NSW Roads and Maritime Services

WOOLGOOLGA TO BALLINA | PACIFIC HIGHWAY UPGRADE

THREATENED MAMMAL MANAGEMENT PLAN

Version 3.1

October 2015

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Contents

Glossary and abbreviations

Term	Definition
BACI	Before-After-Control-Impact
BMF	Biodiversity Mitigation Framework
CEMP	Construction Environmental Management Plan
CoA	Commonwealth Condition of Approval
Construction footprint	The direct area of the design alignment (also referred to as the clearance limits)
CRA	Comprehensive Regional Assessment
DECCW	NSW Department of Environment, Climate Change and Water (now known as EPA)
Direct impact	An impact that causes direct harm within the project boundary (i.e. clearing of vegetation)
DoE	Commonwealth Department of the Environment (previously known as the Department of Sustainability, Environment, Water, Population and Communities)
DP&E	NSW Department of Planning and Environment (formally known as Department of Planning and Infrastructure)
DPI	NSW Department of Primary Industries
DSEWPaC	The former Commonwealth Department of Sustainability, Environment, Water, Population and Community. Now DoE.
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPA	NSW Environment Protection Authority
EPBC Act	Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*
EIS	Environmental Impact Statement (Biodiversity Assessment Working Paper)
FFMP	Flora and Fauna Management Plan
Indirect impact	An impact that causes harm outside of the project boundary as a result of a direct impact (i.e. edge effects, erosion etc.)
MCoA	NSW Minister's Condition of Approval
Monitoring sites	BACI Monitoring Sites have been established that consist of impact and control sites (as detailed in Section 8.2.2). Impact sites (these would be monitoring sites such as near dedicated and combined crossing structures within 200 m of the road edge and where possible on both sides of the road). Control sites (>500 m from the project and impact sites to account for home range sizes).
NBMP	Nest Box Management Plan
NSW	New South Wales
Trigger for corrective action	This is a measurable target that, should it be reached, will trigger an assessment as to why the mitigation objectives are not being met and evaluation and implementation of appropriate corrective actions.
The Project	Refers to all the proposed works in all eleven sections which includes the construction footprint with a 10 metre construction buffer, ancillary and compound sites and design changes.
Roads and Maritime	NSW Roads and Maritime Services
RTA	Roads and Traffic Authority
SPIR	Submissions / Preferred Infrastructure Report
SSI	State Significant Infrastructure
Targeted surveys	Field surveys completed post SPIR in late 2013, 2014 and 2015 that include targeted surveys for threatened mammal species under the EPBC Act and TSC Act.

Term	Definition
Threatened mammals	For the purposes of this plan threatened mammals are: • Rufous Bettong (*Aepyprymnus rufescens*) • Spotted-tailed Quoll (*Dasyurus maculatus maculatus*) • Brush-tailed Phascogale (*Phascogale tapoatafa*) • Long-nosed Potoroo (*Potorous tridactylus*).
Threatened species	Any organism listed as vulnerable, endangered or critically endangered under state and/or Commonwealth legislation.
TMMP	Threatened Mammal Management Plan (this plan)
TSC Act	*Threatened Species Conservation Act 1995*
W2B	Woolgoolga to Ballina Pacific Highway Upgrade
WIRES	NSW Wildlife Information Rescue and Education Service Inc
WQMP	Water Quality Management Program

1. Introduction

1.1 Project overview

NSW Roads and Maritime Services (Roads and Maritime) has received approval for the Woolgoolga to Ballina (W2B) Pacific Highway upgrade project (the project / the action), on the NSW North Coast. Approvals were granted under Part 5.1 of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act) on 24 June 2014, and under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) on 14 August 2014. The location of the project is shown in **Figure 1-1.**

Since 1996, both the Australian and NSW governments have contributed funds to the upgrade of the 664 kilometre section of the Pacific Highway between Hexham and the NSW/Queensland border, as part of the Pacific Highway Upgrade Program.

The Project will upgrade around 155 kilometres of highway and on completion will result in a four-lane divided road between Hexham and the NSW / Queensland border. For the purposes of the EIS the project has been divided into 11 sections as illustrated in **Figure 1-1**.

Key features of the upgrade include:

- Duplication of 155 kilometres of the Pacific Highway to a motorway standard (Class M) or arterial road (Class A), with two lanes in each direction and room to add a third lane if required in the future
- Split-level (grade-separated) interchanges at Range Road, Glenugie, Tyndale, Maclean, Yamba / Harwood, Woombah (Iluka Road), Woodburn, Broadwater and Wardell
- Bypasses of South Grafton, Ulmarra, Woodburn, Broadwater and Wardell
- About 40 bridges over rivers, creeks and floodplains, including major bridges crossing the Clarence and Richmond rivers
- Bridges over and under the highway to maintain access to local roads that cross the highway
- Access roads to maintain connections to existing local roads and properties
- Structures designed to encourage animals over and under the upgraded highway where it crosses key animal habitat or wildlife corridors
- Rest areas located at about 50 kilometre intervals at Pine Brush (Tyndale), north of Mororo Road and north of the Richmond River; and
- A heavy vehicle checking station near Halfway Creek and north of the Richmond River.

Construction and delivery of the project will be undertaken in a number of separate stages. These stages are detailed in the Staging Report prepared to satisfy NSW Government Approval – Minister's Condition of Approval (MCoA) A7. The Staging Report submitted in March 2015 deals in detail with Stage 1 of the Project.

The project is separated into 11 Sections as outlined below:

- Section 1 – Woolgoolga to Halfway Creek
- Section 2 – Halfway Creek to Glenugie
- Section 3 – Glenugie interchange to the Tyndale interchange
- Section 4 – Tyndale interchange to the existing highway at the Maclean interchange
- Section 5 – Maclean interchange to the Iluka Road interchange at Woombah
- Section 6 – Iluka Road at Woombah to Devil's Pulpit
- Section 7 – Devils Pulpit to Trustums Hill
- Section 8 – Trustums Hill to Broadwater National Park
- Section 9 – Broadwater National Park to the Richmond River
- Section 10 – Richmond River to the interchange at Coolgardie Road
- Section 11 – Coolgardie Road to the tie-in with the Pimlico to Teven project.

The project is jointly funded by the NSW and Australian governments. Both governments have a shared commitment to finish upgrading the highway to a four-lane divided road as soon as possible. Construction timing for Stage 1 is estimated for commencement in mid 2015 and completion of the entire project is planned for the end of 2020. The project does not include the Pacific Highway upgrades at Glenugie and Devils Pulpit, which are located between Woolgoolga and Ballina. These are separate projects, with both of these additional projects now complete. Altogether, these three projects will total to an upgrade of 164 kilometres of the Pacific Highway. The project does include a partial upgrade of the existing dual carriageways at Halfway Creek.

For a more detailed project description (as approved in late 2014) refer to the Roads and Maritime Services Woolgoolga to Ballina Pacific Highway Upgrade Submissions/Preferred Infrastructure Report (SPIR) dated November 2013 and the Woolgoolga to Ballina Staging Report (2015).

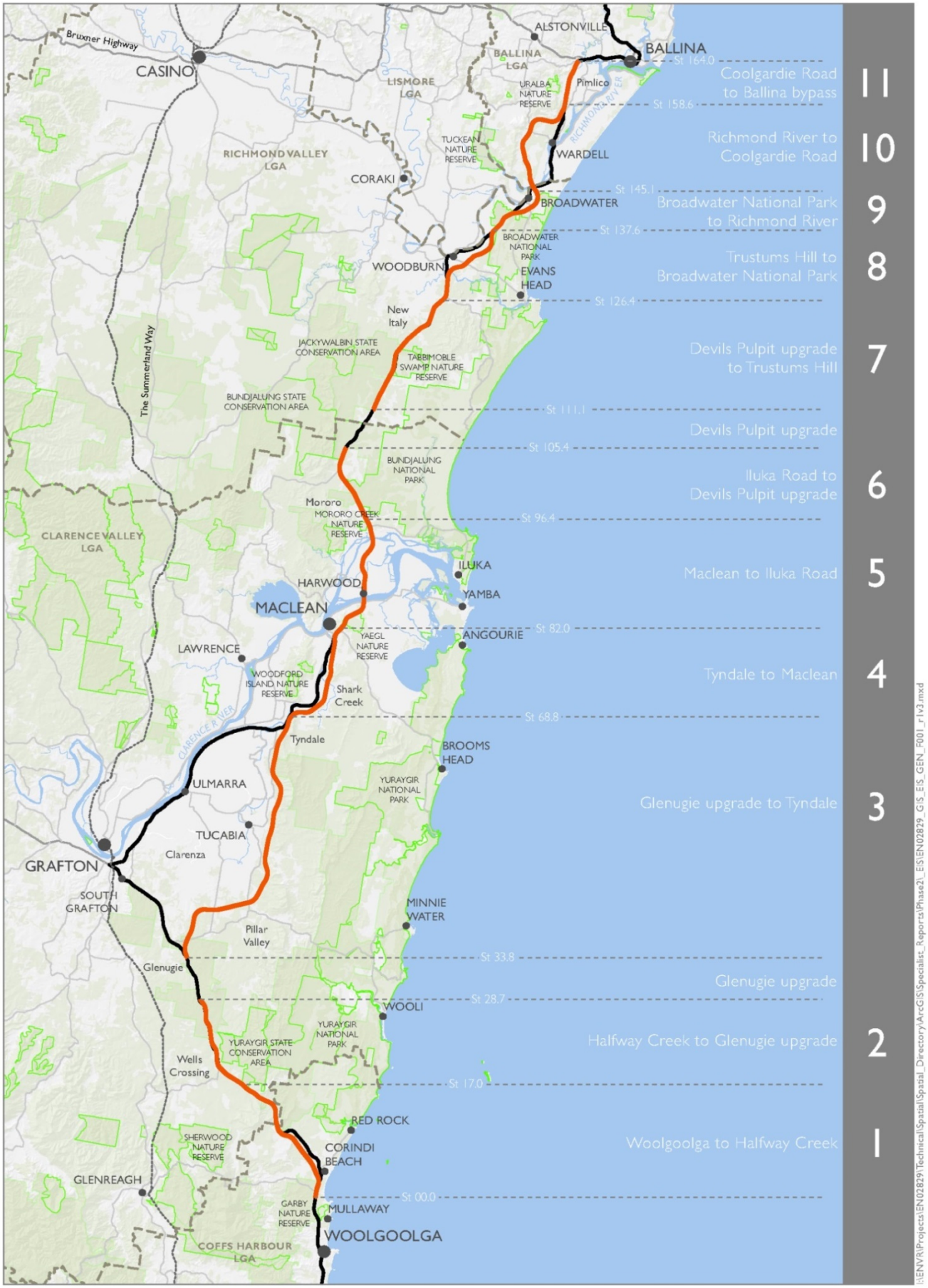

Figure 1-1 Woolgoolga to Ballina project sections

This Threatened Mammal Management Plan (TMMP) has been developed to meet the requirements of the NSW Government Approval MCoA D8, and Commonwealth EPBC Act Condition of Approval (CoA) 12. The requirements of these approvals and where it is addressed in this report are detailed in **Table 1-1**.

Table 1-1 Project approval requirements and where addressed

Approval requirement		Where addressed
NSW approval		
MCoA D2	The Applicant shall prepare and implement a Connectivity Strategy, to be submitted and approved by the Secretary prior to the commencement of construction. The strategy shall describe the rationale for, and final design and location of, fauna connectivity structures for the State Significant Infrastructure (SSI) and shall demonstrate the effectiveness of connectivity measures for the species targeted for the crossing. The Strategy shall be developed from the draft Connectivity Strategy in the documents listed in condition A2 in consultation with the OEH, DPI (Fisheries) and DoE, to the satisfaction of the Secretary. The Strategy shall include: (a) details of all crossings for terrestrial and aquatic fauna, including but not limited to land bridges, bridge, arch and culvert crossings, and crossings for arboreal fauna; (b) justification for the location and design, and spacing of the connectivity structures, with reference to relevant State and Commonwealth threatened species guidelines and the results of on-ground surveys as required by D2(d); (c) demonstration of the effectiveness of the connectivity structures (including exclusionary fencing) in terms of location, design and number of connectivity structures to mitigate impacts to the relevant threatened species, and that the crossings: (i) maintain or improve connectivity and movement pathways; (ii) reduce the risk of mortality for threatened species; (iii) are located at locations, at sufficient frequency along the alignment, based on the ecological requirements of the targeted species, including but not limited to home range size, movement patterns, and habitat use; (d) the results of surveys undertaken to determine the habitat, species movement patterns, distribution of species to confirm the design and location; (e) consideration of connectivity under the existing highway, service roads and local roads (servicing over 100 vehicles per day); (f) commitment that pathways to connectivity structures are not to be impeded by ancillary facilities, rest areas or service roads, or local roads (servicing over 100 vehicles per day) that are realigned as part of the SSI or experience an increase in traffic volumes during operation of the SSI; (g) commitment to implement the landscaping of vegetation leading to connectivity structures; (h) a fencing strategy, describing the location, design and length of fencing, which must extend beyond the edges of habitat for threatened species; (i) the maintenance of connectivity measures and fencing for the life of the impact of the action, including the timing and frequency; (j) an assessment of the flooding risk for proposed structures, and measures to confirm and provide for flood immunity of those structures in light of this assessment. The agreement of the OEH on flood immunity levels shall be obtained prior to the commencement of construction of the relevant stage; (k) commitment that all bridges in identified wildlife corridors, or adjacent to threatened species habitat, or are likely to provide connectivity for threatened species based on surveys undertaken in accordance with the Mitigation Framework required in condition D1, shall provide a minimum three metre wide dry passage from toe of the scour protection to the top of the bank, with natural substrate and refuge features. Where this criteria cannot be achieved and with the agreement of the OEH, consideration shall be given to the use of suitable materials in, and the final form of, the scour protection to provide for the safe and effective passage of fauna; (l) detailed consideration of the effects of connectivity structures on the maintenance or improvement of population viability and gene flow; and (m) incorporate the outcomes of the Mitigation Framework required under condition D1.	The requirements of this condition in the context of threatened mammal species are addressed in this plan in the following sections: (a) Section 6.3.7, Table 6.3 and Table 6.4. (b) Fauna Connectivity Strategy (Sections 1 and 2), Section 2, Section 4.4 and Section 6.3.7. (c) Fauna Connectivity Strategy (Sections 1 and 2), Section 4.4 and Section 6.3.6 and 6.3.7. (d) Section 2, Table 2.1, Section 3.2 and Appendices C, D, E, F and G (Lewis Ecological, 2014). (e) Section 6.3.7 (f) Addressed in Fauna Connectivity Strategy (Sections 1 and 2) 2014 (g) Section 6.3.8, Table 6.1 and Urban Design and Landscape Plan (UDLP) (h) Fauna Connectivity Strategy (Section 1 and 2) and Section 6.3.6 (i) Section 7.3. (j) Addressed in Fauna Connectivity Strategy (Section 1 and 2). (k) Addressed in Fauna Connectivity Strategy (Section 1 and 2) and Section 6.3.7 (l) Section 4.4 (m) Mitigation Framework has been prepared and submitted for approval. Relevant provisions including results of targeted surveys are summarised in this TGMP, Section 2. Additional details associated with these conditions can be found in the final Fauna

Approval requirement		Where addressed
	Unless connectivity measures can be demonstrated to be effective at successfully mitigating the barrier and fragmentation impact to relevant species, in accordance with the requirements of the construction flora and fauna management plan required under condition D26(e), and threatened species management plans required under conditions D8 and D9, the residual impact to connectivity shall be offset. Where the location and/or design of connectivity structures has changed from that identified in the documents listed under conditions A2(c) and A2(e), the Strategy shall demonstrate how the new location and/or design would result in an improved biodiversity outcome. The Strategy shall clearly identify how the connectivity structures will work in conjunction with other biodiversity measures, such as complementary fauna exclusion fencing measures and the regeneration/replanting of native vegetation, to be implemented for the SSI. The Applicant shall demonstrate to the satisfaction of the Secretary how public authority comments on the Strategy have been addressed. The Strategy may be submitted in stages to suit the staging of the SSI.	Connectivity Strategy (GHD, December 2014). Public authority comments and responses are summarised in Appendix A and Table 1.3.
MCoA D6	Prior to the commencement of construction of the relevant stage that would result in the disturbance of native vegetation (or as otherwise agreed by the Secretary), the Applicant shall prepare and implement a Nest Box Plan to provide replacement hollows for displaced fauna. The Plan shall be prepared in consultation with the OEH and to the satisfaction of the Secretary. The Plan shall be prepared by a suitably qualified and experienced ecologist and detail the number and type of nest boxes to be installed, which shall be justified based on the number and type of hollows removed (based on pre clearing surveys), the density of hollows in the area to be cleared and in adjacent areas, and the availability of adjacent food resources. The Plan shall also provide details of maintenance protocols for the nest boxes installed including responsibilities, timing and duration.	The requirements of this condition in the context of the threatened mammal species are addressed in Section 6.3.10. Nest Box Management Plans have been submitted and approved for Sections 1 and 2.
MCoA D8	The Applicant shall prepare and implement Threatened Species Management Plans to detail how impacts of the project (referred to as State Significant Infrastructure (SSI)) will be minimised and managed specifically for each species identified as significantly impacted in the documents listed in condition A2 or in accordance with condition D1. The Plans shall be developed from the draft Threatened Species Management Plans included in the documents listed in condition A2(c) (subject to condition D9), in consultation with OEH, DPI (Fisheries) and DoE, and to the satisfaction of the Secretary, and shall include but not necessarily be limited to: (a) demonstration that adequate surveys have been undertaken to assess the impacts of the SSI with reference to the Mitigation Framework developed under condition D1, including baseline data collected from surveys, undertaken by a suitably qualified and experienced ecologist on threatened species and ecological communities within all habitat areas to be cleared of vegetation for the SSI, that are likely to contain these species and that are likely to be adversely impacted by the SSI (as determined by a suitably qualified expert). The data shall address the densities, distribution, habitat use and movement patterns of these species; (b) identification of potential impacts on each species; (c) details of and demonstrated effectiveness of the proposed avoidance and mitigation and management measures to be implemented for each threatened species including measures to at least maintain habitat values of habitat areas compared to baseline data and maintain connectivity for the relevant species; (d) an adaptive monitoring program to assess the use of the mitigation measures identified in conditions B10 and D2. The monitoring program shall nominate appropriate and justified monitoring periods, performance parameters and criteria against which effectiveness of the mitigation measures will be measured and include operational road kill and fauna crossing surveys to assess the use of fauna crossings and exclusion fencing implemented as part of the SSI; (e) monitoring methodology for threatened flora and fauna adjacent to the SSI footprint, (f) goals and performance indicators to measure the success of mitigation measures, which shall be specific, measurable, achievable, realistic and timely (SMART), and be compared against baseline data; (g) methodology for the ongoing monitoring of road kill, the species densities, distribution, habitat use and movement patterns, and the use of fauna crossings during construction and operation of the SSI, including the proposed timing, and duration of that monitoring; (h) provision for the assessment of monitoring data to identify changes to habitat usage and whether this can be attributed to the SSI;	The requirements of this condition in the context of threatened glider species are addressed in this plan in the following sections: (a) Section 2 and Appendices C, D, E, F and G (Lewis Ecological, 2014). (b) Section 4.1. (c) Section 4.3, Section 4.4. (d) Section 8. (e) Section 8. (f) Section 4.5, Section 5.5, Section 6.4 and Section 7.4. (g) Section 8. (h) Section 8.1 and Section 8.7. (i) Section 8.2.4. (j) Section 8.7. (k) Section 8. (l) Section 8.7. Expert and agency recommendations regarding the TMMP are summarised and details as to how they have been addressed in this plan are provided in Appendix A.

Approval requirement		Where addressed
	(i) details of contingency measures that would be implemented in the event of changes to habitat usage patterns, entities, distribution, and movement patterns attributable to the construction or operation of the SSI, based on adequate baseline data; (j) mechanisms for the monitoring, review and amendment of these plans; (k) provision for ongoing monitoring during operation of the SSI (for operation/ongoing impacts) until such time as the use and effectiveness of mitigation measures can be demonstrated to have been achieved over a minimum of three successive monitoring periods, unless otherwise agreed by the Secretary in consultation with the OEH, DPI (Fisheries) and DoE; and (l) provision for annual reporting of monitoring results to the Secretary and the OEH, DPI (Fisheries) and DoE, or as otherwise agreed by those agencies.	
Commonwealth approval		
CoA 11	A Threatened Mammal Management Plan pursuant to NSW approval condition D8 must be developed for each stage impacting on the Spotted-tail Quoll and Long-nosed Potoroo. The plan must minimise impacts to the Spotted-tail Quoll and Long-nosed Potoroo to the satisfaction of the Minister and must be submitted to the Minister for approval. The relevant stage(s) cannot commence until the Threatened Mammal Management Plan for that stage is approved by the Minister. The approved plan must be implemented.	This TMMP addresses Spotted-tail Quoll and Long-nosed Potoroo. Results of targeted surveys are summarised in Section 2. Additional surveys for the Long-nosed Potoroo have been completed and results are incorporated into Version 3 of this TMMP. Survey reports are included in Appendices C, D, E & F.
SPIR Environmental Management Measure		
B7	Tree height surveys will be conducted at proposed arboreal crossing zones to determine the most appropriate location to place rope or pole structures. Where feasible, the design will place arboreal crossing zones, where average tree heights exceed 20 metres, and/ or taller trees are able to be safely retained close to the road edge.	Tree height surveys have been completed and summarised in the Threatened Glider Management Plan. Crossing structures for arboreal species are summarised in the Fauna Connectivity Strategy for Sections 1 and 2 and Section 6.3.7 of this TMMP.
B9	Where feasible and reasonable, native vegetation forming part of the identified widened medians will not be disturbed for any ancillary construction purpose including access tracks, stockpiles, materials laydown and ancillary facilities.	This commitment has been retained and forms part of the mitigation measures for threatened mammals during construction. Wording is provided in Section 6.3.5 of this plan.
B11	The threatened species management plans prepared for the project will be finalised, as relevant to the element of the project to be constructed. Development of the plans will include responding, where feasible and reasonable to: • Recommendations from expert review undertaken as part of the Submissions / Preferred Infrastructure Report (and detailed in Section 1.4 of the management plans). • Any conditions of approval. • Results from baseline monitoring undertaken. • The threatened species management plans will be finalised in consultation with the relevant State and Federal government agencies. The threatened species management plans will be finalised in consultation with the relevant State and Federal government agencies.	This report forms the Threatened Mammal Management Plan. Expert recommendations, conditions of approval and baseline surveys have been considered and addressed in this plan. The TMMP will be approved prior to construction commencing in Sections 1 and 2.
B23	The pre-clearing process will would be consistent with Roads and Maritime Biodiversity Guidelines: Protecting and Managing Biodiversity on RTA projects (RTA, 2011) and include: • Pre-clearing surveys by an experienced ecologist for large bird nests, particularly for listed species such as the Black-necked Stork, Eastern Osprey, Square-tailed Kite and Little Eagle during the nesting and breeding season (July to December) and tree	Details of the surveys conducted to date for threatened mammal species are detailed in Appendices C, D, E & F.

Approval requirement		Where addressed
	roosting (eg Southern Myotis) or cave dwelling bats in trees or existing culvert/bridge structures. If the species is present in or directly adjacent to the project footprint (including ancillary facilities), measures to manage any species including buffer and exclusion zones, translocation of nests or establishment of adjacent nesting platforms would be considered, if required. Mapping the location of any threatened flora and/or fauna species, Threatened Ecological Communities and habitat.	Pre-clearance surveys prior to clearing will be conducted by suitably qualified ecologists. The requirements for these surveys are detailed in Section 6.3.4.
B24	The location of exclusion zones will be identified, with temporary fencing or flagging tape to indicate the limits of clearing (in accordance with the Roads and Maritime Biodiversity Guidelines (RTA, 2011a). Permanent fauna exclusion fencing for the project (as described in the Connectivity Strategy), where reasonable and feasible, will be installed prior to clearing and can function as exclusion fencing.	The requirements of this condition in the context of threatened mammal species are addressed in Section 5.4.2, Section 6.3.6 and Table 6.1 and Table 6.2.
B31	Nest boxes will be installed as per Roads and Maritime Biodiversity Guidelines (RTA, 2011) and a nest box strategy developed as part of the CEMP, detailing: • The number and type of nest boxes required based on the number, quality and size of the hollows that would be removed. • Specifications for nest box dimensions, installation requirements, locations of nest boxes and ongoing monitoring and maintenance. Installation timeframes, including the installation of 70% of nest boxes prior to the removal of any vegetation in the vicinity of the hollows.	Nest boxes form a mitigation measure for Brush-tailed Phascogale and are described in Section 6.3.10. Nest Box Management Plans have been prepared and approved. Each plan identifies the number, dimensions and location of hollows that are to be replaced as well as other detail required under this condition.
B32	To prevent injury and mortality of fauna during the clearing of vegetation and drainage of farm dams, an experienced and licensed wildlife carer and/or ecologist will be present to capture and relocate fauna where required. Further details regarding fauna handling and vegetation clearing procedures are provided in the Roads and Maritime Biodiversity Guidelines (RTA, 2011).	The requirements of this condition, and information on pre-clearance surveys and fauna spotter catchers in the context of threatened mammal species are addressed in Sections 6.3.3, 6.3.4 and 6.3.5.
B51	Ancillary facilities will be located in cleared or sparsely treed portions of the ancillary facility sites and avoid unnecessary clearing of native vegetation.	The requirements of this condition are addressed in Section 4.3, Section 6.3.4 and Section 6.3.5. Table 2-1 describes assessment of ancillary facilities that has been completed.

This TMMP identifies the potential impacts of the upgrade on threatened mammal species listed under the EPBC Act and NSW *Threatened Species Conservation Act 1995* (TSC Act) which were considered to be directly impacted or at greatest risk of impact from the project. This TMMP identifies the potential impacts to the species as a result of the project and proposed mitigation measures to be implemented. It also summarises a program for monitoring the effectiveness of these measures.

Mammal species covered in this TMMP are as follows:

- Brush-tailed Phascogale (*Phascogale tapoatafa*)
- Long-nosed Potoroo (*Potorous tridactylus*)
- Rufous Bettong (*Aepyprymnus rufescens*)
- Spotted-tailed Quoll (*Dasyurus maculatus maculatus*).

Collectively, these species are referred to as ‘threatened mammals’ in this plan.

The management of other threatened mammals, namely the Koala, Gliders (Squirrel Glider and Yellow-bellied Glider) and cave-roosting microbats (Little Bentwing-bat, Eastern Bentwing-bat, Southern Myotis and Large-eared Pied Bat) are addressed in separate management plans. These are the Koala Management Plan, Threatened Glider Management Plan and Threatened Bat Management Plan.

The objectives of the plan include providing:

- An effective TMMP with consideration to the concerns of main stakeholders including expert and agency review
- An overarching management framework for the Rufous Bettong, Spotted-tailed Quoll, Brush-tailed Phascogale and Long-nosed Potoroo for the project
- Information on the likely extent of direct impacts to these species by the project, including updated information as a result of targeted baseline surveys completed to date as described in **Section 2** of this report
- Management and mitigation measures that would be implemented during pre-construction, construction and operation of the project to minimise impacts on threatened mammal populations
- A monitoring program to be implemented during pre-construction, construction and operation of the project to assess the effectiveness of the mitigation measures and inform an adaptive management approach.

1.2 Management structure and plan updates

1.2.1 Management structure

This plan is intended to address the whole of the project and provide an overarching management framework for any part of the proposed upgrade between Sections 1 to 11 that is of relevance to the subject threatened mammal species and specific locations.

This plan provides up-to-date information using the results of targeted surveys outlining where threatened mammals have been recorded within the project area, the likely impacts to those species and mitigation measures to be put in place. This plan informs future monitoring and reporting; and identifies the locations proposed for conducting monitoring and the methods, variables and timing of the proposed monitoring program. Details have been provided on the selection of the final monitoring sites, both impact and control sites that have been identified through the targeted baseline surveys undertaken for the project.

This plan operates in conjunction with the Construction Environmental Management Plan (CEMP), project specific flora and fauna management plan (FFMP), Fauna Connectivity Strategy, Nest Box Management Plan (NBMP) and aspects associated with updates and delivery incorporated into the Biodiversity Mitigation Framework. An overview of how this TMMP relates to other relevant project documentation is provided in **Figure 1-2**.

General responsibilities for environmental management will be outlined in the CEMP and FFMP. Following approval of the plan, the construction contractor(s) and the contractors ecologists engaged for the relevant project sections would be responsible to oversee implementation of the plan.

Roads and Maritime have finalised this plan in consultation with the NSW Department of Planning and Environment (DP&E), NSW Environment Protection Authority (EPA) and Commonwealth Department of the Environment (DoE).

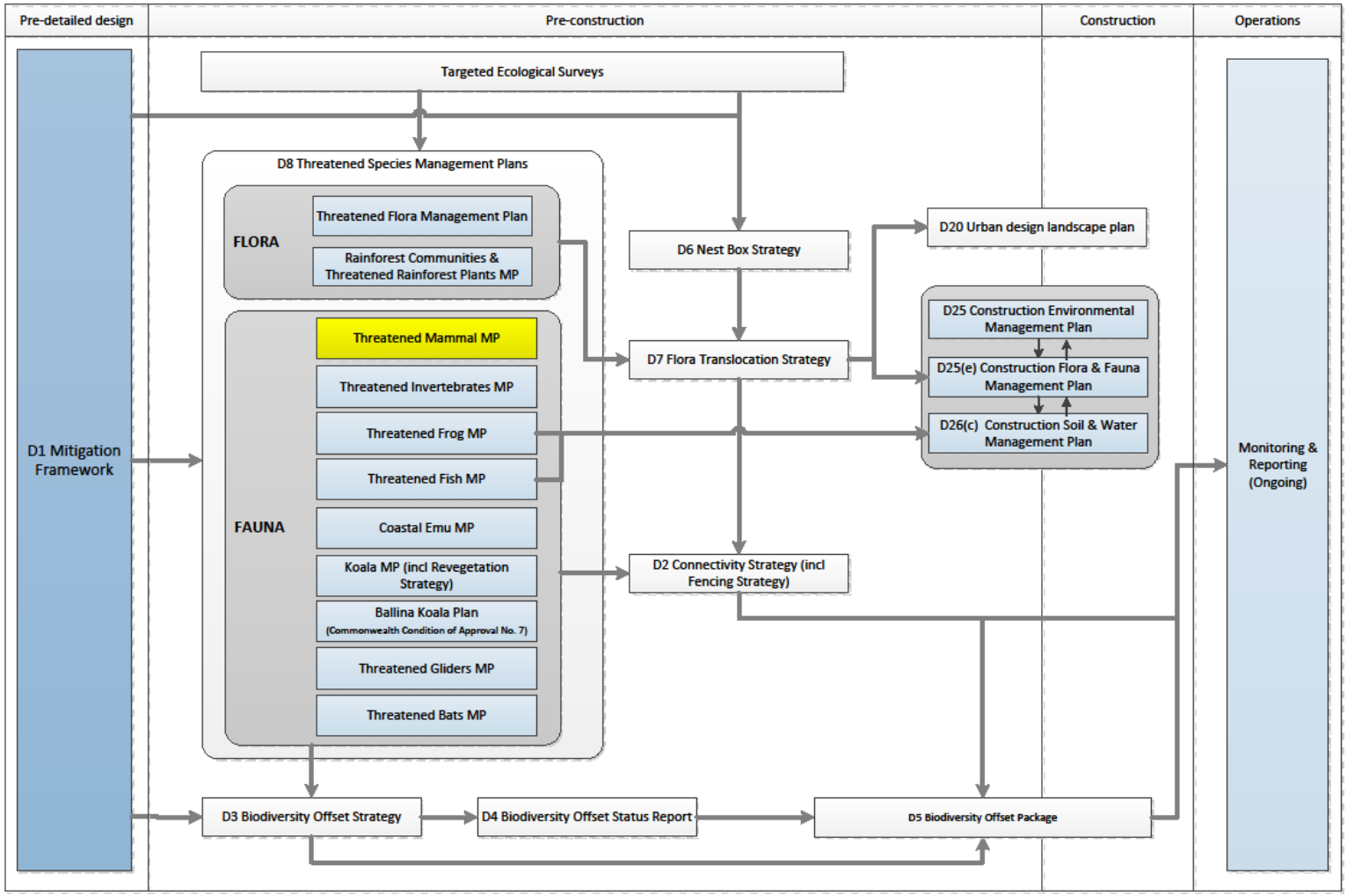

Figure 1-2 Project documentation overview

1.2.2 Plan updates

The plan is intended to be a dynamic document subject to continual improvement. This TMMP has been updated to incorporate the results of targeted baseline threatened mammal surveys post SPIR and meets the mitigation and management measures committed to in the Environmental Impact Statement (EIS), SPIR, and complies with MCoA D8 for the project.

Roads and Maritime propose to update this plan in stages as detailed in the Biodiversity Mitigation Framework (MCoA D1) and the Staging Plan (MCoA A7). This is to reflect the staged nature of construction of the project and also the staggered nature of completing targeted baseline surveys. The first update (Version 1 of the TMMP) incorporated a number of the independent expert review comments. This was completed in November 2013 and was included with the submission of the SPIR documentation.

The second update (Version 2 of the TMMP) was prepared to address the approval conditions received, agency comments provided, remaining subject matter expert comments, and to incorporate results of targeted threatened mammal surveys completed to date. At that time surveys had been completed for the Brush-tailed Phascogale and Rufous Bettong.

This version (Version 3) now incorporates the final pre-construction baseline monitoring for Long-nosed potoroo. No further pre-construction surveys or updates are required for any threatened mammal species. Connectivity structures for mammals have also been finalised for Sections 1 and 2 which are now reflected in this plan and in the Fauna Connectivity Strategy for these sections (GHD, 2015). A summary as to how the independent expert and agency comments have been addressed is detailed in **Appendix A**.

A summary of the process for updating the plan is illustrated in **Figure 1-3**.

It is noted that MCoA D8 requires the plan to be submitted and approved by the Secretary prior to commencement of construction of the relevant stages of the action, and implemented prior to commencement of construction of the relevant stages, unless otherwise agreed by the Secretary.

The administering authorities (EPA, DP&E and DoE) have reviewed and approved the TMMP (Version 2). Updated Version 3 with additional potoroo information has been resubmitted to agencies for review and comments received and addressed. The latest round of comments are summarised in Appendix A. Final approval of this version (Version 3.1) will be received prior to construction commencing in Sections 3-11.

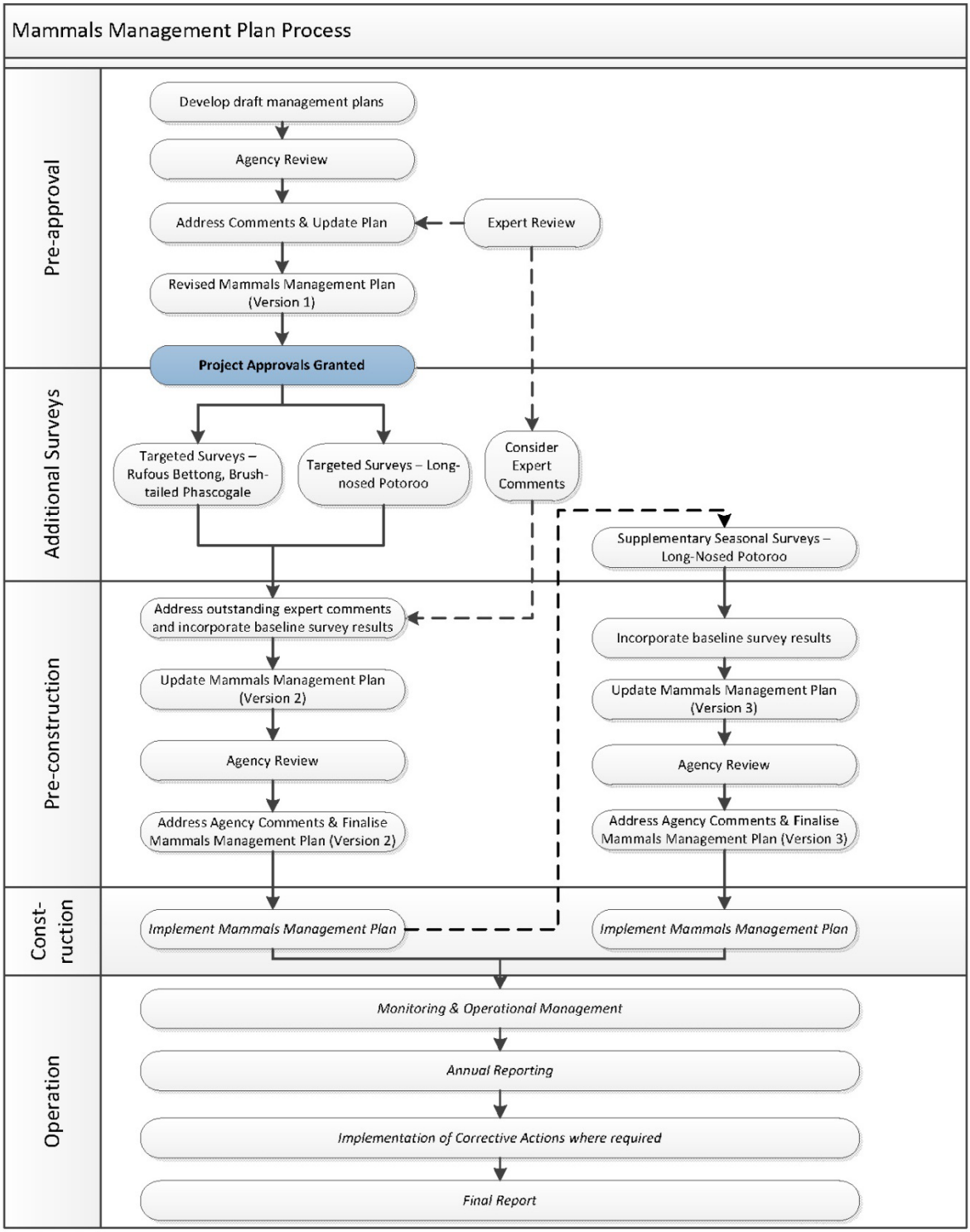

Figure 1-3 Process to develop and update Threatened Mammal Management Plan

1.3 Plan authors and expert review

1.3.1 Plan authors – Version 1

Updates to Version 1 of the plan were prepared by Valerie Hagger and Chris Thomson of Jacobs (previously SKM).

1.3.2 Plan authors – Version 2 and Version 3

Supplementary targeted mammal surveys and baseline studies have been undertaken by Lewis Ecological Pty Ltd. Ben Lewis was the ecologist to lead these surveys and his experience and qualifications are summarised in **Table 1-2**. Revisions to this TMMP (Version 2 and Version 3) to incorporate the results of targeted surveys and address expert and agency comments have been prepared by Mitch Taylor and Berlinda Ezzy of Amec Foster Wheeler. An overview of the experience and qualifications of the authors of the revisions to the report are provided in **Table 1-2**.

Table 1-2 Authors qualifications and experience

Personnel	Qualifications	Experience
Chris Thomson Jacobs (previously SKM)	Bachelor of Applied Science and Graduate Certificate in Natural Resources	Chris Thomson has a Bachelor of Applied Science and Graduate Certificate in Natural Resources with seventeen years' professional experience in the fields of ecology and natural resource management. He is highly experienced in the design and implementation of ecological monitoring programs, flora and fauna surveys, threatened fauna management plans and ecological impact assessment, having completed numerous studies for clients such as the Roads and Maritime and Department of Defence. Chris has considerable experience in the preparation and implementation of species specific management plans and monitoring programs.
Valerie Hagger Jacobs (previously SKM)	Bachelor of Science and Master of Conservation Biology	Valerie has a Bachelor of Science and Master of Conservation Biology. She is a Senior Ecologist with ten years environmental consulting experience specialising in ecological survey, assessment and monitoring and environmental impact assessment (EIA). She has successfully project managed numerous biodiversity and environmental projects in Australia and the United Kingdom, and has been the ecology technical lead for several EIS projects. Valerie is competent in conducting baseline flora and fauna surveys, vegetation surveys and mapping, assessing impacts on ecological values, developing mitigation measures, management plans and monitoring strategies for threatened species and ecological communities and developing offsets strategies.
Berlinda Ezzy AMEC	Bachelor of Applied Science, Natural Systems and Wildlife Management (Honours)	Berlinda has 14 years professional experience including working in the areas of environmental planning, impact assessments, ecology and environmental offsets. Berlinda's experience includes managing flora and fauna studies, delivering environmental offsets including application of various offset assessment tools and developing threatened species management plans. Berlinda has comprehensive knowledge and experience with State and Commonwealth legislation regarding environmental impact assessment, threatened species protection and environmental offset policies. Berlinda also has experience in natural resource management including vegetation management, fire management, weed management and monitoring.
Mitch Taylor AMEC	Bachelor of Environmental Science	Mitch is a senior ecologist with 10 years consulting experience in Queensland and New South Wales. Mitch is a fauna specialist and has led a number of targeted fauna surveys and management strategies in Qld and NSW. Mitch has completed impact assessments in relation to threatened fauna and developed tailored mitigation strategies and monitoring programs. Mitch is licensed by the appropriate authorities to undertake flora and fauna investigations. Mitch's experience in NSW includes: ▪ Threatened microbat management plan development and management in the northern rivers and south western deserts of NSW for mining and quarry development.

Personnel	Qualifications	Experience
		▪ Targeted threatened fauna assessments and impact assessments throughout the northern rivers of NSW for various large scale residential developments and quarry developments. ▪ In-field implementation of threatened fauna management plans including one of Australia's largest macropod management programs. ▪ Threatened flora and ecological community assessments for large scale residential developments in the Lismore, Ballina and Grafton areas.
Ben Lewis Lewis Ecological	Bachelor of Applied Science (Honours)	Ben has 19 years professional experience working as a freelance ecologist throughout eastern Australia. He has considerable experience assisting developing outcomes to meet project specific Conditions of Approval in relation to managing and monitoring impacts on biodiversity for large scale infrastructure projects. This includes extensive experience in the design and implementation of threatened species survey and monitoring programs, management plans and construction strategies. Key examples include: • Developing BACI design monitoring systems for both state and nationally listed threatened species on sections of the Pacific Highway Upgrades including Woolgoolga to Ballina for the Wallum Sedge Frog, Giant Barred Frog, Brush-tailed Phascogale, Rufous Bettong and Long-nosed Potoroo • Design and implementation of the Kempsey Bypass Ecological Monitoring Program (2010-2013); • Design of the Frederickton to Eungai Ecological Monitoring Program and early works Project ecologist for the RMS (2011-2014) • Design and implementation of the Tugun Bypass Integrated Long-nosed Potoroo Plan of Management (2003-2015) • Biodiversity benchmarking surveys for mammals across the Murrumbidgee Irrigation Area (2004-2005) • Development of several nest box plans of management for the Pacific Highway Upgrades which now form part of standard operating procedures for the RMS • Design and early works procedures for micro bat management plans for the removal of bridges and culverts on several highway upgrades • Biodiversity Offsetting Strategies for several highway projects. Whilst Ben's research back ground is in the fields of frogs and avifauna he has performed numerous surveys on other vertebrates and considered to have a broad area of expertise on terrestrial vertebrate fauna. In this capacity, he has attended several recovery planning workshops, been involved in predicted habitat monitoring programs for the EPA and been appointed by the judicial system as a court appointed expert on occasions.

