NSW Roads and Maritime Services

WOOLGOOLGA TO BALLINA | PACIFIC HIGHWAY UPGRADE

THREATENED GLIDER MANAGEMENT PLAN

Version 3.0

February 2018

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Contents

Glossary and Abbreviations

Term	Definition
ARCUE	Australian Research Centre for Urban Ecology
BACI	Before-After Control-Impact
CEMP	Construction Environmental Management Plan
Construction footprint	The direct area of the design alignment (also referred to as the clearance limits)
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
EP&A Act	Environmental Planning and Assessment Act 1979
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
EPA	NSW Environment Protection Authority
EIS	Environmental Impact Statement (Woolgoolga to Ballina – Pacific Highway Upgrade, Roads and Maritime Service, Dec 2012)
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
NBMP	Nest Box Management Pan
NSW	New South Wales
OEH	NSW Office of Environment and Heritage
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.
SPIR	Submissions / Preferred Infrastructure Report 2013
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.
QLD	Queensland
Roads and Maritime	NSW Roads and Maritime Services
RTA	Roads and Traffic Authority
SAP	Sensitive Area Plans
SPIR	Woolgoolga to Ballina Pacific Highway Upgrade Submissions/Preferred Infrastructure Report (SPIR) (November 2013)
SSI	State Significant Infrastructure
Stochastic event	Natural phenomenon such as storms, fires, floods, droughts etc (random event).
TGMP	Threatened Glider Management Plan (this plan)
Threatened gliders	For the purposes of this plan threatened gliders include: • Squirrel Glider (*Petaurus norfolcensis*) • Yellow-bellied Glider (*Petaurus australis*)

Term	Definition
TSC Act	*Threatened Species Conservation Act 1995*
UDLP	Urban Design and Landscape Plan
W2B	Woolgoolga to Ballina Pacific Highway Upgrade
WIRES	NSW Wildlife Information Rescue and Education Service Inc

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 *Environmental Planning and Assessment Act 1979* (EP&A Act) on 24 June 2014 and the *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. Around 155 kilometres of highway will be upgraded as part of the project, which, on completion, will represent the last priority (known as 'Priority 3' in the upgrade program) in achieving a four-lane divided road between Hexham and the NSW/Queensland border. The project therefore forms a major part of the overall Pacific Highway Upgrade Program. For the purposes of the EIS the project has been divided into 11 sections as illustrated in **Figure 1.1**.

Key features of the project 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 Draft Woolgoolga to Ballina Staging Report (RMS, 2015) prepared to satisfy NSW Government Approval – Minister's Condition of Approval (MCoA) A7.

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 April 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 Glenugie and Devils Pulpit now complete. Altogether, these three projects would upgrade 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).

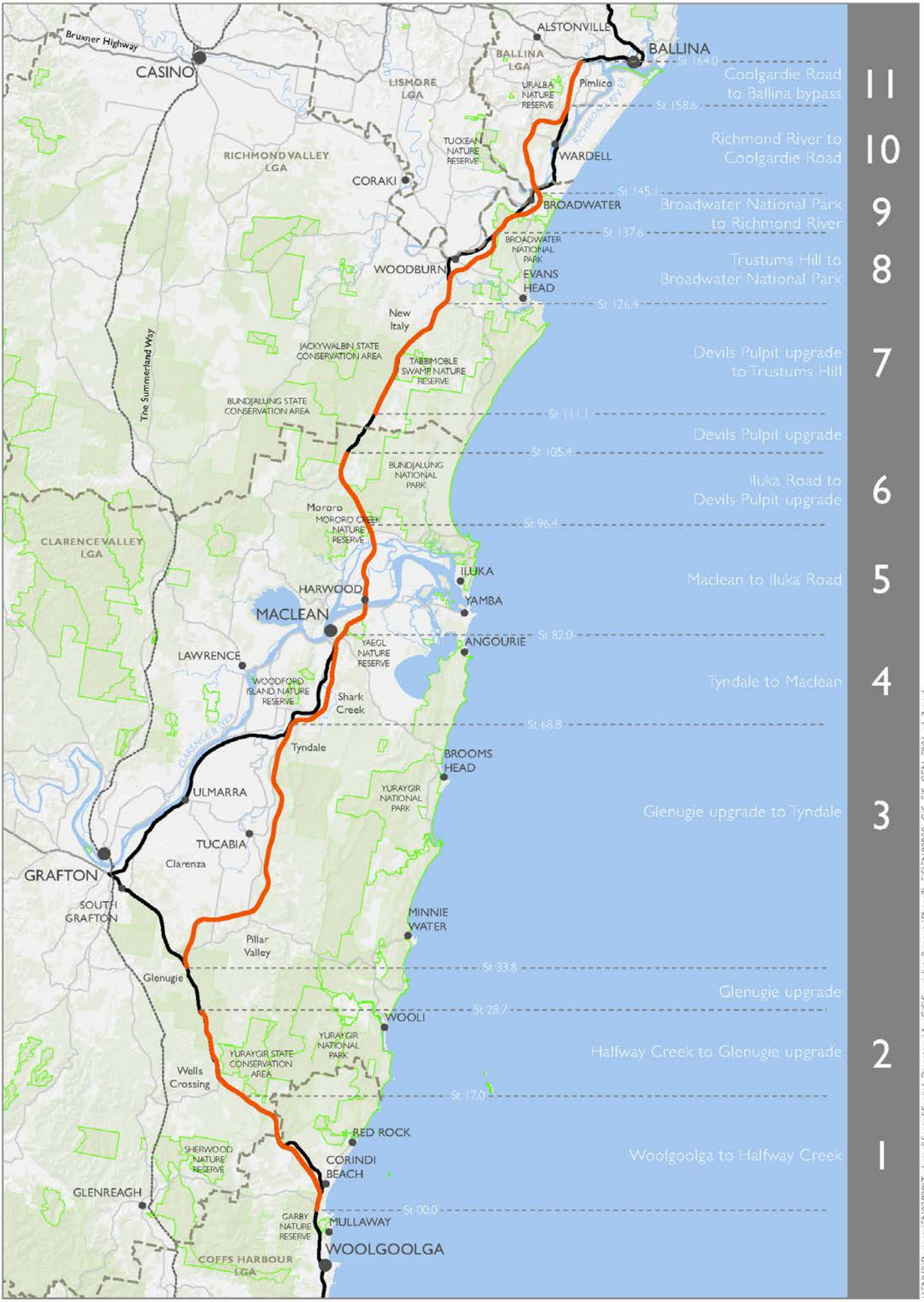


Figure 1.1 Woolgoolga to Ballina Project Sections

1.2 Purpose of this plan

This Threatened Glider Management Plan (TGMP) has been developed to meet the requirements of MCoA D8 and also addresses components of MCoA D2. The requirements of this approval and where it is addressed in this report are detailed in **Table 1.1**. The glider species are not listed under the EPBC Act, and therefore there are no applicable Commonwealth conditions.

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 Connectivity 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	The requirements of this condition in the context of threatened glider species are addressed in this plan in the following sections: (a) Section 6.3.5; Table 6.1 and Table 6.2. (b) Section 3, Section 4.4 and Section 6.3.5. (c) Section 4.4 and Table 4.2. (d) Section 3, Section 4.2 and Appendix C and D (Sandpiper Ecological, 2014). (e) Not relevant for gliders. (f) Connectivity Strategy Section 6.3.6. (g) Connectivity Strategy and Section 3 (crossings structure assessments) (h) Section 7.3.2. (i) Flood risk is not relevant to arboreal crossing structures. (j) Not applicable to gliders and not addressed in this management plan. (k) Mitigation Framework has been submitted for approval. Connectivity Strategy for Sections 1 and 2 has also been submitted for approval outlining proposed crossing structures and their design. Crossing structures are outlined in Section 6.3.5 of this plan. (l) Section 4.4 outlines a commitment for the review of effectiveness of connectivity structures. (m) Mitigation Framework has been prepared and submitted for approval. Relevant provisions including results of targeted surveys are summarised in this TGMP, Section 3. Additional details associated with these conditions can be found in

Approval requirement		Where addressed
	D1. 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.	the final Fauna 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 glider species are addressed in Section 6.3.7. Roads and Maritime has developed Nest Box Management Plans for relevant sections that have been approved by NSW Secretary of Department of Planning and Environment. They relate to Sections 1, 2, 4 & 5, 8 & 9, 10 & 11 and Sections 3, 6 & 7.The plans were informed by results of detailed supplementary targeted surveys that have identified the number and type of hollows to be replaced within each section. The Nest Box Management Plans also provides details regarding maintenance and monitoring of nest boxes.
MCoA D8	The Applicant shall prepare and implement Threatened Species Management Plans to detail how impacts of the project (referred to as 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;	The requirements of this condition in the context of threatened glider species are addressed in this plan in the following sections: (a) Section 3 and Appendix C & D (Sandpiper Ecological, 2014). (b) Section 4.1. (c) Section 4.2, Section 4.3 and Section 4.4. (d) Section 4.5 and Section 8. (e) Section 8. (f) Section 4.5, Section 7.5 and Table 7.3. (g) Section 8. (h) Section 8.1. (i) Section 8.2.4. (j) Section 4.5. (k) Section 8. (l) Section 8.8. Expert and agency recommendations regarding the TGMP are summarised and details as to how they have been addressed in this plan are

Approval requirement		Where addressed
	(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; (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.	provided in Appendix A.
SPIR Environmental Management Measure		
B3	All fauna connectivity structures will be developed in accordance with the design principles outlined in the Connectivity Strategy in Appendix A of the Working paper – Biodiversity, Biodiversity and the Supplementary Biodiversity Report in Appendix J of the SPIR.	Fauna connectivity structures for gliders are described and illustrated in Section 6.3.5. Further detail for Sections 1 and 2 is provided in the Fauna Connectivity Strategy finalised in December 2014.
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.	These surveys have been completed as part of the targeted glider baseline surveys. The surveys and findings are summarised in Section 3. Survey reports are included in Appendix C & D.
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 gliders. Widened medians and retaining vegetation to assist in glider movement is described 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.	This report forms the final Threatened Glider Management Plan. Expert recommendations, conditions of approval and baseline surveys have been considered and addressed in this plan.
B23	The pre-clearing process will be consistent with Roads and Maritime Biodiversity Guidelines: Protecting and Managing Biodiversity on RTA projects (RTA, 2011a) 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 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	Details of the surveys conducted for threatened glider species are detailed in Appendix C and D. Surveys were conducted by ecologists from Sandpiper Ecological (2014). CV's for these ecologists are provided in Section 1.4.1. Pre-clearing surveys prior to clearing are detailed in Section 6.3.3.

Approval requirement		Where addressed
	Ecological Communities and habitat.	
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 glider species are addressed in Section 5.3.3, Section 6.3.3 and Table 5.1.
B31	Nest boxes will be installed as per Roads and Maritime Biodiversity Guidelines (RTA, 2011a) 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 gliders and are described in Section 6.3.7. Separate Nest Box Management Plans have been prepared and approved. The plans identify the number, dimensions and location of hollows that are to be replaced as well as other details required under this condition such as maintenance.
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, 2011a).	The requirements of this condition in the context of threatened glider species are addressed in Section 6.3.4.
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 5.3.2 and Table 5.1.

The TGMP identifies the potential impacts of the upgrade on threatened glider species listed formerly under the NSW *Threatened Species Conservation Act 1995* (TSC Act) and now the NSW Biodiversity Conservation Act, 2016 (BC Act) which were considered to be directly impacted or at greatest risk of impact from the project.

The glider species and populations addressed in this plan relate to species located within the project boundary and targeted as part of supplementary glider surveys undertaken for the project as detailed in **Section 3** of this report. This plan does not include the nest box implementation strategy which is addressed in the Nest Box Management Plan (NBMP).

This plan identifies the proposed mitigation measures to be implemented for threatened gliders and a program for monitoring the effectiveness of these measures.

The objectives of the plan include providing:

- An effective threatened glider management plan with consideration to the concerns of main stakeholders including expert and agency review
- An overarching management framework for threatened gliders for the project
- Information on the likely extent of direct impacts to threatened gliders by the project, including updated information as a result of targeted surveys
- Management and mitigation measures that would be implemented during pre-construction, construction and operation of the project to minimise impacts on threatened gliders populations; and
- 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.

1.3 Management structure and plan updates

1.3.1 Management structure

This Threatened Glider Management Plan (TGMP) has been developed to meet the requirements of MCoA D8. This TGMP 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 of the project that is of relevance to threatened gliders. This plan provides up to date information using the results of targeted and baseline surveys which have identified the occurrence of threatened gliders within the project area, and have been completed to inform the location of mitigation measures such as arboreal crossing structures.

This plan also informs future monitoring and reporting programs, by describing the final monitoring sites, methods, variables and timing of this program as detailed in **Section 8**. Details have also been provided for the parameters of site selection for the final monitoring sites (impact, control and reference sites) which have been identified through targeted 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), NBMP, Urban Design and Landscape Plan (UDLP) and aspects associated with updates and delivery incorporated into the Biodiversity Mitigation Framework. An overview of how this TGMP relates to other relevant project documentation is provided in **Figure 1.2**.

General responsibilities for environmental management would be outlined in the CEMP and FFMP. Responsibilities for implementation of this plan have been described throughout and summarised in **Section 9**.

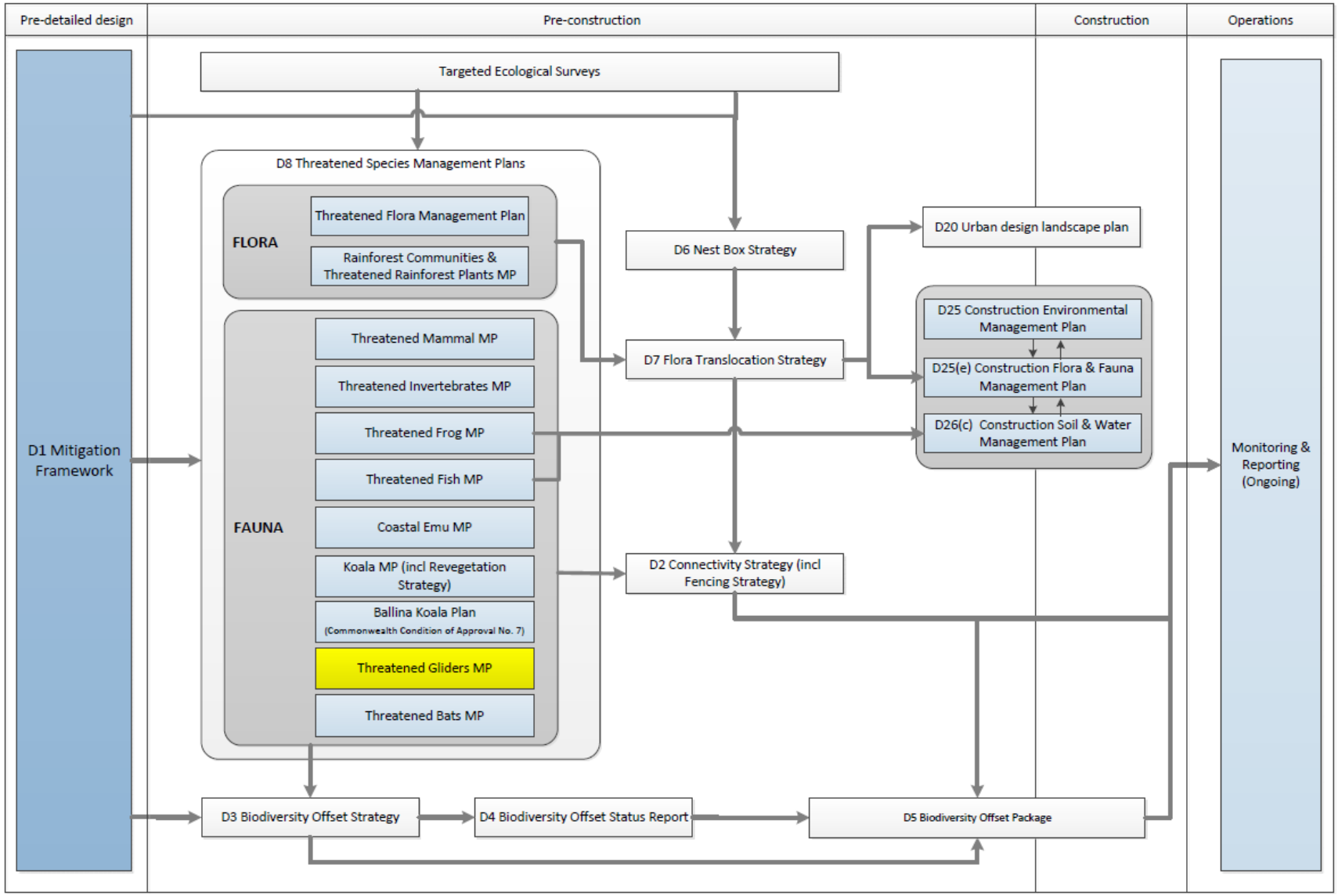


Figure 1.2 Project documentation overview

1.3.2 Plan updates

The plan is intended to be a dynamic document subject to continual improvement. This TGMP has been updated to ensure it incorporates the results of targeted threatened glider surveys, meets the mitigation and management measures committed to in the Environmental Impact Statement (EIS) and SPIR and complies with MCoA D8.

