparian areas. This would suggest resilience to some change in habit quality such that further declines associated with the project may be 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. Further while the distributional extent of the existing populations in the study area has not been determined, the habitat available extends beyond the study corridor east and west along the waterways.

Giant Barred Frog (*Mixophyes iteratus*)
How is the project likely to affect current disturbance regimes?
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*) although these species do not share common habitat with the Giant Barred Frog. The potential increase in pollutants or sediments into waterways may have a short to medium term impact on 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?
There are three existing populations, all identified on waterways that are currently crossed by the existing Pacific Highway. The distribution extent of these population along the waterway is not known. These waterways would be additionally crossed for the new highway and a bridge structure built on each. There is limited evidence to confirm if the Giant Barred Frog is capable of crossing under a bridge to access habitat either side of the road, for home range, breeding movements or dispersal. In the absence of this information as a precaution the project is considered to potentially fragment three existing populations.
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.

Conclusion of the assessment

The project has potential to significantly impact on three identified populations in project sections 1 and 2. This is because it would cross over three waterways known to contain populations of the species and two other waterways that have suitable habitat. These crossings would involve the removal of riparian vegetation across the project boundary and therefore reduce the potential area of occupancy for the population. Indirect impacts associated with noise and runoff would also affect this species.

This conclusion is consistent with the conclusion in the EIS.

6.5.5. Oxleyan Pygmy Perch (*Nannoperca oxleyana*)

6.5.5.1. Background

The EIS presents an assessment of significance for Oxleyan Pygmy Perch (*Nannoperca oxleyana*). It indicated that the project may have a significant impact on this species.

Further information has been requested concerning the potential direct and indirect impacts on the species at the proposed material borrow site at Lang Hill in addition to the proposed ancillary site at Section 8, site 3. These impact assessments are provided in sections 2.4.5 (ancillary facility site assessment) and 3.3.11 (design refinement assessment). These assessments suggest that the proposed material borrow site at Lang Hill would not negatively impacts on the known habitat for the species. This is because the site is sufficiently far from the waterway adjacent to Lang Hill, the poor condition of the waterway, and the unlikely use of this habitat by threatened fish. Proposed mitigation measures for the borrow site – and the ancillary site – would further minimise the potential for impacts on Oxleyan Pygmy Perch.

Therefore, the conclusion of the overall impact of the project on the Oxleyan Pygmy Perch has not been altered (with the greater consideration of the Lang Hill works) and a revised assessment of significance is not required.

6.5.6. Common Planigale (*Planigale maculate*)

6.5.6.1. Background

The findings of the EIS assessment of significance for Common Planigale (*Planigale maculata*) were reviewed, considering the importance of the populations known to occur in the study area and the vulnerability of the species to the threats identified in the EIS.

6.5.6.2. Direct and indirect impacts

The Common Planigale was recorded in project Section 1 (station 13.3) where it was caught in a pitfall trap in a community of Forest Red Gum-Swamp Box open forest with a grassy understorey. This species is very small and difficult to trap, so it's true population status across the project is unknown and there were no other records from the targeted surveys. Current information suggests the species may utilise a wide range of habitats, so it could occur anywhere along the project, and there are records from the NSW Atlas relevant to Section 1 and sections 6 to10.

There is limited data on the distribution of the local and regional populations of Common Planigale. This species inhabits rainforest, eucalypt forest, heathland, marshland, grassland and rocky areas where there is surface cover, and usually close to water.

Table 6-52 provides a list of vegetation types identified in the project area that would be expected to support the regional population, and the area that would be directly lost from each project section. In total, around 925.7 hectares of habitat would be lost, which would be a significant loss for the regional population.

Table 6-52 Habitat types in the study area linked to the Common Planigale

Vegetation / habitat types linked to target species	Area in project boundary (ha)
Black Bean - Weeping Lilly Pilly Riparian Rainforest of the North Coast	1.7
Blackbutt - Bloodwood Dry Heathy Open Forest on Sandstones of the Northern North Coast	93.6
Blackbutt Grassy Open Forest of the Lower Clarence Valley of the North Coast	37.6
Coast Cypress Pine Shrubby Open Forest of the North Coast Bioregion	3.3
Coastal Floodplain Sedgelands, Rushlands, and Forblands	5.1
Coastal Heath on Sands of the North Coast	14.9
Flooded Gum - Tallowwood - Brush Box Moist Open Forest of the Coastal Ranges of the North Coast	1.4
Forest Red Gum - Swamp Box of the Clarence Valley Lowlands of the North Coast	53.7
Grey Gum - Grey Ironbark Open Forest of the Clarence Lowlands of the North Coast	69.5
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast	21.2
Needlebark Stringybark - Red Bloodwood Heathy Woodland on Sandstones of the Lower Clarence of the North Coast	58.6
Orange Gum (Eucalyptus bancroftii) Open Forest of the North Coast	5.6
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast	64.5
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast	42.0
Scribbly Gum - Needlebark Stringybark Heathy Open Forest of Coastal Lowlands of the Northern North Coast	66.2
Spotted Gum - Grey Box - Grey Ironbark Dry Open Forest of the Clarence Valley Lowlands of the North Coast	2.1

Vegetation / habitat types linked to target species	Area in project boundary (ha)
Spotted Gum - Grey Ironbark - Pink Bloodwood Open Forest of the Clarence Valley Lowlands of the North Coast	163.8
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	19.0
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	47.6
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	43.1
Tallowwood Dry Grassy Forest of the Far Northern Ranges of the North Coast	54.4
Turpentine Moist Open Forest of the Coastal Hills and Ranges of the North Coast	42.7
Wet Heathland and Shrubland of Coastal Lowlands of the North Coast	11.5
White Booyong - Fig Subtropical Rainforest of the North Coast	2.6
Total loss	**925.7**

The common planigale has a small home range, which may limit the size and distribution of local populations. The loss of habitat from the project would directly affect foraging, sheltering and breeding life-cycle activities for this species.

In addition, indirect impacts would potentially include the loss of several small local populations and fragment or isolate others, making them less viable over the long term. Given their small home range, it is unlikely that populations fragmented by the road would continue to use both sides of the road. Therefore, the road would restrict the distribution or provide smaller, less viable populations. The species has not been recorded using crossing structures to move across highways, and the large width of the highway corridor in some parts would potentially create a barrier to dispersal of individuals and reduce the opportunities to colonise currently unoccupied areas.

6.5.6.3. Assessment of significance: vulnerable species (TSC Act)

The assessment of significance for this species was undertaken in consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-53.

Table 6-53 Assessment of significance: Common Planigale (TSC Act)

Common Planigale (*Planigale maculata*)
How is the project likely to affect the lifecycle of a threatened species and/or population?
The large-scale removal of potential habitat would directly remove and displace local populations and affect the area of available foraging, shelter and breeding habitat and limit dispersal opportunities. The significance of this impact on the meta-populations or the broader regional population is not known, although the species is widespread but uncommon throughout the northern rivers region and has been recorded in a diversity of habitat conditions. It is highly likely that local populations away from the road corridor would not be directly impacted however longer-term connectivity may affect genetic diversity on a range of scales.
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 925 hectares of potential habitat for this species this would include the loss of habitat resources and habitat connectivity and potentially reduce the size of currently occupied habitats given the small home range of the size and unlikely ability for local populations to use both sides of the road. Indirect impacts may be associated with loss of connectivity and degradation of adjoining areas of habitat through edge effects, further reducing the area of available habitat for residual populations.

Common Planigale (*Planigale maculata*)
Measures to mitigate the barrier effect of the road have been considered in the design and placement of underpass structures to maintain connectivity however these are not proven effective for this species and the small home range relative to the width of the road would suggest that use of both sides of the road would be restrictive. The dispersal distance for this species is unknown and likely to be short and potentially restricted by the width of the road and limit the opportunity to colonise new areas.
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 this 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. The increase potential for weed growth in edge areas would have a smaller indirect impact by potentially changing the structure, shelter and food resources across broad areas adjacent to the project, leading the reduced habitat areas for local populations or altered home range and distribution of populations. The follow-on from this is increased competition for resources, and associated stress. A period of adjustment to these conditions is likely and the longer term impact on meta-populations or regional populations may be low over such a large area.
How is the project likely to affect habitat connectivity?
The common planigale has a small home range which may limit the size and distribution of local populations. Indirect impacts would potentially include the removal of several small local populations and fragment or isolate others making them less viable over the long-term. Given their small home range it is unlikely that populations fragmented by the road would continue to use both sides of the road and would therefore the road may restrict the distribution of local populations or result in a number of smaller less viable populations in some areas. The species has not been recorded using crossing structures to move across highways, and the width of the road corridor in some parts would potentially create a barrier to dispersal of individuals and reduce the opportunities to colonise currently unoccupied areas. The dispersal distance for this species is not known, however may be small.
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.

Conclusion of the assessment

The project is likely to have a significant impact on a number of local populations of Common Planigale. However, the long-term impact on the regional population is unknown. In the absence of this information, and as a precaution, the impact should be considered significant.

This is because the project would remove about 926 hectares of potential habitat for the regional population, which is large. The proportion of this that is actually occupied by local populations, and the number and distribution of these is unknown. The small home range of the species may limit the size and distribution of local populations and the loss of habitat would directly affect life-cycle activities, movement and dispersal leading to the potential removal and fragmentation of a number of local populations.

This conclusion differs from that in the EIS.

6.5.7. Glossy Black-Cockatoo (*Calyptorhynchus lathami*)

6.5.7.1. Background

The findings of the EIS assessment of significance for Glossy Black-Cockatoo (*Calyptorhynchus lathami*) have been reviewed, considering the extent and magnitude of the impact, including clearing of potential nest trees and feed trees.

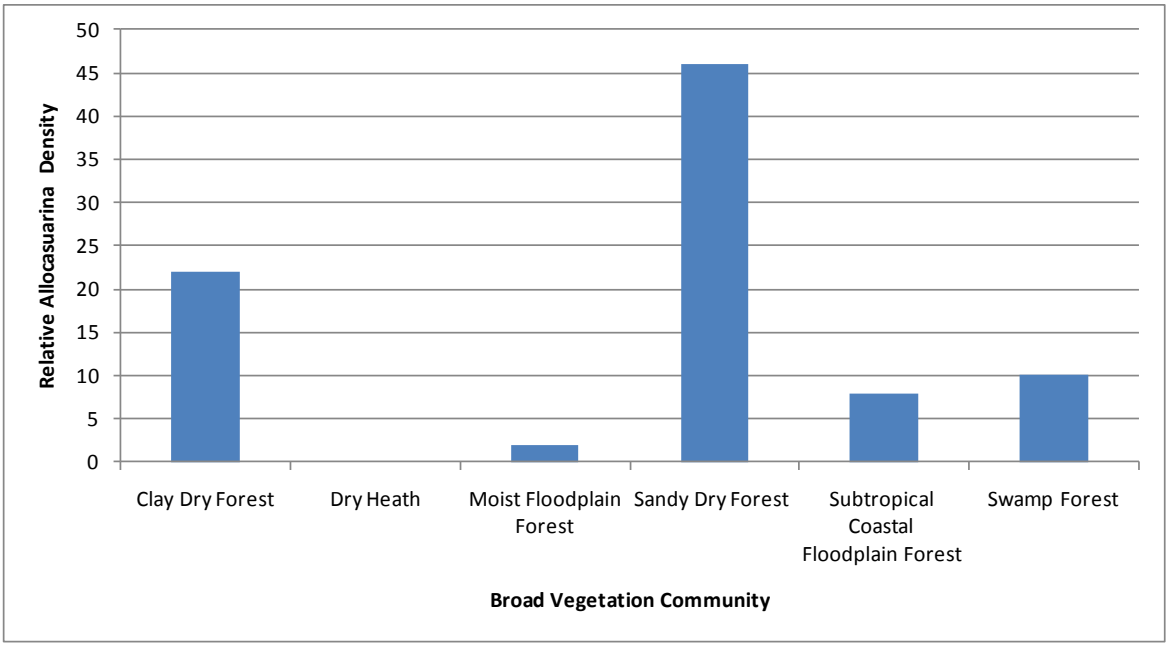
6.5.7.2. Direct and indirect impacts

The Glossy Black-Cockatoo was recorded in Section 1 around Halfway Creek. A pair was also recorded in Section 3 near McRae Knob to the north-east of Tyndale in an area adjoining and contiguous with Pine Brush State Forest. This area supports an abundance of *Allocasuarina* and large tree hollows along the foothills of the Sommervale Range. Glossy Black-Cockatoos were also recorded in Section 7, south of Serendipity Road at Tabbimoble and in suitable habitat near Wardell Road in Section 10. Preferred habitat for this species is widespread and populations of Glossy Black-Cockatoos are considered likely to occur throughout the study area.

Current information on the species suggests that a wide range of habitats may be utilised and that a large regional population occurs across all forested parts of the northern rivers. Therefore it could occur anywhere along the project, and there are records from the NSW Atlas associated with all project sections.

Allocasuarina species are a critical food resource for Glossy-Black Cockatoo, as are large tree hollows for nesting. The species is reliant on mature forest habitats in the study area for breeding and foraging, although this may occur in both large contiguous remnants and small fragmented forests in modified fragmented landscapes provided food resources are abundant and there is access to large hollow-bearing trees. Pairs may repeatedly use favoured nest trees over multiple breeding seasons and family groups exhibit home range territories and repeated use of the same food trees within their home range.

Allocasuarina species were found in a range of habitats in the study area, with the highest densities encountered in dry forests on sandy and clay soils as shown in the graph below.



The vegetation types in the project areas that support potential foraging and breeding habitat for the species, based on the survey of *Allocasuarina* and hollow-tree resources, are listed in Table 6-54. As shown, the project would require the removal of 650.3 hectares of this vegetation.

Table 6-54 Habitat type in the study area linked to the Glossy Black-Cockatoo

Vegetation / habitat types linked to target species	Area in project boundary (ha)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	93.6
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	53.7
Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast	69.5
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast	58.6
Orange Gum (Eucalyptus bancroftii) open forest of the North Coast	5.6
Red Mahogany open forest of the coastal lowlands of the North Coast	40.1
Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast	66.2

Vegetation / habitat types linked to target species	Area in project boundary (ha)
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	163.8
Tallowwood dry grassy forest of the far northern ranges of the North Coast	54.4
Turpentine moist open forest of the coastal hills and ranges of the North Coast	42.7
Total	**650.3 hectares**

Based on the review of NSW Atlas records, the size and distribution of the regional population is extensive and occurs across all dry forested areas of the northern rivers. However there is no data on the distribution of pairs and family groups nor the dynamics associated with dispersal range. The number of pairs that would be affected by the project is unknown, but the scale of habitat loss would likely directly remove a number of current nest sites and a large area of feeding habitat. This species has a low birth rate, with only 1 to 2 individuals born each season and breeding may not occur in all years, depending on predation on eggs and other stochastic events. The loss of habitat may lead to reduced breeding success and affect recruitment to local populations on a number of scales, which may take some years to recover.

The Glossy Black-Cockatoo prefers to forage at sites where food is abundant and avoids open sites where predation risk is greater. This preference may have further implications for indirect impacts where clearing and fragmentation is concerned, as some currently used feeding habitats may become too fragmented or small for continued use.

6.5.7.3. Assessment of significance: vulnerable species (TSC Act)

The assessment of significance for this species was undertaken in consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-55.

Table 6-55 Assessment of significance: Glossy Black-Cockatoo (TSC Act)

Glossy Black Cockatoo
How is the project likely to affect the lifecycle of a threatened species and/or population?
This species distribution is linked to its reliance on their primary food source, the seeds of *Allocasuarina* species, which are widespread but patchy in the project area. The species prefers *Allocasuarina* with abundant cones and many areas of smaller regrowth or younger trees may therefore not be suitable. The actual area of known and potential food resources and the number and distribution of pairs is not known. The number of pairs that would be affected by the project is unknown, however the scale of habitat loss associated with the project would likely directly remove a number of current nest sites and potentially large area of current or further feeding habitat. This species has a low birth rate, with only 1–2 individuals born each and breeding may not occur in all years depending on predation on eggs and other stochastic events. The loss of habitat may lead to reduced breeding success for a number of established pairs and affect recruitment to local populations on a number of scales, which may take some years to recover.
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 650 hectares of potential foraging and nesting habitat for this species affecting several pairs and indirectly impact on breeding success and dispersal opportunities for juveniles. 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

Glossy Black Cockatoo
for Glossy Black-Cockatoo in the study area.
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, particularly within fire prone dry forests favoured by this species. 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.
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 currently used for feeding and create barriers to the dispersal movements. The species is known to favour denser forests for feeding and avoids small open habitats where the risk of predation is higher. This highly mobile species is adapted to moving across forest clearings such as roads and agricultural lands to access foraging 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.

Conclusion of the assessment

Although the project would remove about 650 hectares of potential foraging and breeding habitat for the species, the longer-term impact on the regional population is not expected to be significant. This is because there is evidence of a widespread and moderately large regional population of the Glossy Black-Cockatoo, and the species is mobile and adapted to moving across forest clearings such as roads and agricultural lands to access foraging and nesting habitat.

This conclusion is consistent with the conclusion in the EIS.

6.5.8. Three-toed Snake Tooth Skink (*Coeranoscincus reticulatus*)

6.5.8.1. Background

The Three-toed Snake Tooth Skink (*Coeranoscincus reticulatus*) was not recorded in the project study area from the targeted surveys and was considered to have a low likelihood of occurring across all project sections. The following information aims to provide further detail of the survey methods and effort for this species.

The Three-toed Snake Tooth Skink is a fossorial species. It is usually found sheltering under leaf litter or moist rotting logs or in loose friable soil beneath sheltering sites. It is usually recorded from rainforest habitat on loamy basaltic soils, and wet sclerophyll forest supporting a rainforest understorey, a vegetation type typically located adjacent to rainforest. The potential habitats linked to this species and the area within the project that would be impacted are shown in Table 6-56).

Table 6-56 Habitat for Three-toed Snake Tooth Skink

Vegetation / habitat types linked to target species	Area in project boundary (ha)
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast	1.7
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	1.4
White Booyong - Fig subtropical rainforest of the North Coast	2.5
Total	**5.6 hectares**

The current information on this species suggests that only these select few habitat types may be occupied and a review of the Atlas data for the Northern Rivers region shows there are no records along the project boundary. The nearest record to the project occurs near Section 10 in subtropical rainforest habitat at Marom Creek several kilometres to the west of Wardell.

6.5.8.2. Survey methods

The survey method for this species involves turning objects under which they shelter, including rocks and fallen litter, and raking the surface layer of soil. It may also be recorded in pitfall traps although the targeted search method is considered more effective for crepuscular burrowing species.

The reptile surveys targeted all species, including a number of threatened species and were conducted during the preferred route studies, the EIS and the supplementary biodiversity assessment. The methods used were common for all investigations and consisted of dedicated searches for active and sheltering individuals under rocks, logs, bark, leaves and timber and artificial debris when encountered. The surveys were both time-based and area-based and varied in duration according to the size of the habitat. Survey sites and effort are described in Table 6-57.

Table 6-57 Survey efforts for Three-toed Snake Tooth Skink (*Coeranoscincus reticulatus*)

Survey method	Number of sites	Timing
Reptile searches were conducted at all general fauna trap sites and involved a 30-minute general traverse across a 1–2 hectare plot, turning logs, rocks and raking leaves.	The number of sites corresponding with the preferred habitat of the species as described above was 6 sites	Section 3 (July 2005, Oct 2007) Section 10-11 (March 2006, Jan 2007)
Systematic reptile searches were conducted at habitat assessment sites. This involved an active area-search across the habitat plot (20 x 50 metres) and turning logs, rocks and raking leaves.	A total of 5 dedicated reptile searches were conducted in the preferred habitat for this species using this technique.	Section 3 (November 2011) Section 7 and 8 (January 2012)

Survey method	Number of sites	Timing
Opportunistic reptiles searches were conducted during the dedicated Koala scat plot surveys. This involved raking leaf litter around 30 trees in each plots. This methods proved to be effective at locating a number fossorial skinks	A total of 160 plots were searches using this methods, of this 9 plots were in wet sclerophyll forest considered suitable for this species	Section 10 and 11 (February 2012)
Pitfall trap sites were surveyed in suitable habitat targeted at this species both consisting of 4 pits for five nights (20 trap nights) and using drift fencing	Two sites in moist floodplain forest with loose sandy soil	Section 3 (January 2012) Section 8 (January 2012)

As the species was not recorded in the study area and has a low likelihood of occurring, an assessment of significance is not required.

6.5.9. White-crowned Snake (*Cacophis harriettae*)

6.5.9.1. Background

The White-crowned Snake (*Cacophis harriettae*) was targeted in the preferred route studies and EIS surveys along with other threatened snake species. The species was reported as having a low likelihood of occurrence and this has been revised based on the critical review as having at least a moderate likelihood to occur. An assessment of significance for this species is provided.

6.5.9.2. Direct and indirect impacts

The White-crowned Snake favours low to mid-elevation dry eucalypt forest and woodland, particularly areas with a varied and well-developed litter layer, where the prey of small lizards may be more abundant. There are only three records of this species within a 10-kilometre radius of the project and this may reflect low population densities or its nocturnal activities and the difficulty in locating it. The range of habitat types potentially occupied by the species across the project is extensive and includes dry and moist sclerophyll forests and swamp forest types, although this prediction is based on dominant flora species and not on the structure of the understorey or presence of critical microhabitat features such as well–developed leaf litter and logs and is likely to be an overestimate. The type of habitat for White-crowned Snake and the amount impacted in the project is provided in Table 6-58.

Table 6-58 Habitat for White-crowned Snake

Vegetation / habitat types linked to target species	Area in project boundary (ha)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	93.6
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	37.6
Coast Cypress Pine shrubby open forest of the North Coast Bioregion	3.3
Coastal floodplain sedgelands, rushlands, and forblands	5.1
Coastal heath on sands of the North Coast	14.9
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	1.4
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	53.7
Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast	69.5

Vegetation / habitat types linked to target species	Area in project boundary (ha)
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	21.2
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast	58.6
Orange Gum (Eucalyptus bancroftii) open forest of the North Coast	5.6
Paperbark swamp forest of the coastal lowlands of the North Coast	64.5
Red Mahogany open forest of the coastal lowlands of the North Coast	42.9
Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast	66.2
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	163.8
Swamp Box swamp forest of the coastal lowlands of the North Coast	19.0
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast	47.6
Swamp Oak swamp forest of the coastal lowlands of the North Coast	43.1
Tallowwood dry grassy forest of the far northern ranges of the North Coast	54.4
Turpentine moist open forest of the coastal hills and ranges of the North Coast	42.7
Wet heathland and shrubland of coastal lowlands of the North Coast	11.5
Total	**828.7 hectares**

There is no detailed information available on the home range or habitat use of this species. If present, populations would be impacted by vegetation clearing and the loss of and isolation of suitable habitat. This would directly reduce the availability of foraging and sheltering habitat and reduce breeding success. Indirect impacts may be associated with weeds in edge-affected zones as well as a potential change in the fire regime cause by accidental fires near the road. Altered fire regimes may also affect foraging and sheltering habitat.

6.5.9.3. Assessment of significance: vulnerable species (TSC Act)

The assessment of significance for this species was undertaken in consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-59.

Table 6-59 Assessment of significance: White-crowned Snake (TSC Act)

White-crowned Snake
How is the project likely to affect the lifecycle of a threatened species and/or population?
The direct loss and isolation of habitat would reduce the availability of foraging and sheltering resources, placing pressure on in situ populations and competition for resources and may affect breeding success for a portion of the population. Suitable habitat is very widespread and impacts may affect low density local populations although is unlikely to be significant for the regional populations which is potentially very widespread and occurs over several state forests and conservation reserves.
How is the project likely to affect the habitat of a threatened species, population or ecological community?
The favoured habitat of the species is broadly described and could be associated with a wide diversity of dry and moist sclerophyll forest types and therefore extend over very large areas of the northern rivers region. This may include direct impacts on around 828 hectares of forest habitat on the project. There is no detailed information available on the home range or habitat use of this species. If present, populations would be impacted by vegetation clearing and the loss of and isolation of suitable habitat. This would directly reduce the availability of foraging and sheltering habitat and reduce breeding success. Indirect impacts may be associated with

White-crowned Snake
weeds in edge-affected zones as well as a potential change in the fire regime cause by accidental fires near the road. Altered fire regimes may also affect foraging and sheltering habitat
Does the project affect any threatened species or populations that are at the limit of its known distribution?
The species distribution is not limited in the study area and ranges over coastal and near-coastal areas from central eastern Queensland south to the vicinity of Coffs Harbour in north-east NSW. The western limit is the Legume area near the NSW-Queensland border; however, their stronghold appears to be the middle Clarence Valley. The distribution of local and regional populations is not known, although portions of the project through sections 1–3 and 6–8 may be considered within the range of an important regional population.
How is the project likely to affect current disturbance regimes?
The current disturbances to the habitat of this species are a result of clearing and logging, roads, tracks and easements, weed invasion and altered fire regimes. The project would contribute to these through extensive areas of clearing of suitable forest habitats, potential isolation of habitat and increased opportunity for edge effects mainly wed invasion. Human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease as a result of the road, particularly where large deviation from the highway is proposed as part of Section 3
How is the project likely to affect habitat connectivity?
The project would potentially traverse large areas of suitable habitat for this species across a large geographic area and would likely impact on landscape connectivity and isolation of habitat over a range of spatial scales. The project has potential to isolate remnant vegetation patches occupied by local populations, which is detrimental to species that exhibit smaller home ranges and low dispersal potential such as snakes. The effectiveness of fauna crossing structures for this specie is unknown.
How is the project likely to affect critical habitat?
No critical habitat has been identified for this species

Conclusion of the assessment

The project would not have a significant impact on this species. The likely direct loss and isolation of habitat from would reduce the availability of foraging and sheltering resources, placing pressure on local populations and creating competition for resources that may affect breeding success for a portion of the population. However, suitable habitat is very widespread and while the impacts may affect low-density local populations they are unlikely to be significant for the regional population which is potentially very widespread and occurs over several State forests and conservation reserves in the Northern Rivers region.

This conclusion is consistent with the conclusion in the EIS.

6.5.10. Varied Sittella (Daphoenositta chrysoptera)

6.5.10.1. Background

The Varied Sittella (*Daphoenositta chrysoptera*) was targeted in general bird survey techniques and the EIS surveys along with other woodland birds. The species was not listed as threatened at the time of the preferred route studies and received little focus despite being recorded at a few locations. The species was recorded at several locations and is identified in Appendix H of the EIS as occurring in sections 1 to 8, but an assessment of significance reported for threatened woodland birds did not discuss this species. Therefore, an assessment of significance for this species is now provided.

6.5.10.2. Direct and indirect impacts

The Varied Sittella is sedentary and inhabits most of mainland Australia except the treeless deserts and open grasslands. Distribution in NSW is nearly continuous from the coast to the far west. The Varied Sittella's population size in NSW is uncertain but is believed to have undergone a moderate reduction over

the past few decades. The species inhabits eucalypt forests and woodlands, especially those containing rough-barked species and mature smooth-barked gums with dead branches, mallee and Acacia woodland. It builds nests for breeding and is not reliant on tree hollows for nesting or shelter. The species and its favoured habitat are likely to be very widespread across the project, which would include the drier eucalypt forests listed in Table 6-60.

Table 6-60 Habitat for Varied Sittella

Vegetation / habitat types linked to target species	Area in project boundary (ha)
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	93.6
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	37.6
Coast Cypress Pine shrubby open forest of the North Coast Bioregion	3.3
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	1.4
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	53.7
Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast	69.5
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	21.2
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast	58.6
Orange Gum (Eucalyptus bancroftii) open forest of the North Coast	5.6
Red Mahogany open forest of the coastal lowlands of the North Coast	42.0
Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast	66.2
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	163.8
Swamp Box swamp forest of the coastal lowlands of the North Coast	19.0
Tallowwood dry grassy forest of the far northern ranges of the North Coast	54.4
Turpentine moist open forest of the coastal hills and ranges of the North Coast	42.7
	734.7 hectares

The apparent decline of the species has been attributed to declining habitat, which has particularly affected western populations. The project would contribute directly to a decline in the known and potential habitat for this species. The sedentary nature of the Varied Sittella makes cleared land a potential barrier to movement. Fragmentation and isolation of habitats may indirectly impact on population viability on a small scale and affect dispersal ability. The species feeds on arthropods taken from crevices in rough or decorticating bark, dead branches, standing dead trees and small branches and twigs in the tree canopy. The native vegetation cleared to construct the project would therefore contribute to a reduction in prey availability on a local scale.

Given the species favours habitats that are well-represented and widespread, the project would likely have minimal impact on the regional population and only a small number of local populations may be significantly impacted. Persistence and recovery of populations surrounding the project could be expected.

6.5.10.3. Assessment of significance: vulnerable species (TSC Act)

The assessment of significance for this species was undertaken in consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-61.

Table 6-61 Assessment of significance: Varied Sittella (TSC Act)

Varied Sittella (Daphoenositta chrysoptera)
How is the project likely to affect the lifecycle of a threatened species and/or population?
Habitat for this species is common and widespread across most project sections within the exception of 9-11. The species was found to be associated with the more open dry sclerophyll forest types. The clearing of open forest and woodland would impact on prey availability and affect the foraging 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 lifecycle activities potentially affected by the project include breeding and roosting as a direct result of habitat loss. The clearing and isolation of habitat may significantly alter movements and dispersal affecting a number of small local populations. The number of birds affected in relation to the size of local populations and the regional population 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 regional 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 734 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 prey availability. However the habitats suited on 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 this species in forestry areas during this project indicates a resilience 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 Varied Sittella is sedentary and inhabits most of mainland Australia except the treeless deserts and open grasslands. Distribution in NSW is nearly continuous from the coast to the far west. The Varied Sittella's population size in NSW is uncertain but is believed to have undergone a moderate reduction over the past several decades. The distribution of populations in the study area is not known but expected to be widespread.
How is the project likely to affect current disturbance regimes?
The current disturbances to the habitat of this species are a result of clearing and logging, roads, tracks and easements, weed invasion and altered fire regimes. It is believed to be negatively affected by linear clearings which may affect dispersal. The project would contribute to these through extensive areas of clearing of suitable forest habitats, potential isolation of habitat and increased opportunity for edge effects mainly weed invasion. Human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease as a result of the road, particularly where large deviation from the highway are planned through section 3.
How is the project likely to affect habitat connectivity?
The species is apparently threated by small-scale clearings for fencelines and road verges and loss of paddock trees which may provide stepping stones across the landscape for this small bird. The clearing of the road corridor through large areas of suitable habitat would create a barrier effect for local populations and potentially divide local populations or isolate populations leading to loss of population viability. The interruptions to connectivity in the landscape may be more associated with dispersal ability in addition to foraging movements between fragmented habitats. Their ability to cross gaps is not well documented.
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.

Conclusion of the assessment

The project would lead to a likely direct loss of around 735 hectares of habitat for the Varied Sittella, and the isolation of habitat would reduce the availability of foraging and sheltering resources, placing pressure on local populations and creating competition for resources. The project would also create large gaps between suitable habitat that may affect breeding success and dispersal for a portion of the population.

The project's impact on habitat may affect local populations. However, suitable habitat is very widespread and vegetation clearing for the project is unlikely to have a significant impact on regional populations which are very widespread and occur over several State forests and conservation reserves in the Northern Rivers region.

6.5.11. Eastern Pygmy Possum (*Cercartetus nanus*)

6.5.11.1. Background

The Eastern Pygmy Possum (*Cercartetus nanus*) was not recorded in the targeted surveys for the preferred route studies or the EIS. This species is small and difficult to trap, so it's true population status across the project is unknown. Current information suggests the species may utilise a wide range of habitats, so it could occur anywhere along the project. Records from the NSW Atlas support this with records associated with project sections 1 and 3, and 6 to10. The findings of the EIS assessment of significance for Eastern Pygmy Possum have been reviewed, considering the importance of the populations known to occur in the study area and the vulnerability of the species to the threats identified in the EIS. The review suggests that the impacts to the species should be reassessed considering the small home range of the species, its dependence on important microhabitats which are likely to be impacted on a large scale, and the species low dispersal ability.

6.5.11.2. Direct and indirect impacts

The Eastern Pygmy Possum is found in a broad range of habitats from rainforest through sclerophyll 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.

The species feeds largely on nectar and pollen collected from banksias, eucalypts and bottlebrushes; soft fruits are eaten when flowers are unavailable. It 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. It shelters in tree hollows, rotten stumps, holes in the ground, abandoned bird-nests, Ringtail Possum (*Pseudocheirus peregrinus*) dreys or thickets of vegetation (such as grass-tree skirts). The species appears to be mainly solitary, with each individual using several nests. Males have non-exclusive home-ranges of about 0.68 hectares and females about 0.35 hectares.

The species and its favoured habitat are likely to be very widespread across the project, which would include the drier eucalypt forests, heath and rainforest habitats. The type of habitat for Eastern Pygmy Possum and the amount that would be impacted by the project is provided in Table 6-62. It shows that around 932 hectares of habitat for the species are within the project boundary and would be cleared.

Table 6-62 Habitat for Eastern Pygmy Possum

Vegetation / habitat types linked to target species	Area in project boundary (ha)
Black Bean - Weeping Lilly Pilly Riparian Rainforest of the North Coast	1.7
Blackbutt - Bloodwood Dry Heathy Open Forest on Sandstones of the Northern North Coast	93.6
Blackbutt Grassy Open Forest of the Lower Clarence Valley of the North Coast	37.6
Coast Cypress Pine Shrubby Open Forest of the North Coast Bioregion	3.3
Coastal Floodplain Sedgelands, Rushlands, and Forblands	5.1
Coastal Heath on Sands of the North Coast	14.9

Vegetation / habitat types linked to target species	Area in project boundary (ha)
Flooded Gum - Tallowwood - Brush Box Moist Open Forest of the Coastal Ranges of the North Coast	1.4
Forest Red Gum - Swamp Box of the Clarence Valley Lowlands of the North Coast	53.7
Grey Gum - Grey Ironbark Open Forest of the Clarence Lowlands of the North Coast	69.5
Mangrove - Grey Mangrove Low Closed Forest of the NSW Coastal Bioregions	5.8
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast	21.2
Needlebark Stringybark - Red Bloodwood Heathy Woodland on Sandstones of the Lower Clarence of the North Coast	58.6
Orange Gum (Eucalyptus bancroftii) Open Forest of the North Coast	5.6
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast	64.5
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast	42.0
Scribbly Gum - Needlebark Stringybark Heathy Open Forest of Coastal Lowlands of the Northern North Coast	66.2
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	163.8
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast	19.0
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	47.6
Swamp Oak Swamp Forest of the Coastal Lowlands of the North Coast	43.1
Tallowwood Dry Grassy Forest of the Far Northern Ranges of the North Coast	54.4
Tuckeroo - Riberry - Yellow Tulipwood littoral rainforest of the North Coast	0.2
Turpentine Moist Open Forest of the Coastal Hills and Ranges of the North Coast	42.7
Wet heathland and shrubland of coastal lowlands of the North Coast	11.5
White Booyong - Fig subtropical rainforest of the North Coast	2.6
	931.7 hectares

The species is threatened by loss and fragmentation of habitat through land-clearing. Changed fire regimes that affect the abundance of flowering proteaceous and myrtaceous shrubs, particularly banksia, would also reduce seasonal food resources and have a short-term effect on foraging lifecycles. The project has potential to clear extensive areas of suitable habitat as described above; however, this is an estimate on the habitat that is available and not on data from known populations, which is not available. This clearing would remove shelter and food resources and reduce breeding success, and dispersal between populations. As the species has a very small home range, if the project has the potential to completely remove and/or isolate populations over multiple areas, if populations are present in the project area.

6.5.11.3. Assessment of significance: vulnerable species (TSC Act)

The assessment of significance for this species was undertaken in consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-63.

Table 6-63 Assessment of significance: Eastern Pygmy Possum (TSC) Act)

Eastern Pygmy Possum (Cercartetus nanus)
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 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. Suitable habitat occurs widely across all project sections and would be conserved in Broadwater National Park and a number of state forests traversed by the project. Impacts to the lifecycle of the species would be particularly evident through the loss of shelter resources (hollows and stumps or dense vegetation) and a direct loss of food resources. For surviving individuals home range movements would be affected as would future dispersal opportunities through the barrier effect of the highway. Edge effects and altered fire has the potential to further affect foraging activities. 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 modified habitats dominated by Camphor Laurel and may be tolerant on disturbed and modified habitats.
How is the project likely to affect the habitat of a threatened species, population or ecological community?
The species is threatened by loss and fragmentation of habitat through land-clearing. Changed fire regimes that affect the abundance of flowering proteaceous and myrtaceous shrubs, particularly banksia would also reduce seasonal food resources and have a short-term effect on foraging lifecycles. The project has potential to clear extensive areas of suitable habitat as described above, however this is an estimate on the habitat that is available and not on data from known populations which is not available. This clearing would remove shelter and food resources.
Does the project affect any threatened species or populations that are at the limit of its known distribution?
The species is known from the western slopes and coastal plains of the Great Dividing Range from south-east Queensland to south-east South Australia and is not restricted to the study area. Given the preference rainforest habitats in the northern rovers there is potential for the regional population to be widespread across the far northern region of the state.
How is the project likely to affect current disturbance regimes?
The current disturbances to the habitat of this species are a result of clearing and logging, weed invasion and altered fire regimes. The project would contribute to these disturbances through extensive areas of clearing of suitable forest habitats, potential isolation of habitat and increased opportunity for edge effects mainly weed invasion. Human-caused fire ignitions and suppressions may increase, and average fire sizes and fire spread decrease as a result of the road, particularly where large deviation from the highway are planned in areas where there has been limited access in the past.
How is the project likely to affect habitat connectivity?
The species has a small home range and for this reason, the clearing of the road corridor through large areas of suitable habitat would create a barrier effect for local populations and potentially divide local populations or isolate populations leading to loss of population viability. The interruptions to connectivity in the landscape may be associated with loss of normal movements across a home range area and reduced dispersal ability. Their ability to cross gaps or use connectivity structures is not well documented.
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.

6.5.11.4. Conclusion of the assessment

The project has potential to impact on multiple local populations at a range of scales by directly clearing suitable habitat, altering the home range and dispersal capabilities of individuals and removing shelter and food resources. These losses may be significant and lead to a reduction in population viability through isolation, competition for resources and stress.

Overall, the project is expected to have a significant impact on the species.

This conclusion is not consistent with the EIS.

6.5.12. Green-thighed Frog (*Litoria brevipalmata*)

The conclusion in Chapter 6 of the EIS biodiversity working paper states that the project would have a non-significant impact on the Green-thighed Frog (*Litoria brevipalmata*).

However, a critical review of the biodiversity working paper identified that the assessment of significance for the Green-thighed Frog under the EP&A Act indicates that a significant impact is likely.

Therefore, the conclusion in Chapter 6 is incorrect and should indicate a significant impact for this species.

6.5.13. Australasian Bittern (*Botaurus poiciloptilus*)

6.5.13.1. Background

The EIS assessed the potential impacts of the project on listed wetland bird species considered to have a moderate to high likelihood of occurring in the study area. Separate assessments of significance were undertaken for the Australasian Bittern (*Botaurus poiciloptilus*) and the Australian Painted Snipe according to criteria for endangered species in the DEWHA (2009) assessment guidelines. No further assessment is required under the EPBC Act.

The assessment of significance under the NSW EP&A Act for State listed wetland birds assessed species with distinct taxonomic, behavioural and ecological differences as one group. This method may not have adequately considered the unique requirements of each species and was identified as a gap in the critical review of the biodiversity working paper. As such, a revised assessment of significance is provided which assesses species separately, or in some cases groups species according to their occupancy of microhabitats.

6.5.13.2. Direct and indirect impacts

The Australasian Bittern favours permanent freshwater wetlands with tall, dense vegetation, particularly bulrushes (*Typha* spp.) and spikerushes (*Eleocharis* spp.). As the project would traverse a portion of the floodplain of the Clarence River and Richmond River in addition to the Corindi River north of Woolgoolga, this would result in direct impacts on around 5.1 hectares of freshwater wetlands. In addition, around 41.4 hectares of wetland were identified in surrounding areas immediately adjoining the project that may be indirectly impacted from runoff of sediment or pollutants during construction and operation. This species exhibits some resilience in modified habitats and can occupy wetlands modified by draining, grazing and weeds.

The species is uncommon but there is a widespread regional population across the Northern Rivers region. While there is limited data on the distribution of breeding pairs or local populations, it is expected that the project may directly and indirectly affect the lifecycle of populations persisting around the major wetlands of the Clarence River and Richmond River and to a lesser degree the smaller Corindi River floodplains which are more degraded. Of particular importance are the Coldstream River wetlands, Chaffin Swamp and Champions Creek in Section 3, Shark Creek wetlands in Section 4 and Broadwater National Park in Section 9.

The project may have impacts associated with removal of nesting, foraging and roosting habitat. This may have an indirect impact on breeding success and dispersal. There may also be indirect impacts on habitat associated with edge effects, lights and noise, which 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.

The project may cause fragmentation of habitat as it crosses the Coldstream wetlands, but in general the potential habitat of the species would be avoided such that the areas impacted would be those located on either side of the project. For this reason, the isolation of populations is not expected and this effect is made less likely by the mobility of the species and its ability to disperse cleared lands to access suitable habitat.

6.5.13.3. Assessment of significance: endangered species (TSC Act)

The assessment of significance for this species was undertaken in consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-64.

Table 6-64 Assessment of significance: Australasian Bittern (TSC Act)

Australasian Bittern (*Botaurus poiciloptilus*)
How is the project likely to affect the lifecycle of a threatened species and/or population?
It is expected that the project may directly and indirectly affect the lifecycle of populations persisting around the major wetlands of the Clarence River and Richmond River and to a lesser degree the smaller Corindi River floodplains which are more degraded. Of particular importance are the Coldstream River wetlands, Chaffin Swamp and Champions Creek in Section 3, Shark Creek wetlands in Section 4 and Broadwater National Park in Section 9. These impacts may be associated with removal of nesting, foraging and roosting habitat and have an indirect impact on breeding success and dispersal ability. These impacts may have short to medium term impacts on established pairs, however the given the low direct impact on the habitat of the species compared to remaining areas of suitable habitat, and the resilience of the species in modified habitats, it is likely that local populations would persist.
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 River and Richmond River in addition to the Corindi River north of Woolgoolga, this would result in direct impacts on around 5.1 hectares of freshwater wetlands. Around 46 hectares of wetland were identified in surrounding areas immediately adjoining the project that may be indirectly impacted from runoff of sediment or pollutants during construction and operation. Of particular importance are the Coldstream River wetlands, Chaffin Swamp and Champions Creek in Section 3, Shark Creek wetlands in Section 4 and Broadwater National Park in Section 9.
Does the project affect any threatened species or populations that are at the limit of its known distribution?
The species in uncommon but there is a widespread regional population across the northern rivers.
How is the project likely to affect current disturbance regimes?
The identified known and potential habitats of the species predominantly occur in modified landscapes that have been subject to a long history of draining and agricultural, this is particularly evident in the wetlands on Section 3 around the Coldstream, Chaffin and Shark Creek and also the Corindi River floodplain. The least disturbed habitats occur in Broadwater National Park. Disturbances are associated with clearing of vegetation and the resulting change in sediment and nutrient loads in the wetlands and associated change in structure of the macrophytes vegetation. This is likely to have led to an increase in vegetation such as Typhya and other macrophytes and may have benefited the species. The project would contribute to these disturbances by further clearing of vegetation with the catchment of the wetlands, leading to increased runoff and further potential increased in sedimentation and nutrients into the wetlands. Other disturbances associated with weeds are already very abundant in the wetlands and adjacent catchments and the project may contribute to weed invasion in edge areas. Although this is expected to be a lower risk over the remaining areas of wetland and difficult to separate from the on-gong continual weed impacts from historical clearing.
How is the project likely to affect habitat connectivity?
Fragmentation of habitat may occur through the crossing the Coldstream wetlands, however in general the potential habitat of the species has been avoided such that the areas impacted are those located on either side of the project. For this reason the isolation of populations is not expected and is further supported by the mobility of the specie and ability to disperse cleared lands to access suitable habitat.
How is the project likely to affect critical habitat?
No critical habitat has been identified for this species

Conclusion of the assessment

The project would not have a significant impact on the local and regional population of the Australian Bittern, and it is likely that local populations would persist. This is because the project would have a low direct impact on the habitat of the species compared to remaining areas of suitable habitat, and because of the resilience of the species in modified habitats.

This conclusion is consistent with the conclusion in the EIS.

6.5.14. Australian Painted Snipe (*Rostratula australis*)

6.5.14.1. Background

See introduction to Australian Bittern.

6.5.14.2. Direct and indirect impacts

The Australian Painted Snipe (*Rostratula australis*) prefers shallow freshwater wetlands, particularly fringes of swamps and nearby marshy areas where there is a cover of grasses, lignum, low scrub or open timber. Pairs nest on the ground amongst tall vegetation, such as grasses, tussocks or reeds. Suitable habitat in the project study area is difficult to define due to the variation in wetland types, and the degree of forest cover. Also the species has been known to use artificial habitats, such as dams and waterlogged grassland. It is likely that important habitats are those areas that provide consistent food and shelter resources particularly in the drier months of September to December, which is the breeding period. This would include open wetlands with limited tree cover and areas where there have been limited grazing impacts.

For this reason, the important area for this species in the project area is likely to be the Coldstream and Clarence River floodplains wetlands in Section 3 and possibly Section 4, and the species has been recorded at these locations.

The project may have impacts associated with the removal of around two hectares of nesting, foraging and sheltering habitat. This may have indirect impacts on breeding success and dispersal. There may also be indirect impacts on habitat associated with edge effects, lights and noise, which would be localised.

Impacts clearing of vegetation would result in a change in sediment and nutrient loads in the wetlands and an associated change in structure of the macrophytes vegetation. This is likely to disadvantage the species, which prefers open wetlands with minimal tall vegetation.

The movements of the Painted Snipe are poorly known and it may be a migratory species. Sightings are erratic, as the species is likely to be nomadic as it responds to suitable conditions, such as floods. Populations are widespread across modified landscapes and it is unlikely that the project would have a significant impact on the breeding or dispersal movements of the species.

6.5.14.3. Assessment of significance: vulnerable species (TSC Act)

The assessment of significance for this species was undertaken in consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-65.

Table 6-65 Assessment of significance: Australian Painted Snipe (TSC Act)

Australian Painted Snipe (*Rostratula australis*)
How is the project likely to affect the lifecycle of a threatened species and/or population?
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 lifecycle of populations by temporarily displacing or disturbing individuals or established pairs. This may include nesting, foraging and roosting lifecycle activities. 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. 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 number of pairs, if there are major flood events during this time which may attract breeding pairs. However this impact would be localised and minimal in the scale of the wetland habitats available to the species in this location.
How is the project likely to affect the habitat of a threatened species, population or ecological community?
The project would result in direct impacts on around 5.1 hectares of wetland habitats of these around two hectares in the Clarence and Coldstream floodplain are expected to be potentially important for a portion of the regional population. Impacts may be associated with the removal of nesting, foraging and sheltering habitat which equates to around two hectares in the location described. There may be indirect impacts on breeding success and dispersal as well as indirect impacts on habitat associated with edge effects, lights and noise, these would be localised. Disturbances are associated with clearing of vegetation and the resulting change in sediment and nutrient loads in the wetlands and associated change in structure of the macrophytes vegetation. This is likely to have disadvantaged the species which prefers open wetlands with minimal tall vegetation.
Does the project affect any threatened species or populations that are at the limit of its known distribution?
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. Populations are therefore widespread and the species can disperse over large distances.
How is the project likely to affect current disturbance regimes?
The identified known and potential habitats of the species predominantly occur in modified landscapes that have been subject to a long history of draining and agricultural, this is particularly evident in the wetlands on Section 3 around the Coldstream, and Chaffin Swamp Shark Creek wetlands. Current disturbances are associated with clearing of vegetation and the resulting change in sediment and nutrient loads in the wetlands and associated change in structure of the macrophytes vegetation. This is likely to have led to an increase in vegetation such as Typhya and other macrophytes and may have disadvantaged this species which favours open areas for foraging, but denser areas of shelter. The project would contribute to these disturbances by further clearing of vegetation with the catchment of the wetlands, leading to increased runoff and further potential increased in sedimentation and nutrients into the wetlands. Other disturbances associated with weeds are already very abundant in the wetlands and adjacent catchments and the project may contribute to weed invasion in edge areas. Although this is expected to be a lower risk over the remaining areas of wetland and difficult to separate from the on-gong continual weed impacts from historical clearing.
How is the project likely to affect habitat connectivity?
The potential habitat of the species has been largely avoided such that the areas impacted are those located on either side of the project. For this reason the isolation of populations is not expected and is further supported by the mobility of the species and ability to disperse cleared lands to access suitable habitat. The movements of the Painted Snipe are poorly known and it may be a migratory species. Sightings are erratic, as the species is likely to be nomadic in response to suitable conditions, such as floods. Populations are widespread across modified landscapes and it is unlikely that the project would impact on the breeding or dispersal movements of the species.
How is the project likely to affect critical habitat?
No critical habitat has been identified for this species

Conclusion of the assessment

The project would not have a significant impact on the local and regional population of the Australian Painted Snipe, and it is likely that local populations would persist. This is because the project would have a low direct impact on the habitat of the species compared to remaining areas of suitable habitat, and because of the resilience of the species in modified habitats.

This conclusion is consistent with the conclusion in the EIS.

6.5.15. Black-necked Stork (Ephippiorhynchus asiaticus) and Brolga (Grus rubicunda)

6.5.15.1. Background

See introduction to Australian Bittern.

6.5.15.2. Direct and indirect impacts

The Black-necked Stork (*Ephippiorhynchus asiaticus*) and Brolga (*Grus rubicunda*) exhibit similar habitat preferences and are mainly found on shallow, permanent, freshwater 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 mainly forage in shallow, still water, preferring open wetlands.

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 that 86.2 per cent of nests were located in cleared or modified farmland (grazing land for beef cattle) and 14 per cent were within 200 metres of a road, including highways, with the closest nest 50 metres from a road.

There are no reported nests of the Brolga inside the project boundary.

Both species are tolerant of, and indeed frequent, modified habitats including wetlands modified by draining, grazing and weeds. As the project would traverse a portion of the floodplain of the Clarence River and Richmond River in addition to the Corindi River north of Woolgoolga, this would result in direct impacts on around 5.1 hectares of freshwater wetlands. Around 46 hectares of wetland were identified in surrounding areas immediately adjoining the project that may be indirectly impacted from runoff of sediment or pollutants during construction and operation.

The review of habitat availability and records of Black-necked Stork and Brolga suggest that potential habitat for these wetland species is widespread throughout the study area including adjacent to the project boundary (in dense vegetation on the margins of freshwater creeks, rivers and natural or artificial wetlands). Because of the existence of widespread habitats and resources for these species, the project is expected to have minimal adverse impacts.

6.5.15.3. Assessment of significance: endangered (Black-necked Stork); vulnerable (Brolga) (TSC Act)

The assessment of significance for this species was undertaken in consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-66.

Table 6-66 Assessment of significance: Black-necked Stork and Brolga (TSC Act)

Black-necked Stork (*Ephippiorhynchus asiaticus*) **and Brolga** (*Grus rubicunda*)
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 on around 5.1 hectares of wetland habitats that provide known and potential habitat for these species. The areas of open grassland and waterlogged paddocks have not been quantified and are widespread and common in Section 1 and 3–5. If there are nest sites in proximity to the project during the construction phase, there may be a temporary disturbance and disruption to the breeding cycle of established pairs. Long-term impacts on foraging, breeding and dispersal are not expected for this wide-ranging species which frequent modified habitats and are capable of long dispersal distances in response to local conditions.
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 on around 5.1 hectares of wetland habitats. Around 46 hectares of wetland were identified in surrounding areas immediately adjoining the project that may be indirectly impacted from runoff of sediment or pollutants during construction and operation. 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 boundary including dense vegetation on the margins of freshwater creeks, rivers and natural or artificial wetlands. In particular there are widespread habitats and resources for the Black-necked Stork and Brolga 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*. 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.
How is the project likely to affect current disturbance regimes?
The identified known and potential habitats of the species predominantly occur in modified landscapes that have been subject to a long history of draining and agricultural, this is particularly evident in the wetlands on Section 3 around the Coldstream, and Chaffin Swamp Shark Creek wetlands. Current disturbances are associated with clearing of vegetation and the resulting change in sediment and nutrient loads in the wetlands and associated change in structure of the macrophytes vegetation. This is likely to have led to an increase in vegetation such as Typha and other macrophytes and may have disadvantaged these species which favour open areas for foraging. The project would contribute to these disturbances by further clearing of vegetation with the catchment of the wetlands, leading to increased runoff and further potential increased in sedimentation and nutrients into the wetlands. Other disturbances associated with weeds are already very abundant in the wetlands and adjacent catchments and the project may contribute to weed invasion in edge areas. Although this is expected to be a lower risk over the remaining areas of wetland and difficult to separate from the on-gong continual weed impacts from historical clearing.
How is the project likely to affect habitat connectivity?
Fragmentation of habitat may occur through the crossing the Coldstream wetlands, however in general the potential habitat of the species has been avoided such that the areas impacted are those located on either side of the project. For this reason the isolation of populations is not expected and is further supported by the mobility of the species and ability to disperse cleared lands to access suitable habitat.
How is the project likely to affect critical habitat?
No critical habitat has been identified for these species

Conclusion of the assessment

The project has potential to temporarily impact on lifecycles of the Brolga and the Black-necked Stork close to the project construction area. However, long-term, widespread impacts on the local and regional populations are not expected to be significant. This is because both species are widespread and adapted to utilising modified habitats.

This conclusion is consistent with the conclusion in the EIS.

6.5.16. Black Bittern (Ixobrychus flavicollis)

6.5.16.1. Background

See introduction to Australian Bittern.

6.5.16.2. Direct and indirect impacts

The Black Bittern (*Ixobrychus flavicollis*) inhabits both terrestrial and estuarine wetlands, generally in areas of permanent water and dense vegetation. Where permanent water is present, the species may occur in flooded grassland, forest, woodland, rainforest and mangroves.

It is difficult to predict the distribution of the species. Around 344 water crossing structures (bridges, culverts and pipes) would be constructed across the project. Of these structures:

- 68 per cent would be built across shallow ephemeral drainage lines consisting of class 3 or class 4 waterways, which are unsuitable or marginal habitat for this species.
- 10 per cent would be built across 20 class 1 waterways.
- 22 per cent would be built across 74 class 2 waterways.

Therefore, 32 per cent of the proposed waterways crossings on the project may constitute potential habitat for the Black Bittern, although this species is dependent on dense vegetation for its lifecycle and this limitation would determine the distribution of populations.

Many waterways such as the Corindi River and Clarence River are poorly vegetated near the project and not suitable for the Black Bittern, while areas upstream or downstream of the project may be occupied by this species.. Preferred habitat for the species would be the smaller permanent waterways in densely forested areas such as Redbank Creek (Section 1), Dirty Creek (Section 2), Chaffin Creek and Champions Creek (Section 3), Tabbimoble Creek (Section 6) and several unnamed tributaries in sections 7 and 8.