1.3.3 Expert review

An independent expert review of the plan was undertaken in August 2013 by Dr Martin Schulz. Martin has more than 30 years of experience in conducting fauna surveys, research and monitoring, including conducting PhD research on the Golden-tipped Bat (*Kerivoula papuensis*) at a number of sites across north-eastern NSW including Woolgoolga Flora Reserve. His experience includes research of bat usage of culverts and bridges (including abandoned Fairy Martin nests in these structures), which has been published in a number of journals including *Emu* and the *Australasian Bat Society Newsletter.*

Martin knows the fauna of the area well and was team leader of a number of Comprehensive Regional Assessment (CRA) surveys carried out by the Office of Environment and Heritage (OEH) in the region and also a member of a team investigating the fauna in Wedding Bells State Forest. He also has a good knowledge of the fauna along the existing highway, having traversed the current route and roads in the Pillar Valley/Tyndale areas over a 5-year period while residing at Minnie Water. He has worked on a number of projects involving highway upgrades, including an investigation of the impacts of roads on Koalas (at Bonville, with Australian Museum Consulting) and investigations of fauna occurring around crossings of the Hume Freeway between Campbelltown and Mittagong.

A curriculum vitae for Dr Martin Schulz is provided in **Appendix B**. The recommendations have now been assessed and where appropriate incorporated into the TMMP. A summary of the expert recommendations and responses that have been incorporated are summarised in **Appendix A**.

1.4 Consultation

Roads and Maritime have consulted with NSW EPA, DP&E and Commonwealth DoE during the development of this plan. Each agency was provided a copy of the Draft TMMP (Version 2) on 9 January 2015 and subsequently a revised TMMP (Version 3) with additional information regarding supplementary potoroo surveys and monitoring sites. All comments received and Roads and Maritime responses to how those comments have been addressed are included in **Appendix A** of the TMMP.

A summary of the key issues raised by each agency and proposed amendments in finalising the plan is outlined in **Table 1-3**. Where comments were made in relation to the supplementary information on the Long-nosed Potoroo these have also now been included.

Table 1-3 Summary of agency consultation and how comments have been addressed

Document Version	Review Date	Summary of Comments	Section of Report Addressing Comments
Commonwealth Department of the Environment			
2	February 2015	The Department notes that while this plan appears to cover the Potoroo, RMS has stated that a revision of the plan with further updates for this species will be submitted at a later date. While comments are provided on the species below, the Department notes that these may be covered in the later version of the plan, and that this revised plan will address the species in sections 5, 6 and 10.	The TMMP now addresses all sections of the project and all threatened mammal species. The remaining targeted pre-construction baseline surveys for Potoroo have been completed and incorporated into this version of the TMMP. Addressing Sections 6, 7 and 10. The threatened mammal pre-construction baseline surveys have now been completed and summarised in Section 2 of this TMMP.
		Given the new information about specific occurrences of these species, the Department notes that the plan still includes relatively general information about site specific mitigation measures proposed and still defers some of the key mitigation measures to other sub plans (e.g. location of fencing, habitat revegetation, and erosion and sedimentation measures to be implemented). The Department considers that if key mitigation measures are to be deferred to sub plans, this plan needs to set the standards that these sub plans must meet and should include key commitments the sub plans must adhere to. This would then provide confidence that mitigation measures will effectively reduce the level of impacts to threatened mammals.	More detail has been included regarding site specific mitigation measures where available. Additional detail included regarding mitigation measures include: Permanent exclusion fencing – Table 6-1 and Table 6-2 Crossing structures – Table 6-3 and Table 6-4 Water quality – Section 6.3.9 It is considered appropriate that for some mitigation measures the TMMP refer to more specific and detailed sub plans as that is, or will be, the primary document. For example this may be the Fauna Connectivity Strategy or CEMP. All applicable mitigation measures to be adopted for threatened mammals are outlined in this TMMP and where applicable a reference is made to a separate sub plan as to where further detail will be provided. It is also noted a number of these sub plans have been prepared to meet approval conditions such as the Fauna Connectivity Strategy which has been prepared and submitted for approval.
		There seems to be confusion in the plan between performance thresholds and triggers for corrective actions. Performance thresholds are thresholds that are trying to be met and for which deviation from these thresholds would result in corrective actions being implemented (as is written in the headings of tables within the document). On the other hand triggers for corrective actions are negative outcomes which would trigger corrective actions. Currently the majority of the actions/statements under the performance measures heading are actually triggers for corrective actions. Therefore, as currently written, deviation from these measures, which would trigger corrective actions, would in effect result in corrective actions being implemented when the desired outcome is being achieved. The actions under the heading or the terminology used in the heading needs to be amended to address this inconsistency.	Within all tables regarding performance indicators and corrective actions, the column originally titled as 'Performance Thresholds' has been changed to 'Triggers for Corrective Actions'. Additionally, all information contained within this column has been modified to reflect this change so that a corrective action is assessed and implemented when the desired outcome is not being achieved.

Document Version	Review Date	Summary of Comments	Section of Report Addressing Comments
		The Department notes that this plan is proposed to meet some of the requirements of condition D2 (as per the table in the beginning of the document). The Department notes that the justification for the location and design of connectivity measures, based on the results of the further surveys is not provided. Rather, the connectivity measures as originally proposed in the EIS are presented. This issue is also relevant to the BACI monitoring locations for the Long nosed Potoroo, which appear to be based on the predetermined locations of connectivity structures from the EIS, which were proposed prior to the Potoroo being found to occur in these areas. Reassessment of the suitability of the location and number of structures based on the survey results is required, as per the conditions of approval.	The finalised connectivity structure locations for Sections 1 and 2 are sourced from the Fauna Connectivity Strategy for these sections (GHD 2014). Connectivity structures for Sections 3 – 11 are proposed and yet to be finalised. This will occur after further survey and detailed design activities occur. Connectivity structures relevant to mammals are detailed in Table 6.3 and Table 6.4. Roads and Maritime consulted with relevant agencies in finalising the location of connectivity structures for Sections 1 and 2 and they will be approved through the Fauna Connectivity Strategy prior to construction. Potoroo surveys are now complete and BACI sites finalised. This has informed locations recommended for permanent fencing based on the confirmed presence of Potoroo activity and will inform detailed design for Sections 6, 7 and 10 regarding connectivity structures.
		The Department recommends that this section includes further information and justification about the fence design, length and location, based on the requirements of the specific threatened mammals targeted.	Fauna exclusion fencing design and a justification for this design is summarised in Section 6.3.6. Fencing locations have been refined post 2015 Potoroo surveys and fence locations are detailed in Table 6-1 and Table 6-2. Further detail of the design of fauna exclusion fencing for Sections 1 and 2 can be found in Section 7.2.4 of the Fauna Connectivity Strategy: Woolgoolga to Glenugie (GHD 2014a). .
		Mitigation goals – the Department recommends that these goals need to address the impacts listed in section 7.2 The Department recommends that a goal for edge effects be included, as well as a goal that fauna fencing is installed in locations and designed so that incidents of road kill for threatened species is prevented, and a similar mitigation goal for connectivity structures.	The mitigation goals throughout the document have now been cross-referenced with the relevant impacts to ensure alignment. Relevant mitigation tables updated to address edge effects and fauna fencing recommendations.
NSW Department of Planning and Environment			
2	February 2015	Is the update required to reflect all summer Long-nosed Potoroo surveys or just the February 2015 work (cf. page 16)? If the latter, this should be revised unless the update is intended to form part of the final plan.	This TMMP has been updated to reflect the 2015 April (Autumn) Potoroo surveys and results.
		It is noted that Cane Toads may poison the Spotted-tail Quoll; what is the management response to this? Also, what is the likelihood of this being an issue on the project?	There is anecdotal evidence cane toads may poison Quolls. Cane toads are mentioned in the impact and mitigation sections of this TMMP. Roads and Maritime through preparation of the CEMP and FFMP will identify measures that can be taken to minimise the presence and breeding of cane toads in the

Document Version	Review Date	Summary of Comments	Section of Report Addressing Comments
			Project boundary. This may include managing ponds to minimise access by cane toads.
		The performance thresholds adopt the SMART formula, but some of the required corrective actions are not sufficiently certain—for example, it is not clear what the criteria are for consideration of additional structures.	Language used to describe mitigation measures and corrective actions has been clarified and refined throughout this document.
		It is noted that the plan does not adopt some of the recommended threshold values of this Appendix (eg. 25% reduction in Rufous Bettong activity at a site). It would be useful for some discussion of this in text, given the inclusion of this appendix.	Plan has been updated to reflect recommended thresholds now the final baseline monitoring report has been completed. The final baseline monitoring report for Phascogale and Bettong is in Appendix E and final baseline monitoring report for Long-nosed Potoroo is in Appendix F. A 25% threshold for activity levels is still recommended by the Potoroo expert as appropriate for the monitoring program.
NSW Environmental Protection Agency			
2	February 2015	Has the RMS undertaken an assessment of the adequacy of connectivity for the newly discovered Long-nosed Potoroo populations in sections 6 and 7? Please see further comment below. Additionally it is stated in the Plan that new records of the Long-nosed Potoroo were located west of Old Bagotville Road – wouldn't this place the new records west of the alignment? If so has the adequacy of connectivity structures been assessed in this habitat area? Has the extent of likely and known habitat been recorded? Spotted-tailed Quoll – the EPA agrees it is too difficult to survey in such low density populations.	Recommendations prepared for connectivity structures as a part of the 2015 baseline monitoring surveys (Appendix F) for Long-nosed Potoroo have been incorporated into this report. The report recommends an additional crossing structure be assessed during detailed design at approximately chainage 115.750 (+/- 100 m). Potoroo were recorded at a control site (number 21) in Doubleduke State Forest to the west of the proposed highway in Section 7. A dedicated connectivity structure is proposed at this location (chainage 118.828) to facilitate movement of Potoroo and other mammals such as Spotted tail Quoll between Doubleduke State Forest to Tabbimoble Swamp. Connectivity measures for Potoroo in Sections 3-11 are summarised in Section 6.3.7. Final connectivity structures for Potoroo and other mammals in Sections 3-11 will be detailed in the next Fauna Connectivity Strategy. Known and likely habitat for the Potoroo has been prepared and provided in Appendix G of this TMMP. .
2	February 2015	Long-nosed Potoroo – The Table identifies future pre-clearance surveys for Long-nosed Potoroo in sections 6 and 7, particularly given the planned removal of habitat in this area. It is stated these proposed surveys aim to map the extent of Long-nosed Potoroo habitat in these areas. The EPA recommends these proposed surveys are brought forward and undertaken prior to pre-clearing surveys. This will then provide ample time to assess the extent of the population and habitat and assess the adequacy of mitigation. It is noted on page 3, Appendix C, that mitigation structures	Results of the autumn 2015 Long-nosed Potoroo pre-construction baseline surveys have been included in the most recent update to this TMMP for EPA approval. Pre-clearing surveys will then occur just prior to any clearing taking place and requirements for the pre-clearing surveys are stipulated in Section 6.3.4. It is recognised additional Potoroo records have been found post connectivity structures being developed, however Roads and Maritime are still in a position to refine these crossing structures in Sections 6, 7 and 10 if

Document Version	Review Date	Summary of Comments	Section of Report Addressing Comments
		are detailed, however these structures were already proposed prior to the additional records. Was this Table updated following the new records in section 10? i.e. has the population been confirmed to the west of the alignment? This is not explicitly stated in the Plan. Refer to Figure 3-5 of Appendix C which shows site 32 at 44% activity level – it appears from the diagram this survey site is west of the alignment. Also note Table 4-1 of Appendix C confirms the Potoroo record as occurring on the western side of the alignment. Noting these comments, the RMS will need to edit the TMMP to ensure all discussions on Potoroo distribution are consistent within the document and appendices.	needed during the detailed design phase and to take into account results of the 2014/15 baseline surveys. Potoroo was recorded at a control site (number 21) in Doubleduke State Forest to the west of the proposed highway in Section 7. A dedicated fauna connectivity structure is proposed at this location (chainage 118.828) to facilitate movement of Potoroo and other mammals such as Spotted tail Quoll between Doubleduke State Forest to Tabbimoble Swamp. Baseline monitoring surveys have recommended the fauna connectivity strategy for Sections 3 to 11 include a fauna crossing commensurate for Potoroo movements at 115750 (±100 m) and this information be considered during further development of the existing road concept design. Habitat mapping for Potoroo is included in Appendix G.
2	February 2015	Performance Thresholds – please clarify where the performance thresholds were referenced or derived. A decline <25% is significant, especially given the local abundance of these species'. Additionally a decline <50% is also very significant i.e. conceivably locally extinct within 2 years prior to corrective action implementation. The EPA recommends more conservative deviations from the paired control are used as triggers for corrective action eg/ 10%. However the EPA will also discuss possible variations from this if activity level changes can be explained and are unrelated to the impact (highway upgrade).	The species thresholds have been based on recommendations from a suitably qualified ecologist Ben Lewis who led the baseline surveys for threatened mammals. The survey methods and findings are outlined in the final report included as Appendix E & F. The technical report that was finalised in December 2014 recommends tolerance levels from the baseline dataset. This is a 25% decline of Bettong activity recorded at camera traps when compared to the control site activity levels and 50% decline of Bettong activity from spotlight surveys when compared to the control site. Spotlighting results have a higher threshold as spotlighting is not as effective in capturing the species as camera traps. Performance thresholds for the Long-nosed Potoroo have been identified at >25% decline in the difference in detection values across the control and impact sites to account of other cues for decline outside of the measured effects of the project. Further information on the baseline results and thresholds are now provided in Section 8 of the TMMP. Roads and Maritime currently do not propose to change these thresholds. They have been recommended by a suitably qualified ecologist with extensive experience conducting surveys for threatened mammals in the project area. It should be noted the thresholds are based on activity levels not species number decline. Also after each monitoring event if the impact sites are showing reduced activity when compared to control sites this will be assessed and discussed in the annual monitoring reports. Where thresholds are met this will then trigger a more in depth evaluation as to why and corrective actions will be implemented as appropriate.

2. Threatened mammal surveys

In accordance with the mitigation strategies described for pre-construction management in this document (**Section 5**), and in line with the objectives of the project Biodiversity Mitigation Framework (BMF), Roads and Maritime have commissioned a number of targeted mammal surveys to be completed for the project. This information builds on that presented in the EIS and SPIR which provides a significant baseline of survey data and analysis for fauna species and populations within and adjacent to the project area, and has helped refine the final baseline monitoring methodology. Surveys for the EIS and SPIR were conducted over a period of 9 years between 2005 and 2013 and consisted of various seasonal surveys in accordance with relevant state and federal survey guidelines at the time of survey. Survey efforts undertaken during this period are summarised in **Table 2-1**.

Table 2-1 Summary of EIS and SPIR mammal survey efforts

Component	Project section	Survey period	Purpose
EIS	1-2	16-21 Oct 2006 18-24 Feb 2007	Surveys for arboreal and terrestrial mammals, reptiles, frogs, microchiropteran bats, nocturnal birds and mammals and birds. Targeted searches for quolls, bandicoots and Koalas.
		Nov 2011	Habitat surveys (including identification of hollow bearing trees).
EIS	3-5	July-Aug 2005 Oct 2005	Surveys for arboreal and terrestrial mammals, frogs, microchiropteran bats, nocturnal birds and mammals, birds and reptiles Targeted searches for quolls, bandicoots and Koala.
		2-7 July 2007 6-11 Aug 2007 14-19 Oct 2007	Surveys for arboreal and terrestrial mammals, microchiropteran bats, birds (including emus), nocturnal birds and mammals, frogs and reptiles Targeted surveys for quolls and bandicoots.
		12-16 Dec 2011	Habitat survey (including identification of hollow bearing trees).
		Jan 2012	Targeted surveys for mammals, microchiropteran bats, nocturnal mammals and birds, frogs, reptiles and Koalas Habitat survey (including identification of hollow bearing trees).
EIS	6-8	March 2005	Habitat survey (including identification of hollow bearing trees).
		May-June 2005	Surveys for arboreal and terrestrial mammals, microchiropteran bats, nocturnal birds and mammals, birds, frogs and reptiles Targeted surveys for quolls, bandicoots and Koalas.
		16-20 Jan 2012	Targeted surveys for arboreal and terrestrial mammals, reptiles and frogs.
EIS	9-11	11-16 March 2006	Survey for arboreal and terrestrial mammals, microchiropteran bats, nocturnal birds and mammals, birds, frogs, reptiles and invertebrates Targeted surveys for quolls, bandicoots and Koalas Habitat survey (including identification of hollow bearing trees).
		Jan 2007	Surveys for arboreal and terrestrial mammals, microchiropteran bats, nocturnal birds and mammals, birds, frogs and reptiles Targeted surveys for quolls, bandicoots and Koalas Habitat survey (including identification of hollow bearing trees).
		16-20 Jan 2012 13-16 March 2012	Targeted survey for small terrestrial mammals.
SPIR	Ancillary Sites Sections 1-10	3-7 December 2012 17-21 December 2012 14-18 January 2013	Supplementary biodiversity assessments were completed for the SPIR. This included threatened species fauna surveys within sites that contained patches of remnant vegetation, farm dams and wetlands, or mature paddock trees. Fauna surveys identified important habitat features and potential Koala habitat and activity. Live trapping was also employed to detect Rufous Bettong and Brush-tailed Phascogale. A supplementary Ancillary Infrastructure Assessment Report was submitted to the Department of Planning and Infrastructure (now DP&E) on 13 December 2013. This report included an evaluation of proposed ancillary sites against the established criteria, provided constraint mapping to provide consolidated information on proposed ancillary areas.
	1	29-31 August 2012	An ecological survey was completed for an alternative site and layout for the Range Road Interchange at chainage 9,800. The survey included a flora and fauna assessment.
	5 and 6	29 January to 15 February 2013	Supplementary field surveys were conducted on Firth Heinz Road, Crowleys Road, Koala Drive, New Italy Swan Bay Road and Mororo Road as part of supplementary biodiversity assessments.

As per the objectives of the BMF, the methodologies used for surveys of threatened mammal species within the project area have been designed with specific reference to relevant State and Commonwealth survey guidelines, namely:

- The Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities – Working Draft (DEC, 2004)
- Commonwealth Survey Guidelines for Australia's Threatened Mammals (DSEWPaC, 2011).

Pre-construction surveys were focused on collecting baseline information to inform the monitoring program including impact sites and control sites for each species.

Targeted baseline surveys have included desktop surveys to identify records of target species in proximity to the project area, field surveys to assess habitat suitability for the target species, and surveys to confirm records of the species through methods such as spotlighting, camera traps and road kill traverses to maximise compliance with state and Commonwealth survey guidelines for the relevant species in accord with MCoA D1 (a). The surveys were also to confirm the suitability of selected monitoring sites and gather baseline information on species abundance in these areas.

Baseline surveys for the threatened mammals are now complete. The surveys and findings are summarised in the following sections, along with copies of technical reports presented in **Appendices C - F**, and these reports provide an easily replicable methodology to be utilised for ongoing monitoring efforts.

2.1 Long-nosed Potoroo survey

Lewis Ecological Surveys Pty Ltd was commissioned by Roads and Maritime to undertake targeted surveys for the Long-nosed Potoroo with the aim of locating between four to six paired sites. These sites will be used in a Before-After-Control-Impact (BACI) survey design for future pre-construction and post-construction monitoring of Potoroo population density, activity patterns and habitat use in response to the upgrade.

The surveys for Long-nosed Potoroo included the following techniques:

- Desktop surveys to assess historic data on records within 10 km of the project centre line and suitable habitats to guide overall BACI survey design
- Consultation with the Jali Local Aboriginal Land Council to refine monitoring locations
- Habitat Critiquing – thirty-eight (38) sites were selected from Sections 1, 2, 3, 6, 7, 9, 10 and 11. A brief critique of habitat suitability to determine the likelihood of Long-nosed Potoroo detection was undertaken
- Camera traps – used to detect the presence of Long-nosed Potoroos within areas of suitable habitat and used to analyse data on the populations' density, their activity patterns and their activity levels (activity levels of Potoroo were derived as a percentage of cameras that detected Potoroo at each site within a four night sampling period as a percentage).
- Spotlighting surveys – used to indicate presence and abundance and gauge the usefulness of this survey technique
- Road kill transects – used to record information on the location, age and sex of any road-killed Potoroo along with the survey effort
- Vehicle traverses – undertaken at night to locate Potoroos along small tracks or easements in the vicinity of the survey sites.

2.1.1 Survey Period 1 – Long-nosed Potoroo

The first round of surveys conducted by Lewis Ecological was between 26 May and 14 October 2014 across 38 sites from sections 1, 2, 3, 6, 7, 9, 10, and 11. Each site was critiqued based on their likelihood of detecting the target species. Data recorded included:

- Broad habitat type
- Proximity of crossing structures at three scales of <0.3 km; 0.3-1 km and > 1 km

- Diggings consistent with Potoroo observed
- Substrate type
- Assess whether the area supported >50 ha of suitable habitat on either side of the upgrade corridor
- The number of records within 2 km of the proposed mitigation device
- Consideration of the existing land tenure
- Suitability of a neighbouring control site which exhibited similar habitat attributes.

Initial surveys did however, recorded Long-nosed Potoroos at 15 of the 38 sites, within Sections 6, 7 and 10 each detecting Long-nosed Potoroos at multiple locations within these regions. All sightings were from camera traps, apart from the observation of a 'likely' Long-nosed Potoroo skull from a site in Section 10. The location of these sightings are illustrated in **Figure 2-1.** Surveys discovered new records in close proximity to the Project in Sections 6 and 7, whilst a record west of the Project in Section 10 is also an important discovery. These additional findings suggests the potential for this species to be more widespread than previously documented in the first version of the TMMP and recent studies (Andren et al. 2013; RMS 2013).

This survey was not able to reconfirm Long-nosed Potoroo from Julies Road east of Section 2 which had been burnt in the Kremnos Creek fire in early August 2014 and had not regenerated enough at the time field surveys were undertaken, given this, BACI sites could not be established. It should be noted, other survey efforts within Sections 1 and 2 in proximity to the Kremnos Creek site of the Project were conducted in suitable un-burnt habitat for the Long-nosed Potoroo; however, surveys failed to detect this species (see **Appendix C**). Furthermore, it is recommended that based on the results of this study, Sections 1, 2 and 3 of the Project no longer require consideration for monitoring the Long-nosed Potoroo as part of the Project. Monitoring survey methodologies for crossing structures should be sufficient to detect Long-nosed Potoroo through the use of camera trapping methods. Further, fauna exclusion fencing and crossing structures proposed for Sections 1 and 2 are considered suitable for this species. Sixteen sites were surveyed in these sections with no activity recorded. For further information regarding the survey methodology and results refer to the technical report Woolgoolga to Ballina Pacific Highway Upgrade: Long-nosed Potoroo Site Survey and Selection Study (Lewis Ecological Surveys, 2014a) (see **Appendix C**).

The report identified eight paired sites for monitoring and allowed for replication of monitoring sites in Section 6, 7 and 10 of the Upgrade (i.e. ch. ~96000-156000). At this time, there was also an opportunity to refine some of the previously proposed survey techniques, namely reducing the 600 x 600 m (36 ha) grid to a 300 x 400 m (12 ha) grid comprising 12 camera traps and thus enabling monitoring sites to be established in the Wardell and Bagotville areas (i.e. Potoroo habitat areas were only 12 ha in size) (Lewis Ecological Surveys, 2015).

2.1.2 Survey Period 2 – Long-nosed Potoroo

The purpose of this survey was to conduct two pre-construction baseline surveys (Baseline Survey 1) and (Baseline Survey 2) at the established eight BACI monitoring sites to collect baseline activity levels of Potoroo. The surveys were undertaken between November 2014 and May 2015. Baseline Survey 1 was undertaken between November 2014 and January 2015 whilst Baseline Survey 2 was undertaken between April and May 2015, with the commencement of each survey timed to avoid forecast rainfall events of >1mm within the first 3-4 nights of sampling (Lewis Ecological Surveys, 2015).

Potoroo were recorded from seven (87.5%) of the eight paired monitoring sites and reconfirmed their broad distribution from the Mororo and Jacky Bulbin area's in Section 6, north to the northern limits of the Wardell sand plain in Section 10. Potoroo were not recorded from Site 1 and any of its options in Section 6 despite their presence being detected only a few kilometres away at Site 2 (Section 6). Consequently, their absence following two rounds of monitoring suggests there is little likelihood of detecting them in the future and the retention of Site 1 in the monitoring program is of little use as the baseline dataset for any potential paired treatment is zero. At the remaining seven paired treatments (i.e. Site 2-8), Potoroo were detected on almost all monitoring events, the exception being Site 2A (impact treatment) during Baseline Survey 2 when no Potoroo were recorded. Mean Potoroo activity levels after 14 nights ranged from 87.5% at the control or reference treatment for Site 8B (Wardell)

down to 12.5% at both the impact treatments for Site 2A (Mororo/Jacky Bulbin) and Site 3A (Tabbimoble) (Lewis Ecological Surveys, 2015).

The investment of an additional 7 nights of monitoring (i.e. 14 nights) contributed to some small incremental increases in overall Potoroo activity, however, the data suggests a 95% confidence interval can be obtained after just 3 nights of sampling to determine presence if using a 12 trap camera grid with 100 m spacing at a time without any measurable rainfall event (> 1mm).

Recommendations from this report have been addressed in the TMMP. A summary of the key recommendations and how they have been addressed are as follows:

Table 2-2 Survey recommendation references

Recommendation Reference	Recommendation	How recommendation is addressed
1	Remove Site 1 from the monitoring program leaving seven of the paired BACI sites (Site 2–8).	Based on this recommendation BACI site 1 has been removed. The final BACI sites are provided in Section 8.
2-4	Future monitoring utilise the same camera trap locations and methodologies at each of the monitoring grids.	The monitoring methodology has been updated in Section 8.
5	Future monitoring episodes avoid sampling during periods of wet weather (>1 mm) within the first 3-4 nights of monitoring.	Timing of monitoring has been updated in Section 8.
6	RMS proactively engage with relevant government stakeholders and adjacent landowners to identify and support opportunities to implement a coordinated approach to management of exotic predators within the broader region.	Engagement with stakeholder has been included in Table 7-3.
7	The performance measure and thresholds of >25% decline should be adopted for all future construction and operational monitoring episodes.	This threshold has been defined in Tables 6-5, 7-3 and 8-5.
8	The fauna connectivity strategy be updated to include a fauna crossing commensurate for Potoroo movements at 115750 (±100 m) and this information be considered during further development of the existing road concept design.	Table 6-2 states that consideration will be given to a crossing structure at 115750.
9	Future monitoring of connectivity structures consider the preconstruction baseline data in the vicinity of Site 2 indicates Potoroo may be absent from the immediate areas to the west of the Upgrade. Therefore, Potoroo should not necessarily be expected to utilise the underpass structures at this location.	Acknowledged.
10	Install permanent exclusion fencing. Suitable fence designs include the standard floppy top normally used to exclude Koala or could be scaled back to variants of netted fences not unlike the design used for the Glenugie Upgrade near Grafton.	Acknowledged. Exact design specifications of exclusion fencing will be addressed in final connectivity strategy for Sections 3-11..
11	Consistency reviews and additional surveys associated with works beyond the approved project boundary should be guided by a minimum sampling effort of a 12 trap camera grid with 100 m spacing at a time without any measurable rainfall event (> 1mm) over 3-4 nights.	Sampling methodologies for monitoring have been revised and are discussed in Tables 8-3 and 8-4.

Based on the latest recommendations the final Long-nosed Potoroo monitoring program will consist of seven BACI sites with 2 paired sites in Section 6, 1 paired site in Section 7 and 4 paired sites in Section 10. These are illustrated in **Figure 8-3** of this TMMP.

The location of final and proposed monitoring sites is detailed in **Section 8** of this plan and further information is included in technical reports provided in **Appendix C & F** (Lewis Ecological Survey, 2014a and 2015).

Section 1

12000
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0

Pacific Hwy
Bee Range Rd
Lookout Rd
Dirty Creek Trl
Dirty Creek Rd
Dirty Creek
Kathleen Dr
Red Ridge Rd
Corindi River
Sherwood Creek Rd
Taylors Rd
Upper Corindi Rd
Quarry Trl
Nashs Rd
Tramway Trl
Stuarts Rd
Saltwater Creek
Muller Creek
Corindi Park Dr
Red Rock Rd
Coral St
Corindi Beach Park
Corindi Beach
Matthews Pde
Kangaroo Creek Rd
Eggins Dr
Arrawarra
Arrawarra Headland
Arrawarra Rd
Coffs Coast Regional Park
The Broadwater
Coffs Harbour
Red

221 m
64 m
100 m
140 m
60 m
128 m
111m
59 m

ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 2.1
Mammal Records Baseline Monitoring and Atlas of NSW Wildlife

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits:

LEGEND

- Chainage (metres)
- Alignment
- Project boundary
- Section excluded from TMMP

Atlas of NSW Wildlife Records

- *Aepyprymnus rufescens* (Rufous Bettong)
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- *Potorous tridactylus* (Long-nosed Potoroo)

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ISSUE DATE	AUTHOR	QA CHECK	APPROVED	MAP REV.	REVISION NOTE
16/03/2015	JH	BE	BE	0	Issued for Use

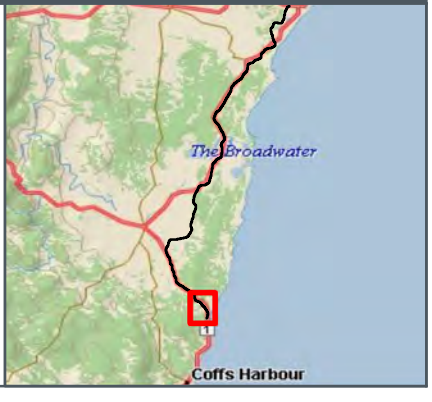
amec foster wheeler

N

0 250 500
Metres

(A3) GCS GDA 1994

LOCATION DIAGRAM



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Section 2
Section 1
Bald Knob Tick Gate Rd
Reserve Rd
Coldstream River
Coast Range Rd
Georges Rd
Quarry Rd
Pigeon Gully Fire Trl
Julies Rd
Halfway Creek
Luthers Rd
Browns Rd
Gilmores Ln
Grays Rd
McPhillips Rd
Bee Range Rd
Dirty Creek Rd
Lookout Rd
Pacific Hwy
158 m
318 m
323 m
141 m
127 m
232 m
252 m
265 m
221 m
311 m
100 m
200 m
300 m

Figure 2.1
Mammal Records Baseline Monitoring and Atlas of NSW Wildlife

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N

0 250 500
Metres

(A3) GCS GDA 1994

LOCATION DIAGRAM

The Broadwater
Coffs Harbour

ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

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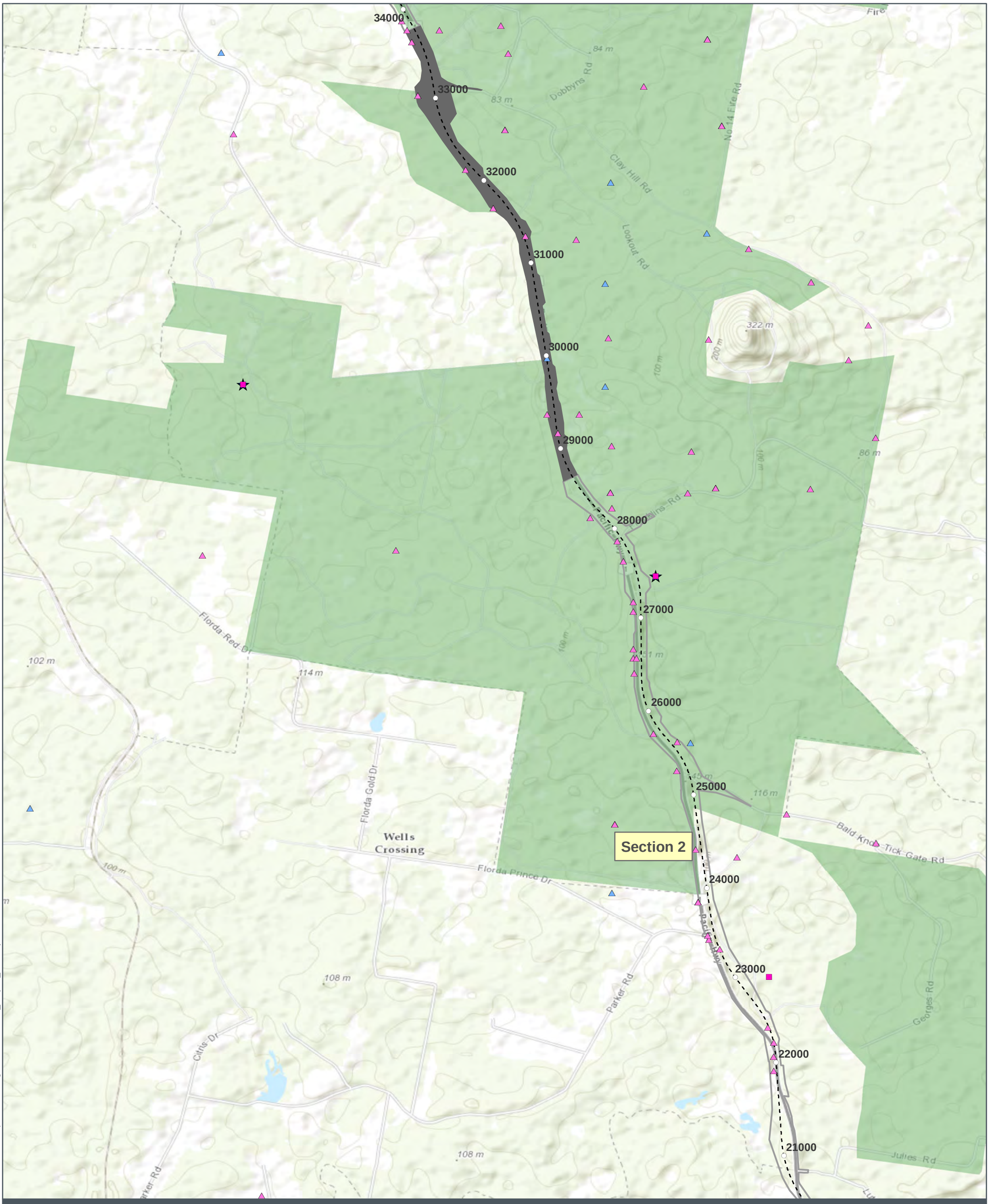

ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

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amec foster wheeler

0 250 500
Metres

(A3) GCS GDA 1994

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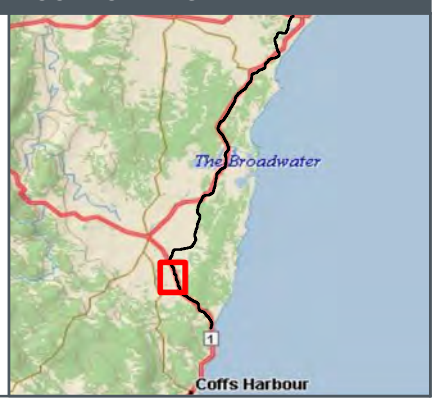

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Bom Bom
71 m
Glenugie Creek
Reilleys Ln
No 3 Fire Rd
No 10 Fire Rd
No 2 Fire Rd
No 4 Fire Rd
No 9 Fire Rd
Pacific Hwy
Glenugie
Six Mile Ln
Grafton Airport
40000
41000
39000
89 m
No 6 Fire Rd
No 8 Fire Rd
No 7 Fire Rd
Popes Rd
Old Six Mile Ln
38000
Section 3
37000
83 m
56 m
Aerodrome Rd
36000
No 2 Fire Rd
Fire Road No 4
35000
Dunger Rd
Shields Rd
No 5 Fire Rd
34000
84 m
Dobbyns Rd
33000
83 m
Clay Hill Rd
32000
Lookout Rd
31000
Dinjera Rd
Poley House Rd
95 m
51 m
Avenue Rd

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ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

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N

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Metres

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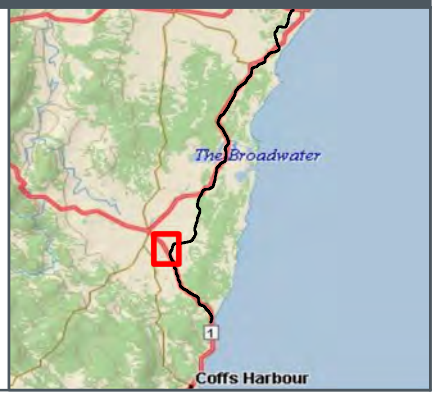

Section 3

40000 41000 42000 43000 44000 45000 46000 47000 48000 49000 50000 51000

Lavadia

Sandy Crossing

Wooli Rd

Mitchell Rd

Lloyds Rd

Avenue Rd

Wants Ln

Eight Mile Ln

Sunnyside Rd

Stonehouse Rd

Fire Road No 2

Fire Road No 4

Fire Road No 6

Fire Road No 7

No 5 Fire Rd

No 14 Fire Rd

Monilla Rd

Dobbyns Rd

Clay H

50 m 43 m 46 m 51 m 40 m 59 m 84 m 68 m 64 m 100 m 141 m

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ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 2.1
Mammal Records
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amec foster wheeler

N

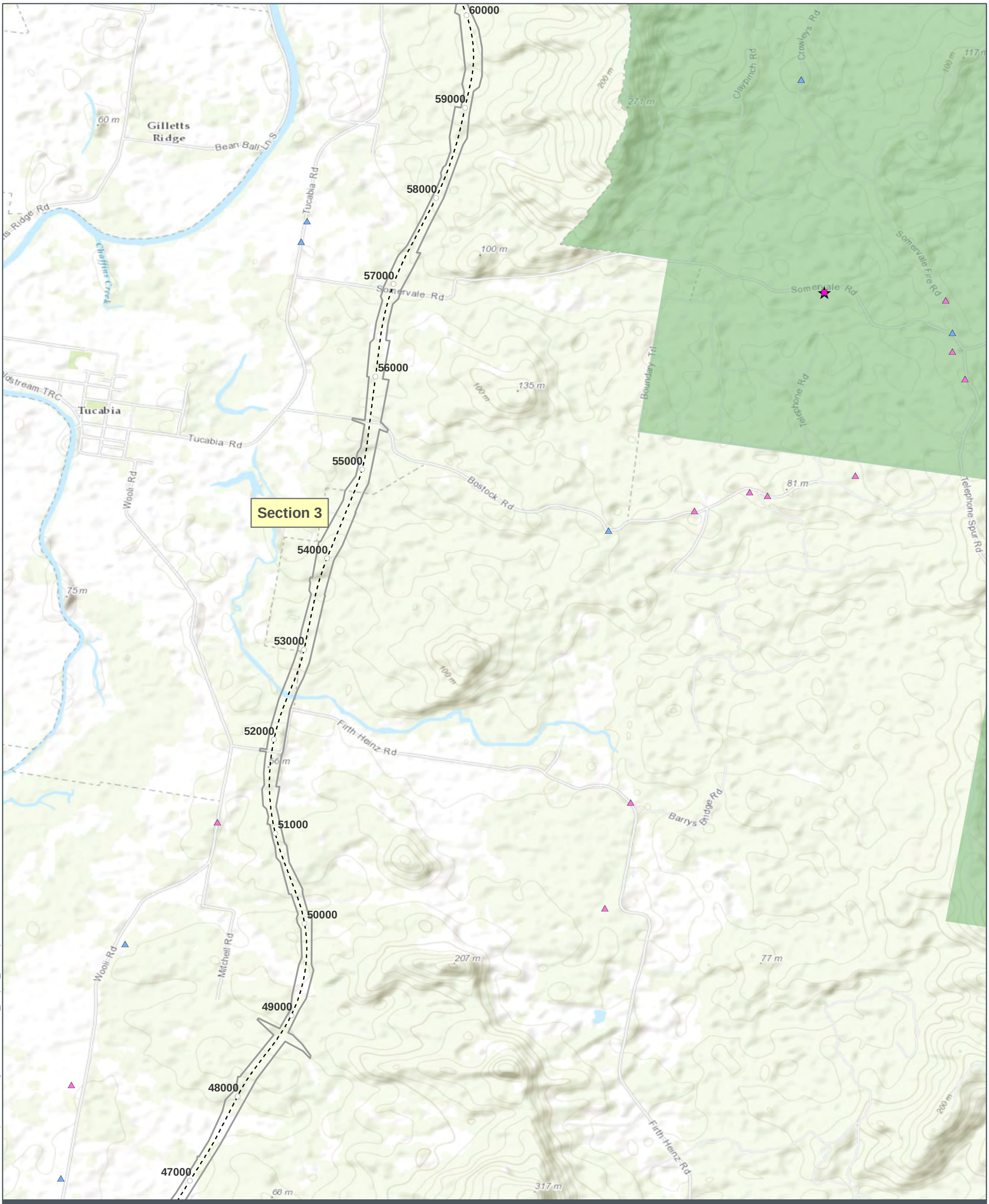
0 250 500
Metres

(A3) GCS GDA 1994

LOCATION DIAGRAM

The Broadwater

Coffs Harbour



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ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

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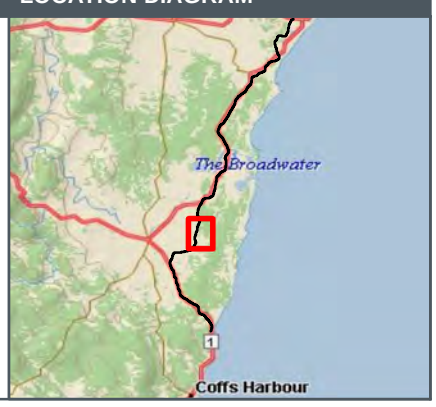

Section 4
Section 3
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Tyndale
Cowper
Coldstream
Gilletts Ridge
South Arm
Coldstream River
Pacific Hwy
South Arm School Rd
Riverbank Rd
Gibbons Ln
Sherrys Ln
Colds
Coldstream Rd
Bean Ball Ln N
Bean Ball Ln S
Tucabia Rd
Gilletts Ridge Rd
Chuffins Creek
Somervale Rd
Fiths Rd
Crowleys Rd
Claypinch Rd
28 m
136 m
148 m
101 m
22 m
45 m
60 m
222 m
229 m
200 m
100 m
271 m

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ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

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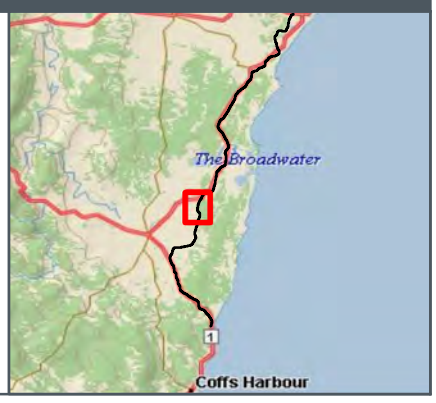
Metres

(A3) GCS GDA 1994

LOCATION DIAGRAM



Section 4

Section 3

ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 2.1
Mammal Records Baseline Monitoring and Atlas of NSW Wildlife

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amec foster wheeler

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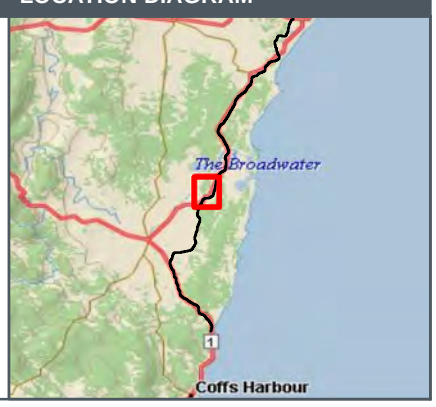
Metres