Roads and Maritime have updated this plan in two versions. The first update (Version 1 of the TGMP) incorporated the majority of independent expert review and comments. This was completed in November 2013 and was included with the submission of the S/PIR documentation. The expert comments are summarised in **Appendix A**.

The second update (Version 2.1 of the TGMP) has been undertaken to address the approval conditions received, agency comments provided, and to address remaining expert comments. This update also incorporates results of targeted threatened glider surveys undertaken for all sections of the project. A summary as to how the remaining independent expert and agency administering authority comments have been addressed is detailed in **Appendix A**.

The third update (Version 3.0 of the TGMP) has been undertaken to update the plan with details of the final suite of glider monitoring locations adopted under the W2B biodiversity monitoring program. This update also includes a description of the logistical approach that is proposed to conduct monitoring of glider connectivity structures along the entire project, to be consistent with the approved Version 2.2 of the plan.

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 and DP&E) have now reviewed the updated TGMP and approval will be granted prior to construction commencing.

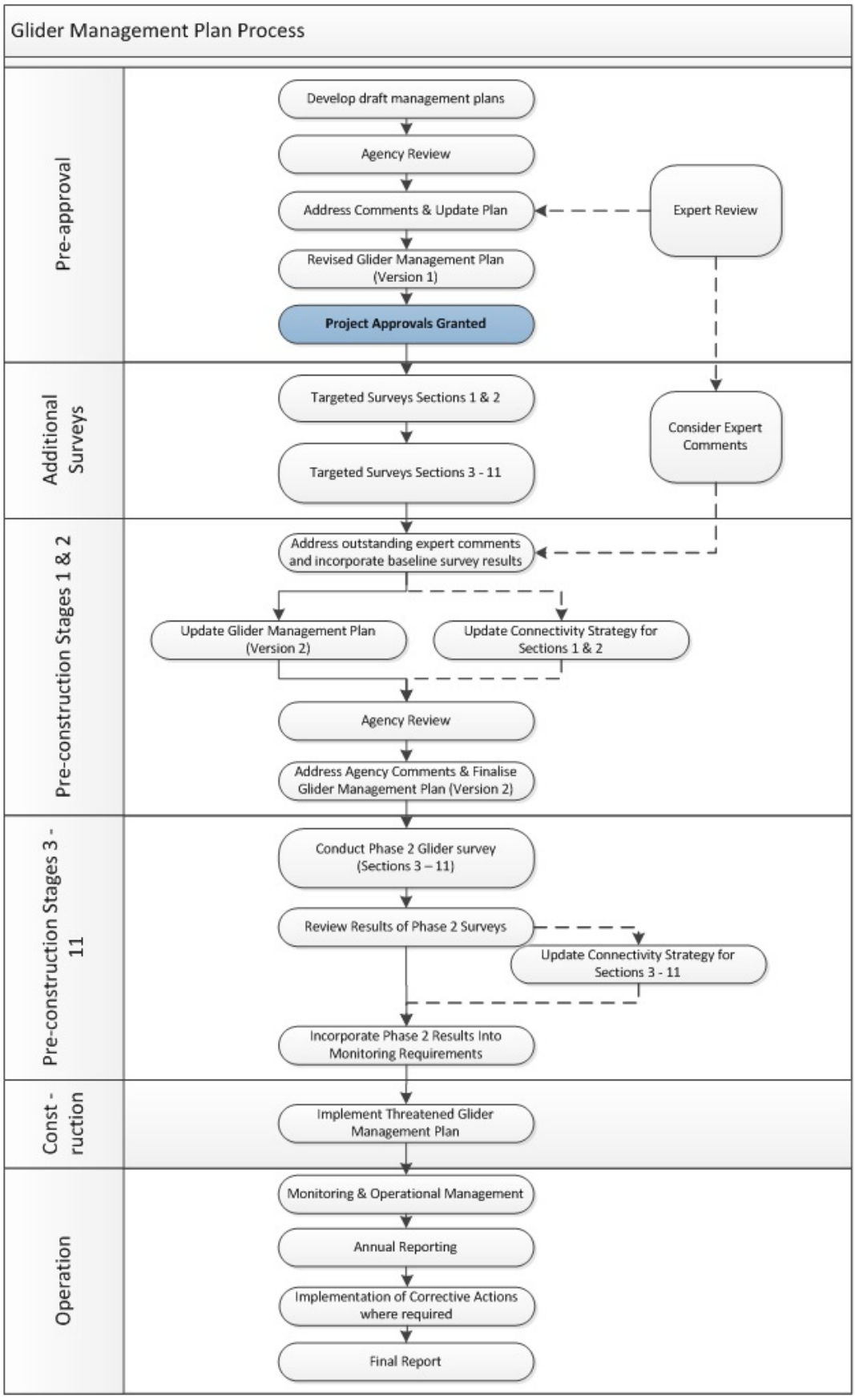


Figure 1.3 Process to update and finalise the management plan

1.4 Plan authors and expert review

1.4.1 Authors

Version 1

The first version of the TGMP was prepared by Chris Thomson and Valerie Hagger of Jacobs (previously known as Sinclair Knight Merz (SKM)) and addressed expert reviewer comments from Dr Rodney van der Ree (as outlined in **Appendix A**). A summary of personnel involved including their experience and qualifications are summarised in **Table 1.2**.

Version 2

Supplementary targeted glider surveys and baseline studies have been undertaken by Sandpiper Ecological Surveys. The field ecologists that led these surveys and reporting including their experience and qualifications are summarised in **Table 1.2**. Revisions of the TGMP (Version 2) to incorporate the results of targeted surveys and address remaining 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**.

Version 3

The results of threatened glider baseline surveys for Sections 3-11 (Sandpiper Ecological Surveys October 2016) have been provided in Appendix D. A complete list of glider population monitoring locations have been added in Table 8.5 and illustrated in Figure 8.1. The field ecologists that led these surveys and reporting including their experience and qualifications are summarised in **Table 1.2**. In addition, consistent with the intent of the TGMP, the approach to monitoring of arboreal crossing structures has been revised to schedule monitoring for all arboreal crossing structures within a project section at the same time, rather than individually. This approach will enable meaningful and robust data comparisons, particularly with the population monitoring data. This approach will also reduce the potentially confounding effects of differing stages of construction.

The installation of hair funnels on crossing structures (glide poles and rope bridges) has been removed from this Version based on expert advice from Brendan Taylor (Sandpiper Ecological Consultants) that funnels may provide an attractant and distort any assessment to determine use of the structures by arboreal animals. These changes have been made in Section 8.3.3 of the report.

Revisions of the TGMP (Version 3) have been prepared by Chris Thomson and Jaci Tebb of Jacobs. 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	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	Bachelor of Science and Master of Conservation Biology	Valerie Hagger 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.
Dr Rodney van der Ree ARCUE	Ph.D. School of Ecology and Environment, Deakin University "Ecology of arboreal	Rodney is currently employed at ARCUE which is a research division of the Royal Botanic Gardens Melbourne and is also part of the School of Botany at The University of Melbourne. Rodney is responsible for conducting high quality scientific

Personnel	Qualifications	Experience
	marsupials in a network of remnant linear habitats". Bachelor of Science (1st Class Honours), Deakin University. Bachelor of Applied Science, Deakin University, with majors in Biology, Terrestrial Ecology, Earth Sciences and Environmental Science.	research on the impacts of human activities on wildlife as well as managing the commercial and collaborative research partnerships and consultancies between ARCUE and its clients. Rodney's research projects are diverse, and broadly cover the effects of habitat loss and fragmentation due to the construction of cities and towns as well as other infrastructures, such as roads, and agricultural activities. Rodney's experience includes successfully completing a number of consultancy projects for a range of clients in Victoria and New South Wales, including the New South Wales National Parks and Wildlife Service, VicRoads, and the Albury-Wodonga Development Corporation. The research included studies of the distribution and abundance of Squirrel Gliders in New South Wales and Victoria and the development of mitigation measures to facilitate the crossing of major roads by fauna.
David Rohweder Sandpiper Ecological	PhD - Shorebird Ecology Bachelor of Applied Science Diploma of Applied Science & Resource Management	David has over 20 years' experience conducting surveys and designing monitoring programs for a diverse array vertebrate fauna in northern NSW and southern Queensland. David is experienced with the range of survey techniques required to sample vertebrate fauna. He has undertaken targeted surveys for several threatened mammal species including the Yellow-bellied Glider, Squirrel Gliders, Spotted-tailed Quoll, Koala and Brush-tailed Rock Wallaby. Relevant examples of David's previous experience includes: • Ecological impact assessments, glide tree identification, nest box tree identification, pre-clearance surveys, nest-box monitoring, tree hollow assessments and the implementation of fauna management strategies for the Nambucca Heads to Urunga Pacific Highway Upgrade. • Ecological impact assessments, glide tree identification, nest box tree identification, pre-clearance surveys, nest-box monitoring, tree hollow assessments and the implementation of fauna management strategies for the Oxley Highway to Kundabung Pacific Highway Upgrade. • Identify preferred locations and design for aerial crossings and design and specify the extent of exclusion fencing for brush-tailed phascogale within the Woolgoolga to Glenugie upgrade alignment. • Monitoring of fauna mitigation measures installed as part of the Bonville Pacific Highway Upgrade. This included monitoring the use of three large bridge fauna underpasses by vertebrate fauna, vegetated medians by gliders and a rope bridge by gliders. • Conducting a vertebrate fauna survey of the proposed route for the Devils Pulpit Pacific Highway Upgrade and assessment of the impact of the upgrade on fauna. The survey involved managing a team of three staff in the field and the application of a range of survey procedures to determine the biodiversity values of the study area. • Implementing the operational phase fauna monitoring program for the Glenugie Pacific Highway Upgrade. Tasks include monitoring three aerial crossings (rope bridges), seven underpasses, nest boxes and fauna fence to assess suitability for targeted threatened fauna. In addition to his experience as an ecological consultant, David has also published 17 peer reviewed journal articles in a range of scientific Journals including Wildlife Research, Australian Zoologist and Australian Mammalogist.
Brendan Taylor Sandpiper Ecological	PhD - Wildlife Ecology and Management Bachelor of Applied Science (Honours)	Brendan has had a diverse professional history spanning more than12 years in both the public and private sectors throughout Eastern Australia. Beyond survey and reporting work, much of Brendan's professional ecological experience has been associated with the monitoring and management of Australian native mammal species, particularly in the context of the impacts related to large scale infrastructure projects. Examples of Brendan's previous experience include: • Monitoring use of rope bridges and glide poles by gliders on the Oxley Highway as a part of the Oxley Highway operational phase monitoring program. • Targeted field surveys for squirrel glider, yellow-bellied glider and brush-tailed phascogale for the Iluka Road to Ballina Pacific Highway Upgrade. • Monitor use of vegetated medians by gliders. Used radio-telemetry to track sugar gliders in the vicinity of vegetated medians for the Bonville Pacific Highway upgrade. • Monitored use of aerial crossing by arboreal mammals for the Karuah to Bulahdelah Pacific Highway Upgrade. • Assessment of the arboreal mammal use of road crossing structures for Brisbane City Council.

Personnel	Qualifications	Experience
		• Monitoring the use of underpasses, aerial crossings and nest boxes for the Glenugie Pacific Highway Upgrade operational phase fauna monitoring program. Additionally, Brendan has conducted research for, and co-authored, a number of publications on Australian gliding mammals including *Facilitated movement over major roads is required to minimise extinction risk in an urban metapopulation of a gliding mammals* (2012) and *Restoring Connectivity in Landscapes Fragmented by Major Roads: a Case Study Using Wooden Poles as "Stepping-Stones" for Gliding Mammals* (2012). Brendan is considered to be an expert in this field.
Thomas St Vincent Welch Sandpiper Ecological	Bachelor of Applied Science	In his two years of professional experience Thomas has developed valuable knowledge and skills conducting threatened fauna surveys and implementing management and monitoring plans for a variety of vertebrate species. Examples of Thomas' previous experience includes: • Conducting targeted surveys for the Yellow-bellied Glider and Squirrel Glider on the Woolgoolga to Glenugie Pacific Highway Upgrade project. • Conducting fauna surveys, fauna relocation and providing advice on the implementation of the fauna management plan for Nambucca Heads to Urunga Pacific Highway Upgrade. • Monitoring of Spotted-tailed Quoll populations in the vicinity of the Nambucca Heads to Urunga Pacific Highway Upgrade. • Conducting spotlighting surveys along transects between Woolgoolga and Ballina for the Woolgoolga to Ballina Pacific Highway Upgrade. • The monitoring of fauna activity in culverts and nest boxes for Glenugie Pacific Highway Upgrade post construction monitoring. • The monitoring of fauna activity in culverts and nest boxes for Coopernook to Herons Creek post construction monitoring.
Don Owner Benchmark Environmental management	Bachelor of Applied Science (Hons)	Don's ecological consulting career spans over 17 years and during this time Don has contributed to over 200 environmental assessment and/or management projects. Don has a significant amount of experience in the development and implementation of fauna monitoring programs, flora and fauna management plans and biodiversity surveys design. Examples of Don's relevant experience include: • Developing the Nest Box Management Plan for the Sapphire to Woolgoolga Pacific Motorway Upgrade. • The Flora and Fauna Sub-Management Plans for Karuah to Bulahdelah Pacific Highway Upgrade Stage 1. • Koala Population Monitoring at the Coffs Harbour Base Hospital Cancer Care Facility. • A Nest Box Management Plan for the Karuah to Bulahdelah Pacific Highway Upgrade Stages 2 and 3. • The Nymboi-binderay National Park Threatened Fauna Survey. • The Moonee Forest Vertebrate Fauna Survey. • The Ecological Monitoring Program for the Warrell Creek to Urunga Pacific Motorway Upgrade.
Berlinda Ezzy Amec Foster Wheeler	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 Foster Wheeler	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. • Targeted threatened fauna assessments and impact assessments throughout

Personnel	Qualifications	Experience
		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.

1.4.2 Expert review

An expert review of the plan was undertaken in August 2013 by Dr Rodney van der Ree. Dr van der Ree is currently the Deputy Director and Manager, Ecological Sciences: Australian Research Centre for Urban Ecology (ARCUE) and responsible for conducting high quality scientific research on the impacts of human activities on wildlife. His current research projects are diverse, and broadly cover the effects of habitat loss and fragmentation due to the construction of cities and towns as well as other infrastructures, such as roads, and agricultural activities.

Rodney has successfully undertaken consultancy projects for a range of clients in Victoria and New South Wales, including the New South Wales National Parks and Wildlife Service, VicRoads, and the Albury-Wodonga Development Corporation. His research has included studies of the distribution and abundance of Squirrel Gliders in New South Wales and Victoria, particularly in networks of linear remnants and also the development of mitigation measures to facilitate the crossing of major roads by Squirrel Gliders.