Impacts would be associated with the crossing of these waterways and the direct clearing of riparian vegetation and potential indirect impact on adjacent areas through edge effects.

There may also be indirect impacts from:

- Noise and lights from the road, which may make nearby areas of habitat no longer suitable and therefore impact on the territory and spatial distribution of individuals or established pairs.
- The potential for increased runoff in the catchment and sediment and nutrient loads into the waterway habitats and the effect on food resources. (The species feeds on frogs, aquatic invertebrates and fish that depend on good water quality.)

6.5.16.3. Assessment of significance: vulnerable species (TSC Act)

The assessment of significance for this species was undertaken in consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-67.

Table 6-67 Assessment of significance: Black Bittern (TSC Ac)

Black Bittern (*Ixobrychus flavicollis*)
How is the project likely to affect the lifecycle of a threatened species and/or population?
Impacts would be associated with the crossing of these waterways and the direct clearing of riparian vegetation and potential indirect impact to adjacent areas through edge effects. The noise and lights associated with the road may make areas of habitat in proximity of the project no longer suitable and therefore impact on the territory and spatial distribution of individuals or established pairs. This may impact on the breeding success of established pairs and increase competition for space and resources. Indirect impacts would be associated with the potential for increase runoff in the catchment and sediment and nutrient loads into the waterway habitats and the effect on food resources and foraging lifecycles. The species feeds on frogs, aquatic invertebrates and fish dependent on water quality. The impacts are likely to be localised around the project boundary, and birds present in other adjoining large areas of suitable habitat, particularly in state forests and private forested lands are unlikely to be affected. The project may directly and indirectly affect the lifecycle of localised populations by displacing or disturbing individuals or established pairs. This may include nesting, foraging and roosting lifecycle activities within the home range of established pairs. These species are not restricted to the study area and extend across other states and territories.
How is the project likely to affect the habitat of a threatened species, population or ecological community?
It is difficult to predict the distribution of the species. Suitable habitat would include permanent class 1 and 2 waterways but only those in densely forested areas such as Redbank Creek (Section 1), Dirty Creek (Section 2), Chaffin Creek and Champions Creek (Section 3), Tabbimoble Creek (Section 6) and several unnamed tributaries in Section 7 and 8. The Black bittern is dependent on dense vegetation for its lifecycle and this limitation would determine the distribution of populations. Many waterways such as the Corindi River, Clarence River for example are poorly vegetated near the project and not suitable, while areas upstream or downstream from the project may be occupied. Impacts would be associated with the crossing of these waterways and the direct clearing of riparian vegetation and potential indirect impact to adjacent areas through edge effects (weeds, altered habitat structures, sedimentation and increased nutrient in waterways.
Does the project affect any threatened species or populations that are at the limit of its known distribution?
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.
How is the project likely to affect current disturbance regimes?
Given that the preferred habitat of the species is creeks through densely forested areas, current disturbances are expected to be low compared to the open agricultural areas, cleared and ephemeral waterways. Some disturbances may relate to forestry activities and small scale clearing including tracks, firetrails and power easements including clearing for the existing Pacific Highway and local road network. The project is expected to contribute to these disturbance regimes through clearing of vegetation within the local catchment and the associated ground disturbance and potential for increase sediment into waterways. The impacts would likely be mitigated and potentially effect localised areas, while upstream and downstream habitats would continue to be occupied.
How is the project likely to affect habitat connectivity?
The project would directly traverse several waterways in forested areas predicted to provide potential habitat for this species. The traverse of the creek and placement of infrastructure would potentially create a barrier to home range, breeding or dispersal movements along the waterway. The ability of the species is disperse across this infrastructure or clearings along riparian areas is not known, however it is likely that the birds rely on dispersal and movements through semi-cleared landscapes to find pairs and establish territories that are outside the parent home range. This would include crossing below bridge structures or across roadways.
How is the project likely to affect critical habitat?
No critical habitat has been identified for this species

Conclusion of the assessment

The project would not have a significant impact on populations of the Black Bittern. This is because there are multiple permanent creeks that may provide suitable habitat for the species and these extend across the landscape beyond the project boundary. In addition, impacts are likely to be localised around the project boundary, and birds present in other adjoining large areas of suitable habitat, particularly in State forests and private forested lands, are unlikely to be affected.

This conclusion is consistent with the conclusion in the EIS.

6.5.17. Magpie Goose (Anseranas semipalmata), Freckled Duck (Stictonetta naevosa) and Comb-crested Jacana (Irediparra gallinacea)

6.5.17.1. Background

See introduction to Australian Bittern.

6.5.17.2. Direct and indirect impacts

The Magpie Goose (*Anseranas semipalmata*), Freckled Duck (*Stictonetta naevosa*) and Comb-crested Jacana (*Irediparra gallinacea*) share similar habitats and prefer shallow freshwater wetlands with dense growth of rushes or sedges. The Comb-crested Jacana particularly prefers floating vegetation.

As the project would traverse a portion of the floodplain of the Clarence River and Richmond River in addition to the Corindi River north of Woolgoolga, this would result in direct impacts on around 5.1 hectares of freshwater wetlands. Around 46 hectares of wetland were identified in surrounding areas immediately adjoining the project that may be indirectly impacted from runoff of sediment or pollutants during construction and operation. These species exhibit some resilience in modified habitats and can occupy wetlands modified by draining, grazing and weeds.

All three species are uncommon although there are widespread regional populations across the Northern Rivers and NSW. All three species are dispersive, moving about in response to the condition of wetlands and occasionally turn up well beyond the normal range. There are no permanent populations known from the project area and lifecycle activities may include infrequent visits for foraging and temporary refuge, or a single breeding event depending on the conditions of the wetlands.

While there is limited data on the distribution of breeding pairs or local populations, the project may directly and indirectly affect the lifecycle of populations if present around the major wetlands of the Clarence River and Richmond River and, to a lesser degree, the smaller Corindi River floodplains, which are more degraded. Of particular importance are the Coldstream River wetlands, Chaffin Swamp and Champions Creek in Section 3, Shark Creek wetlands in Section 4 and Broadwater National Park in Section 9.

The project would have direct impacts associated with removal of nesting, foraging and roosting habitat.

There may also be indirect impact on breeding success and dispersal as well as indirect impacts on habitat associated with edge effects, lights and noise. These impacts 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 floodplains of the Clarence River.

Another impact could include fragmentation of habitat through the crossing of the Coldstream wetlands, but in general the potential habitat of the species would be avoided such that the areas impacted are those small patches located immediately either side of the project. For this reason the isolation of populations is not expected. The likelihood of the project isolating populations would be further lessened by the mobility of these species and their ability to disperse cleared lands to access suitable habitat.

6.5.17.3. Assessment of significance: vulnerable species (TSC Act)

The assessment of significance for this species was undertaken in consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-68.

Table 6-68 Assessment of significance: Magpie Goose, Freckled Duck and Comb-crested Jacana (TSC Act)

Magpie Goose (*Anseranas semipalmata*), Freckled Duck (*Stictonetta naevosa*) and Comb-crested Jacana (*Irediparra gallinacea*)
How is the project likely to affect the lifecycle of a threatened species and/or population?
It is expected that the project may directly and indirectly affect the lifecycle of populations persisting around the major wetlands of the Clarence River and Richmond River and to a lesser degree the smaller Corindi River floodplains which are more degraded. Of particular importance are the Coldstream River wetlands, Chaffin Swamp and Champions Creek in Section 3, Shark Creek wetlands in Section 4 and Broadwater National Park in Section 9. These impacts may be associated with removal of nesting, foraging and roosting habitat and have an indirect impact on breeding success and dispersal ability. These impacts may have short to medium term impacts, however the given the low direct impact on the habitat of the species compared to remaining areas of suitable habitat and the dispersive nature of these species, it is likely that the existing habitats and resources would continue to provide for the lifecycle needs of the species.
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 River and Richmond River in addition to the Corindi River north of Woolgoolga, this would result in direct impacts on around 5.1 hectares of freshwater wetlands. Around 46 hectares of wetland were identified in surrounding areas immediately adjoining the project that may be indirectly impacted from runoff of sediment or pollutants during construction and operation. Of particular importance are the Coldstream River wetlands, Chaffin Swamp and Champions Creek in Section 3, Shark Creek wetlands in Section 4 and Broadwater National Park in Section 9.
Does the project affect any threatened species or populations that are at the limit of its known distribution?
All three species in uncommon but there are widespread regional populations across the northern rivers and NSW. All three species are dispersive, moving about in response to the condition of wetlands and occasionally turn up well beyond the normal range. There are no permanent populations known from the project area and lifecycle activities may include infrequent visits for foraging and temporary refuge, or a single breeding event depending on the conditions of the wetlands.
How is the project likely to affect current disturbance regimes?
The identified known and potential habitats of the species predominantly occur in modified landscapes that have been subject to a long history of draining and agricultural, this is particularly evident in the wetlands on Section 3 around the Coldstream, Chaffin and Shark Creek and also the Corindi River floodplain. The least disturbed habitats occur in Broadwater National Park. Disturbances are associated with clearing of vegetation and the resulting change in sediment and nutrient loads in the wetlands and associated change in structure of the macrophytes vegetation. This is likely to have led to an increase in vegetation such as Typha and other macrophytes and may have benefited these species. The project would contribute to these disturbances by further clearing of vegetation with the catchment of the wetlands, leading to increased runoff and further potential increased in sedimentation and nutrients into the wetlands. Other disturbances associated with weeds are already very abundant in the wetlands and adjacent catchments and the project may contribute to weed invasion in edge areas. Although this is expected to be a lower risk over the remaining areas of wetland and difficult to separate from the on-gong continual weed impacts from historical clearing.
How is the project likely to affect habitat connectivity?
Fragmentation of habitat may occur through the crossing the Coldstream wetlands, however in general the potential habitat of the species has been avoided such that the areas impacted are those located on either side of the project.

Magpie Goose (*Anseranas semipalmata*), Freckled Duck (*Stictonetta naevosa*) and Comb-crested Jacana (*Irediparra gallinacea*)
For this reason the isolation of populations is not expected and is further supported by the mobility of the species and ability to disperse cleared lands to access suitable habitat.
How is the project likely to affect critical habitat?
No critical habitat has been identified for these species

Conclusion of the assessment

The project may directly and indirectly affect the lifecycle of local populations if present around the major wetlands of the Clarence River and Richmond River and, to a lesser degree, the smaller Corindi River floodplains. The project would also contribute indirectly to the existing and long history of disturbance regimes on these wetlands through vegetation clearing and potential increased runoff impacts. These impacts may have short to medium term implications on established pairs and interrupt a potential breeding season.

However, the impact would not be significant due to the low direct impact on the habitat of these species compared to remaining areas of suitable habitat, and the widespread and dispersive nature of these species. It is highly likely that these species will continue to return to the study area post-construction.

This conclusion is consistent with the conclusion in the EIS.

6.5.18. Pale-vented Bush-hen (*Amaurornis moluccana*)

6.5.18.1. Background

See introduction to Australian Bittern.

6.5.18.2. Direct and indirect impacts

The Pale-vented Bush-hen (*Amaurornis moluccana*) 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. It also occurs 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.

Key elements of their habitat are dense undergrowth two to four metres tall and within 300 metres of water. The range of potential habitats and possible distribution for this species in the study area is extensive. Records of the species in the NSW Atlas and in relation to the project area all occur north of Woodburn, which includes project sections 8 to 11; this is considered the core range in relation to this project. If present, populations would occur in floodplain areas, which may include cleared land or low-lying forests and rainforest near waterways. This would suggest that habitat near Eversons Creek in Section 9 and Randles Creek in Section 10 would be suitable. Broadwater National Park (Section 9) may also provide potential habitat.

With the exception of Broadwater National Park, the project would traverse largely cleared and fragmented landscapes and avoid large contiguous areas of forest.

Impacts may be associated with the removal of nesting, foraging and sheltering habitat which is difficult to quantify given the range of habitats used and known occurrence in modified and cleared landscapes. There may also be indirect impacts on breeding success and dispersal. Edge effects are not expected to significantly impact on the species, which is reportedly adapted to dense weedy habitats and disturbed land and may favour this disturbance for shelter, refuge and breeding.

6.5.18.3. Assessment of significance: vulnerable species (TSC Act)

The assessment of significance for this species was undertaken in consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-69.

Table 6-69 Assessment of significance: Pale-vented Bush-hen (TSC Act)

Pale-vented Bush-hen (*Amaurornis moluccana*)
How is the project likely to affect the lifecycle of a threatened species and/or population?
Impacts may be associated with the removal of nesting, foraging and sheltering habitat which is difficult to quantify given the range of habitats used and known occurrence in modified and cleared landscapes. There may be indirect and temporary impacts on breeding success and dispersal. Edge effects are not expected to significantly impact on the species lifecycle which is reportedly adapted to dense weedy habitats and disturbed land and may favour this disturbance for shelter, refuge and breeding.
How is the project likely to affect the habitat of a threatened species, population or ecological community?
Impacts may be associated with the removal of nesting, foraging and sheltering habitat, including cleared grassland with tall grass cover which is difficult to quantify in area given the range of habitats used and known occurrence in modified and cleared landscapes. The review of habitat availability and records of these species suggest that potential habitat for this species would occur in Section 9-11 and that there are widespread habitats and opportunities for this species which frequents 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, 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.
How is the project likely to affect current disturbance regimes?
Current disturbance regimes impacting the habitat for this species are mainly associated with weed invasion and potentially increased sediment and nutrient loads into wetlands and creek. Edge effects are not expected to significantly impact on the species which is reportedly adapted to dense weedy habitats and disturbed land and may favour this disturbance for shelter, refuge and breeding.
How is the project likely to affect habitat connectivity?
Given the species preference for disturbed habitats and high mobility of the species, it is unlikely that the additional of the road would impact on habitat connectivity or potential movements for accessing habitats, breeding or dispersal.
How is the project likely to affect critical habitat?
No critical habitat has been identified for this species

Conclusion of the assessment

Potential impacts on the Pale-vented Bush-hen are expected to be minor, temporary and not significant. This is because there are widespread habitats and opportunities for this species, which frequents disturbed and modified habitats. This conclusion is consistent with the conclusion in the EIS.

6.5.19. Double-eyed Fig Parrot (*Cyclopsitta diophthalma*)

6.5.19.1. Background

The EIS assessed the potential impacts of the project on listed rainforest bird species considered to have a moderate to high likelihood of occurring in the study area.

A separate assessment of significance was undertaken for the Double-eyed Fig Parrot (*Cyclopsitta diophthalma*) according to criteria for endangered species in the DEWHA (2009) assessment guidelines. This assessment concluded that the project was unlikely to have a significant impact on known populations of the Double-eyed Fig Parrot.

The design refinements for the proposed Wardell interchange would reduce the impacts on potential habitat for this species, which further support the conclusions of the impact assessment. No further assessment is required under the EPBC Act.

The assessment of significance under the NSW EP&A Act for State listed rainforest birds assessed species with distinct taxonomic, behavioural and ecological differences as one group. This method may not have adequately considered the unique requirements of each species and was identified as a gap in the critical review of the biodiversity working paper. Therefore, a revised assessment of significance is provided which assesses species separately, or in some cases groups species according to their occupancy of microhabitats.

6.5.19.2. Direct and indirect impacts

The Double-eyed Fig Parrot is associated with five discrete populations, all of which occur outside the study area, mainly north and west of Ballina. It is considered unlikely to be resident or heavily dependent on smaller fragments of rainforest within or around the project boundary. The habitats present are not considered critical for the regional population and any records from the area are likely to be from transient, dispersing individuals.

The clearing of habitat for the project, in particular Lowland Rainforest (4.2 hectares) and some wet/moist sclerophyll forest (225 hectares) would affect the availability of food resources and therefore may have a minor impact on the foraging and roosting activities of the species. As the documented breeding populations all occur outside of the study area, any impacts from the loss of habitat along the project boundary would more than likely affect foraging resources rather than a significant breeding/nesting area.

6.5.19.3. Assessment of significance: endangered species (TSC Act)

The assessment of significance for this species was undertaken in consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-70.

Table 6-70 Assessment of significance; Double-eyed Fig Parrot (TSC Act)

Double-eyed Fig Parrot *(Cyclopsitta diophthalma)*
How is the project likely to affect the lifecycle of a threatened species and/or 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.
How is the project likely to affect the habitat of a threatened species, population or ecological community?
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. The clearing of habitat for the project in particular, Lowland Rainforest (4.2 hectares) and wet/moist sclerophyll forest (225 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 4.2 hectares of Lowland Rainforest and 225 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.
Does the project affect any threatened species or populations that are at the limit of its known distribution?
The total population of Double-eyed Fig-Parrot is estimated at 100 breeding birds and expected to occur in four sub-populations: 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.
How is the project likely to affect current disturbance regimes?
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.
How is the project likely to affect habitat connectivity?
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.
How is the project likely to affect critical habitat?
No critical habitat has been identified for this species

Conclusion of the assessment

The project would not have a significant potential impact on this species. This is because all reported breeding populations of the species occur outside the project area and any impacts from the loss of habitat along the project boundary would more than likely affect foraging resources rather than a significant breeding/nesting area.

This conclusion is consistent with the conclusion in the EIS.

6.5.20. Barred Cuckoo-shrike (*Coracina lineata*)

6.5.20.1. Background

The assessment of significance under the NSW EP&A Act for State listed rainforest birds assessed species with distinct taxonomic, behavioural and ecological differences as one group. This method may not have adequately considered the unique requirements of each species and was identified as a gap in the critical review of the working paper. Therefore, a revised assessment of significance is provided which assesses species separately, or in some cases groups species according to their occupancy of microhabitats.

6.5.20.2. Direct and indirect impacts

The Barred Cuckoo-shrike (*Coracina lineata*) inhabits rainforest, eucalypt forests and woodlands, clearings in secondary growth, swamp woodlands and timber along watercourses. The range of potential habitat for this species in the region is extensive and it is difficult to predict or quantify the potential direct and indirect impacts. It is a wide-ranging species that feeds on fruits and insects and may move nomadically in response to changing food resources, which are widespread. The species does not rely on tree hollows for nesting, which favours its widespread and dispersive behaviour.

The project would include extensive clearing of habitat that could provide food resources, shelter and breeding habitat for the species. However, given the broad habitat needs of the species, the impact would likely be low, localised and of short-term duration.

6.5.20.3. Assessment of significance: vulnerable species (TSC Act)

The assessment of significance for this species was undertaken in consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-71.

Table 6-71 Assessment of significance: Barred Cuckoo-shrike (TSC Act)

Barred Cuckoo-shrike (*Coracina lineata*)
How is the project likely to affect the lifecycle of a threatened species and/or population?
The clearing of extensive forest habitats for the project would affect the availability of food resources and therefore may affect the foraging, roosting and breeding activities of birds in the study area. The distribution of the barred cuckoo-shrike is very widespread across the region reflecting their nomadic and dispersive movements in relation to spatially and temporally separated food resources. There are extensive areas of potential habitat available in the project study area suggesting that the impacts would be low, localised and of short-term duration.
How is the project likely to affect the habitat of a threatened species, population or ecological community?
The range of potential habitat for this species in the region is extensive and it is difficult to predict or quantify the potential direct and indirect impacts. It is a wide-ranging species feeds on fruits and insects and may move nomadically in response to changing food resources which are widespread. The clearing of forest habitats in including dry forest, wet and moist forests, floodplain forest and rainforests, would reduce the availability of foraging and breeding habitat for this species. Additional edge effects are not expected to be of significance and the species is highly likely to use edge areas as long as suitable food resources are present.
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 this species which is widespread across coastal eastern Australia from Cape York to the Manning River in NSW. Barred Cuckoo-shrikes are generally uncommon in their range, and are rare in NSW
How is the project likely to affect current disturbance regimes?
The range of disturbance regimes that currently exists in the study area which 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

Barred Cuckoo-shrike (*Coracina lineata*)
inputs into aquatic systems exacerbated by land-clearing and farming. The project has potential to affect these current disturbance regimes, for example human-caused fire ignitions and suppressions may increase, and fire spread decrease. 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. This species is adapted to moving across fragmented landscapes to access spatially and temporally separated food resources. Any impacts from changed habitat condition associated with altering disturbance regimes in proximity to the road may be offset by their ability to move widely throughout the landscape.
How is the project likely to affect habitat connectivity?
This highly mobile species ranges across diverse habitats 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?
No critical habitat has been identified for this species

Conclusion of the assessment

The project would have only minimal impacts on the availability of food resources and breeding habitat for the Barred Cuckoo-shrike. This is because it is a highly mobile species and there are extensive areas of potential habitat in the project study area (and throughout the region), which suggests that the impacts would be low, localised and of short-term duration.

This conclusion is consistent with the conclusion in the EIS.

6.5.21. Wompoo Fruit-dove (*Ptilinopus magnificus*), Rose-crowned Fruit-dove (*P. regina*) and Superb Fruit-dove (*P. superbus*)

6.5.21.1. Background

See introduction to Barred Cuckoo-shrike.

6.5.21.2. Direct and indirect impacts

The Wompoo Fruit-dove (*Ptilinopus magnificus*), Rose-crowned Fruit-dove (*Ptilinopus regina*) and Superb Fruit-dove (*Ptilinopus superbus*) have been grouped together in this assessment of significance as they are taxonomically similar, and share similar ecological requirements, including diet, movements and preferred habitats.

These rainforest fruit doves 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. They prefer larger, mature, fruit-bearing trees.

There are no documented local populations in the study area and any use of the habitats along the project would be temporary and to access available food resources. The clearing of habitat for the project, particularly Lowland Rainforest (4.2 hectares) and wet/moist sclerophyll forest (225 hectares), would affect

the availability of food resources for local populations. The distribution of the fruit-doves is very widespread across the region reflecting their nomadic movements in relation to spatially and temporally separated food resources.

6.5.21.3. Assessment of significance: vulnerable species (TSC Act)

The assessment of significance for this species was undertaken in consideration of the Department of Environment and Conservation/ Department of Primary Industries (2005) draft *Guidelines for Threatened Species Assessment*. The assessment is provided in Table 6-72.

Table 6-72 Assessment of significance: Rainforest fruit-dove species (TSC Act)

Wompoo Fruit-dove (*Ptilinopus magnificus*), Rose-crowned Fruit-dove (*Ptilinopus regina*) and Superb Fruit-dove (Ptilinopus superbus)
How is the project likely to affect the lifecycle of a threatened species and/or population?
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 clearing of habitat for the project in particular, Lowland Rainforest (4.2 hectares) and wet/moist sclerophyll forest (225 hectares) would affect the current availability of food resources and therefore affect the local foraging activities of birds in the study area. The distribution of the fruit doves 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 5 hectares of Lowland Rainforest and 225 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. Potential for increased weeds near roadside environments may have an indirect impact on adjacent retained habitats as would runoff 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.
How is the project likely to affect current disturbance regimes?
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 are currently subject to invasive weeds impacting on the floristic structure and diversity. The project would likely contribute to these disturbance regimes. The project has been positioned to avoid rainforest as much as possible and al areas being impacted currently show high levels of weed invasion along edge habitats. Frugivorous rainforest birds are wide-ranging adapted to moving across fragmented landscapes to access spatially and temporally separated food resources. Any impacts from changed 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?
There is currently a high degree of habitat fragmentation across much of the study area. This is due to the broadscale 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 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?
No critical habitat has been identified for these species

Conclusion of the assessment

The project is unlikely to result in a significant impact on these rainforest fruit-dove species under State assessment criteria. This is due to the efforts to avoid and minimise impacts on rainforest communities in Section 10 of the project.

Although the clearing of habitat for the project, particularly Lowland Rainforest (4.2 hectares) and wet/moist sclerophyll forest (225 hectares), would affect the availability of food resources and therefore affect the local foraging activities of birds in the study area, other lifecycle activities are not expected be impacted and the impact associated with a reduction in available food resources is expected to be minimal.

This conclusion is consistent with the conclusion in the EIS.

6.5.22. Rufous Bettong (*Aepyprymnus rufescens*) and Brush-tailed Phascogale (*Phascogale tapoatafa*)

6.5.22.1. Background

Both the Rufous Bettong (*Aepyprymnus rufescens*) and Brush-tailed Phascogale (*Phascogale tapoatafa*) frequent natural and modified habitats in the Northern Rivers region, where there is an abundance of records in the NSW Atlas for both species. Many of these records originate from the route selection studies and preferred route studies undertaken for this project. The distribution of these records suggests the presence of regional populations and this data was used in preparation of the connectivity strategy for the EIS. Several crossing structures were included in the design to target regional populations of both species, particularly in sections 1–4 and 6–8 for the Brush-tailed Phascogale.

From a critical review of the work done for both species in the EIS, it is considered that the impact assessment provides a comprehensive account of the distribution of populations and likely habitat. Subsequent surveys conducted for the detailed design phase of sections 1 and 2 (Woolgoolga to Glenugie) (Sandpiper Ecological Surveys, 2013) confirmed that populations of both species are present, particularly between Halfway Creek and Glenugie State Forest (Section 2). This correlates with the EIS assessment conclusions, in particular the connectivity strategy.

As a result of the work to date and the critical analysis, further field studies for these two species were deemed not required to inform the impact assessment.

However, further surveys are planned for the detailed design phase of all future projects to the level of detail reported for sections 1 and 2 (Sandpiper Ecological Surveys, 2013). The objective of these surveys is to refine the locations of proposed connectivity structures and associated fauna exclusion fencing targeted for these two species.

6.5.22.2. Predictive habitat mapping

This report provides predictive habitat mapping for these two species to guide decision-making regarding the design of future fauna surveys for the detailed design phase and to assist in the ongoing development of the connectivity strategy and ecological monitoring programs. This mapping is presented in Figure 6-1 to Figure 6-11.

The predictive habitat mapping in these figures is based on the BioMetric Vegetation Types that have been linked to these two species according to NRCMA BioMetric database (OEH, 2012). These vegetation types are listed in Table 6-73.

It should be noted that the BioMetric habitat mapping does not take into account the broad range of modified habitats that are utilised by these species, particularly the Rufous Bettong. This species is not restricted to forested habitat but also occurs in:

- The Pillar Valley (Section 3) north to Tyndale in low-grazing-intensity pastureland with dense patches of grassland around wetlands and stands of trees.
- Treed roadside vegetation (such as along Wooli Road).
- Sugarcane areas and weed-infested habitat adjoining the Clarence River in Section 4 along the existing highway between Tyndale and Harwood.

Table 6-73 BioMetric vegetation types used in the predictive modelling of habitat for Brush-tailed Phascogale and Rufous Bettong

BioMetric vegetation types linked to target species	Rufous Bettong	Brush-tailed Phascogale
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast	√	
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast	√	√
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast	√	√
Coast Cypress Pine shrubby open forest of the North Coast Bioregion	√	√
Coastal floodplain sedgelands, rushlands, and forblands	√	√
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast	√	√
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast	√	√
Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast	√	√
Hoop Pine - Yellow Tulipwood dry rainforest of the North Coast		
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast	√	√
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast	√	
Orange Gum (Eucalyptus bancroftii) open forest of the North Coast	√	
Red Mahogany open forest of the coastal lowlands of the North Coast	√	
Scribbly Gum - Needlebark Stringybark heathy 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	√	
Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast	√	
Swamp Oak swamp forest of the coastal lowlands of the North Coast	√	
Tallowwood dry grassy forest of the far northern ranges of the North Coast	√	
Turpentine moist open forest of the coastal hills and ranges of the North Coast	√	

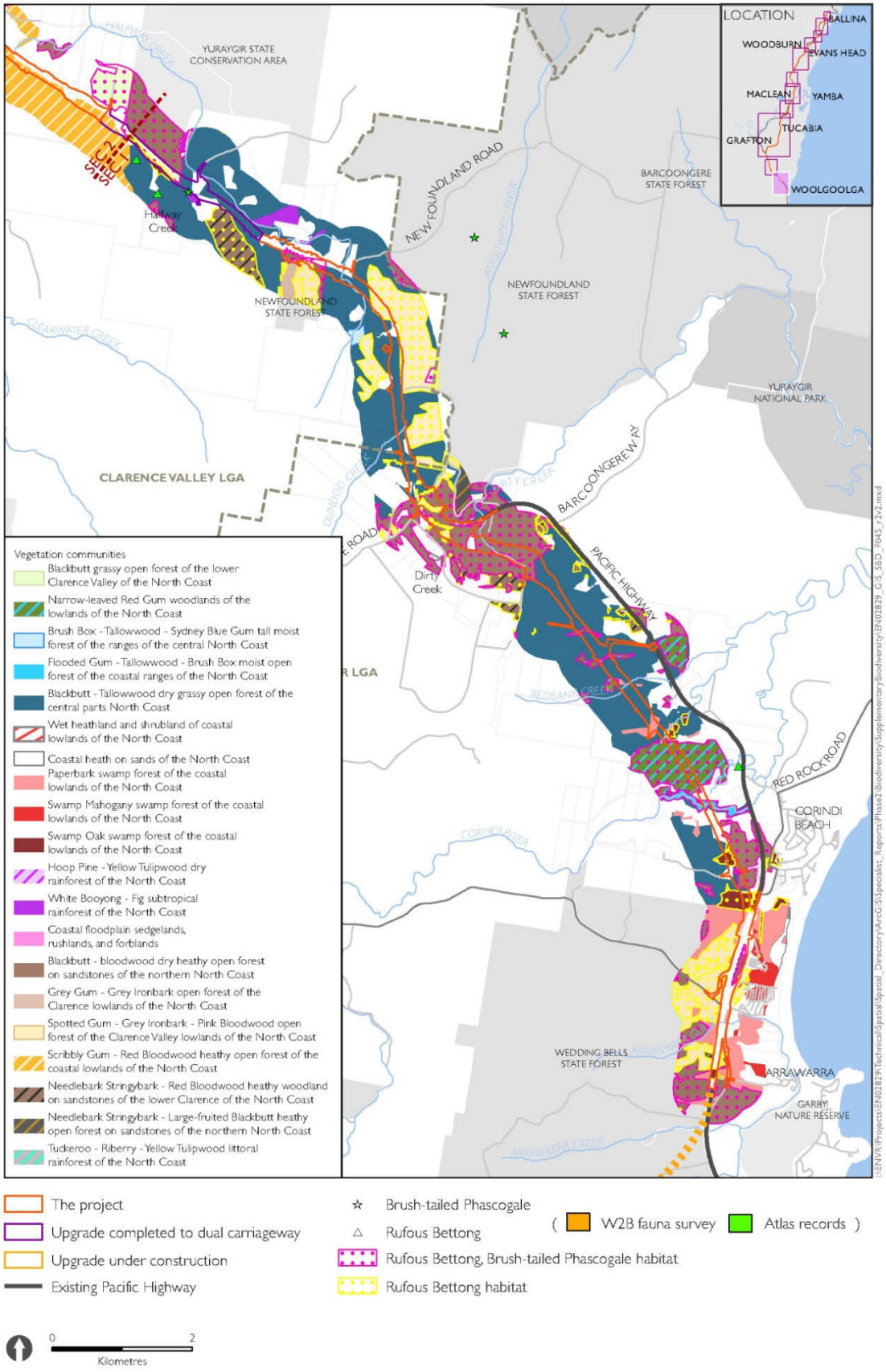


Figure 6-1 Potential habitat and records of Rufous Bettong and Brush-tailed Phascogale (s1)

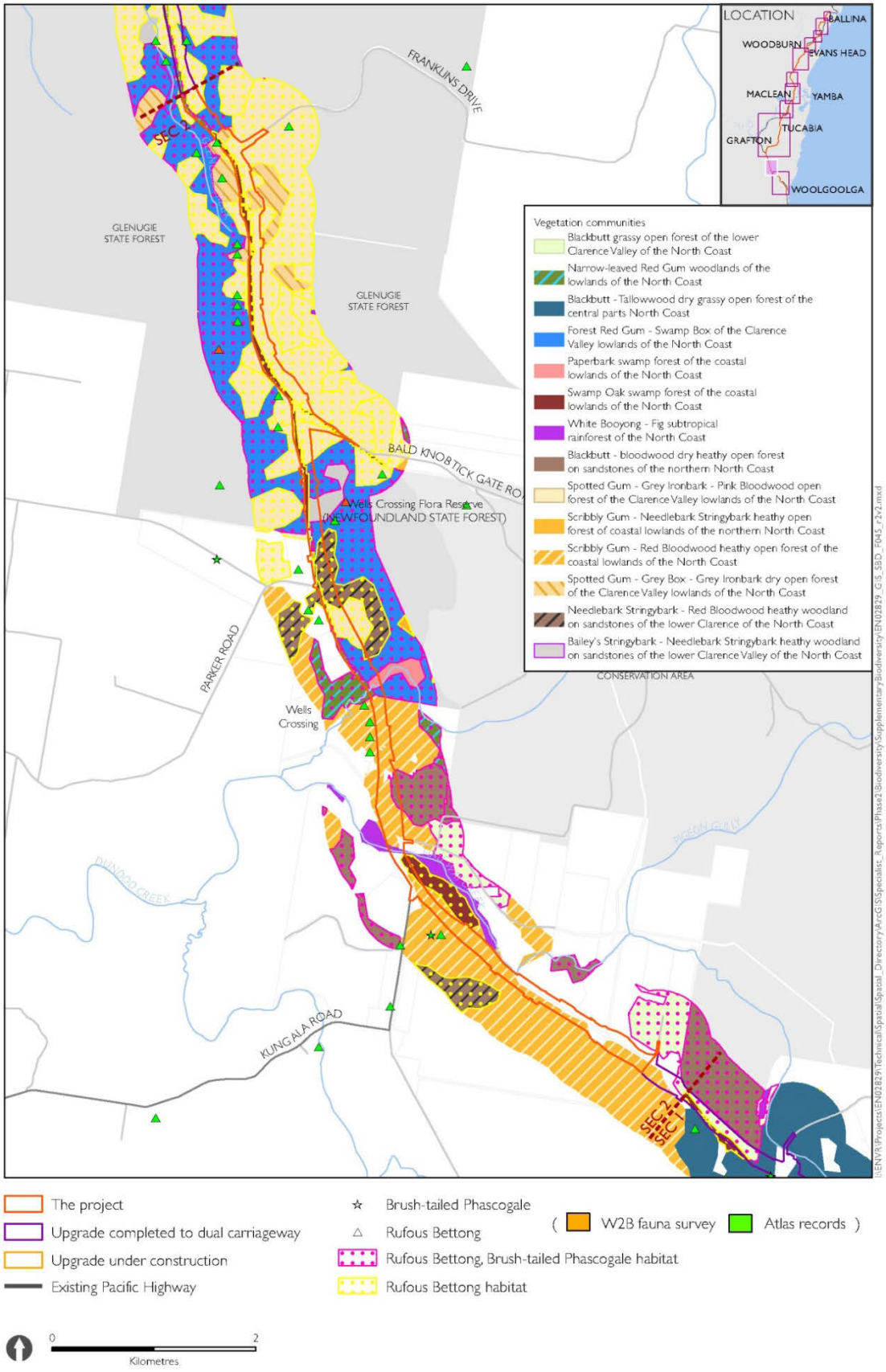


Figure 6-2 Potential habitat and records of Rufous Bettong and Brush-tailed Phascogale (s2)

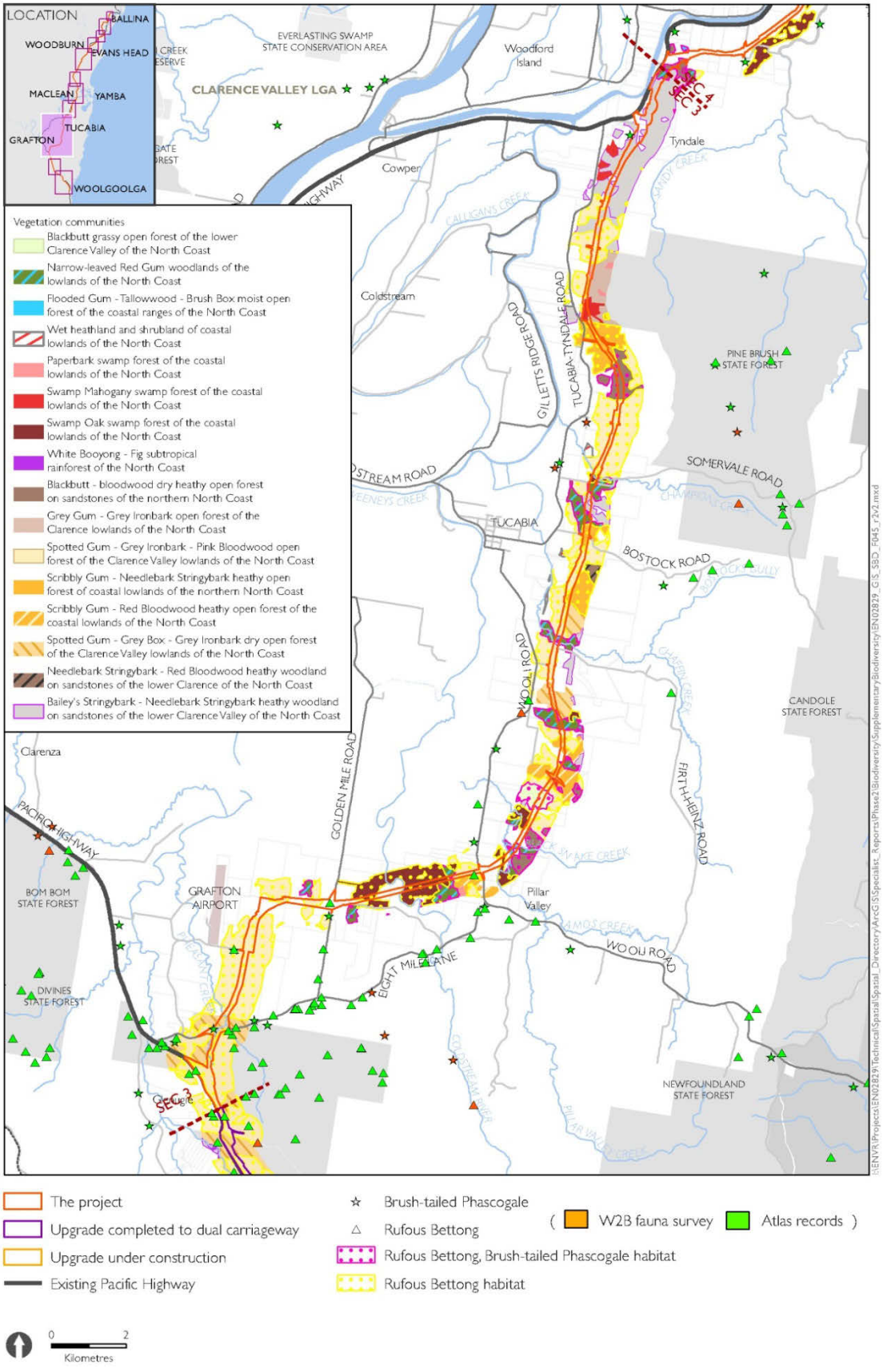


Figure 6-3 Potential habitat and records of Rufous Bettong and Brush-tailed Phascogale (s3)

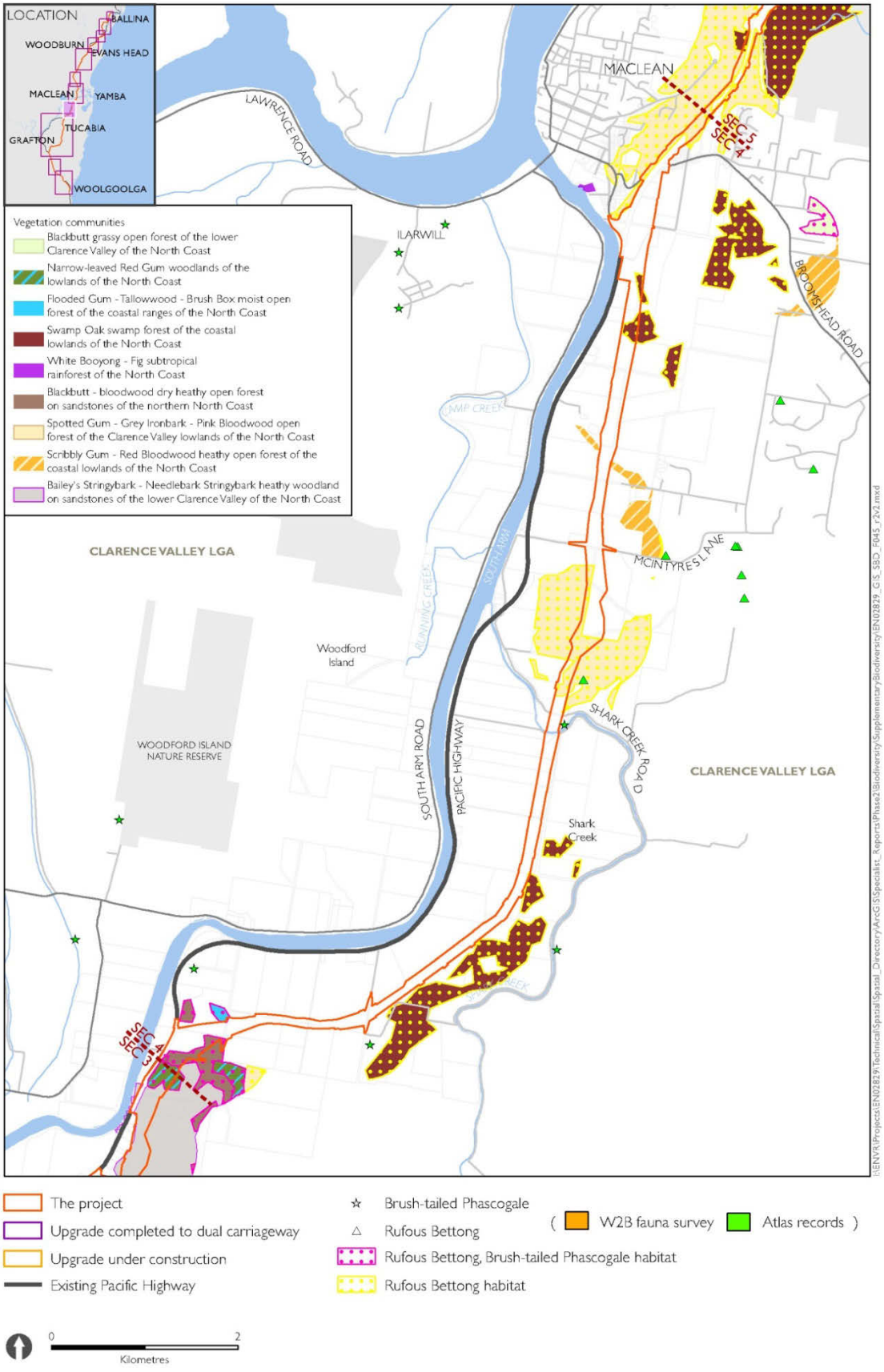


Figure 6-4 Potential habitat and records of Rufous Bettong and Brush-tailed Phascogale (s4)

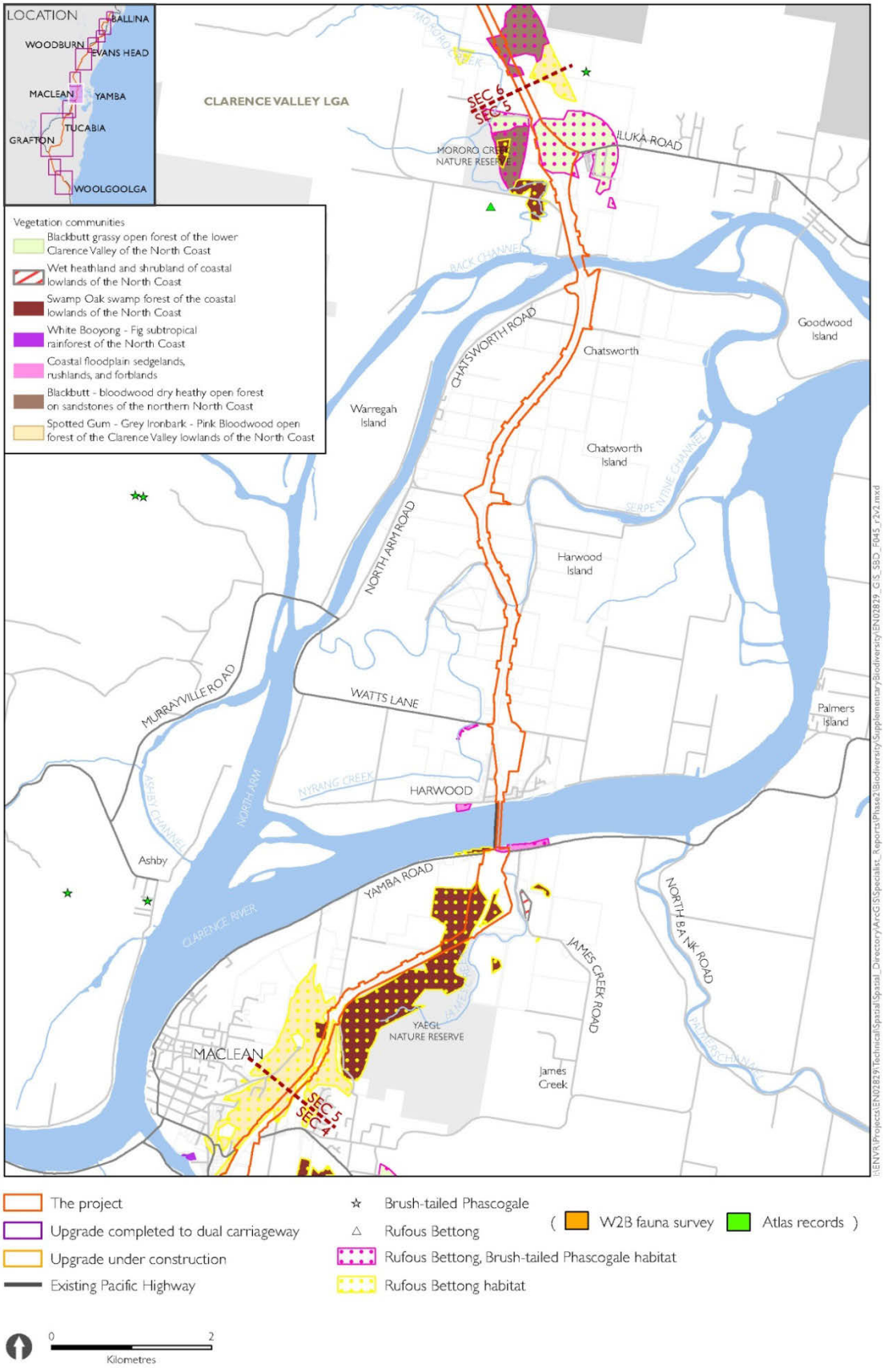


Figure 6-5 Potential habitat and records of Rufous Bettong and Brush-tailed Phascogale (s5)

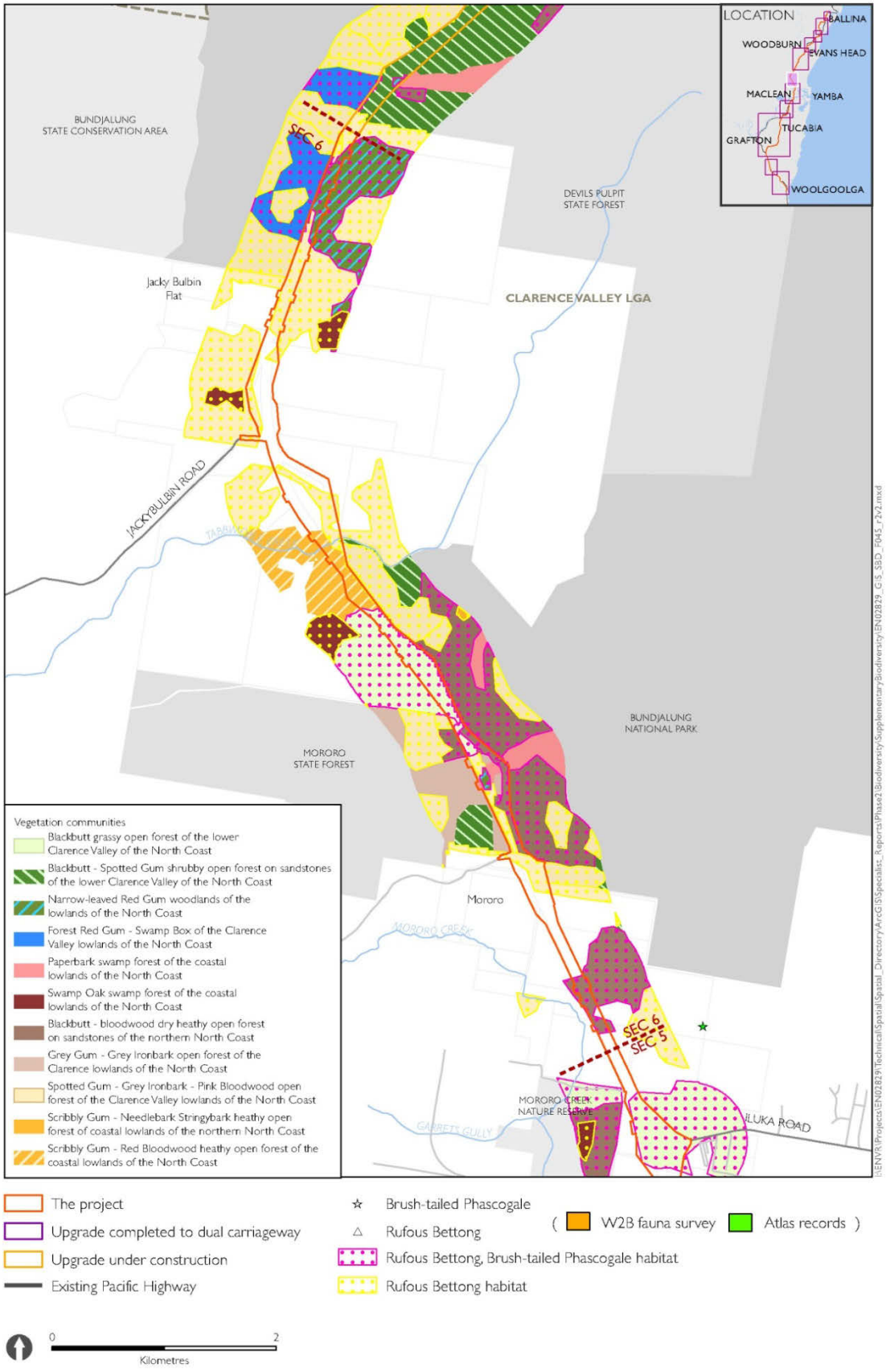


Figure 6-6 Potential habitat and records of Rufous Bettong and Brush-tailed Phascogale (s6)

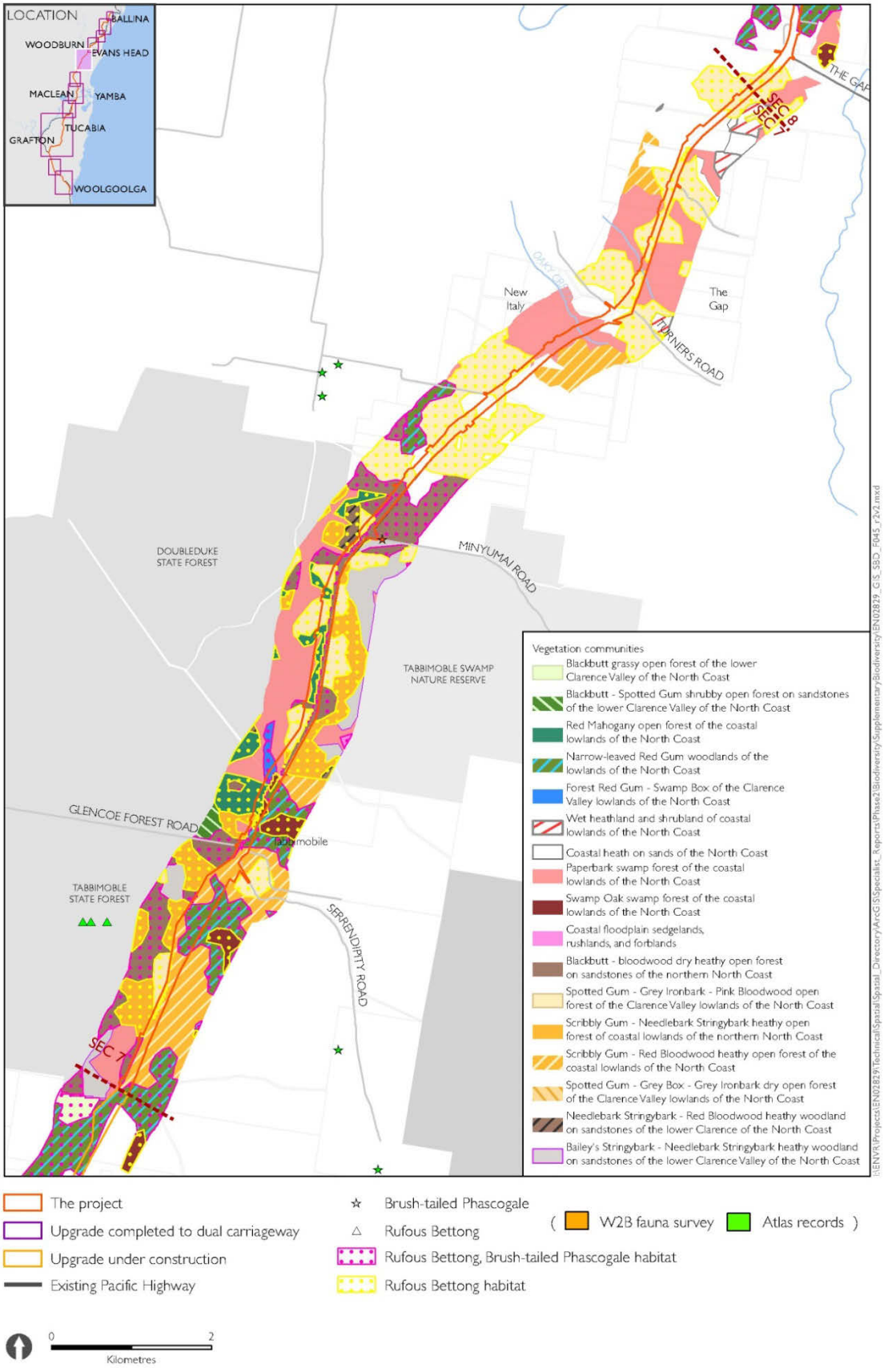


Figure 6-7 Potential habitat and records of Rufous Bettong and Brush-tailed Phascogale (s7)