(A3) GCS GDA 1994

LOCATION DIAGRAM



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ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

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amec foster wheeler

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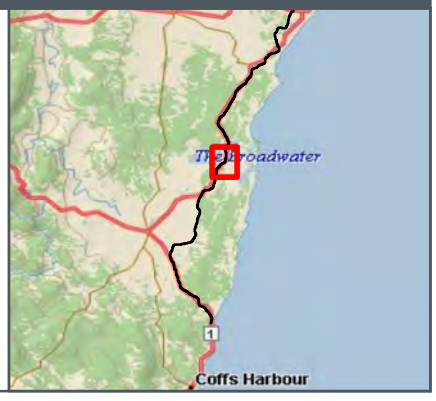
Metres

(A3) GCS GDA 1994

LOCATION DIAGRAM



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Metres

(A3) GCS GDA 1994

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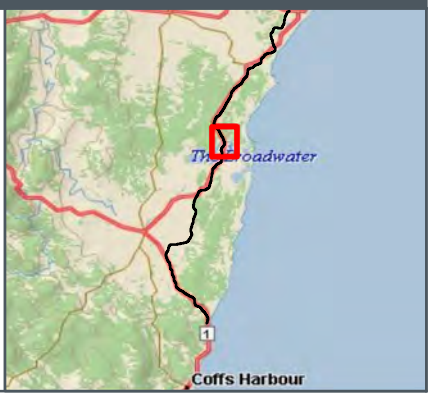

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Section 7

Section 6

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Range Rd
Island Rd
Tick Fence North Trl
Thompsons Rd
Pine Rd
Big Marsh Rd
Slys Rd
Funnells Rd
Mervs Rd
Mororo Rd
Claires Rd
Mororo Fire Trl
Number Two Trl
Eastern Boundary Trl
Washed Out Trl
Bundjalung National Park
The Broadwater
Coffs Harbour

51 m
211 m
73 m
49 m
270 m
203 m
200 m
185 m
100 m
238 m
72 m
67 m
80 m
171 m
187 m
68 m

ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 2.1
Mammal Records
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Metres

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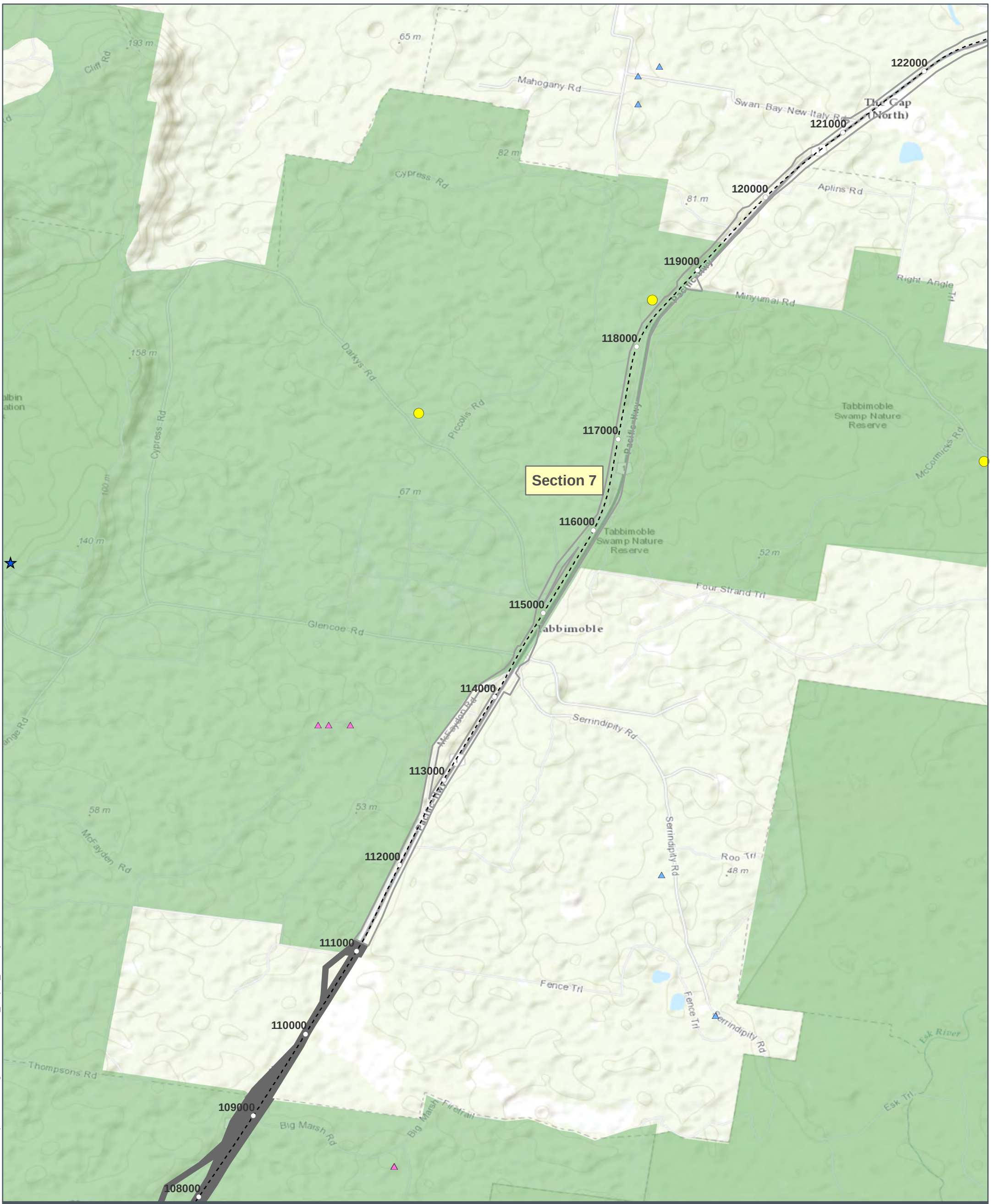

ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

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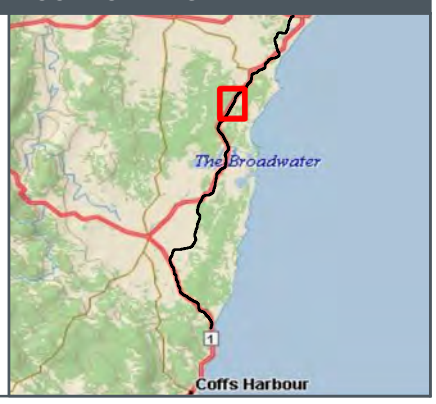

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Section 8

Section 7

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118000

Woodburn (North)
Woodburn Park
Trustums Hill
Tuckombil Canal
Pacific Hwy
Woodburn-Rd
Bank St
Richmond St
Woodburn-Evans-
Rocky Mouth Creek Rd
Golf links Rd
Swan Bay-New Italy Rd
Brickella Rd
The Gap Rd
McGearys Trl
Turners Rd
Red Gate Rd
Aplins Rd
Right Angle Trl
Posthammer Trl
Tick Fence Trl
Mirryumai Rd
Tabbimoble
Swampy Creek
34 m
38 m
42 m
43 m
68 m
166 m
100 m
41 m
40 m
186 m
81 m
57 m

Path: W:\PROJECTS\EII\Roads & Maritime Services\651570 - W2B Species Management Plans\2.0_Project_Delivery\GIS\MammalSites.mxd

ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

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amec foster wheeler

N

0 250 500
Metres

(A3) GCS GDA 1994

LOCATION DIAGRAM

The Broadwater
Coffs Harbour

Section 10

Section 9

Section 8

Broadwater (North)

Dungarubba

Kilgin

Riley's Hill

Broadwater National Park

Airforce Beach

Evans Head Airport

Bundjalung

North Woodburn

Doonbah

Broadwater-Rd

Coraki-Broadwater-Rd

Pacific-Hwy

Kilgin-Rd

Rileys-Hill-Rd

Woodburn-Evans-Head-Rd

Dungarubba Creek

Campbell-Ln

Forest Rd

Buckendoon School-Ln

Richmond St

Golf links Rd

Banks-Ln

Plenkovich Rd

Morris Trl

Riley's Hill Trl

Central Trl

Old Mining Trl

Crash Trl

McDonalds Trl

Doonbah Trl

Death Adder Trl

Powerline Trl

The Broadwater

Coffs Harbour

38 m

42 m

67 m

27 m

39 m

27 m

54 m

31 m

139000	140000
141000	142000
138000	137000
136000	135000
134000	133000
132000	131000

Figure 2.1
Mammal Records
Baseline Monitoring and Atlas of NSW Wildlife

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits:

LEGEND

- Chainage (metres)
- Alignment
- Project boundary
- Section excluded from TMMP

Atlas of NSW Wildlife Records

- *Aepyprymnus rufescens* (Rufous Bettong)
- *Phascogale tapoatafa* (Brush-tailed Phascogale)
- *Potorous tridactylus* (Long-nosed Potoroo)

Baseline Monitoring Records

- *Aepyprymnus rufescens* (Rufous Bettong)
- *Phascogale tapoatafa* (Brush-tailed Phascogale)
- *Potorous tridactylus* (Long-nosed Potoroo)

ISSUE DATE	AUTHOR	QA CHECK	APPROVED	MAP REV.	REVISION NOTE
16/03/2015	JH	BE	BE	0	Issued for Use

amec foster wheeler

N

0 240 480
Metres

(A3) GCS GDA 1994

LOCATION DIAGRAM

Path: W:\PROJECTS\E\Roads & Maritime Services\651570 - W2B Species Management Plans\2.0_Project_Delivery\GIS\MammalSites.mxd

Section 10

Section 9

153000
152000
151000
150000
149000
148000
147000
146000
145000
144000
143000
142000
141000
140000
139000
138000

Wardell
East Wardell
Bagotville
Broadwater (North)
Goat Island
Wardell Park

Wardell Rd
Pacific Hwy
Old Bagotville Rd
Bagotville Rd
Gahans Rd
Kilgin Rd
Broadwater Rd
Coraki-Broadwater Rd
Banks Ln
Plenkovich Rd
Pimlico Rd
River Dr
Owens Ln
Meaneys Ln
Back Channel Rd
Eversons Ln
Legges Ln
North Boundary Trl
Broadwater Quarry Rd
Ponderosa Trl
Finns Trl
Broadwater Beach Rd
Morris Trl
Rileys Hill Trl
Central T

Tuckean Broadwater

175 m
178 m
93 m
34 m
69 m
67 m
54 m
27 m
22 m

1
26

ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 2.1
Mammal Records Baseline Monitoring and Atlas of NSW Wildlife

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits:

LEGEND

- Chainage (metres)
- Alignment
- Project boundary
- Section excluded from TMMP

Atlas of NSW Wildlife Records

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ISSUE DATE	AUTHOR	QA CHECK	APPROVED	MAP REV.	REVISION NOTE
16/03/2015	JH	BE	BE	0	Issued for Use

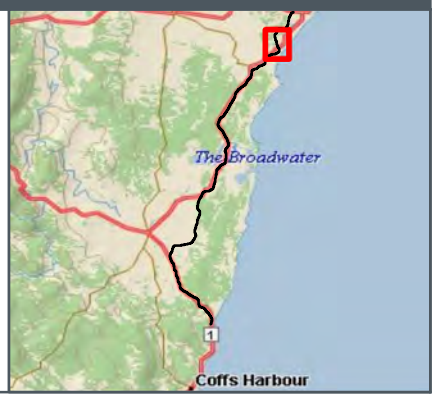
amec foster wheeler

N

0 240 480
Metres

(A3) GCS GDA 1994

LOCATION DIAGRAM



Path: W:\PROJECTS\EIA\Roads & Maritime Services\651570 - W2B Species Management Plans\2.0_Project_Delivery\GIS\MammalSites.mxd

2.2 Rufous Bettong and Brush-tailed Phascogale survey

Lewis Ecological Surveys Pty Ltd was commissioned by Roads and Maritime to develop a BACI survey design using a subset of sites identified as 'impact' sites and pairing these with suitable control sites located in areas adjacent to the Upgrade.

Surveys for Rufous Bettong and Brush-tailed Phascogale included the following techniques:

- Desktop surveys to assess historic data on records within 10 km of the project centre line to guide overall BACI survey design
- Habitat assessment to assess each site as to its suitability for the target species
- Spotlighting surveys – used to indicate presence and abundance with two people performing spotlight surveys over 300 m transects for 1 hour within 600 m x 600 m grids at a subset of sites; and
- Road kill transects – used to record information on the location, age and sex of any road killed bettong or phascogale along with the survey effort.

Surveys were conducted over two survey periods as described in the following sections.

2.2.1 Survey Period 1 - Rufous Bettong and Brush-tailed Phascogale

The survey techniques as described above were carried out and data collected during a week-long field survey between 16 and 23 February 2014 along with some days in March 2014. Seven control sites and nine impact sites were surveyed.

The road kill transects failed to record either species, which was attributed to the short survey period, prevailing season and potential presence of predators. Bettong were recorded at three of the seven control sites spotlighted with a potential bettong recorded at one of the nine impact sites. These sightings are illustrated in **Figure 2-1**. No Phascogale were recorded during the survey, despite nine of the nominated areas scoring high habitat suitability and the remainder scoring moderate habitat suitability. The habitat critique similarly suggested high suitability of seven out of eight sites for the Bettong.

For further information regarding the survey methodology and results refer to the technical report Woolgoolga to Ballina Pacific Highway Upgrade: Rufous Bettong and Brush-tailed Phascogale Site Selection (Lewis Ecological Surveys, 2014b) provided in Section 2 of **Appendix D**.

These initial field surveys identified improvements to methodologies for baseline monitoring surveys for both species. During initial targeted surveys a paucity of records at all sites through the proposed standard methodologies triggered a review of survey methods. Subsequently, camera trapping methodologies were included to assist with increasing records and determine an activity level for each site.

2.2.2 Survey Period 2 – Rufous Bettong and Brush-tailed Phascogale - Amendments to survey effort and adequacy

Given the lack of records during the initial targeted survey periods, survey methods were modified to include camera trapping to provide greater opportunity to detect target species. This methodology subsequently provided records to undertake a baseline monitoring program which can be statistically compared over time through species activity levels. Activity levels were calculated as a function of the number of individuals recorded at a site, divided by the survey effort (no. of individuals / number of survey nights) and have been utilised as a surrogate for relative density for comparison between surveys and thus population fluctuations between impact and control sites. The inclusion of camera trapping has increased the statistical power of the surveys and improved their overall adequacy. It should be noted this method does not simply replace the initial survey methods; moreover, it adds to them.

At each site, 36 camera traps (Scoutguard 560 k zero glow) were installed across a 600 m grid (36 ha) with 100 m trap spacing and left operating over a continuous 14 night period (a total of 504 nights effort). Cameras were installed at each site using the following recording parameters:

- Timer mode set from dusk till dawn whilst adjusting for differing daylight hours and changes in daylight saving
- Sensitivity mode was set to 'high' and where required, vegetation such as long grass was trimmed to reduce false trigger events (i.e. grass being blown in the wind)
- Each triggering event recorded two still images set in 8 mb file size; and
- Reset time interval for retriggering was set at 30 seconds.

Each camera trap site was baited using one large handful of peanut butter, honey and oats bait with added natural vanilla extract (Queen Brand). The bait was scattered over an area of 4-9 m2 and the earth was partly disturbed to increase the likelihood of the area being visited by the target species. Cameras were generally fixed to a tree or stump in a horizontal facing position around 1 m off the ground with the primary objective of obtaining the largest field of view possible. The positioning of cameras was guided by recent field survey evaluations of camera trap orientation whilst surveying for other small macropods and potoroids (see Taylor et al. 2013). For further information regarding the second baseline surveys refer to the technical report Woolgoolga to Ballina Pacific Highway Upgrade: Rufous Bettong and Brush-tailed Phascogale Preconstruction Baseline Monitoring Survey (Lewis Ecological Surveys, 2014c) provided in **Appendix E**.

Survey Period 2 – Rufous Bettong

A second round of surveys were undertaken using a refined survey design for Rufous Bettong. This survey document identified five paired sites for Bettong in Sections 2 and 3 of the project.

The revised survey methodology focused on the use of camera traps and spotlighting at each of the five paired sites previously identified. Spotlighting was carried out by two experienced spotlighters for 1 hour per night at all 10 sites, on two non-consecutive nights. Thirty-six baited camera traps were installed across a 600 m grid with a 100 m trap spacing. Camera traps were set to continuously operate over a 14 night (504 night's effort) period between 3 March and 5 July 2014. Additional ancillary techniques such as nocturnal drive transects and morning road kill surveys were also employed to compliment these survey efforts.

Bettong were detected at four of the five impact sites and four of the five control sites. Bettong were recorded at both impact and control sites 2, 3 and 4, as well as sites 1A and 5B. However, they were absent at the adjacent control site 1B located in the Yuraygir State Conservation Area, where bettongs have previously been reported and impact site 5A. A band of increased activity level was also identified to extend from the eastern extent of Glenugie State Forest west through to Bom Bom State Forest on the outskirts of South Grafton. Sighting of Rufous Bettong are illustrated in **Figure 2-1**. No evidence of a response from bettong to exotic predators was reported during this pre-construction monitoring. For further information regarding the baseline surveys refer to **Appendix E**.

Survey Period 2 – Brush-tailed Phascogale

The survey evaluated five paired sites for Phascogale in Section 2, 3, 6 and 7. Elliot B traps were positioned on tree mounted brackets 2 m above the ground and set out in a 1 ha configuration. Phascogale were also surveyed for during the spotlighting, nocturnal drive transects, morning road kill surveys and camera trap surveys as described for Bettong.

Upon review of the initial field results by Lewis Ecological, there was an opportunity to refine and improve the Phascogale preconstruction monitoring program. Surveys were amended to include two separate sets of BACI Sites:

1. BACI Survey Sites – Arboreal Tree Trapping;
2. BACI Survey Sites – Camera Traps, Spotlighting, Drive Transects.

It should be noted that the two species share some monitoring sites and subsequently share combined BACI sites increasing the survey results at:

- Bettong and Phascogale Site 1B is the same site located in Yuraygir State Conservation Area;
- Bettong Site 3A was used as Phascogale Site 2A at the southern end of Section 3;
- Bettong Site 4B was also used as Phascogale Site 2B;
- Bettong Site 5A and 5B was also used as Phascogale Site 3A and 3B.

Survey sites are illustrated within **Section 8.2.2**.

Arboreal traps were deployed to detect Phascogales at each of the 10 sites over four consecutive nights between 3 and 8 April 2015 (stage 1 surveys) and 26 May to 3 June 2015 (stage 2 surveys).

Phascogale were recorded at two of the five impact sites and four of the five control sites as illustrated in **Figure 8-2**. Phascogale was not recorded at Site 4 nor was it recorded from impact Site 1A or Site 5A despite there being historic records broadly scattered through the Tabbimobile and Mororo areas. All five sites which received camera monitoring recorded Phascogale (Site 1B, 2A, 2B, 3A, 3B).

For further information regarding the second baseline surveys refer to the technical report Woolgoolga to Ballina Pacific Highway Upgrade: Rufous Bettong and Brush-tailed Phascogale Preconstruction Baseline Monitoring Survey (Lewis Ecological Surveys, 2014c) provided in **Appendix E**.

2.3 Overall findings

Rufous Bettong

Preconstruction baseline surveys were able to confirm the presence of Rufous Bettong at most of the sites proposed in the site selection survey report. Bettong activity was used as a surrogate for deriving a density measure at each of the survey sites. In this way the data confirmed previous assertions of the upgrade bisecting an area of high Bettong activity in the vicinity of 8 Mile Lane (within Section 3) where during the course of this survey one in every 2-3 cameras were visited by Bettong. The band of increased activity extends from at least the eastern extent of Glenugie State Forest west through to Bom Bom State Forest on the outskirts of South Grafton. This activity tends to decline in the northern end of Section 2 and there is notable variation on either side of the existing carriageway which has provided some useful insights prior to any post-construction monitoring of the culverts.

Camera traps set across 36 ha grids proved the most useful technique for this type of monitoring simply because they could be deployed in a standardised way and the cameras themselves can readily capture an animal of this size and produce easily identifiable pictures. Opportunities to refine the Bettong survey methodology could be investigated to exclude spotlighting as sites cannot be confidently spotlighted due to the groundcover often being taller than the target species. The use of a 14 night sampling period is expected to adjust well for this as animals probably cover most of their usual range during this period. It therefore should be maintained during future monitoring events.

Brush-tailed Phascogale

Phascogale were recorded at only a few of the assigned preconstruction monitoring sites using the approved survey method of arboreal tree traps. However the use of cameras bolstered the baseline dataset with their contribution revealing Phascogale occur at a number of sites where the species went undetected from arboreal tree trapping. The integration of camera trapping into future monitoring episodes will assist in documenting their distribution and possible responses to the various types of fauna mitigation currently being proposed.

The trapping data showed Phascogale were reliably encountered at Sites 1B and 2A which occur in the northern part of Section 2 and the southern end of Section 3 respectively. Their consistent presence across the trap grid at these two locations indicates that some individuals may focus their foraging efforts and probably choose den sites in close proximity given the regularity in which they were often repeatedly caught. On some occasions individuals were captured on most nights of the survey and some of the individuals were suspected of being recaptured during the second round of surveys.

It was found there will be efficiencies with pairing the Phascogale monitoring program with the Bettong program and for this to focus on the use of cameras across the 36 ha grid. For simplicity, the configuration of these traps should be the same as the Bettong program that uses 36 cameras over a 600 m grid with 100 m spacing.

The use of arboreal tree trapping if it were to continue should be increased to 25 traps set over a larger area of 2.5-3.0 ha grids during the post construction monitoring surveys. The timing of any field sampling should be restricted from late summer through autumn with no surveys to be conducted after June. This sampling approach would avoid periods of increased insect activity, particularly cicadas which tend to provide an abundant foraging resource to Phascogale and make field sampling with traps during this time less efficient. The survey timing for Phascogale monitoring should be restricted from late summer through to the start of winter as this time represents a period of increased activity and movement during the breeding season.

The results of the baseline surveys and recommendations have been incorporated into the monitoring program for Phascogale and Bettong as detailed in **Section 8** of this plan.

Long-nosed Potoroo

Desktop surveys revealed Potoroo have been previously recorded from locations adjacent to Sections 2, 4 and 10 with a concentration of records between chainage 146000-156000 often referred to as the Wardell Sandplain or Jali Lands. Field surveys used in the site selection process resulted in the discovery of new populations in close proximity to the Upgrade in Sections 6 and 7 whilst a new location in Section 10 (west of Old Bagotville Road) represents an important discovery. Records are illustrated in **Figure 2-1.**

As a result of pre-construction baseline surveys for Potoroo in 2014 and 2015 recommendations are that there is seven permanent BACI monitoring sites across Sections 6, 7 and 10 of the project. This allows for adequate replication of habitats and includes new locations where species have been recorded. The duration of cameras installed should remain at 14 nights. Although Potoroo activity data from surveys suggest a 95% confidence interval after 3 nights of sampling, the additional 7 nights monitoring data collected over this duration proved more reliable when sampling is restricted to two monitoring periods within any given monitoring year. Further, there is also a requirement to understand how exotic predators may also utilise the monitoring grid which supports the longer survey period (Lewis Ecological Surveys, 2015). Spotlighting, road kill transects and vehicle transects are recommended to be removed from the monitoring program because they don't contribute an acceptable amount of information to the program. Based on the results of surveys Sections 1, 2 & 3 no longer require consideration for Potoroo as part of the project.

The detection of Potoroo at seven monitoring sites indicates there is more than one population in the vicinity of the upgrade corridor, and that Potoroo occur in Sections 6, 7 and 10 where suitable mitigation is planned. The southern population is recognised by the repeat records of Potoroo from Site 2 where it appears confined to the western precinct of Bundjalung National Park up to the edge of the existing carriageway. Given the absence of Potoroo from monitoring sites on the western side of the highway (i.e. Site 1A1, 1A2 and 1B1), due consideration will need to be given when interpreting the performance of any provided connectivity structures, simply because there is no clear evidence to suggest Potoroo occupy both sides of the carriageway (Lewis Ecological Surveys, 2015).

The middle population occurs broadly within Section 7 with all four monitoring sites depicting a population that is closely associated with the drainage lines of Tabbimoble overflow and its associated drainages or low rises which support suitable microhabitat components of dense shrubs growing in friable soils with discreet nearby open areas. This population extends for a number of kilometres either side of the Upgrade and there is an assumption that it extends beyond Tabbimoble Swamp Nature Reserve into Bundjalung National Park where it could represent the largest known Potoroo population in north east NSW given a lot of this park's 17738 ha represents suitable habitat (Lewis Ecological Surveys, 2015).

Consequently, any fauna connectivity structure that seeks to provide habitat connectivity for Potoroo should do so by providing a structure at ch.115750 (±100 m).

The northern population occurs almost entirely within Section 10 where all eight monitoring sites depict a population that extends over perhaps 1500-2000 ha often described as the Wardell sand plain and associated low coastal hills. At locations further to the south, Potoroo are expected to occur further to west of ch.146700-147800 where a fauna mitigation structure has been proposed to maintain habitat connectivity.

The results of the baseline surveys and recommendations have been incorporated into the monitoring program for Potoroo as detailed in **Section 8** of this plan and the final baseline survey report is included in **Appendix F**

Spotted-tailed Quoll

Two targeted Spotted-tailed quoll surveys have been undertaken for the Glenugie Pacific Highway Upgrade (Sandpiper 2011) and the Pacific Highway Upgrade - Devils Pulpit (Sandpiper 2013). These projects occur within the Woolgoolga to Ballina Pacific Highway Upgrade study area. These targeted quoll surveys found a paucity of potential den sites in proximity to the highway and that the forest types in these areas were of lower forest productivity. The targeted surveys did not detect any individuals. As a consequence of these surveys Sandpiper Ecological concluded that quoll numbers are likely to be very low throughout the project area, and if quolls are present, their home ranges are likely to be large, thus surveys or monitoring are not likely to yield sufficient data. Sandpiper Ecological (2013) concluded that if present, the wider ranging individuals or populations with smaller population densities, suggest that the objectives of the further targeted survey programs proposed in the Spotted-tailed Quoll Management Plan may not yield any meaningful results for the Woolgoolga to Ballina Pacific Highway Upgrade study area. Further, Dr Martin Schulz's expert review highlighted the lack of records during the initial surveys would mean monitoring for this species will be very difficult to establish meaningful monitoring sites and investigate population trends.

It should be noted though that outside of the 2013 surveys two separate road mortalities of Spotted-tail Quoll have been recorded within proximity to the project. The first was recorded on the Pacific Highway in December 2012 at the northern Glenugie Creek bridge crossing, approximately 1.2km north of the upgrade (Craig Harre, 2012), and the second was recorded in May 2013 at the southern end of Devils Pulpit project, on the western side of existing highway. Recently in June 2015 as part of the fauna underpass monitoring at Glenugie Pacific Highway Upgrade a single record of Spotted-tail Quoll was recorded at the Glenugie Creek Underpass (3m high by 9m wide Bebo arch).

Based on these findings, Roads and Maritime have not commissioned any further targeted surveys for the Spotted-tailed Quoll. However as a precautionary approach this species has been retained in the TMMP and monitoring proposed for other mammal species will also potentially pick up Spotted-tailed Quoll in the area. Offsets are being provided for residual impacts to potential Spotted-tailed Quoll habitat. The offset requirements are detailed in the W2B Offset Strategy. Monitoring, mitigation and management measures to minimise impacts to the species should it occur are discussed.

3. Threatened mammal populations

3.1 Background

The threatened mammals are listed as follows under the TSC Act:

- Brush-tailed Phascogale (*Phascogale tapoatafa*) - Vulnerable
- Long-nosed Potoroo (*Potorous tridactylus*) - Vulnerable
- Rufous Bettong (*Aepyprymnus rufescens*) - Vulnerable
- Spotted-tailed Quoll (*Dasyurus maculatus maculatus*) - Endangered

In addition, the Spotted-tailed Quoll and Long-nosed Potoroo are also listed under the EPBC Act as endangered and vulnerable, respectively.

3.2 Existing knowledge

3.2.1 Habitat requirements and known or expected occurrence

A description of the habitat requirements and known and expected occurrence of these threatened mammals is provided in **Table 3-1**. Information in **Table 3-1** has been updated post SPIR to incorporate the results of targeted surveys completed for the Rufous Bettong, Brush-tailed Phascogale and Long-nosed Potoroo. Known records of the three species are shown in **Figure 2-1**.

Table 3-1 Habitat requirements, local abundance and distribution of threatened mammals within the project

Species	Habitat requirements	Records in 10 km of the project [2]	Identified records and project sections	Project section known or potential to occur within
Rufous Bettong[1]	Prefer forests with a grassy to sparse understorey including coastal forest, tall wet sclerophyll forest and dry forests west of the Great Diving Range. It is most commonly found on sites derived from sedimentary rock and in north-eastern NSW in forests characterised by Spotted Gum (*Corymbia maculata* and *C. henryi*). Broad habitat requirement/s: tall moist eucalyptus forests and woodlands. They sleep during the day in cone-shaped nests constructed of grass in a shallow depression at the base of a tussock or fallen log. At night they feed on grasses, herbs, seeds, flowers, roots, tubers, fungi and occasionally insects (Lewis, 2014).	208	Based on Atlas of NSW records and the results of baseline surveys Rufous Bettong is known to occur, or has potential to occur, in Sections 1-4 and 6 -7. Numerous records exist in dry open forest and woodlands north of the Halfway Creek Service Centre, and numerous road kills on Six Mile Lane and Airport Road have been reported (Sections 1 and 2 and the southern end of Section 3). Records for this population in the southern end of the project extend up to Section 3 in the Pheasants Creek and upper Coldstream localities and Sections 2-3 is considered a preferred location for this species. Targeted baseline surveys focused efforts in these areas with higher numbers of records and road kill for this species with habitat found through Sections 2 and 3. Bettong were recorded in Section 2 and Section 3 at four of the five impact sites and four of the five control sites. Further incidental observations of this species during Long-nosed Potoroo surveys within the northern portions of Section 3 indicate its presence outside of the proposed monitoring areas.	Section 1 to 4 Sections 6 to 7
Brush-tailed Phascogale[1]	Preferred habitat is dry open forest with a sparse open understorey, however, has been located in heath, swamps and rainforest and wet sclerophyll forest. Females have exclusive territories of approximately 20–60 ha, while males have overlapping territories of up to 100 ha (Soderquist and Rhind 2008). Tree hollows with entrances typically 25-40 mm wide are used as nest/shelter sites, and many may be used over a short period of time. Mating occurs between May-July with the males dying soon after the mating season whereas females can live for up to three years but generally only produce one litter (Soderquist and Rhind 2008). Broad habitat requirement/s: dry, open sclerophyll forests.	117	Suitable habitat for Brush-tailed Phascogale was identified north from Halfway Creek to Glenugie (Section 1-4) and the species was confirmed in Section 2 and 4 and 6-8. Targeted surveys for this species have also confirmed its presence within Section 3 of the project on both the eastern and western side of the highway. For the most part, the sections of the project where this species has been identified proposed upgrades will seek to widen the existing carriageway therefore impacts to habitat will be minimised. However, Section 3 of the project traverses large parcels of remnant forest where this species has been identified during targeted surveys.	Section 1 to 9
Spotted-tailed Quoll	The species is very widespread throughout all areas and habitats of the North Coast Bioregion. Individual animals inhabit hollow bearing trees, fallen logs, small caves, and rocky areas (such as boulder fields and cliff faces) (Department of Environment, Climate Change and Water (DECCW) 2012b). Broad habitat requirement/s: rainforests, open woodlands, coastal heathlands and inland riparian forests.	64	The Spotted-tailed Quoll was not confirmed in project corridor.	Section 1 to 2 Section 6 to 7

Species	Habitat requirements	Records in 10 km of the project [2]	Identified records and project sections	Project section known or potential to occur within
			It should be noted though that outside of the targeted surveys for W2B two separate road mortalities of Spotted-tail Quoll have been recorded within proximity to the project. The first was recorded on the Pacific Highway in December 2012 at the northern Glenugie Creek bridge crossing, approximately 1.2km north of the upgrade (Craig Harre, 2012), and the second was recorded in May 2013 at the southern end of Devils Pulpit project, on the western side of existing highway. Based on the habitats present, in particular the larger state forests and conservation reserves, two main areas exist which may represent important potential habitat for regional populations. These are the areas from Woolgoolga to Glenugie including Halfway Creek, Wells Crossing and Glenugie State Forest (Sections 1 and 2) and Bundjalung National Park to Devils Pulpit, Tabbimoble State Forest and Doubleduke State Forest (Sections 6 and 7).	
Long-nosed Potoroo	This species is known to inhabit coastal heaths and sclerophyll forests (dry and wet) and requires a dense understorey with occasional openings as an essential part of its habitat, and may consist of grass-trees, sedges, ferns or heath, or of low shrubs of tea-trees or *Melaleuca*. The fruit-bodies of hypogeous (underground-fruiting) fungi are a large component of the diet of the Long-nosed Potoroo. They also eat roots, tubers, insects and their larvae and other soft-bodied animals in the soil (Bennett and Baxter 1989). This species is commonly associated with sandy loam soils (Department of Environment, Climate Change and Water (DECCW) 2012c). Broad habitat requirement/s: coastal heath, dry and wet sclerophyll forests. Individuals are mainly solitary, non-territorial and have home range sizes ranging between 2 and 5 ha in north eastern NSW (Bali *et al.* 2003). Breeding typically occurs in late winter to early summer and a single young is born per litter. Adults are capable of two reproductive bouts per annum.	22	The Long-nosed Potoroo has been confirmed in the project corridor. Multiple records of this species were identified during pre-construction targeted and baseline surveys at sites proximate and adjacent to Sections 6, 7 and 10 (including habitats adjacent to and on both sides of the existing Pacific Highway in Sections 6 & 7). For the most part, proposed upgrades to the project within Sections 6 and 7 will seek to widen the existing carriageway of the Pacific Highway through habitats identified as supporting Long-nosed Potoroo populations. Pre-clearance surveys within Sections 6, 7 and 10 have identified locations for proposed crossing structures as well as locations for, and the type of exclusion fencing, which is required for the Potoroo. The proposed location of crossing structures and exclusion fencing for threatened mammals including Potoroo are outlined in this TMMP. Section 10 of the project will traverse for the most part an area of known Long-nosed Potoroo habitat. This area of habitat is known to support an important population of Long-nosed Potoroo within the JALI Aboriginal Lands near Wardell. Recent targeted surveys detected the presence of Long-nosed Potoroo throughout this area of habitat as well as detecting individuals within a small node of suitable habitat falling on the south-western fringe of the Project footprint at approximately chainage 148000. This small node of habitat is likely to be isolated or lost as a result of the Project.	Section 6, 7 and 10

Species	Habitat requirements	Records in 10 km of the project [2]	Identified records and project sections	Project section known or potential to occur within
			Similar habitats on sandy soils with a Eucalypt canopy and heathy understorey also occur to the west of the alignment near chainage 146500, while the species has not been confirmed in this location through targeted EIS and pre-construction surveys, it should be considered suitable habitat for the species given the habitats present and the presence of populations in close proximity to the north-east and within the small node of habitat at chainage 148000. Results of the targeted surveys have confirmed the species is not likely to occur in Sections 1 to 3.	

Broad habitat requirement/s from Table D1 (Appendix D) of the Biodiversity Assessment Working Paper (Roads and Maritime 2012).
[1] Habitat requirements from Table C11 (Appendix C) of the Biodiversity Assessment Working Paper (Roads and Maritime 2012).
[2] Atlas of NSW Wildlife (OEH 2013) and BioNet Wildlife Atlas.

3.3 Key threats

All identified mammal species are threatened by habitat loss, particularly any direct loss or impact to habitats needed for life-cycle events associated with breeding habitat, foraging or shelter resources. Indirect impacts include fragmentation of habitat leading to isolation and loss of population viability. Further specific threats are described in the following.

The Rufous Bettong and the Brush-tailed Phascogale are threatened from habitat loss and fragmentation as a result of forest clearing for logging, agricultural expansion and urban development (DECCW 2012a). Habitat fragmentation leads to increased predation by foxes and cats and reduced habitat quality at the forest edges. The Brush-tailed Phascogale is particularly sensitive to the loss of hollow-bearing trees (Queensland Museum 2007). These species are also sensitive to the loss of foraging and shelter resources resulting from inappropriate fire regimes. Both species are affected by competition; the Brush-tailed Phascogale is affected by competition from the introduced honey bee for nesting hollows (NSW NPWS 1999), and the Rufous Bettong faces competition from rabbits (DECCW 2012a).

The Spotted-tailed Quoll is threatened by habitat loss and fragmentation which reduces numbers of suitable den sites and prey (DECCW 2012b). The Spotted-tailed Quoll is also susceptible to inadvertent poisoning such as 1080 during wild dog and fox control programs and competition for food from introduced predators such as cats and foxes. There is anecdotal evidence that suggests that the Spotted-tailed Quoll is susceptible to poisoning by Cane Toads (*Bufo marinus*). This species is also known to feed on road kill where it is vulnerable to vehicle strike.

The Long-nosed Potoroo is threatened by habitat loss and fragmentation from land clearing for residential and agricultural development (DECCW 2012c). Geographical separation is also a major threat to the species where isolated populations face difficulties breeding (DECCW 2012c). The Long-nosed Potoroo is vulnerable to predation by foxes, dogs and cats (Queensland Museum, 2007) and the reduction of understory vegetation by grazing and fire. There is also the potential for this species to be adversely affected by the removal of top order predators such as wild dogs and dingoes as this can increase numbers of feral cats and foxes which then predate on Long-nosed Potoroo.

4. Potential impacts and management approach

The following section describes the potential impacts to threatened mammals with reference to the more detailed impact assessment presented in the Biodiversity Working Paper (Roads and Maritime 2012). The impact assessment also takes into consideration the results of additional targeted surveys completed in 2014. It describes potential impacts to the species at specific locations along the project and during the pre-construction, construction and post-construction (operational) stages of the project to provide context to the management approach. The mitigation approach presented in the EIS and further documented in **Sections 4**, **5** and **6** of this TMMP target the predicted impacts.

4.1 Potential impacts associated with the project

4.1.1 Rufous Bettong

The project is likely to impact the Rufous Bettong within three broad locations where known populations of the species have been confirmed or are predicted to occur:

- Woolgoolga to Glenugie including Halfway Creek, Wells Crossing and Glenugie State Forest (Sections 1 - 2).
- Pillar Valley to Harwood (Section 3 and 4) in the foot slopes of the Sommervale Range extending to intact and fragmented habitats on lower undulating lands near Bostock Road, Sommervale Road to Tyndale and Gulmarrad and upper Shark Creek.
- Bundjalung National Park to Devils Pulpit, Tabbimoble State Forest and Doubleduke State Forest (Sections 6 and 7).

Potential impacts to the Rufous Bettong are discussed in Section 4.3.2 (pp. 311-312) of the Biodiversity Assessment Working Paper (Roads and Maritime 2012). In summary impacts to the Rufous Bettong as a result of the project include:

- Loss of habitat, in particular clearing of mature trees, ground-cover and logs. This may impact on the home range territory of a number of individuals, remove a percentage of the shelter and foraging resources for these animals and potentially disrupt multiple breeding seasons.
- The barrier effect of the highway and potential isolation of habitat and populations. A reduction in movements could also lead to potential separation of sub-populations and reduced viability. The severity of the impact on the regional population is low, as the species is widespread over a large portion of the bioregion.
- Potential for increased predation pressure associated with displacement of individuals from home ranges.
- Fragmentation and degradation of habitat adjoining the project and the effects on dispersal of individuals. These impacts would temporarily affect dispersal, foraging, sheltering and breeding events.
- Vehicle strike during all phases of the project.

This species is known to also inhabit, and was recorded in cleared or modified habitats including forestry areas and grazing land with small patches of remnant or riparian vegetation and suitable microhabitats.

Measures to mitigate the barrier effect of the road have been considered in the design and placement of fauna crossing structures to maintain connectivity and fauna exclusion fencing to reduce impacts from vehicle strike. Crossing structures and exclusion fencing are further detailed in **Sections 6.3.6** and **Section 6.3.7** of this plan.

4.1.2 Brush-tailed Phascogale

The project is likely to impact the Brush-tailed Phascogale in three broad locations where known populations occur:

- Woolgoolga to Glenugie including Halfway Creek, Wells Crossing and Glenugie State Forest (Section 1-2).
- Pillar Valley to Harwood (Section 3 and 4) in the foot slopes of the Sommervale Range extending to intact and fragmented habitats on lower undulating lands near Bostock Road, Sommervale Road to Tyndale and Gulmarrad and upper Shark Creek.
- Bundjalung National Park to Devils Pulpit, Tabbimoble State Forest and Doubleduke State Forest (Sections 6 and 7).

Impacts of the Brush-tailed Phascogale are discussed in **Section 4.3.2** (pp. 311-312) of the Biodiversity Assessment Working Paper (Roads and Maritime 2012). In summary, impacts to the Brush-tailed Phascogale as a result of the Project include:

- Loss of habitat, in particular those containing hollow bearing trees.
- The barrier effect of the highway.
- Potential for increased predation associated with fragmentation and degradation of habitat adjoining the project. These impacts would temporarily affect dispersal, foraging, sheltering and breeding events. The severity of the impact on the regional populations is low, as the species is widespread over a large portion of the bioregion.
- The project would remove core habitats for this species including open forest and woodland vegetation; this also includes the loss of foraging resources and habitat connectivity. The overall reduction of habitat is a small proportion of the available potential habitat throughout the broader bioregion. The species is known to be resilient to some habitat disturbance and is known to inhabit modified habitats in agricultural areas indicting a degree of tolerance. Measures to mitigate the barrier effect of the road have been considered in the design and placement of fauna crossing structures to maintain connectivity. Crossing structures for Phascogale are further detailed in **Section 6.3.7** of this plan.

4.1.3 Spotted-tailed Quoll

Likely impacts to the Spotted-tailed Quoll are discussed in **Section 4.3.2** (p. 314) of the Biodiversity Assessment Working Paper (Roads and Maritime 2012). It is estimated that the project will impact 763.12 ha of habitat for this species as outlined within Table 16 (Potential impacts on MNES and indicative offset requirements) of the W2B Biodiversity Offset Strategy (February 2015).

In summary impacts to the Spotted-tailed Quoll as a result of the project include:

- Loss of habitat including potential den sites.
- Fragmentation and the barrier effect of the highway potentially leading to increased genetic isolation of sub-populations.
- The species is known to frequent roadsides feeding on road kill where they would be threatened by vehicle strike.
- The species is susceptible to inadvertent poisoning by poisons such as 1080 during wild dog and fox control programs, competition for food and are potentially susceptible to poisoning by cane toads (*Bufo marinus*).
- The severity of the impact on the regional population is low as the species is very widespread over a large portion of the bioregion and there are considerable areas of potential habitat over private and conserved lands. Impacts to sub-populations or individuals may be more moderate and associated with fragmented and isolation. Large areas of habitat would remain in state forests and reserved habitats for the longer-terms viability of the regional population.

The species is very widespread throughout all areas and habitats of the North Coast Bioregion. No quolls were recorded during surveys for the project. It should be noted though that outside of the W2B surveys two separate road mortalities of Spotted-tail Quoll have been recorded within proximity to the project. The first was recorded on the Pacific Highway in December 2012 at the northern Glenugie Creek bridge crossing, approximately 1.2km north of the upgrade (Craig Harre, 2012), and the second was recorded in May 2013 at the southern end of Devils Pulpit project, on the western side of existing highway.