Rodney has ten peer reviewed scientific journal articles on gliders and many more on small mammals and road interactions. He has also supervised postdoctoral fellows and students researching gliders.

Rodney has is an active member a number of professional organisations and has been invited to sit on a number of expert scientific committees across Australia. In addition, he has published more than 60 reports and popular articles, given in excess of 70 presentations at conferences, workshops, community groups and more than 20 media appearances, including TV, radio, and newspaper.

A curriculum vitae for Dr Rodney van der Ree is provided in **Appendix B**.

1.5 Consultation

Roads and Maritime have consulted with DP&E and EPA during the development of this plan. Each agency was provided a copy of the Draft TGMP on 12 December 2014. Feedback received and Roads and Maritime responses to all comments raised have been included in **Appendix A** of the TGMP. A summary of the key issues and proposed amendments in finalising the plan is outlined in **Table 1.3**.

Table 1.3 Summary of agency consultation and how comments have been addressed

Document Version	Review Date	Review Agency	Summary of Comments	Section of Report Addressing Comments
Version 2	11/02/15	EPA	The performance threshold is stated as Low (<5). This may be considered low in the context of the entire project, i.e. W2B sections 1-11, however in a single section of project with a low density of gliders this would be a poor outcome. Please clarify whether the measure (<5) is to be used for each project section or does it refer to a clearing front or the entire project? The EPA recommends a lower mortality rate depending on the geographic area. The section on Monitoring/timing frequency is referring to the retention period of habitat trees (that may house gliders). Please clarify if the suggested timing range (24 – 48 hours) represents the retention period and if so please maintain a 48 hour retention period.	Wording has been updated to now state that any mortality of a threatened glider is reported to the EPA within 24 hours. Baseline studies have a relatively small number of glider records therefore after further consideration an acceptable mortality rate cannot be reliably determined. Any mortality should be considered significant and evaluated. Table 6.3 has been updated. Amend the retention of habitat trees for a minimum of 48 hours.
Version 2	11/02/15	EPA	In this section and in a number of places throughout this document the monitoring	Updated with MCoA (D8) (k) wording throughout document.

Document Version	Review Date	Review Agency	Summary of Comments	Section of Report Addressing Comments
			period is suggested to continue until effectiveness is established or for a maximum period of 5 years. This is inconsistent with MCoA (D8)(k) which states that monitoring shall continue until effectiveness is established over three monitoring periods, or until such time as agreed by EPA. Please amend the plan to reflect the MCoA.	
Version 2	11/02/15	EPA	If monitoring reveals a glider road kill hot spot, rather than mitigating this by clearing roadside vegetation the EPA would prefer to see the installation of additional crossing poles or rope bridges. This could be justified readily if arboreal crossing structures in the vicinity have proven to be ineffective. If after a period of say 3 - 5 years, any non-utilised structures could be considered for shifting to these road kill hot spots.	Crossing structures serve as 'insurance' in the case of stochastic events such as fire or disease which may occur at long time intervals. Further the cost of decommissioning and relocating a rope bridge or glide pole array is likely to be comparable to the cost of installing a new structure. Accordingly, RMS does not intend to remove/relocate structures. However, should road kill data indicate a road-kill hot spot for gliders where there is limited crossing structures RMS will investigate the feasibility of installing an additional crossing structure. These provisions are addressed in Table 7.3 and Table 8.3.
Version 2	11/02/15	EPA	Whilst this plan proposes all probable mitigation measures to facilitate YBG connectivity across the highway barrier, it remains unknown whether this species will utilise these structures, including the widened medians. The EPA is therefore seeking an adaptive approach to possible contingency measures as monitoring and population results become available over time. It is difficult to predict how this will manifest, however the EPA is seeking a commitment to review the effectiveness of mitigation and impacts to YBG populations 3 years after highway operation.	Updated to reflect EPA comments. Wording has been updated in Section 8 (third paragraph) to state a review of the effectiveness of connectivity structures for YBG and other monitoring results will occur after 3 years of monitoring post highway operation. With the intent of this review to take an adaptive approach and vary mitigation measures if they aren't proven to be effective. In accordance with MCoAD2 if it is determined connectivity measures have not successfully mitigated the barrier and fragmentation impact to relevant species, the residual impact to connectivity shall be offset. These requirements are addressed in Table 8.3.
Version 2	13/02/2015	DP&E	Figure 6.1 does not show the survey results for the two glider species which are described in Section 3.1. Consistency with the proposed measures should be shown. Otherwise add a separate figure showing the survey results in Section 3 for all surveys conducted to date.	Figure has been created highlighting the survey results (Figure 2-1). Figure 3.1 illustrates survey locations.
Version 2	13/02/2015	DP&E	Did the 2013 and/or December 2014 survey include the ancillary facility sites and if so, what did the results show in terms of glider species at the ancillary facility sites? It isn't clear from the information provided in Section 3.	These areas will be determined closer to construction and will be sited outside of glider habitat where practicable. Further details will be outlined within the Ancillary Facility Report (Table 4.1, Section 5.2.3 and Table 5.1).
Version 2	13/02/2015	DP&E	The location of crossing structures must be consistent with the structures proposed in Appendix A – Connectivity Structure Register of the Fauna Connectivity Strategy Woolgoolga to Glenugie (December 2014).	Crossing structures for gliders have been finalised for Sections 1&2 and are detailed in the Fauna Connectivity Strategy and Table 6.1 of the TGMP. Sections 3-11 have not been finalised as yet. Proposed crossing locations were developed during the SPIR and

Document Version	Review Date	Review Agency	Summary of Comments	Section of Report Addressing Comments
				now refined based on Sandpipers targeted survey results and are listed in Table 6.2 in the TGMP. These will be updated after the final targeted and baseline assessments have been completed by Sandpiper. A Fauna Connectivity Strategy will also be finalised at a later date for Sections 3-11 post detailed design.
Version 2	13/02/2015	DP&E	Confirm that monitoring will occur along the whole project corridor where the glider species are known to occur and where management measures are proposed. The second paragraph on page 45 focuses on hot spots.	Updated Section 8 Monitoring to clarify that monitoring will be conducted along the whole project corridor where glider species are known or have the potential to occur. Monitoring will include locations where management measures such as crossing structures and land bridges are proposed.

2. Glider populations

2.1 Background

The Squirrel Glider (*Petaurus norfolcensis*) and Yellow-bellied Glider (*Petaurus australis*) are currently listed as Vulnerable in NSW under the BC Act.

2.1.1 Habitat requirements and populations within the project

Threatened gliders require a landscape mosaic of old growth trees and plant species diversity which meet both foraging and sheltering needs throughout the seasons. Population numbers are likely to be higher in larger patches of contiguously linked forest, but populations will also occur in highly cleared and fragmented areas where suitable denning and foraging resources occur, such as small parcels of vegetation with occasional relict canopy trees, vegetated road verges or riparian corridors.

Squirrel Glider

Adult Squirrel Gliders are described by OEH (2014) as having a head and body length of about 20 cm and a soft and bushy tail averaging about 27 cm in length. They have blue-grey to brown-grey fur above, white on the belly and the end third of the tail is black. There is a dark stripe from between the eyes to the mid-back. The species lives in family groups of a single adult male one or more adult females and offspring (OEH 2014). Their diet varies seasonally and consists of acacia gum, eucalypt sap, nectar, honeydew and manna, with invertebrates and pollen providing protein (OEH 2014).

The species is widely distributed in eastern Australia, from northern Queensland to western Victoria (OEH 2014). The distribution of the Squirrel Glider throughout the North Coast Bioregion is widespread within coastal sclerophyll forests and swamp forests, extending into drier forests and woodlands of the tablelands in the northern regions. There are 603 Squirrel Glider sightings in the Atlas of NSW Wildlife for the NSW North Coast Bioregion, with the bulk of these records from the eastern areas of the bioregion (OEH 2013).

They nest in bowl-shaped, leaf lined nests in tree hollows (OEH 2014). They frequent habitats with an abundant and varied supply of nectar and arthropods (Kavanagh 1984). Access to winter flowering species and species with abundant nectar producing qualities is optimal. They are also dependent on tree hollows for shelter and breeding. Their reliance on these microhabitat features limits their distribution to older growth vegetation which may occur wholly across the landscape or may occur patchily in riparian areas in combination with managed production forests.

Recent home range studies carried out in Bungawalbin Nature Reserve (approximately 17 km west of the existing Pacific Highway near Woodburn) estimate home ranges for this species to encompass approximately 6.2 ha for individuals and 6.7 ha for groups and on average measuring 482 x 178 m (D. Sharpe and Goldingay 2007). This study also identified individuals of this species to move on average 1,174 m for females and 1,043 m for males. Van der Ree, Bennett and Gilmore (2003) also found similar nightly movement distances.

Refer to Section 4.3.2 (pp 365-366 and 312-313) of the Biodiversity Working Paper (Roads and Maritime 2012) for a more detailed description of habitat requirements.

Within the project area Squirrel Glider populations are associated with mature dry and moist sclerophyll forests. They rely primarily on a diversity of eucalypt species in the canopy and in some locations, nectar supply from Banksia and Melaleuca species.

Squirrel Gliders have been recorded throughout large portions of the project corridor– with the three broad locations of Squirrel Glider populations intersected by the project include:

- Woolgoolga to Glenugie including Halfway Creek, Wells Crossing and Glenugie State Forest (Sections 1 and 2 of the project)
- The slopes of the Summervale Range from Pillar Valley to Gulmarrad and Tyndale (Section 3); and

- Bundjalung National Park to Devils Pulpit, Tabbimoble State Forest and Doubleduke State Forest (Sections 6 and 7 of the project).

The Atlas of NSW Wildlife shows 144 Squirrel Glider records within 10 km of the project (OEH 2013). Squirrel Glider records captured during Sandpipers targeted and baseline threatened glider surveys, and Atlas of NSW Wildlife records within proximity of the project are illustrated in **Figure 2.1**.

It should also be acknowledged that the species may occur in lower densities in areas of highly cleared or fragmented forest adjacent to the project area.

Yellow-bellied Glider

Adult Yellow-bellied Gliders are described as having a head to body length of about 28 cm, with a long and fluffy tail generally about 42 cm (NPWS 2003), approximately one and a half times the length of the body. The species weighs about 700 g and is the largest Petaurid known in Australia (NPWS 2003). It is grey above, with underparts that range from whitish through yellow to orange with increased age and it has large, pink-grey and bare ears (NPWS 2003).

It inhabits a wide range of forest types but prefers resource rich forests where mature trees provide nesting hollows and tree species composition provides year-round continuity of food resources (NSW 2003). Plant and insect exudates (nectar, sap, honeydew and manna) provide the bulk of the Yellow-bellied Glider diet (NPWS 2003).

The Yellow-bellied Glider inhabits tall, mature dry and moist sclerophyll forests on nutrient rich soils. They rely primarily on plant and insect exudates, including nectar, sap, honeydew and manna with pollen and insects providing protein. The species is very mobile and require large home ranges of up to 85 ha (OEH 2014); however, home ranges may vary based on the abundance and access to seasonally variable food resources (Goldingay and Kavanagh 1991). Extensive areas of mixed forest are required and they are also dependent on tree hollows for shelter and breeding which limits their distribution to older growth vegetation. This habitat may occur wholly across the landscape or may occur patchily in riparian areas in combination with managed production forests. This species is noted as having high levels of gliding capability and is highly mobile within its home range (Goldingay and Kavanagh 1991).

Refer to Section 4.3.2 (pp 365-366) of the Biodiversity Working Paper (Roads and Maritime 2012) for a more detailed description of habitat requirements.

The Yellow-bellied Glider has a patchy distribution across a wide range of eastern and south-eastern mainland Australia (NPWS 2003). The distribution of the Yellow-bellied Glider is widespread across the slopes, ranges and coastal areas of the North Coast Bioregion in large key habitats and corridors. It is generally absent from the heavily fragmented alluvial floodplains, wetlands and north of the Richmond River in the coastal heath and floodplains. There are 4,802 Yellow-bellied Glider records in the Atlas of NSW Wildlife for the NSW North Coast Bioregion (OEH 2013).

The Atlas of NSW Wildlife shows 288 records within 10 kilometres of the project (OEH 2013). Yellow-bellied Gliders have been recorded in Sections 1 to 3 and 6 to 8 of the project. The location of populations of Yellow-bellied Glider occur from Woolgoolga to Wells Crossing (Sections 1 and 2 of the project), Tabbimoble (Section 6 and 7 of the project) and Broadwater National Park (Section 9 of the project) have been determined through ecological surveys undertaken from 2006 to 2012, review of NSW Atlas data identifying broad population hotspots and consultation with the EPA.

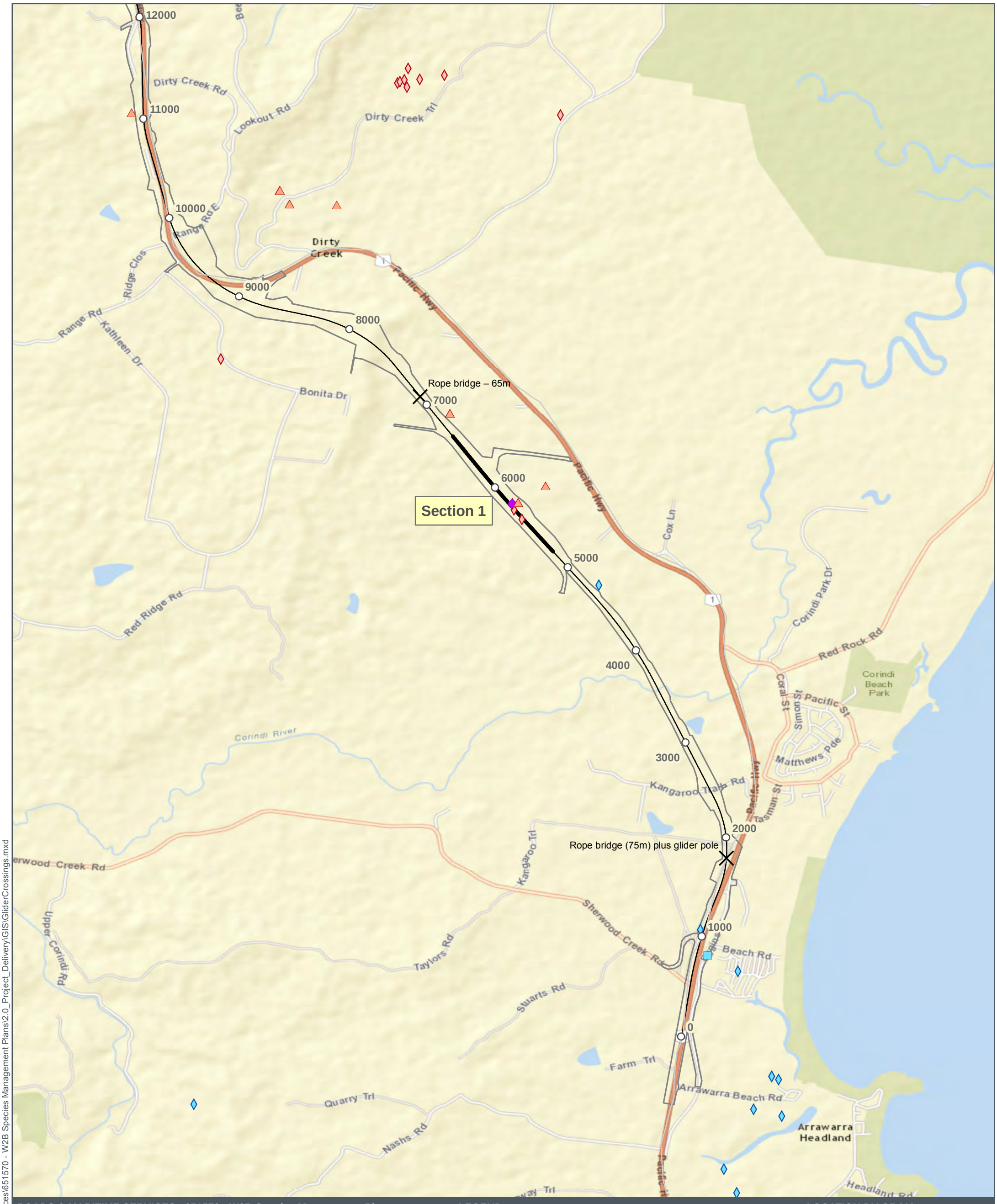
There are several records for the species in the Halfway Creek area (Section 2 of the project) which is considered a hotspot for this species. The two main locations of Yellow-bellied Glider population intersected by the project include:

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

Sandpiper Yellow-bellied Glider records and Atlas of NSW Wildlife records within proximity of the project are illustrated in **Figure 2.1**. It should also be acknowledged that the species may occur in lower densities in areas of highly cleared or fragmented forest adjacent to the project area.