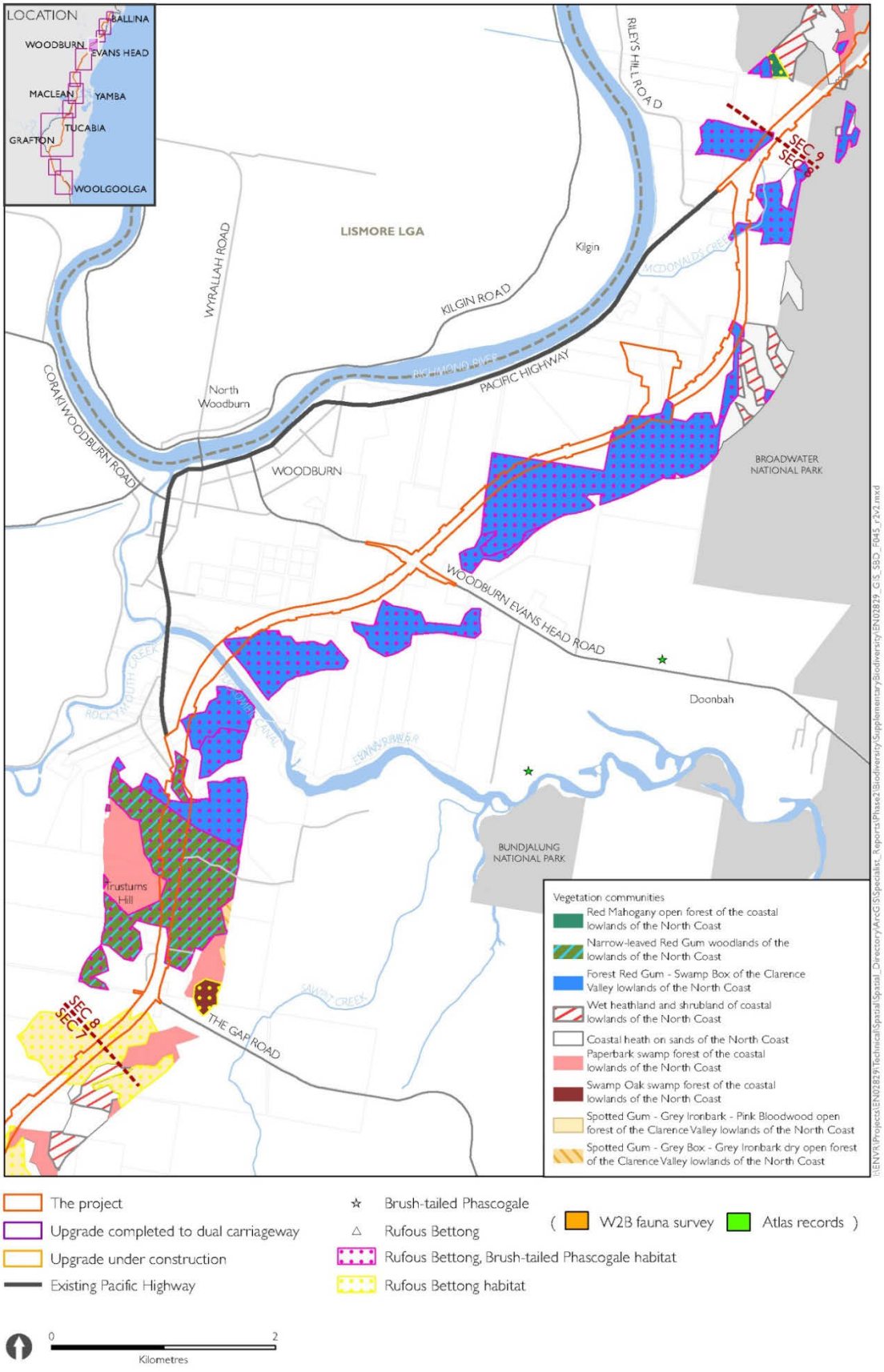


Figure 6-8 Potential habitat and records of Rufous Bettong and Brush-tailed Phascogale (s8)

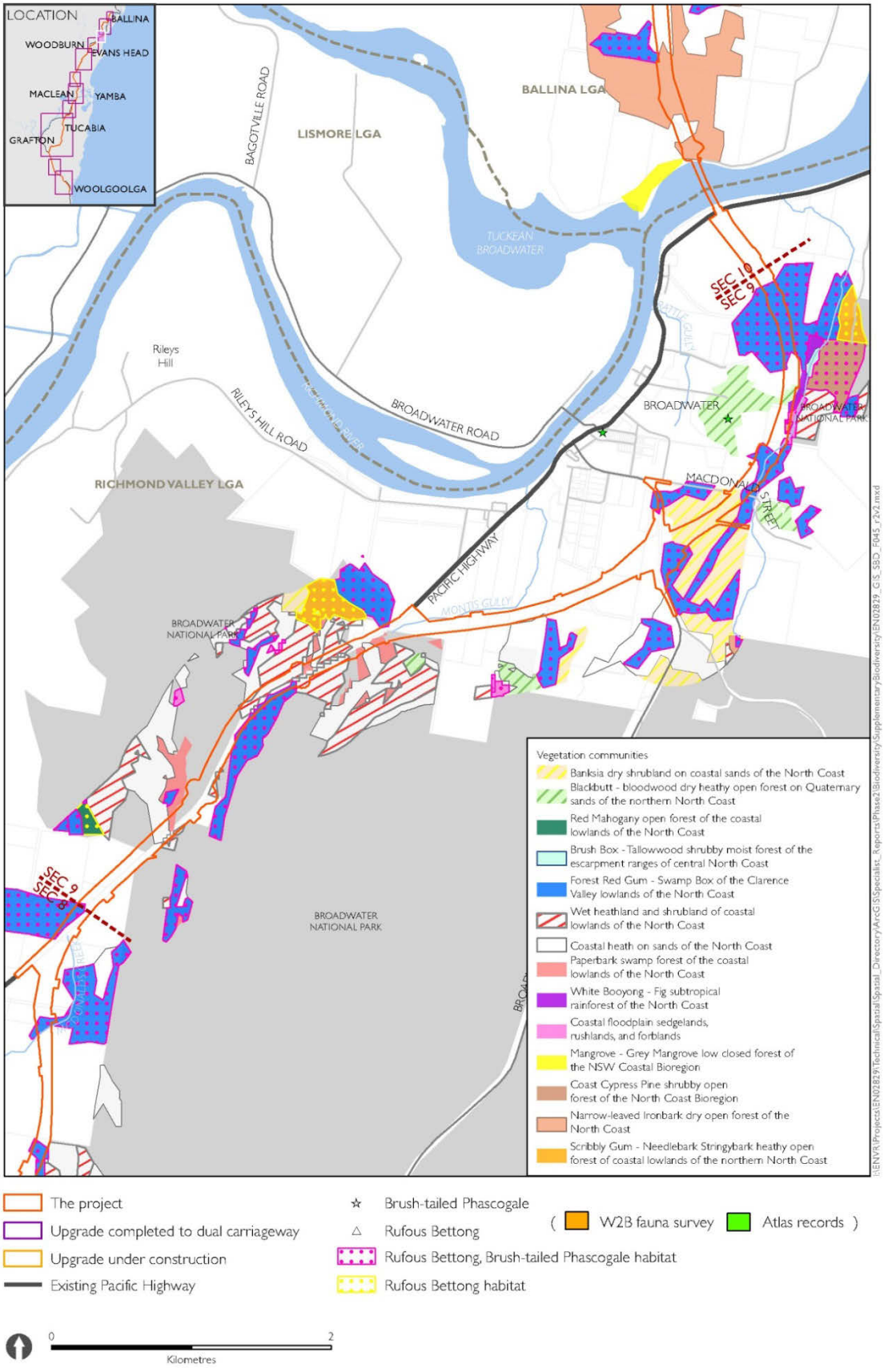


Figure 6-9 Potential habitat and records of Rufous Bettong and Brush-tailed Phascogale (s9)

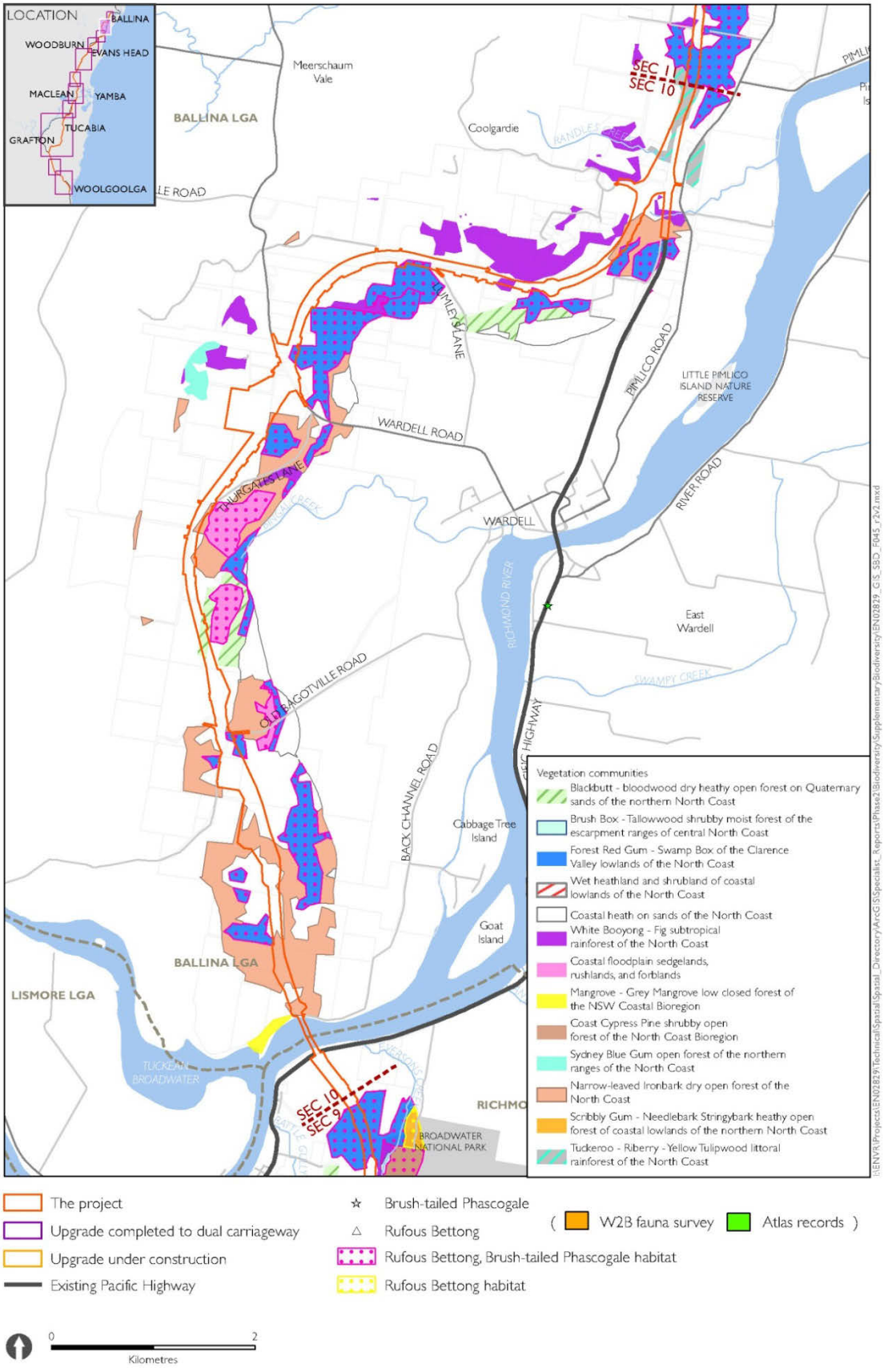


Figure 6-10 Potential habitat and records of Rufous Bettong and Brush-tailed Phascogale (s10)

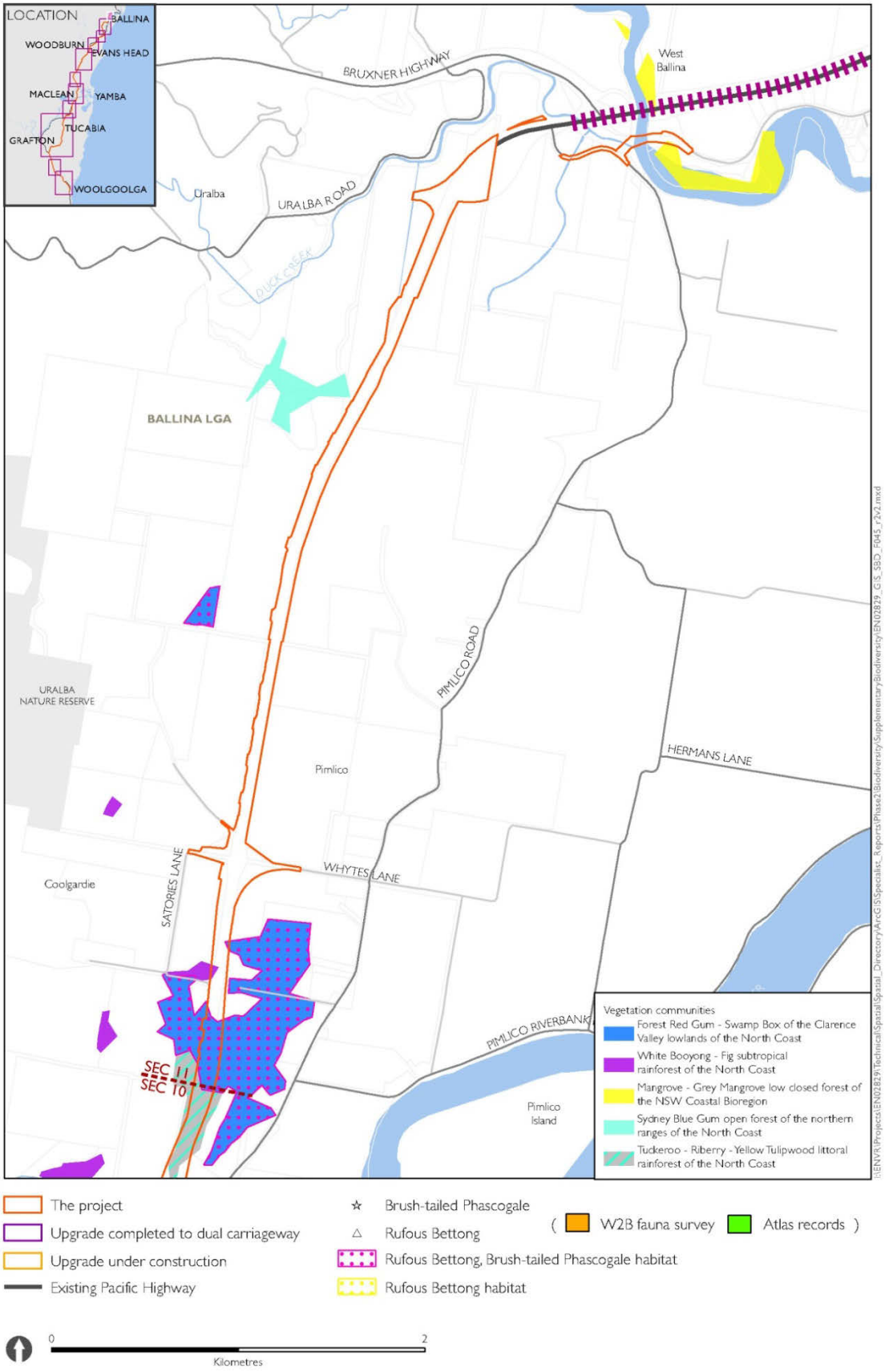


Figure 6-11 Potential habitat and records of Rufous Bettong and Brush-tailed Phascogale (s11)

6.5.23. Green and Golden Bell Frog (*Litoria aurea*)

The EIS biodiversity assessment reported a low likelihood of occurrence for the endangered Green and Golden Bell Frog (*Litoria aurea*) (listed in the EPBC Act and TSC Act) across all project sections. This is supported by the results of the field surveys conducted for the EIS and, most recently, during detailed design studies for project sections 1 and 2 and the lack of records from the NSW Atlas of Wildlife. The population distribution for this species in NSW is as described within the species status for NSW (White and Pyke, 1996, and 2008). These authors report the distribution of populations across NSW based on a comprehensive literature review, personal communications with researchers and comprehensive surveys conducted across NSW since 1990.

In northern NSW, Green and Golden Bell Frog populations are largely confined to coastal regions and are known from Ballina, Brunswick Heads and Byron Bay (north of the study area), and Yuraygir National Park (Diggers Camp and Stations Creek), to south of Woolgoolga. There are no populations recorded in the study area and the likelihood of occurrence is considered low or unlikely as the species was not recorded during the preferred route field surveys and fits one or more of the following criteria:

- It has not been recorded previously in the project study area/ surrounds, which would be beyond the coastal distributional range.
- It requires species-specific habitats or resources that have not been identified in the study area.

Therefore, it is concluded that the project would not impact on a local or regional population of the Green and Golden Bell Frog and no assessment of significance is required.

6.5.24. New Holland Mouse (Pseudomys novaehollandiae)

6.5.24.1. Background

The New Holland Mouse (*Pseudomys novaehollandiae*) was targeted in the preferred route studies and EIS surveys along with other threatened mammal species. The species was reported as having a low likelihood of occurrence and this has been revised, based on the critical review, with the species having at least a moderate likelihood to occur in some project sections. An assessment of significance for this species is provided.

6.5.24.2. Direct and indirect impacts

Across the species range, the New Holland Mouse is known to inhabit open heathland, open woodland with a heathy understorey and vegetated sand dunes. These habitats are restricted in the project corridor and well represented in surrounding coastal areas, particularly Bundjalung National Park, Broadwater National Park, Yuraygir National Park and the east of the project corridor near Wardell in open sandy heath country. The species has a small home range (0.44 to 1.4 hectares) and populations prefer heathland that is in early stages of regeneration (three to five years) following fire or disturbance.

Table 6-74 presents the BioMetric vegetation associations for the New Holland Mouse, and the areas of this vegetation that would be removed by the project.

Table 6-74 Impact on BioMetric vegetation associations for New Holland Mouse

BioMetric vegetation association	Direct loss (hectares)
Coastal Heath on Sands of the North Coast	14.9
Wet Heathland and Shrubland of Coastal Lowlands of the North Coast	11.5
Total	26.4 hectares

The species is threatened by loss and fragmentation of habitat through land-clearing and inappropriate fire regimes. These impacts reduce seasonal food resources and shelter, and have a short-term effect on foraging and breeding lifecycles.

The project has potential to clear relatively small areas of suitable habitat, mainly along the edge-affected areas of Broadwater National Park and associated with the duplication of the highway in this location. In the Wardell area (Section 10) there would be no direct impacts on open heath. The distribution of populations is not known and the area of habitat to be cleared (as described above) is an estimate of the habitat that is available and not on data from known populations, which is not available. This habitat clearing would remove shelter and food resources and reduce breeding success and dispersal opportunities between populations. As the species has a very small home range, the project has the potential to completely remove and/or isolate populations. However, for Broadwater National Park, it is possible that populations are already fragmented by the highway and that the inclusion of four key connectivity structures (two overpasses and two underpasses) to re-establish a link within the national park would significantly improve connectivity for this species between habitat areas on either side of the highway.

6.5.24.3. Assessment of significance: vulnerable species (EPBC Act)

The assessment of significance was undertaken according to criteria for vulnerable species in the DEWHA (2009) assessment guidelines. The assessment is provided in Table 6-75.

Table 6-75 Assessment of significance: New Holland Mouse (EPBC Act)

New Holland Mouse (*Pseudomys novaehollandiae*)
According to the DEWHA (2009) 'significant impact criteria' an action is likely to have a significant impact on an vulnerable species if there is a real chance or possibility that it would:
Lead to a long-term decrease in the size of an important population
There is no evidence of an important population in the study area. The preferred habitat of the species is well represented in the larger national parks of the locality and represents the likely stronghold for local populations and the regional meta population. The impacts on edge areas of Broadwater National Park is not expected to lead to a long-term decrease in the population, indeed the provision of targeted connectivity structures may improve dispersal and expansion of populations into the future.
Reduce the area of occupancy of an important population
The area of occupancy is not known. The project has potential to clear relatively small areas of suitable habitat, mainly along the edge-affected areas of Broadwater National Park and associated with the duplication of the highway in this location. In the Wardell area (Section 10) there will be no direct impacts on open heath. The distribution of populations is not known and the area of habitat to be cleared as described above is an estimate on the habitat that is available and not on data from known populations which is not available. Other factors contribute the suitability of the habitat, for example soft soils and areas disturbed by fire are preferred
Fragment an existing population into two or more populations
Unlikely, it is possible that the exiting highway already fragments populations in Broadwater National Park, east and west of the highway. The inclusion of four key connectivity structures (two overpasses and two underpasses) to re-establish a link the park will significantly improve connectivity for this species. other potential locations are east of the high in the

New Holland Mouse (*Pseudomys novaehollandiae*)
Wardell area and would not be fragmented.
Adversely affect habitat critical to the survival of a species
Across the species range the New Holland Mouse is known to inhabit open heathland, open woodland with a heathy understorey and vegetated sand dunes. These habitats are restricted in the project corridor and well represented in surrounding coastal areas in particular Bundjalung National Park, Broadwater National Park, Yuraygir National Park, and the east of the project corridor near Wardell in open sandy heath country. The species has a small home range between 0.44 ha and 1.4 ha and populations prefer heathland that is in early stages of regeneration (3–5 years) following fire or disturbance. The species is threatened by loss and fragmentation of habitat through land-clearing and inappropriate fire regimes that reduce seasonal food resources, and shelter and have a short-term effect on foraging and breeding lifecycles. The project has potential to clear relatively small areas of suitable habitat, mainly along the edge-affected areas of Broadwater National Park and associated with the duplication of the highway in this location. In the Wardell area (Section 10) there will be no direct impacts on open heath. The distribution of populations is not known and the area of habitat to be cleared as described above is an estimate on the habitat that is available and not on data from known populations which is not available. This clearing would remove shelter and food resources and reduce breeding success, and dispersal opportunities between populations
Disrupt the breeding cycle of an important population
There is no evidence of an important population in the study area. The preferred habitat of the species is well represented in the larger national parks of the locality and represents the likely stronghold for local populations and the regional meta population. The species favours disturbance associated with fire and these factors influence breeding cycles. Any impacts on breeding cycles would affect a small proportion of the regional population, given the expanse of better quality habitats outside of the disturbance area.
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline
The project has potential to clear relatively small areas of suitable habitat, mainly along the edge-affected areas of Broadwater National Park and associated with the duplication of the highway in this location. In the Wardell area (Section 10) there will be no direct impacts on open heath. The distribution of populations is not known and the area of habitat to be cleared as described above is an estimate on the habitat that is available and not on data from known populations which is not available. This clearing would remove shelter and food resources and reduce breeding success, and dispersal opportunities between populations. As the species has a very small home range, the project has the potential to completely remove and / or isolate populations. However for the Broadwater national park, it is possible that populations are already fragmented by the existing highway and that the inclusion of four key connectivity structures (two overpasses and two underpasses) to re-establish a link the park will significantly improve connectivity for this species
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat;
The project would include the removal of potential habitat in Broadwater National Park. 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 species from its habitat.
Introduce disease that may cause the species to decline
No evidence of disease in this species, or likelihood that this would be introduced by the project.
Interfere with the recovery of the species.
The route has been selected on the basis of avoiding high quality habitats for threatened fauna and relative impacts on the habitat of this species have been identified as minimal. The habitat of the species is very well conserved in Broadwater, Bundjalung and Yuraygir National Parks.

Conclusion of the assessment

The project is unlikely to significantly impact on an important population of the New Holland Mouse. There would be minimal impact on potential habitat, and very large areas of potential habitat are well represented and conserved in the region. The project may improve opportunities for local populations through the inclusion of targeted connectivity structures linking sections of Broadwater National Park on either side of the highway.

6.5.25. Summary of the assessments of significance for threatened fauna

The assessments of significance for threatened fauna are summarised in Table 6-76.

Table 6-76 Summary of impact assessment for threatened fauna

Species	Common name	EPBC Act	TSC Act	Significant impact
Anseranas semipalmata	Magpie Goose		V	No
Daphoenositta chrysoptera	Varied Sitella		V	No
Ephippiorhynchus asiaticus	Black-necked Stork		E	No
Grus rubicundus	Brolga		V	No
Irediparra gallinacea	Comb-Crested Jacana		V	No
Ixobrychus flavicollis	Black Bittern		V	No
Amaurornis molucanna	Pale-vented Bush Hen		V	No
Botaurus poiciloptilus	Australasian Bittern	E	E	No
Stictonetta naevosa	Freckled Duck		V	No
Rostratula australis	Australian Painted Snipe	E	E	No
Ptilinopus magnificus	Wompoo Fruit-dove		V	No
Ptilinopus regina	Rose-crowned Fruit-dove		V	No
Ptilinopus superbus	Superb Fruit-dove		V	No
Coracina lineata	Barred Cuckoo-shrike		V	No
Cyclopsitta diophthalma coxeni	Double-eyed Fig Parrot	E	E	No
Calyptorhynchus lathami	Glossy Black-cockatoo		V	No
Pseudomys novaehollandiae	New Holland Mouse	V		No
Cercartetus nanus	Eastern Pygmy Possum		V	Yes
Phascolarctos cinereus	Koala	V	V	Yes
Planigale maculata	Common Planigale		V	Yes
Litoria brevipalmata	Green-thighed Frog		V	Yes
Mixophyes iteratus	Giant Barred Frog	E	E	Yes
Nurus atlas	Atlas Rainforest Ground Beetle		E	Yes
Phyllodes imperialis smithersi	Southern Pink Underwing Moth	E	E	Yes

6.6. Impacts on threatened species and wetland habitats due to groundwater changes at embankment cutting sites

The groundwater working paper in the EIS assessed the potential impacts from groundwater drawdown associated with excavation of embankment cutting sites. The high risk sites were designated 'type A' cutting types in the EIS. Without mitigation, these cuttings would potentially reduce groundwater to adjoining local creeks, streams, springs and local water resources within around 100 metres of the cutting.

A review was undertaken to assess how this potential impact may indirectly affect threatened terrestrial and aquatic species, wetland habitats and groundwater-dependent ecosystems (GDEs). This review is presented in Table 6-77. It aims to identify potential habitats within 200 metres of a cutting site. These habitats include Matters of National Environmental Significance (MNES), State-listed wetlands, and known and potential threatened species habitat.

Table 6-77 shows there is a high likelihood that high potential impact cuttings would affect groundwater regimes and any associated GDEs. The table also identifies the potential risks at each site from low to high risk. Proposed mitigation and monitoring measures are presented in Section 6.6.5.

Cutting sites that may potentially affect groundwater and indirectly impact on surrounding biodiversity values are (as described as moderate of high risk category in Table 6-77) are detailed in Figure 6-12 to Figure 6-17.

Table 6-77 Assessment of significant biodiversity values near proposed cutting sites

Approx station		Cut type*	Directly over wetlands / aquatic systems	Adjacent to Wetlands / aquatic systems (within 200 m)	Threatened ecological community (within 1 km)	Biodiversity values including MNES within 2 km	Risk category
Start	Finish						
Section 1							
2320	2690	A	No	No	Swamp Sclerophyll Forest on Coastal Floodplain	SEPP No. 14 wetland 314 (500 m east) Habitat critical to the survival of koalas	Low
3010	3060	B to A	No	Off-stream farm dam	Subtropical Coastal Floodplain Forest on Coastal Floodplain	SEPP No. 14 wetland 314 (1.2 km SE) Habitat critical to the survival of koalas	Low
3230	3480	A	No	No, Corindi River 240 metres NE	None	Habitat critical to the survival of koalas Giant Barred Frog population in Corindi River	Low
5170	5560	A	No	No, Cassons Creek 260 metres SE	Subtropical Coastal Floodplain Forest on Coastal Floodplain	Habitat critical to the survival of koalas	Low
5880	6050	A	No	No, Redbank Creek 260 m south	Partially Swamp Sclerophyll Forest on Coastal Floodplain Partially Subtropical Coastal Floodplain Forest on Coastal Floodplain	Habitat critical to the survival of koalas	Low
6990	7090	A	No	No	Close to Subtropical Coastal Floodplain Forest on Coastal Floodplain	Habitat critical to the survival of koalas	Low
7620	8370	A	No	No	None	Habitat critical to the survival of koalas Adjacent to Quassia population	Low
8750	8860	A	No	Yes, Dirty Creek 135 metres to the east	None	Habitat critical to the survival of koalas Giant Barred Frog population in Dirty Creek	Low
9360	9490	A	No	No	None	Habitat critical to the survival of koalas	Low
9760	10000	A	No	No	None	Habitat critical to the survival of koalas	Low
Section 2							
26480	27330	B to A	No	No	None	Habitat critical to the survival of koalas	Low
27510	29200	B to A	No	No, 360 metres east of Glenugie Creek	Close to Subtropical Coastal Floodplain Forest on Coastal Floodplain		Low

Approx station		Cut type*	Directly over wetlands / aquatic systems	Adjacent to Wetlands / aquatic systems (within 200 m)	Threatened ecological community (within 1 km)	Biodiversity values including MNES within 2 km	Risk category
Start	Finish						
Section 3							
36540	37050	A	No	No	Partially Subtropical Coastal Floodplain Forest on Coastal Floodplain	Habitat critical to the survival of koalas	Low
37460	39010	A	No	No	None	Habitat critical to the survival of koalas	Low
39120	39550	A	No	No	None	Habitat critical to the survival of koalas	Low
39730	41260	A	No	No	None	Habitat critical to the survival of koalas	Low
44650	45720	A	No	No	None	SEPP No. 14 wetland 292 (1 km NW) (Upper Coldstream Wetlands) Habitat critical to the survival of koalas *Angophora robur*	Low
48080	48600	A	No	No	Subtropical Coastal Floodplain Forest on Coastal Floodplain	SEPP No. 14 wetland 292, 290 (1.5 km west) (Upper Coldstream Wetlands / Pillar Valley creek) Habitat critical to the survival of koalas *Angophora robur* and threatened terrestrial fauna	Low
48900	49100	A	No	No	None	SEPP No. 14 wetland 292, 290 (2.6 km west) (Upper Coldstream Wetlands) Habitat critical to the survival of koalas *Angophora robur* and threatened terrestrial fauna	Low
50510	50660	A	No	No	Partially Swamp Sclerophyll Forest on Coastal Floodplain	SEPP No. 14 wetland 292, 290 (2.7 km west) (Upper Coldstream Wetlands) Habitat critical to the survival of koalas Adjacent to *Angophora robur*	Low
50890	51180	A	No	No	None	SEPP No. 14 wetland 292, 290 (2.8 km west) (Upper Coldstream Wetlands) Habitat critical to the survival of koalas	Low
51570	52310	A	No	No, Chaffin Creek 970 m NE, Coldstream River (2.5 km W)	None	SEPP No. 14 wetland 289, 290 (2.7 km SW) (Upper Coldstream Wetlands). Chaffin Creek 970 m NE	Low

Approx station		Cut type*	Directly over wetlands / aquatic systems	Adjacent to Wetlands / aquatic systems (within 200 m)	Threatened ecological community (within 1 km)	Biodiversity values including MNES within 2 km	Risk category
Start	Finish						
						Habitat critical to the survival of koalas *Angophora robur*	
52720	53550	A	No	Yes Chaffin Creek and waterhole (190 m SE)	Partially Subtropical Coastal Floodplain Forest on Coastal Floodplain	SEPP No. 14 wetland 289 (770 m NW) (Upper Coldstream Wetlands) Habitat critical to the survival of koalas	Low
53830	54590	A	No	No	Close to Subtropical Coastal Floodplain Forest on Coastal Floodplain	SEPP No.14 wetland 289 (423 m W) (Chaffin Swamp) Australasian Bittern Habitat critical to the survival of koalas Close to *Angophora robur*	Low
55230	56600	A	No	No	Partially Subtropical Coastal Floodplain Forest on Coastal Floodplain	SEPP No. 14 wetland 289 (623 m W) (Chaffin Swamp). Australian Bittern habitat Habitat critical to the survival of koalas *Angophora robur* and threatened fauna habitat	Low
57470	58210	A	No	No, Champions Creek 270 m SE)	Close to Subtropical Coastal Floodplain Forest on Coastal Floodplain Partially Swamp Sclerophyll Forest on Coastal Floodplain	SEPP No. 14 wetland 287 (350 m W), Champions Creek Habitat critical to the survival of koalas *Angophora robur* and threatened fauna habitat	Low
58340	58550	A	No	No, Champions Creek, 800 m	Close to Swamp Sclerophyll Forest on Coastal Floodplain	SEPP No. 14 wetland 289, 287 (700 m SW), Champions Creek) Habitat critical to the survival of koalas Low density Koala populations *Angophora robur*	Low
58840	59160	A	No	No, Champions Creek 800 m	None	SEPP No. 14 wetland 287 (1km SW) Champions Creek Habitat critical to the survival of koalas Low density Koala populations *Angophora robur*	Low
59400	59990	A	No	No, Coldstream River 1.6 km	Partially Subtropical Coastal Floodplain Forest	SEPP No. 14 wetland 287 (1.5 km SW), Champions Creek Habitat critical to the survival of koalas	Low

Approx station		Cut type*	Directly over wetlands / aquatic systems	Adjacent to Wetlands / aquatic systems (within 200 m)	Threatened ecological community (within 1 km)	Biodiversity values including MNES within 2 km	Risk category
Start	Finish						
60310	60690	A	No	No, Coldstream River 1.5 km	Close to Swamp Sclerophyll Forest on Coastal Floodplain	Habitat critical to the survival of koalas *Angophora robur*	Low
61230	61380	A	No	No, Coldstream River 1.3 km	Partially Subtropical Coastal Floodplain Forest on Coastal Floodplain	Habitat critical to the survival of koalas	Low
62500	62710	A	No	No, Coldstream River 1.8 km	Partially Swamp Sclerophyll Forest on Coastal Floodplain	Habitat critical to the survival of koalas Angophora robur population Threatened fauna habitat	Low
63040	63500	A	No	No, Coldstream River 1.9 km	Partially Swamp Sclerophyll Forest on Coastal Floodplain Partially Subtropical Coastal Floodplain Forest on Coastal Floodplain	Habitat critical to the survival of koalas Angophora robur population Threatened fauna habitat	Low
63620	63840	A	No	No, Sandy Creek 1.3 km E)	Partially Subtropical Coastal Floodplain Forest on Coastal Floodplain	Habitat critical to the survival of koalas Angophora robur population Threatened fauna habitat	Low
64660	65250	A	No	No, Sandy Creek 1.3 km E)	None	Habitat critical to the survival of koalas Angophora robur population Threatened fauna habitat	Low
65720	65960	A	No	No, Sandy Creek 1.5 km E)	None	Habitat critical to the survival of koalas Angophora robur population Threatened fauna habitat	Low
66540	66990	A	No	No, Sandy Creek 1.7 km E), Clarence River 1.3 KM W)	None	Habitat critical to the survival of koalas Angophora robur population Threatened fauna habitat *Angophora robur*	Low
67560	67940	A	Close	Clarence River (390 m W)	Close to Swamp Sclerophyll Forest on Coastal Floodplain	SEPP No. 14 wetland 285, 232 (>1.5 km) Upper Coldstream Wetlands Habitat critical to the survival of koalas *Angophora robur*	Low
68120	68640	A	Close	Clarence River (150 m W)	Close to Subtropical Coastal Floodplain Forest on Coastal Floodplain	SEPP No. 14 wetland 232 (1.8 km E) Habitat critical to the survival of koalas Adjacent to *Angophora robur*	Low

Approx station		Cut type*	Directly over wetlands / aquatic systems	Adjacent to Wetlands / aquatic systems (within 200 m)	Threatened ecological community (within 1 km)	Biodiversity values including MNES within 2 km	Risk category
Start	Finish						
Section 4							
69080	69430	A	Close	Clarence River (360 m W)	Close to Subtropical Coastal Floodplain Forest on Coastal Floodplain	SEPP No. 14 wetland 232 (1.9 km SE) Habitat critical to the survival of koalas	Low
75240	75440	A	No	No, Shark Creek 250 m S)	None	Potential and known threatened fauna habitat	Low
75950	76410	A	No	No	Close to Subtropical Coastal Floodplain Forest on Coastal Floodplain	Habitat critical to the survival of koalas	Low
76620	77065	A	No	No	None	Habitat critical to the survival of koalas	Low
77550	77850	A	No	Clarence River (1km W)	Partially Subtropical Coastal Floodplain Forest on Coastal Floodplain	Habitat critical to the survival of koalas	Low
78050	78390	A	No	Clarence River (1 km W)	Close to Swamp Sclerophyll Forest on Coastal Floodplain	Habitat critical to the survival of koalas	Low
80890	81030	A	No	Clarence River (600 m SW)	None	SEPP No. 14 wetland 220a (1.6 km m NE) Clarence River Estuary Habitat critical to the survival of koalas	Low
81290	81660	B to A	No	Clarence River (800 m SW)	None	SEPP No. 14 wetland 220a (1.4 km NE) Clarence River Estuary Habitat critical to the survival of koalas	Low
81720	81750	C to A	No	No	None	SEPP No. 14 wetland 220a (1 km NE) Clarence River Estuary Habitat critical to the survival of koalas	Low
81890	81920	C to A	No	No	None	SEPP No. 14 wetland 220a (1 km NE) Clarence River Estuary Habitat critical to the survival of koalas	Low

Approx station		Cut type*	Directly over wetlands / aquatic systems	Adjacent to Wetlands / aquatic systems (within 200 m)	Threatened ecological community (within 1 km)	Biodiversity values including MNES within 2 km	Risk category
Start	Finish						
Section 5							
82080	82240	C to A	No	No	None	SEPP No. 14 wetland 220a (570 m NE) Habitat critical to the survival of koalas	Low
94900	94930	A	No	No, Mororo Creek 940 m W), Clarence River 700 m S)	Close to Swamp Sclerophyll Forest on Coastal Floodplains	SEPP No. 14 wetland 153b (920 m SW) Habitat critical to the survival of koalas Mororo Creek Nature Reserve	Low
95125	95125	B to A	No	Mororo Creek 135 m W)	Close to Subtropical Coastal Floodplain Forest on Coastal Floodplain	Habitat critical to the survival of koalas Known Koala Habitat Mororo Creek Nature Reserve	Moderate, mitigation and monitoring impacts required
95280	95350	B to A	No	Mororo Creek 175 m SW)	Close to Subtropical Coastal Floodplain Forest on Coastal Floodplain	Habitat critical to the survival of koalas	Low
95440	95500	B to A	No	Mororo Creek 240 m SW)	Close to Subtropical Coastal Floodplain Forest on Coastal Floodplain	Habitat critical to the survival of koalas	Low
Section 6							
101240	101310	A	No	Tabbimoble Creek 300 m E)	Close to Subtropical Coastal Floodplain Forest on Coastal Floodplain	Habitat critical to the survival of koalas Habitat for threatened fauna Identified OPP habitat Tabbimoble Creek	Low
103440	103440	B to A	No	No	Close to Subtropical Coastal Floodplain Forest on Coastal Floodplain	SEPP No.14 153a (1.8 km E) Potential OPP habitat 460 m S Habitat critical to the survival of koalas	Low
Section 7							
110910	111170	A	No	No	Close to Subtropical Coastal Floodplain Forest on Coastal Floodplain	SEPP No. 14 wetland 153 (>1.5 km) Known OPP habitat (unnamed stream) Habitat critical to the survival of koalas	Low
111240	111520	A	No	No	Close to Subtropical Coastal Floodplain Forest on Coastal Floodplain	SEPP No. 14 wetland 153 (1.5 km E) Potential OPP habitat (unnamed stream) (500 m) Habitat critical to the survival of koalas	Low

Approx station		Cut type*	Directly over wetlands / aquatic systems	Adjacent to Wetlands / aquatic systems (within 200 m)	Threatened ecological community (within 1 km)	Biodiversity values including MNES within 2 km	Risk category
Start	Finish						
112580	112950	A	No	No	None	SEPP No. 14 wetland 153 (1.5 km E) Potential OPP habitat (unnamed stream) (800 m N) Habitat critical to the survival of koalas	Low
114090	114580	A	No	No	Partially Subtropical Coastal Floodplain Forest on Coastal Floodplain	Known OPP habitat (unnamed streams) (90 m S) Tabbimoble Swamp Nature Reserve Tabbimoble Floodway No.1 (Potential OPP habitat) Habitat critical to the survival of koalas	High, mitigation and monitoring of impacts required
117590	117710	C to A	No	No	Close to Swamp Sclerophyll Forest on Coastal Floodplain	Tabbimoble Swamp Nature Reserve Habitat critical to the survival of Koala	Low
118090	118290	C to A	No	No	Close to Swamp Sclerophyll Forest on Coastal Floodplain	Tabbimoble Swamp Nature Reserve Habitat critical to the survival of koalas	Low
118590	119710	A	No	No	Close to Swamp Sclerophyll Forest on Coastal Floodplain	Tabbimoble Swamp Nature Reserve Habitat critical to the survival of koalas	Low
120830	121425	A	No	Small floodplain wetlands	None	Potential OPP habitat (920 m NE) Habitat critical to the survival of koalas	Low
122770	123320	A	No	Small floodplain wetlands	Close to Swamp Sclerophyll Forest on Coastal Floodplain	Potential OPP habitat (240 m W) Habitat critical to the survival of koalas	Low
124820	125030	A	No	Floodplain wetland	Partially Swamp Sclerophyll Forest on Coastal Floodplain	Habitat critical to the survival of koalas	Low
125300	125420	B to A	No	Floodplain wetland	Close to Swamp Sclerophyll Forest on Coastal Floodplain	Habitat critical to the survival of koalas Potential habitat for Australasian Bittern and Painted Snipe	Moderate mitigation and monitoring of impact required
125970	126030	B to A	No	Floodplain wetland	None	Habitat critical to the survival of koalas	Low

Approx station		Cut type*	Directly over wetlands / aquatic systems	Adjacent to Wetlands / aquatic systems (within 200 m)	Threatened ecological community (within 1 km)	Biodiversity values including MNES within 2 km	Risk category
Start	Finish						
Section 8							
127000	127220	C to A	No	Small floodplain wetlands	None	Habitat critical to the survival of koalas Sawpit Creek 930 E, potential Giant Barred Frog Habitat	Low
127690	127860	C to A	No	Small floodplain wetlands	Partially Subtropical Coastal Floodplain Forest on Coastal Floodplain Partially Swamp Sclerophyll Forest on Coastal Floodplain	SEPP No. 14 wetland 133 (1.3 km NE) Habitat critical to the survival of koalas	Low
128090	128870	A	No	No, Evans River 1km	Partially Subtropical Coastal Floodplain Forest on Coastal Floodplain Partially Swamp Sclerophyll Forest on Coastal Floodplain	SEPP No. 14 wetland 133 (950 m NE) Habitat critical to the survival of koalas	Low
129020	129080	A	No	No, Evans River 1km	Close to Swamp Sclerophyll Forest on Coastal Floodplain	SEPP No. 14 wetland 133 (715 m E), Evans River (1km E) Habitat critical to the survival of koalas	Low
134690	134890	A	No	Richmond River 890 m N	Partially Swamp Sclerophyll Forest on Coastal Floodplain Partially Swamp Oak Floodplain Forest on Coastal Floodplain	Known OPP habitat 500 m NE Habitat critical to the survival of koalas	Low
136040	136180	A	No	Richmond River (>1km)	Close to Coastal Cypress Pine Forest in NSW North Coast Bioregion	SEPP No. 14 wetland 121 Known OPP habitat (McDonalds Creek 480 m NW) Habitat critical to the survival of koalas	Low
136250	136253	A	No	Richmond River (>1km)	Close to Coastal Cypress Pine Forest in NSW North Coast Bioregion	SEPP No. 14 wetland 121 Known OPP habitat (McDonalds Creek 320 m NW) Habitat critical to the survival of koalas	Low

Approx station		Cut type*	Directly over wetlands / aquatic systems	Adjacent to Wetlands / aquatic systems (within 200 m)	Threatened ecological community (within 1 km)	Biodiversity values including MNES within 2 km	Risk category
Start	Finish						
144800	144850	A	No	Richmond River (800m N)	Swamp Sclerophyll Forest of Coastal Floodplain	SEPP No. 14 wetland 118, 118a (>1 km) Habitat critical to the survival of koalas High density Koala population, and Koala feed tree species	Moderate, mitigation and monitoring of impacts
Section 10							
146090	146140	A	No	Richmond River 90 m S	None	SEPP No. 14 wetland 118 (500 m), 118a (240 m) Habitat critical to the survival of koalas High density Koala population	Low
146450	146480	A	No	Richmond River (460 m S)	None	SEPP No. 14 wetland 118 (770 m), 118a (480 m) Habitat critical to the survival of koalas High density Koala population	Low
147350	147890	A	No	No	None	SEPP No. 14 wetland 118, 118a (>840 m) Habitat critical to the survival of koalas High density Koala population	Low
148190	148240	A	No	No	Partially Swamp Oak Floodplain Forest on Coastal Floodplains	SEPP No. 14 wetland 118, 118a (> 1km) Habitat critical to the survival of koalas High density Koala population	Low
148330	148440	A	No	No	Close to Swamp Oak Floodplain Forest on Coastal Floodplains	SEPP No. 14 wetland 118, 118a (>1km) Habitat critical to the survival of koalas	Low
149015	149100	A	No	No		SEPP No.14 wetland 118 (>1km) Habitat critical to the survival of koalas High density Koala population and Koala feed trees species present	Moderate, mitigation and monitoring of impacts required
152400	152540	A	No	No	Close to Swamp Sclerophyll Forest on Coastal Floodplain	SEPP No. 14 wetland 114 (2.4 km) Habitat critical to the survival of Koala	Low

Approx station		Cut type*	Directly over wetlands / aquatic systems	Adjacent to Wetlands / aquatic systems (within 200 m)	Threatened ecological community (within 1 km)	Biodiversity values including MNES within 2 km	Risk category
Start	Finish						
157100	157600	A	No	No	Partially Lowland Rainforest of Subtropical Australia and Lowland Rainforest on Coastal Floodplains Partially Subtropical Coastal Floodplain Forest on Coastal Floodplains Partially Swamp Oak Floodplain Forests on Coastal Floodplains	SEPP No. 14 wetland 112a (1.3 km) Habitat critical to the survival of koalas High density Koala population Known habitat for Pink Underwing Moth (upslope) Lowland Rainforest of Subtropical Australia (upslope) *Arthraxon hispidus*, Cryptocarya foetida, Endiandra hayesii, *Macadamia tetraphylla*, *Syzygium hodgkinsoniae*	Moderate, mitigation and monitoring of impacts required.

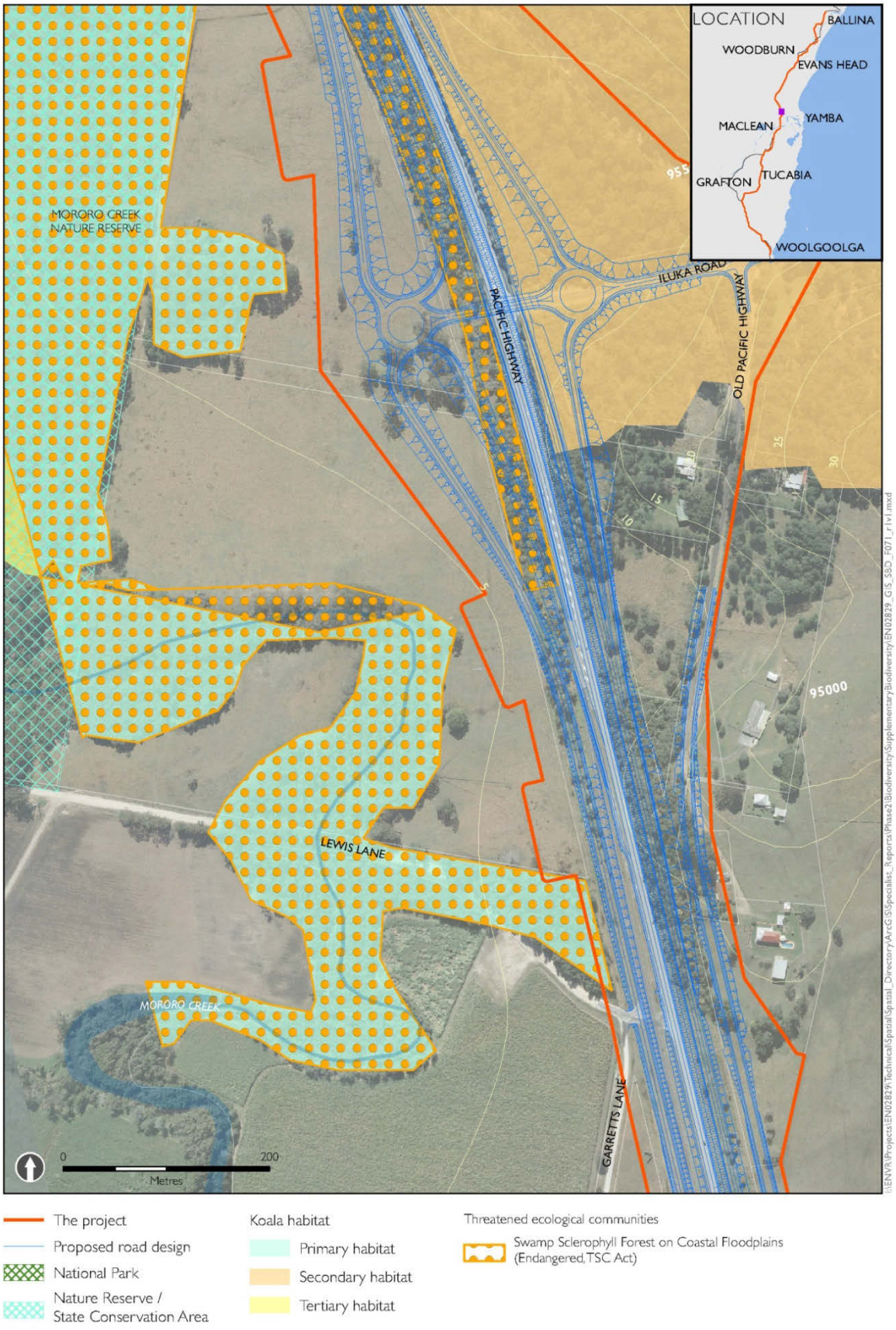


Figure 6-12 Biodiversity values potentially at risk at project cuttings Station 95125

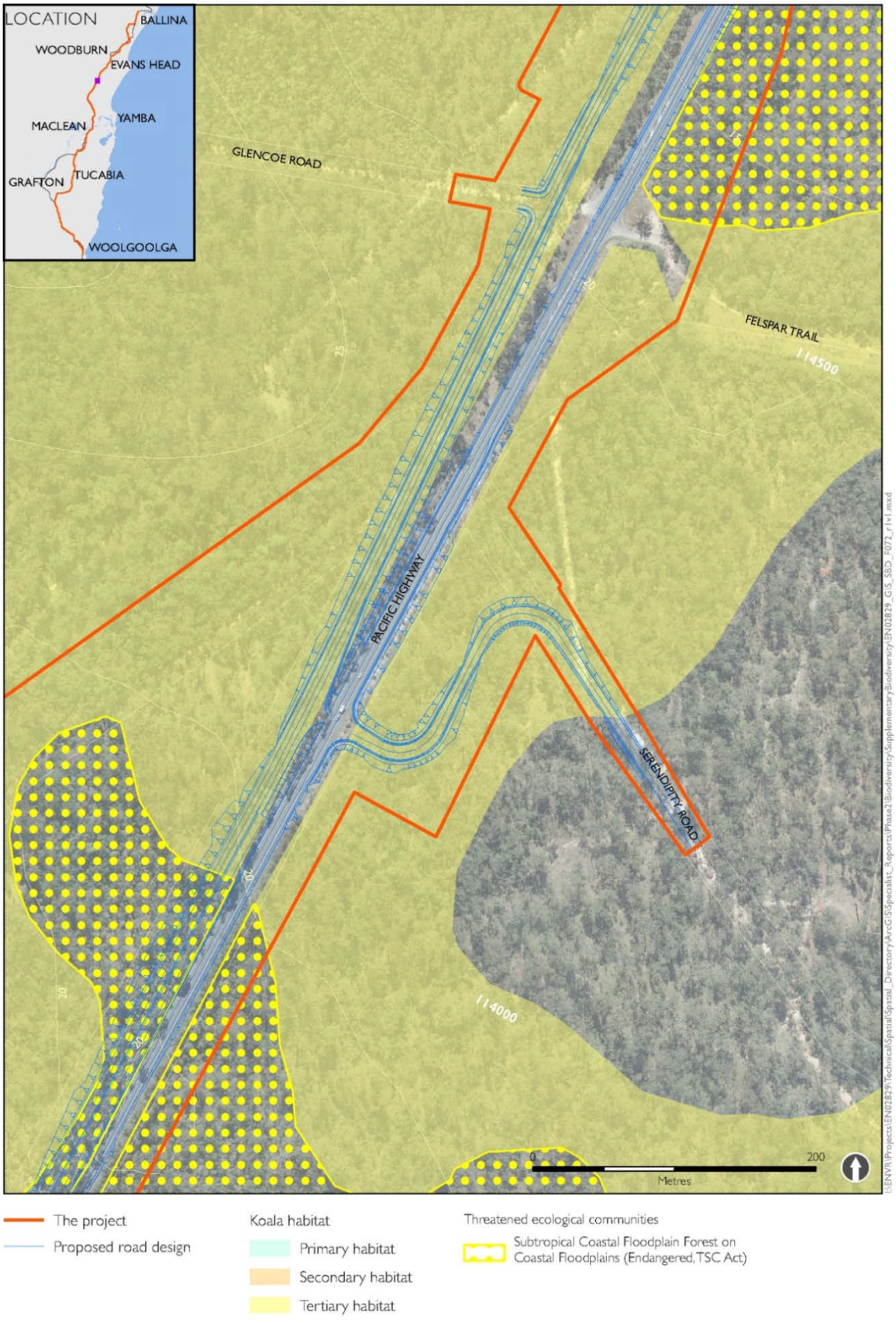


Figure 6-13 Biodiversity values potentially at risk at project cuttings Station 114090-114580