Based on the habitats present, in particular the larger state forests and conservation reserves, two main areas exist which may represent important habitat for regional populations. These are the areas from Woolgoolga to Glenugie including Halfway Creek, Wells Crossing and Glenugie State Forest (Sections 1 and 2) and Bundjalung National Park to Devils Pulpit, Tabbimoble State Forest and Doublebuke State Forest (Sections 6 and 7). These habitats are largely associated with the mature dry and moist sclerophyll forests on both sandy and clay soils. Large areas of habitat would remain in state forests and reserved habitats for the longer-terms viability of this species.

4.1.4 Long-nosed Potoroo

The project is likely to impact the Long-nosed Potoroo in three broad geographic locations where known populations occur:

- Iluka Road to Bundjalung National Park (Section 6)
- Devils Pulpit upgrade to Trustums Hill (Sections 7); and
- Richmond River to Coolgardie Road (Section 10).

Impacts of the Long-nosed Potoroo are discussed in Section 4.3.2 (p. 315) of the Biodiversity Assessment Working Paper (Roads and Maritime 2012). Supplementary information that takes into consideration results of recent targeted surveys and baseline monitoring is provided in this TMMP..

In summary impacts to the Long-nosed Potoroo as a result of the project include:

- Loss of habitat, in particular clearing of understorey vegetation.
- The barrier effect of the highway and potential isolation of habitat and populations. A reduction in movements could also lead to potential separation of sub-populations and reduced viability.
- Potential for increased predation pressure associated with displacement of individuals from home ranges.
- Fragmentation and degradation of habitat adjoining the project and the effects on dispersal of individuals. These impacts would temporarily affect dispersal, foraging, sheltering and breeding events.
- Vehicle strike.

Populations of Long-nosed Potoroo have been identified in habitats proximate and adjacent to Sections 6, 7 and 10, with minimal habitat or recent records of these species occurring in habitat proximate to other sections of the project. The identified populations have been found in habitats associated with the wet and dry heath habitats on sandy soils, a Eucalypt canopy can be present or absent; however, a common thread to these habitats is the presence of a dense understorey with small open areas. The population found within Section 10 occurs within Wardell Heath, a name referring to a large area of land containing a mosaic of heath, forest and swamp habitats positioned adjacent on the western side of the Richmond River near Wardell generally east and south of the project between chainage 148000 to 156000.

Section 10 of the project will traverse for the most part an area of known Long-nosed Potoroo habitat. This area of habitat is known to support an important population of Long-nosed Potoroo within the JALI Aboriginal Lands near Wardell at the Wardell Heath. Recent targeted surveys detected the presence of Long-nosed Potoroo throughout this area of habitat as well as detecting individuals within a small node of suitable habitat falling on the south-western fringe of the Project footprint at approximately chainage 148000. This small node of habitat is likely to be isolated or lost as a result of the Project to its western fringe.

Similar habitats on sandy soils with a Eucalypt canopy and heathy understorey also occur to the west of the alignment near chainage 146500 and 148000, while the species has not been confirmed in this location through targeted EIS and pre-construction surveys, it should be considered suitable habitat for the species given the habitats present and the presence of populations in close proximity to the north-east and within the small node of habitat at chainage 148000. Other subsequent observations of these species occurring within Sections 6 (Tabbimobile) and 7 (New Italy) suggest this species is more widespread throughout the region and project area where suitable habitat is present. These sections of the project are for the most part, co-located with the exiting Pacific Highway thus no new barriers would be established through these sections, however an expanded carriageway would traverse these large contiguous parcels of remnant vegetation increasing the predicted impact area then initially identified.

Those areas considered as providing habitat for Long-nosed Potoroo are provided in **Appendix G** of this TMMP.

Potential indirect impacts to habitat may be associated with impacts on groundwater through construction potentially affecting the condition of the retained habitats. Groundwater impacts are considered to be minimal. There is the impact of the potential barrier effect on dispersal and movements of the species between chainages 98000 – 102000, 104000 – 106000, 111000 – 120000 and 146500 – 148000 where populations have been identified. The population noted within the Wardell Heath has limited connectivity to similar habitats across the North Coast Bioregion, which explains its relative isolation. The Richmond River is a barrier to the east and the only movement opportunities are to the north across a network of existing roads. Large areas of habitat would remain in the landscape within Wardell Heath for the longer-term viability of this species, however the highway will create a barrier to movements and connectivity to other populations to the west and north of Wardell.

4.2 Detailed design considerations

A number of factors will be addressed in the detailed design phase for each section to minimise the impacts of the project. The factors to be considered which will be particularly relevant for the minimisation of impacts to threatened mammals include:

- Avoiding and minimising vegetation / habitat removal wherever possible
- Consideration of water quality and altered hydrology
- Refinement of connectivity mitigation measures including the design and location of underpasses, overpasses, rope crossings and fauna exclusion fencing.

As a minimum, the design of targeted threatened mammal crossing structures and permanent exclusion fencing will be based on the design principles outlined in the EIS and the process for managing threatened mammal connectivity described in the Woolgoolga to Ballina Upgrade Working paper*:* Biodiversity Assessment (Roads and Maritime 2012). This includes a comprehensive program to monitor the effectiveness of crossing structures and the inclusion of precautionary options. For example, given the possibility for threatened mammals to enter the road corridor over the life-time of the road, refinement of the location of fauna exclusion fencing and some crossing structures will be undertaken (refer to **Section 6.3.6** and **Section 6.3.7**). Refinement of the location of these measures has been and will continue to be informed by targeted fauna surveys and future monitoring surveys (refer to **Section 2** and **Section 8** of this document).

Detailed design has been completed for Sections 1 and 2 of the project with the results of baseline threatened mammal surveys informing the finalisation of crossing structures and exclusion fencing for Sections 1 and 2 of the project. A summary of locations for exclusion fencing is in **Table 6.1** and crossing structures associated with faunal groups is in **Table 6.3**. For greater detail regarding crossing structures for fauna refer to the Pacific Highway Upgrade Woolgoolga to Ballina: Fauna Connectivity Strategy Woolgoolga to Glenugie-Sections 1 and 2. (GHD 2015); specifically Chapter 5 which details the type of crossing structures, location, effectiveness and targeted faunal groups.

Fauna crossing structures for Sections 3 to 11 have been proposed. The exact location will be refined as part of detailed design and captured in a supplementary Fauna Connectivity Strategy (Sections 3-11) which will be provided to DoE and DP&E for approval prior to construction commencing in these areas. Proposed locations and crossing types for threatened mammals has been outlined within **Table 6.4**.

4.3 Mitigation and monitoring approach

The aim of the mitigation measures is to ensure the continued viability of threatened mammal populations in the project area by achieving the following goals:

- Minimise threatened mammal mortality due to vehicle strike in the project area
- Minimise loss of habitat (particularly den/shelter sites and foraging resources) within the project area
- Minimise habitat fragmentation
- Provide functional crossing opportunities
- Maintain connectivity for daily movements and allow for the transfer of genes.

A number of mitigation measures to address the goals of the management strategy and monitor the impact of the project on threatened mammals during construction and operation of the project were suggested in the Biodiversity Working Paper (Roads and Maritime 2012). In general these mitigation measures related to:

- The production of project specific flora and fauna management plans
- Exclusion zones to protect adjoining habitats during construction
- Fauna Connectivity Strategy and mitigation measures (arboreal crossing structures, widened medians, dedicated overpasses and underpasses and combined drainage / fauna crossing structures). The strategy is to be informed by targeted surveys for threatened mammals to refine crossing structures and their final location. The minimum design and locations of crossing structures for threatened mammals will be based on the principles outlined in the EIS and the process for managing connectivity requirements described in the Fauna Connectivity Strategy.
- Permanent fauna exclusion fencing to minimise road moralities and direct to crossing structures
- Sensitive pre-clearing and clearing procedures to consider animal welfare and translocation from clearing areas
- Minimise clearing through appropriate location of ancillary facilities, implementation of a staged habitat removal process consistent with the Roads and Maritime Biodiversity Guidelines (RTA 2011), revegetation of areas disturbed during construction and installation of nest boxes
- Management of light, dust and noise will be in accordance with the Construction Environment Management Plan (CEMP)
- Establish a comprehensive monitoring program to assess the effectiveness of mitigation measures and allow for ongoing updates to these measures based on the results of monitoring
- Engagement of appropriate stakeholders to identify appropriate predator and pest control actions; and
- Revegetation of suitable habitat along areas disturbed by construction and land bridge crossings including reuse of woody debris and bush rock.

4.4 Effectiveness of mitigation measures

A summary of the proposed threatened mammal mitigation measures and evaluation of their effectiveness based on past experience for other highway upgrades is described in **Table 4-1**. Specific mitigation measures were taken from the EIS (Section 10) Table 10-32.

Table 4-1 Mitigation measures and evaluation of their effectiveness

Issue	Mitigation measure	History of success	Effectiveness rating
Loss of habitat via the removal of vegetation including the removal of hollow bearing trees	• Identification of clearing limits and establishment of exclusion zones. • Pre-clearing and clearing procedures • Ethical Faunal handling procedures. • Reuse of woody debris and bushrock to re-establish habitat as required • Development and implementation of a next box management plan.	A standard procedure for vegetation clearing has been developed by Roads and Maritime and documented in the Biodiversity Guidelines: protecting and managing biodiversity on RTA roads (RTA 2011). The guidelines were developed in consultation with EPA, 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. Guidance regarding nest box installation and maintenance are provided in the Roads and Maritime Biodiversity Guidelines- Guide 8 Nest Boxes (Roads and Maritime 2012). Nest boxes have been used on the Kempsey Bypass project specifically in relation to the Brush-tailed phascogale. This monitoring program identified the active usage of next boxes by Brush-tailed Phascogale as well as nine other native species with a total usage by native vertebrate fauna being 23.5% at the time of survey.	High, monitor effectiveness and implement corrective actions where appropriate.
Fragmentation of habitat and reduction in movement leading to a potential separation of populations.	• Construction of fauna crossing structures for ground-dwelling mammals. • Arboreal crossing structures and widened median for Brush-tailed Phascogale. • Nest boxes for Brush-tailed Phascogale. • Temporary and permanent fauna exclusion fencing installation. • Monitoring of fauna crossing structures.	Initial monitoring of the use of culverts for Rufous bettong crossing structures has been undertaken for the Glenugie Upgrade project. At the time of writing this plan the results of the monitoring were not published. As monitoring results become available they will be reviewed and inform mitigation measures for the W2B project. Roads and Maritime also undertook a review of the use of fauna passage structures for a number of Pacific Highway projects in 2009. This review found that in general the Potoroo was using bridges, box culverts and purpose built fauna connectivity structures. The Quoll was using box culverts and purpose built fauna connectivity structures and the Brush-tailed phascogale was using cut and cover overpass structures. As noted above, nest boxes have been used on the Kempsey Bypass project specifically in relation to the Brush-tailed Phascogale.	Moderate, monitor effectiveness and implement corrective actions where appropriate.
Mortality due to vehicle strike during both construction and operational phase of the project.	• Installation of permanent fauna exclusion fencing. • 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 in the fence. It has been standard practice on Pacific Highway projects for Roads and Maritime to identify fauna fencing locations in the project environmental impact assessment. Fauna fencing locations would then be refined further in detailed design and also post-construction in cases where road fauna mortality has indicated a need for additional fencing. Examples include Tandys Lane Upgrade, Yelgun to Chinderah Upgrade, Bonville Deviation and Karuah to Bulahdelah.	Moderate, monitor effectiveness and implement contingencies where appropriate.

Issue	Mitigation measure	History of success	Effectiveness rating
Inadvertent poisoning from the use of herbicides and pesticides.	• Development and implementation of a herbicide and pesticide procedure in accordance with the Roads and Maritime Biodiversity guideline.	Roads and Maritime has developed standard weed management procedures that are implemented during construction and are reported as part of the FFMP. This includes pre-clearing weed surveys to identify noxious and environmental species and map their location for on-going monitoring and control during construction and operation. Monitoring noxious and environmental weeds is a routine procedure for road upgrades which has a long history of success in NSW.	Moderate, monitor against performance and implement weed management actions as required.
Introduction of predators and cane toads	• Wild dogs, cats, fox and cane toad control.	Roads and Maritime does not conduct wild dog and/or fox control and would engage with appropriate stakeholders to identify appropriate predator control actions.	Moderate, monitor and engage with relevant agencies regarding corrective actions required.
Disturbance of denning sites.	• Preclearance surveys of culverts and bridges prior to demolition. • Preclearance surveys of vegetation prior to clearing.	Pre-clearance surveys are a routine procedure that has been implemented for a number of Pacific Highway projects to identify and protect fauna. Projects where the pre-clearance surveys have been implemented successfully include the Tintembar to Ewingsdale, Sapphire to Woolgoolga, Coopernook to Herron Creek and Coopernook Bypass.	High, monitor effectiveness and implement contingencies where appropriate
Introduction of pathogens.	• 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). This guide is a standard procedure that has been successfully implemented by Roads and Maritime for a number of Pacific Highway projects.	Moderate, monitor effectiveness and implement contingencies where appropriate
Decline in stream water quality.	• 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.	Moderate, monitor success and implement corrective actions

4.5 Adaptive management approach

The management plan has been presented using an adaptive management approach based on firstly identifying specific goals for management, implementation of management actions followed by monitoring of the performance of these measures against the goals and identified performance indicators. As a final step the monitoring would evaluate the effectiveness of the management measures using identified and measurable triggers for corrective action and implementing the prescribed corrective actions to improve mitigation where required.

To ensure the success of this approach the management goals presented in the plan are based on the following SMART principles:

- **S**pecific.
- **M**easurable.
- **A**chievable.
- **R**esults-based.
- **T**ime-based.

Details of the proposed monitoring program are provided in **Section 8**.

5. Pre-construction management measures

5.1 Potential impacts during pre-construction

- Location of road infrastructure and/or ancillary facility sites may impact on threatened mammal habitat, movements, foraging and behaviour.

5.2 Mitigation goals

- Confirmation of important habitats for threatened mammals prior to commencement of construction
- Completed designs for connectivity mitigation measures prior to construction
- Identify habitat exclusion zones prior to clearing to guide the placement of infrastructure and ancillary facilities outside of threatened mammal habitat where possible.

5.3 Targeted surveys

Targeted surveys have been completed in the pre-construction phase to inform the TMMP by confirming the presence of threatened mammals, collect baseline population data, habitat quality information and identify ongoing monitoring locations for the threatened mammals detailed in this plan. Targeted survey results are summarised in **Section 2**. Approval of this TMMP (Version 3) will be sought prior to commencement of Sections 3-11.

Survey data will also be used to inform the identification of fauna habitat revegetation areas as outlined in the Urban Design and Landscape Plan (UDLP) and refinements to the location of fauna exclusion fencing, fauna crossing structures, permanent monitoring sites and ancillary facility locations (refer to **Section 6** for mitigation structures and **Section 8** for the monitoring program).

The objectives of the targeted baseline surveys are to:

- Confirm threatened mammals presence, habitat suitability and relative density of populations at specific locations to confirm the suitability of impact monitoring sites and control monitoring sites as part of the overall monitoring program
- Inform and/or refine proposed connectivity structures and fauna exclusion fencing locations, which may include the need for additional mitigation such as exclusion fencing, or movement of structures in the case of rope crossing structures.

For crossing structures, the location of threatened mammal populations and habitats from these targeted pre-construction surveys has further informed the detailed design, particularly in relation to the types of revegetation and fauna furniture to be used to suit the target species.

Monitoring locations of reference and impact sites are focused on known and likely habitat areas identified adjacent to the project where the presence of threatened mammal species were confirmed during the targeted surveys or are considered highly likely to occur due to previous records and suitability of habitat. The locations of the final monitoring sites are detailed in **Section 8** of this plan.

The timing and methods of the targeted pre-construction surveys are described in more detail within **Section 2** of this TMMP. The detailed methods and timing for subsequent monitoring surveys is described in more detail within **Section 8**.

5.4 Management measures

5.4.1 Detailed design of permanent fencing and crossing structures

Data gathered from the targeted pre-construction baseline surveys have informed the detailed design with respect to the final locations of permanent exclusion fencing and crossing structure types and locations for Sections 1 and 2. A number of changes have been made with respect to the design and location of bridges, culverts and fauna crossings to improve fauna connectivity in the project area (Section 5.8 of the Pacific Highway Upgrade Woolgoolga to Ballina: Fauna Connectivity Strategy Woolgoolga to Glenugie (Sections 1 and 2) (GHD, 2014)). These have included changes to:

- bridge lengths to allow dry passage for fauna (as required by CoA D2 (k))
- culvert height to improve fauna passage and optimisation of location to reduce culvert length
- additional dedicated underpasses have been included in the detailed design to improve fauna connectivity in some areas.

The final location of exclusion fencing relating to mammals for Sections 1 and 2 is detailed in **Section 6.3.6, Table 6.1** and crossing structures are detailed in **Section 6.3.7**, **Table 6.3**. Crossing structures will be installed prior to operation.

Arboreal crossing locations would be confirmed during the construction phase and after vegetation clearance by an appropriate ecologist in case of changed circumstances such as unexpected loss of adjacent trees. Two supplementary crossings that were not included in the EIS have been included in the connectivity strategy; intended to add value by extending the crossing zones created by the widened medians.

Proposed fencing locations and crossing structures for Sections 3-11 are described in **Section 6.3.6, Table 6.2** and **Section 6.3.7**, **Table 6.4**. The exact location will be refined as part of detailed design and take into consideration the results of baseline surveys and monitoring. Details will be captured in a Fauna Connectivity Strategy (Sections 3-11) which will be provided to DoE and DP&E for approval prior to construction commencing in these areas.

5.4.2 Identify habitat exclusion zones

An exclusion zone is a designated ‘no-go’ area that is clearly identified and appropriately fenced to prevent damage to native vegetation and fauna habitat. This procedure would be documented in the CEMP and project specific FFMP and conducted along the entire construction corridor for flora and fauna prior to construction commencing. The location of threatened species and habitats will be clearly identified in the documentation and exclusion zones clearly marked on the ground prior to construction by the project ecologist. Exclusion zones need to be ground-truthed for identification and then can be reflected on mapping to inform the CEMP and FFMP.

Habitat exclusion zones and limits of clearing include consideration of hollow bearing trees for Brush-tailed Phascogale; hollow bearing trees, hollow logs, rocky outcropping and low escarpment for Spotted-tail Quoll; dense tall native tussock grasses where Rufous Bettong’s cone shaped dreys are found; and dense vegetation or squat sites within identified Long-nosed Potoroo habitats. The location of appropriate habitat exclusion zones will be identified during pre-clearing surveys by an appropriately qualified ecologist as discussed in **Section 6.3.5**. Temporary fencing around these exclusion zones will be erected in the construction phase prior to clearing.

Identification of exclusion zones may be staged with a priority for early works sites and then remaining areas of the construction corridor. Survey personnel would be inducted to ensure they do not encroach outside the limits of clearing.

Ancillary infrastructure would also be planned and sited within cleared or disturbed areas minimising the need for any vegetation removal, more than 50metres away from a waterway and not impede on fauna movement areas. Ancillary sites were outlined within Chapter 4 of the SPIR and supplementary assessments were provided in the Ancillary Assessment Report provided to DP&E in December 2013.

5.5 Mitigation goals and corrective actions

The pre-construction mitigation measures for threatened mammals that are to be completed prior to the commencement of construction and corrective actions should mitigation goals and measures not be achieved are summarised in **Table 5-1**.

Table 5-1 Mitigation goals and corrective actions – pre-construction

Mitigation goals	Proposed mitigation measure	Monitoring/timing frequency	Triggers for corrective actions	Corrective actions	Responsible party for corrective action implementation
Confirmation of important habitats for threatened mammals prior to commencement of construction.	Targeted mammal surveys undertaken during detailed design and crossing structure locations refined. Identification of BACI monitoring sites (impact and control) from targeted survey findings. Baseline surveys at monitoring sites completed.	During detailed design prior to construction.	Targeted surveys for mammals have not been completed prior to commencement of construction. Crossing structure designs for mammals have not been finalised prior to commencement of construction. Monitoring sites for threatened mammals have not been finalised prior to commencement of construction.	Do not commence vegetation clearing or construction until actions have been completed.	RMS
Completed designs for connectivity mitigation measures prior to construction.	Results of targeted surveys to inform final locations of fauna exclusion fencing and connectivity structures where appropriate.	Completed during detailed design and signed off prior to construction commencing.	Designs not updated post targeted surveys or finalised before construction.	Construction delayed until crossing structures and fencing locations are approved as part of the Fauna Connectivity Strategy.	RMS
Identify habitat exclusion zones prior to clearing to guide the placement of infrastructure and ancillary facilities outside of threatened mammal habitat where possible.	Conduct pre-clearing surveys to delineate appropriate exclusion zones along the project corridor and ancillary sites. Clearing limits to be reflected in FFMP (Sensitive Area Plans).	Once only prior to clearing commencing. Hold point – inspection of clearing limits by Project ecologist to ensure clearing limits identified and installed correctly.	Exclusion zones are not clearly marked or fenced in the field prior to clearing occurring. FFMP does not identify clearing limits.	Construction delayed until exclusion zones are reflected in the documents and approved. Clearing ceases until exclusion zones are clearly marked/fenced off on the ground.	RMS

6. Construction management measures

6.1 Potential impacts during construction phase

- Removal of threatened mammal habitat including habitat trees and hollow bearing trees
- Disturbance and degradation to adjoining threatened mammal habitat outside of construction corridor
- Injuries or mortality of threatened mammals during vegetation clearing
- Contamination or isolation of water supplies used by threatened mammals.

6.2 Mitigation goals

- Establish procedures and training to ensure mitigation is incorporated into construction, through implementation of a CEMP
- All threatened mammals recovered from hollows, habitat trees or dens successfully relocated to habitats proximate to their capture
- Provide opportunity for daily movements of target species across the highway
- No damage to threatened mammal habitat within marked exclusion zones
- No vehicle collision incidents with threatened mammal species within construction areas.
- No injuries or mortality of threatened mammals as a result of vegetation clearance
- Threatened mammal habitat is rehabilitated to a functional quality and methods for rehabilitation of threatened mammal habitat adjacent to the road are included in Urban Design and Landscape Plan
- Implement noise, dust and light mitigation identified in the CEMP to mitigate edge effects
- No contamination or isolation of water supplies adjoining the project
- Minimise impacts from road kill and move fauna to crossing structures
- Provide compensatory denning/shelter habitat for hollow-dependent fauna
- Do not contribute to the proliferation of Cane Toad's (*Bufo marinus*) within the region.

6.3 Management measures

6.3.1 Work method statements

Work method statements will be prepared for specific activities (e.g. clearing and grubbing) to ensure sound environmental practices have been implemented and to minimise the risk of environmental incidents or system failures, in accordance with the CEMP. These work method statements will be prepared in accordance with the key commitments and desired outcomes outlined within this TMMP.

Work method statements will be prepared by the construction contractor to address all threatened mammal management requirements related to construction activities as detailed in this TMMP. This will be done in consultation with relevant agencies, Roads and Maritime and the relevant project environmental manager prior to the commencement of identified activities.

General responsibilities for environmental management will be outlined in the CEMP and FFMP.

6.3.2 Construction induction and training

Induction and training will be conducted with all contractors and other staff that would be working in the area of known and potential threatened mammal habitat. This training will highlight to the staff the threatened mammals and their habitats, distribution and key threats, with all personnel shown pictures of the species. The importance of following the clearing, translocation and rehabilitation protocols will be made clear for any personnel that require access to the site.

6.3.3 Fauna rehabilitation protocol

A licensed ecologist will be present on site during all vegetation clearing and habitat removal activities to capture and relocate threatened mammals (and other fauna species) that may be encountered. Identified habitat (such as hollow bearing trees) would be left for at least 48 hours after clearing the non-habitat vegetation to allow fauna to escape. If necessary, fauna may need to be trapped or captured and relocated to pre-determined habitat identified for fauna release. The NSW Code of Practice for Injured, Sick and Orphaned Protected Fauna (OEH 2011) will be followed for trapping and relocating threatened mammals.

All incidences of threatened mammal mortality (resulting from construction activities) will be recorded as well as the number of threatened mammals (and other fauna) injured or relocated. Injured fauna will be transported to the nearest veterinary surgeon or wildlife carer and treated until they regain health (or die) at the cost of the contractor. This will be outlined in the FFMP for the project. The ecologist would manage any injured or displaced fauna with assistance from a wildlife carer or vet for rehabilitating injured wildlife. Organisations such as Wildlife Information Rescue Service (WIRES) and/or Northern Rivers and Clarence Valley Wildlife Carers would be involved in wildlife rehabilitation. The ecologist or wildlife carer would relocate and release displaced fauna upon confirmation of the animal's health. Relocation sites are to be proximate to the individual's original displacement where practicable and data collected about the release location provided to Roads and Maritime.

6.3.4 Pre-clearing surveys

Pre-clearing procedures would be outlined in the CEMP and project specific FFMP, and would be undertaken in accordance with Biodiversity Guidelines: Protecting and managing biodiversity on RTA Projects (RTA 2011), in order to minimise impacts on flora and fauna.

Prior to the commencement of clearing operations, pre-clearance surveys will be undertaken. This consists of an appropriately qualified and experienced ecologist/s surveying the area to be cleared and identifying all exclusion zones where vegetation and habitat is to be retained. In areas of known Long-nosed Potoroo habitat if necessary trapping will be undertaken each night prior to clearing. An experienced ecologist(s) shall set traps targeting Long-nosed Potoroo in areas that are to be cleared the following day. Traps would be checked at first light ahead of any clearing activities occurring with captured animals relocated into adjacent habitat 50 -150m from the clearing boundary. This process would be repeated until all clearing in the Long-nosed Potoroo habitat is completed. Habitat of Long-nosed Potoroo is identified in Appendix G.

6.3.5 Clearing procedures

Clearing procedures would be outlined in the CEMP and project specific FFMP, and would be undertaken in accordance with Biodiversity Guidelines: Protecting and managing biodiversity on RTA Projects (RTA 2011), in order to minimise impacts on flora and fauna.

Clearing of vegetation and habitat features will be undertaken in a two stage process following the completion of pre-clearance surveys. Under scrubbing and the removal of non-habitat trees would be undertaken first. Habitat trees (including hollow-bearing trees) would be removed at least 48 hours after the removal of non-habitat trees, to enable resident hollow-dependent fauna to evacuate the tree prior to felling. An ecologist would be present to supervise the removal of each habitat tree.

If necessary, fauna may need to be trapped and relocated to pre-determined habitat identified for fauna release. The NSW Code of Practice for Injured, Sick and Orphaned Fauna (OEH 2011) would be followed for trapping and relocating threatened mammals.

Where feasible and reasonable, native vegetation forming part of the identified widened medians will not be disturbed for any ancillary construction purpose including access tracks, stockpiles, materials laydown and ancillary facilities as outlined within the 'Ancillary descriptions and impact assessment' and Chapter 4 of the SPIR.

6.3.6 Permanent fauna exclusion fencing

Permanent fauna exclusion fencing will be installed at locations along the carriageway to prevent the movement of ground and arboreal mammals across the carriageway and to funnel mammal movements to a fauna crossing structure. The targeted survey findings have provided further advice for refinement of fauna exclusion fencing locations outlined in the EIS. Design principles and locations for fauna exclusion fencing have been finalised for Sections 1 and 2 of the Project and are summarised in **Table 6-1** of this document, and described in more detail in Section 7.2 of the Fauna Connectivity Strategy. **Table 6-2** details proposed fencing locations for Sections 3 – 11 taking into consideration results of pre-construction baseline surveys including for the Potoroo in Sections 6, 7 and 10. However further refinement of fencing design for these sections will be made during finalisation of the Fauna Connectivity Strategy for Sections 3 -11 as fencing will need to be evaluated for all fauna species requirements.

Fauna exclusion fencing for threatened mammals the subject of this TMMP includes:

- Construction of fencing on both sides of the carriageway and generally extending at least 200 metres either side of a designated crossing structure
- Fencing either side of the crossing structure will have a 'return area' at their ends to guide animals back into habitat rather than across the carriageway
- Perpendicular fencing in widened medians to direct fauna across the median and to ensure that fauna do not colonise habitat within the median, or turn back onto the road
- Mesh size selected to prevent the target species from climbing through, with four different types of fencing being implemented, as outlined for Sections 1 and 2 in Table 51 of the Final Fauna Connectivity Strategy (GHD, 2015)
- Fence design to prevent fauna from digging underneath, or passing through points where fencing crosses drainage lines; and
- The consideration of appropriate additional fauna exclusion fencing should hot spots (areas where incidental observations or road kills of threatened mammals are noted during the construction) are noted.

Arboreal mammal fences would need to be designed to prevent animals from climbing over, with the addition of a barrier in Sections 1-3 and 6-8 of the project for the Brush-tailed Phascogale.

Sections 1 and 2 of the project total approximately 28.5 km in length, with approximately 26 km of this being subject to dedicated fauna exclusion fencing deemed appropriate for the habitat type adjacent to the Project. Most sections which will remain unfenced are larger interchange areas, agricultural areas or urban fringes. Fauna fencing will be installed on the outside edge of the on-load and off-load ramps where interchanges are located within the locations nominated in **Table 6.1** and **Table 6.2**.

The total lengths of the different fauna fencing types that will be installed for Section 1 and 2 are as follows:

- F1 (general fauna fence): 20440 metres
- F2 (combined general fauna fence/frog fence): 4890 metres
- F3 (combined general fauna fence/frog/phascogale fence): 630 metres
- F4 (combined general fauna fence/boundary fence): 80 metres
- Stock fence: 1520 metres.

Fauna fencing has been designed with input from the various fauna specialists involved in the project and installed at specific locations along the alignment as outlined in **Table 6-1** and **Table 6-2**. Fauna fencing proposed for Sections 3-11 has incorporated specific Brush-tailed Phascogale fencing where populations have been noted as this fencing type requires extra specifications to be incorporated. It is also likely that fencing will be required on both sides of the carriageway.

Areas of general fauna fencing envelope Brush-tail Phascogale fencing in some areas, and are suitable for mitigation of other threatened mammal species including the Long-nosed Potoroo. It should be noted the fencing proposed is targeted at threatened mammal species only and additional fencing may be required for other species addressed in separate management plans.

Table 6-1 Fencing types and locations for Sections 1 & 2

Chainage	Western side	Eastern Side	Comment
140		Ties into existing Woolgoolga to Sapphire upgrade	
140-2900	F1	F1	
2900-4420 (4480)	Stock fence	Stock fence (to 4480)	Corindi Creek floodplain
4420-7600	F1	F1	
7600-7900 (western side) 7700-8040 (eastern site)	No fence	No fence (7700-8040)	Steep batters/cliffs
7900 (8040)-12290	F1	F1	
12290-13400	F2	F2	
13400-13700	F1	F1	
13700-17020			Ties into existing fencing (Halfway Creek upgrade)
17020-19010	F1	F1	
19010-19940	F2	F2	
19940-20800	F1	F1	The Section 2 re-use area will also include fauna fencing on the western side of the existing north-bound carriageway. Fencing will be installed for about 250m either side of the crossing structure. Fence type would match that installed on the upgraded highway.
20800-20880	F1	F4	
20880-24520	F1	F1	
24520-24740	F3	F3	
24740-25460	F2	F2	
25460-25560	F3	F3	
25560-25820	F2	F2	
25820-26000	F3	F3	
26000-26350	F2	F2	
26350-26420	F3	F3	
26420-27380	F2	F2	
27380-27440	F3	F3	
27440-28000 (27960)	F2	F2	
28000-31240 (western side) 27960-27420 (eastern side)	F1	F1	

Table 6-2 Proposed indicative fencing locations for Sections 3 – 11

Chainage	Fencing Type	Comment
35000 - 82000	General fauna fencing where specific species fencing is not proposed (F1)	Glenugie Creek and Pheasant Creek
35000-40000	Brush-tail Phascogale (F3)	Known habitat for Phascogale throughout this extent including areas with more sparse tree cover. Extent has four combined crossing structures identified, two of these (35230; 37320) forming impact treatments in the Phascogale monitoring program. As a minimum, Phascogale fencing extents should be installed for 250 m either side of each combined crossing structures or any other suitable crossing point within this area.
47800-52300	Brush-tail Phascogale (F3)	Known habitat for Phascogale throughout entire extent.
53500-56300	Brush-tail Phascogale (F3)	Known habitat for Phascogale throughout entire extent.
58000-61000	Brush-tail Phascogale (F3)	Known habitat for Phascogale throughout entire extent.
63000-66700	Brush-tail Phascogale (F3)	Known habitat for Phascogale throughout entire extent. Extent has two combined and one dedicated crossing structure identified with one of these (64505) forming an impact treatment in the Phascogale monitoring program.
82500 - 85100	General fauna fencing where specific species fencing is not proposed (F1)	Yaegl Nature Reserve
97900 - 101300	General fauna fencing where specific species fencing is not proposed (F1)	Bundjalung NP and Mororo State Forest Includes suitable Long-nosed Potoroo habitat.
98000-102000	Brush-tail Phascogale (F3)	Suitable habitat for Phascogale throughout entire extent. Includes suitable Long-nosed Potoroo habitat.

101300 - 101900	General fauna fencing where specific species fencing is not proposed (F1)	Local corridor connects Bundjalung NP *Noting that no Long-nosed Potoroo have been recorded on the western side of the existing carriageway during the baseline surveys.
111000-118000	Brush-tail Phascogale (F3)	Suitable habitat for Phascogale throughout entire extent. Includes suitable Long-nosed Potoroo habitat.
111600 - 128400	General fauna fencing where specific species fencing is not proposed (F1)	Double Duke SF to Tabbimoble Swamp NR Includes suitable Long-nosed Potoroo habitat.
115300-117000	General fauna fencing where specific species fencing is not proposed (F1)	Install both sides with underpass to be considered at ch. 115750 (±100m) for Long-nosed Potoroo.
122200-122600	Brush-tail Phascogale (F3)	Habitat through the broader area is suitable Phascogale habitat. This area is the only location where a combined or other suitable structure is currently proposed.
123800-124200	Brush-tail Phascogale (F3)	Habitat through the broader area is suitable Phascogale habitat. This area is the only location where a combined or other suitable structure is currently proposed.
127000-129000	Brush-tail Phascogale (F3)	Historic records of Phascogale in this area and the habitat is suitable.
137800 - 141000	General fauna fencing where specific species fencing is not proposed (F1)	Broadwater National Park Includes suitable Long-nosed Potoroo habitat.
142800 - 145120	General fauna fencing where specific species fencing is not proposed (F1)	Local corridor connects Broadwater National Park to floodplain habitats
146100 - 159700	General fauna fencing where specific species fencing is not proposed (F1)	Koala fence in regional link across Richmond River and CC assemblage. Links two key habitats. Includes suitable Long-nosed Potoroo habitat.

Note: Fencing for Sections 3-11 is likely to be on both sides of the highway at most of the proposed chainages. The specifications of the fence at each of these locations will be outlined in the Fauna Connectivity Strategy (Sections 3-11) to be prepared. The fencing locations will be finalised and approved in accordance with MCoA Condition D2.

6.3.7 Fauna connectivity structures

Fauna connectivity structures would be provided to maintain existing levels of landscape connectivity for threatened mammals likely to move between habitat areas on the eastern and western sides of the project. Fauna crossings have been positioned to target known populations of the key species and at appropriate frequencies to account for species distribution, movement patterns and behavioural ecology. Connectivity structures for threatened ground and arboreal mammals include:

- Underpasses (bridges and culverts) – Rufous Bettong, Spotted-tailed Quoll, Long-nosed Potoroo, Brush-tailed Phascogale
- Overpasses (land bridges) – Rufous Bettong, Spotted-tailed Quoll, Long-nosed Potoroo, Brush-tailed Phascogale
- Canopy (rope) bridges – Brush-tailed Phascogale
- Widened medians – Rufous Bettong, Spotted-tailed Quoll and Long-nosed Potoroo. Brush-tailed Phascogale; and
- Fauna exclusion fencing – Rufous Bettong, Spotted-tailed Quoll, Long-nosed Potoroo, Brush-tailed Phascogale.

Final locations and types of connectivity structures for Sections 1 and 2 have been determined as a result of refining the draft connectivity strategy, results of further field surveys and stakeholder workshops and meetings. These are detailed in the Fauna Connectivity Strategy (GHD 2014). Connectivity structures that will be constructed as part of the highway upgrade for Sections 1 and 2 comprise the following:

- Bridges with fauna passage beneath and retained along river banks
- Combined drainage / fauna passage culverts in wet areas
- Dedicated fauna underpasses in dry sclerophyll forest and swamp forest
- Arboreal crossings targeting Brush-tailed Phascogale
- Widened medians.

Both dedicated and combined fauna connectivity structures which have been designed specifically for threatened mammals are summarised in **Table 6-3** and **Table 6-4**. This table does not include all structures targeted for the koala or threatened gliders which are outlined in the Koala Management Plan and Threatened Glider Management Plan. The design principles for fauna connectivity structures were developed in consultation with EPA and designed specifically for this project as detailed in the EIS.

Those connectivity structures presented for Sections 1 and 2 are final. The remaining are still being finalised as part of detailed design and to ensure that results of supplementary targeted surveys are considered. For the purposes of this TMMP update, fauna crossing structures for Sections 3-11 are proposed and based on documentation as part of the SPIR with further refinements taking into consideration results of pre-construction baseline surveys. For example based on recommendations from recent Potoroo surveys RMS will investigate further opportunities to include a Potoroo fauna connectivity structure near 115.750 (±100 m) during detailed design.
The information is current as of 3 July 2015.

Fauna furniture will be placed within dedicated underpasses or crossing structures, including interconnecting logs to provide a dry passage for threatened mammals whilst also providing refuge from predators. With regard to combined structures fauna furniture will be installed at these locations where it will not impact on flooding/hydrological issues. The details of which combined structures will have fauna furniture will be detailed in the Connectivity Strategy required under CoA D2. Refuge poles outside and within the culvert will also be installed to provide refuge from predators for the Brush-tailed Phascogale. A detailed design and furniture association for each crossing type for Section 1 and 2 of the project is outlined within Section 5.3 of the Fauna Connectivity Strategy. Further refinement of detailed design and furniture association for Sections 3 – 11 will be defined and updated within ongoing revisions of the Fauna Connectivity Strategy.