The location of threatened glider records and predicted habitat are also illustrated within **Appendix C and E** (Sandpiper Ecology Report, 2014/15).

Figure 2.1 Threatened glider records in proximity to the project and crossing structures, refer to table 6.2 for updated structure locations in Section 10



ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 2-1 Threatened Glider Populations in Relation to the Project

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits:

LEGEND

- Chainage
- Alignment
- Project Boundary
- Proposed Glider Crossing Structure
- Glider Crossing Structure
- Proposed Vegetated Median
- Vegetated Median

Sandpiper Survey Record
- *Petaurus australis*
- *Petaurus norfolcensis*
- *Petaurus australis* and *Petaurus norfolcensis*

Atlas of NSW Wildlife Record
- *Petaurus australis*
- *Petaurus norfolcensis*

ISSUE DATE	AUTHOR	QA CHECK	APPROVED	MAP REV.	REVISION NOTE
04/03/2015	JH	MT	BE	0	Issued for Use
02/03/2015	JH	MT	BE	A	Issued for Review

amec foster wheeler

N

0 250 500
Metres

1:34,000

(A3) GCS GDA 1994

LOCATION DIAGRAM

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Bald Hill
Tick Gate Rd
24000
23000
Georges Rd
Julies Rd
Coldstream River
Coast Range Rd
22000
Section 2
21000
Julies Rd
Pigeon Gully Fire Tl
Luthers Rd
Quarry Rd
Halfway Creek
20000
Browns Rd
Kungala Rd
19000
18000
Gilmores Ln
17000
Tallowood Trl
Grays Rd
16000
Crawfords Trl
15000
14000
Mcphillips Rd
Section 1
Rope bridge – 61m
12000
Dirty Creek Rd
11000
10000
Gilmores Ln

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

ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 2-1
Threatened Glider Populations in Relation to the Project

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits:

LEGEND

- Chainage
- Alignment
- Project Boundary
- Proposed Glider Crossing Structure
- Glider Crossing Structure
- Proposed Vegetated Median
- Vegetated Median

Sandpiper Survey Record
- *Petaurus australis*
- *Petaurus norfolcensis*
- *Petaurus australis* and *Petaurus norfolcensis*

Atlas of NSW Wildlife Record
- *Petaurus australis*
- *Petaurus norfolcensis*

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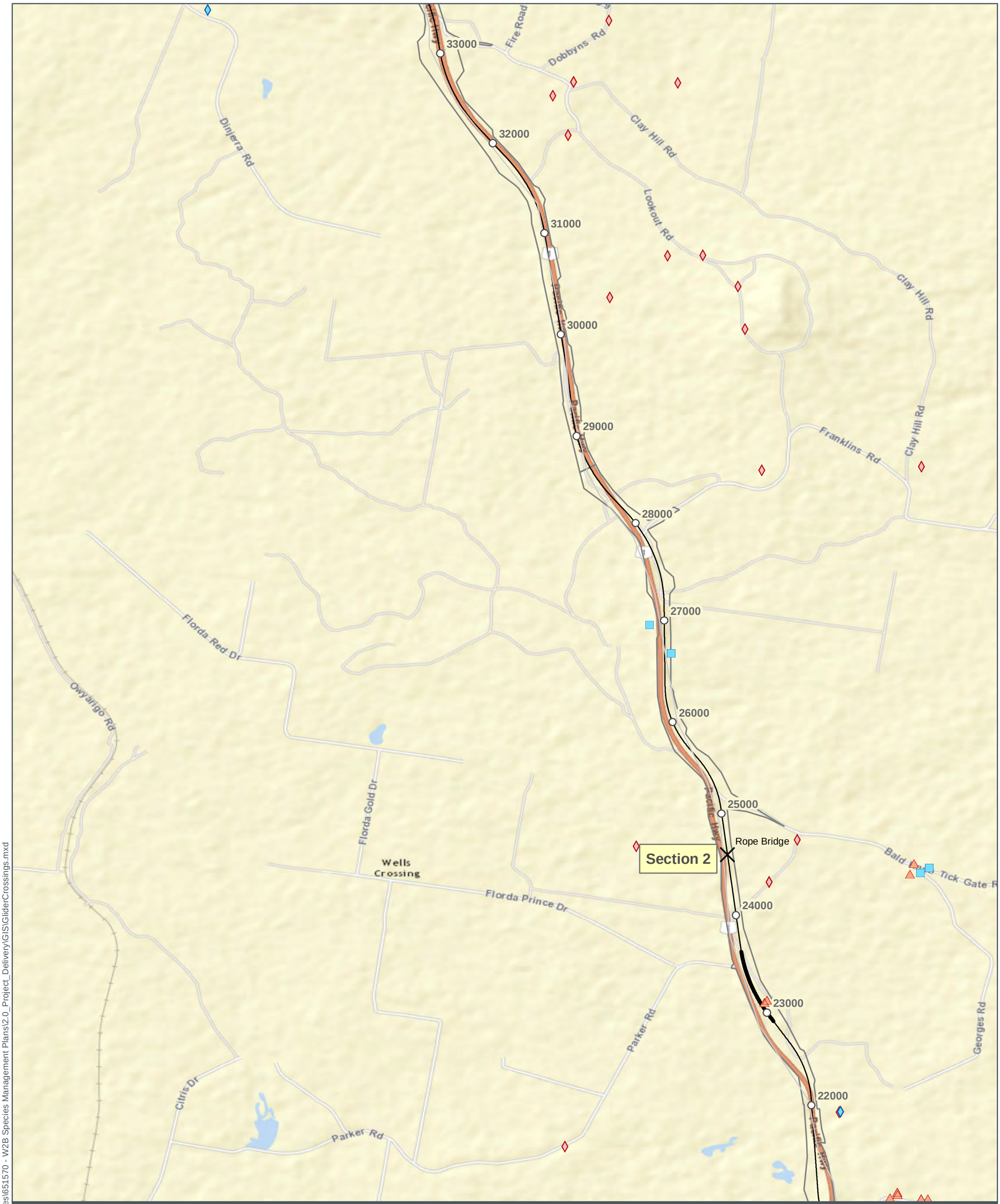
LOCATION DIAGRAM



ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 2-1 Threatened Glider Populations in Relation to the Project

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits:

LEGEND

- Chainage
- Alignment
- Project Boundary
- Proposed Glider Crossing Structure
- Glider Crossing Structure
- Proposed Vegetated Median
- Vegetated Median

Sandpiper Survey Record
- *Petaurus australis*
- *Petaurus norfolcensis*
- *Petaurus australis* and *Petaurus norfolcensis*

Atlas of NSW Wildlife Record
- *Petaurus australis*
- *Petaurus norfolcensis*

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0 250 500
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LOCATION DIAGRAM

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Bom Bom
Pacific Hwy
1
Glenugie Creek
Reilleys Ln
No 3 Fire Rd
Stokers Rd
No 2 Fire Rd
No 4 Fire Rd
No 5 Fire Rd
No 6 Fire Rd
No 7 Fire Rd
No 8 Fire Rd
Popes Rd
Glenugie
Six Mile Ln
Carioca Ln
Grafton Airport
Old Six Mile Ln
Aerodrome Rd
Eight Mile Ln
Dungel Rd
Dinjerra Rd
Shields Rd
No 10 Fire Rd
Fire Road No 3
Fire Road No 9
Dobbyns Rd
Clay Hill Rd
Lookout Rd
Rope bridge
Glide poles
40000
39000
38000
37000
36000
35000
34000
33000
32000
31000
Section 3

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ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 2-1
Threatened Glider Populations in Relation to the Project

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits:

LEGEND

- Chainage
- Alignment
- Project Boundary
- Proposed Glider Crossing Structure
- Glider Crossing Structure
- Proposed Vegetated Median
- Vegetated Median

Sandpiper Survey Record
- *Petaurus australis*
- *Petaurus norfolcensis*
- *Petaurus australis* and *Petaurus norfolcensis*

Atlas of NSW Wildlife Record
- *Petaurus australis*
- *Petaurus norfolcensis*

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02/03/2015	JH	MT	BE	A	Issued for Review

amec foster wheeler

0 250 500
Metres

1:34,000

(A3) GCS GDA 1994

LOCATION DIAGRAM

Rope bridge
50000
Wooli Rd
Mitchell Rd
Avenue Rd
Lavadia
49000
Glide poles
48000
47000
Section 3
46000
45000
Bluff Rd
44000
43000
42000
41000
40000
Old Six Mile Ln
Wants Ln
Wants Ln
Lloyds Rd
Wooli Rd
Sandy
Crossing
Eight Mile Ln
Avenue Rd
Eight Mile Ln
Sunnyside Rd
No 2 Fire Rd
Fire Road No 4
Fire Road No 6
Stonehouse Rd
Dobbins Rd
No 5 Fire Rd
Morilla Rd
Fire Road No 7
No 14 Fire Rd

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ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 2-1 Threatened Glider Populations in Relation to the Project

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits:

LEGEND

- Chainage
- Alignment
- Project Boundary
- Proposed Glider Crossing Structure
- Glider Crossing Structure
- Proposed Vegetated Median
- Vegetated Median

Sandpiper Survey Record

- *Petaurus australis*
- *Petaurus norfolcensis*
- *Petaurus australis* and *Petaurus norfolcensis*

Atlas of NSW Wildlife Record

- *Petaurus australis*
- *Petaurus norfolcensis*

ISSUE DATE	AUTHOR	QA CHECK	APPROVED	MAP REV.	REVISION NOTE
04/03/2015	JH	MT	BE	0	Issued for Use
02/03/2015	JH	MT	BE	A	Issued for Review

amec foster wheeler

N

0 250 500
Metres

1:34,000

(A3) GCS GDA 1994

LOCATION DIAGRAM

Gilletts Ridge
Bean Ball Ln S
Gilletts Ridge Rd
Bowlings Rd
Falconer Rd
Bellengen St
Coldstream TRC
Mookin St
Angouri St
Aradin St
Tucabia Rd
Wooli Rd
Mitchell Rd
Somervale Rd
Boundary Trl
Bostock Rd
Foster Hut Ln
Firth Heinz Rd
Barry's Bridge Rd

59000
58000
57000
56000
55000
54000
53000
52000
51000
50000
49000
48000

Rope bridge
Rope bridge
Glide poles

Section 3

ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 2-1 Threatened Glider Populations in Relation to the Project

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits:

LEGEND

- Chainage
- Alignment
- Project Boundary
- Proposed Glider Crossing Structure
- Glider Crossing Structure
- Proposed Vegetated Median
- Vegetated Median

Sandpiper Survey Record
- *Petaurus australis*
- *Petaurus norfolcensis*
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Atlas of NSW Wildlife Record
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0 250 500
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(A3) GCS GDA 1994

LOCATION DIAGRAM

Gold Coast

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

Clarence River
Dents Ln
South Arm School Rd
South Arm
Pacific Hwy
Sherrys Ln
Coldstream Rd
Calligans Creek Rd
Point Rd
Lower Coldstream Rd
Bean Ball Ln N
Coldstream
Tucabia Rd
Bean Ball Ln S
Gilletts Ridge
Gilletts Ridge Rd
Somervale Rd
Erths Rd
Claypinch Rd
Crowleys Rd
Gold Coast
Section 4
Section 3
69000
68000
67000
66000
65000
64000
63000
62000
61000
60000
59000
58000
57000

ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 2-1
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LOCATION DIAGRAM

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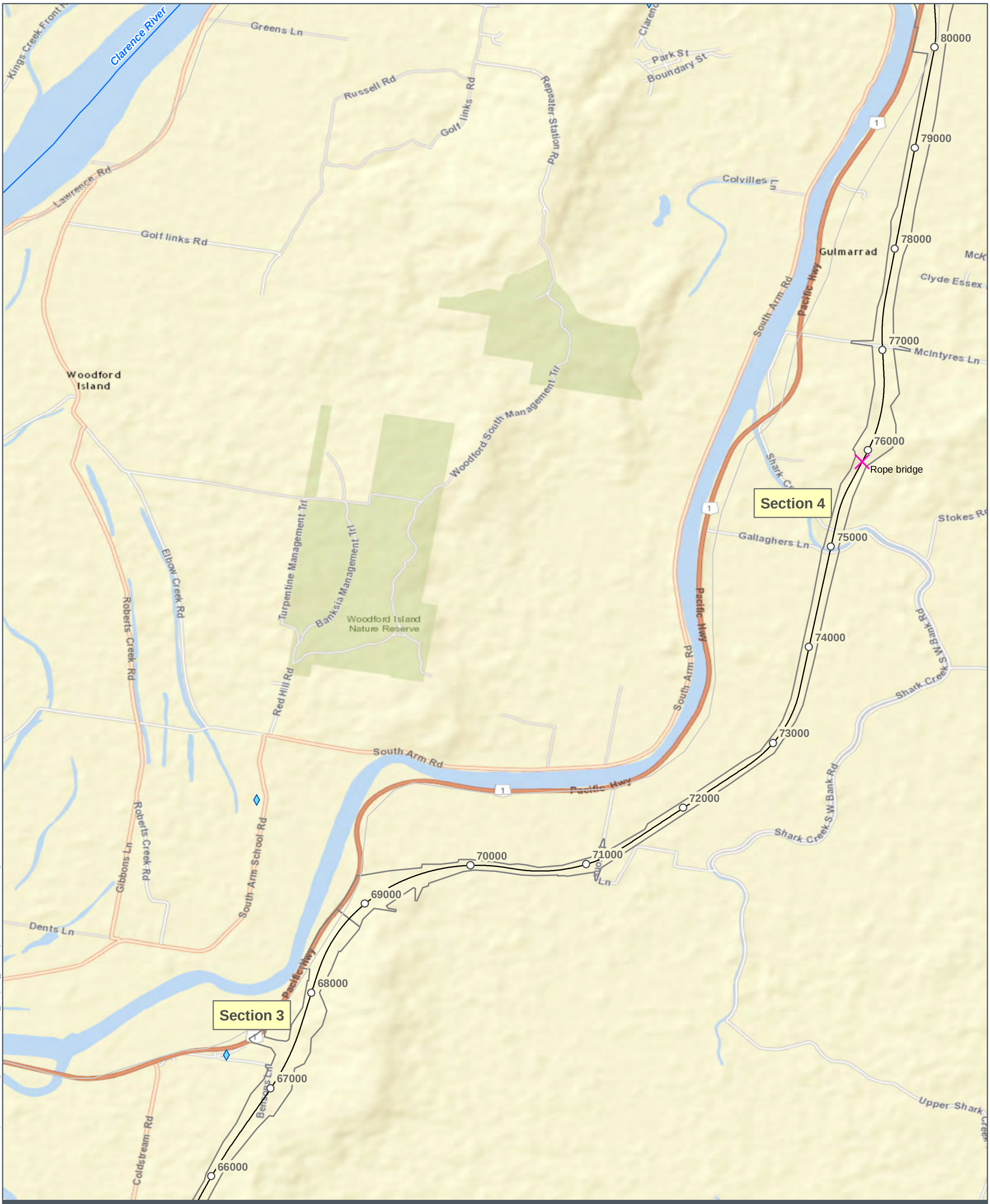

ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 2-1 Threatened Glider Populations in Relation to the Project

WORK REQUEST NUMBER: RMS

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ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 2-1 Threatened Glider Populations in Relation to the Project