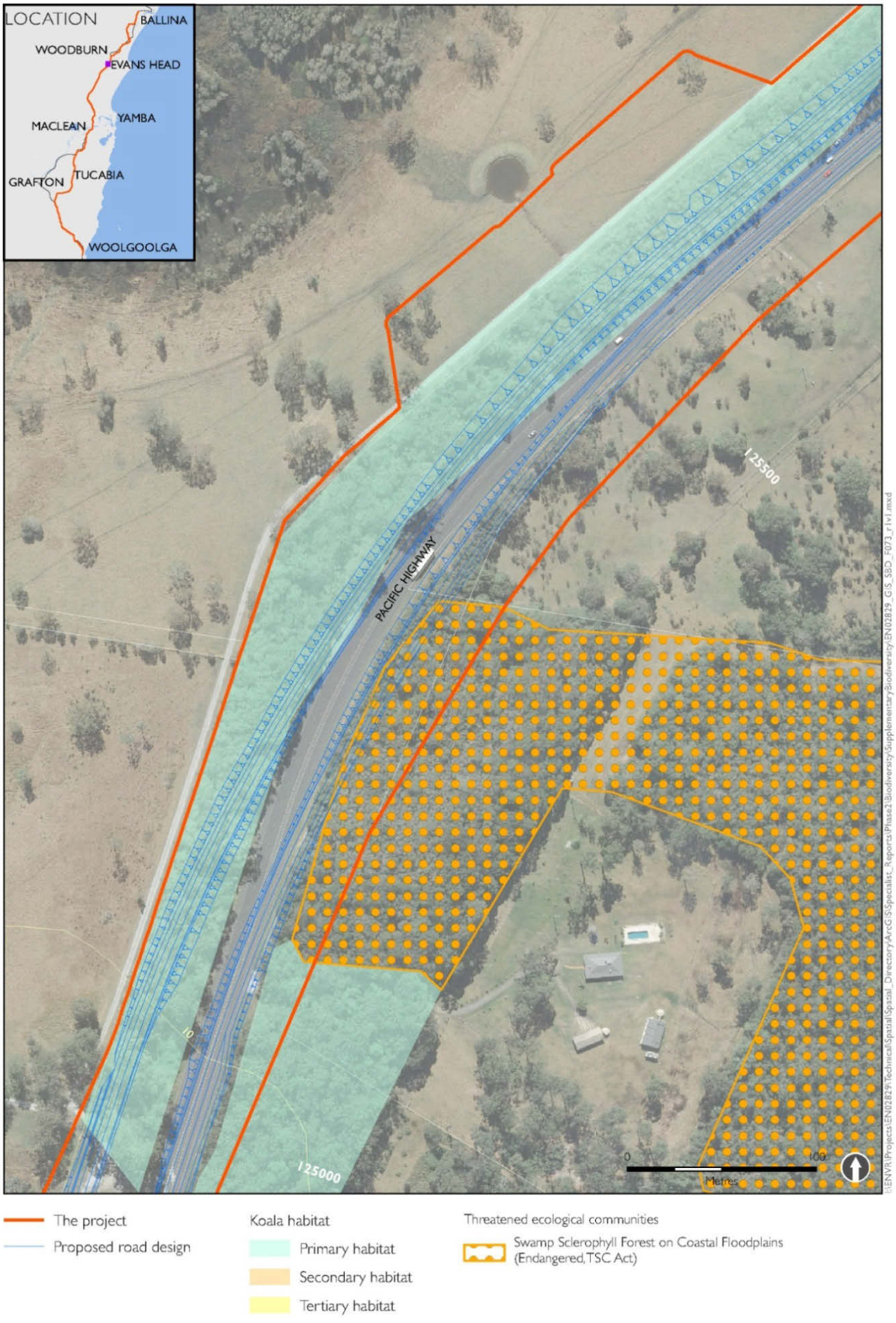


Figure 6-14 Biodiversity values potentially at risk at project cuttings Station 125300-125420

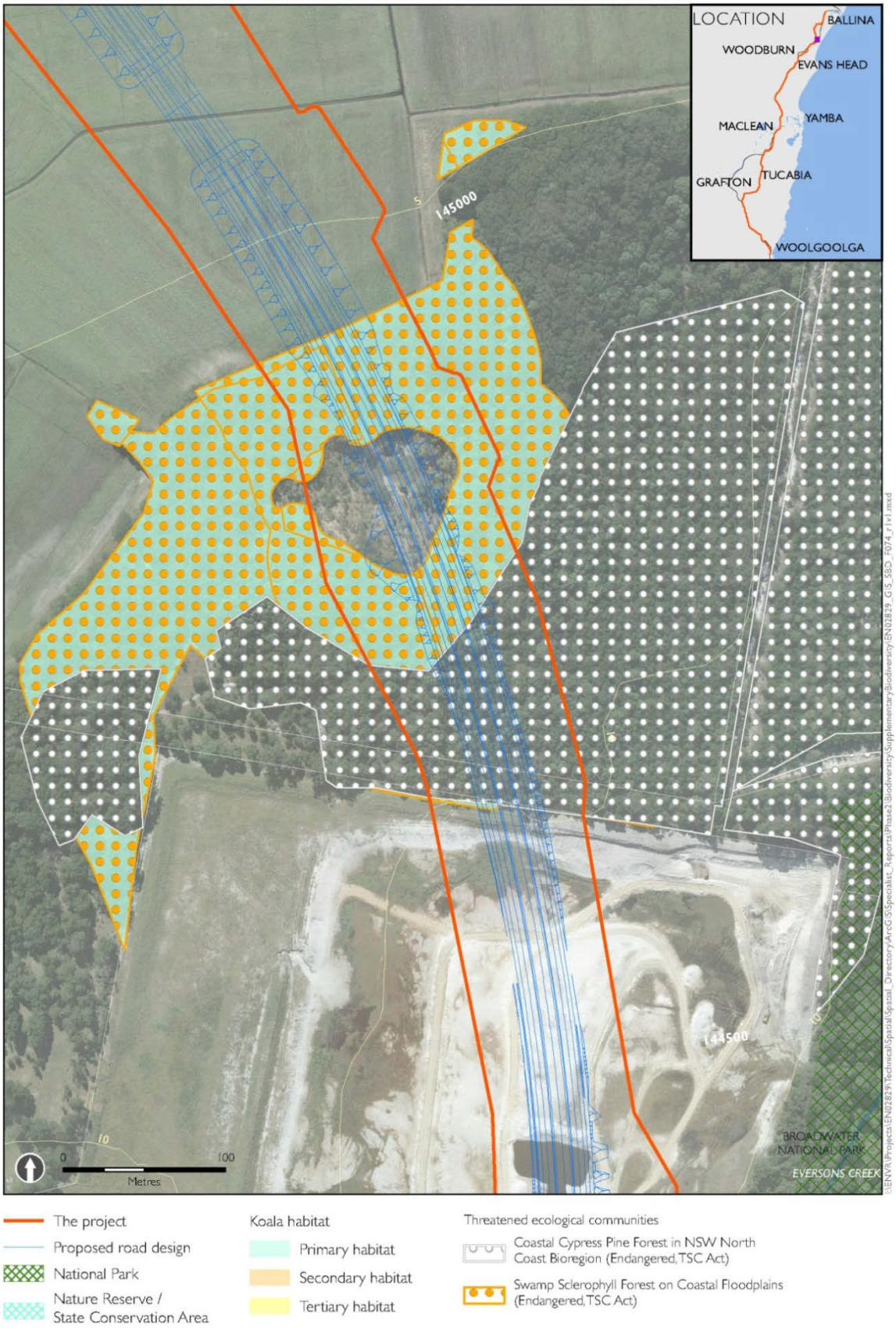


Figure 6-15 Biodiversity values potentially at risk at project cuttings Station 144800-144850

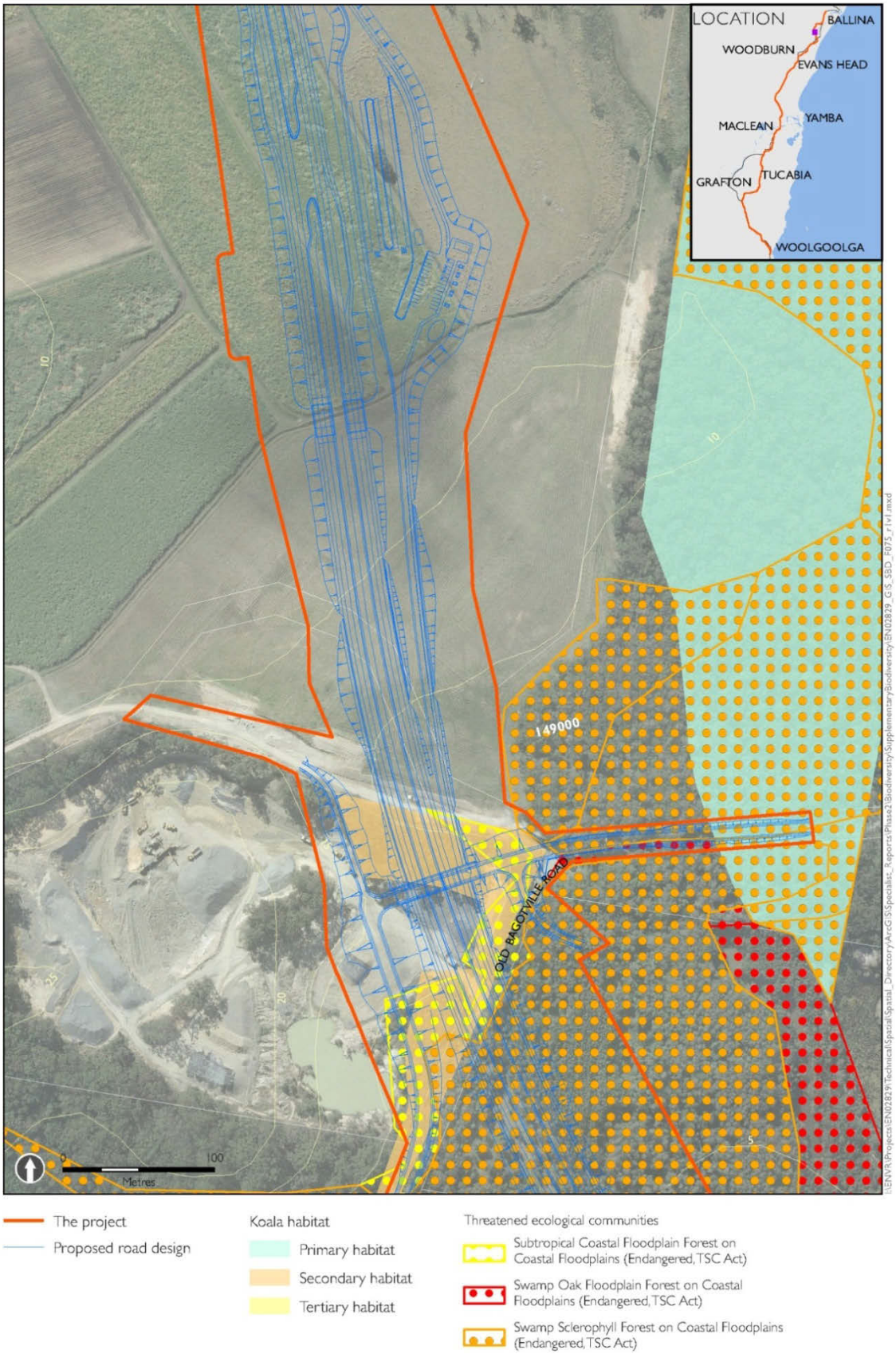


Figure 6-16 Biodiversity values potentially at risk at project cuttings Station 149015-149100

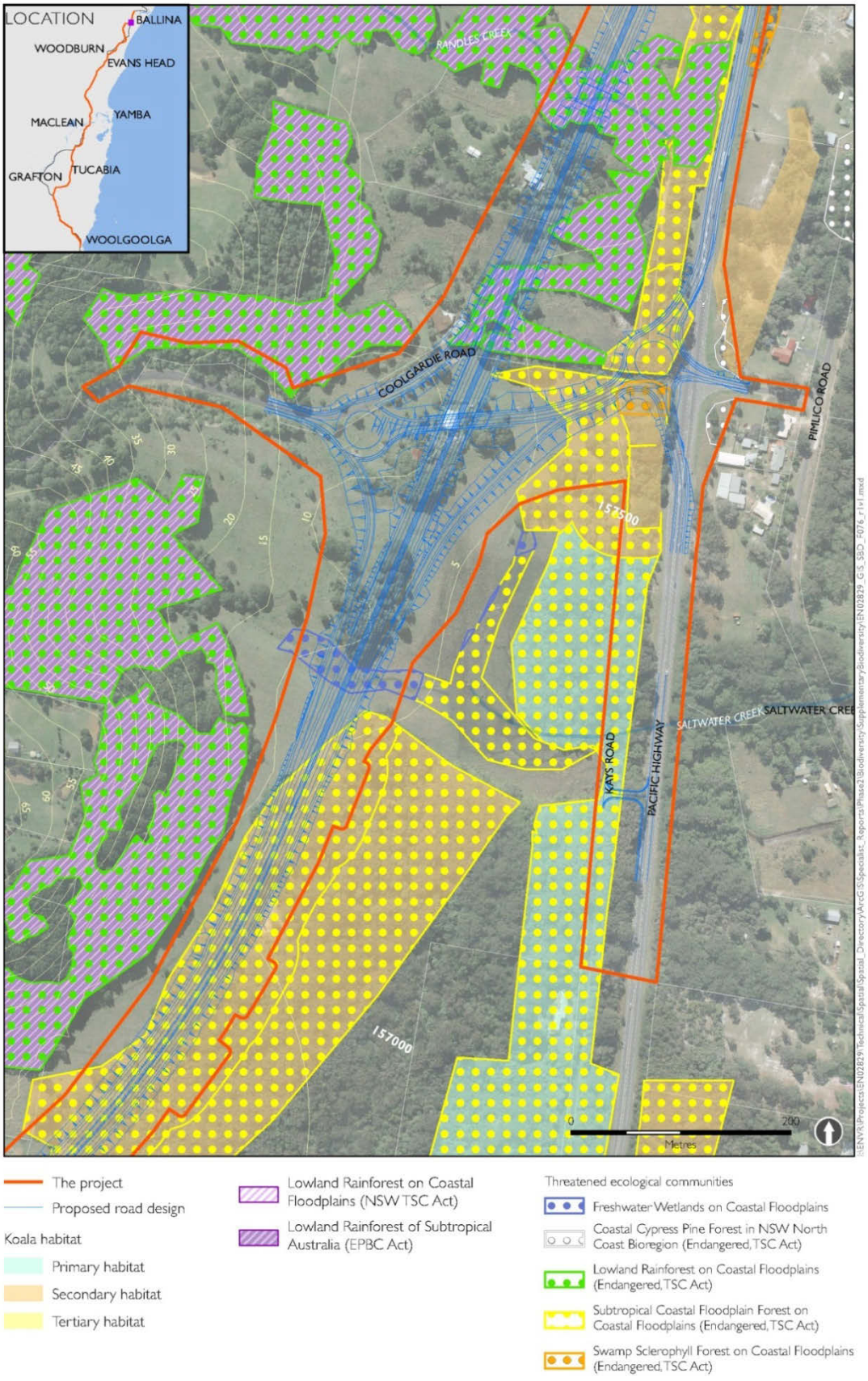


Figure 6-17 Biodiversity values potentially at risk at project cuttings Station 157100-157600

6.6.1. Impacts of groundwater changes on threatened ecological communities

The EIS biodiversity working paper identified a number of threatened ecological communities (TECs) occurring on the floodplains that are watercourse- and groundwater related GDEs. A number of these occur within two kilometres of a proposed cutting site. However, none are within 200 metres, so the risk to these communities is considered low, and there are no groundwater-reliant Freshwater Wetlands.

All areas of identified floodplain TECs within the study area exhibit disturbance regimes associated with a history of altered surface and groundwater hydrology, broadscale clearing of the floodplain, fragmentation and weed invasion leading to a general degradation of the vegetation.

The drawdown of groundwater due to the cuttings has potential for further impacts on these TECs associated with stress on mature trees leading to changed structure and community floristics potentially towards drier habitats. These impacts would increase their vulnerability to weed infestation and dieback. There may also be a flow-on effect for water-dependent biodiversity, including threatened flora and fauna. The impact is likely to be localised (up to 100 metres) and able to be mitigated to a degree, to reduce the short-term and long-term impacts. As a precautionary approach, groundwater dependent TECs located within two kilometres of a type A cutting site has been considered. These TECs and the number of relevant sites are:

- Swamp Sclerophyll Forest on Coastal Floodplains: 22 sites.
- Subtropical Coastal Floodplain Forest: 28 sites.
- Coastal Cypress Pine Forest in the NSW north coast bioregion: two sites.
- Swamp Oak Floodplain Forest on Coastal Floodplains: four sites.

6.6.2. Impacts of groundwater changes on SEPP 14 Wetlands

The EIS recognised and assessed the impacts on SEPP 14 wetlands, particularly GDEs. The review (refer Table 6-74) identified:

- No SEPP 14 wetlands within 100 metres from a cutting site. Therefore, the risk of indirect impacts on GDEs is considered low.
- A number of SEPP 14 wetlands within a range of 240 metres to 1600 metres from a proposed cutting site. Two wetlands are located 240 metres away, which is expected to be outside the zone of impact.

6.6.3. Impacts of groundwater changes on threatened terrestrial species

The project would be near non-gazetted wetlands but none of the proposed cutting sites would occur directly over an aquatic habitat. The cutting sites that would be near a wetland or waterbody are identified in Table 6-76. The proposed cutting sites where groundwater drawdown may impact on threatened species are:

- The cutting at station 3.01: This would be within 100 metres of a large open farm dam. The dam and cutting are within 160 metres of the Corindi River, which is known habitat for the Giant Barred Frog. The Giant Barred Frog has been noted from on-stream dams located along rivers and creeks and this dam may provide temporary refuge during floods. At these times, any localised drawdown is not expected to impact the species. In any case, the site is unvegetated and would not provide critical habitat for the local population. The cutting would be over 100 metres from the Corindi River.

- The cutting at station 67.5, 68.1 and 69.0: This would be around 170 metres east of the south arm of the Clarence River. Given this distance and the size and catchment of the river, drawdown is not expected to have any notable impact and there would be no increased impacts on threatened species.
- The cutting at station 81.2: This would be around 300 metres south of the wetland habitats at Yaegl Nature Reserve, and therefore outside the impact zone.
- The cutting at station 125.3 to 125.4: This would be within 200 metres of a floodplain wetland. This shallow wetland was observed during the field surveys for the EIS and found to be dry at the time, indicative of a natural wetting and drying regime. The wetland is densely vegetated and provides potential habitat for wetland birds including the Australasian Bittern and Australian Painted Snipe during wet periods. Construction of the cutting at station 125.3 to 125.4 would need to consider how this wetting and drying regime would be maintained. The EIS describes a detailed mitigation and monitoring strategy for potential impacts on GDEs, which would apply to this site.
- The cutting at station 127.0 and 127.6: This would be within 700 metres of two freshwater wetlands, one of which occurs in cleared grazing land and the other in forested land. These habitats are likely to be of value to wetland birds and frogs (particularly the densely vegetated sites), which may include the Australasian Bittern, Black Bittern, Australian Painted Snipe, Brolga and Black-necked Stork and the Green-thighed Frog.
- The cuttings in Section 3: These would be near populations of sandstone rough-barked Apple (*Angophora robur*), although this species is not dependent on groundwater and occurs on well-drained sandy soils in elevated positions and is unlikely to be impacted.
- Habitat critical to the survival of the Koala is widespread across all project sections and relates to the presence of Koala feed tree species at suitable densities within the canopy. Those habitats that are associated with Subtropical Coastal Floodplain Forest and Swamp Sclerophyll Forest can contain the primary feed tree species Swamp Mahogany (*Eucalyptus robusta*) and Forest Red Gum (*E.tereticornis*). These habitats may be susceptible to changes in groundwater flows as a result of drawdown from type A cuttings (high potential impact) across the project. The proposed cutting sites with a potential impact on Koala habitat are:
- The cutting at station 95.1 to 95.4: This would be within 100 metres of Mororo Creek, which flows through the Mororo Creek Nature Reserve. There are also GDEs in the nature reserve and critical habitat for the Koala. There is potential for localised impacts along the watercourse given its proximity to the project boundary. This is a high-risk site.
- The cutting at station 144.8: This would be over an isolated patch of Swamp Mahogany dominated forest that is also an area of known habitat for the Broadwater Koala population (Section 9). This is a small cutting and the road would bisect this habitat patch, potentially affecting future use by koalas despite the targeted placement of crossing structures. Potential impacts may arise from long-term drawdown of groundwater near the site, which may cause dieback of Koala feed tree species here including possible home range trees.
- The cutting at station 149.1: This would be within 150 metres of a large area of Swamp Mahogany dominated forest stretching north and south of the Old Bagotville Road on the eastern side of the project (Section 10) and within the range of the Bagotville-Coolgardie Koala population. Impacts may be localised and include dieback of Koala feed trees, including home range trees. However, this swamp forest stretches over a large area several hundred metres from the project, outside of the zone of influence, and is not restricted to the impact area.

- The cutting at station 157.1: This would be adjacent to a large patch of Forest Red Gum and Swamp Mahogany dominated swamp forest that is known Koala habitat south of the proposed Wardell interchange. This habitat is a GDE and there may be localised drawdown impacts adjacent to the road. The habitat extends beyond 100 metres from the road.

6.6.4. Impacts of groundwater changes on threatened aquatic species

This supplementary assessment identifies known and potential habitat for Oxleyan Pygmy Perch to be located in several named and unnamed creeks in project sections 7 to 9. One cutting site is considered high risk and subject to mitigation and monitoring.

The site is the cutting at station 114.090, which would be within 100 metres of a known population of the Oxleyan Pygmy Perch. This is a small, unnamed watercourse and localised drawdown has the potential to isolate pools along the creek. The isolation of pools along this creek occurs naturally, as already noted from the targeted surveys, and Oxleyan Pygmy Perch were already noted from one large pool. The species is adapted to this natural ecological process throughout its range and relies on flooding events for dispersal. Proposed mitigation would help to manage this impact.

All other cutting sites would more than 200 metres away from potential habitat for Oxleyan Pygmy and are therefore considered low risk.

6.6.5. Mitigation and monitoring

- Engineering measures are required as part of construction to mitigate any groundwater impacts, and these are discussed in the groundwater working paper for the EIS.
- Long-term monitoring of the groundwater regime in the vicinity of these cuts would be commenced well in advance of construction to determine the impact mitigation required. Depending on the results of the monitoring, before and during road construction, it is possible that engineering measures to mitigate impacts may not be required at some (or all) of these cuttings. After road construction, the monitoring would continue to verify the effectiveness of any engineering measures, so that modifications can be made, if required.

Changes to the condition of GDEs would be identified by monitoring groundwater quality before and after construction and would be documented in a separate Surface and Groundwater Quality Monitoring Protocol that would be prepared for each section of the upgrade.

7. Supplementary mitigation

7.1. Specific mitigation for key species and communities

The EIS biodiversity working paper presented a mitigation strategy that included a biodiversity connectivity strategy and generic mitigation measures for terrestrial and aquatic flora and fauna. These will inform the development of the project Construction Environmental Management Plan (CEMP) and Flora and Fauna management plans that would be developed post-approval. The strategy provided the framework for a series of threatened species management plans. These plans identify species-specific and site-specific mitigation measures, document monitoring and an adaptive approach to managing impacts on threatened species. The threatened species management plans focused on species considered at greatest risk from the project. The species-specific mitigation measures from these plans are summarised in the following sections.

7.1.1. Rainforest communities and threatened rainforest plants

The following mitigation measures specific to rainforest communities and threatened rainforest plants are proposed:

- Targeted surveys of threatened plant would be conducted pre-construction and would focus on marking and mapping populations in-situ and collecting baseline information on plant health and habitat condition for input into an ongoing monitoring program during construction and operation as part of an adaptive management approach. The location of fencing would be informed by the targeted surveys.
- Exclusion zones and temporary fencing would be provided to protect threatened ecological communities and threatened plants adjacent to the project construction area. These would be clearly delineated on work plans and remain in place for the full construction period.
- Clearing of native vegetation, including threatened ecological communities, would be restricted to the minimum area necessary for construction.
- Site inductions for construction workers would provide information on vegetation to be retained and the identification of threatened species.
- Weed control would be implemented during construction and operation, focusing on existing populations and informed by ongoing monitoring of habitat condition.
- Areas disturbed by construction adjacent to in-situ populations would be revegetated.
- A translocation feasibility assessment and strategy would be prepared for threatened plants in the project corridor in conjunction with the offset strategy.

7.1.2. Threatened plant species (non-rainforest)

The following mitigation measures specific to threatened plant species are proposed:

- Targeted threatened plant surveys would be conducted pre-construction and would focus on marking and mapping populations in-situ and collecting baseline information on plant health and habitat condition for input into an ongoing monitoring program during construction and operation as part of an adaptive management approach.
- Exclusion zones and temporary fencing to protect threatened plants adjacent to the construction area would be clearly delineated on work plans and remain in place for the full construction period. The location of fencing would be informed by the targeted survey.
- Clearing of native vegetation around in-situ threatened plant populations would be restricted to the minimum area necessary for construction.
- Site inductions for construction workers would provide information on vegetation to be retained and the identification of threatened species.
- Weed control would be implemented during construction and operation, focusing on in-situ populations and informed by ongoing monitoring of habitat condition.
- Areas disturbed by construction adjacent to in-situ populations would be revegetated.
- A translocation feasibility assessment and strategy would be prepared for threatened plants in the construction corridor in conjunction with the offset strategy.

7.1.3. Koala

The following mitigation measures specific to the Koala are proposed:

- Targeted Koala surveys would be conducted pre-construction with a focus on collecting further baseline data for important populations in the project area and informing the detailed design and selection of ongoing monitoring locations.
- A Koala fencing strategy would be developed to refine the locations of Koala exclusion fencing. This would aim to exclude koalas from the project corridor during construction and operation and direct koalas to fauna crossing structures.
- A suitably experienced ecologist would undertake pre-clearance surveys. Where reasonable, koalas found in pre-clearance surveys would be relocated in accordance with protocols specifically developed for this species.
- Fauna crossings and wildlife exclusion fencing would be provided. The design and location of Koala crossings are detailed in the EIS biodiversity connectivity strategy, and were identified in consultation with OEH from a series of connectivity workshops. Crossing structures for important populations would be refined during detailed design and in consultation with OEH.
- Permanent fauna crossings would be monitored, maintained and repaired.
- Permanent fauna exclusion fencing would be maintained and repaired. The fencing would restrict Koala access across the Pacific Highway upgrade and facilitate the use of fauna crossings.
- Impacted habitat would be rehabilitated and revegetated in stages and as early as practicable to restore and enhance habitat opportunities.

- Preferred Koala feed trees would be included in the list of native plants for landscaping and revegetation in disturbed areas.
- A weed control and management program would be implemented.
- A program to monitor the effectiveness of the mitigation measures would be implemented and would include performance thresholds and corrective actions.

7.1.4. Threatened invertebrates

The following mitigation measures specific to threatened invertebrates are proposed:

- Targeted surveys would be conducted pre-construction for the Pink Underwing Moth and its host plant and the Atlas Rainforest Ground Beetle to mark and map known locations. The focus would be to collect further baseline data for the populations in the project area and to inform the management actions and ongoing monitoring program.
- Exclusion zones and temporary fencing would be provided to protect the habitat of the target species adjacent to the project construction area. These would be clearly delineated on work plans and remain in place for the full construction period. The locations of fencing would be informed by the targeted surveys and would include protection of the host plant *Carronia multisepalea.* The health of this host plant would be monitored during construction and any impacts from exposure and dust would be managed with shade cloth.
- A suitably experienced ecologist would check potential habitat for Pink Underwing Moth within the project area on each day prior to commencement of any clearing activity to ensure that no host plants or individuals of the moth fall within the clearing zone. This survey, immediately before clearing commences, would be aimed at reducing the risk of mortality of threatened invertebrates during clearing activities.
- Seed and propagation material would be collected from the host plant *Carronia multisepalea* and trials on propagation and planting in adjacent habitats and offset sites would be conducted as part of the offset strategy.
- Clearing of native vegetation and habitat for threatened invertebrates would be restricted to the minimum area necessary for construction.
- Site induction of construction workers would inform and instruct them of the presence of important populations and habitat to be retained.
- Weed control during construction and operation would focus on adjacent rainforest habitats and be informed by ongoing monitoring of habitat condition.
- Areas disturbed by construction adjacent to identified habitat for threatened invertebrates would be revegetated.
- In cases where lighting is essential, the project would consider the use of non- standard types of lighting that would minimise attraction and displacement of adult Pink Underwing Moth and potential disorientation of Atlas Rainforest Ground Beetle. Any bright lighting that has the potential to be directly visible from areas of threatened invertebrate habitat would be shielded.
- The monitoring program would focus on monitoring moth activity around the installed street lights as part of an adaptive management program, and corrective actions would be implemented if required.

7.1.5. Threatened mammals

The following mitigation measures specific to threatened mammals are proposed:

- Targeted surveys would be conducted pre-construction with a focus on the collection of further baseline data for important populations in the project area and informing the detailed design and selection of ongoing monitoring locations.
- A suitably experienced ecologist would undertake pre-clearance surveys. Where reasonable, threatened mammals found in pre-clearance surveys would be relocated in accordance with protocols specifically developed for that species.
- Fauna crossings and wildlife exclusion fencing would be provided. The design and location of fauna crossings are detailed in the EIS biodiversity connectivity strategy, and were identified in consultation with OEH from a series of connectivity workshops. Crossing structures for important populations would be refined during detailed design and in consultation with OEH.
- Permanent fauna crossings would be monitored, maintained and repaired.
- Permanent fauna exclusion fencing would be maintained and repaired. The fencing would restrict threatened mammals from crossing the Pacific Highway upgrade and facilitate the use of fauna crossings.
- Impacted habitat would be rehabilitated and revegetated in stages and as early as practicable to restore and enhance habitat opportunities.
- A weed control and management program would be implemented.
- A program to monitor the effectiveness of the mitigation measures would be implemented and would include performance thresholds and corrective actions.

7.1.6. Threatened gliders

The following mitigation measures specific to threatened gliders are proposed:

- Targeted surveys would be conducted pre-construction with a focus on collecting further baseline data for important populations in the project area and informing the detailed design to refine the locations of arboreal crossings and select ongoing monitoring locations.
- A suitably experienced ecologist would undertake pre-clearance surveys. Where reasonable, gliders found in pre-clearance surveys would be relocated in accordance with protocols specifically developed for this species.
- Fauna crossings and wildlife exclusion fencing would be provided. The design and location of fauna crossings are detailed in the EIS biodiversity connectivity strategy, and were identified in consultation with OEH from a series of connectivity workshops. Crossing structures for important populations would be refined during detailed design and in consultation with OEH.
- Permanent fauna crossings would be monitored, maintained and repaired.
- Permanent fauna exclusion fencing would be maintained and repaired. The fencing would be undertaken and would restrict threatened mammals from crossing the Pacific Highway upgrade and facilitate the use of fauna crossings.
- Impacted habitat would be rehabilitated and revegetated in stages and as early as practicable to restore and enhance habitat opportunities.

- A weed control and management program would be implemented.
- A program to monitor the effectiveness of the mitigation measures would be implemented and would include performance thresholds and corrective actions.

7.1.7. Threatened frogs

The following mitigation measures specific to threatened frogs are proposed:

- Targeted surveys would be conducted pre-construction with a focus on the collection of further baseline data for important populations in the project area and to inform the detailed design for frog mitigation measures and select ongoing monitoring locations.
- A suitably experienced ecologist would undertake pre-clearance surveys. Where reasonable, threatened frogs found in pre-clearance surveys would be relocated in accordance with protocols specifically developed for this species.
- Frog hygiene control measures would be implemented for all personnel and equipment that are required to enter threatened frog areas within the project.
- The dewatering of waterbodies that are identified as threatened frog habitat would be undertaken as per a protocol that has been developed for the project.
- The management of water quality and sediment runoff during construction would focus on important frog populations and habitat.
- Fauna crossings would be provided as per the design and locations detailed in the EIS biodiversity connectivity strategy. The crossings were identified in consultation with OEH from a series of connectivity workshops. Crossing structures would be refined for important populations during detailed design and in consultation with OEH.
- Temporary and permanent frog exclusion fencing and compensatory ponds would be provided. The design would be based on the proven effectiveness on other Pacific Highway upgrade projects and informed by the targeted surveys.
- Permanent fauna crossings would be monitored, maintained and repaired.
- Permanent frog exclusion fencing would be maintained and repaired. The fencing would restrict threatened frogs from crossing the Pacific Highway Upgrade and facilitate the use of fauna crossings.
- Impacted habitat would be rehabilitated and revegetated in stages and as early as practicable to restore and enhance habitat opportunities.
- A weed control and management program would be implemented.
- A program to monitor the effectiveness of the mitigation measures would be implemented and would include performance thresholds and corrective actions.

7.1.8. Coastal Emu

The following mitigation measures specific to the coastal Emu population are proposed:

- Targeted surveys would be conducted pre-construction with a focus on the collection of further baseline data for Emu movements and activities in the project area and to inform the detailed design for Emu mitigation measures and selecting ongoing monitoring locations.
- An Emu fencing strategy would be developed to refine the types and locations of Emu exclusion fencing. It would aim to exclude emus from the construction corridor and direct them to crossing structures.
- Fauna crossings and wildlife exclusion fencing would be provided. The design and location of Emu crossings are detailed in the EIS biodiversity connectivity strategy, and were identified in consultation with OEH from a series of connectivity workshops. Crossing structures and locations would be refined during detailed design and in consultation with OEH.
- The construction of bridges and Emu crossing zones would be prioritised and staged to minimise lengthy disruption to Emu movements and avoid nesting period of the birds.
- Exclusion zones and temporary fencing would be provided to protect Emu habitat and prevent emus from entering the construction area. These would be clearly delineated on work plans and would be put in place for a period prior to construction to encourage early use by emus.
- Temporary fencing would remain in place for the full construction period and gradually be replaced with permanent fencing.
- A suitably experienced ecologist would undertake pre-clearance surveys, focused on finding Emu nests and emus. Protocols have been developed for allowing emus to leave the construction area during clearing and at any stage during construction.
- The CEMP would include a policy that no domestic dogs are to be brought onto the site during pre-construction and construction activities. All construction personnel would be inducted as part of the CEMP.
- During construction, water quality and dust would be managed, as would domestic waste, which may be potentially attractive to emus.
- Cleared areas would be revegetated early with cover crops and native food plants, as soon as each bridge is complete.
- Rehabilitation and revegetation would be undertaken in stages and as early as practicable to restore and enhance habitat opportunities.
- A weed control and management program would be implemented.
- A program to monitor the effectiveness of the mitigation measures would be implemented and would include performance thresholds and corrective actions and a trial of attractants to Emu crossing zones.

7.1.9. Threatened fish

The following mitigation measures specific to threatened fish are proposed:

- Targeted surveys would be conducted pre-construction with a focus on the collection of further baseline data to identify important populations in the project area and to inform the detailed design for fish mitigation measures and select ongoing monitoring locations.
- Bridges would be provided in class one waterways, and other suitable construction measures would be provided in waterways of lower importance, to reduce impacts on flow and facilitate fish passage. The design and location of crossings are detailed in the EIS biodiversity connectivity strategy), and were identified in consultation with DPI (Fisheries) from a series of connectivity workshops. Crossing structures and locations would be refined during detailed design and in consultation with DPI (Fisheries).
- Protocols for construction around waterways identified as known and potential habitat for threatened fish would include:
- Using pre-formed concrete piles and girder elements to minimise the need for concrete pouring in floodways.
- Using reinforced formwork incorporating watertight seals at all joints.
- Using a shroud suspended under the bridge deck to intercept any spills that might occur in the event of any formwork seepage.
- The timely off-site disposal of any seepage caught in the shroud by the on-site supervision team.
- Covering recently poured bridge decks with impermeable and durable plastic to prevent alkaline runoff entering waterways.
- Timing events to avoid spawning periods.
- Designing temporary crossing structures and undertaking a prior risk assessment to identify high-risk and low-risk activities.
- Undertaking cre-clearing surveys in any isolated pools near the construction to relocate trapped fish including the target species.
- Standard earthworks and sediment controls would be implemented during construction.
- A plan for discharge of spill and detention basins would be prepared. The plan would aim to irrigate the discharge over land at distance from waterways, and to ensure no discharge into waterways identified as known or potential habitat for the target species.
- Riparian areas disturbed during construction would be restored, maintained and monitored.

7.2. Review of connectivity strategy

7.2.1. Koala connectivity measures

7.2.1.1. Effectiveness of mitigation measures for koalas

Recent genetic research identifies major roads as a barrier to gene flow for koalas (Lee et al, 2009 and 2010). The project would fragment habitat links for koalas seeking to access preferred habitats on both sides of the highway, particularly between Bagotville and Wardell and the southern parts of Coolgardie (Section 10), and also between Broadwater National Park and Rileys Hill (Section 9). These factors were considered in the EIS biodiversity connectivity strategy.

In NSW, Roads and Maritime has commissioned several long-term studies to investigate the effectiveness of underpasses, overpasses and exclusion fencing. These studies involved radio-tracking of koalas before, during and after construction on the Pacific Highway upgrade, including at Lindsays Cutting (Moon, 1998) and Pine Creek State Forest, near Coffs Harbour, at Raymond Terrace and Bulahdelah, north of Newcastle, and along the Yelgun to Chinderah and Bonville upgrades in northern NSW (AMBS, 2011). koalas have been reported using structures as small as 2.4 metres by 1.2 metres near Brunswick Heads (Taylor and Goldingay, 2003), although this structure was 18 metres long. Larger structures (2.4 by 2.4 metres and 3 by 3 metres) are generally preferred by fauna, and it remains to be determined whether or not there is a distance threshold beyond which some species would not travel.

On the Pacific Highway at Raleigh, an underpass 100 metres long provided safe passage on four occasions for koalas during one study. However, crossing records for this long underpass suggest that the underpass is not perfectly suited for facilitating Koala movement (AMBS, 2011). The study authors suggest that there is some evidence that the length of the underpass is a deterrent to some animals, with some animals investigating the entrance or making a partial passage but not a full crossing.

Notwithstanding this information, monitoring of crossing structures on the Pacific Highway has demonstrated the effectiveness of overpasses and underpasses for koalas crossing the highway particularly during peak breeding and dispersal periods. Furthermore, the knowledge gained from these studies has led to the inclusion of best practice design principles, such as the addition of raised vertical and horizontal logs to encourage use and revegetation around structures to protect koalas from predators.

Similarly, monitoring of Koala exclusion fencing has indicated that these structures are effective at excluding koalas from the road and directing them towards crossing structures. Monitoring is essential in the early stages following construction to identify any weaknesses or gaps in fences and to look at mortality rates of koalas on nearby local roads. A monitoring program has been established for the project and is documented in the Koala Management Plan for this project.

7.2.1.2. Important Koala populations in the project area

The discussion on Koala populations in section 5.5 of this report details findings from the targeted surveys undertaken for the EIS, supplementary surveys, and a comprehensive review of Koala records near the project. The data indicate that koalas could occur in all project sections in a range of habitats that would be impacted by the project and also identifies habitat critical to the survival of koalas, as defined under the EPBC Act, and primary and supplementary habitat as defined under the NSW Koala Recovery Plan (DECC, 2008).

Key areas of Koala habitat, and Koala populations, are outlined below.

Project sections 9 and 10

High-density Koala populations occur in the Richmond Valley LGA between Woodburn and Wardell (sections 9 and 10) particularly around Wardell to Coolgardie and Bagotville (Section 10) and south of the Richmond River from Rileys Hill to Broadwater National Park (Section 9).

(Low-density Koala populations were identified in sections 1, 3, 5 and 7.)

The Richmond River provides a major barrier to the Koala sub-population in the north, particularly at Broadwater, by restricting movements to the west and north. The Koala sub-populations noted in the EIS occurring north and south of the river (sections 9 and 10) are considered separate sub-populations in this regard. The northern sub-population is constrained by the river to the east although there is contiguous habitat to the west towards Tuckean Nature Reserve and north to Alstonville within recognised regional corridors. The EIS recognises that the highway would create a barrier for the important population north of the Richmond River and this has been addressed in the connectivity strategy. These northern sub-populations are considered 'important populations' according to the interim referral advice, and occupy large and small habitat patches between stations 133.0 and 159.0.

Koala habitat in these locations is already extensively fragmented, particularly in Section 9 south of Broadwater, as a result of clearing for farming on the low-lying alluvial areas of the Richmond River floodplain and the presence of the highway, which bisects Broadwater National Park and other known habitats to the east and west. The impact of fragmentation and barrier effects would be more pronounced north of the Richmond River in Section 10, particularly:

- Immediately north of the Richmond River (station 146.0) through to Thurgates Lane (station 154.0).
- From station 155.0 through to Coolgardie Road and Kays Road (station 157.2).

The other areas of habitat for the Broadwater National Park Koala population are already fragmented by the highway, and the upgrade in this location would involve duplicating existing carriageways and constructing land bridges to link the national park and thereby improve the current situation. There may be localised impacts on Koala movements between Broadwater and Broadwater National Park near Pine Tree Road, but there is a lack of suitable habitat around the township of Broadwater compared to further south at Broadwater National Park.

Project Section 5

The Clarence Valley Koala Plan of Management (Clarence Valley Council, 2010) identifies three important Koala sub-populations in the northern parts of the LGA at Iluka, Woombah and Ashby. Until relatively recently, Iluka Peninsula supported a renowned high-density Koala population but a recent drastic decline over the last 10 years or so has left this sub-population functionally extinct (Clarence Valley Council, 2010). This population occurs several kilometres to the east of the highway near the township of Iluka.

The remaining sub-populations at Ashby and Woombah are considered low-density populations. The Clarence Valley Plan of Management reports on the results of Koala activity surveys conducted for the Ashby and Woombah sub-populations and identify the following:

- Koala activity within the Ashby area was neither widespread nor continuous, but was instead indicative of a small, fragmented population comprised of at least three disjunct breeding

aggregations. These aggregations all occur around 10 kilometres to the west and south of the highway upgrade close to the river and are unlikely to the be impacted by the project. There are several waterways dividing the population from the study area including the North Arm, Back Channel and Mangrove Creek tributaries of the Clarence River.

- The distribution of Koala activity for the Woombah sub-population shows an area of habitat with demonstrated low Koala use around 500 metres east of the Pacific Highway between stations 95.7 and 97.1. This habitat is contiguous with Bundjalung National Park to the north and east where there are several preferred habitat types. The range of this sub-population is not well defined and it is likely the highway to the west is a major barrier restricting dispersal to the west. A Koala was observed during the supplementary surveys for this project on the western side of the highway in Mororo Creek Nature Reserve. This individual may be associated with the Woombah sub-population despite the range of the population is reportedly east of the highway.

7.2.1.3. Critical review of connectivity structures for koalas

The connectivity structures proposed for koalas in the EIS were reviewed in light of the additional information gathered from the supplementary surveys. The review identified a number of areas where connectivity could be improved. As a consequence, additional targeted connectivity structures have been incorporated into the project. These are described below along with further assessment of spatial gaps.

The connectivity strategy considered the presence of koalas across multiple project sections and provides targeted structures for this species in conjunction with several other target species. The review focused on mitigation measures provided in sections 5, 9 and 10 aimed at the important populations identified and specially targeted at koalas. The complete list of targeted structures for Koala populations across the remaining sections is provided in the EIS and no further review was conducted. The review of Koala connectivity structures is documented in Table 7-1. It considered:

- The location of crossing structures in the landscape and exclusion fencing in view of the data collected for the EIS and in supplementary investigations.
- The type of structures, including dimensions.

In sections 9 and 10 – where there are two high-density sub-populations – there are 26 potential connectivity structures proposed (combined and dedicated) over an area of around 19 kilometres identified as critical for the Koala populations.

(To further mitigate impacts on koalas, a priority was given to reducing vegetation clearing in this area associated with Lowland Rainforest and habitat for threatened species. This influenced the decision-making on placement and elevation of the road.)

The 26 structures proposed and their dimensions are shown in Table 7-2.

Table 7-1 Review of Koala connectivity structures for important Koala populations

Project section	EIS connectivity structures	Assessment of suitability and recommendations
5	Mororo Creek area (Woombah)	The distribution of Koala activity for the Woombah sub-population reported in CVC (2010) shows an area of habitat with low Koala use around 500 metres east of the Pacific Highway between station 95.7 and station 97.1. The connectivity strategy considered the need to provide connectivity between Bundjalung National Park and Mororo Creek Nature Reserve and was constrained by the presence of the existing Iuka Road intersection and proposed new interchange which sits directly at this location and is not suited to directing animals. The nearest structure to this is a dedicated underpass that has been located north at Station 99.7 (3 x 2.4 metres RCBC 44 metres in length) to provide connectivity for fauna across an important regional corridor while this structure is appropriately located it leaves a gap between Station 95.7 and Station 97.1 where there are no structures proposed. Much of the land on the western side of the highway in this location is cleared, however there are two possibilities for connectivity which should be considered further in the detailed design. It should be noted that there are very low fill heights in this area which would constrain design capabilities. As such other locations could be considered appropriate. Station 96.7 – there is a narrow riparian strip of vegetation connecting Mororo Creek which continues to the Reserve. Station 95.8 to 96.0. This sits adjacent to a proposed Ancillary Facility site (Section 5, site 6). This site reported Koala activity as did the adjoining reserve and was suggested to be revegetated post construction and added to the reserve system
9	South of the Richmond River, a proposed Broadwater viaduct is planned, at station 145.1 and fauna exclusion fencing from 142.80 to 145.120	A small area of known Koala habitat would become isolated on the western side of the highway between station 143.7 and 145.0 which is currently connected with Broadwater National Park. The proposed viaduct is too far north and outside of Koala habitat to provide viable connectivity here. A review of the structures proposed in this location has identified an opportunity to upsize two drainage structures located at Station 144.2 and 144.7 both to a 3.0 m x 3.0 m box culvert, which would provide improved connectivity for koalas in this location. This would require an increase in the grade of the highway at both locations and would be considered further during detailed design. Fauna exclusion fencing is appropriate in length. It is recommended that strategic planting of Koala habitat within the current sand-quarry site (station 144.4) post-construction should be considered in consultation with the property owner to reinforce connectivity on both sides of the highway.

Project section	EIS connectivity structures	Assessment of suitability and recommendations
9	Broadwater National Park, two overpasses planned at 138.7 and 139.9	Location of structures is appropriate based on Koala activity reported at these locations on both sides of the highway and known Koala population in Broadwater National Park to Riley's Hill.
10	Too few structures between Richmond River and Thurgates Lane and structures placed too far apart. Fencing length is appropriate	A review of the structures proposed in this location has identified an opportunity to place additional structures and upsize existing structures to close the gap. The list of structures proposed now are: **146.3 – 3x 3 metre RCBC (existing) length 44 metres.** **146.6 – 3x3 metre RCBC (up-sized) length 55 metres.** **147.6 – Fauna land bridge (new structure) 120 metres x 30 metres.** **148.6 – 3x3 metre RCBC (new structure) length 60 metres.** Also recommend strategic planting of Koala habitat post-construction to reinforce connectivity.
10	North Wardell fauna overpass bridge at station156.0	Location of structure has been moved about 100 metres east as part of the design refinement, however, would still be appropriate for Koala connectivity. Connects large areas of Koala habitat and known population in the Wardell area through to the north in an important corridor linking with habitat in the Meerschaum Vale and Coolgardie area and provides for dispersal of koalas north and south (Richmond to Lismore). Revegetation of the approaches to this bridge is required, particularly on the south side which is currently cleared.
10	Kays Road south of the Wardell Interchange 156.3 a combined drainage, fauna underpass is planned (3.3 x 1.2m high) and 156.9 combined culvert 1.8 x 1.2m high, with Koala fencing from station 146.1 to 159.7.	These structures are planned in low-lying land with limited fill heights. The design refinement at Coolgardie interchange has seen the road raised slightly and can accommodate larger structures and this is recommended. Koala activity was reported on either side of Kays Road and also south of Laws Road near the existing highway. These locations would be fragmented to the east of the new road between station 156.7 and 157.4. The culvert at station 156.9 should be revised and upsized if possible. Further connectivity consideration is required here at detailed design. The fauna exclusion fence extends to station 159.7 and is considered appropriate in this location.

Table 7-2 Review of Koala mitigation measures for important populations in sections 9 and 10

Station	Structure type	Length (m)	No. cells	Width (m)	Height (m)	Bridge (length x width)
138.4	Reinforced Concrete Box Culvert (RCBC)	85	1	1.2	1.2	
138.7	Land bridge					90.4 x 12.2
139.4	RCBC	85	1	1.2	1.2	
139.9	Land bridge					80.3 x 12.2
142.2	Bridge					15 x 11.0 NB x 11.3 SB
143.7	RCBC	52	1	3.6	1.2	
144.2	RCBC	45	1	1.8	3	
144.7	RCBC	46	2	3.3	3	
145.1	Bridge					75.5 x 10.5 NB and 75.5 x 10.5-12.5 SB
145.2	Bridge					789.3 x 11.5 x 2 (Stitched)
146.3	RCBC	44	2	3	3	
146.6	RCBC	52	1	3	3	
147.6	Land bridge					
148.6	RCBC	55		3	3	
142.2	BRIDGE					18.0 x 11.0
150.0	RCBC	46	3	3.6	1.5	
150.5	RCBC	42	1	2.4	1.5	
150.6	RCBC	42	5	3.6	1.65	
151.9	Bridge					18.0 x 11.0
155.4	Bridge					15.0 x 11.0
156.1	Land bridge					62.0 x 12.2
156.3	RCBC	52	4	3.3	1.2	
156.9	RCBC	53	3	1.8	1.2	
157.6	RCBC	27	4	4.2	2.1	
157.6	RCBC	59	2	3.6	1.8	
157.8	Bridge					17.5 X 13 - 13.5 NB, 14.8 - 15.6 SB

As shown in Table 7-2, the project would have:

- Four dedicated overpasses (land bridges). The proposed land bridges have been deliberately placed in important links in the landscape and target koalas. Significant portions of this area are constrained by low elevation, and the project would have low fill heights. The land bridges are proposed to compensate for this.
- Six bridges over waterways with a minimum three metres of bank retained for fauna movements. The bridges, in particular the Richmond River, are important for Koala connectivity.
- 15 box culverts (underpasses). Of these, five structures would be three metres high and are therefore considered optimum for Koala movements, particularly as the length of these five structures ranges

from 44 metres to 52 metres. The remaining 10 structures would range from 1.2 to 2.1 metres high and could be used by koalas. Taylor and Goldingay (2003) recorded three koalas using structures as low as 1.2 metres high but the height is not considered optimum. Of these 10 lower structures:

- Two would be 85 metres long (stations 138.4 and 139.4) and would be unsuitable for Koala movements.
- One would be 59 metres long (Station 157.6) and may also be unsuitable for Koala movements; it would be targeted in the Koala monitoring strategy.
- Seven would be 42 to 53 metres long, and would provide adequate crossing structures for koalas.

- Given the constraints with fill heights and the presence of threatened ecological communities and plants, the number of structures proposed is considered sufficient over this area. There are no significant gaps in relation to linking habitat patches, with the exception of the area around Kays Road (station 156.3 to 156.9). A recommendation has been made in Table 7-1 to further consider connectivity in this area during detailed design.
- All the underpass structures proposed, with the exception of station 138.7 at Broadwater National Park, would be combined structures, designed for combined drainage and fauna use. There is a risk of flooding of these structures at peak rainfall times, which may affect their function temporarily. This would have only minor temporary impacts on structures located in the Bagotville to Coolgardie area (Section 10) where flooding is not expected to persist for long periods given the undulating topography. Structures south of the river on the floodplain would be affected for longer periods, although not likely more than five days. A review of the flooding impacts of the project in the EIS indicated that, during peak flooding events, culverts to the south of the Richmond River would be flooded for three to five days, while culverts between Bagotville and Coolgardie would be flooded for 30 minutes to an hour.

7.2.2. Connectivity structures and gaps in vegetation

The concept design connectivity workshops conducted for the EIS focused on overlaying all existing data for threatened species in the project GIS, including threatened species records from the Atlas of NSW Wildlife, threatened fauna identified from the field surveys, and local and regional wildlife corridors. The structures nominated in the preferred route reports were then critically analysed to determine their suitability on a whole-of-project scale.

This review and the connectivity workshops identified and addressed a number of gaps relating to areas for improvement, which were subsequently addressed in the connectivity strategy and EIS. This process highlighted the need to:

- Address 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, sub-regional corridors and dry forest habitats.
- Address 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.
- Increase the proposed height of structures. Numerous underpasses and bridges were inadequately sized in terms of height, particularly where culvert lengths would be greater than 50 metres. The increase in size was decided based on proven effectiveness as indicated in underpass use monitoring data from other Roads and Maritime projects.

- Review the feasibility of constructing a fauna crossing structure at any specific point in terms of 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.
- Design fauna crossings consistent with structures included on other Pacific Highway upgrade projects that have proven to perform well.

As an additional mitigation measure, the EIS recognised that some cleared land occurs adjacent to proposed crossing structures and discussed the need to restore connectivity where possible through strategic revegetation in these areas. This measure would only be feasible in a few locations such as on Roads and Maritime land, within the road reserve or on acquired properties. The effectiveness of the remaining structures adjacent to privately owned land may be compromised.

All dedicated and combined structures that occur adjacent to cleared land, and the land tenure, are outlined below.

Of the 112 dedicated and combined connectivity structures proposed, 79 structures (70 per cent) would adjoin vegetation on both sides of the road. The remaining structures would adjoin cleared land on at least one side of the road. These include 27 structures (24 per cent) on private land and six structures (five per cent) on land owned by Roads and Maritime. Of the 27 structures adjoining private cleared land, three of these are targeted at coastal emus (the approaches to these would remain cleared as a specific measure to attract emus by providing open vistas). Four structures are targeted at Oxleyan Pygmy Perch and therefore the degree of vegetation on the land is considered unlikely to negatively influence the effectiveness of the structure for this species. The cleared Roads and Maritime land that adjoins connectivity structures can be revegetated.

Therefore, 82 per cent of the structures proposed would retain the existing vegetation or receive new vegetation to the approaches and are considered optimum for the target species. The remaining 18 per cent (20 structures) would require additional strategic revegetation in the road reserve to improve their effectiveness, as proposed in the EIS. It is worth noting that, of these 20 structures, seven are targeted at Rufous Bettong and Brush-tailed Phascogale, which were both observed on cleared and modified land in the study area (Table 7-3). These structures may therefore retain some suitability for these species without revegetation.