Table 6-3 Finalised fauna crossing structures for threatened mammals – Sections 1 & 2

Project Section	Chainage	Connectivity structure	Functionality	Target species
1	1860	Rope Bridge	Rope bridge	Brush-tailed Phascogale
1	2000	Culvert (3x3mx3m) – 45m	Combined	Small – medium mammals
1	3600	Bridge (90m), with 3m wide dry passage at each abutment	Bridge – Combined	Small – large mammals
1	4150	Bridge (300m) across sparsely vegetated floodplain	Bridge – Combined	Rufus Bettong, Small – large mammals
1	4750	Bridge (75.5m) dry fauna passage provided	Bridge – Combined	Small – medium mammals
1	6170	Bridge (64m) with dry passage for access road	Bridge - Combined	Rufous Bettong, Spotted-tailed Quoll
1	6890	Culvert (1x3mx3m) – 45m	Dedicated	Rufous Bettong, Spotted-tailed Quoll
1	7110	Rope bridge	Rope bridge	Brush-tailed Phascogale
1	7280	Culvert (1x3mx3m) – 80m	Combined	Rufous Bettong, Spotted-tailed Quoll
1	8470	Culvert (1x3mx3m) – 51m	Dedicated	Rufous Bettong, Spotted-tailed Quoll
1	8800	Culvert (1x3mx3m) – 50m	Dedicated	Rufous Bettong, Spotted-tailed Quoll
1	10340	Culvert (1x3mx2.7m) – 69m	Combined	Rufous Bettong, Spotted-tailed Quoll
1	10750	Culvert (2x3mx3m) – 62m	Combined	Rufous Bettong, Spotted-tailed Quoll
1	11710	Culvert (1x3mx3m) – 57m	Dedicated	Rufous Bettong, Spotted-tailed Quoll
1	12420	Culvert (1x3mx3m) – 52m	Dedicated	Koala, Spotted-tailed Quoll
1	12880	Culvert (1x3mx3m) – 54m	Combined	Rufous Bettong, Spotted-tailed Quoll, Common Planigale

Project Section	Chainage	Connectivity structure	Functionality	Target species
1	13040	Rope bridge	Rope Bridge	Brush-tailed Phascogale
1	13310	Culvert (2x3.6mx3.3m) Highway – 66m	Combined	Rufous Bettong, Spotted-tailed Quoll, Common Planigale
1	13310	Culvert (2x3.6mx3.3m) side road – 27m	Combined	Rufous Bettong, Spotted-tailed Quoll, Common Planigale
1	13800	Culvert (1x3mx3m) – 49m	Combined	Rufous Bettong, Spotted-tailed Quoll, Common Planigale
1	14280	Culvert (1x3mx3m) – 71	Combined	Rufous Bettong, Spotted-tailed Quoll, Common Planigale
2	17710	Culvert (1x3mx2.4m) – 57m	Dedicated	Rufous Bettong, Brush-tailed Phascogale
2	18120	Culvert (2x2.7mx2.1m) – 79m	Combined	Rufous Bettong, Brush-tailed Phascogale
2	19180	Culvert (1x3mx3m) – 59m	Combined	Rufous Bettong, Brush-tailed Phascogale
2	19880	Culvert (1x3mx3m)- 34m	Dedicated	Rufous Bettong, Brush-tailed Phascogale
2	20650	Culvert (4x3.6mx2.4m) – 64m	Combined	Rufous Bettong, Brush-tailed Phascogale
2	20780	Bridge (57m) with dry passage	Bridge – Combined	Rufous Bettong, Brush-tailed Phascogale
2	20880	Culvert (1x3mx3m) – 66.4m	Combined	Rufous Bettong, Brush-tailed Phascogale
2	21290	Culvert (1x3mx3m) – 46.7m	Combined	Rufous Bettong, Brush-tailed Phascogale
2	22400	Bridge (77.5m) with dry passage	Bridge - Combined	Rufous Bettong, Brush-tailed Phascogale
2	23130	Widened median underpass culvert (1x3mx2.4m) – 22m	Dedicated	Rufous Bettong, Brush-tailed Phascogale
2	23131	Widened median underpass culvert (1x3mx2.4m) – 22m	Dedicated	Rufous Bettong, Brush-tailed Phascogale
2	23750	Culvert (1x3mx2.7m) – 43m	Dedicated	Rufous Bettong, Brush-tailed Phascogale
2	24580	Rope bridge – 64m	Arboreal	Brush-tailed Phascogale
2	24570	Culvert (1x3mx3m) – 42m	Combined	Rufous Bettong, Brush-tailed Phascogale
2	25850	Culvert (1x3mx3m) – 45m	Dedicated	Rufous Bettong, Brush-tailed Phascogale
2	27420	Culvert (1x3.6mx3m) – 60m	Combined	Rufous Bettong, Brush-tailed Phascogale
2	29300	Culvert (1x2.4mx2.4m) – 25m	Dedicated	Rufous Bettong, Brush-tailed Phascogale
2	29360	9x3m Bebo Arch – 26m	Combined	Rufous Bettong, Brush-tailed Phascogale

Table 6-4 Proposed indicative fauna crossing structures for threatened mammals – Sections 3 to 11*

Project Section	Indicative Chainage	Connectivity structure	Functionality	Target species	Adjacent habitat/s
3	35.211	RCBC (box culvert 2 x 2.4 x2.4. 58m in length) linked with fauna fencing from 35000 to 80200	Underpass – combined	Rufous Bettong, Brush-tailed Phascogale	Glenugie State Forest, Dry open sclerophyll

Project Section	Indicative Chainage	Connectivity structure	Functionality	Target species	Adjacent habitat/s
3	36.379	Bridge 3.6m height x 34.5m length)	Under bridge – combined	Rufous Bettong, Brush-tailed Phascogale	Glenugie Creek and Pheasant Creek, Dry open sclerophyll
3	37.301	RCBC (box culvert 2.4 x 2.4 x 47m) linked with fauna fencing 35000 to 80200	Underpass – combined	Rufous Bettong Brush-tailed Phascogale	Glenugie Creek and Pheasant Creek, Dry open sclerophyll
3	39.671	RCBC (box culvert 3.0 1.2 x 11m) linked with fauna fencing from 35000 to 80200	Underpass – combined	Rufous Bettong, Brush-tailed Phascogale	- Dry open sclerophyll
3	42.522	Bridge (135.5 x 10.5m)	Twin bridges – Under bridge – combined (Emu)	Medium to large mammals including Rufous Bettong,	Coldstream wetlands
3	43.102	Bridge 3.6m height x 31m length	Twin bridges – Under bridge – combined (Emu)	Medium to large mammals including Rufous Bettong,	Coldstream wetlands
3	43.887	Bridge 3.6m height x 31m length	Twin bridges – Under bridge – combined (Emu)	Medium to large mammals including Rufous Bettong,	Coldstream wetlands
3	46.055	Bridge 3.6m height x 31m length	Underpass – combined (Emu)	Medium to large mammals including Rufous Bettong,	Coldstream wetlands to Yuraygir NP
3	46.325	Bridge 3.6m height x 31m length	Underpass – combined (Emu)	Medium to large mammals including Rufous Bettong,	Coldstream wetlands to Yuraygir NP
3	46.647	Bridge 3.6m height x 31m length	Underpass – combined (Emu)	Medium to large mammals	Coldstream wetlands to Yuraygir NP
3	47.181	RCBC (box culvert 3.6 x 3.6 x 50m)	Underpass – combined (Emu)	Medium to large mammals including Rufous Bettong,	-
3	47.643	Bridge 3.6m height x 31m length	Twin Bridges – Under bridge – combined (Emu)	Medium to large mammals including Rufous Bettong,	
3	48.081	Rope crossing (length 65m)	Dedicated fauna crossing for arboreal mammals	Brush-tailed Phascogale	Dry open sclerophyll forest on sand
3	48.742	Bridge 4.6m height x 31m length	Dual Bridges – Under Bridge – combined (Emu)	Medium to large mammals including Rufous Bettong,	Clarence floodplain wetlands to Yuragir NP
3	49.246	Bridge 3.6m height x 31m length	Dual Bridges – Under bridge – combined (Emu)	Medium to large mammals including Rufous Bettong,	Clarence floodplain wetlands to Yuraygir NP
3	50.280	Bridge 3.6m height x 32m length	Twin Bridges – Under bridge – combined (Emu)	Medium to large mammals including Rufous Bettong,	Clarence floodplain wetlands to Yuraygir NP
3	50.481	Rope crossing (length 65m)	Dedicated fauna crossing for arboreal mammals	Brush-tailed Phascogale	Dry open sclerophyll forest on sand
3	51.419	RCBC (box culvert 2 x3.6 x 3.6 x 48m) linked with fauna fencing from 35000 to 80199	Underpass – combined (Emu)	Medium to large mammals including Rufous Bettong,	Clarence floodplain wetlands to Yuraygir NP
3	51.854	Bridge 5.3m height x 61m length	Bridge Firth Heinz Road– combined over bridge (Emu)	Incidental	Clarence floodplain wetlands to Yuraygir NP
3	52.427	Bridge 3.6m height x 31m length	Under Bridge – combined (Emu)	Medium to large mammals including Rufous Bettong	Clarence floodplain wetlands to Yuraygir NP
3	52.594	RCBC (box culvert 3.6 x 2.1 x 60m) linked with fauna fencing	Underpass – combined (Emu)	small to medium mammals including Rufous Bettong	Chaffin Swamp to Chaffin Hill
3	53.699	Bridge structure 3.6m in height x 31m length)	Underpass bridge – combined (Emu)	-	Chaffin Swamp to Chaffin Hill
3	53.839	Rope crossing (length 65m)	Dedicated fauna crossing for arboreal mammals	Brush-tailed Phascogale	Dry open sclerophyll forest on sand
3	54.695	Bridge 3.6m height x 31m length	Underpass – combined (Emu)	Medium to large mammals including Rufous Bettong,	Clarence floodplain wetlands to Yuraygir NP
3	55.486	Bridge 5.3 height x 61m length	Bridge –Bostock Rd overpass (Emu)	Incidental	Clarence floodplain wetlands to Yuraygir NP

Project Section	Indicative Chainage	Connectivity structure	Functionality	Target species	Adjacent habitat/s
3	56.885	Bridge 5.3 height x 31 length	Dual Bridges – Under Bridge – combined (Emu)	Medium to large mammals including Rufous Bettong	Clarence floodplain wetlands to Yuraygir NP
3	57.014	Bridge 5.0 height x 31 length	Twin Bridge – Under Bridge – combined (Emu)	Medium to large mammals including Rufous Bettong,	Clarence floodplain wetlands to Yuraygir NP
3	58.626	Bridge 5.3 height x31m length)	Under Bridge – combined (Emu)	Medium to large mammals including Rufous Bettong, Brush-tailed Phascogale	Clarence floodplain wetlands to Yuraygir NP
3	59.272	Bridge 3.6m height x 31m length	Dedicated (Emu)- Under bridge	Medium to large mammals including Rufous Bettong, Brush-tailed Phascogale	Clarence floodplain wetlands to Yuraygir NP
3	60.802	Bridge 3.6m in height x 31m length	Dedicated (Emu)- Under bridge	Medium to large mammals including Rufous Bettong, Brush-tailed Phascogale	Clarence floodplain wetlands to Yuraygir NP
3	61.033	Bridge 4.6m height x 29m length	Underpass – combined property access (Emu)	Medium to large mammals including Rufous Bettong,	Clarence floodplain wetlands to Yuraygir NP
3	63.634	Bridge 5.3m height x 101m length	Combined property access (Emu)- Incidental	Incidental	Clarence floodplain wetlands to Yuraygir NP
3	64.492	RCBC (3 x 3m and 55m in length)	Combined (Emu) – Drainage	Medium to large mammals including Rufous Bettong, Brush-tailed Phascogale	Clarence floodplain wetlands to Yuraygir NP
3	64.911	Bridge 3.6m height x 61m length	Crowleys Rd Combined overpass (Emu). Incidental	Incidental	Clarence floodplain wetlands to Yuraygir NP
3	66.190	RCBC (3 x 3m and 60m in length	Dedicated Underpass	Medium to large mammals including Rufous Bettong	Clarence floodplain wetlands to Yuraygir NP
4	70.455	Bridge 3.6m in height x 31m length	Underpass – combined (Emu)	-	-
4	74.755	Bridge (448.6 x 10.5m)	Underpass – combined (Emu)	Medium to large mammals including Rufous Bettong	-
4	76.450	RCBC 2x2.4x2.4x60 in length	Combined drainage	Medium to large mammals	- Dry open sclerophyll forest
4	75.880	Rope crossing (length	Dedicated fauna crossing for arboreal mammals	Brush-tailed Phascogale	Local corridor
4	76.450	RCBC (box culvert 2.4 x 2.4 60m)	Underpass – combined	Small to medium mammals	-
5	83.100	Bridge(30 x 15.8m NB and 12.8m SB)	Underpass – combined	Small to medium mammals	Yaegl Nature Reserve
5	93.990	Bridge(216.6 x 10.5m)	Underpass – combined		Major fish habitat
5	96.150	RCBC 1x2.4x2.4 <50m in length	Dedicated underpass	Koala and small to medium animals	Link important koala habitat – Moro NR (west) and koala habitat to east
6	99.730	RCBC (box culvert 3.0 x 2.4 x 44m)	Underpass – dedicated	Small to medium mammals	Bundjalung NP and Mororo State Forest
6	100.640	RCBC (box culvert 2.4 x 1.8 x 71m) linked with fauna fencing from Fencing from 97900 to 101300	Underpass – combined	Small to medium mammals	Bundjalung NP and Mororo State Forest
6	101.100	RCBC (box culvert 3.0 x 2.4 x 38m) linked with fauna fencing	Underpass – dedicated	-	-
6	101.541	Bridge(132 x 10.5m)	Underpass – combined	Small to medium mammals	Local corridor connects Bundjalung NP
7	113.920	Bridge(15 x 11m)	Underpass – combined	Small to medium mammals including the Long-nosed Potoroo	-

Project Section	Indicative Chainage	Connectivity structure	Functionality	Target species	Adjacent habitat/s
7	116.400	Rope – 65m length	Arboreal rope crossing	Brush-tailed Phascogale	Double Duke SF to Tabbimoble Swamp NR
7	115.272	Bridge (88 x 10.5m)	Underpass – combined	Small to medium mammals including the Long-nosed Potoroo	Double Duke SF to Tabbimoble Swamp NR
7	115.750 (±100 m)	tbd	Dedicated fauna crossing	Long-nosed Potoroo	Double Duke SF to Tabbimoble Swamp NR
7	116.400	Rope crossing (length 65 m)	Dedicated fauna crossing for arboreal mammals	Brush-tailed Phascogale	Double Duke SF to Tabbimoble Swamp NR
7	118.500.	Bridge – 2.0 height x 20 length	Dedicated fauna crossing structure	Spotted-tailed Quoll, Brush-tailed Phascogale, Long-nosed Potoroo (small, medium & large mammals)	Double Duke SF to Tabbimoble Swamp NR
7	122.550	RCBC (box culvert 3 x 2.4 x 50m) linked with fauna fencing from 111600 to 128400	Underpass – combined	Small to medium mammals	Local corridor
7	123.590	RCBC (box culvert 3 x 2.4 x55m) linked with fauna fencing from 111600 to 128399	Underpass – combined	Small to medium mammals	Local corridor and key fish habitat
8	130.107	Bridge (150.5 x 12.5 NB and 150.5 x 10.5 SB)	Underpass – combined	Macropods	Floodplain grasslands
8	134.600	Bridge 2.4m height x 20m length	Underpass- combined drainage	Bridge for Oxylean Pygmy Perch but suitable for use by koalas other small to medium mammals	Swamp Sclerophyll forest to east
8	135.575	Bridge 1.2m height x 15m length	Underpass- combined drainage	Bridge for Oxylean Pygmy Perch but suitable for incidental use by koalas other small to medium mammals	Currently cleared cane land
8	136.700	Bridge 2.4m height x 20m length	Underpass- combined drainage	Bridge for Oxylean Pygmy Perch but suitable for use by koalas other small to medium mammals	Links areas of koala habitat (Subtropical Coastal Floodplain Forest)
8	137.300	RCBC 2.4x2.4 x <40m length	Underpass- combined drainage	Small to medium mammals	Links Swamp Sclerophyll forest
9	138.430	RCBC (box culvert 1.2 x 1.2 x 85m) linked with fauna fencing from 137800 to 141000	Underpass – incidental	Small mammals	Broadwater National Park
9	138.796	Bridge 4.6m height 35m length	Underpass – dedicated	Koala and small l to large mammals	Broadwater National Park
9	139.440	RCBC (culvert)	Underpass – dedicated	Small mammals	Broadwater National Park
9	140.520	RCBC 2.4x2.4m x < 40m length	Underpass- dedicated	Koala small to medium mammals	Broadwater National Park
9	140.620	Rope crossing	Dedicated fauna crossing for arboreal mammals	Brush-tailed Phascogale and gliders	Broadwater National Park
9	143.790	RCBC (box culvert 3.6 x 1.2 x 52m) with fauna fencing from142800 to 145119	Underpass – combined	Koala small to medium mammals	Local corridor connects Broadwater National Park to floodplain habitats
9	141.120	Bridge 1.5m height x20m length	Underpass combined drainage	Bridge for Oxylean Pygmy Perch but suitable for use by koalas other small to medium mammals	Links Swamp Oak Forest on Coastal Floodplains and Freshwater wetlands

Project Section	Indicative Chainage	Connectivity structure	Functionality	Target species	Adjacent habitat/s
9	142.220	RCBC 2.4x2.4m	Underpass combined drainage	Small to medium mammals	-
9	143.420	RCBC 2.4x2.4m	Underpass combined drainage	Small to medium mammals	Linking area of koala habitat
9	142.620	2 x RCBC 2.4x2.4m Under Macdonald Street (Interchange)	Dedicated Underpass	Small to medium mammals	Linking area of koala habitat under interchange service road
9	143.420	RCBC 2 x 2.4x2.4m <40m length	Underpass combined	Small to medium mammals	Linking area of koala habitat
9	143.720	RCBC 3.6x1.2m <40m length	Underpass – incidental	Small mammals	Linking area of koala habitat
9	144.280	RCBC (box culvert 3 x 3 m linked with fauna fencing	Dedicated structure added for koala, however potential for other threatened fauna including Brush-tailed Phascogale	Brush-tailed Phascogale and Koala	Local corridor connects Broadwater National Park to floodplain habitats
9	144.700	RCBC (box culvert 3 x 3 x 48 m) linked with fauna fencing	Dedicated structure added for koala, however potential for other threatened mammals	Brush-tailed Phascogale and Koala	Local corridor connects Broadwater National Park to floodplain habitats
10	145.106	Bridge (viaduct 75.5 x 10.5m NB and 75.5 x 10.5-12.5m SB)	Underpass – incidental	-	Floodplain grasslands/caneland
10	146.050	Bridge (789.9 x 11.5m)	Underpass – combined	- Small to large mammals including Koala	Regional link across Richmond River, CC assemblage. Links two key habitats
10	146.220	RCBC 3x3m <50m length	Underpass- dedicated	small to large mammals including koala	Koala habitat- . Links two key habitats
10	146.400	RCBC 3x3m <50m length	Underpass – combined	Small to large mammals including the Long-nosed Potoroo and Koala	Koala and Long-nosed Potoroo habitat- . Links two key habitats
10	146.650	Bridge minimum 15m plank length	Underpass -combined structure added for koala,	Small to medium mammals including the Long-nosed Potoroo and Koala	Koala and Long-nosed Potoroo habitat- . Links two key habitats
10	146.800.	Bridge minimum 15m plank length	Underpass- combined structure added for koala,	Small to medium mammals including the Long-nosed Potoroo and Koala	Koala and Long-nosed Potoroo habitat- . Links two key habitats
10	147.100	RCBC 3.2x2.4m height)	Underpass- dedicated	Small to medium mammals including the Long-nosed Potoroo and Koala	Link revegetation area
10	148.600	RCBC 3.0x3.0 < 50m length	Underpass -combined	Small to medium mammals including the Long-nosed Potoroo and Koala	Link revegetation area
10	149.227	Bridge Bingle Creek-minimum height 1.8m	Underpass – incidental	Small to medium mammals	Cleared land
10	150.030	Bridge minimum 15m plank length	Underpass- combined structure added for koala,	Small to medium mammals including the Koala and Long-nosed Potoroo	Fish habitat waterways. Links two regional corridors
10	150.530	RCBC 2.4x2.4m <45m length	Underpass – dedicated	Small to medium mammals including the Koala	Fish habitat waterways. Links two regional corridors
10	150.580	Bridge minimum 15m plank length	Underpass- combined structure added for koala,	Small to medium mammals including the Koala	Fish habitat waterways. Links two regional corridors
10	151.170	RCBC 2.4x2.4m	Underpass- dedicated	Small to medium mammals including the Koala	Links two regional corridors

Project Section	Indicative Chainage	Connectivity structure	Functionality	Target species	Adjacent habitat/s
10	151.933	Wardell Viaduct 6 (twin bridges 18.0 x 11.0m x 2.4m height	Underpass – combined	Macropods and small to medium mammals including the Koala	Grasslands and links two regional corridors
10	152.860	2 x RCBC 2.4 height under Wardell Rd east and west of new alignment	Underpass- dedicated	Koala	Linking koala habitat north and south of Wardell road
10	153.050	2 x RCBC 3x3m <50m length	Underpass- combined	Koala	Linking koala habitat
10	153.600	RCBC 3x3m <50 length	Underpass- combined	Koala	Linking revegetation area for koalas
10	153.690	3 x RCBC 3.0x1.8m	Underpass- combined	Koala	Linking revegetation area for koalas
10	153.880	Bridge minimum 15m plank length	Underpass- dedicated	Koala	Linking revegetation area for koalas
10	154.030	Bridge minimum 15m plank length	Underpass- combined structure added for Koala	Koala	Linking revegetation area for koalas
10	154.630	RCBC 2.4x2.4m	Underpass- dedicated	Koala	Linking revegetation area for koalas
10	155.230	RCBC 2.4x2.4m	Underpass -dedicated	Koala	Linking revegetation area for koalas
10	155.900	RCBC 2.4x2.4m	Underpass- dedicated	Long-nosed Potoroo and other small to medium sized mammals	Linking Lowland Rainforest habitat
10	156.260	RCBC 4x 3.3mx2.4m	Underpass – combined	Long-nosed Potoroo	Wardell Heath and link revegetation area
10	156.910	RCBC 2 x 2.4mx2.4m	Underpass – combined	Long-nosed Potoroo and Koala	Wardell Heath
10	157.200	RCBC 2 x 2.4mx2.4m	Underpass – combined	Long-nosed Potoroo, Koala and small to medium mammals	Linking Lowland Rainforest and Koala Habitat
10	157.740	RCBC 2 x 2.4mx2.4m	Underpass – combined	Koala and small to medium mammals	Linking Lowland Rainforest and Koala Habitat
10	157.870	Bridge 18m span 2.4m height	Bridge -underpass – combined	Koala and small to medium mammals	Linking Lowland Rainforest and Koala Habitat. Also local corridor connects Richmond River to Uralba Nature Reserve
11	158.850	RCBC 2.4mx2.4m	Underpass combined	Koala and small to medium mammals	-Linking koala habitat. Also local corridor connects Richmond River to Uralba Nature Reserve.
11	158.903	RCBC (box culvert 3.6 x 1.8 x 25m)	Underpass – drainage. Needs to have raised cells to maintain fauna passage	Small to medium mammals	Local corridor connects Richmond River to Uralba Nature Reserve
11	159.644	RCBC (3.6 x 1.2m)	Combined Drainage – raised cells to maintain fauna passage	Small to medium mammals	Local corridor connects Richmond River to Uralba Nature Reserve
11	164.694	Land bridge (221.9 x 12.5m)	Under Bridge	Small to medium mammals	Local riparian corridor
+NOTE:					

*Note: The proposed structures detailed in Table 6-4 are based on concept design and are subject to review during the detailed design process. Final locations of structures will be detailed in the Connectivity Strategy(s) prepared for Sections 3-11 of the project.

6.3.8 Habitat revegetation

An Urban Design and Landscape Plan (UDLP) will be prepared for each stage of the project. The UDLP will provide specific details regarding the location for re-establishment of native vegetation on batters, cut faces, surrounding sediment basins and other areas disturbed during construction including approaches to fauna connectivity structures and riparian corridors. Methods for topsoiling, seeding and planting will be in accordance with the Biodiversity Guidelines: Protecting and managing biodiversity on RTA Projects (RTA 2011) and Specifications R178 Vegetation and R179 Landscape Planting.

The UDLP provides for a combination of landscape techniques to provide the best suited revegetation response based on the intrinsic characteristics of the landscape and to allow for contingencies should seasonal or other constraints impact the success of any one technique.

Disturbed known and potential habitat areas within the project would be revegetated progressively through and at the end of the construction period. Details on monitoring the performance of the revegetation, as well as, corrective actions to be implemented in instances of change from performance measures are provided in **Section 8**.

Revegetation around the potential dedicated overpasses (e.g. Tabbimoble Nature Reserve Fauna Bridge, Broadwater National Park Fauna Bridges 1 and 2 and north and south Wardell Fauna Bridge) would be planted with appropriate native vegetation from adjacent areas and habitat features to encourage the threatened species to utilise these structures. Details on the plantings must be documented in the UDLP. Usage of the dedicated fauna bridges will be enhanced through the identification of landscape connections that, along with fauna bridges, will be planted with appropriate native species that provide habitat for threatened mammals in those areas and species consistent with that of the adjacent habitat (while complying with the Koala Management Plan and Threatened Glider Management Plan) to provide habitat linkage across the structures.

Appropriate native species would also be used in revegetation for enhancing landscape connections by revegetating areas that connect to culverts and combined underpasses. The revegetation of riparian corridors impacted by construction of combined underpasses (i.e. culverts and bridges) will also occur.

Strategic revegetation would be undertaken to enhance connectivity through revegetation of lands within the road reserve and completed ancillary areas (where owned by Roads and Maritime). Priority for this road reserve revegetation should be given to:

- Local or regional fauna corridors, SEPP 14 wetlands and environmental protection zones, particularly where these might provide seasonal foraging resources
- Habitat for important populations
- Areas that have been identified to have road kills of threatened mammal species
- Cleared landscapes with limited connectivity, aiming to link current isolated patches with potential habitat for threatened mammals.

6.3.9 Hydrology and water quality

To manage potential impacts associated with water quality, erosion and sediment; management considerations have been incorporated into the project design and will be further detailed in the CEMP. These designs have taken into account the guidelines, principles and design standards as defined in *Managing urban stormwater: soils and construction volume 1* (Landcom, 2004), and *Managing urban stormwater: soils and construction – main road construction (*DECC, 2008). These documents describe RMS's commitment on how soils and water quality are to be managed during road construction, and during the ongoing operation of the NSW state road network, so as to prevent environmental pollution.

The key surface water quality objective of the project is to protect downstream environments from the potential impacts associated with surface runoff during the construction and operational phases of the project (RMS, Aurecon, SKM, 2012c:58). Similarly, the key groundwater objectives of the project are to protect environmental receivers of groundwater flows, and groundwater users from the potential impacts on groundwater levels and quality during the construction and operational phases of the project (RMS, Aurecon, SKM, 2012d:10).

The W2B Water Quality Management Program (WQMP) will play a crucial role in ensuring construction and operation of the W2G project does not have a negative impact on sensitive receiving environments, particularly those environments that provide important habitat to threatened frog species. The key mitigation measures during construction will be sediment basins and additional erosion and sediment controls to intercept run-off and retain the associated sediments and pollutants. Maintenance and monitoring of these measures by the Contractor will form a key component of the mitigation measures as per Section 8 of the WQMP.

During operation, permanent water quality management and protection measures will be installed to protect adjacent waterways from pollutants generated by the project. These will include:

- Where sites used for stockpiles, wash-down, batch plants, refuelling and chemical storage are located in areas of sensitive/shallow water table, best practice management for siting, erosion and sediment controls, and bunding of storage areas in combination should be employed
- Water quality ponds
- Grassed swales.

Water quality monitoring, particularly following rainfall events, would identify if the hydrology and water quality has been adversely impacted by the project. Standard project water quality objectives criteria are as follows:

- Total suspended solids: <50mg/L
- pH: 6.5 – 8.5
- Oil and grease: no visible trace.

In the event that adverse impacts are identified from the monitoring, the following procedure should be implemented:

- Identify potential pollutant source based on the parameters that were exceeded (eg. sediment for high TSS reading, or fuel spill / leak for high hydrocarbon reading)
- Inspect and rectify water quality ponds and grassed swales in area where adverse impacts are identified. This would include inspection of water quality ponds to assess available water storage capacity, water quality, sediment build-up, structural integrity and debris levels
- Add alkalising agents to acidic (low pH) waters or sulphuric acid to alkaline (high pH) waters.

6.3.10 Nest boxes

Nest boxes will be installed to compensate for the loss of hollow-bearing trees from the Project. Nest boxes will be installed as compensation for loss of hollows for the Brush-tailed Phascogale. Installation and maintenance will be in accordance with the Guide 8: Nest Boxes of the Roads and Maritime Biodiversity Guidelines (RTA 2011). This document describes an equation for calculating the number of nest boxes required to offset the removal of hollow bearing trees based on the density of hollow bearing trees within the disturbance area, the mean number of hollows per tree and factors in a 20% error factor.

The number and type of nest boxes required will be determined during pre-construction surveys based on the number, quality and size of the hollows that would need to be removed and the target species inhabiting the area. These surveys have been completed for all sections of the project and Nest Box Management Plans (NBMP) have been finalised and approved for all Sections of the Project. The NBMP include specifications for nest box dimensions, installation requirements, locations of nest boxes and ongoing monitoring and maintenance.

Seventy per cent of the nominated nest boxes would be installed prior to or during the clearing works with the objective of providing temporal refuge habitat for those hollow dependant fauna displaced during clearing operations. The remaining thirty percent of nest boxes will be installed once a final tally of functional tree hollows has been compiled and reviewed as a result of the data collected during the clearing supervision. Occupancy rates of tree hollows during the clearing supervision would also facilitate the final number and types of nest boxes being installed.

6.4 Mitigation goals and corrective actions

The construction mitigation goals and mitigation measures for threatened mammals and the associated corrective actions are summarised in **Table 6-5**.

Table 6-5 Mitigation goals and corrective actions – construction

Mitigation Goals	Mitigation / control measure	Monitoring/timing frequency	Trigger for corrective actions	Corrective actions	Responsible party for corrective action implementation
Establish procedures and training to ensure mitigation is incorporated into construction, through implementation of a CEMP.	Construction work method statements integrated into CEMP and implemented. Construction training and induction conducted for all personnel.	CEMP and training and induction is to be implemented prior to and during construction. Training is to be recorded on a register.	Not all personnel have undergone inductions prior to commencing work on site. Not all personnel are aware of the CEMP and responsibilities for implementing it.	Any personnel that have not completed training and inductions must stop work immediately until they have been completed.	Project Contractor
All threatened mammals recovered from hollows or habitat trees without injury and are successfully relocated to habitats proximate to their capture.	Staged clearing around habitat trees to provide time for fauna to vacate the area. Implementation of fauna handling protocols as per the Roads and Maritime biodiversity guidelines.	24 hours to 48 hours prior to clearing of habitat trees that may potentially support Brush-tailed Phascogale. Daily monitor procedures to ensure effectiveness.	A single threatened mammal species is injured or killed during construction activities.	Review cause for mortality or injury against existing procedures and processes within one week of incident. Re-evaluate risks and modify pre-clearance activities accordingly.	Project Contractor and Project Ecologist
Provide opportunity for daily movements of target species across the highway.	Installation of connectivity structures at pre-defined locations (supported by targeted survey findings).	All crossing structures completed prior to operation.	Connectivity structures not installed prior to operation. Threatened mammal hot spots are identified during construction phases where no crossing structure is proposed.	Project operation is delayed until crossing structure requirements are met. Consideration of additional adequate fauna crossing structures in areas identified as threatened mammal hotspots.	Project Contractor
No damage to known Potoroo habitat and other threatened mammal habitat outside of approved clearing limits.	Clearing limits pegged with each peg showing the chainage and revision number to manage confusion. Pennant flagging to be bright coloured and strung between clearing limit pegs.	Clearing limits and pegs to be inspected before releasing 'hold point' for clearing by the contractor (i.e. G40 walk/hold point). Weekly inspections of clearing limits by environmental coordinator, an agenda item for RMS audits and Environmental Representative Group	Clearing occurs outside of approved limits. One or more breaches in the exclusion fence that could enable Potoroo and other threatened mammals to move onto the carriageway.	Stop clearing immediately. Investigate extent of additional clearing and reason for breach. Investigate damage/breach in fencing. Agencies notified and determine if there is a need for additional offset area.	Project Contractor and Project Ecologist

Mitigation Goals	Mitigation / control measure	Monitoring/timing frequency	Trigger for corrective actions	Corrective actions	Responsible party for corrective action implementation
		(ERG) monthly inspections.		Put in place additional measures as required to ensure breach does not reoccur.	
No vehicle collision incidents with threatened mammal species within construction areas.	For Potoroo: Site specific Vehicle Management Plan (VMP) identifies that within known Potoroo habitat driving speeds are not to exceed 40 kmph between 1800-0600 hrs (i.e. out of hours) unless temporary or permanent exclusion fencing has been installed.	Site specific vehicle VMP reviewed for consistency as part of independent audits.	A single threatened mammal species is injured or killed during construction activities. Vehicles observed operating in a manner not consistent with the site specific VMP.	Consideration of temporary fauna exclusion fencing in areas identified as threatened mammal hotspots. A corrective action identified to the principal contractor to avoid vehicle collision with Potoroo.	Project Contractor and Project Ecologist
No injuries or mortality of threatened mammals as a result of vegetation clearance.	Pre-clearing and clearing procedures conducted as per protocol outlined in the FFMP. Experienced ecologist(s) shall set traps targeting Long-nosed Potoroo in areas that are to be cleared the following day. Traps would be checked at first light ahead of any clearing activities occurring with captured animals relocated into adjacent habitat 50 - 150m from the clearing boundary. This process would be repeated until all clearing in the Long Nosed Potoroo habitat is completed	Weekly fauna incident log to be maintained as per FFMP during clearing works. Daily while clearing known Long-nosed Potoroo habitat	A single threatened mammal species injured or killed during vegetation clearance.	Construction activities to cease within the immediate area. Review exclusion fence strategy and traffic control procedures as appropriate. Review performance of Contractor. Review the Environmental Work Method Statement for consistency and relevance to tasks being performed. In case of Ecologists performing trapping pre clearing surveys review survey technique in accordance with their Animal Care and Ethics Licence.	Project Contractor and Project Ecologist

Mitigation Goals	Mitigation / control measure	Monitoring/timing frequency	Trigger for corrective actions	Corrective actions	Responsible party for corrective action implementation
				Review the clearing procedures and approach between ecologists and contractor and modify the techniques if found to be ineffective.	
Threatened mammal habitat is rehabilitated to a functional quality and methods for rehabilitation of threatened mammal habitat adjacent to the road are included in Urban Design and Landscape Plan	Implementation of the UDLP that considers threatened mammal populations, habitat and revegetation of habitat areas, including strategic revegetation around crossing structures and in disturbed areas.	UDLP to be implemented progressively throughout construction as sections are completed.	Revegetation or strategic planting around crossing structures not commenced in completely constructed sections of the project as per the timeframes outlined in the UDLP.	Implement UDLP as soon as possible. Sign off for completion of a section of the project cannot be undertaken until planting is implemented as per UDLP.	Project Contractor
No spread of pest plant material.	Implementation of weed control during construction	In accordance with schedules outlined in FFMP	Presence of pest plant species within the project area.	Pest plant removal to be undertaken (local government authority policies should be consulted).	Project Contractor
No contamination or isolation of water supplies adjoining the project.	Implement water quality procedures from the CEMP.	Weekly and event based monitoring of water quality and erosion controls.	A notable change in water quality, as defined in the CEMP, is identified during construction activities.	Review CEMP water management procedures as soon as water quality breach issue is identified. Implement corrective actions as required.	Project Contractor
Minimise impacts from road kill and move fauna to crossing structures.	Installation of permanent fauna exclusion fencing as per Fauna Connectivity Strategy.	Monitor fence installation as per specifications and final inspection prior to operation of highway.	Exclusion fencing has not been built to specification prior to completion of that stage of highway.	Section cannot be signed off until permanent exclusion fencing has been constructed to specifications.	Project Contractor

Mitigation Goals	Mitigation / control measure	Monitoring/timing frequency	Trigger for corrective actions	Corrective actions	Responsible party for corrective action implementation
Provide compensatory denning/shelter habitat for target hollow-dependent fauna	Prepare and implement a Nest Box Management Plan for each project Installation of 70% of the nest boxes prior to construction commencing	Monitoring of nest boxes as per monitoring protocol (Section 8). Audit of outcomes prior to construction	An appropriate numbers of nest boxes have not been installed prior to construction, as per the requirements of the Nest Box Management Plan.	Construction activities cannot commence until appropriate number of nest boxes are installed within vicinity of proposed construction activities.	Project Contractor and Project Ecologist
Do not contribute to the proliferation of Cane Toad's (*Bufo marinus*) within the region.	Do not retain or transport water containing Cane Toad tadpoles.	Monitor water storage areas created during construction monthly for Cane Toad tadpoles.	Any Cane Toad tadpoles identified in a waterbody created during construction.	Implement management measures, eg pump sieves, to reduce risk of tadpoles being transferred from one location to another during construction.	Project Contractor
Monitoring identifies Potoroo activity levels are not declining beyond 25% at paired monitoring stes 2-8.	Exclusion fencing and pre clearing surveys successfully capturing and relocating Potoroo.	12 ha grid survey twice over 14 nights with minimum 90 days between late spring/summer survey and the autumn survey.	>25% decline from the paired control site	Consider potential for natural variation to be responsible for decline in population numbers/density by comparison with control sites. Evaluate potential changes to habitat or predators that may be impacting on Potoroo populations. Discuss findings with suitably qualified ecologist and discuss appropriate corrective actions. Engage with regulators.	Roads and Maritime

7. Operational management measures

7.1 Potential impacts during operational phase

- Reduction in the availability of suitable habitat.
- Barrier to access of important habitat for life-cycle events.
- Reduced dispersal ability and genetic isolation or creation of sub-populations.
- Reduction in the availability of nesting sites.
- Direct mortality of threatened mammal from vehicle collisions.
- Increased predation of threatened mammals due to exotic predator activity close to connectivity structures.
- Degradation of adjacent habitats due to edge effect.

7.2 Mitigation goals

- Maintain habitat revegetation effort until revegetated habitat is returned to a suitable level of cover and diversity.
- Maintain fauna exclusion fencing and connectivity structures for the life of the project.
- Nest boxes are used by the target mammal species and remain functional for the life of the project.
- Minimise impacts from pest animals on threatened mammals usage of crossing structures. Contribute to regional pest control where exotic predators are found using connectivity structures.
- Crossing structures for threatened mammals facilitates natural daily movements.

7.2.1 Maintenance of habitat revegetation

Inspection, monitoring and maintenance of revegetated areas is specified within the Roads and Maritime specifications including R178 and R179. The recommended maintenance and monitoring schedule for the revegetated areas in the first year is outlined in **Table 7-1** and for years two to three in **Table 7-2**. An increased level of maintenance and monitoring will be completed in the first twelve month period and then tapers off as the revegetation becomes self-sustaining, but will be subject to performance measures being met.

Table 7-1 Recommended monitoring and maintenance schedule (Year 1)

Monitoring	Timing	Maintenance
Site preparation	Commencement	Where weed infestations occur spray the area for weeds prior to planting using appropriate herbicides or pesticides and to the manufacturer's specifications. The area is to be left for at least two weeks prior to planting.
Watering	First month	Immediately post planting undertake watering in accordance with Specification R179. Undertake watering at 2 day intervals for four weeks after planting.
Watering	2-6 months	Watering will continue at weekly intervals gradually decreasing over time. The amount of watering will be in accordance with Specification R179.
Plant health	Monthly for 12 months	Carry out maintenance inspections of plantings at intervals not exceeding one month. Weeds not smothering plants, plants healthy with active growth, replanting required if plant survival not at required percentage. A written report to be submitted to Roads and Maritime by contractor after each maintenance inspection.
Weed control	Monthly	Keep all planting areas free of weeds. Weed removal to be undertaken at intervals not more than four weeks and ensure weeds do not flower to form seed heads. For noxious weeds take action as required by that local government authority. Dispose of weeds off site.
Plant replacement	Monthly for 12 months	The contractor will be responsible to replace missing or dead plants within fourteen days of detection. They must be of similar size and quality and identical species to that lost. Replacement plantings are to be watered for the first 12 weeks.
Stakes and tree guards	Monthly for 12 months	Repair any tree ties or tree guards that have broken or are missing. Replace as soon as practicable after being identified.

Table 7-2 Recommended monitoring and maintenance schedule (Year 2 and Year 3)

Monitoring	Timing	Maintenance
Mulch/weed suppression. Plant nutrient deficiency.	Every 6 months in Year 2 and 3.	Addition of mulch where required. Addition of fertiliser/nutrients where required. Weeds controlled within 2 metres of planting locations, blanket treatment of weed areas if appropriate or targeted treatment of weed outbreaks.
Weed and plant health	Every 6 months in Year 2 and 3.	Weeds not smothering plants, healthy active plant growth, replanting required if the target percentage survival rate not achieved.

7.2.2 Maintenance of fauna exclusion fencing and fauna crossing structures

The Roads and Maritime would conduct monitoring and maintenance of fauna crossing structures and fauna exclusion fencing, the schedule of which will coincide with the survey periods described in **Table 8-4**. The program would include inspections of the structures as part of the standard maintenance requirements along the highway for stability and damage for the life of the project and replacement where necessary or removal of debris where this is blocking the structure. Monitoring would also be conducted in response to observations and reports of fauna road kills in the vicinity of the crossing structures.

Where road kill is identified for targeted species and fencing is not in place the Roads and Maritime will evaluate the need for additional exclusion fencing and install where required. Road kill monitoring may also be increased in these areas to determine the effectiveness of any further mitigation measures installed. The future installation of fauna fencing and connectivity structures will be undertaken with guidance from Sections 5 and 7.2 of the Pacific Highway Upgrade Woolgoolga to Ballina: Fauna Connectivity Strategy Woolgoolga to Glenugie (Sections 1 and 2) (GHD, 2014) or subsequent plans for Sections 3-11.

To minimise the risk of rope bridges falling onto the road, poles suspending the ladder would be made from treated timber. Rope would be inspected periodically for signs of decay or weakening, and replaced where necessary for the life of the project.

7.2.3 Maintenance of nest boxes

The NBMP outlines a consistent approach to the monitoring and maintenance of nest boxes. Monitoring would be required to determine the usage of nest boxes by the target species and identification of maintenance requirements. Monitoring requirements for nest boxes will be outlined in the NBMP and is summarised in **Section 8.6**.

Factors that would be considered as part of the maintenance requirements for nest boxes include:

- The need to remove exotic pest species such as Common Mynas, Common Starling and European Bees.
- Replacement of fallen, damaged or degraded nest boxes.
- Repositioning, re-erection or relocation of dysfunctional nest boxes.
- Checking each box is not holding water or leaking.
- Removing excess nesting material as this may impede access over time.

7.2.4 Predator control

Predators can exploit the channelling function of fauna fencing by hunting near the entrance to a crossing structure such as an underpass or overpass (Harris *et al.* 2010). Should monitoring demonstrate wild dogs, cats or foxes to be predating on threatened mammals or inhibiting mammal movement through the crossing structures, Roads and Maritime would engage with the Northern Rivers Catchment Management Authority, EPA (Parks and Wildlife Grafton), and Rural Lands Protection Board (North East) and adjacent landowners to identify and implement strategies to reduce this predation risk. Monitoring results will be reviewed after each subsequent monitoring period to address predator and pest densities and identify areas in which regional scale programs can be implemented by the aforementioned parties. In terms of Section 10 Roads & Maritime would seek to engage with JALI (adjacent landholder) to investigate feasibility of proactive feral animal control program for Long-nosed Potoroo that would complement areas adjacent to key crossing structures for this species.

7.3 Mitigation goals and corrective actions

The operational mitigation goals and mitigation measures for threatened mammals and their associated corrective actions are summarised in **Table 7-3**.

Table 7-3 Mitigation goals and corrective actions – operation

Mitigation Goals	Mitigation / control measure	Monitoring/timing frequency	Trigger for corrective actions	Corrective actions	Responsible party for corrective action implementation
Maintain habitat revegetation effort until revegetated habitat is returned to a suitable level of cover and diversity.	Revegetation of areas outlined in the UDLP for threatened mammal habitat. Targeted plantings in areas of crossing structures.	For the first twelve months monitoring of revegetation will be monthly. It will then go to every 6 months for years two and three. Monitoring will occur in Spring/Summer to evaluate the success of revegetation against performance objectives.	Monitoring and maintenance activities not being undertaken. More than 10% of plants have died after year one, and more than 20% have died after three years.	Review maintenance schedule for revegetated areas within one month of trigger being identified and plant more feed and habitat trees as required. Increase monitoring period as advised by landscape designer.	Project Contractor
Maintain fauna exclusion fencing and connectivity structures for the life of the project.	Maintenance of fauna exclusion fencing connectivity structures as part of routine highway maintenance to remove debris and replace damaged rope crossings. Monitor road kill as part of the routine road maintenance and repair broken exclusion fencing or install new fencing where required.	Regular monitoring as part of the Roads and Maritime routine highway maintenance program. Exclusion fencing will be monitored twice per year during mammal surveys.	A single reported road kill of a threatened mammal species.	A maintenance check is to be performed within 5 days of any reported road kill incident. Any fence or structure found to be damaged during a maintenance check is to be repaired. Initiate repair works within 5 days of identification.	RMS
Nest boxes are used by the target mammal species and remain functional for the life of the project.	Inspection of nest boxes and confirmation that nest boxes have been used by the target species.	12 months after installation followed by summer or winter census to account for seasonal variation. It is proposed that annual monitoring and maintenance would continue annually for four years then every two years for the next four years.	Threatened mammals identified as not using nest boxes for three consecutive monitoring periods. Nest boxes are found to be damaged.	Re-evaluate nest box strategy if boxes continue not to be used by target species or are used by pest species. Upgrade maintenance schedule and/or nest box design if nest boxes are continually being found to be damaged. Replace nest boxes within one month of being identified as damaged.	RMS and RMS Ecologist

Mitigation Goals	Mitigation / control measure	Monitoring/timing frequency	Trigger for corrective actions	Corrective actions	Responsible party for corrective action implementation
Minimise impacts from pest animals on threatened mammals usage of crossing structures. Contribute to regional pest control where exotic predators are found using connectivity structures.	Engage in consultation with regional pest control agencies. Implement pest control program focused at crossing structures where deemed appropriate.	Monitoring for presence of pest animals at crossing structures will form part of overall mammal monitoring program described in Table 8.3.	High usage of crossing structures (>25% increase) by exotic predators reported after the first monitoring period and each subsequent monitoring period as per Table 8.3.	Meet with regional pest control stakeholders as soon as practical and contribute to pest control program where reasonable and feasible. Implement pest control program around crossing structures to reduce pest animal predation.	RMS and Northern Rivers Catchment Management Authority, EPA (Parks and Wildlife Grafton), and Rural Lands Protection Board (North East)
Crossing structures for threatened mammals facilitates natural daily movements. Potoroo recorded using underpasses after three consecutive monitoring periods after installation.	Maintenance of fauna connectivity structures as part of routine highway maintenance to remove debris and replace damaged furniture etc.	Regular monitoring as part of the Roads and Maritime routine highway maintenance program. Monitoring of culverts with remote sensing cameras for 60 days in spring/summer and again in autumn.	Threatened mammals are not recorded using connectivity structures for three consecutive monitoring periods. No Potoroo recorded using underpass structures at Site 3A, 4A, 5A, 6A post three consecutive monitoring periods after installation.	Evaluate potential reasons for species not using crossing structure within three months of trigger. Assess fencing in the area of the structure, vegetation and habitat condition. Assess if pest animals are having an impact on mammals use of structures. Corrective actions may include: ● Greater maintenance of the existing connectivity structure/s ● Update design of existing measures where feasible and reasonable	RMS and RMS Ecologist

Mitigation Goals	Mitigation / control measure	Monitoring/timing frequency	Trigger for corrective actions	Corrective actions	Responsible party for corrective action implementation
				• Consider additional offset measures to improve connectivity elsewhere. • Increase pest animal control if they are found to occur at crossing structures. Roads and Maritime to consult with relevant agencies to determine appropriate actions as soon as practical.	
Monitoring identifies Potoroo activity levels are not declining beyond 25% at paired monitoring stes 2-8.	Exclusion fencing and pre clearing surveys successfully capturing and relocating Potoroo.	12 ha grid survey twice over 14 nights with minimum 90 days between late spring/summer survey and the autumn survey.	>25% decline from the paired control site	Consider potential for natural variation to be responsible for decline in population numbers/density by comparison with control sites. Evaluate potential changes to habitat or predators that may be impacting on Potoroo populations. Discuss findings with suitably qualified ecologist and discuss appropriate corrective actions. Engage with regulators.	Roads and Maritime

8. Monitoring program

Monitoring will be undertaken to confirm the effectiveness of mitigation measures for threatened mammals. The monitoring program will use a BACI approach comparing before and after data between impact versus control sites. Monitoring will focus on areas of known and potential habitat for the target species and has been informed by the targeted baseline surveys to ensure that each species has appropriate monitoring locations and methods.