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- Vegetated Median

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Metres

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(A3) GCS GDA 1994

LOCATION DIAGRAM

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

Mororo
100000
Glide poles
99000
Section 6
98000
Mororo Rd
Mororo Fire Trl
Washed Out Trl
Bundjalung National Park
Bazzas Fire Trl
Woombah East Fire Trl
Woombah Fire Trl
97000
Lewis Ln
Banana Rd
96000
Section 5
Mororo Creek Nature Reserve
Iluka Rd
Woombah
95000
North St
Emu Dr
Adams St
Andersons Trl
Garretts Ln
94000
Middle Channel
Fischers Rd
Goodwood Island Rd
Chatsworth Rd
Carrolls Ln
93000
Goodwood Island Rd
Chatsworth
92000
Warregah Island
Warregah Island Rd
91000
Durringtons Ln
Serpentine Chan N Bran Rd
Chan S Bran Rd
90000
Serpentine
Clarence River
McConnells Ln
Palmers Island Middle Rd
North Arm Dr
Back Channel Ln
Ryans Rd
89000
Youngs Ln
Ashby Heights
Martins Point Rd
Bewleys Ln
Gillies Ln
Wiblens Ln
Olsons Ln
Eckmans Ln

ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 2-1 Threatened Glider Populations in Relation to the Project

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits:

LEGEND

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- Alignment
- Project Boundary
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- Glider Crossing Structure
- Proposed Vegetated Median
- Vegetated Median

Sandpiper Survey Record
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- *Petaurus norfolcensis*
- *Petaurus australis* and *Petaurus norfolcensis*

Atlas of NSW Wildlife Record
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amec foster wheeler

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0 250 500
Metres

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(A3) GCS GDA 1994

LOCATION DIAGRAM

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

Section 7

Section 6

Range Rd
Slys Rd
Island Rd
Tick Fence North Trl
Pine Rd
Thompsons Rd
Big Marsh Rd
Mervs Rd
Khams Rd
Pacific Hwy
Mororo Rd
Slys Rd
Tullymorgan Jackybulbin Rd
Claires Rd
Mororo Fire Trl
Number Two Trl
Mororo
Eastern Boundary Trl
Washed Out
Glide poles

111000
110000
109000
108000
107000
106000
105000
104000
103000
102000
101000
100000
99000
98000

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ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 2-1
Threatened Glider Populations in Relation to the Project

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LEGEND

- Chainage
- Alignment
- Project Boundary
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- Glider Crossing Structure
- Proposed Vegetated Median
- Vegetated Median

Sandpiper Survey Record
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amec foster wheeler

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0 250 500
Metres

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(A3) GCS GDA 1994

LOCATION DIAGRAM

Gold Coast

Mahogany Rd
Forest Rd
Swan Bay New Italy Rd
The Gap (North)
122000
121000
Cypress Rd
Aplins Rd
120000
Piccolis Rd
Cypress Rd
119000
Land bridge
Glide poles
Right Angle Trl
North Pacific Trl
118000
Darkys Rd
Minyumai Rd
Tabbimoble Swamp Nature Reserve
Piccolis Rd
Cypress Rd
117000
Section 7
McCormicks Rd
116000
Rope bridge
Darkys Rd
Tabbimoble Swamp Nature Reserve
Four Strand Trl
Glencoe Rd
115000
Tabbimoble
114000
Felspar Trl
Serrindipity Rd
McFayden Rd
McFayden Rd
113000
Rope bridge
Serrindipity Rd
112000
Roo Trl
Glide poles
111000
Roo Trl
Fence Trl
Fence Trl
Serrindipity Rd
Esk River
110000
Esk Trl
109000
Big Marsh Firetrail
Big Marsh Rd

ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

LEGEND

- Chainage
- Alignment
- Project Boundary
- Proposed Glider Crossing Structure
- Glider Crossing Structure
- Proposed Vegetated Median
- Vegetated Median

Sandpiper Survey Record

- *Petaurus australis*
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Atlas of NSW Wildlife Record

- *Petaurus australis*
- *Petaurus norfolcensis*

LOCATION DIAGRAM

Figure 2-1
Threatened Glider Populations in Relation to the Project

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Metres

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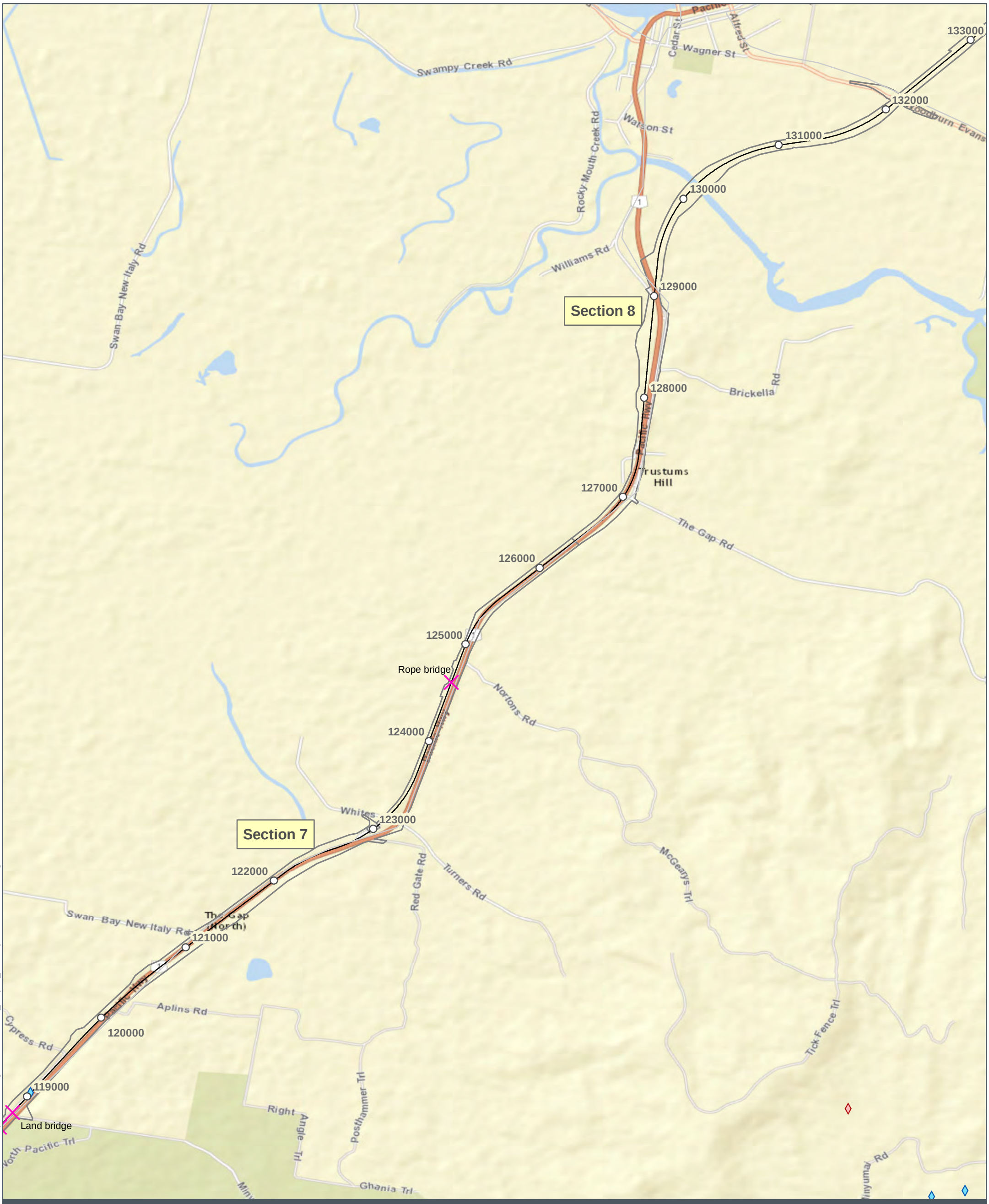

ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 2-1 Threatened Glider Populations in Relation to the Project

WORK REQUEST NUMBER: RMS

DATA SOURCES:
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- Alignment
- Project Boundary
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- Glider Crossing Structure
- Proposed Vegetated Median
- Vegetated Median

Sandpiper Survey Record

- *Petaurus australis*
- *Petaurus norfolcensis*
- *Petaurus australis* and *Petaurus norfolcensis*

Atlas of NSW Wildlife Record

- *Petaurus australis*
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Metres

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LOCATION DIAGRAM

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Figure 2-1
Threatened Glider Populations in Relation to the Project

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- Chainage
- Alignment
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- Glider Crossing Structure
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- Vegetated Median

Sandpiper Survey Record
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N

0 250 500
Metres

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LOCATION DIAGRAM

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153000
152000
151000
150000
149000
148000
147000
146000
145000
144000
143000
142000
141000
140000
139000
Section 10
Section 9
Poles/rope on land bridge
Rope bridge
Land bridge
Land bridge
Wardell Rd
Bagotville Rd
Gahans Rd
Old Bagotville Rd
Bagotville
Lumleys Ln
Wilson St
Pacific Hwy
Pimlico Rd
Wardell Park
Bath St
Carlisle St
Pine St
Creek St
Bridge Dr
Byron St
River Dr
River St
East Wardell
Richmond River
Owens Ln
Meaneys Ln
Cabbage Tree Island (North)
Walshs Ln
Back Channel Rd
Goat Island
Tuckean Broadwater
Banks Ln
Plenkovich Rd
Eversons Ln
Legges Ln
Byrnes St
North Boundary Trl
Coraki Broadwater Rd
Hills Rd
Bessies Trl
Pitt St
Broadwater Quarry Rd
Sugar Co Trl
Ponderosa Trl
Finns Trl
New Block Trl
Rileys Hill Rd
Vales Trl
Cutts Trl
Montis Link Trl
Old Mining Trl
Beryls Trl
Baxters Trl
Maloneys Trl
Broadwater Beach Rd

ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 2-1 Threatened Glider Populations in Relation to the Project

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits:

LEGEND

- Chainage
- Alignment
- Project Boundary
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- Glider Crossing Structure
- Proposed Vegetated Median
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Sandpiper Survey Record
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(A3) GCS GDA 1994

LOCATION DIAGRAM

Gold Coast

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

Bruxner Hwy
Duck Creek Mountain Rd
Gap Rd
Westbridge Ln
Uralba
Uralba Rd
Grays Ln
Wardell Rd
Lynwood
Dees Ln
Behs Ln
Newports Ln
Rous Rd
Dou Jea Ln
Platypus Dr
Davey Rd
Forest Rd
Lovegroves Ln
Pimlico Rd
Hermans Ln
Whytes Ln E
Whytes Ln
Sartories Rd
Pacific Hwy
Laws Rd
Barnes Ln
Perrys Ln
Uralba Nature Reserve
Bartletts Ln
Marom Creek Rd
Meerschaum Vale
Coolgardie Rd
Coolgardie
Meridian Dr
Kays Rd
Richmond River
River Dr
Moylans
Flood Ln
Sneesbys Ln
Patchs Bea
Bagotville Rd
Buckombil Mountain Rd
Lumleys Ln
Thurgates Ln
Wardell Park
Wilson St
Bath St
Carlisle St
Pine St
Bridge Dr
Byron St
Creek St

164000
163000
162000
161000
160000
159000
158000
157000
156000
155000
154000
153000
152000
151000

Section 10
Section 11
Single rope

Figure 2-1 Threatened Glider Populations in Relation to the Project

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- Chainage
- Alignment
- Project Boundary
- Proposed Glider Crossing Structure
- Glider Crossing Structure
- Proposed Vegetated Median
- Vegetated Median

Sandpiper Survey Record
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Metres

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LOCATION DIAGRAM

Gold Coast

ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

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2.2 Key threats

Key threatening processes listed under the BC Act that impact on threatened gliders include:

- Loss of habitat and fragmentation of habitat from the clearing of native vegetation
- Competition from feral honey bees
- High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition
- Loss of hollow bearing trees; and
- Removal of dead wood and dead trees.

The *Action Plan for Australian Marsupials and Mammals* (DSEWPaC 1996) lists the following current threats for Squirrel Gliders including:

- Loss of habitat due to timber clearing for forestry, agriculture and mining
- Lack of suitable hollows
- Lack of regeneration of trees and shrubs due to grazing by stock, rabbits and macropods
- Inappropriate fire regimes
- Outbreaks of lerp (leaf-skeletonising caterpillars) in riverine forests; and
- Coastal development in NSW and south-east Qld.

In addition, the Action Plan attributes the lack of conservation of intact, extensive areas of forest to the decline of the Yellow-bellied Glider due to their requirement for a variety of feed trees and hollows over a large home range**.**

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3. Threatened Glider Surveys

In accordance with the mitigation strategies described for pre-construction management in this document (**Section 5**), a number of targeted glider surveys have been completed for all relevant sections of the project. These surveys have been completed in various phases over a period of approximately two years, building on information presented in the EIS (2012). Surveys were undertaken in known and likely glider habitat areas in the vicinity of the project to confirm presence of threatened gliders, refine the location of connectivity structures (glider poles, widened medians and rope bridges) and inform the selection of monitoring sites.

The targeted surveys undertaken in the vicinity of the project area include three components:

1. Glider surveys – spot-lighting surveys to detect the presence of gliders and indicate occupational abundance in known and likely habitat areas
2. Tree surveys – particularly focused on proposed location of connectivity structures to ascertain habitat suitability, tree heights and adequacy for glider use (i.e. 20m height or more); and
3. Habitat tree surveys – to identify the number and size classes of habitat trees (i.e. trees with hollows for denning) in areas of known and likely habitat.

Targeted threatened glider and crossing structure surveys have been completed for the entire project. Results of these surveys have informed the projects Fauna Connectivity Strategy (for Sections 1 and 2) and are consistent with MCoA D2 of the projects approvals. Results and recommendations of these surveys can be found in full in **Appendix C** and **Appendix E**. The final seasonal (2014/15 and 2015/16)), baseline glider surveys for all Sections have been completed by Sandpiper Ecological and are presented in **Appendix C and Appendix D**. The location of these baseline survey sites are illustrated in **Figure 3.1**.

Baseline surveys have informed the finalisation of arboreal crossing structures for all Sections during the detailed design phase, and final control and reference monitoring sites for all Sections..

3.1 Sections 1 – 2 (Woolgoolga to Glenugie)

In late 2012 and early 2013 a survey was conducted to provide further advice on the location and design of aerial crossings for threatened gliders in Sections 1 and 2 of the project. Tree surveys (for habitat suitability and height adequacy) and glider surveys were the main components of this investigation. One of the prescribed aims for the survey was to:

- Recommend preferred locations and designs for aerial crossings that recognise the importance of the Woolgoolga to Glenugie upgrade area for threatened arboreal mammals and maintains connectivity at key locations.

These surveys were conducted by Sandpiper Ecological Surveys (2013) from October 2012 to February 2013, where the locations of connectivity structures were finalised. Inspections were conducted at five potential connectivity structure sites and 12 sites with existing connectivity structures. At each site information on habitat types, distribution and suitability for threatened gliders was obtained. Data recorded included: dominant canopy species, tree height, width of canopy, topographic position, connectivity and suitability for gliders. At the five sites for potential connectivity structures, spot-lighting occurred at each site twice in the summer of 2012 and involved two ecologists walking along a transect of 500 - 1000 m as detailed within **Appendix C**. Call playback was conducted for Yellow-bellied Glider.

The survey recorded Yellow-bellied Glider at three locations between chainages 5800 and 6100, and at 12700 and 16800 within Sections 1 - 2 of the project area (**Figure 2.1**). Squirrel gliders were recorded in two locations at chainages 16200 and 1100 (**Figure 2.1**). It recommended three preferred and three supplementary sites for connectivity structures to be located within Section 1-2 of the project area. All of these locations have since been adopted by the Fauna Connectivity Strategy for Section 1 and Section 2 (Woolgoolga to Glenugie) (GHD 2014). These connectivity structure locations are illustrated in **Figure 2.1** of this plan.

In 2014/15 further surveys were conducted to detect the presence and relative abundance of gliders within the vicinity of the project area and particularly in relation to the location of proposed connectivity structures.