Table 7-3 Review of connectivity structure locations and adjoining cleared land

Station (km)	Structure type	Functionality	Targeted fauna group / spp.	Structure adjoins cleared land[#]	Strategic revegetation in road reserve required
1.5	Arboreal crossing	Dedicated			
2.1	RCBC	Combined	Frogs, small-medium mammals, reptiles		
3.545	Bridge	Combined	Fish, small- large mammals, frogs, reptiles		
4.01	Bridge	Combined	Rufous Bettong, + small- large mammals, herpetofauna		Yes
4.685	Bridge	Combined	Oxleyan Pygmy Perch, small-medium mammals, herpetofauna		
5.66	RCBC	Combined	Oxleyan Pygmy Perch		

Station (km)	Structure type	Functionality	Targeted fauna group / spp.	Structure adjoins cleared land#	Strategic revegetation in road reserve required
5.67	RCBC	Combined	Oxleyan Pygmy Perch		
6.78	RCBC	Dedicated	Rufous Bettong, Spotted-tailed Quoll, Oxleyan Pygmy Perch		
7.285	RCBC	Combined	Rufous Bettong, Spotted-tailed Quoll		
8.51	RCBC	Dedicated	Rufous Bettong, Spotted-tailed Quoll		
10.745	RCBC	Combined	Rufous Bettong, Spotted-tailed Quoll		
11.785	RCBC	Dedicated			
12.325	RCBC	Combined	Koala, Spotted-tailed Quoll		
12.75	Arboreal crossing	Dedicated	Yellow-bellied Glider, Squirrel Glider		
12.885	RCBC	Combined	Rufous Bettong, Spotted-tailed Quoll, Common Planigale		
13.315	RCBC	Combined	Rufous Bettong, Spotted-tailed Quoll, Common Planigale		
13.315	RCBC	Combined	Rufous Bettong, Spotted-tailed Quoll, Common Planigale		
13.835	RCBC	Combined	Rufous Bettong, Spotted-tailed Quoll, Common Planigale		
14.28	RCBC	Combined			
17.02	Arboreal crossing	Dedicated	Yellow-bellied Glider, Squirrel Glider		
20.65	RCBC	Combined	Rufous Bettong, Brush-tailed Phascogale		Yes
20.718	Bridge	Combined	Rufous Bettong, Brush-tailed Phascogale		
20.88	RCBC	Combined	Rufous Bettong, Brush-tailed Phascogale		
21.29	RCBC	Combined	Rufous Bettong, Brush-tailed Phascogale		
22.373	Bridge	Combined	Rufous Bettong, Brush-tailed Phascogale		
23.125	RCBC	Dedicated	Rufous Bettong, Brush-tailed Phascogale		
23.125	RCBC	Dedicated	Rufous Bettong, Brush-tailed Phascogale		
24.575	RCBC	Combined	Rufous Bettong, Brush-tailed Phascogale		
24.665	RCBC		Rufous Bettong, Brush-tailed Phascogale		
25.95	RCBC	Dedicated	Rufous Bettong, Brush-tailed Phascogale		
27.42	RCBC	Combined	Rufous Bettong, Brush-tailed Phascogale		
35.23	RCBC	Combined	Rufous Bettong		
36.398	Bridge	Combined	Rufous Bettong		
37.32	RCBC	Combined	Rufous Bettong		
39.69	RCBC	Combined	Rufous Bettong, herpetofauna		
42.54	Bridge	Combined (Emu)	Emu, medium to large mammals including Rufous Bettong, herpetofauna, major fish habitat		
43.121	Bridge	Combined (Emu)	Emu, medium to large mammals including Rufous Bettong, herpetofauna, major fish habitat		

Station (km)	Structure type	Functionality	Targeted fauna group / spp.	Structure adjoins cleared land[#]	Strategic revegetation in road reserve required
43.906	Bridge	Combined (Emu)	Emu, medium to large mammals including Rufous Bettong, herpetofauna, major fish habitat		
46.074	Bridge	Combined (Emu)	Emu, medium to large mammals including Rufous Bettong, herpetofauna, major fish habitat		
46.344	Bridge	Combined (Emu)	Emu, medium to large mammals including Rufous Bettong, herpetofauna, major fish habitat		
46.666	Bridge	Combined (Emu)	Emu, medium to large mammals, herpetofauna		
47.662	Bridge	Combined (Emu)	Emu, medium to large mammals including Rufous Bettong, herpetofauna, major fish habitat		
48.1	Arboreal crossing	Dedicated	Squirrel Glider, Sugar Glider		
49.265	Bridge	Combined (Emu)	Emu, medium to large mammals including Rufous Bettong, herpetofauna		
50.299	Bridge	Combined (Emu)	Emu, medium to large mammals including Rufous Bettong, herpetofauna		
50.5	Arboreal crossing	Dedicated	Squirrel Glider, Sugar Glider		
51.43	Rcbc	Combined (Emu)	Emu, medium to large mammals including Rufous Bettong, herpetofauna		
52.438	Bridge	Combined (Emu)	Emu, medium to large mammals including Rufous Bettong, herpetofauna, major fish habitat		
52.605	RCBC	Combined (Emu)	Small to medium mammals including Rufous Bettong and herpetofauna		
53.71	RCBC	Combined (Emu)			
53.85	Arboreal crossing	Dedicated	Squirrel Glider, Sugar Glider		
54.706	Bridge	Combined (Emu)	Emu, medium to large mammals including Rufous Bettong, herpetofauna		
57.027	Bridge	Combined (Emu)	Emu, medium to large mammals including Rufous Bettong, herpetofauna		
58.639	Bridge	Combined (Emu)	Emu		
59.285	Arch	Combined (Emu)	Emu		
60.815	Arch	Combined (Emu)	Emu		
64.505	Arch	Combined (Emu)	Emu		
66.19	Arch	Dedicated (Emu)	Emu, medium to large mammals including Rufous Bettong, herpetofauna		
70.455	Bridge	Combined	Emu		

Station (km)	Structure type	Functionality	Targeted fauna group / spp.	Structure adjoins cleared land[#]	Strategic revegetation in road reserve required
		(Emu)			
74.755	Bridge	Combined (Emu)	Emu, medium to large mammals including Rufous Bettong, herpetofauna, major fish habitat		
75.565	RCBC	Combined	Small to medium mammals		Yes
75.88	Arboreal crossing	Dedicated	Possums		
75.92	Arboreal crossing	Dedicated	Gliders		
76.45	RCBC	Combined	Small to medium mammals		
83.1	Bridge	Combined	Small to medium mammals, herpetofauna		Yes
93.99	Bridge	Combined	Major Fish Habitat		
99.73	RCBC	Dedicated	Small to medium mammals		
100.64	RCBC	Combined	small to medium mammals		
101.1	RCBC	Dedicated	Small to medium mammals		
101.541	Bridge	Combined	Small to medium mammals and herpetofauna, Major fish habitat		
111.55	Arboreal crossing	Dedicated	Gliders and possums		
113.92	Bridge	Combined	Oxleyan Pygmy Perch		
115.272	Bridge	Combined	Oxleyan Pygmy Perch, small to medium mammals, herpetofauna		
116.4	Arboreal crossing	Dedicated	Gliders and possums		
118.828	Land bridge	Dedicated	Spotted-tailed Quoll, Koala, Brush-tailed Phascogale (small, medium & large mammals, birds & herpetofauna)		
122.55	RCBC	Combined	Small-medium mammals, herpetofauna		
123.59	RCBC	Combined	Small-medium mammals, herpetofauna		
130.107	Bridge	Combined	Macropods, Major fish habitat		Yes
131.066	Bridge	Combined	Oxleyan Pygmy Perch		
134.6	RCBC	Combined	Oxleyan Pygmy Perch		
136.666	Bridge	Combined	Oxleyan Pygmy Perch		
138.43	RCBC	Dedicated	Small mammals, herpetofauna		
138.796	Land bridge	Dedicated	Koala, small to large mammals, birds, herpetofauna		
139.44	RCBC	Dedicated	Small mammals, herpetofauna		
139.918	Land bridge	Dedicated	Koala, small to large mammals, birds, herpetofauna		
140.62	Arboreal crossing	Dedicated	Gliders, possums		
142.24	Bridge	Combined	Oxleyan Pygmy Perch		
143.2	RCBC	Combined	Oxleyan Pygmy Perch		

Station (km)	Structure type	Functionality	Targeted fauna group / spp.	Structure adjoins cleared land#	Strategic revegetation in road reserve required
143.79	RCBC	Combined	Small-medium mammals, herpetofauna		Yes
144.29	RCBC	Combined	Koala		Yes
144.77	RCBC	Combined	Koala		
145.106	Bridge	Combined	Macropods, birds		Yes
145.287	Bridge	Combined	Macropods, birds, major fish habitat		Yes
146.36	RCBC	Combined	Koala, small to large mammals, Black Bittern, herpetofauna		
146.6	RCBC	Combined	Koala		
147.6	Land bridge	Dedicated	Koala		Yes
148.6	RCBC	Combined	Koala		Yes
142.227	Bridge	Combined	Koala		yes
150.03	RCBC	Combined	Small-medium mammals, herpetofauna		Yes
150.52	RCBC	Combined	Small-medium mammals, herpetofauna		Yes
150.6	RCBC	Combined	Small-medium mammals, herpetofauna		Yes
151.933	Bridge	Combined	Macropods, herpetofauna		Yes
155.409	Bridge	Combined	Small-medium mammals, herpetofauna		
156.1	Land bridge	Dedicated	Koala, Long-nosed Potoroo		
156.305	RCBC	Combined	Long-nosed Potoroo		
156.955	RCBC	Combined	Long-nosed Potoroo		
157.605	RCBC	Combined	Small-medium mammals, herpetofauna		Yes
157.655	RCBC	Combined	Small-medium mammals, herpetofauna		Yes
157.825	Bridge	Combined	Small-medium mammals, herpetofauna		Yes
158.85	RCBC	Combined	Small-medium mammals, herpetofauna		
158.85	RCBC	Combined	Small-medium mammals, herpetofauna		
164.65	Bridge	Combined	Major fish habitat + small-medium mammals, herpetofauna		Yes

Green = No; Amber = yes but land owned by Roads and Maritime; Red = yes and land in private ownership.

7.2.3. Connectivity structures and spatial gaps for target species

The EIS reports significant regional links in the landscape that would be intersected by the project in sections 1 and 2 and 6 and 7. This includes several named regional corridors recognised in DEC (2003). These two key areas would have the following number of structures:

- Sections 1 to 2 (a distance of 28.7 kilometres between station 0.0 and station 28.7): 35 connectivity structures and one widened median.
- Sections 6 to 7 (a distance of around 24.0 kilometres between station 96.4 and station 126.4): 11 connectivity structures and one widened median.

In comparison, sections 3 to 5 would have there are 57 structures (a distance of around 62 kilometres), and sections 8 to 11 would have 30 connectivity structures (a distance of 37 kilometres).

The review of connectivity structures for sections 1 to 2 and 6 to 7 is summarised in Table 7-4.

Table 7-4 Review of connectivity structures in recognised regional corridors in sections 1–2 and 6–7

Project sections	Proposed fauna crossing structures
1–2	• 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. • Five arboreal crossings targeting gliders. • Widened median.
6-7	• 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. • A dedicated dry sclerophyll forest underpass structure, within known wildlife crossing location linking Mororo State Forest. • One dedicated culvert structure in dry sclerophyll forest for fauna movements. • Two arboreal crossing structures targeted at gliders. • Three combined culverts in wet areas designed for combined drainage and fauna capabilities. • Widened median.

Two issues arise from this review:

- There are only 11 structures and one widened median in sections 6–7 over a distance of 24 kilometres. This is around one structure every two kilometres, which is not consistent with the connectivity goal presented in the EIS of maintaining and improving movement pathways for all fauna groups.
- The targeted strategy for threatened gliders over the entire project provides seven arboreal crossings, two widened medians and five land bridges with glider poles over a distance of 155 kilometres. This is around one structure every 11 kilometres. Even with the subtraction of 5.4 kilometres of habitat in Section 11 and large portions of Section 5 that are considered unsuitable for threatened gliders, it is likely that this would be insufficient.

The EIS connectivity strategy and threatened species management plans have described the need to refine locations of connectivity structures based on the findings of the targeted surveys to be undertaken at detailed design stage. It would therefore be considered appropriate in this context to consider the shortfalls identified above, with a view to adding additional structures during detailed design where feasible and reasonable.

7.3. Effectiveness of other mitigation measures proposed in the EIS

The biodiversity working paper for the EIS provided a general discussion on the effectiveness of proposed mitigation measures (EIS Working paper – biodiversity section 5.2.4). This review has reported on the effectiveness of these measures, including:

- Vegetation management measures (implementation of pre-clearing and clearing procedures and weed and disease management).
- Connectivity measures (installation of fauna underpasses, overpasses and arboreal crossing structures, fauna fencing and retention of vegetated medians).
- Provision of nest boxes for hollow-dependent fauna.

This information has been expanded in the threatened species management plans to describe the species-specific mitigation measures and a review of their effectiveness.

The review is based on experience of mitigation measures at other highway upgrades conducted by Roads and Maritime and reported from audits and ongoing monitoring.

Species-specific management plans have been prepared outlining a proposed program for monitoring the effectiveness of mitigation measures against performance criteria. Where performance does not meet a designated threshold, corrective actions are proposed in the plans.

Table 7-3 provides a summary of the proposed mitigation measures for key threatened species and a review of their effectiveness. (Where there is some uncertainty about the effectiveness of a measure, this is identified and addressed in the adaptive management framework.)

Within Table 7-5 the following definitions for the effectiveness rating of measures is provided:

- High, indicating demonstrated effectiveness on multiple road upgrades including the Pacific Highway
- Moderate, indicating some success but not conclusive. Further monitoring is required and proposed during construction and operation to determine effectiveness and where required provisional or corrective measures are to be implemented.
- Unknown, indicating not known or proven to be effective. Monitoring against performance measures is required to determine success and corrective actions are to be implemented where appropriate.

Table 7-5 Specific mitigation measures and review and rating of their effectiveness

Issue	Threatened species / groups	Mitigation measure	History of success	Effectiveness rating
Loss of adjacent habitat via the removal of vegetation during construction, including loss of potential den / shelter sites.	Threatened plants TECs Ground-dwelling mammals Arboreal mammals Herpetofauna Emu Invertebrates Birds Bats	Identification of clearing limits and establishment of exclusion zones. Pre-clearing and clearing procedures Faunal handling procedures. Reuse of woody debris and bushrock to re-establish habitat as required. Development and implementation of a next box strategy to replace lost tree hollows	A standard procedure has been developed by Roads and Maritime for identifying clearing limited and exclusion zones and documented in the Biodiversity Guidelines for Construction (RTA 2011). The guidelines were developed in consultation with the NSW Office of Environment and Heritage (OEH), NSW Department of Primary Industries (DPI) (Fisheries), biodiversity specialists and Roads and Maritime staff including project managers, construction personnel and designers. Consultation was facilitated through a number of workshops carried out in 2009. These procedures have been developed using knowledge gained from a long history of upgrades on the Pacific highway and other road projects in NSW and are highly effective at ensuring accidental incursions into adjoining habitat does not occur. Guidance regarding the dimensions of nest boxes, installation and maintenance are provided in the Roads and Maritime Biodiversity Guidelines - Guide 8 Nest Boxes (Roads and Traffic Authority (RTA) 2011). Nest boxes have been used on multiple upgrades of the Pacific Highway and Hume highway over several years. There are numerous published research in the scientific literature on the proven effectiveness of nest boxes When combined with monitoring and maintenance program nest boxes have proven to be effective for Squirrel glider, Eastern Pygmy Possum, Brush-tailed Phascogale and a range of common species	High
Fragmentation of habitat and reduction in movement leading to a potential separation of populations and reduced population viability	Ground-dwelling mammals Arboreal mammals Herpetofauna Invertebrates Birds Coastal Emu	Construction of fauna connectivity structures including dedicated overpasses, underpasses and aerial crossings. Arboreal crossing structures and widened medians. Temporary and permanent fauna exclusion fencing Raised bridges and culverts for Emu.	In an international review of the effectiveness of road crossing structures van der Ree et al. (2007), cites numerous studies that demonstrate evidence of fauna using underpasses and overpasses at a species level. Multiple studies have attempted to measure the utilisation and success of fauna crossing structures. Road kill surveys were used by Hayes and Goldingay (2009) and Veage and Jones (2007) indicated that wildlife mortality was lower along highway sections with crossing structures and exclusion fencing, than those without. There are several published and unpublished studies that demonstrate the effectiveness of underpass and overpasses for the key threatened species impacted by this project. These studies are listed in the EIS and management plans and include Koala, Squirrel Glider, Long-nosed Potoroo, and Spotted-tailed	Moderate, monitor effectiveness and implement provisional or corrective measures

Issue	Threatened species / groups	Mitigation measure	History of success	Effectiveness rating
			Quoll. There is recent unpublished work on the Glenugie Upgrade that demonstrates frequent use by Rufous Bettong. There is currently no evidence for Yellow-bellied Gliders, Brush-tailed Phascogale or Emus.	
Vehicle collisions on the upgraded highway. Direct mortality of fauna on roads during operation.	Ground-dwelling mammals Arboreal mammals Herpetofauna Invertebrates Birds Coastal Emu	Develop and implement fauna exclusion fencing strategies. Maintenance of fauna fences, gates and crossing structures.	Roads and Maritime routinely conducts maintenance on exclusion fencing along the Pacific Highway both as a standard procedure and in response to a breach n the fence or spate of fauna road kills. There has been limited monitoring of fauna exclusion fencing. In a study of koalas, commissioned by Roads and Maritime AMBS (2011) found that Koala road deaths did occur where there was fencing and that monitoring was required to identify weaknesses in the fence or breaches and repair these. koalas may also be directed to other local roads and this should be considered in the monitoring and adaptive management program. The results of this study have now been included as Roads and Maritime best practice for design of structures for Koala populations. In a review of mitigation measures for roads Taylor and Goldingay (2010) reported that fauna crossing structures where significantly more effective where fauna exclusion fencing was used. There has been no monitoring of the effectiveness of fences for emus.	Moderate, monitor effectiveness and implement provisional or corrective measures
Mortality during demolition works including loss of potential den and roost sites.	Cave-roosting bats	Pre-clearing and clearing protocols Inspection of bridges and culverts prior to demolition	Pre-construction surveys for cave-roosting bats have been incorporated as a best practice procedure by Roads and Maritime on all upgrades where bridges or culverts would be disturbed or removed. Bats have been successfully relocated on the Millfield Bridge upgrade in the Hunter Valley. A breeding colony of the threatened microbat species *Myotis macropus*, has been successfully relocated on the Tintenbar to Ewingsdale project	High
Introduction of pathogens.	Threatened plants TECs Frogs	Development and implementation of a pathogen management plan.	A guide for pathogen management (guide 7) is included in *Biodiversity Guidelines Protecting and managing biodiversity on RTA projects* (RTA 2011). There has been limited monitoring in the road construction industry to inform the effectiveness of these mitigation measures.	Moderate, monitor effectiveness and implement provisional or corrective measures

Issue	Threatened species / groups	Mitigation measure	History of success	Effectiveness rating
Reduction in stream water quality. Altered water quality associated with polluted water from runoff and overflow of sediment basins in drainage areas	Fish Frogs	Water quality managed in accordance with procedures in the CEMP. Water quality managed in accordance with the Blue Book principles. Specifically, pH monitoring would be undertaken as part of the frog and fish population monitoring.	Roads and Maritime has successfully used water quality controls across a number of Pacific Highway projects. Procedures for water quality management on construction sites have been developed in accordance with the Blue Book principles and form part of the CEMP process. However as stated previously there has been limited monitoring of the impacts of road runoff on the Pacific Highway in terms of impacts on frog and fish habitat and populations. The threatened subject species are known to occur in locations adjacent to the existing highway suggesting some tolerance of road runoff impacts however this has not been tested.	Moderate, monitor effectiveness and implement provisional or corrective measures
Indirect edge effects on habitat remaining adjacent to the road (primarily the encroachment of weeds).	All threatened flora and fauna in adjacent habitats	Weed management plan developed and implemented to control weeds. Revegetation of areas disturbed during construction, particularly adjacent to habitat for threatened species	Roads and Maritime has developed standard weed management procedures that are implemented during construction and are reported as part of the FFMP process. This includes pre-clearing surveys to identify weeds and noxious species and map their location for ongoing monitoring and control during construction. Operational monitoring of weeds is conducted around *in situ* populations of threatened plants and control undertaken where required. Weed monitoring during construction is a routine procedure for road upgrades during initial post-construction periods only. Reporting for ongoing weed impacts and controls around important habitats adjacent to the road during construction and operation have varied greatly in their success. The results suggest they are reliant on persistent effort, with ongoing follow-up actions until such time as the population is proven to remain viable.	Moderate, monitor effectiveness and implement provisional or corrective measures
Domestic dogs brought on site by contractor could lead to dog attack	Emus Koala	CEMP to document dog policy.	A prohibition of dogs policy is implemented as a standard procedure part of the CEMP process and has been used on multiple upgrades on the Pacific Highway including the Bonville and Kempsey upgrade where koalas were an important issue. This policy has ensured that no domestic dogs are brought onto the site by construction contractors and is monitored throughout the construction period with consequences for contractors who bring dogs to the site. There have been no reported deaths as a result of domestic dogs.	High

Issue	Threatened species / groups	Mitigation measure	History of success	Effectiveness rating
Direct loss of habitat over small discrete areas through crossing freshwater aquatic habitats (drainage and creek habitats).	Frogs	Threatened frog fencing and compensatory pond strategy. Identification and clear marking of habitat exclusions zones via the use of temporary and permanent frog exclusion fencing. Installation and maintenance of fauna connectivity structures. Maintenance of constructed compensatory ponds	Roads and Maritime has developed and implemented frog fencing and compensatory ponds for a number of road projects including the Tugun Bypass and Kempsey Bypass projects with positive results showing their use by a number of frogs and success at keeping frogs off the road corridor. Roads and Maritime undertook a review of the use of fauna passage structures in 2009. This review found that a wide range of fauna were using underpass and overpass structures with the exception of amphibians. This is consistent with the results and conclusions of other research (Taylor and Goldingay 2003). Underpass structures have not been proven to date as effective measures for fragmentation of frog habitat.	Moderate, monitor effectiveness and implement provisional or corrective measures
Sediment runoff during construction into know and potential habitat	Frogs Fish	Sediment and erosion control managed in accordance with the Blue Book principles.	Roads and Maritime has successfully used erosion and sediment controls across all their Pacific Highway Upgrade projects with a high level of success as determined from regular monitoring during construction. Procedures for sediment and erosion management on construction sites have been developed in accordance with the Blue Book principles and form part of the CEMP. However as stated previously there has been limited monitoring of the impacts of road runoff on the Pacific Highway in terms of impacts on frog and fish habitat and populations. The threatened subject species are known to occur in locations adjacent to the existing highway suggesting some tolerance of road runoff impacts however this has not been tested.	Moderate, monitor success and implement corrective actions
Accidental damage to threatened invertebrates host plants during clearing.	Threatened invertebrates	Installation of temporary fencing to exclude construction activities from known threatened invertebrate habitat areas.	Temporary exclusion fencing has been used in association with all Pacific Highway upgrade over the last 10 years with a high degree of effectiveness to prevent accidental incursion in adjacent remnant vegetation. This measure is also expected to be effective for the protection of habitat for threatened invertebrates.	High
		Pre-clearing and clearing procedures.	A standard procedure has been developed by Roads and Maritime and documented in the Biodiversity Guidelines for Construction (RTA 2011). The guidelines were developed in consultation with the NSW Office of Environment and Heritage (OEH), NSW Department of Primary Industries (DPI) (Fisheries),	High

Issue	Threatened species / groups	Mitigation measure	History of success	Effectiveness rating
			biodiversity specialists and Roads and Maritime staff including project managers, construction personnel and designers. Consultation was facilitated through a number of workshops carried out in 2009. These procedures have been developed using knowledge gained from a long history of upgrades on the Pacific Highway and other road projects in NSW.	
		Translocation of Pink Underwing Moth if any are encountered on each day prior to any clearing in areas of potential habitat.	The New South Wales National Parks and Wildlife Service has a Policy for the Translocation of Threatened Fauna in New South Wales (NPWS 2001), which applies to all fauna, including invertebrates. Roads and Maritime has previously funded studies into the translocation of threatened invertebrates (e.g. Translocation of threatened species and rehabilitation of key habitat (Purple Copper Butterfly – *Paralucia spinifera*).	Unknown; monitor development of immature stages for three weeks following translocation.
Movement disruption and or disorientation of threatened invertebrates due to use of artificial lighting.	Threatened invertebrates	Minimise use of artificial lighting; use lamps with low attractiveness; use lighting shields to block bright lights at interchanges where lighting is required to address road safety requirements.	A rigorous and detailed study of the attractiveness of different artificial light sources to insects was completed by Eisenbeis and Hassel (2000). Information from this study has been used to inform the choice of lamps in design considerations for the project.	Unknown; monitor moth activity at light via a remote camera and implement corrective actions and provisional measures as required.
Propagation of Pink Underwing Moth host plant	Threatened invertebrates	Propagation trials for the host plant for Pink Underwing Moth (*Carronia multisepalea*)	There is no documented evidence that translocation of *Carronia multisepalea* has been undertaken previously.	Unknown; monitor as outlined in Chapter 7.
Emus are curious of new activities and may enter the construction area.	Coastal Emu	Exclusion fencing to exclude emus from the construction corridor.	Temporary and permanent exclusion fencing used on all Pacific Highway upgrade over the last 10 years.	Moderate, monitor success and implement corrective actions.
	Coastal Emu	Develop and implement an Emu finds procedure.	Procedure has been developed by Roads and Maritime for unexpected finds such as threatened species, and has been adopted as part of the CEMP for multiple projects.	Unknown, monitor success and implement corrective actions.

Issue	Threatened species / groups	Mitigation measure	History of success	Effectiveness rating
Potentially lengthy disruption to Emu movements during construction.	Coastal Emu	Provide access for emus crossing corridor during construction and stage construction through priorities at bridge sites.	Bridges have been prioritised on other projects and this is a feasible approach. Traffic control used on all upgrades by Roads and Maritime to account for local traffic and screening of construction areas. This same method could be adapted for emus.	Unknown, monitor success and implement corrective actions.
Emu-vehicle collisions on the highway.	Coastal Emu	Permanent exclusion fencing and escape gates or escape points.	Permanent fauna exclusion fencing has been used on multiple sections of the Pacific Highway to exclude fauna and direct to crossing points. Not been used before for emus.	Unknown, monitor success and implement corrective actions.
Highway creates a barrier to Emu movements and access to known habitats, or isolates proportion of the population.	Coastal Emu	Targeted crossing structures including large arches and raised bridges.	Targeted crossing structures for other fauna have been used on multiple projects in Australia and overseas with high level of success. Raised bridges have been used successfully by cassowaries in north Queensland, however never before targeted at emus.	Unknown, monitor success and implement corrective actions and provisional measures.
Impacts to threatened fish habitat adjacent to the project.	Threatened fish	Strict controls of temporary watercourse crossings. Development of construction methodologies to reduce disturbance to instream habitats. Management of instream woody debris. Implementation of water quality control measures. Management of sedimentation	DPI Fisheries has been consulted on a number of occasions with regard to implementing mitigation measures to facilitate fish passage on Roads and Maritime Highway projects. This involvement has extended over the last 14 years of the Pacific Highway upgrading program. Specific procedures have been drafted for the Oxleyan Pygmy Perch in consultation with NSW Fisheries for the Devils Pulpit Upgrade. Experiences and findings from Devils Pulpit have been used to inform this plan for the Woolgoolga to Ballina project. Initial monitoring for Devils Pulpit has shown no change in water quality during construction.	High

Issue	Threatened species / groups	Mitigation measure	History of success	Effectiveness rating
		and erosion. Management of aquatic weeds and pests. Bed and bank reinstatement, habitat restoration		
Artificial structures creating a barrier to fish passage	Threatened fish	Design to prevent and/or minimise in-stream barriers, including appropriate design of bridges and culverts to ensure no physical, hydraulic and behavioural barriers to aquatic fauna movements. Minimise culvert length where possible. Fisheries data has shown that fish passage is affected when culvert length reaches 60-70m, Bridges on class 1 waterways with no piers in the channel Natural substrate in the floor of culvert for potential habitat Inspection, maintenance and cleaning of culvert structures to prevent blockages and restricted fauna movements.	Watercourse crossing (bridges and culverts) for the Devils Pulpit upgrade have been designed and constructed to be consistent with the Guidelines for Controlled Activities Watercourse Crossings (DWE 2008) and Why do Fish need to Cross the Road? Fish Passage requirements for waterway Crossings (NSW Fisheries 2003.This standard of bridge design meets with Roads and Maritime management goals of maintaining natural streamflow and velocity, and connectivity for threatened fish. Monitoring of fish passage would be undertaken during the operation of the Devils Pulpit upgrade and any findings would be used to inform fish passage for the Woolgoolga to Ballina upgrade. The lessons learnt from the Devils Pulpit Upgrade have been consulted and developed for the remainder of the Woolgoolga to Ballina upgrade.	Moderate, monitor success and implement corrective actions
Fish trapped in pools adjacent to construction zone	Threatened fish	Development and implementation of a translocation strategy. Translocation of fish outside the construction zone	Roads and Maritime has successfully translocate fish as part of the Banora Point Upgrade however this has not included translocation of Oxleyan Pygmy Perch or Purple Spotted Gudgeon. Oxleyan Pygmy Perch and Purple Spotted Gudgeon have been successfully maintained in aquaria (McDowall, 1996) and therefore it would be feasible that these species could be cleared from the immediate impact area and held in aquaria for the duration of the proposed construction activities.	Unknown, monitor success and implement corrective actions

Issue	Threatened species / groups	Mitigation measure	History of success	Effectiveness rating
Impacts to threatened flora outside the construction (exclusion) zone.	Threatened plants *in-situ*	Determine extent of threatened flora populations *in situ* to be directly impacted. Identify and maintain exclusion zones and limits of clearing. Weed management near threatened populations Erosion and sediment control Pre-clearing and clearing procedures.	Standard procedures have been developed by Roads and Maritime and documented in the Biodiversity Guidelines (RTA2011). The guidelines were developed in consultation with OEH, NSW Department of Primary Industries (Fisheries), biodiversity specialists and Roads and Maritime staff including project managers, construction personnel and designers. Consultation was facilitated through a number of workshops carried out in 2009. These procedures have been developed using knowledge gained from a long history of upgrades on the Pacific Highway and other road projects in NSW. Protection of threatened plant populations *in situ* has been used successfully on multiple upgrades of the Pacific Highway and other major highways in NSW. Recent examples include Glenugie, Tintenbar to Ewingsdale and Sapphire to Woolgoolga, however the associated mitigation measures go back over at least 15 years on other upgrades. Construction and operational monitoring has been reported for numerous threatened flora species and reported on survival, resilience and recruitment of species such as Quassia species Moonee Creek. Where mortalities are reported these are included in an adaptive management framework.	High

Issue	Threatened species / groups	Mitigation measure	History of success	Effectiveness rating
Direct loss of threatened plants during construction.	Threatened plants	Seed collection from threatened plant species as appropriate, for establishment of *ex-situ* populations on offset sites. Establishment of *ex-situ* populations from seed and cutting material collected from impact areas (or other sites) to offset sites. Revegetation of appropriate sites with germinated/struck seedlings. Translocation strategy developed to identify suitable plants and locations, translocation of plants out of areas of direct impact. Establishment of translocation population in appropriate areas away from construction. Maintenance of translocated threatened flora population/s.	The procedures used depend on the species and Roads and Maritime typically follows industry best practice as reported in *RTA Seed Collection QA Specification R176* and the *Florabank Guidelines and Model Code of Practice* (www.florabank.org.au) and the Nursery Industry Accreditation Scheme Australia (NIASA) Best Management Practice Guidelines - 4th Edition, updated 2010. Propagation and replanting of threatened plant species and translocation of threatened plants may be done in conjunction with offset requirements and has not been done often by Roads and Maritime as a general construction procedure. However Roads and Maritime has successfully translocated the following threatened flora species included in this plan on the following projects:. Linsaea incisa: Sapphire to Woolgoolga project. Melaleuca irbyana: Glenugie upgrade. Roads and Maritime has also successfully translocated a number of other threatened plants not included in this plan, as such they have not been detailed in this table. Translocation is not seen as a mitigation measure and would be trialled for other species if required as a condition of approval with ongoing monitoring to be conducted to measure the success.	Moderate, monitor against performance and implement contingencies where required.
Populations of threatened flora impacted by changes to the water quality within and immediately adjacent to the project.	Threatened plants and EECs	Water quality managed in accordance with procedures in the CEMP.	Roads and Maritime has successfully used water quality controls across a number of Pacific Highway projects. Procedures for water quality management on construction sites have been developed in accordance with the Blue Book principles and form part of the CEMP process.	High

8. Biodiversity offsets

8.1. Background

In the Woolgoolga to Ballina EIS (Roads and Maritime, 2013), it was identified that biodiversity offsets would be required for the project for NSW and Commonwealth listed threatened species due to residual impacts. A biodiversity offset strategy was prepared as part of the Working paper – Biodiversity.

This chapter provides further details on the biodiversity offsets, including the framework to guide the development and implementation of the biodiversity offset package for the project. Offsets for those significantly impacted Commonwealth listed species have been identified and quantified against the EPBC Act offset calculator.

Further information on offsets and investigations into potential offset properties is provided in Appendix H of this report.

8.2. Decision framework

In accordance with the Roads and Maritime Pacific Highway upgrade offset principles, the following steps will be followed in obtaining biodiversity offsets.

Step 1 - Identification of project impacts
Impacts as a result of the project have been included in the Woolgoolga to Ballina EIS (Roads and Maritime, 2012) and the Submissions / Preferred Infrastructure Report (Roads and Maritime, 2013), including a determination of the level of impact to threatened species and vegetation communities.

Step 2 - Investigation into direct biodiversity offsets
In targeting potential offset lands, Roads and Maritime aims to meet the following criteria for the project:

- Properties located within 30km radius of the project extending to 100km with the agreement of the Department of Planning and Infrastructure, OEH and DotE, where it can be demonstrated that a suitable offset could not be found.
- Offset land would contain vegetation communities as detailed in Section 5.1.3.
- Land would be assessed as to its suitability as habitat for the threatened species impacted by the project (including patch sizes) based on OEH and DotE threatened species profiles database.
- Offset land would comprise land that enables connectivity between adjacent areas of vegetation, where possible.
- Offset land must be suitable for ongoing management for conservation through an appropriate legal instrument.

Potential offset properties have been identified (refer to Appendix H). Field investigations are ongoing to determine the suitability of these parcels of land. The status of these preliminary investigations is detailed in Appendix H.

Step 3 - Identification of other biodiversity offset measures
At this stage of the project, no other compensatory measures have been proposed as part of the biodiversity offset package. Should this change in future, Roads and Maritime will review any potential other offset measures against the requirements detailed in Appendix A of the EPBC Offsets Policy (2012) to determine their suitability in consultation with the Department.

Step 4 - Assessment using EPBC Act offsets calculator
Section 8.3 of this report provides a preliminary EPBC Act offset calculation based on the impacts to the MNES. To provide suitable offsets, Roads and Maritime will use potential offset properties from three different scenarios:

- Properties Roads and Maritime currently owns or has commenced acquisition discussions with the landowners.
- Private properties where landowners and Roads and Maritime have previously discussed the suitability of their properties for offsets.
- Review of the NSW BioBanking Register to identify any potential registered sites.

Once potentially suitable sites have been located, they will be assessed using the EPBC offset calculator to determine how they meet the offset requirements for the project. Refer to Section 7 and Appendix B for further details on these investigations into potential offset properties.

Step 5 - Seek approval of offsets
Following receipt of project approval, Roads and Maritime will be seeking formal approval for the Biodiversity Offset Strategy and Package for the project. Following receipt of approval Roads and Maritime can progress any property/ negotiations and acquisitions required to meet the offset package requirements.

Step 6 - Implementation
Once approved the relevant biodiversity offset actions would be implemented in accordance with the approval conditions and any plans of management developed for the proposed offset properties.

8.3. Assessment using the EPBC Act Environmental Offsets Policy

8.3.1. Background

The EPBC Act Environmental Offsets Policy (the policy) (DSEWPaC, 2012) was published in November 2012 and provides a methodology for the calculation of offset requirements for Matters of National Environmental Significance (MNES). The policy relates to all MNES including heritage items, with offsets required only if there is a significant residual impact. Offset requirements are one of the considerations that are weighed at the decision stage of an approval in determining the overall acceptability of the proposed action, and are included as a Condition of Approval for projects under Section 134 of the EPBC Act.

The offsets policy is accompanied by an offsets assessment guide. This guide explains a 'balance sheet' approach to estimating impacts and offsets for EPBC Act listed threatened species and ecological communities.

Suitable offsets under the policy must be specific to the particular area, habitat type (ie foraging or roosting habitat) and habitat condition or number of individuals of impacted MNES. The offsets must result in an overall conservation outcome that improves or maintains the viability of a protected matter (a MNES). The offset package is to contain a minimum of 90 per cent direct offsets of the total offset requirement for each

MNES, and a maximum of 10 per cent comprising other compensatory measures such as contributions towards research or particular threat abatement works.

Other key considerations in the policy include:

- The offset must account for the status of the protected matter that is being impacted (ie MNES that are critically endangered require a greater degree of offsetting than MNES that are listed as vulnerable).
- Suitable offsets must be additional to what is already required, determined by law or planning regulations, or agreed to under other schemes or programs.
- The offset must have transparent governance arrangements including the ability to be readily measured, monitored, audited and enforced.
- The offset must be informed by scientifically robust information and incorporate the precautionary principle in the absence of scientific certainty.
- Where relevant, the quality of the offset site must be at least equal to that of the impact site.

Offset requirements under the EPBC Act were not assessed in the EIS. This section aims to address the policy only where the project is likely to have a residual significant impact on a MNES (as identified in section 8.3.2). Impacts on MNES from the project have been assessed using the offset calculator and the criteria in the policy to ensure any potential offset satisfies the requirements of the policy.

8.3.2. Matters of National Environmental Significance (MNES)

The project would potentially significantly impact 17 MNES. These are listed in Table 8-1 along with the legal status as listed under the EPBC Act. An EPBC Act offset assessment is provided for each of these MNES in the following sections.

Table 8-1 MNES potentially significantly impacted by the project

Protected matter	Common name	EPBC Act status
Threatened ecological communities		
Lowland Rainforest of Subtropical Australia		Critically Endangered
Threatened flora species		
Acronychia littoralis	Scented Acronychia	Endangered
Angophora robur	Sandstone Rough Barked Apple	Vulnerable
Arthraxon hispidus	Hairy Joint-grass	Vulnerable
Cryptocarya foetida	Stinking Cryptocarya	Vulnerable
Endiandra hayesii	Rusty Rose Walnut	Vulnerable
Eucalyptus tetrapleura	Square fruited Ironbark	Vulnerable
Quassia sp. 'Moonee Creek'	Moonie Quassia	Endangered
Prostanthera cineolifera	Singleton Mint Bush	Vulnerable
Syzygium hodgkinsoniae	Red Lily Pilly	Vulnerable
Threatened fauna species		
Mixophyes iteratus	Giant Barred Frog	Endangered
Phascolarctos cinereus	Koala	Vulnerable

Protected matter	Common name	EPBC Act status
Nannoperca oxleyana	Oxleyan Pygmy Perch	Endangered
Phyllodes imperialis	Pink Underwing Moth	Endangered
Xanthomyza phrygia	Regent Honeyeater	Endangered
Dasyurus maculatus maculatus	Spotted-tail Quoll	Endangered
Lathamus discolor	Swift Parrot	Endangered

For the purposes of this assessment, protected maters listed in Table 8-1 are grouped in the following review as either rainforest habitats, sclerophyll forest habitats or threatened fauna species.

All impacts noted include impacts that would result from the project described in the EIS, any design refinements (as described in Chapter 3 of this report), any impacts resulting from the use of ancillary facility sites (as described in Chapter 2 of this report), or as a result of supplementary surveys (as described in Chapter 5 of this report).

As result of design refinements and further survey data some MNES reported as being significantly impacted in the EIS (such as *Macadamia tetraphylla*), would no longer be significantly impacted by the proposal.

8.3.3. EPBC Act offsets calculator

The offsets calculator provided with the offsets policy allows for calculation of the level of habitat quality and area or number of individuals required to be offset based on the level of impact from the project. The calculator requires a habitat quality 'score' as a measure of how well a particular site supports a particular threatened species or ecological community and contributes to its ongoing viability. Three components contribute to the calculation of this score:

- Site condition.
- Site context.
- Species stocking rate.

The offsets calculator guide only briefly explains the scoring system data based on indicators from these three components and there is no specific field methodology provided in the guide for calculating habitat condition scores. Habitat condition was determined by assessing existing data and collected field data regarding habitat qualities across the entire area of habitat for the species/ecological community that would be impacted by the project. This is discussed further in this chapter for each protected matter. Considering the wide variation in habitat condition observed across the entire study area, an average habitat condition score was estimated in some cases based on existing data. (It should be noted that habitat condition scores are not required when calculating offsets based on the number of individuals being impacted.)

The impacts on each MNES are based on the direct and likely indirect impacts from the project. Some species are more vulnerable to potential indirect impacts than other species; potential impacts relate to life history attributes, the proximity of the remaining individuals/areas to the project boundary, topographic factors, and local habitat conditions.

Inputs into the calculator for the impact area include:

- The 'start area'. This is the area of habitat that would be impacted for each species or, if feasible, the number of individuals. If these data are not available, then the area of habitat attribute may be more appropriate.
- The 'start quality'. This is a measure of the quality of each area of habitat for a species on a scale of 1 to 10.

Given the very long duration of the project and difficulty in identifying discrete habitat patches or polygons for threatened species, there are difficulties in determining the start area and start quality for some species. This is particularly an issue for widespread species with generalist habitat requirements (such as Spotted-tailed Quoll, Swift Parrot and Regent Honeyeater). It is difficult to determine quantitatively the density of a species known to use a site (ie the stocking rate), as per the guideline, and this data has been estimated based on the habitat condition and using a precautionary approach.

For example, Hairy Joint Grass (*Arthraxon hispidus*) currently occupies cleared and modified habitat, but some areas of seemingly suitable habitat are not occupied by the species. This means that it is not possible to model the predicted presence of some species across the whole project accurately. Therefore, the known extent of this species is used as the basis for the assessment of impacts (refer section 8.3.5).

Inputs into the calculator for the offset area include:

- Temporal scales including time over which loss is averted (maximum 20 years) and time until ecological benefit.
- Risk scales including risk of loss without and with the establishment of the offset.
- Future habitat quality with and without the establishment of an offset.
- Confidence in the result is the level of certainty about the success of the proposed offset.

Once all the above data attributes are entered into the offsets calculator, a percentage of the impact offset is provided.

The following assessments for each MNES provide further explanation of the above factors and working examples of this assessment methodology.

8.3.4. Rainforest habitats

This section details potential offset requirements for rainforest habitat communities and rainforest plant species that would be significantly impacted by the project. This includes Lowland Rainforest of Subtropical Australia and the following threatened rainforest flora species: *Acronychia littoralis, Cryptocarya foetida, Endiandra hayesii* and *Syzygium hodgkinsoniae.*

Lowland Rainforest of Subtropical Australia

The project would result in:

- Direct impacts on two hectares of the critically endangered community Lowland Rainforest of Subtropical Australia ('Lowland Rainforest').
- Potential indirect impacts on the remaining areas of three patches, comprising a total of around three hectares. These areas are conservatively estimated to comprise all of patch 1 (1.4 hectares), the

remaining areas of patch 2 downslope on the eastern side of the project (1.5 hectares) and a small area of patch 3 (0.1 hectares). As mitigation measures would be implemented to minimise potential indirect impacts, and because of the conservative nature of the above estimate, only half of this potential indirect impact has been assigned to the calculator (that is, 1.5 hectares).

This would result in a total direct and indirect impact to Lowland Rainforest community of 3.5 hectares.

According to the values assigned to the calculator (refer to Table 8-2), an offset supporting 40 hectares of Lowland Rainforest with similar habitat quality would be sufficient to offset the 3.5 hectares impacted. Due to the critically endangered status of this ecological community a larger degree of offset is required compared with endangered and vulnerable listed protected matters.

The values and a rationale for the offset measures are provided in Table 8-2.

Table 8-2 Lowland Rainforest – impacts and rationale for offset measures

Attribute	Value	Rationale
IMPACT AREA		
Area (ha)	3.5	The area of direct (2 hectares) and indirect impact (1.5 hectares) to rainforest habitats which conform to the condition criteria for the critically endangered community.
Start quality (scale of 0-10)	8	This is based on the proportion of exotic and native canopy cover and species diversity with up to 20% Camphor Laurel recorded in one patch. All three patches had a relatively high diversity of species (listed in Appendix A of the EPBC Act listing advice) comprising 32 to 38 species and 80% or greater native canopy cover.
OFFSET AREA		
Risk-related time horizon (max. 20 years)	20	This describes the timeframe over which changes to the in the level of risk to a proposed offset site can be considered and quantified. This value is capped at 20 years or the life of an offset whichever is shorter. Considering the offset is proposed to be established in perpetuity, the maximum risk-related time horizon was assigned.
Time until ecological benefit (years)	10	Although an offset site would support high quality rainforest habitats, restoration measures would likely be required to manage/eliminate existing threatening processes and improve habitat quality attributes. Management activities to minimise existing threats are likely to be achieved within 10 years.
Area (ha)	40	An offset of 40 hectares of lowland rainforest with similar habitat qualities would be sufficient to offset the impacts from the project.
Start quality (scale of 0-10)	8	Habitat quality of a potential offset site has been assumed to be the same as the impact area.
Risk of loss (%) without offset	30	Considering the existing threats to areas of lowland rainforest on private property are likely to include weed invasion, livestock, feral fauna species, ongoing clearing and underscrubbing for development and/or other activities such as agriculture/hobby farming, a risk of loss without the offset has been identified as 30%.
Future quality without offset (scale of 0-10)	7	Considering the likely existing threats to areas of lowland rainforest on private property, the future quality has been reduced by a single point from the start quality.
Risk of loss (%) with offset	10	Considering the existing high level of threat to lowland rainforest a residual risk of 10% has been assigned.
Future quality with offset (scale of 0-10)	8	It is envisaged with the implementation of management and restoration measures the future quality of the of the offset would be maintained at existing levels

Attribute	Value	Rationale
Confidence in result (%)	90	There is a high confidence of a potential offset providing an improved outcome for lowland rainforest provided adequate restoration, monitoring and management actions are implemented.
% of impact offset	102	This scenario would provide for 102% of the required offset, depending upon the attributes of any proposed offset, the values can be modified within reason to achieve a minimum of 90% of the offset.
Other measures (up to 10%)	10	There is potential to provide up to 10% of the offset as other measures. This may include contributions towards research of lowland rainforest.

Acronychia littoralis

A small area within a drainage line on the edge of the existing highway and north of Coolgardie Road is dominated by a stand of *Acronychia sp*. that appeared entirely clonal (estimated 125 stems, but only one individual). It is unclear if this clonal stand of *Acronychia sp.* is a form of *A. littoralis* descended from an *A. oblongifolia* hybrid or a sterile form of *A. oblongifolia*. As a precaution, this plant is considered as being *A. littoralis* and the total impact is considered to comprise a single individual. The number of individuals would be used to determine offsets for this species. As there is only a single individual of this species known from the study area, and this individual would be directly impacted by the project, the consideration of potential indirect impacts on remaining individuals is not applicable and has not been included in the calculations.

According to the values assigned to the calculator, an offset supporting two individuals would provide a suitable offset for the species. This may comprise translocation of the impacted individual (or part of) into an offset site or plantings of propagated seeds or cuttings. The values and a rationale for the offset measures are provided Table 8-3.

Table 8-3 *Acronychia littoralis* – impacts and rationale for offset measures

Attribute	Value	Rationale
IMPACT		
Number of individuals impacted	1	A single clonal individual suspected to be *Acronychia littoralis* would be impacted by the project.
OFFSET		
Time horizon (years)	20	Considering the offset is proposed to be established in perpetuity, the maximum risk-related time horizon was assigned.
Start value (number of individuals)	0-1	A start value of 0 to 1 individuals has been assigned (these both yield the same result in the calculator) based on the potential for translocation and/or an offset supporting an existing individual.
Future value without offset (number of individuals)	0	Considering the existing threats to areas of habitat for this species and the potential for translocation to an offset site supporting 0 individuals a future site value of 0 is assigned.
Future value with offset (number of individuals)	2	A future site value of 2 individuals has been assigned based on the potential for translocation and/or an offset supporting existing individuals.
Confidence in result (%)	60	Considering the potential for the offset for this species could comprise translocated/propagated plants there is some risk that translocation and plantings may fail therefore a confidence of 60% has been assigned.
% of impact offset	95	This scenario would provide for 95% of the required offset, there is potential for this to be increased with increased number of individuals existing on an offset site or established on an offset through translocation

Attribute	Value	Rationale
		or plantings of propagated seed/cuttings.
Other measures (up to 10%)	10	There is potential to provide up to 10% of the offset as other measures. This may include contributions towards research of the species. Further taxonomic assessment of *Acronychia littoralis* is likely to contribute to the knowledge about life cycle attributes and understanding of the species.

Cryptocarya foetida

A total of 88 individuals have been recorded in the study area, of which 13 individuals would potentially be directly impacted by the project; this would be around 15 per cent of the known population in the study area. According to the calculator, an offset supporting 70 individuals with restoration measures to increase the population by at least 10 individuals would provide a suitable offset for the species. The values and a rationale for the offset measures are provided in Table 8-4.

Table 8-4 *Cryptocarya foetida* – impacts and rationale for offset measures

Attribute	Value	Rationale
IMPACT		
Number of individuals impacted	13	A total of 13 individuals would be directly impacted from the proposal. Indirect impacts to the remaining individuals in adjacent areas upslope of the project is considered unlikely.
OFFSET		
Time horizon (years)	20	Considering the offset is proposed to be established in perpetuity, the maximum risk-related time horizon was assigned.
Start value (number of individuals)	70	A start value of 70 individuals has been assigned based on the presence of at least this many plants on surrounding properties
Future value without offset (number of individuals)	65	The existing threats to areas of habitat on private property are likely to include weed invasion, livestock, ongoing clearing and underscrubbing for development and/or other activities such as agriculture/hobby farming. Therefore the future value without the offset includes a reduction of 5 individuals in recognition of these ongoing threats.
Future value with offset (number of individuals)	80	A future site value of 80 individual has been assigned based on the potential for translocation and/or plantings, and ongoing management improving habitat conditions to facilitate natural recruitment of individuals increasing the start value by 10 individuals.
Confidence in result (%)	90	There is a high confidence of a potential offset to provide an improved outcome for the species considering the number of individuals that would potentially be protected (70 individuals) providing an improved outcome for the species. This is based on adequate restoration, monitoring and management actions being implemented.
% of impact offset	100	This scenario would provide for 100% of the required offset.
Other measures (up to 10%)	10	There is potential to provide up to 10% of the offset as other measures. This may include restoration or protection of areas of habitat for the species (ie fencing a council reserve) and/or contributions towards research of the species.

Endiandra hayesii

A total of 30 individuals have been recorded in the study area, of which three individuals would potentially be directly impacted by the project, comprising around 10 per cent of the known population in the study area. There is potential for an additional two individuals of the species close to the project footprint to be indirectly impacted and therefore the total impact assigned for this species in the calculations is five individuals. According to the calculator, an offset supporting 10 individuals with restoration measures to increase the population size by at least five individuals would provide a suitable offset for the species. The values and a rationale for the offset measures are provided in Table 8-5.

Table 8-5 *Endiandra hayesii* – impacts and rationale for offset measures

Attribute	Value	Rationale
IMPACT		
Number of individuals impacted	5	A total of 5 individuals would be impacted, 3 directly and potentially 2 indirectly from the project. Any further indirect impacts to remaining individuals in adjacent areas upslope of the project is considered unlikely.
OFFSET		
Time horizon (years)	20	Considering the offset is proposed to be established in perpetuity, the maximum risk-related time horizon was assigned.
Start value (number of individuals)	10	A start value of 10 individuals has been assigned based on the presence of at least this many plants on surrounding properties.
Future value without offset (number of individuals)	9	The existing threats to areas of habitat on private property are likely to include weed invasion, livestock, ongoing clearing and underscrubbing for development and/or other activities such as agriculture/hobby farming. Therefore the future value without the offset includes a reduction of 1 individual (10%) in recognition of these ongoing threats.
Future value with offset (number of individuals)	16	A future site value of 16 individuals has been assigned based on the potential for translocation and/or plantings, and ongoing management improving habitat conditions to facilitate natural recruitment of individuals increasing the start value by 6 individuals.
Confidence in result (%)	75%	There is a high confidence of a potential offset to provide an improved outcome for the species considering the existing number of individuals that would potentially be protected providing an improved outcome for the species. There are some potential risks with translocation of this species (limited to three individuals) failing, however there is a better chance of propagated individuals surviving and therefore the confidence has been reduced to 75%. This is based on adequate restoration, monitoring and management actions being implemented.
% of impact offset	101	This scenario would provide for 101% of the required offset.
Other measures (up to 10%)	10	There is potential to provide up to 10% of the offset as other measures. This may include restoration of areas of habitat for the species elsewhere and/or contributions towards research of the species.

Syzygium hodgkinsoniae

The project would avoid all known locations of this species. However, one individual occurs less than one metre from the project footprint and is likely to be indirectly impacted. An additional eight individuals occur around 4.5 kilometres to the north of this individual on the edge of the project footprint and are likely to be part of a separate sub-population of this species. Indirect impacts on the single individual could result from edge effects and altered hydrology regimes. According to the calculator, an offset supporting two individuals would provide a suitable offset for the species. This may comprise translocation of the impacted individual (or part of) into an offset site or plantings of propagated seeds or cuttings. The values and a rationale for the offset measures are provided in Table 8-6.

Table 8-6 *Syzygium hodgkinsoniae* – impacts and rationale for offset measures

Attribute	Value	Rationale
IMPACT		
Number of individuals impacted	1	A single individual of this species is within one metre of the project footprint and would potentially be indirectly impacted. This individual constitutes the known population in the study area.
OFFSET		
Time horizon (years)	20	Considering the offset is proposed to be established in perpetuity, the maximum risk-related time horizon was assigned.
Start value (number of individuals)	0-1	A start value of 0 to 1 individuals has been assigned (these both yield the same result in the calculator) based on the potential for translocation and/or an offset supporting an existing individual.
Future value without offset (number of individuals)	0	Considering the existing threats to areas of habitat for this species and the potential for translocation to an offset site supporting 0 individuals a future site value of 0 is assigned.
Future value with offset (number of individuals)	2	A future site value of 2 individuals has been assigned based on the potential for translocation and/or an offset supporting existing individuals.
Confidence in result (%)	50	Considering the potential for the offset for this species could comprise translocated/propagated plants there is some risk that translocation and plantings may fail therefore a confidence of 50% has been assigned.
% of impact offset	96	This scenario would provide for 96% of the required offset.
Other measures (up to 10%)	10	There is potential to provide up to 10% of the offset as other measures. This may include restoration of areas of habitat elsewhere (ie council reserves) and/or contributions towards research of the species.

8.3.5. Sclerophyll forest habitats

This section details potential offset requirements for *Angophora robur* and *Quassia sp.* Moonee Creek which generally occur in dry sclerophyll forest habitats including drainage lines within dry forest areas.

Angophora robur

Table 8-8 presents the impacts of the project on *Angophora robur* as well as habitat quality attributes and a calculation of required offset values. The number of individuals that would be impacted has been quantified along with the area of habitat. However, for this assessment, the area is considered more appropriate to provide an estimate of the offset requirements, rather than population number.

Indirect impacts on the remaining individuals of *Angophora robur* adjacent to the project footprint are not anticipated to be substantial and mitigation measures would be implemented to manage weeds, water quality and diseases that may potentially result in indirect impacts on individuals and habitats. The project footprint would be downstream of the majority of the retained individuals and therefore minimising potential impacts from altered hydrological and soil conditions, weed invasion and limiting the potential for habitat changes. Considering *Angophora robur* has been observed growing in edge-affected habitats throughout the study area and grows in low nutrient soils with a lower susceptibility to weeds (including roadsides), impacts from edge effects are not anticipated to be substantial.

Considering the lower susceptibility of the species to indirect impacts and the relatively large area of habitat included in the impact and offset calculations, no additional impact has been assigned for indirect impacts. According to the calculator, an offset ratio of around 5:1 would be required for any indirect impacts.

According to the calculator, an offset supporting 400 hectares of occupied *Angophora robur* habitat with similar habitat quality would be sufficient to offset the 84.1 hectares directly impacted. The values and a rationale for the offset measures are provided in Table 8-7.