8.1 Objectives

Monitoring will be conducted until such time as the mitigation measures have been proven to be effective over three consecutive monitoring periods. The monitoring data would aim to provide robust information to draw sound conclusions around the effectiveness of mitigation measures for the target species and inform adaptive management actions. The objective of the monitoring and adaptive management program is to evaluate the success of mitigation measures against performance indicators and apply corrective management actions or contingency plans where poor performance or failing measures are detected.

The monitoring program and methods, including impact and control site selection, may be subject to modification and refinement during the course of the program and would be dependent on the on-going results, access to monitoring sites or outcomes of the adaptive management actions and contingency planning.

Table 8-1, Table 8-2 and **Table 8-3** present the pre-construction baseline monitoring data for the Rufous Bettong, Brush-tailed Phascogale and Long-nosed Potoroo, as described in the baseline monitoring report (Lewis 2014a and 2015 respectively), along with the acceptable tolerance levels for deviation away from the paired control sites.

Table 8-1 Rufous bettong baseline monitoring guidelines

Technique	Description	Tolerance for deviation from control site level	Bettong Site Reference Name	Site 1A Impact	Site 1B Control	Site 2A Impact	Site 2B Control	Site 3A Impact	Site 3B Control	Site 4A Impact	Site 4B Control	Site 5A Impact	Site 5B Control
Camera Traps	36 cameras installed on a 600 x 600 m grid	25% decline of Bettong and 25% increase in exotic predators	Baseline Mean	1.4	0	8.5	26.4	42.6	32.1	55.5	57.2	0	2.7
Spotlight Surveys	4 units x 1 person hour (30 min per person) non consecutive nights	50% decline from the baseline data	Baseline Mean	0	0	1	0.5	0.25	0.25	1	0.75	0	0.5
Nocturnal Drive Transect	4 units of 2-3 km Transect employed on nights of spotlight surveys	Absence after 2 years of monitoring	Baseline Mean	0	0	0.25	0	0.25	0.25	0.25	0.25	0	0.5
Road Kill Surveys	surveys on multiple days and season in areas of suitable habitat and distance recorded	>200% increase	Preconstruction Base	1 Bettong per 1500 km road transect									

Table 8-2 Brush-tailed phascogale baseline monitoring guidelines

Technique	Description	Tolerance for deviation from control site level	Bettong Site Reference Name	Site 1A Impact	Site 1B Control	Site 2A Impact	Site 2B Control	Site 3A Impact	Site 3B Control	Site 4A Impact	Site 4B Control	Site 5A Impact	Site 5B Control
Camera Traps	36 cameras installed on a 600 x 600 m grid	25% decline of Phascogales and 25% increase in exotic predators	Baseline Mean	0	2.8	8.5	2.7	11.1	10.4	8.3	1.4	2.8	4.2
Spotlight Surveys	4 units x 1 person hour (30 min per person) non consecutive nights	50% decline from the baseline data	Baseline Mean	0	0	0	0	0	0	0	0	0	0
Nocturnal Drive Transect	4 units of 2-3 km Transect employed on nights of spotlight surveys	Absence after 2 years of monitoring	Baseline Mean	0	0	0	0	0	0	0	0	0.25	0.25
Arboreal tree trapping	10 Elliot B type traps on ~ 1 ha grid and mounted 2 m above ground. Traps operating for 4 consecutive nights	25% decline	Baseline Mean	0	1 female	1.5 males	0	0	0	0	0	0	0.5 females 1.5 males
Road Kill Surveys	surveys on multiple days and season in areas of suitable habitat and distance recorded	>200% increase	Preconstruction Base	1 Phascogale per 750 km road transect									

Table 8-3 Long-nosed Potoroo baseline monitoring guidelines

Technique	Description	Tolerance for deviation from control site level	Long-nosed Potoroo Site Reference Name	Site 2A Impact	Site 2B Control	Site 3A Impact	Site 3B Control	Site 4A Impact	Site 4B Control	Site 5A Impact	Site 5B Control	Site 6A impact	Site 6B Control	Site 7A Impact	Site 7B Control	Site 8A Impact	Site 8B Control
Camera Traps	12 cameras installed on a 300 x 400 m grid 12 ha grid survey twice over 14 nights with minimum 90 days between late spring/summer survey and the autumn survey.	Potoroo activity levels not declining beyond 25% at paired monitoring sites 2-8.	Baseline Mean	12.5	37.5	12.5	25	20.83	29.17	29.17	62.5	33.34	45.84	54.17	37.5	58.33	87.5

8.2 Population densities

8.2.1 Monitoring goals

The ultimate goals of the population monitoring surveys focus on detecting any change in activity levels between impact and reference sites. Declines in activity levels at impact sites and not reference sites are likely to be the result of impacts from the project (unless otherwise identified), thus surveys will assess the performance and location of crossing structures, fencing and other mitigation measures to determine the most appropriate corrective action(s) where required.

The specific monitoring goals are to reflect no significant change in threatened mammal population densities adjacent to the project at impact sites.

The monitoring program focuses on the Brush-tailed Phascogale, Rufous Bettong, Spotted-tailed Quoll and Long-nosed Potoroo. However, Spotted-tailed Quoll has not been confirmed to occur in the project area during surveys efforts. Should occasional individuals be present within the project area, it will be very difficult to establish meaningful monitoring sites and investigate population trends. This is due to: the paucity of Spotted-tailed Quoll records in the project area; the species' large and diverse home range; and the low likelihood of achieving sufficient meaningful data (to provide evidence of decline/stability of populations). Given this, no specific Spotted-tailed Quoll monitoring surveys have been proposed. Survey efforts which have been tailored towards the other threatened mammals do however, utilise a broad spread of baited camera traps in many habitats throughout the project area and surrounding habitats which the Spotted-tailed Quoll may forage in. These baited camera traps may potentially provide incidental records of this species.

8.2.2 Selection of monitoring locations

The results of targeted surveys for threatened mammals have confirmed the presence or (potential presence) and activity levels of populations. The surveys are designed to target habitats and locations reported in the EIS with the aim of establishing a set of monitoring sites that meet the following criteria:

- Impact sites (these would be monitoring sites such as near dedicated and combined crossing structures within 200 m of the road edge and where possible on both sides of the road).
- Control sites (>500 m from the project and impact sites to account for home range sizes).

Baseline surveys have finalised impact and control sites for the Rufous Bettong, Brush-tailed Phascogale and Long-nosed Potoroo which are illustrated in **Figure 8-1 Figure 8-2** and **Figure 8-3**. These figures also show where crossing structures occur in proximity to the monitoring sites. There are five paired impact and control sites for Bettong and seven paired impact and control sites for Phascogale. Seven paired impact and control sites have been finalised for the Long-nosed Potoroo.

Monitoring of the target species have adopted a whole of project approach by sampling populations of suitable density to provide sufficient data for analysis. In this way sites have been selected across multiple upgrade sections only where populations are detected. The total number of impact and control sites would therefore be analysed across the whole project as a single monitoring program for each species and not per upgrade section. The timing of these surveys however, will reflect the construction commencement date to avoid monitoring not capturing the monitoring requirements for the operational period.

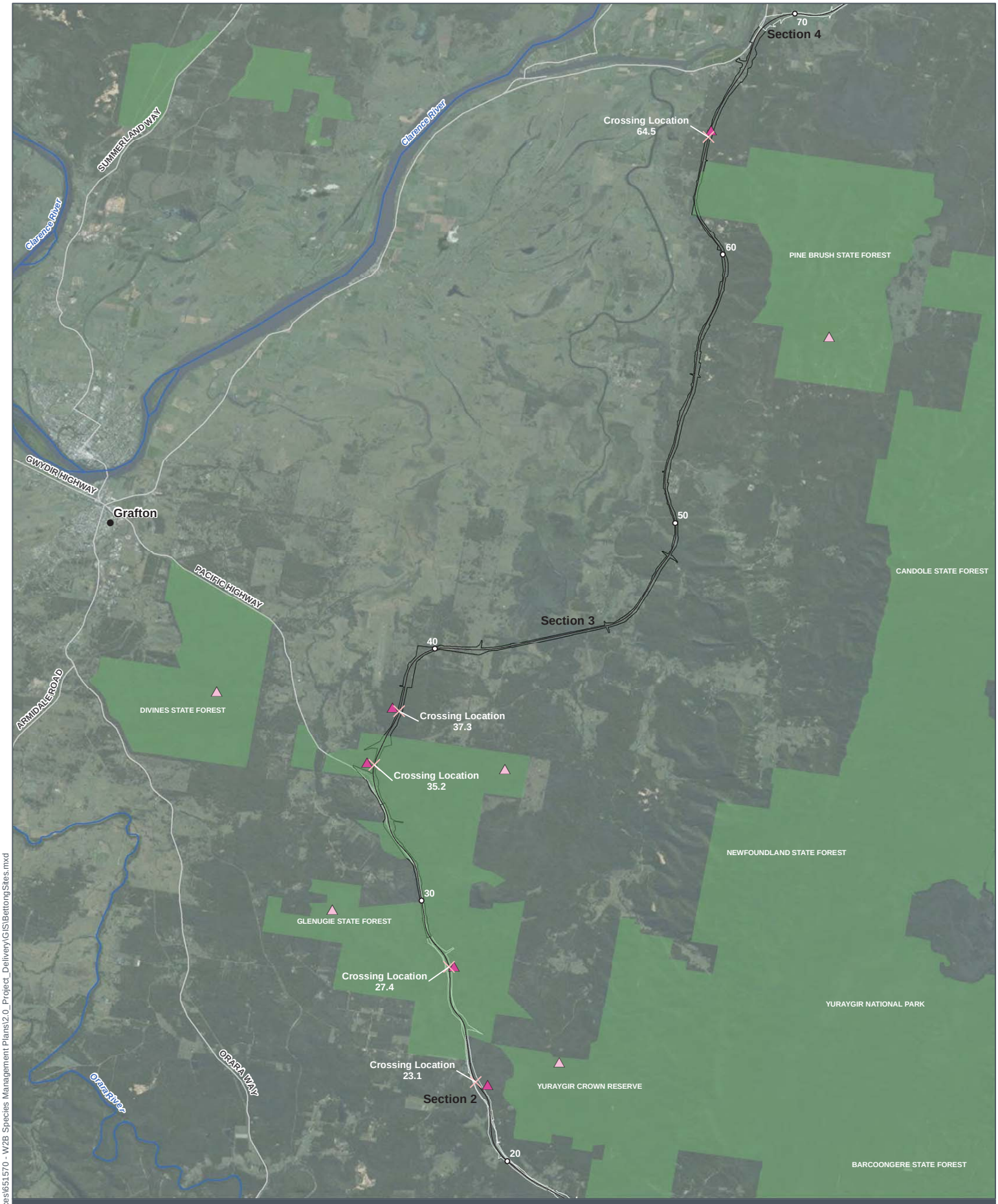


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Figure 8-1
Rufous Bettong Impact and Control Site Locations

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

LEGEND

- Kilometre point
- Alignment

Rufous Bettong

- Control site
- Impact site
- Crossing site

ISSUE DATE	AUTHOR	QA CHECK	APPROVED	MAP REV.	REVISION NOTE
08/10/2015	JH	MT	BE	0	Issued for Use
15/12/2014	JH	MT	BE	A	Issued for Review

amec foster wheeler

N

0 1 2
Kilometres

(A3) GCS GDA 1994

LOCATION DIAGRAM

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Figure 8-2
Brush-tailed Phascogale Impact and Control Site Locations

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

LEGEND

- Kilometre point
- Alignment

Brush-tailed Phascogale

- Control site
- Impact site
- Crossing site

ISSUE DATE	AUTHOR	QA CHECK	APPROVED	MAP REV.	REVISION NOTE
08/10/2015	JH	MT	BE	0	Issued for Use
15/12/2014	JH	MT	BE	A	Issued for Review

amec foster wheeler

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Kilometres

(A3) GCS GDA 1994

LOCATION DIAGRAM

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Figure 8-3
Long-nosed Potoroo Impact and Control Site Locations

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits:

LEGEND

- Impact site
- Control site
- Kilometre point
- Alignment
- Project boundary

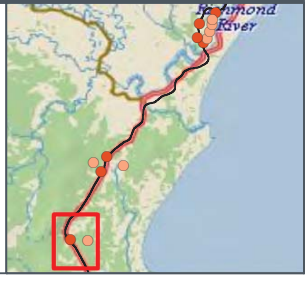
ISSUE DATE	AUTHOR	QA CHECK	APPROVED	MAP REV.	REVISION NOTE
08/10/2015	JH	MT	BE	0	Issued for Use
15/12/2014	JH	MT	BE	A	Issued for Review

amec foster wheeler

0 500
Metres

(A3) GCS GDA 1994

LOCATION DIAGRAM



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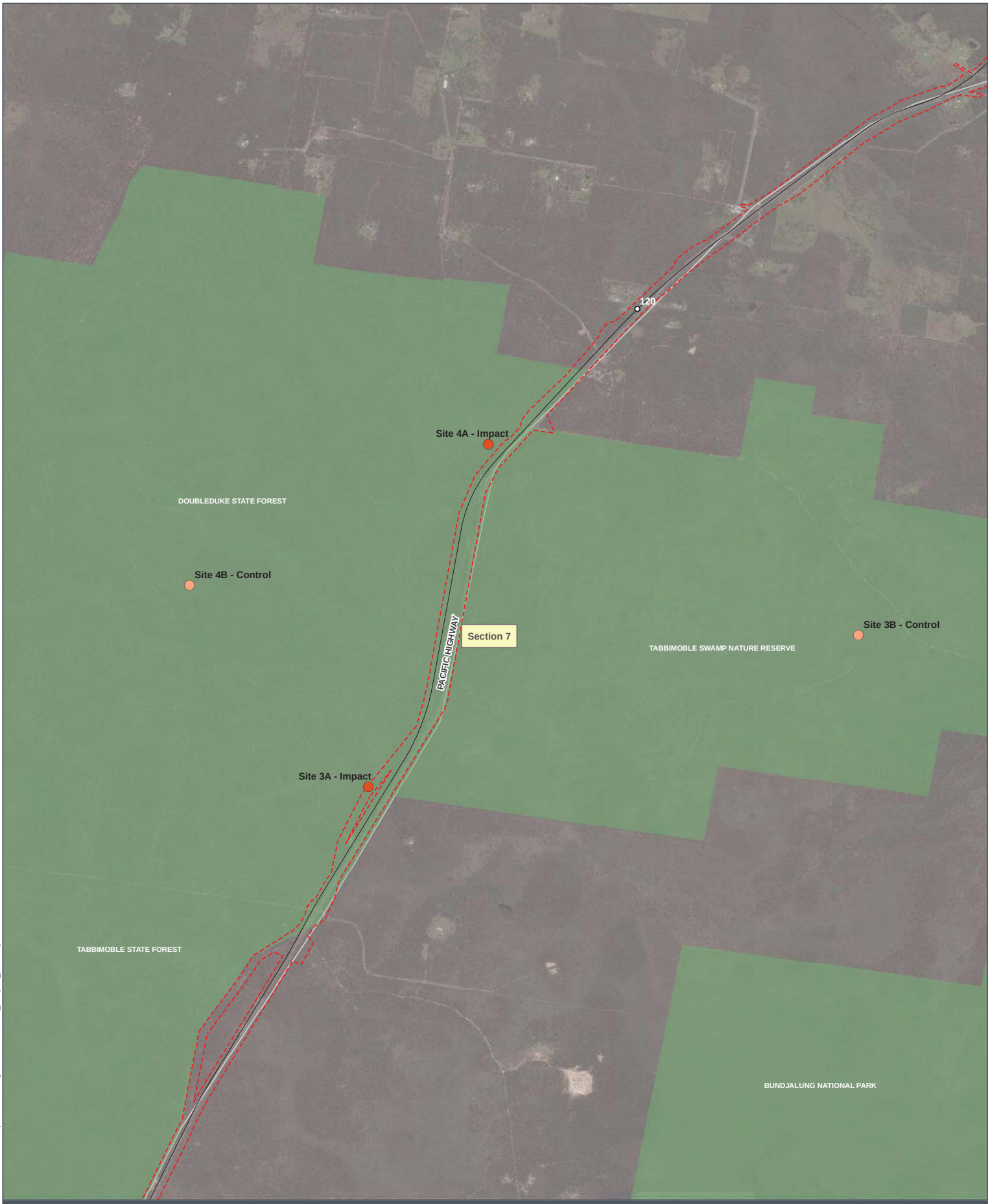

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Figure 8-3
Long-nosed Potoroo Impact and Control Site Locations

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits:

LEGEND

- Impact site
- Control site
- Kilometre point
- Alignment
- Project boundary

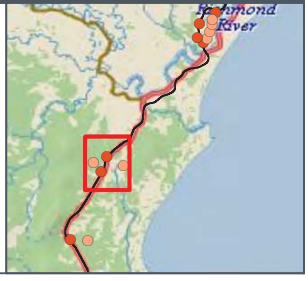
ISSUE DATE	AUTHOR	QA CHECK	APPROVED	MAP REV.	REVISION NOTE
08/10/2015	JH	MT	BE	0	Issued for Use
15/12/2014	JH	MT	BE	A	Issued for Review

amec foster wheeler

0 500
Metres

(A3) GCS GDA 1994

LOCATION DIAGRAM



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ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 8-3
Long-nosed Potoroo Impact and Control Site Locations

LEGEND

- Impact site
- Control site
- Kilometre point
- Alignment
- Project boundary

LOCATION DIAGRAM

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits:

ISSUE DATE	AUTHOR	QA CHECK	APPROVED	MAP REV.	REVISION NOTE
08/10/2015	JH	MT	BE	0	Issued for Use
15/12/2014	JH	MT	BE	A	Issued for Review

0 500
Metres

(A3) GCS GDA 1994

Path: W:\PROJECTS\ENRoads & Maritime Services\651570 - W2B Species Management Plans\2.0_Project_Delivery\GIS\PotorooSites.mxd

8.2.3 Timing and methods

Surveys will be conducted during pre-construction, construction and post-construction and aim to sample peak activity times of the target species. Biannual surveys (twice a year) are required for each species to capture the breeding and dispersal periods as described in **Table 8-4**. All baseline surveys for threatened mammals have been completed prior to construction (Lewis 2014 and 2015). Biannual monitoring surveys will commence during the construction phase and continue through the operational phases. Monitoring surveys will continue in the operational phase for a minimum of three survey periods (i.e three years) and will continue until the effectiveness of mitigation measures can be demonstrated to have been achieved over a minimum of three successive monitoring periods.

The survey methodology used has been based on DoE's '*Survey guidelines for Australia's threatened mammals*' (DSEWPaC 2011); the NSW (former) Department of Environment and Conservation '*Threatened Species Survey and Assessment: Guidelines for developments and activities*' (DEC 2004); or the recommendations of expert ecologists based on the results of pre-clearance survey results. Activity levels would be recorded using the time and area based searches (capture rate per trap night or camera night or number of animals per search time and area). All results should continue to test for the significance and strength that prevailing abiotic variables might have on the recorded datasets. The abiotic categories should include the following; the amount of rainfall, the number of days with rain in each sample period, number of days with rainfall events exceeding 1 mm in 24 hrs and mean minimum temperature and mean temperature at 0900 hrs as detailed in Section 7 of **Appendix E**.

Table 8-4 Threatened mammal survey methods for monitoring

Target species	Monitoring Site Location		Timing and justification	Method
	Impact	Control		
Rufous Bettong	Site 1A - CH23125 dedicated culvert 2.4 x 3, 22m long.	Site 1B - 3 km to the east and south of Bald Knob Tick Gate Road	Autumn/winter and Summer to capture breeding and dispersal periods. (pre-construction completed)	<u>Camera Survey</u> 36 cameras installed on a 600 x 600 metre grid with camera traps set at every 100 metre interval. Traps stations are baited with a mixture of rolled oats, peanut butter, vanilla essence and honey. Continuous monitoring for 14 nights during each survey period (504 night effort). Cameras were generally fixed to a tree or stump in a horizontal position around 1m off the ground. <u>Spotlight Surveys</u> 4 units x 1 person hour (30 min per person) non-consecutive nights. Spotlighting may be excluded going forward for Bettong. <u>Nocturnal Driving Transect</u> These surveys were done whilst commuting between survey sites for distances of 2-3km either side of the grid. Vehicle was driven at speeds commensurate to the road or track being traversed. All Bettong observed were recorded and behaviour documented. 4 units of 2-3 km transect employed on nights of spotlight surveys. <u>Road kill transects</u> 1-2 observers scanned the roadway and recorded information on location, age and sex of any road killed Bettong. Vehicle speed was between 60-90kmph and 3m from road verge was inspected. Performed over 26 days and 1256 km was inspected between Section 1-8.
	Site 2A – CH27420 combined culvert 3.6 x 2.4, 104m long.	Site 2B – 3.6 km to the north west towards Braunstone in Glenugie State Forest		
	Site 3A – CH35230 combined culvert 2.4 x 2.4, 65m long.	Site 3B – North eastern section of Glenugie State Forest to the east of 8 Mile Lane		
	Site 4A – CH37320 combined culvert 2.4 x 2.4, 69m long.	Site 4B – 5.5 km north west in Bom Bom State Forest		
	Site 5A – CH64505 combined arch 5.5m high, 60m long.	Site 5B – 8 km south east in Pine Brush State Forest		

Target species	Monitoring Site Location		Timing and justification	Method
	Impact	Control		
Brush-tailed Phascogale	Site 1A – CH24580 arboreal rope crossing	Site 1B – 3 km to the east and south of Bald Knob Tick Gate Road	Late summer (January) to the start of winter (June) (pre-construction completed) Arboreal tree trapping should be timed from March to June. No surveys should be conducted after June. Surveys are timed to coincide with and occur just after the hatching of cicadas and during the earlier stages of the breeding season when both males and females would be present across the grid as opposed to sampling later in the season when males would have died off, following the typical dasyurid mating strategy.	<u>Arboreal Tree Trapping</u> This was done at 1A, 1B, 5A and 5B. 1ha sampling grid (35m spacing) was installed. Each grid comprised 10 Elliot B traps positioned on tree mounted brackets 2m above the ground and baited with peanut butter, honey and oats. These were left operating for four consecutive nights. This was methodology for first round. However it is recommended the next survey adopt 4-5ha grid using 25 traps (Elliot type B) set on tree brackets approximately 2-3 metres from ground level. Baited with rolled oats, peanut butter and honey. Trapping over four consecutive nights. <u>Camera Survey</u> Identical to Bettong. <u>Spotlighting Survey</u> Identical to Bettong <u>Nocturnal Driving Transect</u> Identical to Bettong <u>Road kill transects</u> Identical to Bettong.
	Site 2A - CH35230 combined culvert 2.4 x 2.4, 65m long.	Site 2B - 5.5 km north west in Bom Bom State Forest		
	Site 3A - CH64505 combined arch, 5.5m high, 60m long.	Site 3B - 8 km to the south east off Somervale Road		
	Site 4A - CH101100 dedicated culvert 2.4 x 3, 38m long	Site 4B - 3 km east in Bundjalung National Park		
	Site 5A - CH116400 arboreal crossing	Site 5B - 7 km west in Jackywalbin Conservation Park		
	Site 6A CH27420 combined culvert 3.6 x 2.4, 104m long. (Site 2A for Bettong)	Site 6B 3.6 km to the north west towards Braunstone in Glenugie State Forest (Site 2B for Bettong)		
	Site 7A CH37320 combined culvert 2.4 x 2.4, 69m long. (Site 4A for Bettong)	Site 7B 5.5 km north west in Bom Bom State Forest (Site 4B for Bettong)		
Spotted-tailed Quoll	No targeted monitoring proposed	No targeted monitoring proposed	-	As noted, the Spotted-tailed Quoll has not been confirmed to occur in the project area during a variety or generic and targeted surveys efforts. Regardless, even if occasional individuals are present it will be very difficult to establish meaningful monitoring sites and investigate population trends based on the likely paucity or observations. Based on: the paucity of Spotted-tailed Quoll records in the project area; the species large and diverse home range; and the low likelihood of achieving sufficient meaningful data no monitoring surveys have been proposed. Survey efforts tailored towards the other threatened mammals do however, engage a significant spread of baited camera traps in many habitats which the Spotted-tailed Quoll may forage in, thus potentially providing incidental records of this species.
Long-nosed Potoroo	Section 6, Site 2A - Ch.100640 combined culvert 1.8 x 2.4, 71m long; Ch.101100 dedicated culvert 2.4 x 3, 38m long; and Ch.101541 bridge, 132 long x 10.5m wide	Section 6 Site 2B - (Bundjalung National Park)	Winter/Spring (pre-construction completed) and late summer/early autumn to capture breeding and dispersal periods.	<u>Camera Survey</u> 300 x 400 metre grid with camera traps set at every 100 metre interval (n=14). Camera traps set to video mode and at a 10 second recording period. Traps stations are baited with a mixture of rolled oats, peanut butter, vanilla essence and honey. Continuous monitoring for 14 nights during each survey period.

Target species	Monitoring Site Location		Timing and justification	Method
	Impact	Control		
	Section 7 Site 3A1, 2 = ~Ch.115000 combined culvert	Section 7 Site 3B - (Tabbimobile Swamp Nature Reserve)	A minimum of 90 days between winter/spring and late summer/early autumn monitoring events is required to maintain seasonal and data independence. Monitoring programs should attempt to commence survey periods where there is minimal predicted rainfall for the first 3-4 days to increase the likelihood of potoroo detection.	
	Section 7 Site 4A - Ch.118828 land bridge, 72.6 long x 12.2m wide.	Section 7 Site 4B - (Doubleduke State Forest)		
	Section 10 Site 5A - Ch. 147600 land bridge 120 m long x 30m wide.	Section 10 Site 5B - (JALI Aboriginal Lands)		
	Section 10 Site 6A - Ch. 148600 culvert 3 x 3 x 60m	Section 10 Site 6B - (JALI Aboriginal Lands)		
	Section 10 Site 7A - Ch. 150520 culvert 2.4 x 1.5 x 42 m; Ch. 150600 culvert 3.6 x 1.62 x 42 m	Section 10 Site 7B - (JALI Aboriginal Lands)		
	Section 10 Site 8A - Ch. 156100 land bridge 62 m long x 12.2 m wide.	Section 10 Site 8B - (JALI Aboriginal Lands)		

8.2.4 Performance indicators and corrective actions

There would be potential for natural variation in threatened mammal populations for a range of reasons. Further monitoring/assessment would be undertaken if a decline of relative population density of threatened mammals has been identified as being attributable to the construction and operation of the project and further mitigation or contingency plans developed. The monitoring/assessment to identify the cause of the decline and/or corrective actions would be commenced as necessary, taking into account potential causes such as dry seasons, population fluctuations, sexual adaptations and seasonal fluctuations (e.g. post breeding period of the phascogale) and other natural variation, hence the use of unmitigated impact and control sites.

The monitoring / assessment would be dependent upon the monitoring already conducted prior to the decline being noted. Any corrective actions to be implemented would be agreed to by the relevant regulatory authorities (EPA and DoE) prior to being commenced. The key performance indicators and corrective actions for threatened mammals are outlined in **Table 8-5**. Although addressed in part in this version of the TMMP, the Long-nosed potoroo is not associated with Sections 1 and 2 of the project. Performance indicators and corrective actions for this species are outlined below and are applicable to the Long-nosed Potoroo where monitoring sites are proposed within Section 6, 7 and 10.

Table 8-5 Corrective actions – population densities

Trigger for corrective actions	Corrective actions	Responsible party for corrective action implementation
• Statistically significant declines in threatened mammal activity levels or abundance between impact site and control site after each monitoring event. This may include any of the following:	• Review monitoring methods and implement a more intensive monitoring and assessment schedule to confirm a decline in population density. • Consider potential for natural variation to be responsible for decline in population numbers/density by comparison with control sites. • Review results in conjunction with the road kill monitoring to check correlation with fence absence or breaches of the fence.	• RMS and RMS Ecologist

Trigger for corrective actions	Corrective actions	Responsible party for corrective action implementation
a. >25% decline in Bettong, Phascogale or Long-nosed Potoroo activity levels from paired control site through the use of camera trap grids b. >50% decline from paired control site from spotlighting surveys c. >200% increase in road kill records during surveys. Baseline is 1 Bettong per 1500km of road transect and 1 Phascogale per 750km of road transect d. > 25% decline from paired control site for arboreal tree trapping Brush-tailed Phascogale surveys e. Absence of records for >2 years during nocturnal driving surveys.	• Investigate habitat adjoining the highway and consider improving habitat condition and connectivity.	

8.3 Fauna connectivity structures

8.3.1 Monitoring goals

- Monitoring shows fauna crossing structures effective at facilitating the movements of threatened mammals.
- Monitoring shows fauna exclusion fencing effective at reducing road kill.

8.3.2 Selection of monitoring locations

Designated fauna crossing structures and exclusion fencing are to be monitored following completion of construction. The selection criteria for structures to be monitored are as follows:

- The target species monitoring program will select a range of structures located within 5 km from the population surveys as informed by the targeted surveys as illustrated in **Figure 8-1, Figure 8-2** and **Figure 8-3** and include all dedicated fauna crossing structures within the home range and dispersal range of populations to be monitored.
- Monitoring will focus on targeting those underpass structures which currently have minimal data available on fauna usage. As little information is currently available on fauna usage patterns for combined underpasses of 60 m or more in length, underpasses that: are equal to or greater than 60m in length; occur within proximity to native vegetation; and occur within target species populations will be specifically targeted. The focus of this monitoring is aimed at contributing to the working knowledge of these structures and faunal habituation to such structures.
- No combined structures that are located in cleared, disturbed or modified areas would be monitored.

- Should overpass structures be installed between Sections 3 to 11 that facilitate movement of the target mammal species, at least one impact monitoring site will be installed at the overpass location to monitor and evaluate the usage of these structures by the target mammal species.

8.3.3 Timing and methods

The timing of surveys would coincide with the biannual surveys described in **Table 8-4** and be completed in conjunction with the population surveys. Lengthy periods of adaptation and habituation have been recorded for Northern Hemisphere species, however evidence suggests that use of crossing structures (specifically overpasses and underpasses) is regular shortly after construction (Bond and Jones 2008). Monitoring of selected crossings would commence during the first high detection season for a species following construction completion and would be undertaken biannually (twice a year) for the target species and continue until the success of the mitigation measures has been proven over three consecutive monitoring periods (years)

Monitoring of arboreal crossing structures and widened medians would be conducted under the Threatened Glider Management Plan as this would also detect the Brush-tailed Phascogale if using these structures. A separate monitoring procedure for these structures is therefore not provided.

The methodology for underpass monitoring is as follows:

- A single motion-detecting camera with infrared flash installed at either end of the fauna crossing structures. Cameras would operate continuously for a period of eight weeks during the autumn/winter period and eight weeks during summer
- Hair-tubes placed upon fauna furniture within crossing structures and placed in habitat adjoining wildlife crossing structures. Hair-tubes would be baited with a mixture of rolled oats, peanut butter, and honey and left in place for 14 nights per monitoring period. Hair samples will be sent to an appropriately experienced specialist for identified
- Scat searches within crossing structures including 5 m from the entrance. Searches to be conducted when checking hair tube and camera traps (i.e. twice per monitoring period)
- For Long-nosed Potoroo monitoring of culverts with remote sensing cameras for 60 days in spring/summer and again in autumn.

Sand plots have not been included as part of this monitoring methodology. The inclusion of sand plots would be reviewed following the initial results of the camera monitoring.

8.3.4 Performance indicators and corrective actions

If during operation target threatened mammals are found to be unable or unwilling to use designated fauna crossing structures particularly where it can be determined that the impact is leading to relative population decline, it would be assumed as a mitigation fail. Should this be identified, other provisional options and contingencies will be developed and implemented where research and/or monitoring identifies that additional or alternative measures are required.

Depending on the outcome of the monitoring of fauna crossing structures the following options would be considered in consultation with EPA:

- Maintenance of the existing connectivity measures
- Update design of existing measures where feasible and reasonable
- Consider additional offset measures to improve connectivity elsewhere.

The performance indicators and corrective actions are detailed in **Table 8-6**.

Table 8-6 Corrective actions – connectivity structures

Triggers for corrective actions	Corrective actions	Responsible party for corrective action implementation

• Monitoring surveys undertaken identify no evidence of use of designated connectivity structures by targeted threatened mammal species after three consecutive monitoring periods. • Relative population decline at the impact monitoring sites in proximity to the connectivity structure, compared to the population density at control site. • High levels of structure usage (>25% as per Table 8-1) by exotic predators reported after each monitoring period.	• Review monitoring methods, considering increasing frequency, intensity and duration, to ensure individuals are identified. • Check connectivity structures for damage. Any structure found to be damaged during a maintenance check is to be repaired. Initiate repair works within 5 days of identification. • Investigate habitat adjoining the crossing. Consider improving habitat condition and connectivity. • Consider need for additional fauna furniture/retro fitting existing structures. Where deemed appropriate; work will be completed within six months of identification. • Check fauna exclusion fencing- any fence found to be damaged during a maintenance check is to be repaired. Initiate repair works within 5 days of identification. • Meet with regional pest control stakeholders as soon as practical and contribute to pest control program where reasonable and feasible. • Implement pest control program around crossing structures to reduce pest animal predation where deemed required. After a minimum of three consecutive monitoring periods Roads and Maritime will evaluate if there is a residual impact to connectivity. Unless connectivity measures can be demonstrated to be effective at successfully mitigating the barrier and fragmentation impact to threatened mammal species, the residual impact to connectivity shall be further offset. This is in accordance with MCoA D2. Predator monitoring results will be reviewed after each subsequent monitoring period to review their presence and density. Results will guide discussions with relevant stakeholders and management programs at a regional scale.	• RMS and RMS Ecologist

8.4 Road mortality monitoring

8.4.1 Monitoring goals

- Zero mortality of threatened target mammal species at mitigation sites.

8.4.2 Timing and methods

Monitoring of threatened mammal mortality along the highway would be undertaken during the connectivity structure and population monitoring periods described in **Table 8-4**.

However it should be noted that specific road kill monitoring is not proposed for the Potoroo. It has been recommended this measure be removed as it is not likely to contribute an acceptable amount of information to inform the monitoring program. However if incidental records of Potoroo road kill are found these will be recorded and reported.

The survey would involve walking a transect 250 m either side of the targeted connectivity structure on both sides of the project to collate and identify the number of road mortalities and geographic coordinates for each road kill specimen. Further, surveys for incidental road kill will be undertaken during operation monitoring periods (every three months until complete) and occur during travel between structures to increase survey effort during monitoring. Incidental road kill observations will allow further analysis of areas which fall outside of fenced sections of the carriageway and allow a review of the need to install further fencing or connectivity structures to mitigate fauna vehicular strike. Further, collation of road kill reports from local government authorities, cares, vets and organisations (such as WIRES) where available should be utilised in the monitoring program to aid in identifying any further sections of the road regularly attributable to threatened mammal road mortalities.

The GPS location of each road kill specimen would be recorded and assessed in relation to the closest fauna crossing structure to evaluate its effectiveness. The condition of the crossing structure and fauna exclusion fence in the vicinity of the road kill site would be investigated for any problems or breach and repairs, maintenance carried out as appropriate as described in **Section 7**.

Reliance on this method alone could result in an under-estimation of the number of individuals struck by vehicles. Incidental observations of road mortalities will also be collected by Roads and Maritime during regular maintenance activities. Road kill monitoring proposed meets MCoA D8(g).

8.4.3 Performance indicators and corrective actions

Performance of the connectivity structures in preventing threatened mammal road mortalities would be measured by achievement of a zero rate of vehicle strikes. Detection of small mammal road kill can sometimes be difficult, as most individual animals if struck are thrown far from the road by the collision, or damaged too extensively to be identified. Reliance on this method alone could result in an under-estimation of the number of individuals struck by vehicles. Performance indicators and corrective actions are described in **Table 8-7**.

Table 8-7 Corrective actions – road mortality

Trigger for corrective actions	Corrective actions	Responsible party for corrective action implementation
A single reported road kill of a target threatened mammal species.	• Check fauna exclusion fencing in proximity to road kill for any damage. Any fencing found to be damaged is to be repaired. Initiate repair works within 5 days of identification. • If road kill is found in an area with no fauna exclusion fencing evaluate the need for additional fencing. • If the road kill is found in proximity to a crossing structure check connectivity structure for damage. Any structure found to be damaged during a maintenance check is to be repaired. Initiate repair works within 5 days of identification. • Review habitat adjoining the structure. Consider improving habitat condition and connectivity. • Re-evaluate mitigation measures if target threatened mammals if road mortality to threatened mammal species is observed over three monitoring periods. • Consider additional mitigation measures. After a minimum of three consecutive monitoring periods Roads and Maritime will evaluate if there is a residual impact to connectivity. Unless connectivity measures can be demonstrated to be effective at successfully mitigating the barrier and fragmentation impact to threatened mammal species, the residual impact to connectivity shall be further offset. This is in accordance with MCoA D2.	• RMS and RMS Ecologist

8.5 Habitat revegetation

An UDLP is being finalised for Sections 1 and 2 that deals with landscaping across these areas of the project. Subsequent UDLPs will be prepared prior to construction commencing for remaining stages. This sections deals with habitat revegetation near crossing structures and adjacent to known populations of the targeted species where these have been disturbed during construction and are outside the exclusion fence. The number and location of sites would be determined post-construction with the aim of selecting multiple sites as a minimum around the east and western approaches to connectivity structures including land bridges and a number of plots on top of a land bridge.

8.5.1 Monitoring goal

Evidence of successful habitat revegetation for threatened mammal species adjacent to known populations.

8.5.2 Timing and methods

After the first year of maintenance of habitat revegetation (**Section 7.3.1**), annual monitoring of revegetated areas adjacent to crossing structures and widened medians would be undertaken using a condition assessment approach, modified from the BioBanking assessment methodology (DECC 2008) to evaluate the progress of revegetation against benchmark data for the target vegetation community. Methodologies will also include photo monitoring. These tasks would be integrated into the landscape design for the project, as habitat restoration would benefit a diversity of species. Annual monitoring reports will be submitted by the contractor to Roads and Maritime detailing the success of habitat revegetation.

Annual monitoring of revegetated areas would be undertaken using a condition assessment that evaluates the progress of revegetation by assessing cover of native vegetation and weeds and plant health. Following selection of monitoring sites, a cluster of permanent monitoring plots (20 m x 20 m) would be established in revegetation areas, with the number of plots dependent on the size of the site area. The following would be recorded in each plot:

- Native plant species richness.
- Native over storey cover.
- Native mid-storey cover.
- Native ground cover (grasses).
- Native ground cover (shrubs).
- Native ground cover (other).
- Exotic plant cover.

Monitoring of revegetation areas would commence 12 months after initial establishment and would occur annually (in spring/summer) until success of the revegetation has been demonstrated over three consecutive monitoring periods. The geographic coordinates of plot locations are to be recorded and a photograph taken of the centre of the plot from the south east corner.

8.5.3 Performance indicators and corrective actions

Performance indicators and corrective actions for habitat revegetation are described in **Table 8-8**.

Table 8-8 Performance indicators and corrective actions – habitat revegetation

Trigger for corrective actions	Corrective actions	Responsible party for corrective action implementation
• Greater than 10% of plants have died after first 12 months of maintenance. • Greater than 20% of plants have died after three years of maintenance. • Total weed coverage is more than 30% in revegetation areas.	Review maintenance schedule for revegetated areas. Replace dead plants within specified timeframes. Increase weed control if required or review control methods being used.	Project Contractor

8.6 Nest boxes

The NBMP's for Sections 1 and 2 detail a consistent monitoring approach for nest boxes that will be used across all sections of the upgrade. As the procedures for installation and monitoring of nest boxes relate to a range of fauna species this monitoring methodology will be consistently applied across all project sections.

The finalised NBMP's for Sections 1 and 2 define a monitoring program characterised by bi-annual monitoring every year for the first four years, and followed by bi-annual monitoring every second year for a further four years. During each monitoring event, a visual inspection of each nest box will be conducted to collect data such as occupancy, evidence of use by targeted species, pest species use, condition of nest boxes and maintenance requirements (such as changing the aspect of a nest box to address thermoregulatory considerations) and other general features such as changes to the surrounding vegetation, weather conditions etc.

Refer to the NBMP for more detail regarding monitoring of nest boxes.

8.7 Evaluation, project review and reporting

Detailed threatened mammal reports will be prepared outlining the results of any monitoring undertaken pertaining to the project.

Annual reports would be prepared outlining the results of the targeted surveys and monitoring undertaken pertaining to the project. This may include a separate monitoring report per target species or a combined report for one or more species. A brief annual report would be prepared by the contractor(s) for distribution to the Roads and Maritime and other relevant government agencies (EPA and DoE) for threatened mammals.

The contractor(s) employed to undertake the threatened mammal monitoring would be responsible for the evaluation of the monitoring information collected against performance thresholds.

A final report would be prepared at the conclusion of the monitoring period. This report would incorporate all the results of the monitoring and recommend any additional measures (if deemed necessary) to facilitate the long term survival of the target threatened mammal population in the locality.

9. Summary table and implementation schedule

An overall summary of the actions proposed in the above plan is provided **Table 9-1**. It also identifies the person responsible for the actions and the estimated timing of the project.