The prescribed aims of the survey were to:

1. Investigate and locate baseline transects for threatened gliders in roadside habitat proximal to proposed connectivity structures (impact site), away from proposed connectivity structures (control site) and away from the road (reference site).
2. Conduct spot-light surveys to establish glider proportion of site occupancy prior to construction.

These surveys were conducted by Sandpiper Ecological Surveys (2014a and 2015) and referred to as 'pre-construction baseline surveys' for Sections 1 – 2 (see **Appendix C**). A total of 28 transects were selected for investigation, as follows:

- 11 impact sites (adjacent to proposed connectivity structures and within 100m of the road)
- 8 control sites (within 100m of the road but at least 1km from an impact site); and
- 9 reference sites (at least 800m from the road).

At each transect a basic habitat assessment was conducted to record habitat type, dominant species, hollow trees, disturbance (fire, roads, clearing etc.) and connectivity. Spot-lighting was undertaken at each site four times over summer and winter 2014 and late summer 2015. Spot-lighting was undertaken by two ecologists walking for 30 minutes along a 500 m transect. The species of each animal sighted was recorded (each transect walked is illustrated in **Appendix C**).

The survey recorded eleven Yellow-bellied Gliders in 28 transects (5 at impact sites, 4 at reference sites and 2 in control sites). Squirrel Gliders were recorded at 9 transects (2 at impact sites, 4 at reference sites and 3 at control sites). There was no significant difference in the use of various types of sites by each species. The density of hollow trees was also recorded at each site and varied between 0 and 8 habitat trees per hectare with an average of 3 habitat trees per hectare.

The location of each survey transect and methodologies engaged are summarised in **Section 3** of **Appendix C** and illustrated in **Figure 3-1**. Final monitoring locations are outlined in **Section 8** and illustrated in **Figure 8.1**.

3.2 Sections 3 – 11 (Glenugie to Ballina)

In 2014 Sandpiper Ecological Surveys was contracted to undertake part of the prescribed pre-construction targeted surveys at proposed locations of aerial crossing structures in sections 3, 4, 7, 9, 10 and to examine the potential for crossings in sections 6 and 8 of the project area. The aims of the surveys were to:

- Assess whether additional aerial crossing locations are required to promote gene flow and provide functional crossing opportunities for threatened gliders along Sections 3 - 10
- Recommend preferred locations and designs for aerial crossings informed by these assessments; and
- Recommend baseline monitoring locations.

To achieve these aims, detailed site assessments were undertaken at each site and supplemented by surveys to establish presence or absence of threatened glider species. A total of 20 transects were investigated along the alignment (6 of these sites contain existing connectivity structures). At each transect information on habitat types, distribution and suitability for threatened gliders was obtained. Data recorded included: dominant canopy species, tree height, width of canopy, topographic position, connectivity and suitability for gliders.

Spot-lighting occurred at each site twice in the late-autumn of 2014 and involved two ecologists walking along a transect of 500 -1000 m. Call playback was conducted for Yellow-bellied Glider at those sites considered suitable for the species (based on habitat assessments).

The survey recorded Yellow-bellied Glider at two locations near chainages 48200 and 54500 within Section 3 of the project area. Squirrel gliders were recorded in three locations at chainages 37350 (Section 3), 118900 (Section 7) and 140400 (Section 9). A total of 15 preferred and one

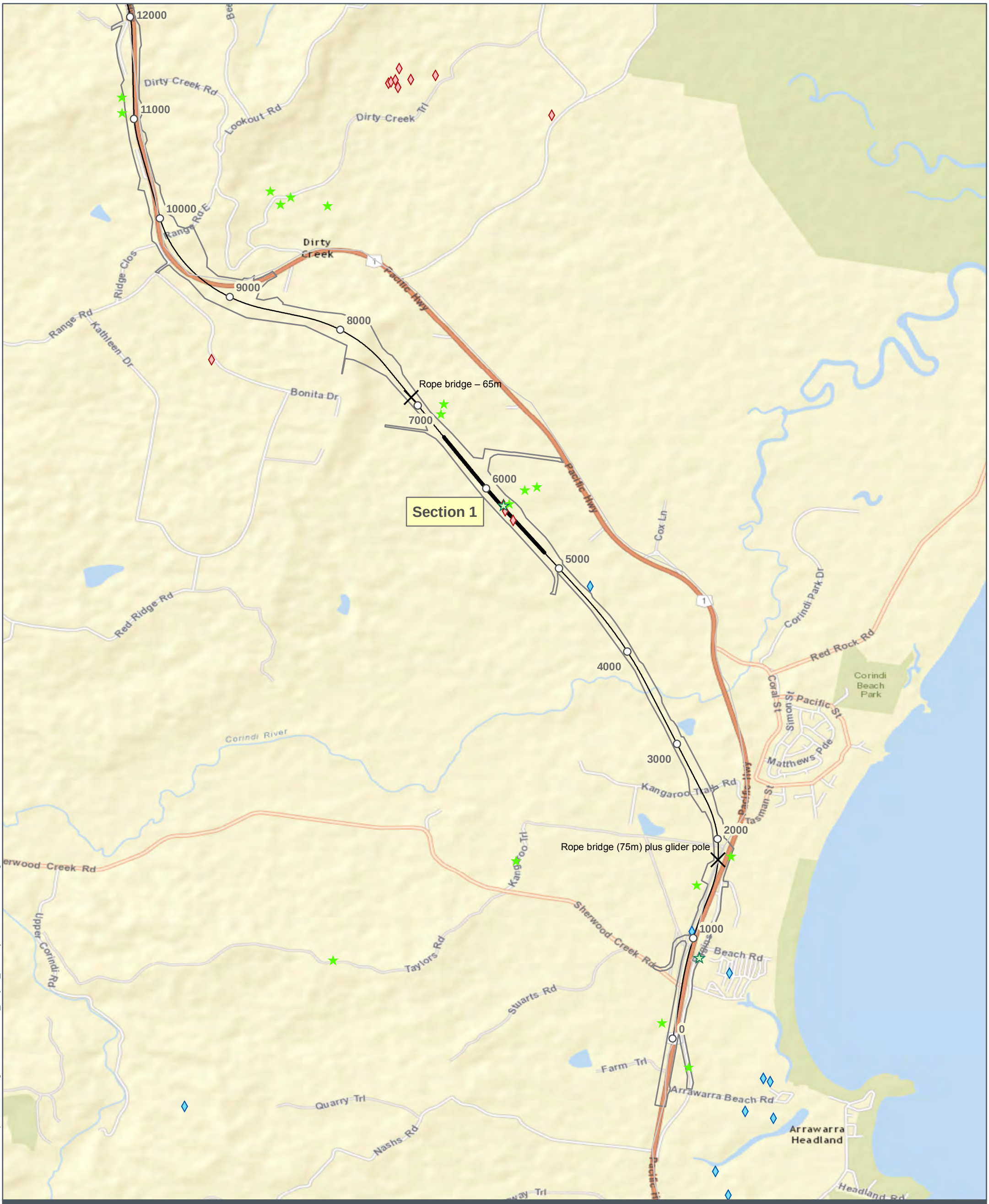
supplementary site for connectivity structures are proposed to be located within Section 3-11 of the project area (which includes five more connectivity structures than presented in the EIS). Proposed crossing structures for Sections 3 - 10 are illustrated in **Figure 2.1** including records of individual gliders.

The information from these surveys and proposed additional connectivity structures will be included within the Fauna Connectivity Strategy for Sections 3 - 11 as required under MCoA D2.

A crossing structure priority rating was assigned to each targeted site using a high, medium and low scoring. This was based on the perceived importance of each crossing structure for threatened gliders, the crossing type and likelihood of providing new insights for threatened gliders. Of the 20 targeted sites, 8 have been identified as a high or medium priority which will be subject to ongoing monitoring (two low priority sites have also been included to provide sufficient replication over the project area). Ongoing monitoring surveys will aim to assess the presence, activity and occupational abundance of threatened gliders at control, impact and reference sites to build on additional baseline information, monitor populations, crossing structure usage and road mortality. The location of each survey site (including mapping of each transect) and methodologies engaged during targeted surveys are summarised within **Section 4** and **Section 5** of **Appendix E**.

The locations of each survey transect and methodologies engaged are summarised in **Appendix D** and illustrated in **Figure 3-1**. Final glider monitoring locations are outlined in **Section 8** and illustrated in **Figure 8.1**.

Figure 3.1 Glider Survey Locations 2012 – 2014. Refer to table 6.2 for updated structure locations in Section 10



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ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 3-1
Threatened Glider Survey Locations 2012-2014

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits:

LEGEND

- Chainage
- Alignment
- Project Boundary
- Proposed Glider Crossing Structure
- Glider Crossing Structure
- Proposed Vegetated Median
- Vegetated Median

Glider Survey Sites

- 2013 - Targeted Surveys (Section 1 & 2)
- 2014/15 - Baseline Surveys (Section 1 & 2)
- 2014 - Targeted Surveys (Section 3 - 11)
- Crossings Review Section

Atlas of NSW Wildlife Record

- *Petaurus australis*
- *Petaurus norfolcensis*

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amec foster wheeler

N

0 250 500
Metres

1:34,000

(A3) GCS GDA 1994

LOCATION DIAGRAM

Bald Hill Tick Gate Rd
24000
23000
Georges Rd
Julies Rd
Coldstream River
Coast Range Rd
22000
Section 2
21000
Julies Rd
Pigeon Gully Fire Tl
Luthers Rd
Quarry Rd
Halfway Creek
20000
Browns Rd
Kungala Rd
19000
18000
Gilmores Ln
17000
Tallowood Trl
Grays Rd
16000
Crawfords Trl
15000
14000
Section 1
Rope bridge – 61m
12000
Dirty Creek Rd
11000
10000
Gilmores Ln

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ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 3-1
Threatened Glider Survey Locations 2012-2014

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits:

LEGEND

- Chainage
- Alignment
- Project Boundary
- Proposed Glider Crossing Structure
- Glider Crossing Structure
- Proposed Vegetated Median
- Vegetated Median

Glider Survey Sites

- 2013 - Targeted Surveys (Section 1 & 2)
- 2014/15 - Baseline Surveys (Section 1 & 2)
- 2014 - Targeted Surveys (Section 3 - 11)
- Crossings Review Section

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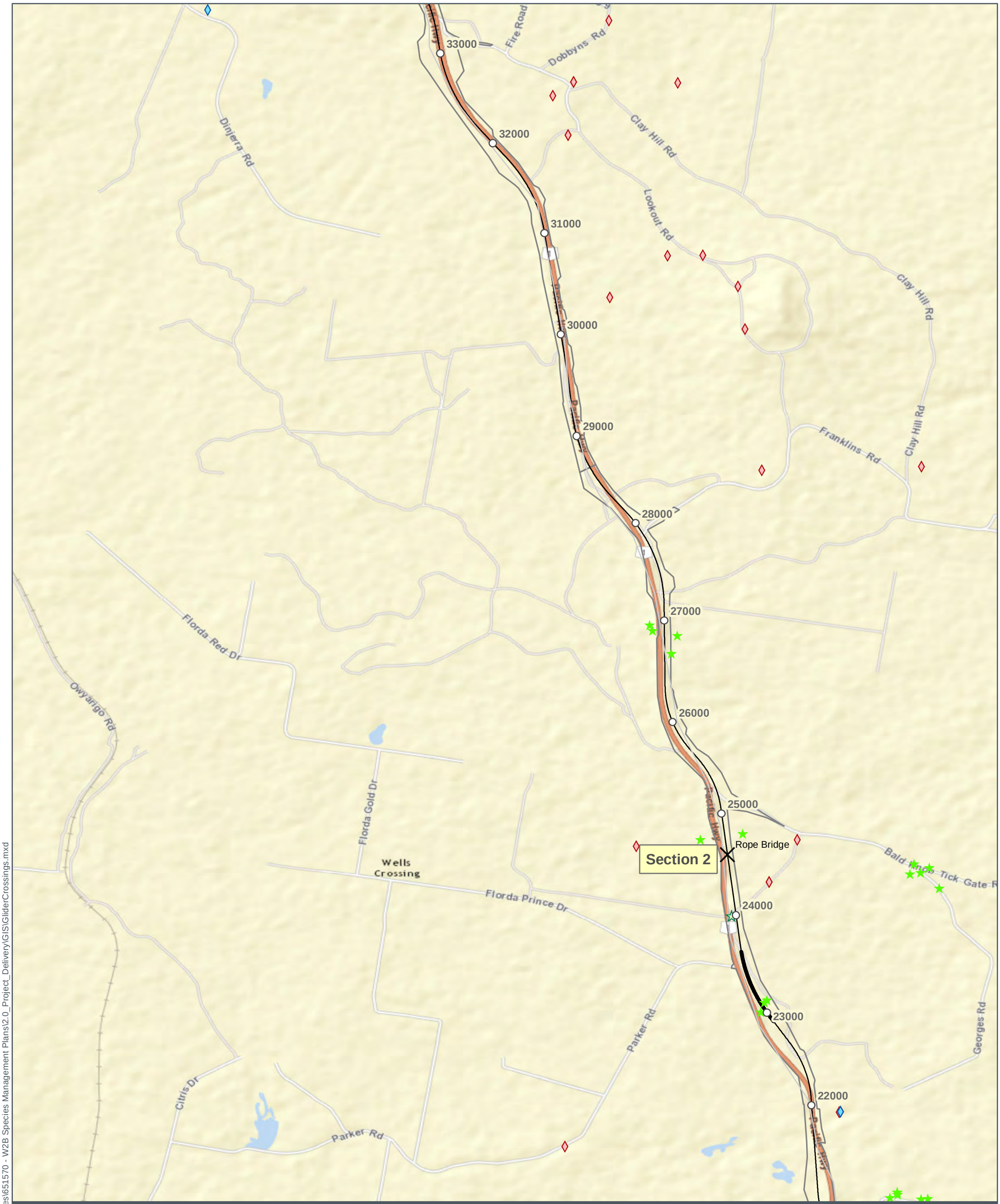
LOCATION DIAGRAM



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ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 3-1
Threatened Glider Survey Locations 2012-2014

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits:

LEGEND

- Chainage
- Alignment
- Project Boundary
- Proposed Glider Crossing Structure
- Glider Crossing Structure
- Proposed Vegetated Median
- Vegetated Median

Glider Survey Sites

- 2013 - Targeted Surveys (Section 1 & 2)
- 2014/15 - Baseline Surveys (Section 1 & 2)
- 2014 - Targeted Surveys (Section 3 - 11)
- Crossings Review Section

Atlas of NSW Wildlife Record

- *Petaurus australis*
- *Petaurus norfolcensis*

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LOCATION DIAGRAM

Bom Bom
Pacific Hwy
1
Glenugie Creek
Reilleys Ln
No 3 Fire Rd
Stokers Rd
No 2 Fire Rd
No 4 Fire Rd
No 5 Fire Rd
No 6 Fire Rd
No 7 Fire Rd
No 8 Fire Rd
Popes Rd
Glenugie
Six Mile Ln
Carioca Ln
Grafton Airport
Old Six Mile Ln
40000
39000
38000
Rope bridge
37000
Section 3
Aerodrome Rd
36000
Eight Mile Ln
Glide poles
35000
Dungel Rd
Dobbyns Rd
Fire Road No 4
Dinjerra Rd
Shields Rd
34000
No 10 Fire Rd
No 5 Fire Rd
Fire Road No 3
Fire Road No 9
33000
Clay Hill Rd
32000
Lookout Rd
31000

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ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 3-1
Threatened Glider Survey Locations 2012-2014

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits:

LEGEND

- Chainage
- Alignment
- Project Boundary
- Proposed Glider Crossing Structure
- Glider Crossing Structure
- Proposed Vegetated Median
- Vegetated Median

Glider Survey Sites

- 2013 - Targeted Surveys (Section 1 & 2)
- 2014/15 - Baseline Surveys (Section 1 & 2)
- 2014 - Targeted Surveys (Section 3 - 11)
- Crossings Review Section