Table 8-7 *Angophora robur* – impacts and a rationale for offset measures

Attribute	Value	Rationale
IMPACT AREA		
Area (ha)	84.1	The area of habitat occupied by *Angophora robur* directly impacted by the project.
Start quality (scale of 0-10)	9	This is based on the high quality of the majority of habitat in which *Angophora robur* occurs in the project footprint
OFFSET AREA		
Time over which loss is averted (max. 20 years)	20	Considering the offset is proposed to be established in perpetuity, the maximum risk-related time horizon was assigned.
Time until ecological benefit (years)	5	Considering the relatively high condition and moderate/minimal threats to the majority of habitat in the locality occupied by *Angophora robur*, there is envisaged to be minimal management requirements on a potential offset site supporting a relatively large area of occupied habitat. Therefore five years has been assigned for the establishment and initial management of an offset site, and similarly the time until ecological benefit has been assigned the same value.
Area (ha)	400	An offset of 400 hectares of habitat occupied by *Angophora robur* with similar habitat qualities would be sufficient to offset the impacts from the project. Based on stocking rates quantified in the project footprint (84 individuals per hectare) a 400 hectare offset site would support around

Attribute	Value	Rationale
		33,600 individuals.
Start quality (scale of 0-10)	9	Habitat quality of a potential offset site has been assumed to be the same as the impact area.
Risk of loss (%) without offset	20	The existing threats to areas of occupied habitat on private property are likely to include weed invasion, livestock, feral fauna species, ongoing clearing and underscrubbing for development and/or other activities such as agriculture/quarries and altered fire regimes. As such, a risk of loss without the offset has been identified as 20%.
Future quality without offset (scale of 0-10)	8	Considering the likely existing threats to areas of occupied habitat on private property, the future quality has been reduced by a single point from the start quality.
Risk of loss (%) with offset	5	An offset site would substantially reduce the risk of loss eliminating the majority of threats to the species, however some residual risk is considered to be present and a value of 5% has been assigned.
Future quality with offset (scale of 0-10)	9	It is envisaged with the implementation of management and restoration measures the future quality of the of the offset would be maintained at existing levels
Confidence in result (%)	90	There is a high confidence of a potential offset providing an improved outcome for *Angophora robur* provided adequate restoration, monitoring and management actions are implemented.
% of impact offset	99	This scenario would provide for 99% of the required offset, depending upon the attributes of any proposed offset, the values can be modified within reason to achieve a minimum of 90% of the offset.
Other measures (up to 10%)	10	There is potential to provide up to 10% of the offset as other measures. This may include restoration of areas of habitat and/or contributions towards research of *Angophora robur*.

Quassia sp. Moonee Creek

Detailed surveys of this species recorded a total of 899 stems of which 35 would be directly impacted in the project footprint (four per cent of the local population). The remaining individuals are within 50 metres of the road edge, with up to 167 stems within 10 metres of the construction edge. There is potential for further indirect impacts on these plants within 10 metres of the project footprint, and therefore these have been included in the calculations, resulting in a total impact on 202 stems (22 per cent of the local population).

Indirect impacts could result from altered exposure and light levels and increased potential for competition from weeds and other flora due to the altered conditions. The counting of stems was considered more appropriate as the extent of each individual was unknown (as this plant is known for suckering, shoots would grow from lateral roots or buried stems and may emerge some distance from the originating plant). Therefore the offset assessment has been based on the number of stems.

According to the calculator, an offset supporting up to 670 stems with similar habitat quality would be sufficient to offset the 202 stems potentially impacted. The values and a rationale for the offset measures are provided in Table 8-8.

Table 8-8 *Quassia sp.* Moonee Creek – impacts and rationale for offset measures

Attribute	Value	Rationale
IMPACT		
Number of individuals impacted	202	A total of 202 stems would be directly (35 stems) and potentially indirectly impacted (167 stems) from the proposal.
OFFSET		
Time horizon (years)	20	Considering the offset is proposed to be established in perpetuity, the maximum risk-related time horizon was assigned.
Start value (number of individuals)	670	A start value of 670 stems has been assigned based on the presence of at least this many plants on surrounding properties.
Future value without offset (number of individuals)	603	The existing threats to areas of habitat on private property are likely to include ongoing clearing and underscrubbing for development and/or other activities such as agriculture/quarries. The future value of the offset includes a reduction of 67 stems (10%) in recognition of these ongoing threats.
Future value with offset (number of individuals)	834	A future site value of 834 individuals has been assigned based on the potential for translocation and/or plantings, and ongoing management improving habitat conditions to facilitate natural recruitment of individuals increasing the start value by 164 stems.
Confidence in result (%)	90	There is a high confidence of a potential offset considering the existing number of individuals that would potentially be protected providing an improved outcome for the species. This is based on adequate restoration, monitoring and management actions being implemented.
% of impact offset	100	This scenario would provide for 100% of the required offset.
Other measures (up to 10%)	10	There is potential to provide up to 10% of the offset as other measures. This may include restoration of areas of habitat and/or contributions towards research of the species.

Prostanthera cineolifera

This species was recorded along Tabbimoble Creek inhabiting a narrow belt of deep sandy soils on the creek banks and surrounding flats. Surveys for this species were considered adequate and no supplementary surveys were undertaken. Impacts on this species are estimated to consist of 250 individuals occurring over 0.4 hectares, from an estimated population of 5000 to 8000 individuals occurring over around 2.2 hectares surrounding Tabbimoble Creek. The taxonomic status and distribution of this species and other species in the same genus is uncertain.

There is potential for indirect impacts on this species, but habitat for the species impacted is currently edge-affected and open to livestock, so the species is likely to be somewhat tolerant of edge effects and it persists in areas adjacent to the existing highway.

Indirect impacts have been accounted for with individuals in close proximity to the footprint (less than five metres away) included in the 250 individuals that would be impacted. Proposed mitigation measures would limit the potential for indirect impacts to have a substantial impact on the surrounding population.

According to the calculator, an offset supporting up to 800 individuals with habitat restoration measures to facilitate expansion of the population would be sufficient to offset the impact on 250 individuals. The values and a rationale for the offset measures are provided in Table 8-10.

Table 8-9 *Prostanthera cineolifera* – impacts and rationale for offset measures

Attribute	Value	Rationale
IMPACT		
Number of individuals impacted	250	Impacts to this species are estimated at 250 individuals occurring over 0.4 hectares
OFFSET		
Time horizon (years)	20	Considering the offset is proposed to be established in perpetuity, the maximum risk-related time horizon was assigned.
Start value (number of individuals)	800	A start value of 800 individuals has been assigned based on at least this many individuals being present on adjacent properties and this number is sufficient to offset the proposed impacts. However an offset in this area of habitat will include a greater number of individuals (5000–8000).
Future value without offset (number of individuals)	600	Considering the existing threats to this species on private property comprising ongoing degradation of habitat and removal of plants for agricultural activities the future value without offset has been reduced by 200 individuals from the start value. The population in the study area is currently open to grazing cattle.
Future value with offset (number of individuals)	900	A future site value of 900 individuals has been assigned which is 100 individuals greater than the start value, in recognition that threatening processes would be minimised/removed and habitat restoration implemented with the establishment of the offset.
Confidence in result (%)	90	There is a high confidence of a potential offset considering the existing number of individuals that would potentially be protected providing an improved outcome for the species. This is based on adequate restoration, monitoring and management actions being implemented.
% of impact offset	104	This scenario would provide for 104% of the required offset.
Other measures (up to 10%)	10	There is potential to provide up to 10% of the offset as other measures. This may include contributions towards research of the species. Considering the unknown taxonomic status and distribution of the species, scientific research into these factors would substantially contribute towards the conservation of the species.

Arthraxon hispidus

This species occurs in or on the edges of rainforest and in wet sclerophyll forest, including modified habitats such as exotic grasslands. In the study area it occurs in areas of low elevated pasture and derived grassland subject to flooding, including the edges of rainforest patches. Habitat quality for this species is relatively difficult to quantify due its occurrence in cleared and modified habitats, with the major habitat factor linked to hydrological regimes. Considering the relatively high abundance of the species recorded in these habitats, the habitat quality has been assumed to be relatively high. There are difficulties in identifying individuals due to the creeping habit and density of the species where it occurs. Therefore the assessment is based on the area of direct and indirect impact on habitat occupied by this species.

The total area of occupied habitat identified in the study area comprises 20.9 hectares of which the project would potentially impact 8.4 hectares (around 40 per cent). There is also potential for indirect impacts on at least five hectares of the remaining areas of occupied habitat.

The total direct impact and potential indirect impact comprises 13.4 hectares. According to the calculator, an offset supporting 54 hectares of occupied *Arthraxon hispidus* habitat with similar habitat quality would be sufficient to offset the impacts of the project. The values and a rationale for the offset measures are provided in Table 8-10.

Table 8-10 *Arthraxon hispidus* – impacts and rationale for offset measures

Attribute	Value	Rationale
IMPACT AREA		
Area (ha)	13.4	The area of occupied habitat directly and potentially indirectly impacted by the project.
Start quality (scale of 0-10)	7	This is based on the high population numbers recorded in the areas of habitat in the study area.
OFFSET AREA		
Time over which loss is averted (max. 20 years)	20	Considering the offset is proposed to be established in perpetuity, the maximum risk-related time horizon was assigned.
Time until ecological benefit (years)	5	A time horizon of 5 years has been assigned to establish the offset site following the impacts from the project and for the ecological benefit of the offset to be realised. This may include translocation and establishment of impacted individuals on an offset site and appropriate monitoring and management actions.
Area (ha)	30	An offset of 30 hectares of occupied habitat with similar habitat qualities would be sufficient to offset the impacts from the project.
Start quality (scale of 0-10)	7	Habitat quality of a potential offset site has been assumed to be the same as the impact area.
Risk of loss (%) without offset	40	Considering the occurrence of the species within existing areas of pasture currently grazed by livestock and potentially subject to impacts from other agricultural activities on private property, the potential for loss in the absence of an offset and appropriate management is considered to be greater for this species. Therefore a risk of loss without the offset has been identified as 40%.
Future quality without offset (scale of 0-10)	5	Considering the existing threats to occupied habitat on private property, the future quality has been reduced by a single point from the start quality.
Risk of loss (%) with offset	10	Considering the existing high level of threat to occupied habitat a residual risk of 10% has been assigned.

Attribute	Value	Rationale
Future quality with offset (scale of 0-10)	7	It is envisaged with the implementation of management and restoration measures the future quality of the offset would be maintained at existing levels.
Confidence in result (%)	90	There is some level of risk from translocation of individuals, however there is a high confidence of a potential offset with an existing population providing an improved outcome for this species provided adequate restoration, monitoring and management actions are implemented.
% of impact offset	92	This scenario would provide for 92% of the required offset, depending upon the attributes of any proposed offset, the values can be modified within reason to achieve a minimum of 90% of the offset.
Other measures (up to 10%)	10	There is potential to provide up to 10% of the offset as other measures such as contributions towards research of the species.

8.3.6. Threatened fauna

Pink Underwing Moth (*Phyllodes imperialis smithersi*)

The Pink Underwing Moth (*Phyllodes imperialis smithersi*) was identified in areas of lowland rainforest at Section 10. Areas of potential and known habitat for the species were identified in the field and used to score 'habitat condition' based on the known breeding and feeding requirements of the species. This included the presence of the host plant (*Carronia multisepalea*) required for breeding, the number of native fleshy-fruited tree species present (more than 20 species were recorded) and a measurement of canopy cover.

In Section 10 of the study area, two large areas (covering 33.2 hectares) were identified as known habitat for Pink Underwing Moth where moth larvae were detected on the host plant (*Carronia multisepalea*), and an additional 18.1 hectares of habitat that comprised areas where the host plant was detected with no larvae, yet represents potential breeding habitat for the moth. The remaining areas comprised potential habitat where the host plant was not recorded but some food plant species were. Impacts on Pink Underwing Moth from the project would be limited to vegetation of this potential habitat type with no host plant present and no confirmed presence of the moth.

There is still potential for indirect impacts on areas of known habitat, mainly from road lighting at the interchange at Wardell. This impact is anticipated to be low, however, given the intersection has been relocated away and lighting structures to minimise light spill into adjacent areas. In addition, impacts on the *Phyllodes* spp from artificial lights are considered unlikely, with the species showing little attraction to them (Dr Don Sands, *pers. comm.*). Considering the potential for indirect impacts, an additional 0.5 hectares of indirect impact has been added to the 2.5 hectares of direct impact, making the total area to be considered for offsets as three hectares.

According to the calculator, an offset supporting up to 10.2 hectares of potential habitat would be sufficient to offset the impact on three hectares of habitat. The values and a rationale for the offset measures are provided in Table 8-11.

Table 8-11 Pink Underwing Moth – impacts and rationale for offset measures

Attribute	Value	Rationale
IMPACT AREA		
Area (ha)	3	The area of potential lowland rainforest habitat directly impacted (2.5 hectares) and potentially indirectly impacted (0.5 hectares).
Start quality (scale of 0-10)	6	This is based on the absence of the host plant in areas of potential rainforest habitats impacted
OFFSET AREA		
Time over which loss is averted (max. 20 years)	20	Considering the offset is proposed to be established in perpetuity, the maximum risk-related time horizon was assigned.
Time until ecological benefit (years)	10	Restoration measures would likely be required on an offset site supporting lowland rainforest to manage/eliminate existing threatening processes threatening processes and improve habitat quality attributes. Although an offset site would support high quality rainforest habitats management activities to minimise existing threats are likely to be achieved within 10 years.
Area (ha)	10	An offset of 10 hectares of habitat occupied by the host plant and Pink Underwing Moth would be sufficient to offset the impacts from the project.
Start quality (scale of 0-10)	9	This is the habitat quality of adjacent areas of habitat avoided by the project which support Pink Underwing Moth (and the host plant) habitat. If the habitat quality of a potential offset site is assumed to be the same as the impact area (6) the offset requirements can still be achieved provided a larger offset area is provided.
Risk of loss (%) without offset	30	The existing threats to areas of lowland rainforest (potential habitat) on private property are likely to include weed invasion, livestock, feral fauna species, ongoing clearing and underscrubbing for development and/or other activities such as agriculture/hobby farming. As such, a risk of loss without the offset has been identified as 30%.
Future quality without offset (scale of 0-10)	8	Considering the likely existing threats to areas of lowland rainforest (potential habitat) on private property, the future quality has been reduced by a single point from the start quality.
Risk of loss (%) with offset	10	Considering the existing high level of threat to potential habitat a residual risk of 10% has been assigned.
Future quality with offset (scale of 0-10)	9	It is envisaged with the implementation of management and restoration measures the future quality of the offset would be maintained at existing levels.
Confidence in result (%)	90	There is a high confidence of a potential offset providing an improved outcome for Pink Underwing Moth provided adequate restoration, monitoring and management actions are implemented.
% of impact offset	102	This scenario would provide for 102% of the required offset, depending upon the attributes of any proposed offset, the values can be modified within reason to achieve a minimum of 90% of the offset.
Other measures (up to 10%)	10	There is potential to provide up to 10% of the offset as other measures. This may include restoration of areas of habitat and/or contributions towards research of Pink Underwing Moth.

Koala (*Phascolarctos cinereus*)

Habitat for the Koala (*Phascolarctos cinereus*) was identified in the project area based on the proportion of known feed tree species present in each BioMetric vegetation type as determined in the field (that is, habitat critical for survival). Details of important Koala populations were also identified in the EIS and this report. Preferred Koala habitat was identified within discrete polygons or habitat patches centred on the project corridor. The number of habitat patches and their size was quantified and a habitat condition score applied to each using the Koala habitat categories as described in the *Koala Recovery Plan* (DECC, 2008) as a basis for habitat condition and their ability to support Koala populations. These categories included primary, secondary and tertiary Koala habitat.

The project would directly impact on 375 hectares of potential habitat. The area of impact for the Koala is considered to be areas of primary and secondary habitat that are capable of supporting to medium- to high-density Koala populations. Indirect impacts on Koala would be mitigated through connectivity structures, including large underpasses, overland bridges and exclusion fencing, as well as through general mitigation measures including Koala habitat revegetation and weed management. Considering the proposed measures to mitigate indirect impacts on Koala, no additional values have been assigned to the calculator for indirect impacts.

According to the calculator, an offset supporting up to 1450 hectares of potential habitat with similar proportions of primary and secondary habitat would be sufficient to offset the impact on 375 hectares of potential habitat directly impacted. The values and a rationale for the offset measures are provided in Table 8-12.

Table 8-12 Koala – impacts and rationale for offset measures

Attribute	Value	Rationale
IMPACT AREA		
Area (ha)	375.4	This is the area of habitat impacted by the project that meets the criteria for 'habitat critical to the survival of koalas'.
Start quality (scale of 0-10)	7	This is based on an approximate average of habitat quality throughout the project corridor, including primary (8-10) and secondary habitat (4-6).
OFFSET AREA		
Time over which loss is averted (max. 20 years)	20	Considering the offset is proposed to be established in perpetuity, the maximum risk-related time horizon was assigned.
Time until ecological benefit (years)	2	An offset area supporting primary and secondary habitat for Koala would potentially require minimal management measures for habitat qualities to be present for Koala, considering the presence of feed tree species. Therefore a period of 2 years from the impact has been assigned to secure an offset with the required habitat.
Area (ha)	1450	An offset of 1450 hectares occupied by primary and secondary habitat would be sufficient to offset the impact on 368 hectares of primary and secondary habitat from the project.
Start quality (scale of 0-10)	7	This is the habitat quality of the area of habitat impacted comprising an approximate average of primary and secondary habitat quality scores.
Risk of loss (%) without offset	20	Considering the existing threats to areas of habitat on private property are likely to include weed invasion, forestry, livestock, feral fauna species, ongoing clearing and underscrubbing for development and/or other activities such as agriculture/hobby farming, a risk of loss without the

Attribute	Value	Rationale
		offset has been identified as 20%.
Future quality without offset (scale of 0-10)	6	Considering the likely existing threats to areas of habitat on private property, the future quality has been reduced by a single point from the start quality.
Risk of loss (%) with offset	2	Considering an offset site would remove the majority of threat to potential habitat for Koala (ie removal of feed tree species) a residual risk of 2% has been assigned.
Future quality with offset (scale of 0-10)	7	It is envisaged with the implementation of management and restoration measures the future quality of the offset would be maintained at existing levels
Confidence in result (%)	90	There is a high confidence of a potential offset providing an improved outcome for Koala provided adequate restoration, monitoring and management actions are implemented.
% of impact offset	100	This scenario would provide for 100% of the required offset, depending upon the attributes of any proposed offset, the values can be modified within reason to achieve a minimum of 90% of the offset.
Other measures (up to 10%)	10	There is potential to provide up to 10% of the offset as other measures. This may include planting of feed trees and/or contributions towards research of Koala.

Giant Barred Frog (*Mixophyes iteratus*)

The Giant Barred Frog (*Mixophyes iteratus*) was confirmed from three locations including Corindi Creek and Dirty Creek in Section 1, and Halfway Creek in Section 2. Potential habitat was identified in small areas of sections 1, 3 and 7.

The condition of the habitat for the Giant Barred Frog at each of the sites surveyed was determined using information on specific attributes thought to influence the distribution of Giant Barred Frog. Broad habitat attributes were recorded at each site, including an assessment of the aquatic microhabitats, vegetation structure, disturbance and substrate type. Areas of known habitat were identified and rated as high, moderate and low quality.

The project would impact 14 hectares comprising three hectares of known habitat, 2.2 hectares of moderate quality habitat and 8.8 hectares of low quality habitat. There is also potential for the project to result in indirect impacts on adjacent areas of habitat, but mitigation measures would be implemented to minimise the potential for indirect impacts. Considering that 8.8 hectares of low-quality habitat has been included, and this habitat is unlikely to support the species, relative to 5.2 hectares of known and moderate quality habitat, potential indirect impacts are considered to be covered within the 14 hectares of impact.

According to the calculator, an offset supporting up to 50 hectares with suitable habitat for the species would be sufficient to offset the impact on 14 hectares of potential habitat directly and indirectly impacted, provided sufficient management and restoration measures are implemented. The values and a rationale for the offset measures are provided in Table 8-13.

Table 8-13 Giant Barred Frog – impacts and rationale for offset measures

Attribute	Value	Rationale
IMPACT AREA		
Area (ha)	14	The project would impact 14 hectares comprising 3 hectares of known habitat, 2.2 hectares of moderate quality habitat and 8.8 hectares of low quality habitat. The impact on 14 hectares is considered to adequately cover any area subject to indirect impacts.
Start quality (scale of 0-10)	7	This is based on an approximate average of habitat quality throughout the project corridor, including known habitat (10), moderate quality habitat (7) and low quality habitat (4).
OFFSET AREA		
Time over which loss is averted (max. 20 years)	20	Considering the offset is proposed to be established in perpetuity, the maximum risk-related time horizon was assigned.
Time until ecological benefit (years)	10	Although an offset site would support some areas of high or known quality habitat, management activities to minimise existing threats or restoration of disturbed areas of habitat may be required and are likely to be achieved within 10 years.
Area (ha)	50	An offset of 50 hectares occupied by known habitat or high quality habitat and potentially some degraded areas of habitat which could be restored would be sufficient to offset the impact on 14 hectares of known and potential habitat from the project.
Start quality (scale of 0-10)	7	This is the habitat quality of the area of habitat impacted comprising an approximate average of habitat quality scores.
Risk of loss (%) without Offset	20	The existing threats to areas of habitat on private property are likely to include poor water quality, availability of water, sedimentation and erosion, weed invasion, livestock, feral fauna species, ongoing clearing and underscrubbing for development and/or other activities such as agriculture/hobby farming. As such, a risk of loss without the offset has been identified as 20%.
Future quality without offset (scale of 0-10)	6	Considering the likely existing threats to areas of habitat on private property as riparian habitats can often be subject to disturbance from agricultural activities, the future quality has been reduced by a single point from the start quality.
Risk of loss (%) with offset	5	Considering the existing high level of threat to potential habitat a residual risk of 5% has been assigned.
Future quality with offset (scale of 0-10)	8	It is envisaged with the implementation of management and restoration measures (assuming there are some areas of degraded habitat within proposed offset sites), the future quality of the offset would be increased by one point above the start quality.
Confidence in result (%)	90	There is a high confidence of a potential offset providing an improved outcome for Giant Barred Frog provided adequate restoration, monitoring and management actions are implemented.
% of impact offset	109	This scenario would provide for 109% of the required offset, depending upon the attributes of any proposed offset, the values can be modified within reason to achieve a minimum of 90% of the offset.
Other measures (up to 10%)	10	There is potential to provide up to 10% of the offset as other measures. This may include restoration of areas of habitat and/or contributions towards research of Giant Barred Frog.

Oxleyan Pygmy Perch (*Nannoperca oxleyana*)

The presence of the endangered species Oxleyan Pygmy Perch (*Nannoperca oxleyana*) was confirmed in seven locations in sections 7, 8 and 9 comprising:

- Unnamed watercourse south of Serendipity Road (station 114.0, Section 7).
- Tabbimoble Floodway No. 1 (station 115.3, Section 7)
- Unnamed watercourse at Lang Hill (station 134.7, Section 8).
- Tributaries of McDonalds Creek (station 135.53, Section 8).
- McDonalds Creek (station 136.6, Section 8).
- Montis Gully area (station 141.47, Section 9)
- Swamps in Broadwater National Park (Section 9).

The potential habitat around these locations has been mapped and identified as known habitat, which includes:

- Permanent aquatic habitats. Habitats that provide permanent refuge and potential breeding habitat comprise non-ephemeral streams and lagoons and areas of swamp forest and wet heathland inundated for longer periods. Potential impacts for the offset calculations have been based on direct and indirect impacts on these areas of permanent aquatic habitats. The project would directly impact on around 4.2 hectares of permanent aquatic habitats
- Temporary habitats used for dispersal during flood events. Temporary habitat used for dispersal comprise areas of wet heathland (9.8 hectares), swamp forest (9.8 hectares) and floodplain forest (16.3 hectares) where the species is known to occur.

There is potential for indirect impacts on habitat through altered water quality, sunlight exposure, water temperature, habitat connectivity and change in stream flow velocities. Mitigation measures would be implemented to minimise the risk of these indirect impacts.

In recognition of the potential for indirect impacts on areas of permanent habitat adjacent to the project, an additional 20 per cent has been added to the area of direct impact, resulting in a total direct and indirect impact on five hectares.

According to the calculator, an offset supporting up to 10 hectares of suitable habitat for the species would be sufficient to offset the impact on five hectares of potential habitat potentially directly and indirectly impacted. The values and a rationale for the offset measures are provided in Table 8-14.

Table 8-14 Oxleyan Pygmy Perch – impacts and rationale for offset measures

Attribute	Value	Rationale
IMPACT AREA		
Area (ha)	5	A total of 5 hectares of permanent aquatic habitat has been identified as being directly and indirectly impacted.
Start quality (scale of 0-10)	9	Considering the species is known from these areas of habitat and the condition is generally high (although there are small areas of low condition habitat), a start quality of 9 has been assigned.
OFFSET AREA		
Time over which loss is averted (max. 20 years)	20	Considering the offset is proposed to be established in perpetuity, the maximum risk-related time horizon was assigned.
Time until ecological benefit (years)	5	Although an offset site would support some areas of high or known quality habitat, management activities to minimise existing threats or restoration of disturbed areas of habitat may be required and are likely to be achieved within 5 years.
Area (ha)	10	An offset of 10 hectares of permanent aquatic habitat occupied by Oxleyan Pygmy Perch and/or potentially including some degraded areas of habitat which could be restored would be sufficient to offset the impact on 5 hectares of known/potential habitat from the project.
Start quality (scale of 0-10)	7	Considering much of the high quality habitat for the species is within conserved lands, there may be limited opportunities to provide an offset with high quality known habitat. However areas of degraded habitat such as drainage lines and channels through cleared and open paddocks which are connected to areas of known habitat are present in areas surrounding the project which could potentially be restored as habitat for the species. Therefore a lower start quality for the offset area has been assigned.
Risk of loss (%) without Offset	50	The existing threats to areas of habitat on private property are likely to include poor water quality, sedimentation and erosion, weed invasion, livestock, feral fauna species, ongoing clearing and underscrubbing for development and/or other activities such as agriculture/hobby farming. As such, a higher risk of loss without the offset has been identified as 50%.
Future quality without offset (scale of 0-10)	6	Considering the likely existing threats to areas of habitat on private property as riparian habitats can often be subject to disturbance from agricultural activities, the future quality has been reduced by a single point from the start quality.
Risk of loss (%) with offset	5	Considering the existing high level of threat to potential habitat a residual risk of 5% has been assigned.
Future quality with offset (scale of 0-10)	9	It is envisaged with the implementation of management and restoration measures (assuming there are some areas of degraded habitat within proposed offset sites) the future quality of the offset would be increased by two points above the start quality. The aim would be to restore the habitats in the study area to the habitat quality of impacted areas.
Confidence in result (%)	90	There is a high confidence of a potential offset providing an improved outcome for Oxleyan Pygmy Perch provided adequate restoration, monitoring and management actions are implemented.
% of impact offset	92	This scenario would provide for 92% of the required offset, depending upon the attributes of any proposed offset, the values can be modified within reason to achieve a minimum of 90% of the offset.
Other measures (up to 10%)	10	There is potential to provide up to 10% of the offset as other measures. This may include restoration of areas of potential habitat and/or contributions towards research of Oxleyan Pygmy Perch.

Spotted-tailed Quoll (*Dasyurus maculatus maculatus*)

The Spotted-tailed Quoll (*Dasyurus maculatus*) is a wide-ranging species with large home ranges known to use a diversity of habitat types.

The project would directly and indirectly impact an area of habitat for this species comprising 932.6 hectares (including all vegetation types). The area of offset for this species is therefore likely to be substantial and it would be likely that several different offset properties would need to be combined to achieve an appropriate offset area.

According to the calculator, an offset supporting up to 2000 hectares of potential habitat would be sufficient to offset the impact on 932.6 hectares of potential habitat potentially directly and indirectly impacted. The values and a rationale for the offset measures are provided in Table 8-15.

Table 8-15 Spotted-tailed Quoll – impacts and rationale for offset measures

Attribute	Value	Rationale
IMPACT AREA		
Area (ha)	932.6	The total area of habitat impacted for this species includes all vegetation types impacted by the project comprising 932.6 hectares.
Start quality (scale of 0-10)	7	This is based on an approximate average of habitat quality throughout the habitat types along the project corridor.
OFFSET AREA		
Time over which loss is averted (max. 20 years)	20	Considering the offset is proposed to be established in perpetuity, the maximum risk-related time horizon was assigned.
Time until ecological benefit (years)	10	Restoration measures would likely be required on several offset sites including rehabilitation of cleared and modified land to manage/eliminate exiting threatening processes threatening processes and improve habitat quality attributes. Although an offset site would support areas of high quality habitats management activities to minimise existing threats are likely to be achieved within 10 years.
Area (ha)	2000	An offset of 2000 hectares occupied by a mix of high quality habitat and disturbed/cleared areas where habitat restoration would be implemented would be sufficient to offset the impact on 932.6 hectares of habitat from the project.
Start quality (scale of 0-10)	6	Considering the potential for some offset sites to require restoration of cleared and modified land, the start quality for the offset has been reduced by one point below the impact start quality.
Risk of loss (%) without Offset	30	The existing threats to areas of habitat on private property are likely to include weed invasion, forestry, livestock, feral fauna species, ongoing clearing and underscrubbing for development and/or other activities such as agriculture/hobby farming. As such, a risk of loss without the offset has been identified as 30% in recognition of these threats. Note that the risk of loss without the offset for this species is larger than other species considering multiple offset sites would likely be required which could potentially be widespread in the landscape including a range of threatening processes and different land uses.
Future quality without offset (scale of 0-10)	5	Considering the likely existing threats to areas of habitat on private property, the future quality has been reduced by a single point from the start quality.
Risk of loss (%) with offset	2	Considering an offset site would remove the majority of threat to potential habitat for the species on private properties a residual risk of 2% has been assigned.

Attribute	Value	Rationale
Future quality with offset (scale of 0-10)	8	With the implementation of management and restoration measures including rehabilitation of cleared and modified lands, the future quality of the offset has been increased by two points from the start quality in recognition of the significant restoration efforts which are likely to be required on some offset sites
Confidence in result (%)	90	There is a high confidence of a potential offset providing an improved outcome for Spotted-tailed Quoll provided adequate restoration, monitoring and management actions are implemented.
% of impact offset	100	This scenario would provide for 100% of the required offset, depending upon the attributes of any proposed offset, the values can be modified within reason to achieve a minimum of 90% of the offset.
Other measures (up to 10%)	10	There is potential to provide up to 10% of the offset as other measures. This may include restoration of areas of habitat and/or contributions towards research of Spotted-tailed Quoll.

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

As both the Swift Parrot and Regent Honeyeater are semi-nomadic species that move large distances in search of flowering resources, their presence in a particular area of coastal NSW is unpredictable and dependent on seasonal and local factors. Habitat for these two species is relatively similar, comprising flowering trees and shrubs, particularly winter-flowering species; therefore, these species have been assessed together. For the purposes of this assessment, all impacted vegetation types with flowering trees and shrubs were included as habitat for the species. This area would comprise a total of 869.9 hectares, with areas dominated by rainforest species, open freshwater wetlands, coastal cypress pine, mangroves and swamp oak excluded from the calculations.

Indirect impacts relating to potential modification of understorey floristics and weed invasion are considered to be minor for these species, which rely on flowering trees for foraging. Furthermore, the potential habitats impacted by the project represent non-breeding habitat for these two species.

According to the calculator, an offset supporting up to 1860 hectares of potential habitat would be sufficient to offset the impact on 869.9 hectares of potential habitat potentially directly and indirectly impacted. The values and a rationale for the offset measures are provided in Table 8-16.

Table 8-16 Swift Parrot and Regent Honeyeater – impacts and rationale for offset measures

Attribute	Value	Rationale
IMPACT AREA		
Area (ha)	869.9	For the purposes of this assessment all vegetation types with flowering trees and shrubs were included as habitat for the species, comprising a total of 869.9 hectares, with areas dominated by rainforest species, open freshwater wetlands, coastal cypress pine, mangroves and swamp oak excluded from the calculations.
Start quality (scale of 0-10)	7	This is based on an approximate average of habitat quality throughout the habitat types along the project corridor.
OFFSET AREA		
Time over which loss is averted (max. 20 years)	20	Considering the offset is proposed to be established in perpetuity, the maximum risk-related time horizon was assigned.
Time until ecological	10	Restoration measures would likely be required on several offset sites

Attribute	Value	Rationale
benefit (years)		including rehabilitation of cleared and modified land to manage/eliminate exiting threatening processes threatening processes and improve habitat quality attributes. Although an offset site would support areas of high quality habitats management activities to minimise existing threats are likely to be achieved within 10 years.
Area (ha)	1860	An offset of 1860 hectares occupied by a mix of high quality habitat and disturbed/cleared areas where habitat restoration would be implemented would be sufficient to offset the impact on 869.9 hectares of habitat from the project.
Start quality (scale of 0-10)	6	Considering the potential for some offset sites to require restoration of cleared and modified land, the start quality for the offset has been reduced by one point below the impact start quality.
Risk of loss (%) without offset	30	The existing threats to areas of habitat on private property are likely to include weed invasion, livestock, feral fauna species, ongoing clearing and underscrubbing for development and/or other activities such as agriculture/hobby farming. As such, a risk of loss without the offset has been identified as 30% in recognition of these threats. Note that the risk of loss without the offset for this species is larger than other species considering multiple offset sites would likely be required which could potentially be widespread in the landscape including a range of threatening processes and different land uses.
Future quality without offset (scale of 0-10)	5	Considering the likely existing threats to areas of habitat on private property, the future quality has been reduced by a single point from the start quality.
Risk of loss (%) with offset	2	Considering an offset site would remove the majority of threat to potential habitat for the species on private properties a residual risk of 2% has been assigned.
Future quality with offset (scale of 0-10)	8	It is envisaged with the implementation of management and restoration measures including rehabilitation of cleared and modified lands, the future quality of the offset has been increased by two points from the start quality in recognition of the significant restoration efforts which are likely to be required on some offset sites.
Confidence in result (%)	90	There is a high confidence of a potential offset providing an improved outcome for Swift Parrot and Regent Honeyeater with the protection of habitat and restoration, monitoring and management actions are to improve and maintain habitat quality.
% of impact offset	100	This scenario would provide for 100% of the required offset, depending upon the attributes of any proposed offset, the values can be modified within reason to achieve a minimum of 90% of the offset.
Other measures (up to 10%)	10	There is potential to provide up to 10% of the offset as other measures. This may include restoration of areas of non-breeding habitat and/or contributions towards research of Swift Parrot and Regent Honeyeater.

8.4. Identification of potential offsets

Roads and Maritime has commenced investigations into suitable offset properties for those significantly impacted Commonwealth listed species (refer to section 8.3.2). The principles followed to target suitable biodiversity offsets for the project include:

- Priority has been given to those species or communities that are less mobile, cryptic or more threatened (eg critically endangered communities and endangered species or those with a restricted range or habitat preference, and those of low mobility (disperse-ability)

- Offset areas would reflect the vegetation communities and habitat types impacted by the project.
- Offset areas would contain suitable habitat for threatened and migratory fauna (EPBC Act) and would contain or be suitable for re-establishing threatened flora (EPBC Act) affected by the project.
- Roads and Maritime would prioritise investigations into areas that contain vegetation communities and suitable habitat for Endangered and / or Critically Endangered species listed under the EPBC Act.
- Offset areas are not already funded or protected under another scheme.
- Offset areas are not already managed for conservation by the government, such as flora reserves, national parks and public open space would not be chosen as offsets.
- Offset properties would be located as close to the impact site as feasible.
- 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.

The investigations into suitable offset properties consist of a desktop appraisal and field surveys. The desktop appraisal aims to identify potential offset properties through a review of existing data. This includes:

- Broad scale vegetation mapping (CRAFTI).
- NSW Wildlife Atlas data.
- Key habitats and corridors and climate change corridors.
- Adjacent land use (ie national park, state forest, private).
- Soil landscapes, elevation data and property cadastre.
- Ecological data from route selection and EIS phases.

Aerial photographic interpretation was used to provide additional information where possible, such as local wildlife corridors, habitat patch sizes and land uses.

Field survey of properties was undertaken to confirm the suitability of sites, predominantly focussing on the presence and / or absence of species and communities. The surveys included:

- Identification of endangered and threatened ecological communities or vegetation types (under EPBC and TSC Act).
- Confirmation of presence of high priority species and quantum of area of likely habitat.
- If present, targeted population counts for nationally threatened rainforest flora and other threatened plants.

All data collected from the field surveys have been incorporated into the EPBC Act offset calculator to determine site suitability.

Table 8-17 identifies the required offsets (based on offset calculator), potential offsets investigated and the percentage of required offsets achieved.

The information presented here is current as of October 2013.

Roads and Maritime would continue to investigate offset opportunities for both significantly impacted State and Commonwealth listed species in consultation with OEH and DotE to achieve all required offsets.

Table 8-17: Status of preliminary offset investigations for high priority offsets required for cryptic, less mobile or more threatened MNES

Protected matter	EPBC Act Status	Project impact	Indicative offset	Site	Section	Tenure*	Primary values	Site context	Area / number of individuals present	Direct offset met (%)
Threatened ecological communities										
Lowland Rainforest of Subtropical Australia	CE	3.5 ha	40 ha	17	10	RM	Federally listed Lowland Rainforest of Subtropical Australia (11 ha)	▪ Well connected to adjacent areas of remnant vegetation to the west and loosely connected to remnant vegetation to the north and south ▪ 29 ha of intact vegetation/habitat ▪ 32 ha of modified habitats that could be rehabilitated. ▪ Includes a Big Scrub rainforest remnant ▪ Numerous threatened flora species recorded at site. ▪ Habitat at the site suitable for range of threatened fauna eg Koala, Bats, Birds, Quoll.	11 ha	27.5%
				22	10	Prv	Federally listed Lowland Rainforest of Subtropical Australia (22 ha)	▪ Well connected to adjacent areas of remnant vegetation ▪ Includes low elevated wallum habitats as well as elevated basalt slopes ▪ Good habitat for a number of threatened fauna ▪ Numerous rare and threatened flora species present on site ▪ 41 ha of intact vegetation/habitat ▪ 32 ha of modified habitats that could be rehabilitated	22 ha	55%
				23	10	RM	Federally listed Lowland Rainforest of Subtropical Australia (c. 16 ha)	▪ Loosely connected to areas of habitat to west including areas of rainforest ▪ Includes elevated basalt soil landscapes ▪ Rare and threatened flora species present on site ▪ Pink Underwing Moth (*Phyllodes imperialis smithersi*) has been recorded on the site including the larval host plant ▪ Atlas Rainforest Beetle (*Nurus atlas*) has been recorded on site ▪ 28 ha of intact vegetation/habitat	16 ha	40%

Protected matter	EPBC Act Status	Project impact	Indicative offset	Site	Section	Tenure*	Primary values	Site context	Area / number of individuals present	Direct offset met (%)
								▪ 15 ha of modified habitats that could be rehabilitated.		
				24	10	Prv	Federally listed Lowland Rainforest of Subtropical Australia (c. 7 ha)	▪ Loosely connected to areas of habitat to west including areas of rainforest ▪ Includes elevated basalt soil landscapes Pink Underwing Moth (*Phyllodes imperialis smithersi*) has been recorded on the site including the larval host plant ▪ 23 ha of intact vegetation/habitat ▪ 10 ha of modified habitats that could be rehabilitated	7 ha	17.5%
Threatened flora										
Scented Acronychia (*Acronychia littoralis)*	E	1 plant	2 plants to be translocated	-	-	Prv	-	▪ No site identified. ▪ Loss of individual will be offset through translocation and plantings of the species	0	100%
Moonee Quassia (*Quassia sp. 'Moonee Creek'*)	E	202 stems	670 stems plus 164 stems to be translocated	1	1	Prv	At least 170 stems of Moonee Quassia (Quassia sp. Moonee Creek) present.	▪ Adjoins and supports part of the population of Moonee Quassia impacted by the project . ▪ 41 ha dry sclerophyll forest with diverse heathy understorey habitats. ▪ Habitat for other threatened flora and fauna	170 ha	25%
				3	3	Prv	Large populations of Moonee Quassia with over 1100 stems counted	▪ Includes a large lot occupying the area below McCraes Knob adjoining Pine Brush State Forest ▪ A Voluntary Conservation Agreement (VCA) has been established across c.123 ha of the central area of the lot which has been excluded from this assessment. ▪ At least 62 ha of habitat occupied by *Angophora robur* ▪ Very large population of Four-tailed Grevillea (Grevillea quadricauda)	1100 ha	164%

Protected matter	EPBC Act Status	Project impact	Indicative offset	Site	Section	Tenure*	Primary values	Site context	Area / number of individuals present	Direct offset met (%)
								▪ 343 ha of intact vegetation/habitat ▪ 4 ha of modified habitats that could be readily rehabilitated		
Sandstone Rough Barked Apple *(Angophora robur)*	V	54.1 ha	400 ha	2	3	Prv	At least 60 ha of habitat occupied by *Angophora robur*	▪ Well connected to large areas of remnant vegetation on surrounding properties ▪ 320 ha of intact vegetation/habitat. ▪ TECs include lowland rainforest (TSC Act only) gully area (c. 2.3 ha) and swamp sclerophyll forest (c. 4.4 ha)	60 ha	15%
				3	3	Prv	At least 62 ha of habitat occupied by *Angophora robur*	See Site 3 above	62 ha	15.5%
				4	3	Prv	At least 26 ha of habitat occupied by *Angophora robur*	▪ Breeding Emus have been observed by the property owner. ▪ 115 ha of intact vegetation/habitat. ▪ Includes elevated lands near Pillar Rock southeast of the project alignment ▪ Black Snake Creek runs through part of the property including several tributaries ▪ Potential for other rare and threatened flora species to be present. ▪ Preferred koala feed trees common on site.	26 ha	6.5%
				5	3	Prv	Angophora robur has been recorded on site in low abundance however there is potential for a larger population to be present in unsurveyed	▪ Includes several large lots adjoining Candole State Forest and Yuraygir National Park ▪ *Maundia triglochinoides* was recorded along one of the drainage lines in high abundance ▪ 331 ha of intact vegetation/habitat ▪ Numerous mature senescent trees present with a range of hollow sizes and types	1 ha	0.25%

Protected matter	EPBC Act Status	Project impact	Indicative offset	Site	Section	Tenure*	Primary values	Site context	Area / number of individuals present	Direct offset met (%)
							areas (c. 1 ha)			
				6	3	Prv	At least 137 ha of habitat occupied by Angophora robur	▪ Adjoins Pine Brush State Forest ▪ 146 ha of intact vegetation/habitat. ▪ Good habitat for fauna with important habitat features known to be present	137 ha	34.25%
				7	3	Cr	At least 227 ha of habitat occupied by Angophora robur	▪ Sites used as flood refuge for cattle famers on floodplain ▪ 248 ha of intact vegetation/habitat ▪ Good habitat for fauna with important habitat features present ▪ Potential for other rare and threatened flora species to be present.	227 ha	56.75%
				8	3	Prv	At least 30 ha of habitat occupied by Angophora robur	▪ 33 ha of intact vegetation/habitat ▪ Good habitat for fauna with important habitat features known to be present ▪ TECs include small patches of lowland rainforest (TSC Act only) in sheltered areas.	30 ha	7.5%
				9	3	Prv	At least 64 ha of habitat occupied by Angophora robur	▪ 65 ha of intact vegetation/habitat ▪ 7 ha of modified habitats that could be rehabilitated ▪ Good habitat for fauna with important habitat features known to be present ▪ Includes elevated lands of Bondi Hill.	64 ha	16%
				10	3	Prv	At least 58 ha of habitat occupied by *Angophora robur*	▪ 398 ha of habitat for fauna species with a range of vegetation types ▪ Wallum Froglet and Emu recorded on property ▪ 14 ha of modified habitats that could be readily rehabilitated	58 ha	14.5%
Hairy Joint-grass *(Arthraxon*	V	13.4 ha	30 ha	14	8	Prv	Low elevated wetland areas in pasture potential habitat for	▪ Approximately 2 ha of wetland habitats ▪ 17 ha of cleared grazing land which could be rehabilitated including potential habitat for *Arthraxon hispidus*	4 ha	13%

Protected matter	EPBC Act Status	Project impact	Indicative offset	Site	Section	Tenure*	Primary values	Site context	Area / number of individuals present	Direct offset met (%)
hispidus)							*Arthraxon hispidus*	▪ Oxleyan Pygmy Perch recorded on the site comprising approximately 2 ha of habitat		
				17	8	Prv	At least 1.8 ha of habitat occupied by *Arthraxon hispidus* plus an additional 5.8 ha of suitable habitat	See Site 17 above	7.6 ha	25%
				19	10	Prv	7 ha of potential habitat for *Arthraxon hispidus* which could be a potential translocation recipient site for the species and/or habitat restoration measures implemented	See Site 19 above	7 ha	23%
				20	10	Prv	At least 1 ha of habitat occupied by *Arthraxon hispidus* plus an additional 2.5 ha of suitable habitat	▪ 20 ha of intact vegetation/habitat and 3.5 ha of derived grassland/freshwater wetland (*Arthraxon hispidus* habitat) ▪ 28.5 ha of modified habitats that could be rehabilitated ▪ One individual of *Archidendron muellerianum* has also been recorded on site	3.5 ha	12%
				21	10	RM and	At least 1.2 ha of habitat occupied by	▪ 3 ha of intact vegetation/habitat and 4 ha of derived grassland/freshwater wetland (*Arthraxon hispidus* habitat)	4 ha	13%

Protected matter	EPBC Act Status	Project impact	Indicative offset	Site	Section	Tenure*	Primary values	Site context	Area / number of individuals present	Direct offset met (%)
						Prv	*Arthraxon hispidus* plus an additional 2.8 ha of suitable habitat	▪ 19 ha of modified habitats that could be rehabilitated		
				23	10	Prv	At least 1.8 ha of habitat occupied by Arthraxon hispidus	See Site 23 above	1.8 ha	6%
				24	10	Prv	At least 1 ha of habitat occupied by Arthraxon hispidus	See Site 24 above	1 ha	3%
Stinking Cryptocarya *(Cryptocarya foetida)*	V	13 individuals	70 individuals + 10 individuals planted / translocated	17	8	Prv	*Cryptocarya foetida* (2 individuals)	See Site 17 above	2 ha	3%
				22	10	Prv	*Cryptocarya foetida* (71 individuals)	See Site 22 above	71 ha	101%
				23	10	Prv	*Cryptocarya foetida* (1 individual)	See Site 23 above	1 ha	1.4%
Rusty Rose Walnut *(Endiandra hayesii)*	V	5	10 individuals + 6 individuals planted / translocated	17	8	Prv	*Endiandra hayesii* (4 individuals)	See Site 17 above	4 ha	40%
				22	10	Prv	Endiandra hayesii (10 individuals)	See Site 19 above	10 ha	100%

Protected matter	EPBC Act Status	Project impact	Indicative offset	Site	Section	Tenure*	Primary values	Site context	Area / number of individuals present	Direct offset met (%)
Singleton Mint Bush *(Prostanthera cineolifera)*	V	250 individuals	800 individuals + 164 individuals planted / translocated	12	6	Prv	Very large population of *Prostanthera cineolifera* present surrounding Tabbimoble Creek occurring over 2 ha estimated to comprise 2500 - 5000 individuals	▪ Supports part of Tabbimoble Creek ▪ 111 ha of habitat for fauna species with a range of vegetation types ▪ 49 ha of modified habitats that could be rehabilitated ▪ Preferred koala feed trees common ▪ Habitat for Spotted-tail Quoll, Regent Honeyeater and Swift Parrot	2500 ha	312%
Red Lily Pilly *(Syzygium hodgkinsoniae)*	V	1	1-2 individuals to be translocated / planted	17	8	Prv	Syzygium hodgkinsoniae (24 individuals)	See Site 17 above	24 ha	1200%
Threatened fauna species										
Giant Barred Frog *(Mixophyes iteratus)*	E	14 ha	50 ha	13	6	Prv	Around 3 ha of riparian habitat regraded as moderately suited to Giant-barred Frog *(Mixophyes iteratus)*	▪ Potential habitat for Oxleyan Pygmy Perch with mapped areas of critical habitat approximately 1 km to the east with connectivity along Tabbimoble Creek and approximately 11 ha of habitat. ▪ Adjoins Bundjalung National Park ▪ Tabbimoble Creek runs through part of the property including several billabongs. ▪ 568 ha of intact vegetation/habitat ▪ 11 ha of modified habitats that could be rehabilitated	3 ha	6%
				16	8	RM	Around 22.6 ha of good quality habitat for Giant Barred Frog	▪ Potential for part of the Devils Pulpit offset site to be used for Giant Barred Frog offset.	22.6 ha	45%

Protected matter	EPBC Act Status	Project impact	Indicative offset	Site	Section	Tenure*	Primary values	Site context	Area / number of individuals present	Direct offset met (%)
							(Mixophyes iteratus)			
Oxleyan Pygmy Perch *(Nannoperca oxleyana)*	E	5 ha	10 ha	13	6	Prv	Oxleyan Pygmy Perch *(Nannoperca oxleyana)* potential habitat (11 ha)	See Site 13 above	11 ha	110%
				14	8	Prv	Oxleyan Pygmy Perch *(Nannoperca oxleyana)* known habitat (2 ha)	See Site 14 above	2 ha	20%
				15	8	Prv	Oxleyan Pygmy Perch *(Nannoperca oxleyana)* known habitat (5 ha)	▪ Adjoins Broadwater National Park ▪ McDonalds Creek and several constructed channels and natural tributaries flow through the property ▪ This property is also proposed as compensation for the impacts to areas of Broadwater National Park ▪ Approximately 4.3 ha of critical habitat has been mapped on the property as part of the Preliminary Identification of Critical Habitat for the species ▪ 60 ha of intact vegetation/habitat ▪ 5 ha of modified habitats that could be readily rehabilitated ▪ Good habitat for fauna with important habitat features present ▪ Potential for other rare and threatened flora species to be present	5 ha	50%

Protected matter	EPBC Act Status	Project impact	Indicative offset	Site	Section	Tenure*	Primary values	Site context	Area / number of individuals present	Direct offset met (%)
Pink Underwing Moth *(Phyllodes imperialis)*	E	3 ha	10 ha	22	10	Prv	Pink Underwing Moth *(Phyllodes imperialis)* potential habitat (23 ha)	See Site 22 above	22 ha	220%
				23	10	Prv	Pink Underwing Moth *(Phyllodes imperialis)* potential habitat (16 ha)	See Site 23 above	16 ha	160%
				24	10	Prv	Pink Underwing Moth *(Phyllodes imperialis)* potential habitat (7 ha)	See Site 24 above	7 ha	70%

* Prv – Private. Cr – Crown Land. RM – Roads and Maritime Services – as of September 2013

8.5. Biodiversity offset framework and timing

Project approval conditions for Pacific Highway Upgrade projects contain requirements to provide details of the Biodiversity Offsets Framework to the approval authority once approval has been received. There are two components to the approval requirements, the Biodiversity Offset Strategy and the Biodiversity Offset Package. The relationship between the approval and offset requirements are detailed in **Figure 8-1**, and further details of the Biodiversity Offset Strategy and Packages are detailed in Sections 8.5.1 and 8.5.2 below.

The information provided above on the offset requirements and potential offset properties for Commonwealth listed species would be further developed and form part of the biodiversity offset strategy.

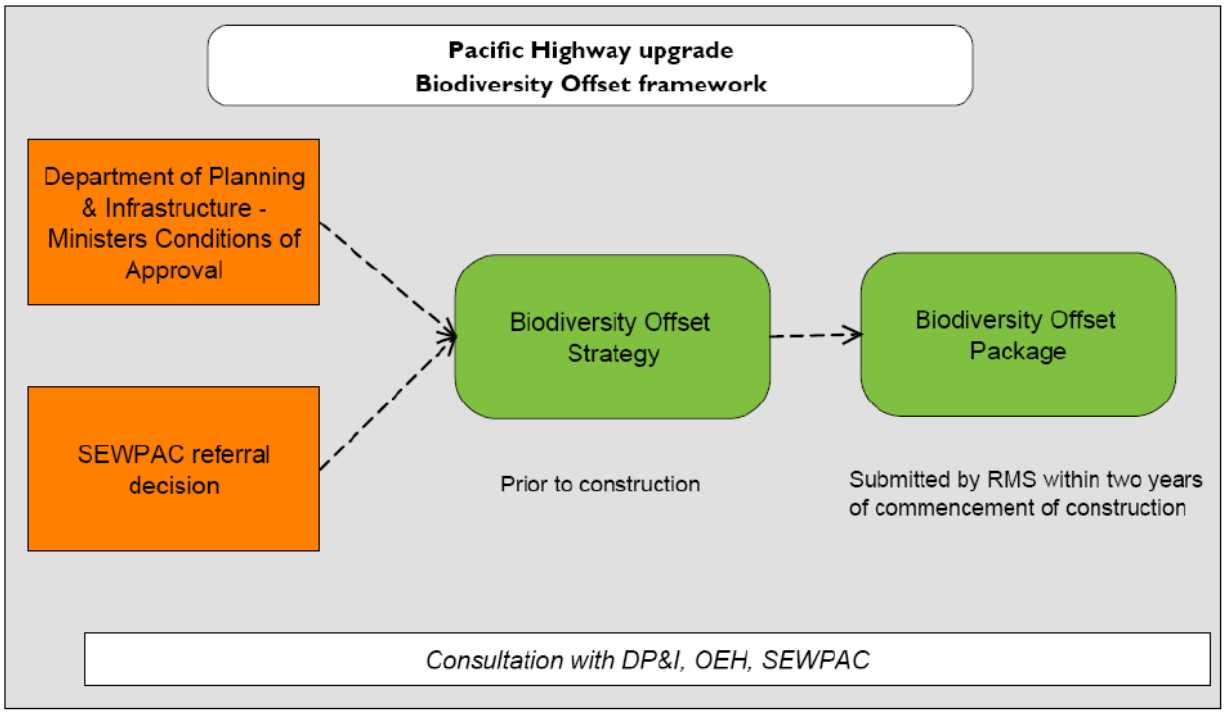


Figure 8-1: Biodiversity offset framework for Pacific Highway Upgrade

8.5.1. Biodiversity Offset Strategy

The Biodiversity Offset Strategy identifies available options for offsetting the biodiversity impacts of the project and includes, but is not limited to:

- Confirmation of the vegetation communities/ habitat (in hectares) to be offset and the size of offsets required (in hectares).
- Details of the available offset measures that have been identified to compensate for the biodiversity impacts of the project, such as (but not necessarily limited to): suitable compensatory land options and/ or contributions towards biodiversity programs for high conservation value areas on nearby lands (including research programs).
- The decision-making framework that would be used to select the final suite of offset measures to achieve the aims and objectives of the Strategy, including the ranking of offset measures.

- A process for addressing and incorporating offset measures for changes to impact (where these changes are generally consistent with the biodiversity impacts identified for the project, including:

    - Changes to footprint due to design changes.
    - Changes to predicted impacts resulting from changes to mitigation measures.
    - Identification of additional species/habitat through pre-clearance surveys.
    - Additional impacts associated with ancillary facilities.
    - Options for the securing of biodiversity options in perpetuity.

The Biodiversity Offset Strategy is submitted to, and approved by, the Director General and/or Minister prior to the commencement of construction unless otherwise agreed by the Director General or Minister.