Table 9-1 Summary table and implementation schedule of management plan

No.	Task	Responsibility	Pre-construction	Construction	Post-construction (Year and Season)																			
					Year 1				Year 2				Year 3				Year 4				Year 5			
					Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring
1. Pre-construction management																								
1.1	Targeted surveys including mammal surveys.	Roads and Maritime	X																					
1.2	Minimise areas for clearing	Roads and Maritime	X																					
1.3	Confirm crossing structure locations and monitoring sites.	Roads and Maritime	X																					
1.4	Identify habitat exclusion zones	Roads and Maritime	X																					
1.5	Nest box installation (70% prior to clearing)	Contractor	X																					
2. Construction management																								
2.1	Construction work method statement	Contractor		X																				
2.2	Construction induction and training	Contractor		X																				
2.3	Implementation of fauna rehabilitation protocol	Contractor		X																				
2.4	Pre-clearing and clearing procedures	Contractor		X																				
2.5	Crossing structures and widened medians implemented	Contractor		X																				
2.6	Habitat revegetation – UDLP	Contractor		X																				
2.7	Nest box installation (remaining)	Contractor		X																				
3. Operational management																								
3.1	Monitoring of operational mammal mortality	Roads and Maritime			X		X						X		X						X		X	
3.2	Maintenance of crossing structures	Roads and Maritime			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3.3	Maintenance of habitat restoration (until performance objectives are achieved)	Contractor			X	X	X	X	X		X		X		X		X							
3.4	Maintenance of nest boxes	Roads and Maritime Services			X		X		X		X		X		X		X		X					
4. Operational monitoring																								
4.1	Threatened mammal monitoring # Biannual surveys during construction and operation	Roads and Maritime		X	X	X			X	X			X	X										
4.2	Crossing structure monitoring#	Roads and Maritime			X	X			X	X			X	X										
4.3	Road mortality monitoring	Roads and Maritime			X	X	X	X	X	X	X	X	X	X	X	X								

No.	Task	Responsibility	Pre-construction	Construction	Post-construction (Year and Season)																			
					Year 1				Year 2				Year 3				Year 4				Year 5			
					Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring
4.5	Habitat revegetation monitoring (until performance objectives are achieved)	Contractor						X				X				X								
4.6	Monitoring of nest boxes	Roads and Maritime			X		X		X		X		X		X		X		X					
5. Evaluation and Reporting																								
5.1	Evaluation	Roads and Maritime	X	X			X				X				X				X				X	
5.2	Reporting	Roads and Maritime	X	X			X				X				X				X				X	

Note: As per MCoA D8(k), monitoring shall continue until the effectiveness of mitigation measures can be demonstrated to have been achieved over a minimum of three successive monitoring periods (years), unless otherwise agreed by EPA.

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Appendix A – Expert Review and Agency Consultation comments

Summary of recommendations from the expert review and agency consultation, and how addressed in this plan

ID No	Section	Comment / Recommendation	Recommendation has been addressed (Version 1)	How recommendation has been addressed (Version 2)
Expert Review Comments				
1	General	Suggest including more information regarding methods of trapping during the pre-clearance survey.	To be reviewed prior to implementation	The TMMP has been updated to incorporate pre-clearance survey methods. In addition, methods of trapping have been addressed in Table 8-1, 8-2 and 8-3 based on the proposed monitoring programs.
2	General	Recommend further consideration of seasonal factors in pre-clearance surveys.	Adopted - plan to be updated prior to implementation	Targeted pre-construction surveys and seasonality have been addressed in the monitoring program Section 8. Optimal timing for monitoring for each species is included in Table 8-1, 8-2 and 8-3.
3	General	Specific information regarding features and furniture in crossing structures is limited.	Adopted - plan to be updated prior to implementation	The location of crossing structures for threatened mammals and furniture is discussed in Section 6.3.7. Table 6-3 describes the final crossing structure locations and type for Sections 1 and 2 of the project and Table 6-4 outlines draft crossing structures for Sections 3-11. A reference has been added to the Fauna Connectivity Strategy (2015) which contains more detail on fauna crossing structures and furniture for each type of structure.
4	General	Specific information regarding permanent fauna exclusion fencing where there are no designated crossing structures is limited.	To be reviewed prior to implementation	Section 7.2 of the Fauna Connectivity Strategy currently defines the fencing strategy, requirements and chainage for Sections 1 and 2. Fauna exclusion fencing has been finalised for these sections during detailed design and taking into consideration results of supplementary targeted surveys. For remaining sections 3-11 areas of fauna exclusion fencing are to be finalised during detailed design however the TMMP does identify proposed chainages for exclusion fencing for mammals which is detailed in Table 6-2. Roads and Maritime are committed to installing exclusion fencing outside of crossing structure locations where there are confirmed threatened fauna populations where risk of vehicle strike is high. Fauna exclusion fencing for Sections 3-11 will be detailed in a subsequent Fauna Connectivity Strategy for Sections 3-11 and approved by relevant agencies prior to construction commencing.

ID No	Section	Comment / Recommendation	Recommendation has been addressed (Version 1)	How recommendation has been addressed (Version 2)
5	General	Recommend the management plan include provision for additional areas of fauna exclusion fencing and/or adaption of crossing structures or potential crossing structures post-construction, if new "hotspots' are detected post-construction.	Adopted - plan to be updated prior to implementation	The TMMP has been updated to identify locations of fauna exclusion fencing and crossing structures for Sections 1 and 2 and proposed exclusion fencing and structures for Sections 3-11 in Section 6.3.6 and Section 6.3.7. The TMMP does make provision for monitoring and evaluating the effectiveness of these mitigation measures during operation of the project. This is outlined in Table 8-6 associated with crossing structures and Table 8-7 associated with exclusion fencing. If mammals do not appear to be utilising crossing structures or there are road mortalities corrective actions provide for the evaluation of changes to crossing structures where possible, such as addition of fauna furniture, evaluating habitats adjacent to the crossing structure, and evaluating the need for additional exclusion fencing.
6	General	Recommend that predators be monitored and predator control undertaken in locations where activity is detected for the duration of the monitoring program.	To be reviewed prior to implementation	Section 7.3.4 of the TMMP addresses predator monitoring stating that, *should monitoring demonstrate wild dogs, cats or foxes to be predating on threatened mammals or inhibiting mammal movement through the crossing structures, Roads and Maritime would engage with the Northern Rivers Catchment Management Authority, OEH (Parks and Wildlife Grafton), and Rural Lands Protection Board (North East) and adjacent landowners to identify and implement strategies to reduce this predation risk.*
7	General	Consider more targeted monitoring of road kill.	Adopted - plan to be updated prior to implementation	Road mortality monitoring forms part of the overall monitoring program (as described in Section 8.4) and has been undertaken as part of targeted baseline surveys. This monitoring occurred in proximity to monitoring sites and between sites. Road kill monitoring is undertaken along the existing roadway to inspect for all dead wildlife on the carriageway or within 3m of the road verge. Results of road kill monitoring for the threatened mammal species Rufous Bettong, Brush-tailed Phascogale and Long-nosed Potoroo are summarised in Section 2 of the TMMP. The baseline survey for the Long-nosed Potoroo recommended removing road kill monitoring for this species as it did not contribute sufficient information to the program which has been adopted by this plan. The baseline surveys for Bettong found that road kill transects and nocturnal drive transects provided very low detection rates. Whilst this is still arguably a result and one that forms the preconstruction baseline dataset, it was originally expected that higher rates of detection would have been achieved. It was recommended road kill monitoring be retained for Bettong to allow future comparisons because fauna fencing will be one of the primary mitigation devices.

ID No	Section	Comment / Recommendation	Recommendation has been addressed (Version 1)	How recommendation has been addressed (Version 2)
				Road kill monitoring for Phascogale confirmed two individuals were hit by vehicles during the baseline surveys. Road kill surveys will be continued for this species. Roads and Maritime will also maintain a register of road kill for the entire project during construction and operation of the project. This will assist to monitor which species are being injured or killed by vehicles, and the locations they are found. This will then inform a review of mitigation measures and appropriate corrective actions.
8	General	Ensure offset areas support populations of the species confirmed to occur within the project area	Adopted - plan updated	
9	Appendix K TMMP p8 Long-nosed Potoroo	Long-nosed Potoroo: The only known population is in the Wardell heath (Section 10). However, in Table 2.1 it is listed as occurring in Sections 1-3 and 6-11. Should this be addressed in the management plan?	Adopted - plan updated	Targeted Potoroo surveys post the draft TMMP findings have shown that Potoroos are not known to occur in Sections 1-3 of the project. Going forward target areas for this species will be Sections 6, 7 and 10. Habitat mapping for Potoroo is provided in Appendix G.
10	Long-nosed Potoroo	Long-nosed Potoroo: Exclusion fence all potential wet and dry heath habitats bordering the highway footprint in the Wardell heath area	To be reviewed prior to implementation	Wardell heath area is in Section 10. The TMMP has been updated to reflect findings from the pre-construction targeted surveys including records of Potoroo in Section 10. The location of fauna exclusion fencing has been finalised for Sections 1 and 2 with 26km of the 28.5km being fenced. This is outlined in Section 6.3.6 of the TMMP. Future areas of exclusion fencing (including for Long-nosed Potoroo) will be finalised as part of detailed design for remaining sections taking into account the results of baseline surveys. However proposed areas of exclusion fencing for mammals is detailed in Table 6-2 including in the vicinity of Wardell heath. The Wardell heath area is acknowledged as important habitat for the species and the extent of fencing and crossing structures will be finalised during detailed design.
11	Long-nosed Potoroo	Long-nosed Potoroo: Overpasses for this species in Wardell heath area to be planted out with a continuous cover of dry heath species which occur in the surrounding areas	Adopted - plan to be updated prior to implementation	Section 6.3.8 addresses habitat revegetation including revegetation proposed around dedicated fauna overpasses. A dedicated fauna overpass is proposed in proximity to the Wardell heath area and appropriate native vegetation (including dry heath species) from the adjacent area and habitat features will be planted on the overpass as well as adjacent either side to encourage the use of fauna species, including the potoroo.

ID No	Section	Comment / Recommendation	Recommendation has been addressed (Version 1)	How recommendation has been addressed (Version 2)
				More specific detail pertaining to the revegetation and species to be used will be included in the Urban Design and Landscape Plan to be prepared for this section of the project.
12	Rufous Bettong	Rufous Bettong: The management plan should address the potential for this species to occur outside of forested habitat.	Adopted - plan to be updated prior to implementation	The occurrence of this species outside of forested areas has been detailed in Section 4.1.1 of the updated TMMP.
20	Rufous Bettong	Rufous Bettong: The plan should include initial findings of the monitoring program for this species in the Glenugie Upgrade, even if it is just initial observations and thoughts by the ecologist involved	Adopted - plan to be updated prior to implementation	This cannot be addressed in the updated TMMP at present as results from monitoring associated with the Glenugie Upgrade are not due to be provided until 2015. As results of monitoring become available they will inform the monitoring program and methods for W2B.
21	Rufous Bettong	Rufous Bettong: If possible, consider pre-construction monitoring in hot spots, particularly in the Pillar Valley (Section 3) and Tyndale to Harwood (Section 4) where the species also occurs in other habitats than forested vegetation types: rank grassland in cleared/semi cleared pasturelands (in former) and rank grassland in sugar cane plantations (latter)	Adopted - plan to be updated prior to implementation	Pre-construction surveys for the Rufous Bettong have been undertaken and the TMMP has been updated to indicate the location of final monitoring sites in Section 8.2.2.
22	Brush-tailed Phascogale	Brush-tailed Phascogale: Design of nest boxes and instalment methodology should follow other projects where they have been successfully used.	Adopted - plan updated	

ID No	Section	Comment / Recommendation	Recommendation has been addressed (Version 1)	How recommendation has been addressed (Version 2)
23	Brush-tailed Phascogale	Brush-tailed Phascogale: Need to avoid undertaking pre-clearance surveys or monitoring during the male die-off period: after the mating period which occurs in May and June, plus the following months when only adult females are about until late spring/early summer. Therefore recommend trapping in summer (January) and autumn (March-April)	Adopted - plan to be updated prior to implementation	These recommended dates for monitoring have been included in Table 8-2 of the updated TMMP. The pre-construction baseline surveys for the Brush-tailed Phascogale have been completed. Survey methods included spotlighting, road kill transects, arboreal traps and camera traps. Surveys were undertaken in February and March 2014 then April and May 2014. Future monitoring surveys will also be undertaken in these recommended periods.
24	Spotted-tailed Quoll	Spotted-tailed Quoll: Habitat exclusion zones for this species should consider low escarpments traversed by the project area which may be used as den sites. Recommend that the detailed design include additional habitat inclusion zones in such areas if data indicate the presence of quolls.	Adopted - plan to be updated prior to implementation	The TMMP has been updated to include references to habitat exclusion zones for Spotted-tailed Quoll in Section 5.4.2 that may include low escarpments.
25	Spotted-tailed Quoll	Spotted-tailed Quoll: As this species has not been confirmed to occur in the project area even if occasional individuals are present it will be very difficult to establish meaningful monitoring sites and investigate population trends.	Adopted - plan to be updated prior to implementation	The suggestion has been acknowledged in the overview of pre-construction surveys undertaken for the Spotted-tailed Quoll, Section 2.2.4.

ID No	Section	Comment	How recommendation has been addressed (Version 3)
Department of the Environment (review of Version 2)			
1.	General	The Department notes that while this plan appears to cover the Potoroo, RMS has stated that a revision of the plan with further updates for this species will be submitted at a later date. While comments are provided on the species below, the Department notes that these may be covered in the later version of the plan, and that this revised plan will address the species in Sections 5, 6 and 10.	This TMMP does include the Potoroo as a relevant species and where information is available from the first round of targeted surveys this has been included. Supplementary baseline surveys for the Potoroo have been completed in mid 2015 and the TMMP has been subsequently updated Section 2.1 now summarises all surveys that have been completed post SPIR for Long-nosed Potoroo and results. The latest survey report for Potoroo is included in Appendix F. Summary of results includes where records were found, activity levels at each monitoring site, location of final monitoring sites and monitoring methods going forward.
2.	General	Given the new information about specific occurrences of these species, the Department notes that the plan still includes relatively general information about site specific mitigation measures proposed and still defers some of the key mitigation measures to other sub plans (e.g. location of fencing, habitat vegetation, and erosion and sedimentation measures to be implemented). The Department considers that if key mitigation measures are to be deferred to sub plans, this plan needs to set the standards that these sub plans must meet and should include key commitments the sub plans must adhere to. This would then provide confidence that mitigation measures will effectively reduce the level of impacts to threatened mammals.	It is considered appropriate that for some mitigation measures the TMMP refer to more specific and detailed sub plans as that is, or will be, the primary document. For example this may be a Fauna Connectivity Strategy, Revegetation Plan or CEMP. All applicable mitigation measures to be adopted for threatened mammals are outlined in this TMMP and where applicable a reference is made to a separate sub plan as to where further detail will be provided. Additional wording has been included in this TMMP to outline where possible what the mitigation measure will entail and then refer to the sub plan and relevant section for more detailed information on that particular mitigation measure/s. It is also noted a number of these sub plans have been prepared to meet approval conditions such as the Fauna Connectivity Strategy.
3.	General	The Department requests that maps identifying the location of potential/known habitat for the Potoroo be included as part of this document. The impact area also needs to be clearly stated now that the additional surveys have been undertaken.	Habitat mapping for Potoroo has been prepared to support the W2B Offset Strategy. This habitat mapping was prepared by Ben Lewis and is provided in Appendix G.
4.	General	There seems to be confusion in the plan between performance thresholds and triggers for corrective actions. Performance thresholds are thresholds that are trying to be met and for which deviation from these thresholds would result in corrective actions being implemented (as is written in the headings of tables within the document).	The headings and wording has been updated to reflect the changes recommended.

ID No	Section	Comment	How recommendation has been addressed (Version 3)
		On the other hand triggers for corrective actions are negative outcomes which would trigger corrective actions. Currently the majority of the actions/statements under the performance measures heading are actually triggers for corrective actions. Therefore, as currently written, deviation from these measures, which would trigger corrective actions, would in effect result in corrective actions being implemented when the desired outcome is being achieved. The actions under the heading or the terminology used in the heading needs to be amended to address this inconsistency.	
5.	General	The Department recommends that additional information regarding the methodology used in surveys, the location of surveys, and the data recorded be provided to ensure the robust replication of these surveys as part of the ongoing monitoring (see for example the water quality management plan). For example, the term "activity levels" is used and different activity levels discussed in the long nosed potoroo survey document, but how these were measures and the basis for scoring activity levels is not detailed. This makes this measure impossible to replicate in the ongoing surveys. The description of the goals, performance measures, and corrective actions linked to the ongoing monitoring using the BACI methodology also needs to be clearly articulated to ensure that this monitoring achieves its intended outcomes. These goals may also need to be tailored to the specific subject species. The document currently states that corrective actions would only be implemented where population declines can be attributable to the poor performance of crossing structures (see section 8.2.1 and 8.2.4, and table 8.2). This decline could be as a result of a number of aspects of the highway, including the crossing structures, fencing, and the impact from clearance or edge effects (etc). The Department considers that should a decline be identified at impact sites and not at control sites, then the decline must be attributed to the highway (rather than a specific aspect of the highway), unless it can be demonstrated otherwise. Please provide further justification to support that sufficient paired sites have been established to generate sufficient baseline data and statistically robust results to determine changes to populations (see for example page 17 and 52), and that these surveys have generated sufficient baseline data.	More detailed descriptions of survey methodologies and scoring for baseline monitoring have been included in Section 2 and Section 8. References to the technical reports in Appendices have also been retained as these documents will form the primary reference for what was undertaken. The descriptions of the goals, performance measures, and corrective actions linked to the ongoing monitoring using the BACI methodology have been more clearly detailed in Section 8. Where a particular goal, performance measure or corrective action is species specific this detail has also been added. Plan updated in reference to declines in populations being attributed to the highway unless proven otherwise. The technical report (Appendix E) provides information and justification for the robustness of the monitoring sites and data for Phascogale and Bettong. Five paired sites have been established for Bettong with the species being recorded at four of the five impact sites and four of the five control sites providing a good baseline level of activity. Some sites recorded high activity levels at 57%. Seven paired sites are established for Phascogale with the species recorded at 80% of impact sites and 100% of control sites using the updated survey techniques. Camera traps were found to be detecting more species than arboreal tree traps. Also by adopting a variety of monitoring techniques in the monitoring program going forward this will increase the detection rate e.g camera traps, spotlighting, nocturnal drive transect and road kill surveys. Guided by the need to provide a reliable survey technique which can measure change in the population from one survey period to the next it was proposed that camera traps be given the highest priority and that the existing sampling strategy be retained (i.e. 36 traps on a 600 x 600 m grid for 14 nights).

ID No	Section	Comment	How recommendation has been addressed (Version 3)
			For Phascogale recommendations made by Lewis Ecological is to incorporate both the Bettong BACI sites into the future post construction monitoring program whilst retaining some arboreal trapping but in an increased capacity (25 traps on a 4-5 ha grid) at the paired sampling sites of Site 1A (ch.25480) and 1B (Yuraygir SCA), Site 5A (ch.116400) and 5B (Jackybulbin Conservation Park) simply because the mitigation devices at these locations are aerial rope crossings and no camera trapping data is available for all of these locations. The differing survey technique should not present too much of a problem apart from limiting the power of any future statistics as the seven paired sites will be comprised of five sites which rely on cameras will have culvert mitigation treatments whilst the two remaining sites will have aerial crossing treatments. Potoroo baseline surveys are now complete. All findings are now incorporated into Version 3. Seven BACI sites have been finalised for Potoroo and monitoring will consist of camera traps.Baseline data for Bettong, Phascogale and Potoroo is presented in Section 8 of the TMMP.
6.	Condition D2 - Connectivity	The Department notes that this plan is proposed to meet some of the requirements of condition D2 (as per the table in the beginning of the document). The Department notes that the justification for the location and design of connectivity measures, based on the results of the further surveys is not provided. Rather, the connectivity measures as originally proposed in the EIS are presented. This issue is also relevant to the BACI monitoring locations for the Long nosed Potoroo, which appear to be based on the predetermined locations of connectivity structures from the EIS, which were proposed prior to the Potoroo being found to occur in these areas. Reassessment of the suitability of the location and number of structures based on the survey results is required, as per the conditions of approval. Sub condition e regarding service roads is not addressed; sub condition h, location of proposed fencing not provided. A discussion and/or commitment to further offsets should connectivity be lost in key locations is also required, should sufficient justification of design, location and frequency of proposed structures, based on the recent surveys undertaken, not be provided.	Connectivity structures have now been finalised for Sections 1 and 2. These were informed by survey results and final engineering design. Government agencies were provided opportunities to review the proposed connectivity measures during finalisation of the Fauna Connectivity Strategy (Sections 1 and 2). The Fauna Connectivity Strategy outlines justification for the location and design of these crossing structures. Connectivity structures for Sections 3-11 are only proposed at this stage and are summarised in Section 6.3.7. They will be finalised during detail design and also will be submitted to agencies for comment and approval as part of a subsequent Fauna Connectivity Strategy for Sections 3-11. BACI sites have been chosen by Lewis Ecological for the Potoroo and their location is justified within the final report (Appendix G). Further information regarding known areas of exclusion fencing for Sections 1 and 2 and proposed exclusion fencing for Sections 3-11 is provided in Section 6.3.6. Further offsets to be considered should connectivity be lost and no more structures can be built. Additional wording and corrective actions have been included in Table 8-5 and Table 8-6.

ID No	Section	Comment	How recommendation has been addressed (Version 3)
7.	Condition D8	Sub condition a - Currently, no reference is made to the Mitigation Framework in the Plan. While additional surveys have been undertaken, further information is required to demonstrate the adequacy of these surveys, as required by this condition and how the requirement of density, habitat use and movement patterns have met by the surveys. Sub condition d - Further justification of the monitoring periods proposed is required to address the requirement of this condition. For example, on page 56 biannual population monitoring is proposed. Justification is required as to why the frequency of monitoring proposed throughout the plan would be sufficient, based on the requirements for each species. Sub condition k - The commitment to undertake monitoring until such time as the use and effectiveness of mitigation measures can be demonstrated to have been achieved over a minimum of three successive monitoring periods for the monitoring proposed must be included in this plan. For example, on page 47, maintenance of revegetation is only proposed for three years, on page 49 nest box monitoring for 5 years, and on page 56 population monitoring is proposed for 3 years. Sub condition f - Further updates to the plan are required to ensure mitigation measures, thresholds and corrective actions are specific and time bound. For example, on page 48 in section 7.3.2, the use of the term 'periodic' monitoring must be defined, and the choice of the frequency of the monitoring proposed justified. Another example is the corrective actions proposed in table 7.3, which are not time bound. Further examples are discussed below.	Stronger connections to the Mitigation Framework have been made in the Plan where necessary. The Mitigation Framework is a summary document that outlines the targeted surveys which have taken place and the guidelines they have complied with, as well as changes that have been made to the management plans post approval. Justification of monitoring frequency for Phascogale and Bettong has been given based on behavioural characteristics. Section 8 has been updated to include the statement that monitoring will continue until such time as the use and effectiveness of mitigation measures can be demonstrated to have been achieved over a minimum of three successive monitoring periods. Monitoring frequencies have been justified based on seasonal, breeding and habitats of target species. For example the monitoring of nest boxes has been finalised and agreed with agencies as part of the Nest Box Management Plans. Therefore there may be some variances in monitoring frequency and timeframes. Where possible through the plan more time specific information has been included for actions such as monitoring or corrective actions.
8.	Page 20	The Department considers that this page should be updated to note the Spotted-tail quoll road kills that have been recorded at Glenugie and Devil's Pulpit Pacific Highway Upgrades. The absence of this information was noted on a previous version of this plan during the assessment of the project.	Road kill records for Spotted tail Quoll in proximity to the project have been included in report in relevant sections.
9.	Page 20	The Department notes and agrees with the conclusion made that the Spotted-tail Quoll occurs at too low densities to undertake the detailed population monitoring. Road kill and connectivity monitoring is still required, as well corrective actions to be implemented should the species be recorded as road kill and/or not using installed connectivity measures.	Road kill monitoring surveys and corrective actions include all species. However specific road kill monitoring is not proposed for Potoroo.

ID No	Section	Comment	How recommendation has been addressed (Version 3)
10.	Page 23	The table states that further surveys need to be undertaken to determine the extent of impact to suitable habitat for the Long nosed potoroo. The Department requests that this information be provided as part of the revised version of the plan that will cover the Potoroo, as the impact to the species will need to be clearly identified in this plan.	Long-nosed potoroo habitat mapping has been prepared and is provided in Appendix G. The total extent of clearing to Potoroo habitat for the project is 49.32ha.
11.	Page 23	It is stated that no suitable habitat will be impacted by Section 10. This is not consistent with information in NSW's assessment and the information available to the Department. Please provide further justification based on the further surveys undertaken to support this statement, or amend as necessary.	This wording has been amended. Section 10 does contain Potoroo habitats and the TMMP now reflects this.
12.	Page 26	This page should also refer to the ongoing surveys that have occurred in the JALI lands in section 10, and the important status of this population. This is noted in the attached site survey and selection study and should also be addressed here. As stated above the Department understands that this update may occur as part of the later version of the plan.	The JALI lands in Section 10 have now been discussed in relevant sections of the report including Table 3-1.
13.	Page 27	As discussed above, please reconsider the statement regarding habitat impacts at section 10.	Plan updated to discuss impacts as per the comment above.
14.	Page 28	The Department recommends that the location for fencing, particularly in known key habitat/wildlife corridors or near known populations needs to be finalised and included as a part of this plan.	Specific references from the Fauna Connectivity Strategy for Section 1 and Section 2 have now been inserted in Table 6-1. Proposed fencing locations for mammals between Sections 3-11 have also been included in Table 6-2. Fencing has been finalised for Sections 1 and 2 therefore is included as part of this plan but it should be noted fencing locations for Sections 3-11 are draft and may be refined during detailed design. The final fencing locations for Sections 3-11 will be included as part of the Fauna Connectivity Strategy.
15.	Page 33	The Department understands that ancillary sites have already been identified and that the level of impacts to threatened mammals is already understood for these sites. More specific information from the ancillary plan document, or reference to where this information can be found should be included.	Table 2-1 summarises surveys that were undertaken during the EIS and SPIR phase. The table includes a reference to surveys and a supplementary report that were completed associated with assessing proposed ancillary sites for the project. This supplementary report was provided to the Department of Planning and Infrastructure in December 2013 as a consolidated document of information pertaining to proposed ancillary sites and an assessment against the criteria developed in how ancillary sites should be located to avoid environmental impacts.

ID No	Section	Comment	How recommendation has been addressed (Version 3)
			Section 6.3.4 and Section 6.3.5 also discuss ancillary sites and measures that will be taken to ensure they are located in areas to avoid vegetation clearing and environmental impacts. Only some ancillary facilities have been identified, specifically Sections 1 & 2. Therefore a broader commitment is made by Roads and Maritime that any ancillary facilities will be located outside of threatened mammal habitat where practical and will avoid clearing of vegetation.
16.	Page 34 – section 5.4.1	The Department recommends that this section includes further information and justification about the fence design, length and location, based on the requirements of the specific threatened mammals targeted.	Specific references from the Fauna Connectivity Strategy for Section 1 and Section 2 have now been inserted in Section 6.3.6. The Fauna Connectivity Strategy is the primary document for information regarding fencing and crossing structures.
17.	Page 34 – section 5.3.2	Further information is required about the basis for choosing the exclusion zones and their locations for each threatened mammal, based on species specific information. This issue also applies to table 6.3.	Exclusion zones are addressed in Section 5.4.2 and additional clarification wording has been included to explain how exclusion zones will be identified and enforced.
18.	Page 35 – section 6.2	Please clarify the sentence "no damage to threatened mammal habitat outside the project exclusion zone". Should this be referring to outside the clearance footprint?	Original wording was unclear, wording updated. The intent was that there will be mammal habitats identified during pre-clearance surveys by suitably qualified ecologists and habitats outside the clearing footprint will be marked/fenced as exclusion zones prior to clearing. No clearing will occur outside the marked areas.
19.	Page 35 section 6.3.1 and 6.3.9	Reference is made to the detail of measures being included in SWMS. The Department recommends that key commitments and outcomes need to be included in this plan to meet the requirement of the conditions of approval.	A SWMS has not been prepared at this stage and would likely be associated with the preparation of a CEMP by the construction contractor. The key commitments and mitigation measures outlined within the pre-construction and construction components of this management plan must be included in the CEMP/SWMS.
20.	Page 45 – Table 6.3	The content of this table still needs to be revised to meet the SMART principles, particularly relating to the timeliness of the actions proposed. For example, for the mitigation goal of recovering all threatened mammals from hollows, the performance measure is stated as being low mortality rates maintained. What timeframe and scale is this measured across? Per day? In total? For the length of the whole upgrade? This issue also applies to other parts of the table, including for road kill measures.	Table has been updated to be more specific and measurable.

ID No	Section	Comment	How recommendation has been addressed (Version 3)
21.	Page 45 – Table 6.3	The Department recommends that the corrective action for the construction of connectivity structures, must include an action to retrofit additional structures or to provide an offset to compensate for the loss of connectivity (and a commitment to a timeframe), as is required by the conditions. This should also be added in table 7.3 on page 50.	Roads and Maritime will review the effectiveness of connectivity structures as part of the monitoring program. If they are not proving to be successful then corrective actions will be considered. A corrective action may be to try different furniture or change a connectivity structure where possible. However it should be noted there will be constraints once construction has been completed to add or retrofit additional structures. Therefore if it is deemed that connectivity has been lost after a specified timeframe, and no further mitigation can be done, then additional offsets will be provided. Table updated to reflect the commitment to review connectivity structure locations or offsets should connectivity or population decline be identified.
22.	Page 45 – Table 6.3	Please update the table to include a discussion of weed management and fauna fencing.	Table updated to include these measures.
23.	Page 46 – Table 6.3	Please update the mitigation goal for rehabilitation to relate to the outcomes of rehabilitation rather than the action of updating a plan. Please clarify the location of proposed rehabilitation now that detailed surveys have been undertaken.	Table updated to address rehabilitation goals. The specific location of rehabilitation is being finalised. The primary document for identifying areas of rehabilitation will be the UDLP.
24.	Page 47	Mitigation goals – the Department recommends that these goals need to address the impacts listed in section 7.2 The Department recommends that a goal for edge effects be included, as well as a goal that fauna fencing is installed in locations and designed so that incidents of road kill for threatened species is prevented, and a similar mitigation goal for connectivity structures.	Relevant mitigation tables updated to address edge effects and fauna fencing recommendations.
25.	Page 48	Please include further information regarding the length, design and location the fauna fencing for each threatened species as per the independent expert's comment.	Fauna fencing has now been finalised for Sections 1 and 2 and described in Table 6.1. Proposed fauna fencing for mammals between Sections 3 – 11 is described in Table 6.2. Specific fencing locations for Phascogale has been defined as this species requires additional fencing specifications. The design of fencing is summarised in Section 6.3.6 and also more detail is provided in the Fauna Connectivity Strategy for Sections 1 and 2.

ID No	Section	Comment	How recommendation has been addressed (Version 3)
26.	Page 50 – Table 7.3	The Department recommends that this table be updated to include the information requested in comment 24 above, for example, addressing the effectiveness of fencing and crossings, measuring the use of crossings and the number of road kills, and triggering the requirement to retrofit or offset, if required.	Specific references to the Fauna Connectivity Strategy and specific sections of this document have been copied over to the plan. This can only be completed for sections 1 & 2 as these have been finalised. Additional wording has been added to reference additional offsets will be provided where connectivity for mammals is proven to be unsuccessful.
27.	Page 58, table 8.2	The corrective actions in this table are not actions. To provide confidence that corrective actions will actually address an impact, these need to be amended to be actions that are clearly committed to and result in an improved outcome (e.g. further fencing, retrofitting structures, offsets to compensate for the decline etc). The independent expert's comments on the original monitoring plan proposed in the EIS have illustrated this issue in other plans and may provide further guidance to assist in addressing this.	Table has been updated to make corrective actions more outcome based.
28.	Page 58, section 8.3.2	Please confirm the selection of underpasses that are over 50 metres for monitoring. Is this because the threatened mammals targeted by this plan have already been confirmed to use crossings under 50 metres?	Reasoning for targeting crossing structures of more than 50 m has been included into the plan. The objective was to provide meaningful data to confirm usage of structures of that length or greater. As there is already quite a lot of data on the usage of fauna structures at lower lengths eg 20, 40m monitoring them again will not be adding to the knowledge base. Targeting the 50m or greater lengths aims to provide meaningful data on how these structures are used by fauna.
29.	Page 59	The corrective actions in this table are not actions and it is recommended that these be revised (this is also an issue in other tables, including table 8.5). Please include a discussion in this table regarding further fencing, changing mitigation measure, or offsets if a decline is found. Both the corrective actions and performance measures should also be amended to meet the SMART requirement and the use of clear terms is required. For example, 'use' must be defined.	Corrective actions in this table have been clarified and, as such, now address the SMART requirements.
30.	Page 60	Road kill monitoring – the Department recommends that monitoring in unfenced areas with suitable habitat present (and areas that have no connectivity structures) is also required to ensure that these measures are actually placed in optimal locations. Please clarify how often road kill monitoring is proposed.	Road kill monitoring is outlined in Section 8. It will consist of monitoring in proximity to crossing structures, it will also include monitoring for road kill between crossing structures as well as incidental observations during operation of the highway. Road kill monitoring will occur twice per year to coincide with population monitoring. Please note specific road kill monitoring is not proposed for Potoroo.

ID No	Section	Comment	How recommendation has been addressed (Version 3)
31.	Page 68	Comment 7 – in the response to this comment, it is noted that road kill monitoring is no longer proposed for the long nosed potoroo, based on the findings of the surveys. While the Potoroo survey document states this, the plan itself has not been updated to reflect this issue. The Department requests that this be clarified in the revised version of the plan.	The TMMP identifies in Section 2.2.4 that post the first round of baseline surveys for Potoroo the ecologist recommended road kill monitoring not be continued as it doesn't contribute an acceptable amount of information to the program. It should be noted that the monitoring section Section 8.4 outlining road kill monitoring has now been updated to include wording that clarifies specific road kill monitoring will not apply to Potoroo. Potoroo road kill will be reported if incidental sightings are made.
32.	Section 2.1, 5.3 Section 2 pg 19.	The department notes that A subsequent update of this TMMP will occur in 2015 post the completion of potoroo surveys, and approval will be sought prior to commencement of Sections 3-11. The level of surveys undertaken for sections 1 and 2 are satisfactory.	Noted
33.	Section 4,5,6,7	The document needs to clearly address who will be responsible for the implementation of corrective actions. To remedy this The department recommends the addition of a table which includes columns for; Species, Potential Impacts, Mitigation measures, Desired outcome, monitoring, Triggers for corrective actions, responsible parties. Tables containing this information for the pre-construction (section 5), construction (section 6), and Operational phases (section 7), would make adherence to Condition 11, D8(f) and 11, D8(d) clear, whilst also providing confidence that mitigation measures will effectively reach desired outcomes for threatened species.	Updated, all sections now include a responsible party column for the implementation of corrective actions. This information was provided in Table 9.1 at a high level prior to the update.
34.	3.3 Appendix E. Section 7.	At present there is not a detailed strategy to address Pest Management included in the TMMP. As recommended in Appendix E section 7 of TMMP, the Department recommends the pro-active implementation of a pest control program by RMS to ensure protection of threatened mammal species.	Updated Section 7.2.4, Tables 4-1, 7-3 and 8-5 to reflect pest monitoring results to be reviewed after each monitoring event not after 3 years.

ID No	Section	Comment	How recommendation has been addressed (Version 3)
		The current triggers for corrective action state that if pest species are detected after 3 three successive monitoring periods then action will commence. Since any threatened mammals will be required to traverse these sites the Department would prefer corrective actions be implemented sooner.	
35.	Table 8-5 pg 72	Table heading still states "performance thresholds" where it should state "trigger for corrective actions"	All tables in Section 8 have the headings "Triggers for corrective actions" and "Corrective actions" except for Table 8-7 which has been amended.
36.		Given the likelihood of Potoroos to occur in the area once the habitat is regenerated after the fire in August 2014, we suggest inclusion of the Potoroo into the monitoring program.	Included words within Section 2.1: ; however, it should be noted monitoring survey methodologies for crossing structures should suffice to detect Long-nosed Potoroo through the use of camera trapping methods.
Additional DoE Comments 14/08/2015 (review of Version 3)			
1.	Section 4.4, Table 4.1, pages 38-39	Why has the 'responsible party for corrective action implementation' column been removed from the table?	It was realised the column is not relevant for this table. Responsible parties for corrective actions are outlined in subsequent sections for each project phase (such as Table 6-5). The purpose of Section 4.4 and Table 4.1 is to provide an evaluation of where previous mitigation measures have been implemented on other projects and their effectiveness.
2.	Section 6.4, Table 6.5, page 63	What is the proposed frequency of monitoring waterbodies created during construction for presence of cane toad tadpoles?	The monitoring action proposed is "to monitor water storage areas created during construction for Cane Toad tadpoles". A monitoring frequency of once per month during construction has been included. This monitoring is likely to occur in conjunction with the monitoring of compensatory ponds and water quality for threatened frogs within the Threatened Frog Management Plan. The frequency is based on a cane toad tadpole life cycle can be as little as 3 weeks in highly favourable conditions (e.g. tropical nth qld) and up to 20 weeks in less favourable conditions (e.g. temporate NSW/SEQ in mild spring/autumn weather) (Australian Museum, 2015).

ID No	Section	Comment	How recommendation has been addressed (Version 3)
3.	Section 8.3.2, page 81	Why has monitoring of overpass structures been removed from this section?	Roads and Maritime are still in the process of finalising crossing structures for Sections 3-11. Initial indications following design workshops/meetings with EPA and koala experts is that overpass structures nominated in the EIS/SPIR are likely not to be required and more than likely to be replaced by other crossing types. To avoid confusion and reflect current thinking it was decided to remove reference to overpass structures in the updated Threatened Mammal Plan. However as a final decision has not been made it is proposed the following wording be reinserted: "Should overpass structures be installed between Sections 3 to 11 that facilitate movement of the target mammal species, at least one impact monitoring site will be installed at the overpass location to monitor and evaluate the usage of these structures by the target mammal species." Currently in the Threatened Mammal Plan there are a number of crossing structures proposed to be monitored. Table 8-4 summarises for each target species the monitoring site locations, including impact monitoring sites and if they are in proximity to a crossing structure. For the Long-nosed Potoroo a few impact monitoring sites are at proposed overpasses in Section 7 and Section 10.

NSW Department of Planning and Environment (review of Version 2)			
1.	General	Review for table reference errors, and review numbering of D8 sub-conditions.	References in Table 1-1 have been revised.
2.	General	Have up-to-date constraint maps been prepared that identify affected habitat?	Not for all species. Habitat mapping has been prepared for the Potoroo and Spotted tail Quoll to support finalisation of the W2B Offset Strategy. Additional information on the Potoroo has now been incorporated into Version 3 of the TMMP. Habitat mapping has not been prepared for the Phascogale and Bettong. Figures have been included as to where records of the Potoroo, Bettong and Phascogale species have been found in the project area which has inturn informed the location of mitigation measures such as exclusion fencing. Habitats for these species will be confirmed and marked during pre-clearance surveys and exclusion areas established.

ID No	Section	Comment	How recommendation has been addressed (Version 3)
3.	Glossary and abbreviations	Mitigated site should be defined here, given its importance to monitoring and performance indicators (see eg. section 8.2.2)	"Mitigated site" isn't used in the TMMP. Section 8.2.2 discusses monitoring sites therefore a definition of monitoring sites (being impact and control sites) has been included in the Glossary.
4.	Page 10	Is the update required to reflect all summer Long-nosed Potoroo surveys or just the February 2015 work (cf. page 16)? If the latter, this should be revised… unless the update is intended to form part of the final plan.	The last update to the TMMP has now been completed (Version 3) to summarise and incorporate the 2014/15 Potoroo baseline surveys. Surveys were completed in November 2014 and January 2015 (Baseline Survey 1) and April and May 2015 (Baseline Survey 2).. This update forms the Final TMMP and will be provided to EPA, DP&E and DoE for approval.
5.	Sections 2.2.2 and 2.2.3	The Department reiterates that adequacy of survey effort is a key requirement of the conditions. As such, further discussion would be useful to clarify, specifically, how the mid-2014 surveys avoided the issues identified for the initial Rufous Bettong and Brush-tailed Phascogale surveys.	Survey effort for Phascogale and Bettong have now been determined as adequate by a suitably experienced ecologist Ben Lewis. The report and findings are detailed in Appendix E. The second round of surveys adopted some different techniques as well as established some additional impact and control sites. It was found the camera traps were more successful in detecting Phascogale and Bettong. Therefore going forward a combination of survey techniques will be utilised to maximise results including camera traps, spotlighting, night drive transects, road kill transects and arboreal tree traps.
6.	Section 2.2.4	On a similar note to the above, this section essentially provides a link between the 2014 monitoring methods and that proposed in Chapter 8 (for instance, see discussion of Rufous Bettong survey duration). It would be useful guidance for this section to make the lessons learned more explicit.	Additional Section 2.2.2 has been included to summarise learnings and discuss amendments to survey efforts.
7.	Section 3.3	It is noted that Cane Toads may poison the Spotted-tail Quoll; what is the management response to this? Also, what is the likelihood of this being an issue on the project?	There is anecdotal evidence cane toads may poison Quolls. Cane toads are mentioned in the impact and mitigation sections of this TMMP. Roads and Maritime through preparation of the CEMP and FFMP will identify measures that can be taken to minimise the presence and breeding of cane toads in the Project boundary. This may include managing ponds to minimise access by cane toads or breeding habitat and removal of cane toad tadpoles.
8.	Section 6.3.9	This discussion is quite generic, and would benefit from a more direct link to the relevant sub-plan and/or discussion of particularly water management/monitoring principles.	Water quality methodologies, measures and standards have now been described in more detail in the relevant sections. A reference to the relevant sub plan has also been retained as this will be the primary document for managing water quality and water quality monitoring.

ID No	Section	Comment	How recommendation has been addressed (Version 3)
9.	Section 6.3.10	This should be updated to reflect the approved nest box plans.	Reference to the Nest Box Management Plans have been included and a summary of information provided in these plans. NSW Secretary of Department of Planning and Environment approved Nest Box Plans for Sections 1, 2, 4 & 5, 8 & 9, 10 & 11 on 16 January 2015 and plans for sections 3, 6 & 7 approved on 17 February 2015.
10.	Section 7.3.2	What constitutes a 'hot spot', and what is the process to identify a hot spot and install fencing?	The term hot spot has been removed from Table 3-1 and response to expert comment 7. As the approach is that any road kill of a target threatened mammal species will be evaluated. Section 7.3.2 has also been updated to state that where any road kill is confirmed of a target threatened mammal species Roads and Maritime will assess the need for additional exclusion fencing, and install where required. This is also reiterated in Table 8-6.
11.	Section 8	The performance thresholds adopt the SMART formula, but some of the required corrective actions are not sufficiently certain—for example, it is not clear what the criteria are for consideration of additional structures.	Language used to describe mitigation measures and corrective actions has been clarified and refined throughout this document.
12.	Appendix A [ID No 20]	When will Glenugie Upgrade information be available?	It is anticipated the results of monitoring for the Glenugie Upgrade will become available by mid 2015.
13.	Appendix C Long-nosed Potoroo Site Survey and Selection Study (Lewis Ecological Surveys, 2014a)	Are the proposed paired sites likely to differ as part of current survey work? The main plan seems to indicate that the sites are as in Appendix C (page 17), and alternatively are not yet determined (Section 8.2.2/Figure 8-3).	As a result of the most recent Potoroo surveys monitoring sites have slightly changed. Potoroo were recorded from seven (87.5%) of the eight paired monitoring sites and reconfirmed their broad distribution from the Mororo and Jacky Bulbin area's in Section 6, north to the northern limits of the Wardell sand plain in Section 10. At Site 1 (Section 6), Potoroo were not recorded at either of the impact or control sites despite their presence being detected only a few kilometres away at Site 2 (Section 6). Consequently, their absence following two rounds of monitoring suggests there is little likelihood of detecting them in the future and the retention of Site 1 in the monitoring program is of little use as the baseline dataset for any potential paired treatment is zero. Therefore the expert ecologist Ben Lewis has recommended dropping Site 1 BACI sites from the monitoring program. Final monitoring sites for Potoroo are summarised in Section 8 and the technical report with recommendations is in Appendix F.