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LOCATION DIAGRAM

Rope bridge
50000
49000
Glide poles
48000
47000
Section 3
46000
45000
44000
43000
42000
41000
40000
Old Six Mile Ln
Wants Ln
Eight Mile Ln
Lloyds Rd
Sandy Crossing
Wooli Rd
Mitchell Rd
Avenue Rd
Lavadia
Sunnyside Rd
No 2 Fire Rd
Fire Road No 4
Fire Road No 6
Fire Road No 7
No 5 Fire Rd
Morilla Rd
No 14 Fire Rd
Stonehouse Rd
Dobbins Rd

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ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 3-1
Threatened Glider Survey Locations 2012-2014

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits:

LEGEND

- Chainage
- Alignment
- Project Boundary
- Proposed Glider Crossing Structure
- Glider Crossing Structure
- Proposed Vegetated Median
- Vegetated Median

Glider Survey Sites

- 2013 - Targeted Surveys (Section 1 & 2)
- 2014/15 - Baseline Surveys (Section 1 & 2)
- 2014 - Targeted Surveys (Section 3 - 11)
- Crossings Review Section

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(A3) GCS GDA 1994

LOCATION DIAGRAM

Gilletts Ridge
Bean Ball Ln S
Gilletts Ridge Rd
Falconer Rd
Bellengen St
Coldstream TRC
Mookin St
Angouri St
Aradin St
Bowlings Rd
Tucabia Rd
Wooli Rd
Mitchell Rd
Somervale Rd
Boundary Trl
Bostock Rd
Foster Hut Ln
Firth Heinz Rd
Barry's Bridge Rd
Section 3
59000
58000
57000
56000
55000
54000
53000
52000
51000
50000
49000
48000
Rope bridge
Rope bridge
Glide poles

Figure 3-1
Threatened Glider Survey Locations 2012-2014

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits:

LEGEND

- Chainage
- Alignment
- Project Boundary
- Proposed Glider Crossing Structure
- Glider Crossing Structure
- Proposed Vegetated Median
- Vegetated Median

Glider Survey Sites

- 2013 - Targeted Surveys (Section 1 & 2)
- 2014/15 - Baseline Surveys (Section 1 & 2)
- 2014 - Targeted Surveys (Section 3 - 11)
- Crossings Review Section

Atlas of NSW Wildlife Record

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LOCATION DIAGRAM

Gold Coast

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ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 3-1
Threatened Glider Survey Locations 2012-2014

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits:

LEGEND

- Chainage
- Alignment
- Project Boundary
- Proposed Glider Crossing Structure
- Glider Crossing Structure
- Proposed Vegetated Median
- Vegetated Median

Glider Survey Sites
- 2013 - Targeted Surveys (Section 1 & 2)
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LOCATION DIAGRAM

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Mororo
100000
Glide poles
99000
Section 6
98000
Mororo Rd
Mororo Fire Trl
Washed Out Trl
Bundjalung National Park
Bazzas Fire Trl
Woombah East Fire Trl
Woombah Fire Trl
97000
Lewis Ln
Banana Rd
96000
tion 5
Mororo Creek Nature Reserve
Iluka Rd
Woombah
95000
North St
Emu Dr
Adams St
Andersons Trl
Garretts Ln
94000
Middle Channel
Fischers Rd
Goodwood Island Rd
Chatsworth Rd
Carrolls Ln
93000
Goodwood Island Rd
Chatsworth
92000
Warregah Island
91000
Durringtons Ln
Serpentine Chan N Bran Rd
Chan S Bran Rd
90000
Clarence River
McConnells Ln
Palmers Island Middle Rd
Back Channel Ln
Ryans Rd
Youngs Ln
89000
Ashby Heights
Martins Point Rd
Bewleys Ln
Gillies Ln
Wiblens Ln

ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 3-1
Threatened Glider Survey Locations 2012-2014

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits:

LEGEND

- Chainage
- Alignment
- Project Boundary
- Proposed Glider Crossing Structure
- Glider Crossing Structure
- Proposed Vegetated Median
- Vegetated Median

Glider Survey Sites
- 2013 - Targeted Surveys (Section 1 & 2)
- 2014/15 - Baseline Surveys (Section 1 & 2)
- 2014 - Targeted Surveys (Section 3 - 11)
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LOCATION DIAGRAM

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Section 7

Section 6

Glide poles

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Figure 3-1
Threatened Glider Survey Locations 2012-2014

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits:

LEGEND

- Chainage
- Alignment
- Project Boundary
- Proposed Glider Crossing Structure
- Glider Crossing Structure
- Proposed Vegetated Median
- Vegetated Median

Glider Survey Sites
- 2013 - Targeted Surveys (Section 1 & 2)
- 2014/15 - Baseline Surveys (Section 1 & 2)
- 2014 - Targeted Surveys (Section 3 - 11)
- Crossings Review Section

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LOCATION DIAGRAM

Gold Coast

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

Mahogany Rd
Forest Rd
Swan Bay New Italy Rd
The Gap (North)
122000
121000
Aplins Rd
120000
Cypress Rd
Piccolis Rd
119000
Land bridge
Glide poles
Right Angle Trl
North Pacific Trl
118000
Darkys Rd
Minyumai Rd
Tabbimoble Swamp Nature Reserve
117000
Section 7
McCormicks Rd
Rope bridge
116000
Four Strand Trl
Glencoe Rd
115000
Tabbimoble
114000
Felspar Trl
Serrindipity Rd
McFayden Rd
113000
Rope bridge
112000
Roo Trl
Glide poles
111000
Fence Trl
110000
Esk River
Esk Trl
109000
Big Marsh Rd
Big Marsh Firetrail

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ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 3-1
Threatened Glider Survey Locations 2012-2014

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits:

LEGEND

- Chainage
- Alignment
- Project Boundary
- Proposed Glider Crossing Structure
- Glider Crossing Structure
- Proposed Vegetated Median
- Vegetated Median

Glider Survey Sites
- 2013 - Targeted Surveys (Section 1 & 2)
- 2014/15 - Baseline Surveys (Section 1 & 2)
- 2014 - Targeted Surveys (Section 3 - 11)
- Crossings Review Section

Atlas of NSW Wildlife Record
- *Petaurus australis*
- *Petaurus norfolcensis*

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Metres

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LOCATION DIAGRAM

Swampy Creek Rd
Cedar St
Alfred St
Wagner St
Watson St
Rocky Mouth Creek Rd
Swan Bay New Italy Rd
Williams Rd
Pacific Hwy
Brickella Rd
Trustums Hill
The Gap Rd
Norfons Rd
Whites
Red Gate Rd
Turners Rd
McGearys Trl
Aplins Rd
Cypress Rd
Right Angle Trl
Posthammer Trl
Tick Fence Trl
Ghania Trl
North Pacific Trl
Goodburn Evans Rd

133000
132000
131000
130000
129000
128000
127000
126000
125000
124000
123000
122000
121000
120000
119000

Section 8
Section 7

Rope bridge
Land bridge

The Gap (North)

ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 3-1
Threatened Glider Survey Locations 2012-2014

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits:

LEGEND

- Chainage
- Alignment
- Project Boundary
- Proposed Glider Crossing Structure
- Glider Crossing Structure
- Proposed Vegetated Median
- Vegetated Median

Glider Survey Sites
- 2013 - Targeted Surveys (Section 1 & 2)
- 2014/15 - Baseline Surveys (Section 1 & 2)
- 2014 - Targeted Surveys (Section 3 - 11)
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- *Petaurus norfolcensis*

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LOCATION DIAGRAM

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ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 3-1
Threatened Glider Survey Locations 2012-2014

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits:

LEGEND

- Chainage
- Alignment
- Project Boundary
- Proposed Glider Crossing Structure
- Glider Crossing Structure
- Proposed Vegetated Median
- Vegetated Median

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Metres

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LOCATION DIAGRAM

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153000
152000
151000
150000
149000
148000
147000
146000
145000
144000
143000
142000
141000
140000
139000
Section 10
Section 9
Poles/rope on land bridge
Rope bridge
Land bridge
Land bridge
Bagotville
Wardell
East Wardell
Cabbage Tree Island (North)
Goat Island
Tuckean Broadwater
Richmond River
Wardell Park
Bagotville Rd
Old Bagotville Rd
Gahans Rd
Wardell Rd
Lumleys Ln
Wilson St
Pacific Hwy
Pimlico Rd
Bath St
Carlisle St
Pine St
Creek St
Bridge Dr
Byron St
River Dr
River St
Owens Ln
Meaneys Ln
Back Channel Rd
Walshs Ln
Banks Ln
Plenkovich Rd
Eversons Ln
Legges Ln
Byrnes St
North Boundary Trl
Coraki Broadwater Rd
Hills Rd
Bessies Trl
Pitt St
Broadwater Quarry Rd
Sugar Co Trl
Ponderosa Trl
Finns Trl
New Block Trl
Rileys Hill Rd
Vales Trl
Beryls Trl
Baxters Trl
Broadwater Beach Rd
Maloneys Trl
Old Mining Trl
Montis Link Trl
Cutting
Pacific Hwy
Gold Coast

ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 3-1
Threatened Glider Survey Locations 2012-2014

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits:

LEGEND

- Chainage
- Alignment
- Project Boundary
- Proposed Glider Crossing Structure
- Glider Crossing Structure
- Proposed Vegetated Median
- Vegetated Median

Glider Survey Sites
- 2013 - Targeted Surveys (Section 1 & 2)
- 2014/15 - Baseline Surveys (Section 1 & 2)
- 2014 - Targeted Surveys (Section 3 - 11)
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0 250 500
Metres

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(A3) GCS GDA 1994

LOCATION DIAGRAM

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Figure 3-1
Threatened Glider Survey Locations 2012-2014

Section 10

Section 11

Single rope

LEGEND

- Chainage
- Alignment
- Project Boundary
- Proposed Glider Crossing Structure
- Glider Crossing Structure
- Proposed Vegetated Median
- Vegetated Median

Glider Survey Sites

- 2013 - Targeted Surveys (Section 1 & 2)
- 2014/15 - Baseline Surveys (Section 1 & 2)
- 2014 - Targeted Surveys (Section 3 - 11)
- Crossings Review Section

Atlas of NSW Wildlife Record

- *Petaurus australis*
- *Petaurus norfolcensis*

LOCATION DIAGRAM

Gold Coast

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Service Layer Credits:

ISSUE DATE	AUTHOR	QA CHECK	APPROVED	MAP REV.	REVISION NOTE
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4. Potential impacts and management approach

The following chapter provides an overview of the potential impacts to the threatened glider populations with reference to the more detailed impact assessment presented in the Biodiversity Working Paper (Roads and Maritime 2012) and taking into consideration results of targeted glider surveys to specifically address MCoA D8 (a), (b) and (c). It describes the potential impacts to the species at specific locations along the project during the pre-construction, construction and post-construction (operational) stages of the project. Measures to mitigate impacts and monitor the effectiveness of those measures are also documented in **Section 5** to **Section 8** of this TGMP which have been developed to meet the requirements outlined in MCoA D8.

4.1 Potential impacts associated with the project

The severity of the impact on a regional scale would be moderate, as the threatened gliders are widespread over a large portion of the bioregion. However impacts on local populations have been assessed as high.

4.1.1 Mortality due to vehicle strike during both the construction and operational phase

Some diurnal and mobile species such as birds and large reptiles may be able to move away from the path of construction tree-clearing. However, other species that are less mobile such as nocturnal species, hollow dependant, or those that have smaller home ranges are less likely to move rapidly away or disperse large distances from this kind of activity. This reduced mobility applies to species such as threatened gliders.

Threatened fauna that have the greatest potential to be negatively affected by vehicle strike over the length of the project are based on published known threats and a review of roadkill databases (Roads and Maritime and WIRES). These include the Squirrel Glider (Claridge and van der Ree 2004), and Yellow-bellied Glider.

4.1.2 Loss of habitat including loss of potential den sites and foraging opportunities

The loss of hollow-bearing trees is listed as a key threatening process under the TSC Act for gliders. Hollow bearing trees are a critical habitat feature for a number of threatened species (Gibbons and Lindenmayer 2002), providing breeding and/or sheltering habitat. Hollow-bearing trees are present in all habitat types and project sections that are proposed to be cleared. Threatened gliders have been identified in the Biodiversity Working Paper (Roads and Maritime 2012) as being impacted by the loss of hollow-bearing trees.

The direct loss of foraging resources can be in the form of foliage, nectar and sap exudates. Foliage and nectar foraging resources are present in multiple strata including the upper canopy, mid to lower and ground level strata. Threatened species potentially impacted at the patch scale are forest dependent species such as threatened gliders.

Known feed tree species for Squirrel Glider have been listed in **Appendix E**. Feed tree species for Yellow-bellied Glider from the Approved Recovery Plan for the Yellow-bellied Glider (NSW NPWS 2003) are listed in **Appendix F**.

A number of threatened species require winter flowering foraging resources to supply food year-round, or to coincide with dispersal movements. As such, the presence of reliable annually winter-flowering species is considered a limiting factor in the distribution of a number of threatened species, including threatened gliders. Threatened gliders rely on a tree species composition providing year-round continuity of nectar and pollen. Of the habitats impacted by the project, at least four of those are dominated by winter-flowering species (including Swamp Mahogany (*Eucalyptus robusta*), Forest Red Gum (*E. tereticornis*), Grey Ironbark (*E. siderophloia*) and Broad-leaved Paperbark (*Melaleuca quinquenervia*).

4.1.3 Fragmentation of habitat

The project has potential to isolate remnant vegetation patches and create barriers to the movement of small ground-dwelling mammals, reptiles and amphibians and potentially discrete arboreal mammal populations on both a patch and landscape scale. It is noted, however, that large areas of habitat would remain in state forests and reserved habitats for the longer-term viability of these species.

The project would be such that the existing barrier effect of the highway would be substantially increased. Sections of the project that deviate substantially from the existing highway would create a new barrier effect (e.g. Sections 3 to 4 and 9 to 10). A barrier effect may also result from a behavioural aversion to a road. Squirrel Gliders regularly crossed a high-volume two-lane highway, whereas female Squirrel Gliders appeared to be inhibited from crossing a high-volume four-lane highway with a median strip (van der Ree 2006). This however may not be specifically associated with an aversion to the road and associated traffic, and could have possibly been linked to the size of the gap between habitats.

Species relying on complex social structures for breeding and feeding are also more sensitive to fragmentation than predominantly solitary species during non-breeding lifecycle events. The Squirrel Glider is one such species reliant on social structure. Hollow-dependent fauna, such as threatened gliders, are more vulnerable to fragmentation.

4.1.4 Loss of ecological connectivity leading to increased isolation of family groups and reduced genetic diversity

The loss of connectivity has potential to impact on populations of several listed fauna species as determined by ecological surveys undertaken 2006 to 2012, review of NSW Atlas data identifying broad population hotspots and through consultation with OEH (OEH 2013). This includes threatened gliders - important populations exist from Woolgoolga to Wells Crossing (Sections 1 and 2 of the project), at Tabbimoble (Section 6 and 7 of the project) and Broadwater National Park (Section 9 of the project).

Loss of connectivity between smaller habitat patches can cause the loss of genetic diversity in populations (Forman *et al.* 2002). As fragmentation proceeds, stochastic forces add to potential declines caused by a dwindling supply of habitat. Some species would be more at risk in fragmented landscapes than others and this relates to the biological characteristics of the species. In this regard species that share similar adaptations to habitat niches and similar life-cycle traits are assumed to be impacted in a similar way, for example threatened gliders.

4.1.5 Edge effects such as altered light levels and noise from construction and general traffic

In respect to potential impacts on edge areas from noise and light, there would be two sources, firstly construction noise which would be associated with vehicles and machinery such as pile drivers and gravel crushing and secondly general traffic noise and road lighting associated with road operation. Lighting from vehicles and roadside lighting would mainly be an operational issue, however, there would only be limited roadside lighting (the project being mostly unlit except for at interchange roundabouts, major bridges and merge and diverge traffic lanes). However, some out of hours construction work would be required for health/safety and engineering reasons and would require lighting.