8.5.2. Biodiversity Offset Package

The Biodiversity Offset Package identifies the final suite of offset measures to be implemented for the project within two years of the approval of the Biodiversity Offset Strategy. The Biodiversity Offset Package provides details of:

- The final suite of the biodiversity offset measures selected for the project demonstrating how it achieves the requirements and aims of the Biodiversity Offset Strategy (including specified offset ratios or calculations).
- The final selected means of securing the biodiversity values of the offset package in perpetuity including ongoing management, monitoring and maintenance requirements.
- Timing and responsibilities for the implementation of the provisions of the package over time.

Once the Offset Package is approved, Roads and Maritime is required to implement the package according to the timeframes set out in the Package.

9. Conclusions

9.1. Scope of revised assessment

This biodiversity report is an addendum to the Woolgoolga to Ballina Pacific Highway upgrade Environmental Impact Statement (EIS) and biodiversity working paper. The report details supplementary assessment information on biodiversity impacts. The report addresses:

Refinements made to the project design. These design refinements have arisen through the ongoing process of concept design review, consultation, or in response to issues raised during the EIS display.

Ancillary facility sites. This updates the desktop appraisal provided in the EIS, and addresses additional sites identified after the EIS was placed on public exhibition.

A critical review of the EIS biodiversity working paper. (The objective of the review was to identify the confidence in survey effort for threatened species; review the assessment of impacts for threatened species, populations and communities; and provide additional mitigation advice including a discussion on the effectiveness of the proposed mitigation measures). This resulted in supplementary surveys and impact assessment, and an appraisal of the effectiveness of the mitigation measures proposed in the EIS.

These aspects are addressed below.

9.2. Design refinements

The design refinements presented in the Submissions/ Preferred Infrastructure Report (SPIR) are addressed in this biodiversity report.

This involved a desktop appraisal of 27 design refinements to identify likely additional impacts from those reported in the EIS and hence identify the need for more detailed assessment. From this appraisal, 15 design refinements were subsequently assessed in detail including nine locations where supplementary ecological field surveys were conducted.

It was found that the design refinements would have the following likely cumulative impacts across multiple locations:

- A net reduction of 4.6 hectares in the clearing of threatened ecological communities.
- No additional net increase in direct loss of Koala habitat.
- An increase of five hectares in the loss of non-listed vegetation communities.

Looked at individually, the design refinements would result in the following changes from the assessment in the EIS:

- Rest area south of Pine Brush State Forest: The design refinement would reduce the loss of habitat for threatened flora and fauna, and would avoid clearing around 408 *Angophora robur* trees.
- Mororo cutting and Range Road intersection: The design refinements would increase the amount of clearing of native vegetation at the cutting and the intersection. Neither site contains any prominent habitat features or plant species that would not otherwise exist within the adjoining forest system.

Further, there would be minimal impact on fauna connectivity and regional and local wildlife corridors and no change to the location of proposed crossing structures.

- Koala Drive: The design refinement would improve current connectivity for fauna in combination with targeted revegetation.
- Firth Heinz Road: The design refinement would have an overall minor increase in the clearing of threatened ecological communities, but would increase the clearing of the threatened *Angophora robur* by around 181 trees and increase impacts on the habitat of threatened forest fauna.
- The Interchange at Wardell: The design refinement would have a net benefit by significantly reducing the clearing of listed rainforest communities and habitat of the endangered Pink Underwing Moth. It would also reduce the clearing of three threatened plant species. However, there would be increased impacts on a small area of Koala habitat, and on non-listed vegetation communities.
- Rest area north of the Richmond River: The design refinement would see a significant reduction in clearing of potential habitat for Koala and Long-nosed Potoroo and a significant improvement in fauna connectivity through the upgrade and inclusion of fauna connectivity structures.

9.3. Ancillary facility sites

This report addresses the potential biodiversity impacts of the proposed ancillary facility sites, which would be located outside of the project boundary and hence were not addressed in the EIS.

The assessment addressed 59 sites and found that 13 did not require further ecological assessment or field investigations as they were located in cleared land, contained planted exotic gardens or lacked any significant habitat features.

Field surveys were conducted on the remaining 46 sites targeted at threatened species and Threatened Ecological Communities (TSC Act and EPBC Act). The investigation also considered cleared portions of sites where potential habitat for the Hairy Joint Grass (*Arthraxon hispidus*) could occur given the habitat preferences of this species.

A number of sites were found to contain extensive cover of remnant vegetation suitable for threatened species or would be constrained in their use by the presence of both Threatened Ecological Communities and threatened species and therefore were hence identified as unsuitable. These are:

- Section 1: Site 1b and additional site 5.
- Section 2: Site 2.
- Section 5, Additional site 7 and additional site 8.
- Section 10: Site 6.

It was found that the remaining ancillary facility sites would be suitable and would add minimal cumulative impacts to the project. The key reasons for this finding were that:

- Any patches of threatened ecological communities noted were highly modified, with a low natural floristic and structural diversity. In most cases, there is scope to avoid vegetation removal through appropriate planning.
- Vegetation on these sites is generally characterised by scattered small and fragmented patches in low condition or isolated trees that are well represented in the surrounding locality.

- There are scattered low densities of trees with some potential value for providing shelter or nesting resources for wide-ranging and highly mobile fauna species such as the threatened Grey-headed Flying-fox and Swift Parrot. These species are capable of exploiting resources occurring over very large spatial areas. These resources are expected to remain on the site during construction and post-construction so that the current opportunity to use these resources would remain.
- At two sites, there is evidence of low use by koalas. Both sites are positioned adjacent to extensive areas of suitable habitat for koalas suggesting the site is of low importance and may only contribute to a small portion of a home range or be used by dispersing individuals. These habitat features have been noted and would be protected.
- Any small-scale potential impacts resulting from the use of these ancillary facility sites are considered able to be mitigated through appropriate planning and consideration for the ecological values noted in this assessment. Site-specific mitigation measures are proposed in the report.
- The proposed revegetation of a small number of currently cleared sites adjacent to proposed fauna connectivity structures would improve the connectivity around these structures for future use by fauna. This should occur as a minimum within the road reserve, and over the residual areas of the site where the property is owned by Roads and Maritime.

9.4. Supplementary surveys

Some gaps were identified in survey effort due to spatial gaps or timing. As a consequence, the following supplementary flora and fauna investigations were conducted:

- Survey of Lowland Rainforest of Subtropical Australia (Critically Endangered under the EPBC Act).
- Survey of Littoral Rainforest and coastal vine thickets of eastern Australia.
- Survey effort for threatened rainforest flora.
- Survey effort for select threatened flora (non-rainforest).
- Survey during optimal moist conditions and season for cryptic flora.
- Survey to update minor spatial gaps in the project vegetation community mapping.
- Targeted Koala surveys and habitat mapping to address the interim referral advice under the EPBC Act.
- Targeted surveys for the endangered Pink Underwing Moth
- Survey effort for Giant Barred Frog
- Survey effort for Oxleyan Pygmy Perch.

The supplementary surveys confirmed the results and assessment of impacts in the EIS biodiversity working paper. The additional ecological data gathered from these surveys was used in conjunction with the existing data to inform the detailed design in some locations, revise the impact assessment and inform the development of a number of species management plans.

9.5. Supplementary impact assessment

The supplementary impact assessment found that there would be notable changes from the impacts reported in the EIS. These would be:

- A reduction of around 60 per cent in the direct impacts on Lowland Rainforest (EPBC Act), which is also critical habitat for the Pink Underwing Moth.
- A reduction of in the direct impacts on Freshwater Wetlands (TSC Act).
- A considerably reduced impact on Coastal Cypress Pine Forest (TSC Act).
- A considerably reduced impact on Subtropical Coastal Floodplain Forest (TSC Act).
- An overall reduction in the direct impact on threatened ecological communities. Overall, the project would have a reduced impact on threatened ecological communities of around 75 hectares from that reported in the EIS. While most communities would have a reduction in impact, there would be an increased impact on two vegetation communities (Littoral Rainforest and Swamp Sclerophyll Forest On Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregions)
- A revision in the impacts on rainforest plants. For several species, the proportion of the population that would be impacted by the project is now known to be lower than reported in the EIS. In addition, impacts would be further reduced through the design refinement at the interchange at Wardell. However, there remains the potential for indirect impacts on individuals close to the project boundary as described in the EIS. These individuals are generally in habitats where new edges would be created and/or are downslope of the project boundary.

The supplementary impact assessment provides a revised assessment of significance for species where there has been a change from the impacts reported in the EIS (either an increase or decrease in the level of impact) or the supplementary surveys reported an increase in population size. The results from the assessment of significance are consistent with the conclusions in the EIS, with the exception of impacts on the following species, which have been revised to not significant and reflect the design changes and impact avoidance measures:

- Archidendron hendersonii.
- Macadamia tetraphylla.
- Endiandra muelleri subsp bracteata.

The revised assessments of significance reported significant impacts for the following species, which were not identified in the EIS (the changes reflect the additional population data and impacts imposed):

- *Eleocharis tetraquetra*: The project would remove six clusters within the project boundary and there is potential for the remaining five locations to be indirectly impacted. (This population was identified as a result of the targeted supplementary surveys and was not assessed in the EIS.)
- *Quassia sp.* Moonee Creek*:* The project would remove up to 22 per cent of the population and there is potential for the remaining individuals to be indirectly impacted.
- *Acronychia littoralis*: The project would result in direct impacts on a single clonal individual and 0.23 hectares of preferred Littoral Rainforest habitat and around four hectares of marginal habitat. This individual represents a local population, and there have been no other reported locations in the study area.

- Common Planigale: The project would remove 925 hectares of potential habitat for the regional population, which is large. The proportion of this habitat that is actually occupied by local populations of Common Planigale, and the number and distribution of these, is unknown. The small home range of the species may limit the size and distribution of local populations and the loss of habitat would directly affect lifecycle activities, movement and dispersal leading to the potential removal and fragmentation of a number of local populations. The impact is likely to be significant for a number of local populations; however, the long-term impact on the regional population is unknown. In the absence of this information, as a precaution the impact should be considered significant.
- Eastern Pygmy Possum: Impacts to the lifecycle of the species would be particularly evident through the loss of shelter resources (hollows and stumps or dense vegetation) and a direct loss of food resources. For surviving individuals home range movements would be affected as would future dispersal opportunities through the barrier effect of the highway. Edge effects and altered fire has the potential to further affect foraging activities.

The revised assessment also provides an analysis of the potential impacts on threatened terrestrial and aquatic species and ecological communities dependent on groundwater, that could result from the proposed highway cuttings. The assessment identified a small number of high-risk sites, where the impacts before mitigation would cause a potential reduction of groundwater to creeks, streams, springs and local water resources within around 100 metres of the cutting.

These high-risk cutting sites may impact on the habitat of a threatened species including Oxleyan Pygmy Perch or other aquatic species such as the Australian Bittern and Australian Painted Snipe, as well as habitat for important Koala populations. These cuttings may also have potential to impact on an adjoining reserve.

9.6. Supplementary mitigation

The EIS biodiversity working paper presented a strategic mitigation framework that included a biodiversity connectivity strategy and generic mitigation measures for terrestrial and aquatic flora and fauna. These would inform development of the project CEMP and Flora and Fauna Management Plan to be developed post-approval.

The intent of this strategy was also to provide the framework for development of a series of threatened species management plans to document species-specific and site-specific mitigation measures and document a monitoring and adaptive management approach. The threatened species management plans have now been developed as separate document to the supplementary biodiversity assessment and focus on species considered at greatest risk from the project. The supplementary assessment provides a summary of the species-specific mitigation measures from these plans.

A critical review is provided on the fauna connectivity mitigation measures provided in the EIS. This focused on all fauna, and in particular on important Koala populations identified in the study area. The quantity and location of fauna crossing structures was reviewed, including and evaluation of the presence and location of cleared land and whether this may compromise the effectiveness of the crossing strategy. The review discusses the following findings:

- The EIS recognises that the highway would create a barrier for the important population north of the Richmond River and this has been addressed in the connectivity strategy and further supported by design refinements in Section 10.

- Given the constraints with fill heights and the presence of threatened ecological communities and plants, the number of structures proposed for the two identified important Koala populations in section 9 and 10 is considered sufficient. There are no significant gaps in relation to linking habitat patches, with the exception of the area around Kays Road (station 156.3 to 156.9). A recommendation has been made to further consider connectivity in this area during detailed design.
- The distribution of Koala activity for the Woombah sub-population shows an area of habitat with demonstrated low Koala use around 500 metres east of the Pacific Highway between stations 95.7 and 97.1 (Section 5). The range of this sub-population is not well defined and it is likely the existing highway to the west is already a major barrier restricting dispersal and recruitment for the Woombah population.
- The nearest structure to this is a dedicated underpass that has been located north at Station 99.7 to provide connectivity for fauna across an important regional corridor while this structure is appropriately located it leaves a gap between Station 95.7 and Station 97.1 where there are no structures proposed. Much of the land on the western side of the highway in this location is cleared, however there are two possibilities for connectivity which should be considered further in the detailed design.
- The EIS recognised that some cleared land occurs adjacent to proposed crossing structures and discussed the need to restore connectivity where possible through strategic revegetation in these areas.
- Of the 112 dedicated and combined connectivity structures proposed, 79 structures (70 per cent) would adjoin vegetation on both sides of the road. The remaining structures would adjoin cleared land on at least one side of the road, although their effectiveness is not expected to be compromised due to the targeted fauna species and their habitat preferences.
- The remaining 18 per cent (20 structures) would require additional strategic revegetation in the road reserve to improve their effectiveness, as proposed in the EIS. It is worth noting that, of these 20 structures, seven are targeted at Rufous Bettong and Brush-tailed Phascogale, which are both known to utilise cleared and modified land in the study area. These structures may therefore retain some suitability for these species without revegetation.

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Appendix A. Summary of critical review of biodiversity working paper

Table 18 Review and recommendations for specific threatened entities (survey effort and method, assessment of significance and mitigation) and details of supplementary surveys conducted

Threatened Entity	Listed status	Review outcomes
Sandstone Rough Barked Apple (*Angophora robur*)	**TSC V EPBC V**	**Survey effort and method** The species was initially identified in 2009 in Section 3and 4 and the distribution of the population mapped within proximity to the route options and final preferred route. General observations of the distribution of Angophora robur in the study area indicated that the species most commonly occurred on the Sommervale Range and Richmond Range landscape units (Mitchell 2003). In relation to the project route, these units are restricted to Section 3 and 4. The distribution of the species was initially mapped at a fine scale following extensive ground truthing along the footslopes of the Sommervale Range between Pillar Valley and Tyndale within proximity to the preferred route alignment though section 3 and 4 of the project. The extent of each of the populations was mapped using a handheld GPS identifying the approximate edge of the distribution of the species, as well as recording point data for individual plants and groups of trees. This data was then reviewed for the EIS gap assessment and the need for additional surveys were identified to inform the impact assessment, specifically to gain appreciation of the population size and extent. Further targeted surveys were conducted in 2010 and 2011 using the following tasks: 1. Targeted survey of the local area in the vicinity of Tucabia-Tyndale (Section 3 and 4) to determine the distribution and population size of Angophora robur. This includes up to 500 m from the corridor. 2. Mark the perimeter of the population using GPS and use field based assessment to calculate population density and size 3. Model the predictive distribution in the locality based on environmental attributes considered influential to the distribution of Angophora robur (see below) 4. Gather further data on the regional population, to include in predictive modelling of the entire regional population. This involved targeted surveys along the alignment in appropriate habitats as well as broader regional surveys to the west of the project. Surveys for this species have been very comprehensive and we are confident that we have gathered a detailed understanding of the project distribution and habitat requirements of this species. Further survey work to the east of the population beyond 500 metres of the project and on the eastern side of the Sommervale Range would potentially increase knowledge of the size of the local population, although this is unlikely to change the outcome of the AoS. **Assessment of Significance** The assessment of impacts for this species reviewed the size and distribution of the local population (Section 3 and 4 of the project and beyond) and the distribution and current known size of two other populations in the region. The assessment considered the local population in the context of the maximum dispersal of pollinators and the fact that the subject population is at the eastern limit. Direct impact is around 5-7% of the population,

Threatened Entity	Listed status	Review outcomes
		based on current knowledge and the project impacts considered have reached a significance threshold considering a large proportion of the remaining population will remain close the project edge. **Options Selection** The route options selection for the Wells Crossing to Iluka road project compared four short-listed route options by considering in the broad context impacts on: ■ Endangered ecological communities ■ Habitat for flora and fauna, focused on threatened species including habitat for Angophora robur ■ Key habitats (conservation reserves and state forests) ■ Wildlife corridors ■ SEPP 14 wetlands The Green and Red Options to the east were identified as having very high impacts on ecological values. The Green option (preferred route) had comparatively lower impacts on ecological values, however did recognise the unique ecological values of the sandstone escarpment along the Pillar Valley / Sommervale Range and therefore was designed to skirt the lower footslopes of the western side of the range and avoid substantially large areas of sandstone geology attributed to the Angophora robur population. **Mitigation Measures** The Biodiversity Working Paper presented a management framework to inform development of a project CEMP and Flora and Fauna Management Plan. Mitigation for Angophora robur included ■ Identifying exclusion zones around important habitat and individual trees close to the construction zone ■ Management of run-off and erosion ■ Weed Management ■ Pathogen Management ■ Re-establishment of native vegetation in areas disturbed by construction Refer discussion above the table for outline of the detailed management plans being prepared and background on suitability of the mitigation measures in addition to methods for monitoring effectiveness as part of an adaptive management approach. Information that addresses a review of effectiveness aims to build on the previous discussion in the working paper (Section 5.2.4). Angophora robur is addressed in the Threatened Plants Management Plan which addresses a species specific approach to management dealing directly with the populations identified in the EIS.
Square-fruited Ironbark (*Eucalyptus*	**EPBC V**	**Survey effort and method** The project length is over 155 kilometres and vegetation was classified into 57 different plant communities and 24 Biometric vegetation types. The

Threatened Entity	Listed status	Review outcomes
tetrapleura)	**TSC V**	vegetation community data was collected initially during the preferred route work with follow up surveys during the EIS targeting gaps. The gap assessment conducted as the first stage of the EIS identified some inaccuracies with the vegetation data including spatial gaps and misidentification of some vegetation types. At the time of the initial preferred route work the OEH Biometric vegetation types database had not been released. As a result considerable effort was taken in the field particularly in Section 1-2 and 9-11 to ground-truth the vegetation data and re-classify according to Biometric vegetation types. The data presented is considered comprehensive and expected to have a high level of accuracy, however it is acknowledged that some inaccuracies may be present at a small scale which is inevitable with a project of this scale. Floristic surveys were stratified by biophysical attributes (geology, elevation, soil type) followed by vegetation structure (forest, woodland, heath, modified) and then floristics. The floristic aspect was based on the initial vegetation types mapped in the preferred route studies, as the biometric classification was not completed until later in the EIS process. The potential presence of Eucalyptus tetrapleura was also considered based on extensive experience by the authors in Glenugie state forest gathered for the Glenugie Upgrade. Comprehensive regional surveys were conducted for this project and the information used to inform the potential presence of the species in targeted surveys. **Assessment of Significance** Details on the size and distribution of the local population are well documented for this species and gathered from this project but also the previous Glenugie upgrade which had a proportionally larger impact. The local population is estimated at around c.160,000 trees of which around 0.8% of the population would be directly impacted by this project. In the vicinity of the population the upgrade will be a duplication of the existing highway and much of the remaining population is contained in state forest tenure as well as edge affected areas of Wells Crossing flora Reserve. The direct and indirect impacts were considered insignificant ■ The areas to be impacted occurred on lands of moderate conservation value and were considered unlikely to play an important role in maintaining the long-term viability of the local population. ■ the size of the local population and low geographic extent of the impact ■ The size and abundance of broader regional populations, including the reservation status, ■ the resilience of the species against anthropogenic disturbances as evidence by regular fire and logging in Glenugie State Forest suggesting low sensitivity. ■ Pollinators for this species include invertebrates which are unlikely to be negatively impacted by the widening of the highway as evidence of stands of trees presently on both sides of the highway ■ The large majority of the population occurs on the eastern side of the highway and impacts from fragmentation would be unlikely. Impacts from the Glenugie project were discussed to provide context to the size of the regional population and address cumulative impacts on the population, however this former project was not considered in reaching the conclusions of the AoS. **Mitigation Measures** Refer discussion above the table for outline of the detailed management plans being prepared and background on suitability of the mitigation measures in addition to methods for monitoring effectiveness as part of an adaptive management approach. Information that addresses a review of effectiveness aims to build on the previous discussion in the working paper (Section 5.2.4).

Threatened Entity	Listed status	Review outcomes
		Eucalyptus tetrapleura is addressed in the Threatened Plants Management Plan which addresses a species specific approach to management dealing directly with the populations identified in the EIS.
Weeping Paperbark (*Melaleuca irbyana*)	**TSC E**	**Survey effort and method** The summary of survey effort for flora provided in Table 2-7 of the working Paper only documents the methods used for this species at New Italy given the finding of an important population at this location. Detailed investigations involved total counts and estimates of abundance were conducted at this site. Due to this focus the table has unintentionally omitted information concerning the methods for overall targeted surveys conducted for this species along the remainder of the project. Floristic surveys were stratified by biophysical attributes (geology, elevation, soil type) followed by vegetation structure (forest, woodland, heath, modified) and then floristics. The floristic aspect was based on the initial vegetation types mapped in the preferred route studies, as the biometric classification was not completed until later in the EIS process. The potential presence of Melaleuca irbyana was considered in the targeted surveys as occurring in up to 14 biometric types as described in Table 2-7. Searches for this species were conducted continuously while traversing all properties and potential habitats along the project corridor. These surveys were conducted over a period of 117 days for the initial preferred route and EIS surveys. Following this a Supplementary Biodiversity Assessment (SBA) was conducted. One of the objectives of the SBA was to critically assess survey effort for all threatened species and identify the need for additional surveys. The project GIS was used to assess sampling effort and identify gaps for all species including Melaleuca irbyana. This spatial analysis used data on the vegetation types mapped along the project footprint, with stratification based on Biometric vegetation types as well as biophysical attributes. The vegetation / habitat data was overlaid with the flora survey locations and gaps were identified where a particular Biometric vegetation type appeared under-represented in the sampling effort for each of the target species or a particular location. While Melaleuca irbyana was not identified as requiring additional targeted surveys, several plant species were. As such additional targeted surveys were conducted over a period of 14 days by three botanists focused on spatial gaps. The survey effort for this species is considered sufficient at sampling all stratification units and achieving representativeness and further surveys are not required to inform the assessment of impacts. **Assessment of Significance** Agreed. The AoS has indicated a likely significant impact to the local population at New Italy. The conclusion for this assessment is missing from Table 6-1.
Slender Screw Fern (*Lindsaea incisa*)	**TSC E**	**Survey effort and method** The stated uncertainties relate to counting abundance not survey effort. One of the objectives of the SBA was to critically assess survey effort for all threatened species and identify the need for additional surveys.

Threatened Entity	Listed status	Review outcomes
		The project GIS was used to assess sampling effort and identify gaps for all species including Lindsaea incisa. This spatial analysis used data on the vegetation types mapped along the project footprint, with stratification based on Biometric vegetation types as well as biophysical attributes. The vegetation / habitat data was overlaid with the flora survey locations and gaps were identified where a particular Biometric vegetation type appeared under-represented in the sampling effort for each of the target species or a particular location. Lindsaea incisa was identified as requiring additional survey effort to target any spatial gaps from the initial stratification and sampling method. As such additional targeted surveys were conducted over a period of 14 days by three botanists focused on spatial gaps. The fact that an additional population was identified in Section 3 as part of the supplementary surveys, suggest that all gaps were addressed and the species has been surveyed sufficiently. The survey effort for this species is considered sufficient at sampling all stratification units and achieving representativeness and further surveys are not required to inform the assessment of impacts. **Mitigation Measures** Refer discussion above the table for outline of the detailed management plans being prepared and background on suitability of the mitigation measures in addition to methods for monitoring effectiveness as part of an adaptive management approach. Information that addresses a review of effectiveness aims to build on the previous discussion in the working paper (Section 5.2.4). Lindsaea incisa is addressed in the Threatened Plants Management Plan which addresses a species specific approach to management dealing directly with the populations identified in the EIS.
Maundia triglochinoides	**TSC V**	**Survey effort and method** The body of work completed for the preferred route studies were conducted over an extended timeframe which included sampling in all seasons, although some locations were only surveyed in cooler months. Additional surveys were deemed to be required to capture warm season flora including some cryptic or seasonally dependent species. This was identified in the original gap assessment for the Working Paper (Section 2.3.4). Hence targeted surveys for cryptic flora were conducted in December 2011. The targeted surveys were aimed at swamp forest species and ephemeral drainage lines, as well as summer flowering cryptic species. Refer to Table 2-2 of the working paper which summarises the findings of a critical review of the preferred route ecological assessments and identified that further surveys were required for cryptic summer flowering threatened flora species to identify and map the extent of the populations affected by the project, particularly sections 6-8 One of the review comments from EPA on the Biodiversity Assessment suggested that the conditions during the surveys for the preferred route were dry. As such this limitation was addressed in the Supplementary Assessment by further targeting cryptic plant species particularly those favouring wetlands or ephemeral drainage lines given the more favourable wetter conditions over 2010-2012. This included Maundia triglochinoides, Phaius australis, Eleocharis tetraquetra, Lindsaea incisa, Prostanthera cineolifera, and Prostanthera palustrus. All these species share similar habitats and were targeted at the same time. Table 4-8 of the Supplementary Assessment highlights the range of habitats and species targeted. The addition of targeted surveys for Lowland Rainforest communities as completed in the Supplementary Assessment this also

Threatened Entity	Listed status	Review outcomes
		allowed further opportunity to search for cryptic species such as Oberonia titania and Tinospora tinosporoides. With the completion of the preferred route studies and additional targeted surveys for the EIS and then Supplementary Biodiversity Assessment there is a moderate level of confidence for the targeted survey and assessment of cryptic species. **Assessment of Significance** Conclusions for AoS are provided in the tables in Chapter 6 of the Working Paper, including Maundia triglochinoides. **Suitability of Mitigation Measures** Refer discussion above the table for outline of the detailed management plans being prepared and background on suitability of the mitigation measures in addition to methods for monitoring effectiveness as part of an adaptive management approach. Information that addresses a review of effectiveness aims to build on the previous discussion in the working paper (Section 5.2.4). Maundia triglochinoides is addressed in the Threatened Plants Management Plan which addresses a species specific approach to management dealing directly with the populations identified in the EIS.
Four-tailed Grevillea (*Grevillea quadricauda*)	**TSC V** **EPBC V**	**Survey effort and method** The species favours sandy soils or gravelly loam, with potential habitat expected to be limited to less than 20% of the project impact area. Within this potential area, two populations were identified and mapped. **Targeted surveys were conducted for the preferred route studies as well as the EIS and supplementary investigations.** The extensive hours spent surveying and mapping Angophora robur in the same habitat types along the footslopes of the Sommervale Range from Pillar Valley to Tyndale allowed for further opportunity to identify this species. The survey effort for this species is considered sufficient at sampling all potential stratification units and achieving representativeness and further surveys are not required to inform the assessment of impacts. **Assessment of Significance** The Working Paper indicates a significant impact on the smaller northern population consisting of 8 individuals. Also suggests that in the absence of any additional occurrences of Grevillea quadricauda within 500 metres of the northern population that the southern and northern populations should be considered separate local populations and were assessed as separate populations. Note we have only surveyed the project corridor and adjacent areas, and there are substantial areas of potential habitat occur in the wider locality, so the broader status of the species unknown. The AoS concludes that the project would have a significant impact on the northern population but not the southern population. Of the southern population (around 200 plants) approximately 1.3% of the area occupied by the species would be directly impacted, with much of the remainder of the population occurring at greater than 200 metres to the east and upslope from the site. The assessment considered indirect impacts to be low on the remaining plants. **Micro-alignment Measures** The need for micro-alignment adjustments here should factor in the likelihood that more plants could occur in adjacent areas further away from the project corridor and that the surveys concentrated on the project corridor and immediately adjacent areas. If more plants occur, than the size of the

Threatened Entity	Listed status	Review outcomes
		local populations may change including the potential linking of the northern and southern populations as one. Also any design refinement is still likely to leave the smaller northern population adjacent to the alignment and within the potential zone of indirect impacts. **Mitigation Measures** Refer discussion above the table for outline of the detailed management plans being prepared and background on suitability of the mitigation measures in addition to methods for monitoring effectiveness as part of an adaptive management approach. Information that addresses a review of effectiveness aims to build on the previous discussion in the working paper (Section 5.2.4). Grevillea quadricauda is addressed in the Threatened Plants Management Plan which addresses a species specific approach to management dealing directly with the populations identified in the EIS.
Singleton Mint Bush (*Prostanthera cineolifera*)	**EPBC V** **TSC V**	**Suitability of Mitigation Measures** Refer discussion above the table for outline of the detailed management plans being prepared and background on suitability of the mitigation measures in addition to methods for monitoring effectiveness as part of an adaptive management approach. Information that addresses a review of effectiveness aims to build on the previous discussion in the working paper (Section 5.2.4). Prostanthera cineolifera is addressed in the Threatened Plants Management Plan which addresses a species specific approach to management dealing directly with the populations identified in the EIS.
Water Nutgrass (*Cyperus aquatilis*)	**TSC E**	**Survey effort and method** The dates for targeted threatened flora surveys are provided in Table 2-5 of the Working Paper. This includes a total of 117 days over multiple seasons. Table 2-7 in the Working Paper only identifies the last survey effort for the EIS and not the preferred route studies and so is incorrect at describing the total survey effort. An additional 17 days have also been spent surveying for this species in targeted areas during the supplementary work. Floristic surveys were stratified by biophysical attributes (geology, elevation, soil type) followed by vegetation structure (forest, woodland, heath, modified) and then floristics. The floristic aspect was based on the initial vegetation types mapped in the preferred route studies, as the biometric classification was not completed until later in the EIS process. One of the review comments from EPA on the Biodiversity Assessment suggested that the conditions during the surveys for the preferred route were dry. As such this limitation was addressed in the Supplementary Assessment by further targeting species favouring wetlands or ephemeral drainage lines given the more favourable wetter conditions over 2010-2012. This included Cyperus aquatilis. With the completion of the preferred route studies and additional targeted surveys for the EIS and then Supplementary Biodiversity Assessment there is a moderate level of confidence for the targeted survey and assessment of this species **Suitability of Mitigation Measures** Refer discussion above the table for outline of the detailed management plans being prepared and background on suitability of the mitigation measures in addition to methods for monitoring effectiveness as part of an adaptive management approach. Information that addresses a review of

Threatened Entity	Listed status	Review outcomes
		effectiveness aims to build on the previous discussion in the working paper (Section 5.2.4). Cyperus aquatilis is addressed in the Threatened Plants Management Plan which addresses a species specific approach to management dealing directly with the populations identified in the EIS.
Hairy-joint Grass (*Arthraxon hispidus*)	**EPBC V** **TSC V**	**Survey effort and method** The species was targeted in the preferred route studies although not recorded probably as a result of the drier and cooler conditions. This was identified as a gap at the start of the EIS and subsequent targeted surveys were conducted as part of the EIS and then Supplementary Assessment. Two surveys were initially conducted in the summer season 2011-12 (8 days in total) and recorded quite different distributions leading to combining habitat polygons in the spatial mapping and conservatively overestimating the area of potential habitat surrounding each population to account for potential habitat. The surveys targeted cleared grassland in low-lying wet sites along the edges of rainforest and wet eucalypt forest in Sections 1-2 and 10-11 which represent the most likely occurrence of the species. Targeted surveys were not conducted in rainforest These populations were found in lightly grazed paddocks. The AoS conclusions were based on the populations identified as well as potential habitat to account for changes in the distribution and abundance over time. Further surveys are planned during detailed design and as part of the monitoring and offset program. **Micro-Alignment Measures** Design refinement completed around Coolgardie Road as part of the SPIR. Impacts on Arthraxon hispidus habitat have been reduced from those presented in the EIS. Revised down from 10.4 ha to 5.5 ha. **Suitability of Mitigation Measures** Refer discussion above the table for outline of the detailed management plans being prepared and background on suitability of the mitigation measures in addition to methods for monitoring effectiveness as part of an adaptive management approach. Information that addresses a review of

Threatened Entity	Listed status	Review outcomes
		effectiveness aims to build on the previous discussion in the working paper (Section 5.2.4). Where proposed measures are uncertain, the approach is to monitor the effectiveness and adapt management response where required. Arthraxon hispidus is addressed in the Threatened Plants Management Plan which addresses a species specific approach to management dealing directly with the populations identified in the EIS The Roads and Maritime have purchased the property where these populations have been found and it is likely to be incorporated as an offset site.
White Lace Flower		**Survey effort and method** Considered to be restricted to the lowlands of the Richmond catchment. Targeted surveys were conducted in rainforest vegetation in riverine flats and lowland areas in Section 10 and 11 and are considered to have been surveyed extensively, from the original preferred route studies, the EIS targeted surveys and more recently the Supplementary Biodiversity Assessment. This species was identified in the Supplementary Assessment critical review and gap assessment for sections 1, 3 and 10. The project GIS was used to assess sampling effort and identify any gaps in survey effort. This spatial analysis used data on the vegetation types mapped along the project footprint, with stratification based on Biometric vegetation types as well as biophysical attributes. The vegetation / habitat data was overlaid with the flora survey locations and gaps were identified where a particular Biometric vegetation type appeared under-represented in the sampling effort for each of the target species or a particular location under surveyed. Archidendron hendersonii was identified as requiring additional survey effort to target any spatial gaps from the initial stratification and sampling method. As such additional targeted surveys were conducted over a period of 14 days by three botanists focused on spatial gaps. An additional 9 plants were recorded outside the project corridor and are report in Table 4-5 of the supplementary report. There were no property access constraints along the project corridor. The comment relating to property access in the Supplementary Assessment refers to opportunities to survey beyond the project footprint to determine if local populations occur in the broader locality. These opportunities were restricted by property access, as only properties along the project corridor were contacted and accessed. This is not considered a limitation to understanding the impacts of the project footprint. With the completion of the preferred route studies and additional targeted surveys for the EIS and then Supplementary Biodiversity Assessment there is a high level of confidence for the targeted survey and assessment of this non-cryptic species. **Species Specific Mitigation Measures** Refer discussion above the table for outline of the detailed management plans being prepared and background on suitability of the mitigation measures in addition to methods for monitoring effectiveness as part of an adaptive management approach. Information that addresses a review of effectiveness aims to build on the previous discussion in the working paper (Section 5.2.4). White Laceflower is addressed in the Rainforest Communities and Threatened Rainforest Plants Management Plan which addresses a species specific approach to management dealing directly with the populations identified in the EIS.
Stinking Cryptocarya	**TSC**	Refer discussion above the table for outline of the detailed management plans being prepared and background on suitability of the mitigation

Threatened Entity	Listed status	Review outcomes
(*Cryptocarya foetida)*	**V** **EPBC V**	measures in addition to methods for monitoring effectiveness as part of an adaptive management approach. Information that addresses a review of effectiveness aims to build on the previous discussion in the working paper (Section 5.2.4). Cryptocarya foetida is addressed in the Rainforest Communities and Threatened Rainforest Plants Management Plan which addresses a species specific approach to management dealing directly with the populations identified in the EIS.
Rusty Rose Walnut (*Endiandra hayesii)*	**TSC V** **EPBC V**	Refer discussion above the table for outline of the detailed management plans being prepared and background on suitability of the mitigation measures in addition to methods for monitoring effectiveness as part of an adaptive management approach. Information that addresses a review of effectiveness aims to build on the previous discussion in the working paper (Section 5.2.4). Endiandra hayesii is addressed in the Threatened Plants Management Plan which addresses a species specific approach to management dealing directly with the populations identified in the EIS.
Green-leaved Rose Walnut (*Endiandra muelleri subsp. bracteata)*	**TSC E**	**Survey effort and method** The Recovery Plan for this species documents potential habitat as lowland subtropical or warm temperate rainforest or potentially wet eucalypt forest on alluvium or poor quality basaltic soils. In terms of potential habitat in the study area this equates to around 12 hectares predominantly within Section 10, with very small patches in Section 2 and Section3 and is notably absent from Section 5 within the project area. The working paper describes confirmation of the species in Section 5 and Section 10, it was actually only confirmed in Section 10 and the mention of confirmation in Section 5 actually relates to records of the species in the NSW Atlas around the Maclean area along the Clarence River to the west of the project. Just to confirm, the species has not been identified in or surrounding the project in Section 5. The stratified surveys conducted for the preferred route studies, EIS and supplementary studies specifically targeted rainforest communities to cover the potential habitat for this species and several other threatened rainforest species known from the region. This included low-lying, flood plain and alluvium and basalt soils and focused around the Clarence and Richmond River floodplains. We are confident that the vegetation and presence of threatened species in Section 5 has been identified with a high level of confidence. The OEH website (threatened species profiles database) links the species to 7 different vegetation classes and 10 biometric types as reported in the Appendix M of the working paper. The information is questionable and likely to overestimate the area of potential habitat for this species, and contradicts the recovery plan. For example the database links the species to a number of dry sclerophyll forest types on coastal hills and ranges such as Blackbutt grassy open forest, Tallowwood dry grassy forest and Turpentine moist open forest. The species is not expected from these habitat types. Section 5 has the least area of natural vegetation and most heavily cleared section of the entire project. According to the OEH threatened species profile potential habitat in section 5 would include Tallowwood dry grassy forest of the far northern ranges (11.2 ha), from which the species is unlikely to occur and 11.8 ha of swamp oak swamp forest, due to suitable soils types although the habitat is marginal. Nonetheless targeted surveys were conducted in both habitats and are described in Table 2-5 (working paper) which included a total of 37 days of targeted flora surveys across Sections 3-5. An additional 5 days was spent covering any spatial gaps in Section 3-5 during the supplementary assessment.

Threatened Entity	Listed status	Review outcomes
		Around 1.4 ha of suitable habitat occurs near the Range Road (Section 2) intersection which was the subject of a detailed investigation as part of the design refinement at this location. Suitable rainforest communities on alluvium and basalt soils were comprehensively surveyed for this project due to their small size and restricted distribution. This work was identified as a gap at commencement of the EIS and therefore targeted at the start of the program as well as targeted again in the supplementary assessment to address further spatial gaps and new information from the EPBC Act listing. The overall survey effort for Section 8-11 was broken down into two main surveys; the first totalled 72 person hours across 25 traverses on targeted habitats and the second totalled 68 hours across 14 rainforest sites. Random meanders were traversed (at transect lengths 199-2200 metres) and timed for 10-110 minutes, conducted over 8 days. Surveys were undertaken at targeted locations within representative areas of vegetation communities in the study area. Survey sites and transects include: o West of the Pacific Hwy and Bruxner Hwy junction – Ballina (ch:164300-163900) Section 11. o Multiple sites from Mc Andrews Lane (Pimlico) to south Coolgardie (ch:155700-159800) Section 10-11. o Several sites at south Coolgardie (ch:154500-155000) Section 10 o Wardell Road (Wardell) (ch:152800) Section 10 o Thurgates Lane (Wardell) (ch:151100) Section 10. o Old Bagotville Road (Wardell) (ch:149800) Section 10. o Several sites near Back Channel Road (Wardell) (ch:146000-146700) Section 10 o Several sites near Richmond Street (Broadwater), west of Broadwater NP (ch:144600-144900) Section 9 This species was identified as requiring additional survey effort to target any spatial gaps from the initial stratification and sampling method (refer Appendix B supplementary report). As such additional targeted surveys were conducted over a period of 14 days by three botanists focused on spatial gaps and reported in the supplementary assessment. These surveys were conducted beyond the road corridor and found additional threatened plants thereby increasing our knowledge of local populations size and impacts. For example originally only 8 individuals were reported in the EIS, and an additional 36 plants were later identified from the supplementary surveys over a much wider area beyond the project corridor. This fact suggests that all gaps were addressed and the species has been surveyed sufficiently. With the completion of the preferred route studies and additional targeted surveys for the EIS and then Supplementary Biodiversity Assessment there is a high level of confidence for the targeted survey and assessment of this non-cryptic species **Species Specific Mitigation Measures** Refer discussion above the table for outline of the detailed management plans being prepared and background on suitability of the mitigation measures in addition to methods for monitoring effectiveness as part of an adaptive management approach. Information that addresses a review of effectiveness aims to build on the previous discussion in the working paper (Section 5.2.4). Endiandra muelleri ssp bracteata is addressed in the Threatened Plants Management Plan which addresses a species specific approach to

Threatened Entity	Listed status	Review outcomes
		management dealing directly with the populations identified in the EIS.
Rough-shelled Bush Nut (*Macadamia Tetraphylla)*	**EPBC V** **TSC V**	**Assessment of Significance** Will be revised in the Supplementary Report. Impacts on this species have been reduced significantly as a result of the design refinement at Coolgardie Road (Section 10). Direct impacts reduced from 37 individuals to 1 individual. **Mitigation Measures** Refer discussion above the table for outline of the detailed management plans being prepared and background on suitability of the mitigation measures in addition to methods for monitoring effectiveness as part of an adaptive management approach. Information that addresses a review of effectiveness aims to build on the previous discussion in the working paper (Section 5.2.4). Macadamia tetraphylla is addressed in the Rainforest Communities and Threatened Rainforest Plants Management Plan which addresses a species specific approach to management dealing directly with the populations identified in the EIS. Design refinement completed around Coolgardie Road as part of the SPIR. Impacts on Macadamia tetraphylla reduced from 37 down to 1 individual
Red-flowered King of the Fairies (*Oberonia titania)*	**TSC V**	**Survey effort and method** A single plant was recorded at Norton's Road (Section 7) by Andrew Benwell in 2006 and was considered unlikely to represent a viable population. This plant was recorded during the winter 2005 survey but was not relocated during a follow-up summer 2006 survey (Benwell 2006) and was considered possibly destroyed by heavy rain. The preferred route study for Iluka Road to Woodburn (Benwell 2006) therefore identified the need for a further targeted survey of this species between New Italy and Gap Road (Section 7) to ascertain whether Oberonia titania is present elsewhere given the previous record. This was identified as a requirement in the gap assessment conducted at commencement of the EIS (Table 2-3 working paper). The coordinates of the original location were obtained and targeted surveys were conducted at this site and surrounding area in 2012 for the EIS, however it was found not to be present, hence it was not mapped in the EIS. Only one plant was recorded from this 2005 survey over 50-100 metres from the existing road where it would be unlikely to be impacted. There were no restrictions to access A second population of Oberonia titania was identified on the Tillsley property in the northern section of Wardell Heath and to the west of the Wardell township (Section 10) by Biosis in 2006, consisting of around 30 plants. As a result of this find the alignment was moved to the west and outside the swamp sclerophyll forest habitat to reduce the impacts on the population of Oberonia titania. This property was no longer affected by the proposal and therefore access restricted. Targeted searches were conducted in the revised project alignment for the EIS (9 days) and Supplementary assessment (5 days) in sections 9-11 (EIS). These surveys focused on the new refined alignment and did not revisit the original property where the population was found, as it was now outside the project footprint. No new populations were found The total area of potential habitat for this species impacted by the total project comprises over 100 hectares of swamp sclerophyll forest and rainforest, and there is an additional 100 hectares of floodplain forest of which some areas may have suitable habitat attributes for Oberonia titania.

Threatened Entity	Listed status	Review outcomes
		Targeted surveys were conducted across all suitable habitats as described in the working paper. Although targeted searches were conducted in most areas of suitable habitat there is potential for other small populations to be present considering the epiphytic nature of the species and the potential for plants to be high in the canopy and the small and cryptic habit of the species. **Species Specific Mitigation Measures** Refer discussion above the table for outline of the detailed management plans being prepared and background on suitability of the mitigation measures in addition to methods for monitoring effectiveness as part of an adaptive management approach. Information that addresses a review of effectiveness aims to build on the previous discussion in the working paper (Section 5.2.4). Oberonia titania is addressed in the Threatened Plants Management Plan which addresses a species specific approach to management dealing directly with the populations identified in the EIS.
Peristeranthus hillii - Orchid	**TSC V**	**Survey effort and method** Identified in Table 3-21 9working paper) as 7 records with 10 km of the project and identified as low chance of occurring in sections 1-7 and moderate likelihood of occurring in sections 8-11 due to the known presence of littoral and lowland rainforest. Indeed the species profile identified in the OEH website indicates the species is restricted to littoral rainforest on aeolian sands and lowland rainforest and links the species to ■ Black Bean – Weeping Lilly Pilly riparian rainforest of the north coast ■ Coastal floodplain sedgelands, rushlands and forblands ■ Hoop Pine Yellow Tulipwood dry rainforest ■ White booyong – fig subtropical rainforest ■ And also adjoining areas of swamp oak floodplain forest The rainforest habitats comprise around 13 hectares and were comprehensively surveyed as described a number of times in this commentary, including supplementary investigations. Swamp oak forest (56 ha) is spread across 8 of the 11 project sections in small fragmented and disturbed patches typically surrounding by cleared farmland. All locations intersected by the project were surveyed and the vegetation type was not identified in the gap assessment fort the supplementary surveys are requiring additional targeted surveys for this species. With the completion of the preferred route studies and additional targeted surveys for the EIS and then Supplementary Biodiversity Assessment there is a high level of confidence for the targeted survey and assessment of this species. An assessment of significance was conducted for this species and identified 'a moderate likelihood of occurring throughout the project boundary in suitable habitats of sandstone sclerophyll forests' this text is considered an error. **Assessment of Significance** Not required, AoS **Species Specific Mitigation Measures** Refer discussion above the table for outline of the detailed management plans being prepared and background on suitability of the mitigation

Threatened Entity	Listed status	Review outcomes
		measures in addition to methods for monitoring effectiveness as part of an adaptive management approach. Information that addresses a review of effectiveness aims to build on the previous discussion in the working paper (Section 5.2.4). Peristeranthus hilli is addressed in the Threatened Plants Management Plan which addresses a species specific approach to management dealing directly with the populations identified in the EIS. If trees have been felled, that would be a post-clearance inspection, is the reviewer suggesting salvaging the orchids from trees cleared for construction?
Square-stemmed Olax (*Olax angulata)*	**TSC V**	**Survey effort and method** The survey summary for this species reported in Appendix M of the working paper only describes the targeted survey conducted in Section 1-2, and this relates to the method for surveying around the known location of the species to determine if there is a wider population. Further information on targeted surveys conducted across the remainder of the project has not been described here and should have been. The potential habitat of the species is referred to in Appendix M of the working paper as being reported in small patches of moist and wet habitat across all project sections particularly in drainage depressions. Targeted surveys were actually conducted in suitable habitat across all project sections as described for threatened species searches in general. There a very few no occurrences (records of this species and in the study area these are closest to sections 1-2. One of the review comments from EPA on the Biodiversity Assessment suggested that the conditions during the surveys for the preferred route were dry and this may have affected the presence of moisture dependent species such as *O.angulata*. As such this limitation was addressed in the Supplementary Assessment by further targeted surveys particularly for species favouring wetlands or ephemeral drainage lines given the more favourable wetter conditions over 2010-2012, this included Olax angulata. **Assessment of Significance** Further survey not expected to be required Commonwealth AoS missing and to be provided in the Supplementary Biodiversity Assessment report
Red Lilly Pilly (*Syzygium hodgkinsoniae)*	**TSC V**	**Survey effort and method** The species profile indicates this species is restricted to littoral and lowland rainforest on alluvium or basaltic soils. Within the study area this equates to around 12 hectares in total or around 1.2 % of the vegetation in the corridor. Given the known presence of lowland rainforest in the study area considerable effort was given to conducting comprehensive targeted surveys for rainforest communities and rainforest plants across Sections 1, 3 and 10 where potential habitat was identified. This included a suite of surveys conducted for the preferred route studies and EIS. Red Lilly Pilly was identified as requiring additional survey effort to target any spatial gaps from the initial stratification and sampling method (refer Appendix B supplementary report). As such additional targeted surveys were conducted over a period of 14 days by three botanists focused on spatial gaps and reported in the supplementary assessment. These surveys were conducted beyond the road corridor and found additional

Threatened Entity	Listed status	Review outcomes
		threatened plants thereby increasing our knowledge of local populations size and impacts. For example Syzygium hodgkinsoniae was originally identified as 1 individual, and an additional 7 plants were later identified from the supplementary surveys. This fact suggests that all gaps were addressed and the species has been surveyed sufficiently. The survey effort for this species is considered sufficient at sampling all stratification units and achieving representativeness and further surveys are not required to inform the assessment of impacts. **Assessment of Significance** Revised assessment of significance to be included in the supplementary report to account for larger population size **Design refinement** A design refinement was completed around Coolgardie Road as part of the SPIR, with the specific objective of reducing impacts on lowland rainforest habitat on basalt soils. This micro-alignment change has seen a reduction in impact from 6.4 hectares to 1.2 hectares.
Scented Acronychia (*Acronychia littoralis*)	**EPBC E1 TSC E**	Additional targeted surveys required
Swamp Foxglove *(Centranthera cochinchinensis)*	**TSC E**	**Survey effort and methods** The body of work completed for the preferred route studies were conducted over an extended timeframe which included sampling in all seasons, although some locations were only surveyed in cooler months and during drier periods which may not have suited this species. Additional surveys were deemed to be required to capture warm season flora including some cryptic or seasonally dependent species. This was identified in the original gap assessment for the Working Paper (Section 2.3.4). Hence targeted surveys for cryptic flora were conducted in **December 2011 (within the appropriate flowering season)**. The targeted surveys were aimed at swamp forest species and ephemeral drainage lines, as well as summer flowering cryptic species. Refer to Table 2-2 of the working paper which summarises the findings of a critical review of the preferred route ecological assessments and identified that further surveys were required for cryptic summer flowering threatened flora species to identify and map the extent of the populations affected by the project, particularly sections 6-8 One of the review comments from EPA on the Biodiversity Assessment suggested that the conditions during the surveys for the preferred route were dry. As such this limitation was addressed in the Supplementary Assessment by further targeting cryptic plant species particularly those favouring wetlands or ephemeral drainage lines given the more favourable wetter conditions over 2010-2012. This included Centrantherea cochinchinensis, and these targeted surveys aimed to address spatial gaps and seasonally wet conditions and were conducted over an additional 15 days in January-February (**within the appropriate flowering season**) With the completion of the preferred route studies and additional targeted surveys for the EIS and then Supplementary Biodiversity Assessment there is a moderate level of confidence for the targeted survey and assessment of this cryptic species.