ID No	Section	Comment	How recommendation has been addressed (Version 3)
14.	Appendix D Rufous Bettong and Brushtailed Phascogale Site Selection (Lewis Ecological Surveys, 2014)	It is noted that the plan does not adopt some of the recommended threshold values of this Appendix (eg. 25% reduction in Rufous Bettong activity at a site). It would be useful for some discussion of this in text, given the inclusion of this appendix.	Section 8 of this plan has been updated to specifically include the baseline monitoring results and thresholds for corrective action. This is taken from the final technical report in Appendix E.
Additional DP&E Comments 25/08/2015 (review of Version 3)			
1.	Table 6-2	Final fencing type and location for sections 3-11 would be subject to detailed design and confirmed in the Connectivity Structure required by Condition D2, and endorsed by the Department of the Environment (DoE) and Environment Protection Authority (EPA).	Acknowledged
2.	Table 6-4	Final fauna crossing structures (type and location) for sections 3-11 would be subject to detailed design and confirmed in the Connectivity Structure required by Condition D2, and endorsed by DoE and EPA.	Acknowledged
3.	Section 6.3.7	Second paragraph lists types of crossing structures that will be constructed in sections 1 and 2. No mention is made of the types of structures that will be considered for sections 3-11.	Crossing structures for Sections 3-11 have yet to be finalised. Final fauna crossing structures (type and location) for sections 3-11 would be subject to detailed design and confirmed in the Connectivity Structure required by Condition D2, and endorsed by DoE and EPA. The draft/proposed crossing structures for these sections have been outlined within Table 6-4. Paragraph 4 states: The remaining are still being finalised as part of detailed design and to ensure that results of supplementary targeted surveys are considered. For the purposes of this TMMP update, fauna crossing structures for Sections 3-11 are proposed and based on documentation as part of the SPIR with further refinements taking into consideration results of pre-construction baseline surveys and workshops with EPA.
4.	Table 8-4	The monitoring site locations would be confirmed by the type and location of structures in the Connectivity Structure required by Condition D2, and endorsed by DoE and EPA.	Section 8 outlines the proposed monitoring program.

ID No	Section	Comment	How recommendation has been addressed (Version 3)
			Table 8-4 outlines the final Impact and Control Monitoring Sites for each target mammal species being Rufous Bettong, Brush-tailed Phascogale and Long-nosed Potoroo. The monitoring site locations and where they are proximate to crossing structures are illustrated in Figures 8-1, 8-2 and 8-3. If crossing structures in Section 3-11 change where an impact monitoring site has been established these may need to be refined post detailed design.
5.	Table 8-5	What is the basis of the quantum (percentage) as an indicator of population decline and the trigger for corrective actions? Greater than 200% increase in road kill records – should any road kill record of these species be the trigger for corrective actions?	Road kill baseline numbers has been placed at 200% as this is the minimum an increase can happen from the baseline which is 1. So if there are two roadkills observed of a species then this will trigger an evaluation of corrective actions. The other percentages have been developed by the expert consultant preparing baseline monitoring programs from various trapping volumes. These percentage declines have been set to reflect change in continued habitat use through the adopted trapping/monitoring methods given their high % confidence in detection methods as demonstrated by the Long-nosed Potaroo explanation of the 25% decline trigger - operational mitigation goals focus on Potoroo utilising fauna mitigation devices such as underpasses, no road kill Potoroo and demonstrated population stability. In this later instance, the continued use of camera traps will prove the most reliable way to measure the threshold for acceptable variation of Potoroo activity away from the paired control site which has been set at <25%. So using this an example for Site 6, the baseline survey (2015) recorded a mean of 33% activity at Site 6A and 25% at Site 6B (see Table 3-2). When the next round of monitoring is performed (i.e. first round of post construction monitoring 2018) Site 6A records 17% and Site 6B records 17%. There is a recorded decline of 16% at Site 6A (impact site), however, Site 6B (paired control/reference) also recorded a decline of 8%. It is the difference between these two values that must be measured because both sites showed an overall decline pointing to other cues beyond the measured effects of the Project. Once this has been adjusted for by subtracting 16% from 8% the measured effect has been calculated at just 8% and still within the acceptable range of <25% presented in Table 5-1. Consequently, no corrective action would be required at this location.

ID No	Section	Comment	How recommendation has been addressed (Version 3)
6.	Section 8.3.2	The monitoring of overpass structures has been deleted from the Plan. The Department considers that the monitoring of overpasses, particularly where they are located in threatened mammal habitat, should be retained in the Plan for sections 3-11. No justification has been provided for this change to the approved Plan.	Roads and Maritime are still in the process of finalising crossing structures for Sections 3-11. Initial indications following design workshops/meetings with EPA and koala experts is that overpass structures nominated in the EIS/SPIR are likely not to be required and more than likely to be replaced by other crossing types. To avoid confusion and reflect current thinking it was decided to remove reference to overpass structures in the updated Threatened Mammal Plan. Section 8.3.2 wording had been updated in Version 3 to state that Roads and Maritime in finalising monitoring sites for each target species was to focus on underpass structures with minimal data. These are underpasses that are 60m or more in length. However as a final decision has not been made it is proposed the following wording be reinserted: "Should overpass structures be installed between Sections 3 to 11 that facilitate movement of the target mammal species, at least one impact monitoring site will be installed at the overpass location to monitor and evaluate the usage of these structures by the target mammal species." Currently in the Threatened Mammal Plan there are a number of crossing structures proposed to be monitored. Table 8-4 summarises for each target species the monitoring site locations, including impact monitoring sites and if they are in proximity to a crossing structure. For the Long-nosed Potoroo a few impact monitoring sites are at proposed overpasses in Section 7 and Section 10.
7.	Section 6.0	Long Nosed Potoroo Pre-construction Baseline Monitoring Survey What is the status of the 11 recommendations of the survey report?	1) Adopted – Table 8-3/8-4 2) Adopted – Table 8-3/8-4 3) Adopted – Table 8-3/8-4 4) Adopted – Section 8.3 and Appendix F 5) Adopted – Section 8.3.3 and Appendix F – could be spelt out more 6) Adopted – Section 8 and general RMS pest management strategy 7) Adopted 8) Required for the connectivity strategy 3-11 9) Adopted – Table 8-4

ID No	Section	Comment	How recommendation has been addressed (Version 3)
			10) Adopted – still in draft for connectivity 11) Adopted Table 8-3/8-4

ID No	Section	Comment / Recommendation	How recommendation has been addressed (Version 3)
NSW Environmental Protection Agency (review of Version 2)			
1.	Page 19 and 20	Has the RMS undertaken an assessment of the adequacy of connectivity for the newly discovered Long-nosed Potoroo populations in sections 6 and7? Please see further comment below. Additionally it is stated in the Plan that new records of the Long-nosed Potoroo were located west of Old Bagotville Road – wouldn't this place the new records west of the alignment? If so has the adequacy of connectivity structures been assessed in this habitat area? Has the extent of likely and known habitat been recorded? Also please note, connectivity measures will need to consider targeting integrated koala and Long-nosed Potoroo landscape and furniture features during detailed design. Spotted-tailed Quoll – the EPA agrees it is too difficult to survey in such low density populations.	Preliminary results are summarised in Appendix C and F, as well as Section 2 of this TMMP. Potoroo was recorded at a control site (number 21 – Appendix C) in Doubleduke State Forest to the west of the proposed highway in Section 7. A dedicated land bridge is proposed at this location (chainage 118.828) to facilitate movement of Potoroo and other mammals such as Spotted tail Quoll between Doubleduke State Forest to Tabbimoble Swamp. It has been recommended by Lewis Ecological RMS consider an additional crossing structure at approximately chainage 115.750 (+/- 100 m) Proposed crossing structures are summarised in Section 6.3.7. Final connectivity structures for Potoroo and other mammals in Sections 3-11 will be detailed in the next Fauna Connectivity Strategy. Known and likely habitat for the Potoroo has been prepared to support the W2B Offset Strategy. Habitat maps are provided in Appendix G.
2.	Page 23 Table 3.1	Long-nosed Potoroo – The Table identifies future pre-clearance surveys for Long-nosed Potoroo in sections 6 and 7, particularly given the planned removal of habitat in this area. It is stated these proposed surveys aim to map the extent of Long-nosed Potoroo habitat in these areas. The EPA recommends these proposed surveys are brought forward and undertaken prior to pre-clearing surveys. This will then provide ample time to assess the extent of the population and habitat and assess the adequacy of mitigation. It is noted on page 3, Appendix C, that mitigation structures are detailed, however these structures were already proposed prior to the additional records.	Pre-clearing surveys will then occur just prior to any clearing taking place and requirements for the pre-clearing surveys are stipulated in Section 6.3.4. It is recognised additional Potoroo records have been found post connectivity structures being developed, however Roads and Maritime are still in a position to refine these crossing structures during the detailed design phase and to take into account results of the 2014/15 baseline surveys. Potoroo was recorded at a control site (number 21) in Doubleduke State Forest to the west of the proposed highway in Section 7. A dedicated land bridge is proposed at this location (chainage 118.828) to facilitate movement of Potoroo and other mammals such as Spotted tail Quoll between Doubleduke State

ID No	Section	Comment	How recommendation has been addressed (Version 3)
		Was this Table updated following the new records in section 10? i.e. has the population been confirmed to the west of the alignment? This is not explicitly stated in the Plan. Refer to Figure 3-5 of Appendix C which shows site 32 at 44% activity level – it appears from the diagram this survey site is west of the alignment. Also note Table 4-1 of Appendix C confirms the Potoroo record as occurring on the western side of the alignment. Noting these comments, the RMS will need to edit the TMMP to ensure all discussions on Potoroo distribution are consistent within the document and appendices.	Forest to Tabbimoble Swamp. It has been recommended by Lewis Ecological RMS consider an additional crossing structure for Potoroo at approximately chainage 115.750 (+/- 100 m)
3.	Page 37 -6.3.7	Why has the widened median been considered as a connectivity structure for terrestrial threatened mammals? The widened median is a proven mitigation measure for gliders however there is no apparent benefit for terrestrial fauna (unless designed in conjunction with a bridge and intact riparian vegetation such as Dalhousie Creek). This perspective regarding widened medians is based on the longer effective length of the crossing (2 culverts + median) and the requirement to traverse 2 culverts to complete passage – which may be an impediment for some species or individuals.	Connectivity structures for Sections 1 and 2 have been finalised. At chainage 23130 and 23131 in Section 2 there is a widened median that will support arboreal crossings. The widened median itself is not proposed to assist mammal crossings. At this location there are also dedicated fauna underpasses (culverts) that will be installed to support fauna movement including for Phascogale and Bettong. Fencing will be installed to ensure fauna stay within the culvert and don't get caught in the vegetated median.
4.	Appendix E Table 6-1	Performance Thresholds – please clarify where the performance thresholds were referenced or derived. A decline <25% is significant, especially given the local abundance of these species'. Additionally a decline <50% is also very significant i.e. conceivably locally extinct within 2 years prior to corrective action implementation. The EPA recommends more conservative deviations from the paired control are used as triggers for corrective action eg/ 10%. However the EPA will also discuss possible variations from this if activity level changes can be explained and are unrelated to the impact (highway upgrade).	The species thresholds have been based on recommendations from a suitably qualified ecologist Ben Lewis who led the baseline surveys for Phascogale and Bettong. The survey methods and findings are outlined in the final report included as Appendix E. The technical report that was finalised in December 2014 recommends tolerance levels from the baseline dataset. This is a 25% decline of Bettong activity recorded at camera traps when compared to the control site and 50% decline of Bettong activity from spotlight surveys when compared to the control site. Spotlighting results have a higher threshold as spotlighting is not as effective in capturing the species as camera traps. Further information on the baseline results and thresholds are now provided in Section 8 of the TMMP. Roads and Maritime currently do not propose to change these thresholds. They have been recommended by a suitably qualified ecologist with extensive experience conducting surveys for threatened mammals in the project area. It should be noted the thresholds are based on activity levels not species number decline. Also after each monitoring event if the impact sites are showing reduced activity when compared to control sites this will be assessed and discussed in the annual monitoring reports. Where thresholds are met this will then trigger a more in depth evaluation as to why and corrective actions will be implemented as appropriate.

ID No	Section	Comment	How recommendation has been addressed (Version 3)
Additional EPA Comments 26/08/2015 (review of Version 3)			
1.	General: Regarding the latest Potoroo survey from Lewis Ecological	Since a large driver of this version is the incorporation of the necessitated Potoroo survey work done by Lewis Ecological it would be nice to see a table of how the 11 recommendations arrived at in this report has been considered/adopted or deferred to another plan (eg. Connectivity strategy)	Wording added to table in Section 2.1 summarising the latest recommendations and how they have been considered/addressed in the plan. Recommendations and where they are addressed are as follows: 1) Adopted – Table 8-3/8-4 2) Adopted – Table 8-3/8-4 3) Adopted – Table 8-3/8-4 4) Adopted – Section 8.3 and Appendix F 5) Adopted – Section 8.3.3 and Appendix F – could be spelt out more 6) Adopted – Section 8 and general RMS pest management strategy 7) Adopted 8) Required for the connectivity strategy 3-11 9) Adopted – Table 8-4 10) Adopted – still in draft for connectivity 11) Adopted Table 8-3/8-4
2.	2.3 Overall findings	Are you going to incorporate the spotted tail quoll record recently acquired by Sandpiper Ecological at Glenugie?	Outside of the 2013 surveys two separate road mortalities of Spotted-tail Quoll have been recorded within proximity to the project. The first was recorded on the Pacific Highway in December 2012 at the northern Glenugie Creek bridge crossing, approximately 1.2km north of the upgrade (Craig Harre, 2012), and the second was recorded in May 2013 at the southern end of Devils Pulpit project, on the western side of existing highway. In June 2015 as part of the fauna underpass monitoring at Glenugie Pacific Highway Upgrade a single record of Spotted-tail Quoll was recorded at the Glenugie Creek Underpass (3m high by 9m wide Bebo arch). This information has been added to Section 2.3.
3.	6.3.6 fencing	You state that 'areas that remain unfenced are larger interchange areas….'? Interchanges are particularly relevant to fencing.	To clarify, fauna fencing will be installed on the outside edge of the on-load and off-load ramps where interchanges are within the locations nominated in Table 6.1 and Table 6.2. This information has been added to Section 6.3.6.

ID No	Section	Comment	How recommendation has been addressed (Version 3)
4.	6.3.7 Fauna Connectivity Structures	Fauna furniture is to be placed in combined and dedicated fauna connectivity structures, not just dedicated as stated in this Special reference should be made to the surface substrate and revegetation of underpasses. Natural substrate needs to be the focus for these targeted threatened mammals. 'Furniture' needs to include timbers, hollows, debris and litter on the ground. In bridge underpasses and in linking to Culverts revegetation needs to create a dense and complex ground cover/understory.	Fauna furniture will be installed in dedicated structures. With regard to combined structures fauna furniture will be installed at these locations where it will not impact on flooding/hydrological issues. The details of which combined structures will have fauna furniture will be detailed in the Connectivity Strategy required under CoA D2.
5.	6.3.8 Habitat revegetation	As a follow on from the preceding point, the paragraph focussed on revegetation of overpasses/landbridges should be re-directed to include landscape connections to culvert and bridge underpasses. This is particularly relevant in light of the ongoing discussions regarding the finalisation of connectivity structures, particularly the potential reduction/elimination of landbridges.	This section has been updated to include revegetation for maintaining landscape connections to culvert and bridge underpasses.
6.	8.4 Road Mortality Monitoring	More detail needed to clarify the methodology required to capture and collate both survey roadkill and incidental roadkill reporting. This is a valuable datum, triggering corrective actions, but is a bit unclear how it will all be pulled together.	Both formal (for Phascogale and Bettong) and incidental roadkill monitoring will occur during population monitoring events. Other road mortalities observed by road maintenance crews will be reported to RMS and maintained in a central database. Section 8.4.2 specifically identifies that road kill surveys will involve "walking a transect 250 m either side of the targeted connectivity structure on both sides of the project to collate and identify the number of road mortalities and geographic coordinates for each road kill specimen. Further, surveys for incidental road kill will be undertaken during operational monitoring periods (every three months until complete) and occur during travel between structures to increase survey effort during monitoring." After each formal monitoring event the results will be reported to RMS. This data will be managed by RMS on an ongoing basis, assessed, and corrective actions implemented where appropriate. As described in Section 8.7 annual reports will be prepared outlining results of monitoring which will include any roadkill records.

Appendix B – Dr M. Schulz CV

Appendix C – Long-nosed Potoroo Site Survey and Selection Study (Lewis Ecological Surveys, 2014a)

Appendix D – Rufous Bettong and Brush-tailed Phascogale Site Selection (Lewis Ecological Surveys, 2014b)

Appendix E – Rufous Bettong and Brush-tailed Phascogale Preconstruction Baseline Monitoring Survey (Lewis Ecological Surveys, 2014c)

Appendix F – Long-nosed Potoroo Preconstruction Baseline Monitoring Survey (Lewis Ecological Surveys, 2015)

Appendix G – Long-nosed Potoroo Habitat Mapping

Transport Roads & Maritime Services

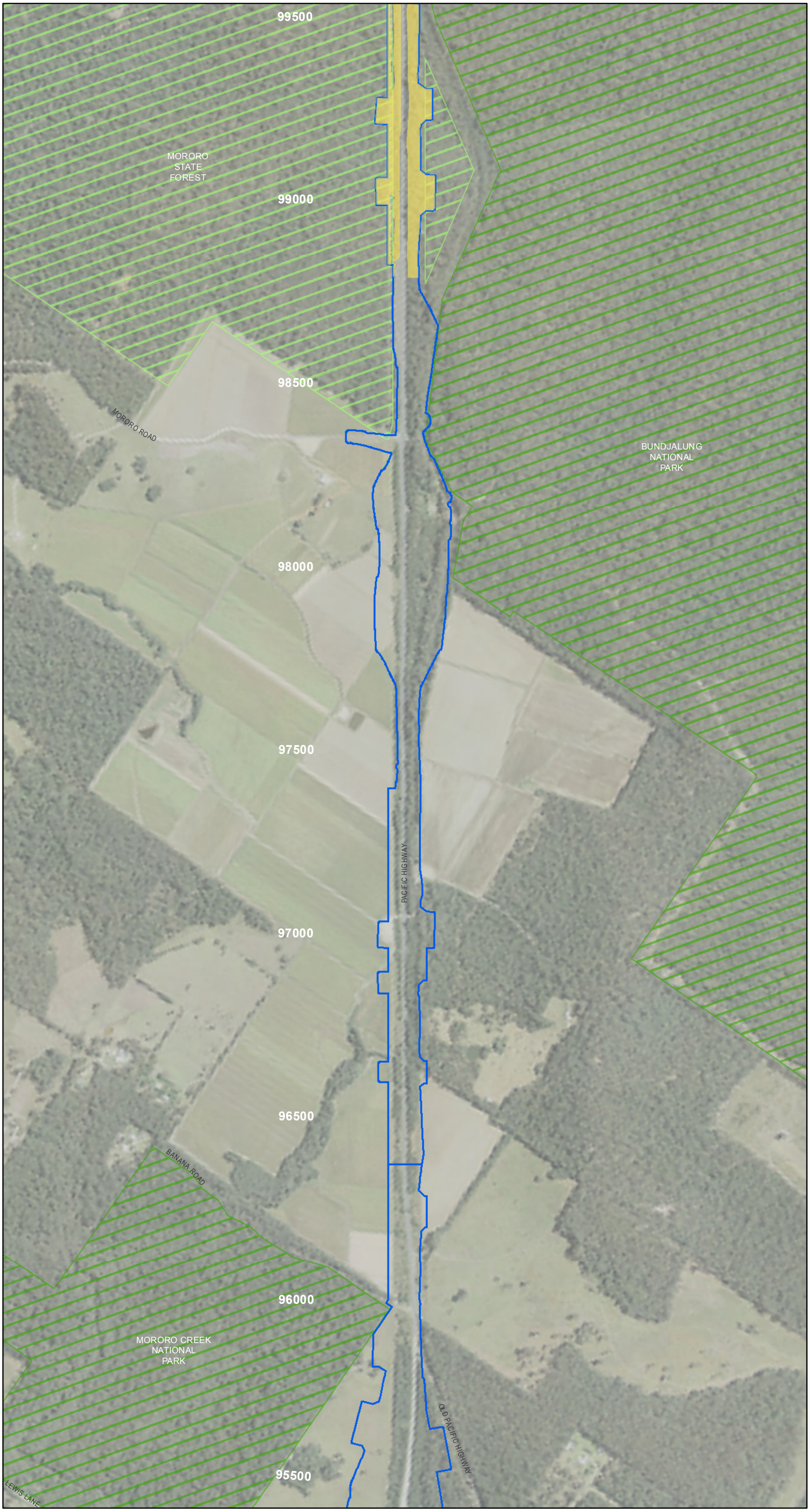
NSW GOVERNMENT

PACIFIC HIGHWAY UPGRADE

Woolgoolga to Ballina

Biodiversity Offset Strategy
Long-nosed Potoroo

Map 1 of 9



Clearing Boundary

Long-nosed Potoroo

Habitat Quality Scores

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NPWS Reserves

State Forests

1:10,000
at A3

0 50 100 200 300 400 500
Metres

Print Date:	27/02/2015
Author:	SBAZ3030

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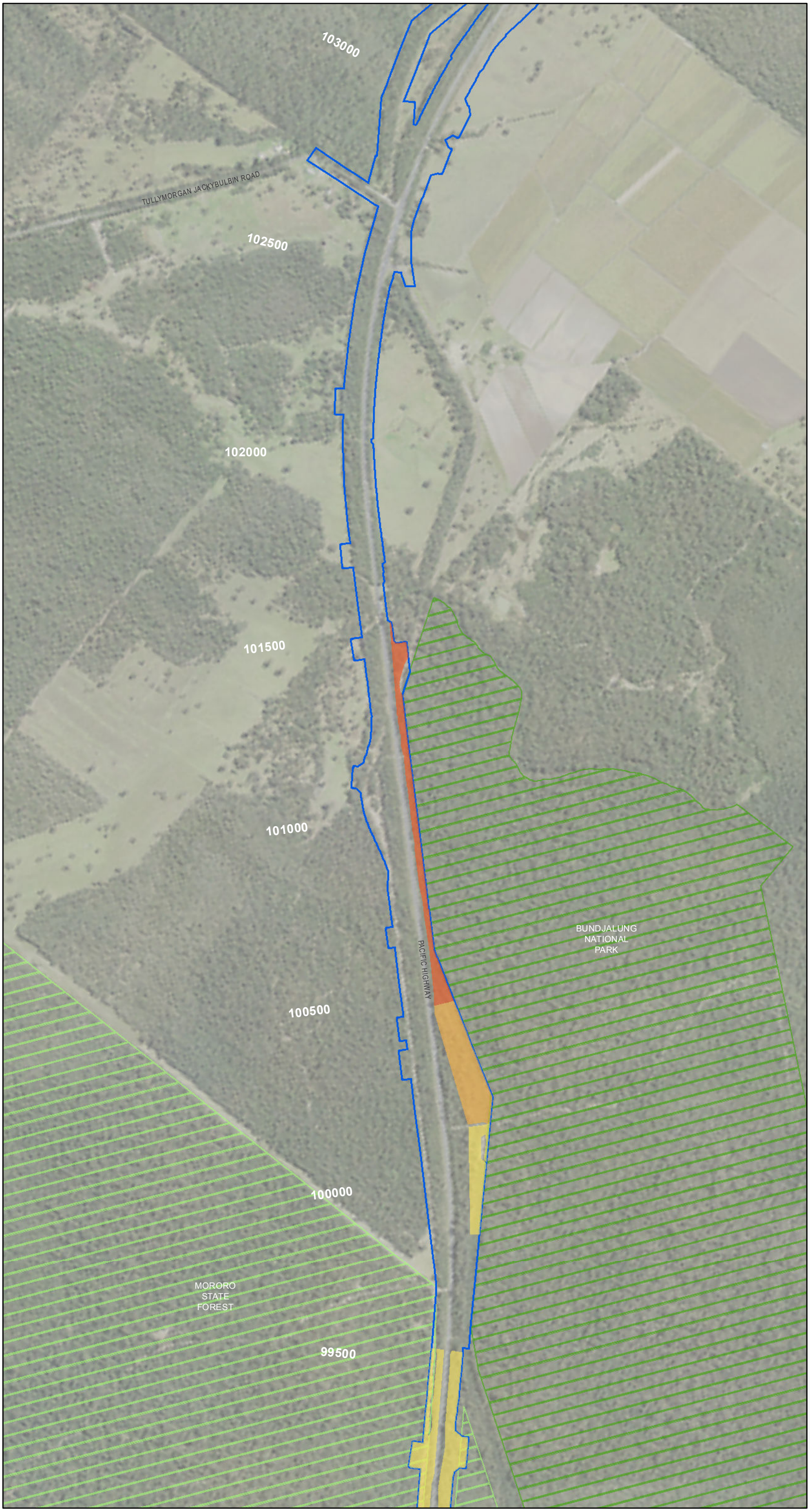
NSW GOVERNMENT

PACIFIC HIGHWAY UPGRADE

Woolgoolga to Ballina

Biodiversity Offset Strategy
Long-nosed Potoroo

Map 2 of 9



Clearing Boundary

Long-nosed Potoroo

Habitat Quality Scores

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NPWS Reserves

State Forests

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at A3

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Metres

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Transport Roads & Maritime Services
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PACIFIC HIGHWAY UPGRADE

Woolgoolga to Ballina

Biodiversity Offset Strategy
Long-nosed Potoroo

Map 3 of 9

Clearing Boundary

Long-nosed Potoroo

Habitat Quality Scores

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NPWS Reserves

State Forests

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at A3

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Metres

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PACIFIC HIGHWAY UPGRADE

Woolgoolga to Ballina

Biodiversity Offset Strategy
Long-nosed Potoroo

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121500
121000
120500
120000
119500
119000
118500
118000
SWAN BAY NEW ITALY ROAD
PACIFIC HIGHWAY
TABBIMOBLE SWAMP NATIONAL PARK
MINYUMAI ROAD
DOUBLEDUKE STATE FOREST
TABBIMOBLE SWAMP NATIONAL PARK

Clearing Boundary

Long-nosed Potoroo

Habitat Quality Scores

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NPWS Reserves

State Forests

1:10,000
at A3

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Metres

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Transport Roads & Maritime Services
NSW GOVERNMENT

PACIFIC HIGHWAY UPGRADE

Woolgoolga to Ballina

Biodiversity Offset Strategy
Long-nosed Potoroo

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RILEYS HILL ROAD
141000
140500
140000
139500
BROADWATER NATIONAL PARK
139000
138500
PACIFIC HIGHWAY
138000
137500

Clearing Boundary

Long-nosed Potoroo

Habitat Quality Scores

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NPWS Reserves

State Forests

1:10,000
at A3

0 50 100 200 300 400 500
Metres

Print Date:	27/02/2015
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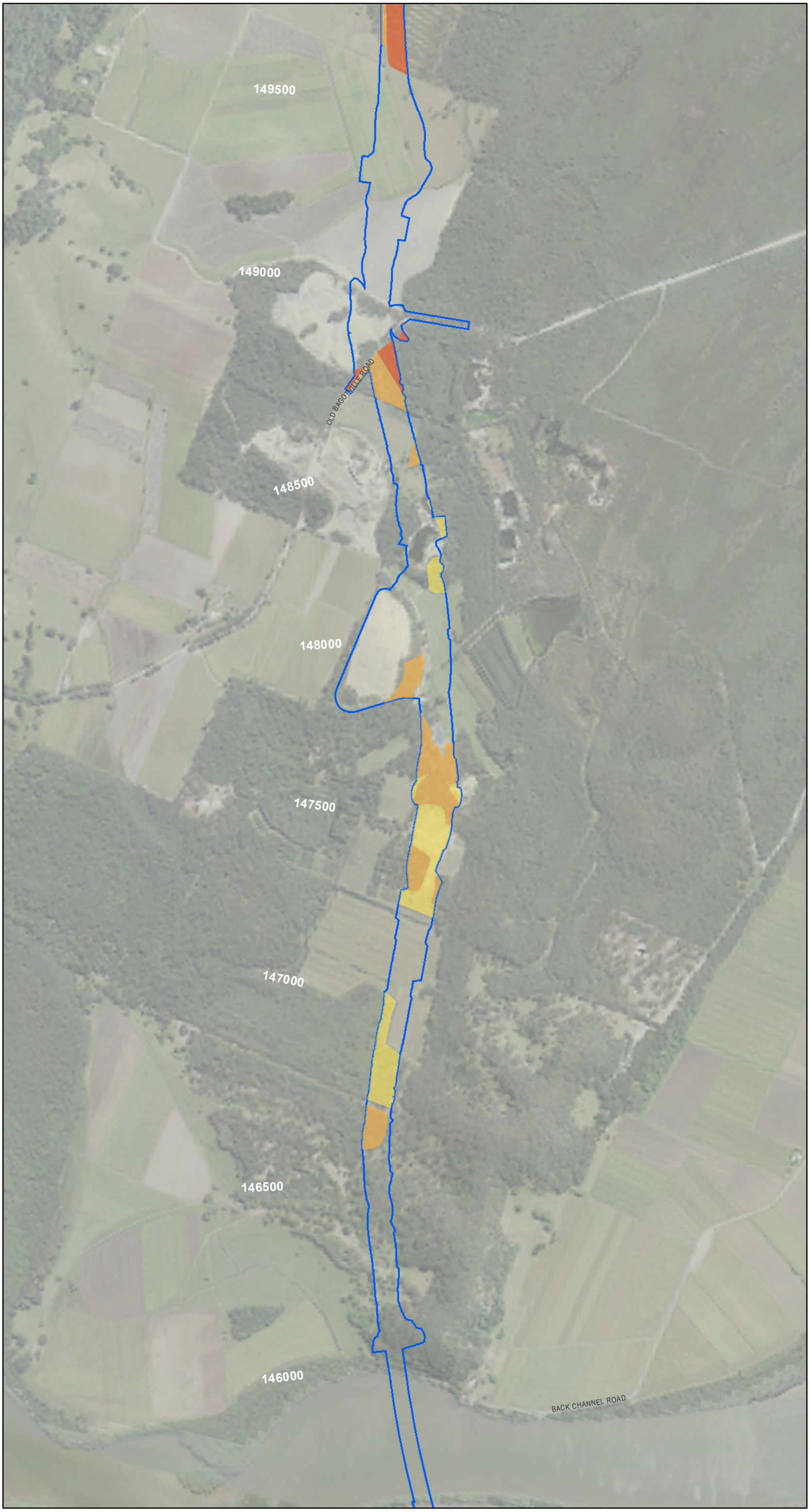

Transport Roads & Maritime Services
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PACIFIC HIGHWAY UPGRADE

Woolgoolga to Ballina

Biodiversity Offset Strategy
Long-nosed Potoroo

Map 6 of 9

Clearing Boundary

Long-nosed Potoroo

Habitat Quality Scores

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NPWS Reserves

State Forests

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at A3

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Metres

Print Date:	27/02/2015
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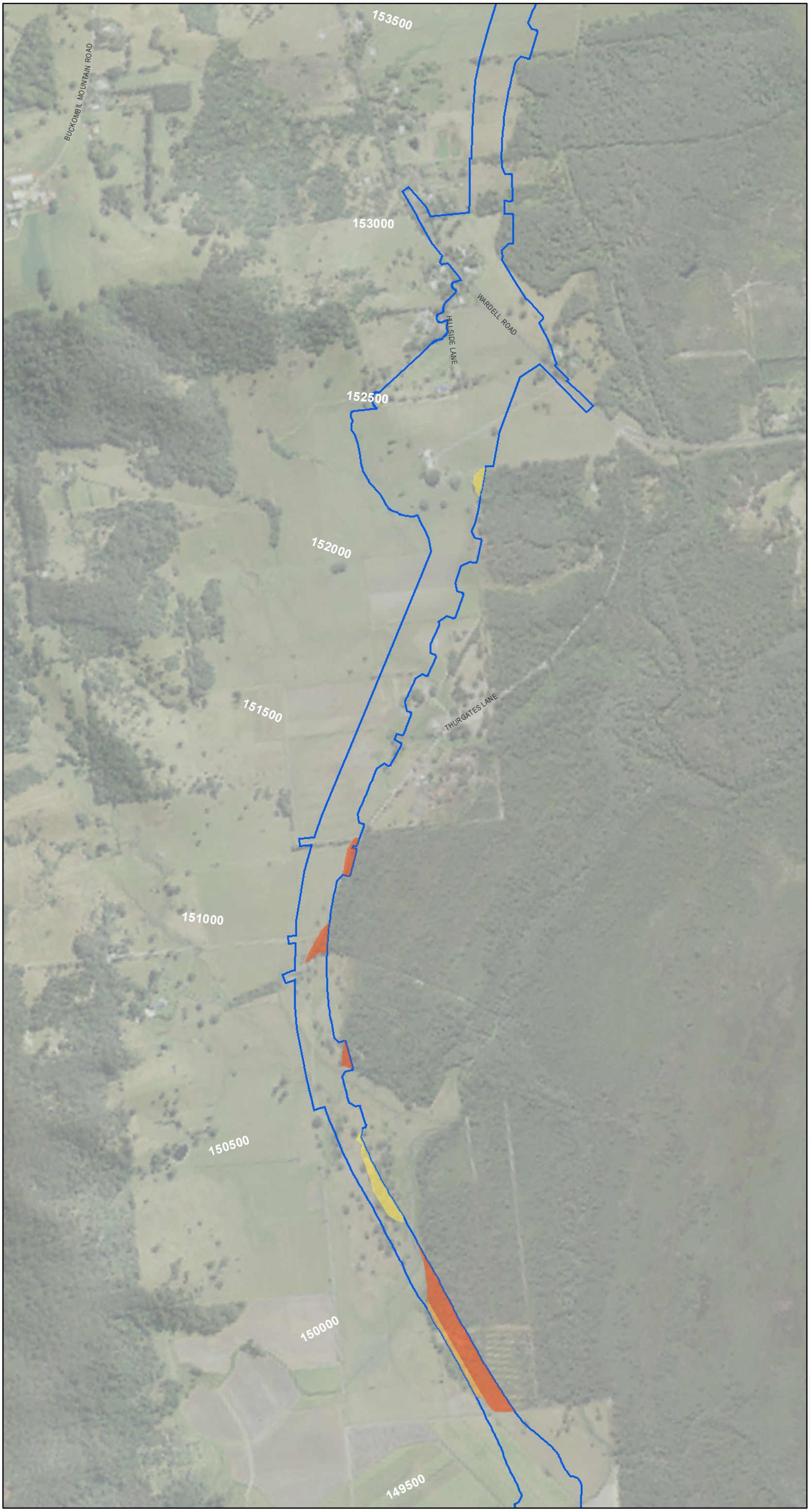

Transport Roads & Maritime Services
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PACIFIC HIGHWAY UPGRADE

Woolgoolga to Ballina

Biodiversity Offset Strategy
Long-nosed Potoroo

Map 7 of 9

Clearing Boundary

Long-nosed Potoroo

Habitat Quality Scores

8

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NPWS Reserves

State Forests

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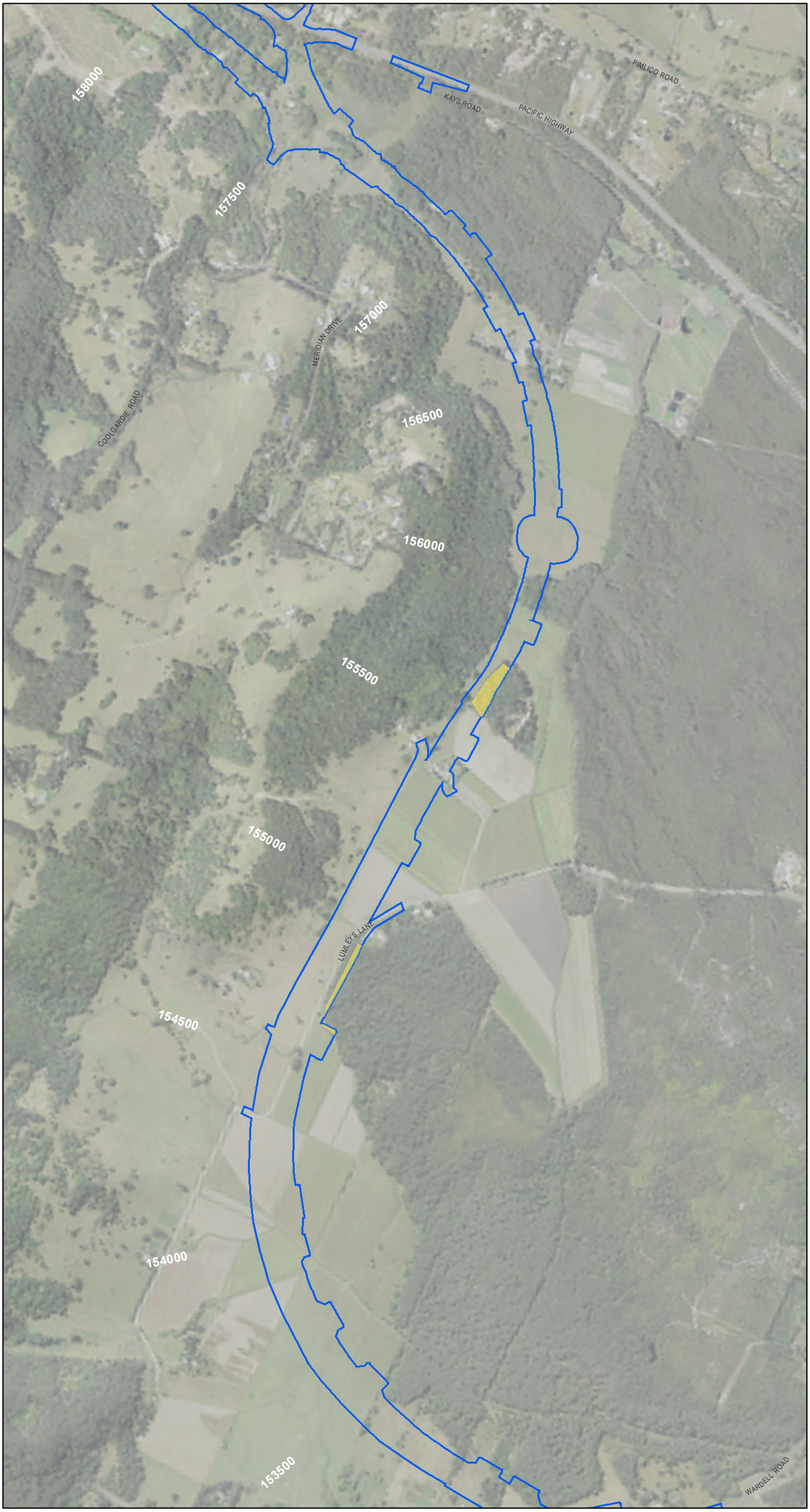

Transport Roads & Maritime Services
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PACIFIC HIGHWAY UPGRADE

Woolgoolga to Ballina

Biodiversity Offset Strategy
Long-nosed Potoroo

Map 8 of 9

Clearing Boundary

Long-nosed Potoroo

Habitat Quality Scores

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NPWS Reserves

State Forests

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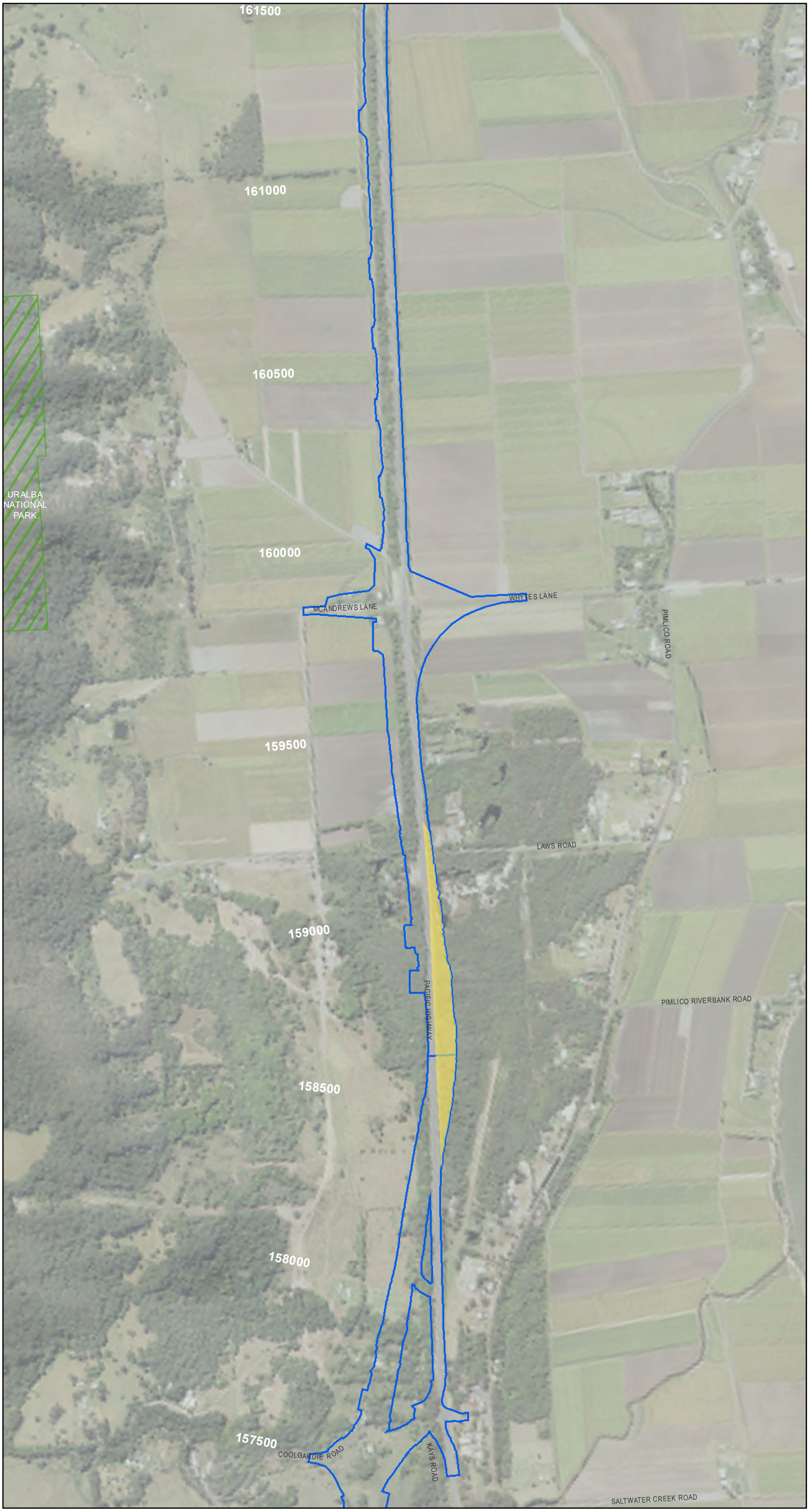

Transport Roads & Maritime Services

NSW GOVERNMENT

PACIFIC HIGHWAY UPGRADE

Woolgoolga to Ballina

Biodiversity Offset Strategy Long-nosed Potoroo

Map 9 of 9

Clearing Boundary

Long-nosed Potoroo

Habitat Quality Scores

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NPWS Reserves

State Forests

1:10,000 at A3

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Metres

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