Threatened Entity	Listed status	Review outcomes
		Suitability of Mitigation Measures. Refer discussion above the table for outline of the detailed management plans being prepared and background on suitability of the mitigation measures in addition to methods for monitoring effectiveness as part of an adaptive management approach. Information that addresses a review of effectiveness aims to build on the previous discussion in the working paper (Section 5.2.4). Centranthera cochinchinensis is not addressed in the Threatened Plants Management Plan which addresses a species specific approach to management dealing directly with the populations identified in the EIS. This species has not been identified in the project area and therefore species specific measures and offsets are not targeted at this species.
Spider Orchid *Dendrobium melaleucaphilum*	**TSC E**	**Survey effort and method** 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. Around 300 ha of potential habitat occurs. There were no spatial gaps identified for this species from the assessment of survey effort against stratification and biometric vegetation types suggesting that the targeted surveys covered sufficient spatial effort and habitat types. 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.
Thorny Pea *Desmodium acanthocladum*	**TSC V**	**Survey effort and method** Not sure what these comment relates to, as targeted surveys were conducted for rainforest flora in addition to rainforest communities. The rainforest community surveys were conducted to classify the communities according to the EPBC Act and TSC Act. Targeted rainforest plant surveys were conducted as separate tasks, however in addition threatened plants may have been identified during the plot surveys for the classification task, although this was not the objective. All rainforest communities, including those of basalt soils favoured by this species were considered to be surveyed with sufficient effort and rigour. These habitats only represent 1.2% of the habitat near the project corridor and targeted traverses looked at all locations, identifying several threatened flora species. **Species Specific Mitigation Measures** This species has not been identified in the project footprint area and therefore species specific measures and offsets are not targeted at this species.
Isoglossa eranthemoides	**TSC E**	**Survey effort and method** The species profile indicates that this species is restricted to lowland subtropical rainforest, in most situations on floodplains and slopes on basalt soils. Within the study area this equates to around 12 hectares in total or around 1.2 % of the vegetation in the corridor. Given the known presence of lowland rainforest in the study area considerable effort was given to conducting comprehensive targeted surveys for

Threatened Entity	Listed status	Review outcomes
		rainforest communities and rainforest plants across Sections 1, 3 and 10 where potential habitat was identified. This included a suite of surveys conducted for the preferred route studies and EIS. All subtropical rainforest species were identified as requiring additional survey effort to target any spatial gaps from the initial stratification and sampling method (refer Appendix B supplementary report). As such additional targeted surveys were conducted over a period of 14 days by three botanists focused on spatial gaps and reported in the supplementary assessment. These surveys were conducted beyond the road corridor and found additional threatened plants thereby increasing our knowledge of local populations size and impacts. The species was confirmed in rainforest habitat outside the project boundary and no additional individuals have been reported from targeted surveys The survey effort for this species is considered sufficient at sampling all stratification units and achieving representativeness and further surveys are not required to inform the assessment of impacts. **Design refinement** A design refinement was completed around Coolgardie Road as part of the SPIR, with the specific objective of reducing impacts on lowland rainforest habitat on basalt soils. This micro-alignment change has seen a reduction in impact from 6.4 hectares to 1.2 hectares.
Marsdenia longiloba	**EPBC V TSC E**	**Survey effort and method** Species profile indicates can occur in moist forests on floodplains and slopes including wet sclerophyll forests and rainforests. Identified in the working paper has a moderate chance of occurring in all project sections. Was not identified from the gap analysis done for the supplementary assessment which addressed survey locations against habitat stratification for all species. One of the review comments from EPA on the Biodiversity Assessment suggested that the conditions during the surveys for the preferred route were dry. Marsdenia longiloba is capable of dying back to its rootstock which is a pencil like tuber. As such this limitation was addressed in the Supplementary Assessment by further targeting plant species favouring wetlands or ephemeral drainage lines given the more favourable wetter conditions over 2010-2012 compared to the original survey. These targeted surveys aimed to address spatial gaps and seasonally wet conditions and were conducted over an additional 15 days in January-February. Most plants are generally actively growing during an average summer and can be detected There were no spatial gaps identified for this species from the assessment of survey effort against stratification and biometric vegetation types suggesting that the targeted surveys covered sufficient spatial effort and habitat types. With the completion of the preferred route studies and additional targeted surveys for the EIS and then Supplementary Biodiversity Assessment there is a moderate level of confidence for the targeted survey and assessment of this species. It is noted that with the presence of widespread areas of potential habitat there is potential for the species to be present outside of the confirmed locations
Quassia sp. 'Moonee Creek'	**EPBC E1 TSC**	**Survey effort and method** This species was identified as requiring additional survey effort to target minor spatial gaps from the initial stratification and sampling method (refer Appendix B supplementary report) for Section 1 and 2 not previously surveyed. As such additional targeted surveys were conducted over a period

Threatened Entity	Listed status	Review outcomes
	E	of 5 days focused on spatial gaps and reported in the supplementary assessment. These surveys were conducted beyond the road corridor and found additional threatened plants thereby increasing our knowledge of local population size and impacts. A previously unknown population was located during these supplementary surveys. This fact suggests that all gaps were addressed and the species has been surveyed sufficiently. **Assessment of Significance** AoS being updated and addressed in the Supplementary Biodiversity Assessment. Will include conclusions and recent micro-alignment changes in this location.
Swamp Mint Bush *Prostanthera palustris*	**EPBC V** **TSC V**	**Survey effort and method** Not sure what this comment refers to. One of the review comments from EPA on the Biodiversity Assessment suggested that the conditions during the surveys for the preferred route were dry. As such this limitation was addressed in the EIS surveys and the Supplementary Assessment by further targeting plant species favouring wetlands or ephemeral drainage lines given the more favourable wetter conditions over 2010-2012 compared to the original survey. These targeted surveys aimed to address spatial gaps and seasonally wet conditions and were conducted over an additional 49 days for the EIS and 15 days for the supplementary surveys in all times during spring and summer seasons. Most plants are generally actively growing during an average summer and can be detected. With the completion of the preferred route studies and additional targeted surveys for the EIS and then Supplementary Biodiversity Assessment there is a moderate level of confidence for the targeted survey and assessment of this species. **Species Specific Mitigation Measures** This species has not been identified in the project footprint area and therefore species specific measures and offsets are not targeted at this species.
Arrow-head Vine *Tinospora tinosporoides*	**EPBC V** **TSC V**	**Survey effort and method** The species profile indicates that this species is restricted to lowland subtropical rainforest, in most situations on floodplains and slopes on basalt soils. Within the study area this equates to around 12 hectares in total or around 1.2 % of the vegetation in the corridor. Given the known presence of lowland rainforest in the study area considerable effort was given to conducting comprehensive targeted surveys for rainforest communities and rainforest plants across Sections 1, 3 and 10 where potential habitat was identified. This included a suite of surveys conducted for the preferred route studies and EIS. All subtropical rainforest species were identified as requiring additional survey effort to target any spatial gaps from the initial stratification and sampling method.. As such additional targeted surveys were conducted over a period of 14 days by three botanists focused on spatial gaps and reported in the supplementary assessment. These surveys were conducted beyond the road corridor and found additional threatened plants thereby increasing our knowledge of local populations size and impacts. The species was confirmed in rainforest habitat outside the project boundary and no additional individuals have been reported from targeted surveys

Threatened Entity	Listed status	Review outcomes
		The survey effort for this species is considered sufficient at sampling all stratification units and achieving representativeness and further surveys are not required to inform the assessment of impacts. **Design refinement** A design refinement was completed around Coolgardie Road as part of the SPIR, with the specific objective of reducing impacts on lowland rainforest habitat on basalt soils. This micro-alignment change has seen a reduction in impact from 6.4 hectares to 1.2 hectares. **Species specific mitigation responses** Refer discussion above the table for outline of the detailed management plans being prepared and background on suitability of the mitigation measures in addition to methods for monitoring effectiveness as part of an adaptive management approach. Information that addresses a review of effectiveness aims to build on the previous discussion in the working paper (Section 5.2.4). Species specific mitigation measures have not been identified for this species as it has not been confirmed to occur in the project area. Specific mitigation measures are provided for rainforest communities in the appropriate management plan and are design to protect the habitat of this species.
Square-stemmed Spike-rush *Eleocharis tetraquetra*	**TSC E**	**Survey effort and method** The species can be hard to detect outside the flowering season, as potential to die-off during extended drought conditions. This is evident by the results of the surveys in section 2 for the preferred route studies and EIS which did not detect the species, and the fact that it was later picked up after a third survey in Section 2 in the same location conducted for the supplementary investigations several months later. Supplementary investigations specifically targeted moist areas and drainage lines due to sub-optimal conditions in the original surveys. The supplementary surveys were conducted during January-February and following considerable rainfall for a number of months, therefore in appropriate conditions. This is evidence that we got it right. With the completion of the preferred route studies and additional targeted surveys for the EIS and then Supplementary Biodiversity Assessment there is a moderate level of confidence for the targeted survey and assessment of this species. It is noted that with the presence of widespread areas of potential habitat there is potential for the species to be present outside of the confirmed locations. However there are no other confirmed records of the species from the study area. **Assessment of Significance** Conclusion will be provided for this species AoS under the Supplementary Biodiversity Assessment **Mitigation Measures** Refer discussion above the table for outline of the detailed management plans being prepared and background on suitability of the mitigation measures in addition to methods for monitoring effectiveness as part of an adaptive management approach. Information that addresses a review of effectiveness aims to build on the previous discussion in the working paper (Section 5.2.4). Eleocharis tetraquetra is addressed in the Threatened Plants Management Plan which addresses a species specific approach to management

Threatened Entity	Listed status	Review outcomes
		dealing directly with the populations identified in the EIS.
Wetland and migratory bird species	**Aus Bitrn EPBC E** **APS EPBC E TSC E** **BB TSC E**	**Survey** The predominant wet bird habitats in the study area are the numerous small vegetated creeks that are crossed by the project, in addition to the larger Coldstream wetlands and the Clarence and Richmond River. The latter two estuarine habitats are considered unsuitably and are largely devoid of dense vegetation in the vicinity of the project. The Australasian Bittern and Australian Painted Snipe could potentially use wetlands in the vicinity of the project area, which may represent important habitat for these species if present. The project will traverses in relative proximity to a number of regionally significant wetlands as detailed in Table 3-10 of the working paper. Of these those that are densely vegetated and therefore represent potentially important habitats and have potential to be indirectly impacted are situated in Section 3. This includes the Coldstream Wetlands and associated Chaffin Swamp. Indeed this area was targeted and the Australasian Bittern was confirmed from here from the field surveys. This includes at least one SEPP 14 wetland. All three species are assessed a s potentially present in these habitats. Stationary bird surveys were conducted at these wetlands near the project boundary. This involved a point census from wetland edge or vantage point along nearby road during early morning and dusk census. The survey period varied from 5-20 minutes. Surveys were conducted where the project boundary intersects wetland habitat such as the Coldstream River at Wants Lane north of Sandy Crossing, Chaffin Swamp, and floodplain wetlands surrounding lower Shark Creek for a total of one hour per site. The remaining important wetlands are either too far from the project, or tidal and not densely vegetated and therefore do not provide potential habitat or not expected to be impacted. The survey effort for these species involved stratified sampling focused on densely vegetated wetlands and stationary observations as well as spotlighting and multiple hours of opportunistic observations. Black bittern favours permanent creeks in forested areas with dense riparian vegetation which may include small and narrow linear habitats that are not often isolated during the stratification process. Representative areas were surveyed at a number of the dry open forest sites as well as swamp sclerophyll habitats. These surveys were therefore covered by the general bird survey traverses, spotlighting and opportunistic observations described generally. Given the difficulty identifying these cryptic species, the species presence and important habitat was assumed in a number of locations as described in the working paper. Additional survey effort may not provide significant further input into the assessment of impacts. **Assessment of Significance** AoS can be amended in the Supplementary Assessment to assess species separately or group according to microhabitats
Large forest owls and other nocturnal birds		**Survey effort and method** Call playback surveys were stratified according to broad forest types, including dry forests and woodland vegetation associations suited to this species. Surveys were conducted at 26 sites and 47 different sessions. Surveys were conducted at 26 sites and 47 different sessions. Given that around 50% of the study area is cleared (refer Table 4-1), this roughly equates to one site per 3-4 kilometres

Threatened Entity	Listed status	Review outcomes
		Detailed HBT surveys were not asked for in the DGRs and not a requirement of the DEC (2004) draft survey guidelines or the DSEWPaC survey guidelines for birds. The approach in the past has been to do these surveys post-approval and during the pre-clearing phase. The approach used in the EIS was to use stratified habitat plots to estimate HBT density and this information was extrapolated across the entire project. Due to the expected high density of HBT losses on this project, all threatened forest-dwelling hollow-dependent fauna species were assessed as significantly impacted, this includes the large forest owls. The gap assessment conducted for the EIS identified the need for further targeted owl surveys in Sections 3-5, these included repeat surveys at previously sampled sites. The description of the targeted surveys for these species is provided in Table 2-12 of the working paper. This included call playback, day habitat searches and stagwatching during general spotlighting surveys. Stagwatching was conducted at all spotlighting sites where hollows were observed. These techniques are consistent with the DEC (2004) survey guidelines. The DEC survey guidelines suggest surveys for large forest owls should be conducted **all year** (Table 5-7) and do not stipulate surveys should be done during breeding season to identify potential nest sites. Potential nest sites are identified during daytime activities. Location of all breeding pairs unknown and very unlikely to be determined by further targeted surveys at this scale. In fact the guidelines suggest that surveys near nest sites and during the breeding season should be avoided as certain species are sensitive and territorial, such as Powerful Owl. **Assessment of Significance** Assessment of significance assumed presence and has adopted a precautionary assessment for hollow-dependent fauna. Based on known habitat preferences and density of hollow trees. The DEC guidelines also indicate that *'if no evidence of owls is located an evaluation of whether the species are likely to occupy the habitat will need to be made'* This approach was adopted for the assessment of impacts on large forest owls and used a combination of survey records, atlas data and assumed presence where suitable habitat was identified.
Swift Parrot (*Lathamus discolor*)	**EPBCE, MiTSCE**	No additional work required
Regent Honeyeater (*Xanthomyza phrygia)*	**EPBCE, MiTSCCE**	No additional work required
Woodland birds	**BSCEPBCE**	**Survey effort and method** Call playback surveys were stratified according to broad forest types, including dry forests and woodland vegetation associations suited to this species. Surveys were conducted at 17 sites and 36 different sessions. The DEC survey guidelines suggest surveys should be done during the 7

Threatened Entity	Listed status	Review outcomes
	TSC E	month breeding season (August to March). Surveys for this work were conducted over 8 different monthly periods, of which 5 of these were during the breeding season. In addition to call playback, this species can be detected during general spotlighting surveys and general quite listening at dusk. This technique was deployed at 24 dry forest and woodland sites using over 61 person hours. It is acknowledged that the species can be cryptic and that additional surveys over lengthy time periods may pick up new individuals or potentially identify a small number of breeding pairs.. However location of all breeding pairs would remain unknown and very unlikely to be determined by further targeted surveys at this scale, unless they were conducted over several years. One individual was recorded from the surveys, however due to the absence of records over the remainder of the study area a precautionary approach was adopted and records of the species and known habitat types was used to assess the level and magnitude of the impacts on the species. **Assessment of Significance** In assessing the significance of the impacts, consideration was given to the distribution of threatened species and the areas of potential habitat. For example for some species, populations or communities are restricted to discrete project sections such as Angophora robur, Lowland Rainforest or Coastal Emu. Conversely other species are widespread and occur across the entire region and therefore potentially all project sections, eg microchiropteran bats which use a range of habitats and are dependent on specific microhabitat features which are widespread and not restricted by localised conditions. Where there was reasonable doubt regarding the likely impacts, or where detailed scientific information not available, a significant impact has been assumed using the precautionary principle. Where multiple populations occur in the study area, each population was assessed separately on a section by section basis (i.e. local populations assessed separately). Due to the size of the project, there is potential for some small local populations to be impacted while others not, hence the AoS for this species ad GCB discusses local and regional populations. *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 regional population as a whole.*
Rainforest birds		**Assessment of Significance** Noted that a separate AoS could be prepared for the Double-eyed Fig Parrot and Barred Cuckoo-shrike. However they were assessed together due to similar life-cycle traits, such as dependence on temporally and spatially separated food resources that are spread across the landscape, and therefore not supported at any one location. To account for any ecological differences such as breeding requirements the AoS describes impacts separately in some instances. Conclusions for all AoS are provided in Chapter 6. **Design refinement** A design refinement was completed around Coolgardie Road as part of the SPIR, with the specific objective of reducing impacts on lowland

Threatened Entity	Listed status	Review outcomes
		rainforest habitat on basalt soils. This micro-alignment change has seen a reduction in impact from 6.4 hectares to 1.2 hectares and sees a significant reduction in potential impacts on these species **Mitigation Measures** This comment is talking about mitigation and offsetting together? Not clear about this comment. True, difficult to offset direct and indirect impacts on these species, as we can't directly measure the fruiting resources being lost and there are too many unknown factors as to why some areas are preferred over others. Compensatory habitat must provide know food resources within the range of populations and assume species have chance of occurring. Otherwise, offset sites would target sites where individuals are known to frequent, and still there is no guarantee that the species would occur. The fruit-doves are known to frequent dense stands of Camphor Laurel as long as rainforest species are present (Moran et al 2004) and some species feed on introduced camphor laurel.
Forest birds	**SH** **TSC** **V** **VS** **TSC** **V** **BF** **TSC** **V**	**Survey effort and method** Varied Sittella was recorded during the preferred route fauna studies in section 1-2, 3-5 and 6-8 as reported in the appendices to the working paper, suggesting that adequate surveys were conducted. However there is no spatial data for these records as the species may not have been listed as threatened at the time. If possible we can identify sites where the species was recorded in general bird surveys and described these locations. This species should be address in the AoS and was an oversight. Noted Black Falcon and Spotted Harrier are absent from the working paper. Should both be assessed as unlikely to occur in the coastal habitats identified for this project and don't agree that it is likely that they would be present during their life-cycles. These are species of drier inland woodlands of the wheat-sheep belt and Murray –Darling Basin, of arid and semi-arid regions. Extremely rare species covered in the general birds surveys conducted in drier habitats over 24 sites and 262 person minutes. Further targeted surveys are very unlikely to encounter this species. Further surveys are not required. **Assessment of Significance** Varied Sittella is a woodland bird species and would be added to the AoS for woodland birds **Mitigation Measures** Effectiveness of emu mitigation measures is acknowledged and discussed in the report. Monitoring is discussed in the Emu management plan including provisional measures should the measures found to be ineffective.
Glossy Black-cockatoo	**EPBC** **V** **TSC** **V**	**Survey effort and method** Detailed HBT surveys were not asked for in the DGRs and not a requirement of the DEC (2004) draft survey guidelines or the DSEWPaC survey guidelines for birds. The approach in the past has been to do these surveys post-approval and during the pre-clearing phase. The approach used in the EIS was to use stratified habitat plots to estimate HBT density and this information was extrapolated across the entire project. Due to the expected high density of HBT losses on this project, all threatened forest-dwelling hollow-dependent fauna species were assessed as significantly impacted.

Threatened Entity	Listed status	Review outcomes
		The distribution of habitat of this species was surveyed via a habitat assessment (Section 2.3.6). A stratified survey technique was used to representatively sample habitats according to broad vegetation community type. A total of 129 sites were assessed across the entire project area (Table 2 16). A number of site characteristics were recorded in the field in a 50 x 20 metre plot at each survey site including **the number of hollow-bearing trees**, total length of logs greater than 10 centimetre DBH, presence and density of **Allocasuarina,** average overstorey height, percent overstorey foliage cover, dominant tree species, and forest successional stage were each described. Allocasuarina represents the feed tree species for GBC. General birds surveys were conducted over 55 sites to target this species and are consistent with the DEC 2004) guidelines for diurnal birds. **Assessment of Significance** Assessment of significance assumed presence and has adopted a precautionary assessment for hollow-dependent fauna. Based on known habitat preferences and density of hollow trees. Targeted species were conducted. AoS would be reviewed in the supplementary assessment. Note that location of all breeding pairs unknown and very unlikely to be determined by further targeted surveys at this scale **Mitigation Measures** This comment is talking about mitigation and offsetting together? Not clear about this comment. Please explain how mitigation for GBC is dependent on avoidance approach. Mitigation will include protection of hollow-bearing trees and potential habitat outside the exclusion zones.
Diurnal raptors		**Survey effort and method** This is included in the working paper as a standard mitigation measure. Surveys for nests and HBTs is not covered in the DEC (2004) survey guidelines or DGRs for this projects. This is typically done pot-approval and covered by pre-clearance methods as locations of raptor nest change over time, it is best to survey immediately prior to clearing works and adopt buffer zones or staged habitat removal if appropriate including timing of clearing works near a nest site.
Cave roosting Micro bats	**LEPB** **EPBC V** **TSC V**	**Survey effort and method** Surveys would be undertaken during detailed design as documented in the Threatened Mammal Management Plan. This is the adopted approach on all Roads and Maritime projects. In addition refer to section 2.4.4 of the working paper *Both the Duck Creek and Emigrant Creek bridges (project section 10 and 11) were inspected for roosting bats on 2 February 2012 as these bridges would be removed as part of the project.* **Assessment of Significance** Large-eared Pied Bat was assessed under the cave-roosting bats using the EPBC Act heads of consideration and the group assessed as non-significant impact from the project. It has been mistakenly left out of Table 6-1 in this regard. It is however described adequately in the AoS and Table E-1 as a cave roosting species. Also as a non-significant impact using the heads of consideration under the EPBC Act.

Threatened Entity	Listed status	Review outcomes
		The AoS acknowledges that '*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).* The factors considered in addressing the impacts on the life-cycle of the species, feeding, roosting, breeding. Considered impacts from the loss of habitat for prey species, and in turn foraging habitat. Breeding habitat was considered as only cave-roosting sites.
Tree roosting microbats		**Survey effort and method** Detailed HBT surveys were not asked for in the DGRs and not a requirement of the DEC (2004) draft survey guidelines or the DSEWPaC survey guidelines for bats. The approach in the past has been to do these surveys post-approval and during the pre-clearing phase. The approach used in the EIS was to use stratified habitat plots to estimate HBT density and this information was extrapolated across the entire project. Due to the expected high density of HBT losses on this project, all threatened forest-dwelling hollow-dependent fauna species were assessed as significantly impacted. **Mitigation Measures** Habitat tree survey would be done during the pre-construction stage and will be described in the CEMP and FFMP. The information gathered from the habitat tree surveys are designed to inform mitigation measures for tree-roosting microbats, these are documented in Chapter 5 of the working paper and include: ■ Pre-clearing surveys and fauna handling ■ Nest box management strategy
Arboreal mammals	**EPP** **TSC** **V** **SG** **TSC** **V** **BTP** **TSC** **V** **YBG** **TSC** **V**	**Survey effort and method** Why would we conduct additional surveys at known hotspots for the EIS, given we already know that populations of YBG and SQ and BTP are present at these locations such as Halfway Creek. AoS is based on the known occurrence of an important population. The method and approach for additional surveys is documented in the Threatened Mammals Management Plan. These would include habitat tree surveys, spotlighting and trapping to refine the locations of crossing structures and exclusion fencing. For the Eastern Pygmy Possum (EPP) the accepted methods of survey include spotlighting, trapping with Elliott traps and pitfall trapping. All 3 techniques were used to target mammals and stratified to sample the range of habitats present. Acknowledge that additional records may be achieved by conducting lengthy targeted survey. **Assessment of Significance** Stated conclusions are likely to be appropriate, we have identified a significant impact and the locations where significant impacts likely, developed ad appropriate connectivity strategy for the concept design and outlined species specific mitigation and monitoring in the Threatened Mammal Management Plan, in consultation with glider expert. Noted that there is no data on the distribution of populations and has habitat for this species is broad, the project is likely to affect foraging, sheltering and breeding habitats on a number of scales. Agree likely significant impact may be warranted and can be addressed as a revised AoS in the supplementary report.

Threatened Entity	Listed status	Review outcomes
		Mitigation Measures The management plan and mitigation measures have been documented in the management plan and put to independent expert review. The plan and working paper both acknowledge the unknown effectiveness of structures for YBG and propose a detailed monitoring program and corrective measures where appropriate and offsetting measures if ultimately deemed to be ineffective.
Ground Dwelling mammals	**STQ** **EPBC** **E** **TSC** **V** **RB** **TSC** **V** **CP** **TSC** **V**	**Survey effort and method** The use of remote cameras is not discussed under the DEC (2004) survey guidelines for STQ and only sporadic use in EIS in Australia. Cage traps, spotlighting and searches for evidence were used to survey this species Acknowledged that this is discussed in the DSEWPaC survey guidelines however these are not compulsory. Question the value in conducting targeted surveys for this species in locations where we already known there are populations present. The assumed presence in these locations is reported in the biodiversity assessment and AoS for STQ. The use of camera surveys is discussed in the Threatened Mammals Management Plan. **Assessment of Significance** The conclusions of the AoS for RB was not made lightly and is based on extensive surveys, observations and consultation by the authors in the study area including the previous Glenugie upgrade over the last 5 years and consultation with ecologists from State Forests. Acknowledged that project is within part of important area for populations (Sections 1-3), although within this area the species is widespread and adapted to using a range of modified habitats, including forestry land, regrowth and agricultural landscapes with scattered patches of habitat (pers obs). The AoS conclusions are based on the widespread occurrence of populations and habitats which are well conserved, and the adaptability of the species to disturbances. AoS is based on the project level and considered likely threat associated with clearing habitat. Common Planigale, acknowledge that the species is widespread but uncommon throughout the northern rivers region and has been recorded in a diversity of habitat conditions. In the absence of certainty surrounding the impacts on this species that the precautionary principle should apply. Supplementary assessment to address revised AoS. The species was targeted in the EIS. The species is rarely caught in Elliott traps more often trapped in pitfalls (Milledge 1991, Catling et al 1997)). For this reason the sole use of elliott traps during the preferred route studies was seen as a gap. Targeted pitfall traps were used in Section 1-2 in the preferred route studies ad recorded the species/. This technique was subsequently introduced into the targeted field program for Section s 3-5 and 6-8 (review methods chapter of the working paper) **Mitigation Measures** Fauna exclusion fencing is targeted for ground-dwelling mammals, Koala and frogs, as well as emus. Granted WP5.2.1 only discusses emus as there are issues to deal with emu fencing in floodplain areas and therefore comprehensive account of fencing for other species is not well covered. The intent of the Biodiversity Connectivity Strategy (appendix A) and specifically Table A-5 was to show the locations for fauna exclusion fencing

Threatened Entity	Listed status	Review outcomes
		proposed for the concept design. Also this issues is dealt with comprehensively in the threatened species management plans, including specific locations and fence types for consideration in the detailed design.
Koala	**EPBC V** **TSC V**	**Survey effort** **Additional survey required to address interim advice for referral under the EPBC Act** **Mitigation Measures** The approach has used avoidance, mitigation and offsets consistent with the OEH principles for sustainability.
Wetland and swamp dwelling frogs	**GTF** **TSC V**	**Survey effort and method** Justify the need for further surveys? Difficult to comment on broad statement that additional surveys are recommended. The results of two gaps assessment (one of the preferred route stud and one for the EIS) identified gaps in survey effort based on stratification, spatial gaps and seasonal constraints and addressed these in the EIs and supplementary work. For example Table 2-2 (WP) section 6-8 describes the seasonal limitation for frogs from the initial surveys and these were deliberately rectified by a comprehensive survey conducted during appropriate season (Lewis 2007). For section 3-5 '*Weather conditions were not optimal for detection of bats and frogs during the July-August survey period. Further survey for these taxa was therefore conducted in October 2009 to address the shortfall and further fieldwork in summer was recommended'* and subsequently conducted in Summer 2011-2012. While the preferred route studies in Section 1-2 were done in the appropriate season, and therefore no gaps identified. Nonetheless additional targeted surveys have now been done during the detailed design. Similarly the original surveys in Section 9-11 were also done during appropriate seasonal and climatic conditions and hence not identified das a constraint. **Assessment of Significance** Noted the conclusion in Table 6-1 is wrong and should read Y **Mitigation Measures** Refer discussion above the table for outline of the detailed management plans being prepared and background on suitability of the mitigation measures in addition to methods for monitoring effectiveness as part of an adaptive management approach. Information that addresses a review of effectiveness aims to build on the previous discussion in the working paper (Section 5.2.4). Specific mitigation measures for threatened frogs is addressed in the Threatened Frogs Management Plan which addresses a species specific approach to management dealing directly with the populations identified in the EIS. This includes the issues of loss of connectivity and vehicle strike through the inclusion of purpose built frog exclusion fencing
Stream dwelling frogs		**Survey effort and method** Justify the need for further surveys? Difficult to comment on broad statement that additional surveys are recommended. The results of two gaps

Threatened Entity	Listed status	Review outcomes
		assessment (one of the preferred route stud and one for the EIS) identified gaps in survey effort based on stratification, spatial gaps and seasonal constraints and addressed these in the EIs and supplementary work. For example Table 2-2 (WP) section 6-8 describes the seasonal limitation for frogs from the initial surveys and these were deliberately rectified by a comprehensive survey conducted during appropriate season (Lewis 2007). For section 3-5 '*Weather conditions were not optimal for detection of bats and frogs during the July-August survey period. Further survey for these taxa was therefore conducted in October 2009 to address the shortfall and further fieldwork in summer was recommended'* and subsequently conducted in Summer 2011-2012. While the preferred route studies in Section 1-2 were done in the appropriate season, and therefore no gaps identified. Nonetheless additional targeted surveys have now been done during the detailed design. Similarly the original surveys in Section 9-11 were also done during appropriate seasonal and climatic conditions and hence not identified das a constraint. **Assessment of Significance and Mitigation Measures** Refer discussion above the table for outline of the detailed management plans being prepared and background on suitability of the mitigation measures in addition to methods for monitoring effectiveness as part of an adaptive management approach. Information that addresses a review of effectiveness aims to build on the previous discussion in the working paper (Section 5.2.4). Specific mitigation measures for threatened frogs is addressed in the Threatened Frogs Management Plan which addresses a species specific approach to management dealing directly with the populations identified in the EIS. This includes the issues of loss of connectivity and vehicle strike through the inclusion of purpose built frog exclusion fencing
Reptiles	**TTSTS** **EPBC V** **TSC V**	**Survey effort and method** Why single out the WCS (white crowned Snake) and not PHS or STB. All three species potentially occur across the study areas and were targeted by a stratified survey using direct hand-searches in all suitable habitats. This included survey of 125 sites and over 44 person hours in addition to pitfall trapping at 14 sites. Acknowledge the comments regarding stratification based on micro-habitats. The DEC (2004) survey guidelines indicate that '*The survey area should be initially stratified on biophysical attributes (eg. landform, geology, elevation, slope, soil type, aspect), followed by vegetation structure (eg. forest, woodland, shrubland), and then floristics (eg. species)*. This was the approach used for stratification in the biodiversity assessment. It should be noted that there is no GIS data available for the microhabitat types mentioned in order to stratify to this level and for a project of this scale. However it should be noted that further selection of survey sites on the ground including pitfall trapping targeted the search areas at locations with abundant cover for reptiles to maximise the chance of detection and this methods is described as turning logs and raking leaf litter. Three-toed Snake-tooth Skink (TTSTS) addressed in the gap assessment for supplementary biodiversity assessment and found not to be lacking in detail. The surveys described above were also targeted at this species.

Threatened Entity	Listed status	Review outcomes
		Further surveys are not considered necessary for threatened reptiles. It is acknowledged that further targeted surveys may pick up new records for cryptic species over such as large area and the survey used a stratified approach aimed at representative survey sites and in this way did not survey effort metre of the project.. **Assessment of Significance** AoS is required for White-crowned Snake **Mitigation Measures** Pre-clearance surveys would be done during the pre-construction stage and will be described in the CEMP and FFMP. Other measures include replacement of logs and leaf litter in adjacent areas rather mulching and removal and restoration of disturbed habitats following construction.
Fish	**OPP** **EPBC E**	**Survey effort and method and mitigation** As agreed with DP&I and DSEWPaC at the meeting on 14 July 2013, further targeted surveys would be conducted at the detailed design stage for each project section and are aimed at reconfirming the presence or absence of threatened fish in each waterway crossed by the project including unnamed and undefined watercourses and thereby will inform the detailed design and the final selection of monitoring sites. Details of the survey methods and parameters are provided in the Threatened Fish Management Plan and with the intent of these being replicated for all project sections. Upon completion the results of these surveys would be provided to DPI (Fisheries) and the final design updated in consultation with this agency to reflect the results and potential re-classification of waterways. The selection of ongoing monitoring sites for threatened fish would then reflect the results of the targeted surveys such that these focus on known habitat for threatened fish. Waterway crossing structures have been designed to minimise the impacts of altering the natural flow regimes of these waterways as a priority. In achieving this the concept design considered the class of waterways with respect to known location and potential habitats for threatened fish in particular the Oxleyan Pygmy Perch. This was achieved through field surveys during the preferred route and the EIS stage and considered records of threatened fish as reported in the Atlas of NSW Wildlife and DPI (2010). This process has already worked effectively during detailed design for Section 1 and 2.
Mitchells Rainforest Snail (*Thersites mitchellae*)	**EPBC CE**	**Survey effort and method** Targeted surveys for the threatened Mitchells Rainforest Snail carried out in 2006 (Stanisic 2006: in Geolyse 2007) recorded no evidence of the species within or surrounding the project boundary (sections 8 to 11). The ground surveys revealed that the vegetation was not key habitat preferred by the species (Stanisic 2006). The absence of a known co-habitant, the Large Camaenid (Sphaerospira fraseri) also led to the conclusion that Mitchells Rainforest Snail was unlikely to occur in the study area (Stanisic 2006). John Stanisic is a leading expert in molluscs in Australia. Stanisic, J., (2006) Survey for the land snail Thersites mitchellae Woodburn-Ballina Pacific Highway Upgrade. Prepared for Geolyse Pty Ltd. Biodiversity Assessment and Management, Queensland.

Threatened Entity	Listed status	Review outcomes
		Assessment of Significance Not required due to the absence of the species from the study area **Mitigation Measures** Not required due to the absence of the species from the study area
Other invertebrates	**PUM** **EPBC** **E** **TSC** **E** **ARGB** **TSC** **E** **GD** **TSC** **E** **CP** **TSC** **E**	**Survey effort and method** Access restrictions were only placed on properties outside the alignment and not within the project corridor. Granted that additional surveys may find new individuals of the ARGB which is extremely hard to find. However a precautionary approach was adopted assuming that the species could occur in similar habitats which were identified in the assessment. Further refinement of the design has occurred to reduce the impact on this species as discussed below. Giant Dragonfly (P.gigantea) not known from the northern rivers area and has not been recorded, is this meant to mean Petalura litoria (Coastal Petaltail) which is addressed in the working paper. Targeted surveys for the CP were conducted in suitable locations are reported in Appendix L **Assessment of Significance** The need for AoS for CP can be addressed in the supplementary assessment **Mitigation Measures** Avoidance options have been conducted now, as discussed below. Further development of the invertebrates management plan has occurred in consultation with invertebrate expert. Impacts to host plant have been avoided by shifting the alignment and translocation no longer required. **Design refinement** A design refinement was completed around Coolgardie Road as part of the SPIR, with the specific objective of reducing impacts on lowland rainforest habitat on basalt soils. This micro-alignment change has seen a reduction in impact from 6.4 hectares to 1.2 hectares and is a large reduction in the impacts on the potential habitat of this species. There is on direct impact now n 1.2 ha of potential habitat for the species and further specific mitigation provided in the rainforest management plan.
Subtropical Coastal Floodplain Forest	**TSC** **EEC**	No additional work required
Swamp Sclerophyll Forest	**TSC** **EEC**	No additional work required
Swamp Oak Floodplain Forest	**TSC** **EEC**	No additional work required
Freshwater Wetlands	**TSC**	**Assessment of Significance**

Threatened Entity	Listed status	Review outcomes
	EEC	Indirect impacts on freshwater wetlands have been addressed and documented in a number of locations on the WP. Just one example *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.*
Lowland Rainforest	**EPBC** **CE** **TSC** **EEC**	**Survey effort and method** Given the known presence of lowland rainforest in the study area considerable effort was given to conducting comprehensive targeted surveys for rainforest communities across Sections 1, 3 and 10 where potential habitat was identified. This included a suite of surveys conducted for the preferred route studies and EIS. The need for further targeted surveys were identified in the Supplementary Biodiversity Assessment and involved surveys to classify the status of known rainforest areas according to the EPBC Act and TSC act and surveys additional areas beyond the road corridor to gain further insight into the distribution and size of rainforest patches (refer supplementary report). As such additional targeted surveys were conducted over a period of 14 days by three botanists focused on spatial gaps and reported in the supplementary assessment. The survey effort for lowland rainforest is considered sufficient with a high level of confidence. **Design refinement** A design refinement was completed around Coolgardie Road as part of the SPIR, with the specific objective of reducing impacts on lowland rainforest habitat on basalt soils. This micro-alignment change has seen a reduction in impact from 6.4 hectares to 1.2 hectares **Mitigation Measures** The idea of a generic 50 m exclusion zone around all rainforest patches does not take into account the slope and position of the rainforest relative to the road profile, in all cases the rainforest habitat on basalt soils is upslope the road to the west of the corridor. Additionally the road does not clear a new edge through the rainforest and has been deliberately targeted at existing cleared areas with impacts only along the edge. The rainforest areas in Section 10 and currently edge effected.
Littoral Rainforest	**EPBC** **CE** **TSC** **EEC**	**Assessment of Significance** To be provided in the Supplementary Biodiversity Assessment
Coastal Cypress Pine Forest	**TSC** **EEC**	**No additional work required**

Appendix B. Koala field data

ID1	Project section	East _GDA	North _GDA	Veg Type (BIOMETRIC)	Dominant Tree Species						Trees with scats	Tree species	Habitat classification (DEC 2008)				Critical habitat (EPBC Act)		
					Species 1	Cover(%)	Species 2	Cover(%)	Species 3	Cover(%)			Primary	Secondary (Class A)	Secondary (Class B)	Scondary (Class C)	Primary trees >30%	Primary & secondary >50%	Secondary >50%
1	1	513226	6725705	Tallow ood Forest	E.microcorys	80	A.excelsa	5	C.intermedia	15			Yes				Yes		
2	2	505164	6697450	Spotted Gum Ironbark Forest	E.fibrosa	50	C.henryi	50											
3	2	505194	6696755	Spotted Gum Ironbark Forest	C.henryi	50	E.moluccana	25	E.fibrosa	25									
4	2	505611	6694785	Spotted Gum Ironbark Forest	E.fibrosa	80	C.henryi	10			0								
5	2	505997	6693854	Red Gum Grey Ironbark Open Forest	E.bancroftii	50	Allocasuarina littoralis	45	E.fibrosa	5	0		Yes				Yes		
6	1	515776	6681407	Spotted Gum Ironbark Forest	C.henryi	50	E.fibrosa	20	E.acmenoides	30	0								
7	1	514068	6684249	Spotted Gum Ironbark Forest	E.propinqua	25	C.henryi	25	E.siderophloia	40						Yes			
8	1	513521	6684582	Spotted Gum Ironbark Forest	E.pyrocarpa	10	C.henryi	80	E.siderophloia	10	0								
9	1	517770	6675591	Tallow ood - Mahogany Forest	E.resinifera	20	E.acmenoides	60	E.microcorys	20	0				Yes				
10	1	518092	6677520	Blackbutt/Tallow wood Ridgetop and Upper Slopes Forest	C.gummifera	30	E.pilularis	50	Allocasuarina torulosa	20									
11	1	516597	6679895	Blackbutt Pink Bloodw ood Wet Forest	E.pilularis	70	E.resinifera	20	C.gummifera	10						Ye			

																	s			
12	1	516394	6680499	Blackbutt Pink Bloodwood Wet Forest	E.planchoniana	40	E.pilularis	30	C.gummifera	30	0									
13	1	518206	6676455	Swamp Forest - Swamp Mahogany/Forest Red Gum	E.tereticornis	33	Allocasuarina littoralis	33	Melaleuca	33	0			Yes						
14	1	517833	6675995	Swamp Forest - Paperbark	E.resinifera	40	Melaleuca quinquinervia	40	Callistemon salignus	20	0				Yes					
15	1	518069	6676536	Swamp Forest - Paperbark	Melaleuca quinquinervia	90	E.resinifera	10			0					Yes				
16	1	512980	6683500	Moist Floodplain Eucalypt Forest	E.pilularis	70	C.gummifera	15	A.costata	15	0									
17	1	513311	6684746	Spotted Gum Ironbark Forest	C.henryi	35	E.fibrosa	35	E.acmenoides	25	0									
18	1	513319	6684823	Spotted Gum Ironbark Forest	C.henryi	35	E.fibrosa	25	E.acmenoides	35	0									
19	1	513134	6685167	Spotted Gum Ironbark Forest	C.henryi	45	E.propinqua	15	E.siderophloia	40	0					Yes				
20	1	511565	6686438	Blackbutt Pink Bloodwood Wet Forest	E.pilularis	50	C.henryi	50			0									
21	1	509580	6687921	Blackbutt Scribbly Gum Open Forest	E.pilularis	15	E.signata	5	A.costata	20										
22	2	509800	6687719	Blackbutt Pink Bloodwood Wet Forest	E.pilularis	33	E.resinifera	33	C.gummifera	33	0				Yes					
23	1	507120	6689868	Needlebark Stringybark/Scribbly Gum Forest	E.signata	35	E.planchoniana	35	C.gummifera	30										
24	2	506531	6690908	Blackbutt/Tallowwood Ridgetop and Upper Slopes Forest	E.signata	30	C.gummifera	40	E.resinifera	25						Yes				
25	2	505809	6693224	Needlebark Stringybark/Scribbly Gum Forest	E.planchoniana	45	E.resinifera	10	C.gummifera	45	0					Yes				
26	2	507166	6689700	Needlebark Stringybark/Scribbly Gum Forest	E.signata	30	C.gummifera	50	E.acmenoides	20	0									
27	2	507090	6689756	Needlebark Stringybark/Scribbly Gum Forest	E.signata	50	E.planchoniana	50	0	1	0									
28	2	510159	6687435	Swamp Forest - Swamp Mahogany/Forest Red Gum	C.camphor	50	E.robusta	50			0		Yes				Yes			
29	1	513446	6683557	Moist Floodplain Eucalypt Forest	Melaleuca quinquinervi	40	A.costata	30	E.microcorys	30	0			Yes			Yes			

					a															
30	1	511542	6686475	Moist Floodplain Eucalypt Forest	Melaleuca quinquinervia	40	S.glomulifera	15	E.pilularis	10										
31	2	506570	6690593	Moist Floodplain Eucalypt Forest	E.signata	60	Angophora	40			0									
32	1	509112	6688308	Needlebark Stringybark/Scribbly Gum Forest	A.costata	40	L.suaveolens	15	E.pilularis	45	0									
33	3	502299	6704136	Spotted Gum Ironbark Forest	C.henryi	90	E.fibrosa	10												
34	3	502178	6704198	Spotted Gum Ironbark Forest	C.henryi	90	E.pilularis	10												
35	3	502010	6704322	Spotted Gum Ironbark Forest	C.henryi	90	E.pilularis	10												
36	3	501806	6704431	Spotted Gum Ironbark Forest	C.henryi	80	E.moluccana	20												
37	3	502039	6704679	Spotted Gum Ironbark Forest	C.henryi	80	E.pilularis	20												
38	3	502198	6704748	Spotted Gum Ironbark Forest	C.henryi	70	E.propinqua	15	E.fibrosa	15							Yes			
39	3	503822	6705077	Spotted Gum Ironbark Forest	C.henryi	50	E.moluccana	50												
40	3	504190	6707897	Spotted Gum Ironbark Grey Box Forest	C.henryi	80	E.moluccana	20												
41	3	504436	6707993	Spotted Gum Ironbark Grey Box Forest	C.henryi	50	E.moluccana	50												
42	3	504635	6708186	Spotted Gum Ironbark Grey Box Forest	C.henryi	80	E.moluccana	10	E.tereticornis	10						Yes				
43	3	504384	6708416	Spotted Gum Ironbark Forest	C.henryi	20	E.moluccana	60	E.tereticornis	10						Yes				
44	3	502985	6704900	Wet Sclerophyll Forest	E.tereticornis	90	Melaleuca sieberi	5	E.siderophloia	5			Yes					Yes		
45	3	503026	6704936	Wet Sclerophyll Forest	E.tereticornis	90	Melaleuca sieberi	5	L.suaveolens	5			Yes					Yes		
46	3	503127	6707173	Spotted Gum Ironbark Forest	C.henryi	60	E.moluccana	20	E.propinqua	10							Yes			
47	3	503723	6707083	Spotted Gum Ironbark Forest	C.henryi	60	E.fibrosa	25	E.moluccana	15										
48	3	503971	6707332	Spotted Gum Ironbark Forest	C.henryi	70	E.fibrosa	15	E.moluccana	15										

49	3	505554	6708267	Spotted Gum Ironbark Forest	C.henryi	95	E.fibrosa	5											
50	3	505966	6708200	Spotted Gum Ironbark Forest	C.henryi	90	E.propinqua	10								Yes			
51	3	512189	6711659	Needlebark Scribbly Gum Open Forest	E.signata	20	Melaleuca quinquenervia	20	L.suaveolens	20									
52	3	512013	6711797	Scibbly Gum Bloodw ood Open Forest	E.signata	50	C.gummifera	40	A.robur	10									
53	3	512422	6712422	Scibbly Gum Bloodw ood Open Forest	E.signata	40	C.gummifera	20	E.microcorys	40				Yes			Yes		
54	3	512855	6718237	Scibbly Gum Bloodw ood Open Forest	A.robur	50	E.saligna	45	E.microcorys	5					Yes				
55	3	506711	6708299	Sw amp Oak FloodPlain Forest	E.tereticornis	50	Casuarina.glauca	50					Yes				Yes		
56	3	506754	6708288	Sw amp Oak FloodPlain Forest	E.tereticornis	60	Casuarina.glauca	40					Yes				Yes		
57	3	512769	6723892	Wet Sclerophyll Forest	E.robusta	40	Melaleuca	20	L.suaveolens	40				Yes			Yes		
58	3	513710	6721451	Wet Sclerophyll Forest	Melaleuca	80	C.intermedia	5	L.suaveolens	15									
59	3	510131	6708550	Scibbly Gum Bloodw ood Open Forest	E.saligna	10	E.fibrosa	10	E.microcorys	80			Yes				Yes		
60	3	513631	6721294	Needlebark Scribbly Gum Open Forest	E.planchoniana	50	Melaleuca quinquenervia	25	A.robur	10									
61	3	513542	6721359	Needlebark Scribbly Gum Open Forest	E.saligna	70	C.gummifera	15	E.planchoniana	15									
62	3	513664	6721465	Needlebark Scribbly Gum Open Forest	E.saligna	50	C.gummifera	20	E.planchoniana	30									
63	3	512740	6724107	Sw amp Sclerophyll Forest	S.glomulifera	60	E.resinifera	20	C.intermedia	20						Yes			
64	3	513212	6725919	Tallow ood Forest	E.microcorys	33	A.robur	33	A.excelsa	33				Yes			Yes		
65	3	513425	6727258	Tallow ood Forest	E.microcorys	80	E.siderophloia	10	A.concurrens	10	1	Tallow w ood	Yes				Yes		
66	3	513253	6727241	Tallow ood Forest	C.intermedia	80	E.microcorys	20	E.siderophloia	20					Yes				
67	3	513161	6727579	Wet Sclerophyll Forest	E.microcorys	60	L.suaveolens	20	A.excelsa	10			Yes				Yes		
68	4	515052	6730950	Wet Sclerophyll Forest	L.suaveolens	60	E.tereticornis	20	A.excelsa	20					Yes				

69	4	515080	6730994	Wet Sclerophyll Forest	Pinus	50	A.excelsa	25	A.concurrens	25										
70	4	515589	6730894	Tallow ood Forest	A.excelsa	50	E.microcorys	10	A.concurrens	10						Yes				
71	3	512033	6714814	Blackbutt Open Forest	E.pilularis	50	C.henryi	50												
72	5	523132	6743139	Sw amp Sclerophyll Forest	Melaleuca	60	Allocasuarina littoralis	40												
73	5	523209	6743479	Sw amp Sclerophyll Forest	Melaleuca	40	Allocasuarina littoralis	60												
74	4	515508	6730888	Tallow ood Forest	E.microcorys	10	E.propinqua	50	C.intermedia	40					Yes				Yes	
75	4	520640	6740687	Flooded Gum Forest	E.grandis	60	Ceratopetalum apetalum	20	Acacia	20										
76	3	513136	6718975	Turpentine Open Forest	S.glomulifera	80	E.resinifera	10	Allocasuarina littoralis	10										
77	3	513174	6718723	Turpentine Open Forest	S.glomulifera	90	E.resinifera	10												
78	3	513148	6718742	Turpentine Open Forest	S.glomulifera	80	E.resinifera	20												
79	3	513085	6718565	Turpentine Open Forest	C.gummifera	40	E.signata	20	S.glomulifera	40										
80	3	513059	6718569	Turpentine Open Forest	S.glomulifera	70	C.gummifera	20	E.resinifera	10										
81	3	512957	6719643	Scibbly Gum Bloodw ood Open Forest	A.robur	80	C.gummifera	10	A.excelsa	10										
82	3	512942	6719607	Scibbly Gum Bloodw ood Open Forest	E.signata	40	A.robur	40	C.gummifera	10										
83	3	512651	6718269	Scibbly Gum Bloodw ood Open Forest	E.signata	30	A.robur	10	C.gummifera	30										
84	6	522400	6755548	Blackbutt Open Forest	E.pilularis	30	E.acmenoides	10	NA	0	0									
85	6	522465	6756012	Narrow Leaved White Mahogany	E.acmenoides	15	Melaleuca	40	L.suaveolens	10	0									
86	6	522765	6756208	Sw amp Sclerophyll Forest	Melaleuca	40	L.suaveolens	20	NA	0	0									
87	6	521928	6756985	Wet Sclerophyll Forest	E.acmenoides	15	C.intermedia	15	C.henryi	5	0									
88	6	522208	6757044	Angophora/Bloodw ood	E.signata	10	E.acmenoides	15	C.gummifera	5	0									
89	7	525014	6767569	Spotted Gum Ironbark Forest	C.henryi	25	NA	0	NA	0										
90	6	521216	6757751	Angophora/Bloodw ood	BL Mahogany	12	Angophora	7	E.siderophloia	5										

					12%															
91	6	521524	6757913	Ironbark/Grey Gum/Mahogany	BL Mahogany 15%	15	C.intermedia	7	NA	0										
92	6	520858	6760685	Grey Gum Ironbark Open Forest	E.propinqua	10	C.henryi	15	C.gummifera	5	0						Yes			
93	6	520871	6760997	Red Gum	C.intermedia	15	E.propinqua	7	E.siderophloia	7	0						Yes			
94	7	524787	6766805	Scibbly Gum Bloodwood Open Forest	E.signata	5	C.gummifera	7	E.acmenoides	10										
95	7	524647	6766933	Swamp Sclerophyll Forest	Melaleuca	25	E.pilularis	10	Angophora	5										
96	7	524704	6766861	Blackbutt Open Forest	E.pilularis	15	E.umbra	10	C.intermedia	5										
97	7	525073	6767866	Spotted Gum Ironbark Forest	C.henryi	20	E.pilularis	6	Angophora	3										
98	7	525389	6767806	Scribbly Gum	E.signata	17	E.acmenoides	10	C.henryi	7										
99	7	525460	6768449	Red Gum	Angophora	15	Melaleuca sieberi	7	C.gummifera	3										
100	7	525660	6769343	Blackbutt Open Forest	E.pilularis	20	E.resinifera	12	C.intermedia	4							Yes			
101	7	526291	6770096	Red Gum	E.tereticornis	15	Melaleuca	25	L.suaveolens	10	0					Yes				
102	7	526821	6771711	Swamp Sclerophyll Forest	E.resinifera	8	Melaleuca	5	Melaleuca	7	0						Yes			
103	7	527054	6772255	Spotted Gum Ironbark Forest	C.henryi	20	E.resinifera	5	E.acmenoides	10	0									
104	7	527217	6772141	Scribbly Gum	E.signata	13	C.intermedia	7	E.acmenoides	5	0									
105	7	527464	6772574	Bloodwood Smooth Barked Apple open heath Forest	Angophora	10	NA	0	NA	0	0									
106	7	527960	6773860	Blackbutt Open Forest	E.pilularis	15	E.acmenoides	5	NA	0										

107	7	527435	6773185	Needlebark Stringybark Woodland	E.planchoniana	16	C.intermedia	4	NA	0	0									
108	7	531106	6776554	Swamp Forest - Paperbark	E.fibrosa	15	Acacia	15	E.tereticornis	5					Yes					
109	7	530991	6776574	Swamp Sclerophyll Forest	Melaleuca	40	NA	0	NA	0										
110	8	533387	6780437	Grey Gum/Ironbark	E.propinqua	20	E.acmenoides	10	E.siderophloia	5	0					Yes				
111	7	531267	6777042	Swamp Sclerophyll Forest	E.microcorys	30	E.resinifera	50	E.robusta	20	0		Yes				Yes			
112	7	530866	6776245	Swamp Sclerophyll Forest	E.robusta	40	E.microcorys	20	L.suaveolens	30	0		Yes				Yes			
113	7	531115	6777184	Red Mahogany Open Forest	L.suavelolons	60	E.robusta	20	Mel.quni	20	0					Yes				
114	8	532947	6781253	Red Gum	E.tereticornis	15	E.siderophloia	10	C.intermedia	15					Yes					
115	9	538883	6787342	Banksia Callitris Heathland	Banksia aemula	5	Acacia	5	Leptospermum	70										
116	9	539275	6787734	Semi-arid Shrubland	Banksia aemula	45	Leptospermum	25	NA	0										
117	9	539226	6787797	Banksia Callitris Heathland	Acacia sp	15	Leptospermum	25	Banksia aemula	5										
118	8	539842	6788606	Semi-arid Shrubland	Banksia aemula	30	Leptospermum	20	Banksia ericifolia	30										
119	9	539869	6788565	Swamp Oak FloodPlain Forest	Melaleuca	22	Melaleuca	3	NA	0										
120	9	542552	6789672	Banksia Callitris Heathland	Leptospermum	35	Acacia	5	Melaleuca quinquenervia	5										
121	9	540429	6788871	Swamp Sclerophyll Forest	E.robusta	20	Leptospermum	30	Melaleuca	10					Yes					

122	8	536025	6783882	Swamp Oak FloodPlain Forest	Melaleuca	30	Camphor Laurel	10	Casuarina glauca	5	0									
123	8	535850	6783733	Swamp Oak FloodPlain Forest	Melaleuca	30	Casuarina glauca	5	Flindersia	2	0									
124	8	535983	6784081	Swamp Oak FloodPlain Forest	Casuarina glauca	7	Camphor Laurel	8	NA		0									
125	11	546394	6800627	Swamp Sclerophyll Forest	Acronycia imperforata	20	Guioa semiglauca	10	E.pilularis	10										
126	11	546808	6802902	Swamp Oak FloodPlain Forest	C.camphor	35	Commersonia bartramia	10	Acacia	5										
127	11	548207	6806624	Swamp Oak FloodPlain Forest	Casuarina glauca	15	Cupaniopsis anacardioides	25	Ficus obliqua	3										
128	10	542492	6793974	Blackbutt Open Forest	E.siderophloia	13	E.pilularis	10	E.acmenoides	5	0									
129	10	542035	6794967	Swamp Oak FloodPlain Forest	Melaleuca	32	E.seeana	10	Glochidion	3										
130	10	542718	6794567	Blackbutt Open Forest	E.pilularis	30	L.confertus	5	C.intermedia	3										
131	6	524184	6752911		E.propinqua	80	E.siderophoila	10	E.microcorys	5	0			Yes				Yes		
132	6	524076	6753010		E.propinqua	80	E.siderophoila	10	E.microcorys	5	0			Yes				Yes		
133	6	523044	6755155		E.siderophloia	25	C.maculata	35	E.propinqua 20, e.microcorys 15	35	0				Yes					
134	6	522599	6755744		E.pilularis	70	C.gummifera	20	E.microcorys	20	0				Yes					
135	6	522655	6755866		E.pilularis	70	C.gummifera	20	E.microcorys/E.propinqua	20	0				Yes					
136	6	522764	6755626		E.pilularis	70	C.gummifera	20	E.microcorys/E.propinqua	20	0				Yes					

137	7	526526	6770200		E.resinifera	40	E.signata	30	A.floribunda 15, L.suaveolens 10, E.microcorys 5	30	0								
138	7	526709	6770521		E.resinifera	40	E.signata	30	A.floribunda 15, L.suaveolens 10, E.microcorys 5	30	0								
139	7	526635	6770590		E.resinifera	40	E.signata	30	A.floribunda 15, L.suaveolens 10, E.microcorys 5	30	0								
140	7	527598	6773171		E.tindaliae	50	A.paludosa	30	c.gummifera	20	0								
141	7	527619	6773208		E.resinifera	70	E.intermedia	15	E.signata	10	4	E.resinfera (4)		Yes				Yes	
142	7	530343	6775878		E.robusta	50	L.sauveolons	30	E.tereticornis	20	0		Yes				Yes		
143	7	530149	6775724		E.robusta	50	L.sauveolons	45	E.tereticornis	5	0		Yes				Yes		
144	7	530425	6775783		E.tereticornis	50	L.sauveolons	45	E.robusta	5	0		Yes				Yes		
145	8	532665	6779077		E.tereticornis	50	L.sauveolons	45	E.robusta	5	0		Yes				Yes		
146	8	533128	6780035		E.tereticornis	50	L.sauveolons	45	E.robusta	5	0		Yes				Yes		
147	8	533108	6780216		E.tereticornis	40	E.siderophloa	40	C.intermedia	5	0			Yes			Yes		
148	10	546291	6799821		E.robusta	50	M.quin	50			8	E.robusta (8)	Yes				Yes		
149	10	546060	6800159		E.pilularis	30	Rainforest species	50	E.resinifera	20	0								
150	10	545277	6799344		Rainforest species	100	Diploglottis				0								
151	10	545106	6799527		Rainforest species	100	Diploglottis				0								

152	10	541829	6797215		E.robusta	45	E.resinifera	50	E.signata	10	6	E.robusta (1), E.resinifera (5)		Yes			Yes		
153	10	542434	6795190		E.robusta	60	E.resinifera	15	E.signata10 C.intermedia 10	15	4	E.robusta (4 scats)	Yes				Yes		
154	10	542595	6793662		E.acmenoides	35	E.pilularis	35	E.resinifera 15, E.propinqua 10, C.intermedia 5	30	1	Eucalyptus propinqua (18 scats)						Yes	
155	10	542383	6793775		E.microcorys	20	E.robusta	40	E.resinifera20, E.propinqua 10, L.confertus 10	40	3	Eucalyptus microcorys (1), E.robusta (1), E.resinifera (1)		Yes			Yes		
156	10	542576	6793051		E.signata	40	E.pilularis	35	E.seeana	25	2	Eucalyptus signata (2 scats)				Yes			
157	10	542386	6793113		E.signata	70	C.gummifera	30			0								
158	10	542677	6793252		E.resinifera	30	E.seeana	25	E.microcorys10, E.pilularis15, C.gummifera15, E.siderophoila5	35	2	Eucalyptus microcorys (2 scats)		Yes			Yes		
159	9	543019	6790922		E.tereticornis	20	E.microcorys	20			2	E.microcorys (1), E.tereticoris (1)		Yes			Yes		
160	8	537918	6787004		L.suavelolons	35	M.quin	30	Ficus	20	0								
161	4	512580	624900		E.tereticornis	50	E.microcorys	20	E.robusta	10	1		Yes				Yes		