Edge effects would be greatest where the project deviates substantially from the existing Pacific Highway. While portions of the habitat in these sections are already fragmented and edge affected, substantial clearing and creation of a new edge would occur in Section 3 of the project along the western foothills of the Summervale Range from Pillar Valley to Tyndale. Large sections of open forest habitat in moderate to high condition would be exposed to edge effects particularly on the eastern edge of the highway. The Squirrel Glider would be susceptible to edge effects. The extent to which Yellow-bellied Glider avoid highways is unclear, although acoustic masking of calls requires investigation. Yellow-bellied Glider are more vocal than other gliders and rely on calls for a variety of functions (Sandpiper Ecological 2013).

4.2 Detailed design considerations

A number of factors were considered in identifying the key connectivity zones for threatened gliders and the locations of crossing structures incorporated into the concept design stage, which have been refined post supplementary targeted glider surveys as described in **Section 3**. The factors considered in locating the structures included:

- The known distributional range of threatened glider populations, incorporating other known records of sightings and anecdotal evidence
- The presence of known population hotspots based on NSW Wildlife Atlas data and field data from the EIS and supplementary targeted surveys
- The distribution of known habitats and in particular the location of the older growth forests with hollow bearing trees, vegetation patch size, suitable tree species and connectivity with the surrounding landscape; and
- The known effectiveness of pole type, height and rope bridge length as components of the crossing structures.

Targeted surveys that have been undertaken during pre-construction stages (including the detailed design stage for Sections 1 and 2) have focused on refining the location of proposed structures and develop a baseline database for ongoing monitoring of populations and connectivity measures. The basis for the refinement of structure locations has been habitat assessments (including tree surveys to report on tree height and suitability for gliders) and supplementary glider surveys to indicate presence of the animals within proximity of the proposed structures. For Sections 1 and 2 (Woolgoolga to Glenugie) the results of the targeted surveys have been incorporated into the Fauna Connectivity Strategy (Woolgoolga to Glenugie) (GHD 2014). Results of targeted surveys for Sections 3 - 11 will be integrated into a separate connectivity strategy during the detailed design phase of these sections.

4.3 Mitigation and monitoring

The aim of the mitigation measures is to ensure the continued viability of Squirrel Glider and Yellow-bellied Glider populations in the project area by achieving the following goals:

- Minimise loss of habitat (particularly den sites and foraging resources) within the project area
- Provide functional crossing opportunities and minimise habitat fragmentation
- Maintain connectivity for daily movements and allow for the transfer of genes; and
- Minimise edge effects (particularly altered light and noise levels) from the project.

To review the effectiveness of the mitigation measures proposed, targeted threatened glider surveys were conducted in 2014/15 to establish baseline information on threatened glider presence, activity and occupational abundance a minimum of 12 months prior to construction.

A number of mitigation measures to address the goals of the management strategy and monitor the impact of the project on threatened gliders during construction and operation of the project were suggested in the EIS (Biodiversity Working Paper) (Roads and Maritime 2012), along with measures proposed in 2014/15 surveys. These mitigation measures are:

- Targeted rehabilitation to direct glider movements across connectivity structures or locations where a natural crossing may be possible (with the goal to reduce road mortality) without compromising

road safety provisions. Targeted rehabilitation plans are detailed within the Urban Design and Landscape Plan (UDLP)

- Minimise clearing through appropriate location of ancillary facilities (supported by ancillary impact assessment report as an addition to the SPIR, 2014)
- 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 in accordance with the NBMP
- An updated Connectivity Strategy(s) detailing arboreal crossing structures and widened medians with retained vegetation that has been informed by targeted surveys undertaken for Squirrel Glider and Yellow-bellied Gliders in 2014/15 by glider experts from Sandpiper Ecology (**Appendix C** and **Appendix E**)
- The minimum design and locations of crossing structures for threatened gliders will be based on the principles outlined in the EIS, expert feedback and the process for managing connectivity requirements described in the Fauna Connectivity Strategy; and
- Management of light, dust and noise will be in accordance with the CEMP.

A comprehensive monitoring program has been established to assess the effectiveness of mitigation measures and allow for ongoing updates to these measures based on the results of monitoring (**Section 8.5**, **Table 8.4**). The approach to management of potential impacts to the threatened glider populations throughout the pre-construction, construction and operational phases is detailed in **Table 4.1**.

Table 4.1 Staging of management measures

Pre-construction	Completed targeted glider surveys to inform detailed design and nest box strategy (Section 3 and Appendix C & D).	Section 1&2 Targeted Surveys December 2012 Sections 3-11 Targeted Surveys June 2014
	Refine crossing locations (detailed design) and locations for strategic tree planting and consult with EPA (Section 6.3.5 and Fauna Connectivity Strategy).	Finalisation of Detailed Design Section 1 and 2 April 2014 Fauna Connectivity Strategy Section 1 and 2 finalised December 2014
	Finalised monitoring sites (impact, control and reference sites) (Section 8.5 and Appendix C & D for Sections 1 and 2).	Sections 1&2 only - February 2014/15
	Identify habitat exclusion zones and locate ancillary facilities as part of the Construction Flora & Fauna Management Plan required on MCoA D26 (e).	This will vary as it's project specific - Sections 1&2 forecast May 2015
Construction	Pre-clearing surveys to be conducted by licensed ecologist. The presence of a suitably qualified ecologist/fauna spotter catcher during all clearing activities to minimise glider mortality during construction.	This will be project specific and depend on the clearing schedule proposed. Spotter catchers will conduct pre-clearing surveys prior to, and during any vegetation clearing.
	Implement nest box strategy. Nest boxes to be installed as soon as practicable prior to clearing.	Target as per the Nest Box Management Plans is to have 70% of the forecast total number erected prior to clearing. Where possible this will be two months before clearing begins.
	Fauna handling and relocation.	As required by a suitably qualified fauna spotter.
	Construct crossing structures.	As soon as practically possible after clearing is complete and final cut fill levels (earthworks) are achieved. All crossing structures will be installed prior to operation.
	Undertake habitat revegetation and strategic tree planting at identified glider crossing locations.	As soon as practically possible after clearing is complete and final cut fill levels (earthworks) are achieved.
	Implementation of CEMP to manage edge effects.	Once clearing is complete - project dependent.
Operation	Monitoring of glider crossing structures, glider populations, road kill, nest boxes and habitat revegetation. A review of	Cameras will be installed to monitor activity possibly 3 or 6 monthly depending on battery life.

	the effectiveness of crossings structures will be undertaken should a lack of usage be evident.	Glider populations monitored as per Glider Management Plan. Road kill monitored by RMS road maintenance crews on a daily basis - Reported annually. Nest boxes will be maintained and monitored as per the Nest Box Management Plan. Revegetation will be as per the Urban Design Landscape Plans.
	Maintenance of crossing structures.	As required over life of the project.
	Maintenance of habitat revegetation and nest boxes.	A per the site specific Urban Design Landscape Plan and Nest Box Management Plan

4.4 Effectiveness of mitigation measures

Providing connectivity between important habitats either side of the project is considered critical to successfully retaining threatened glider populations. Connectivity can be achieved via appropriately placed crossing structures (i.e. poles and rope bridges) and strategic tree planting. Current evidence suggests this approach can be effective and would be confirmed through the design and implementation of an effective monitoring program as described in this plan.

Road crossing structures have been shown to reduce fauna mortality rates and to reduce the habitat fragmentation impacts of linear infrastructure in areas proximate to their installation. However the extent to which population viability can be maintained subsequent to installing the structures remains unclear.

Studies have shown Squirrel Gliders use glider poles and rope bridges to cross minor and major roads (Veage and Jones 2007, Ball and Goldingay 2008, Goldingay, Taylor and Ball 2011, Soanes et. al. 2013, Goldingay, Rohweder and Taylor 2013). Less is known about Yellow-bellied Glider use of fauna connectivity structures, thus a thorough review of crossing locations combined with other monitoring results regarding Yellow-bellied Glider populations will be undertaken after three years of monitoring. The intent of this review is to apply an adaptive approach to mitigating impacts to Yellow-bellied Gliders and maximising effective connectivity measures for this species.

Monitoring of wildlife road crossing structures by Soanes *et al.* (2013) found the rate of glider crossing increased over several years as animals habituated to the structure. They suggest monitoring periods of at least two years to allow gliders adequate time to habituate to the crossing structures.

A summary of the proposed threatened glider specific mitigation measures and evaluation of their effectiveness based on past experience with other highway upgrades is described in **Table 4.2**.

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 measurable performance indicators 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 have been 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 described in **Section 8**.

Table 4.2 Mitigation measures and evaluation of their effectiveness

Issue	Mitigation measure	History of success	Effectiveness rating
Mortality due to vehicle strike during both the construction and operational phase.	Strategic tree planting to direct glider movement to crossing structures or locations where unassisted crossing is possible. Consideration of further glide poles and rope bridges, particularly where mortality hotspots are noted and proximate mitigation measures are not being utilised.	Revegetation in the vicinity of fauna crossing structures is undertaken as a regular component of asset management. A number of Roads and Maritime projects have included revegetation near fauna crossing structures to increase their usage and potentially decrease fauna mortality. Poles, rope bridges and strategic plantings have been demonstrated as effective at permitting safe crossing of roads by threatened gliders and reducing the interactions or collisions with vehicles.	Moderate, monitor success and implement corrective actions
	Implementation of pre-clearing and clearing procedures.	Pre-clearing and clearing procedures offer the potential to remove existing threatened gliders from the proposed highway areas and median. Targeted inspection of suitable tree hollows, providing time allowance for fauna to vacate the habitat to be cleared and providing alternative nest box sites prior to clearing, all comprise effective methods to reduce the risk to threatened gliders. Further, targeted rehabilitation works will incorporate plantings to replace foraging resources for threatened gliders, particularly around crossing structures in an attempt to focus movement to these crossing structures and habitat away from the road to reduce the likelihood of vehicle strike. Further, rehabilitation will attempt to provide appropriate foraging resources to compensate for those lost during clearing using species as advised by an ecologist present during pre-clearing surveys.	High, monitor success and implement corrective actions
Loss of habitat including loss of potential den sites and foraging opportunities.	Identify exclusion zones and limits of clearing.	A standard clearing procedure has been developed by Roads and Maritime and documented in the Biodiversity Guidelines for Construction (RTA 2011). The guidelines were developed in consultation with the NSW Office of Environment and Heritage (OEH), NSW Department of Primary Industries (DPI) (Fisheries), 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.	High
	Targeted surveys to establish areas of high quality habitat to inform the location of crossing structures and monitoring sites	When appropriately placed, fauna crossing structures targeted at gliders have had moderate to high success. There are numerous surveys illustrating the success of these structures in conveying movement of Squirrel Gliders (Veage and Jones 2007, Ball and Goldingay 2008, Goldingay, Taylor and Ball 2011, Soanes et. al. 2013, Goldingay, Rohweder and Taylor 2013). However, less is known about Yellow-bellied Gliders.	Moderate – High, monitor success and implement corrective actions
	Construction related infrastructure to be planned and sited within cleared or disturbed areas of the ancillary site (particularly avoiding proximity to natural water sources and fauna movement areas).	The Roads and Maritime *Stockpile Site Management Procedures* (RTA 2011) would be used to site ancillary facilities. As such, the siting of temporary construction related infrastructure would be where possible within existing cleared or disturbed areas. This approach can substantially reduce the overall area of impact to vegetation and fauna habitat, while also reducing the area required to be rehabilitated at the end of construction.	High
	Installation of nest boxes	Squirrel Gliders have been known to utilise artificial nest boxes in place of natural hollows, where natural hollow density is low (FNPW 2014), but the effectiveness for Yellow-bellied Gliders is yet to be established (WPS 2014). Guidance regarding the dimensions of nest boxes, installation and maintenance is provided in the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA Projects* (RTA 2011).	Moderate, monitor success and implement corrective actions
Fragmentation of habitat and loss of ecological connectivity leading	Confirmation and installation of targeted crossing structures.	Poles, rope bridges and strategic plantings have been demonstrated as effective at permitting safe crossing of roads by threatened gliders and reducing the interactions or collisions with vehicles. Targeted glider surveys were undertaken during the phase for the Woolgoolga to Glenugie project in February 2013. This survey was to review and confirm the proposed location of connectivity structures. The findings of this survey	Moderate, monitor success and implement corrective actions

Issue	Mitigation measure	History of success	Effectiveness rating
to increased isolation of family groups and reduced genetic diversity		report would be used to inform the detailed design for the Woolgoolga to Glenugie project. Studies have shown Squirrel Gliders use glider poles and rope bridges to cross minor and major roads (Veage and Jones 2007, Ball and Goldingay 2008, Goldingay, Taylor and Ball 2011, Soanes et. al. 2013, Goldingay, Rohweder and Taylor 2013). Less is known about Yellow-bellied Glider use of fauna connectivity structures. A review of crossing structures will be undertaken during the monitoring phase to redress adaptive connectivity measures should a lack of usage be identified.	
	Maintenance of poles, rope bridge crossings and widened medians.	This aspect is considered to be the principal method for providing connectivity to adjacent habitat either side of roadways for glider species and has been proven as effective elsewhere in New South Wales when implemented. Studies have shown Squirrel Gliders use glider poles and rope bridges to cross minor and major roads (Veage and Jones 2007, Ball and Goldingay 2008, Goldingay, Taylor and Ball 2011, Soanes et. al. 2013, Goldingay, Rohweder and Taylor 2013). Less is known about Yellow-bellied Glider use of fauna connectivity structures. Roads and Maritime maintains poles, rope bridge crossings and other connectivity structures such as land bridges as part of operational maintenance.	High, monitor success and implement corrective actions
	Maintenance of revegetation	Maintaining revegetation may generally assist threatened glider populations to utilise existing areas, while potentially providing future habitat trees. Roads and Maritime contract specifications require the successful establishment of landscaping. Where landscaping has failed revegetation would be required to replace failed plantings and/or undertake additional weed control Examples of where landscaping has been undertaken successfully on Roads and Maritime projects include the Bonville Deviation, Brunswick Heads to Yelgun, Karuah Bypass, Halfway Creek, Ewingsdale Interchange, Tandys Lane Upgrade to name a few.	Moderate
Edge effects such as altered light levels and noise from construction and general traffic	Light, dust and noise would be managed in accordance with procedures in the CEMP.	Minimising the effects of light, dust and noise are considered to be essential for maintaining the quality of remnant habitat during construction and minimising impact to threatened gliders. In particular, minimising daytime construction noise and avoiding night time noise would be important for reducing the risk of changes to the foraging behaviour of gliders where population hotspots are known to exist. Glider monitoring studies (van der Ree 2006, McCall 2010 and ngh environmental 2011) on the Hume Highway and Goulburn Valley Freeway indicate a decline in annual survival rates over time for constructed highways compared to areas of lower traffic volumes and small road widths. Environmental variables along the roadside such as vegetation structure, width of the road and traffic volumes may encourage or discourage glider movement. Monitoring glider movements and habitat utilisation during construction and operation of highways (ngh environmental 2011) has been successful for measuring glider population health and identifying risks.	Moderate

5. Pre-construction management measures

5.1 Potential impacts during pre-construction

- Location of infrastructure within ancillary facility sites including heavy vehicle access may impact on threatened glider habitat, movements, foraging and behaviour.

5.2 Mitigation goals

- Ancillary facility sites are located outside of threatened glider habitat during the pre-construction planning phase
- Targeted surveys completed during detailed design to inform where areas of habitat can be retained, location and design of crossing structures and monitoring program
- Complete habitat tree survey to quantify hollows for input into the NBMP; and
- Identify habitat exclusions zones prior to construction.

5.3 Management measures

5.3.1 Targeted surveys

Targeted surveys (and baseline for Sections 1&2) for threatened gliders have now been conducted prior to construction and will inform the detailed design process (as outlined in **Section 3**). Targeted surveys have been conducted to ensure connectivity measures for gliders are identified and incorporated into the Fauna Connectivity Strategy to be approved by the Secretary DP&E. This information builds on the threatened species distributional data presented in the EIS. A component of targeted surveys include baseline surveys which provide data on threatened glider activity and site occupancy rates. This data will then inform the ongoing monitoring program and allow comparison of pre-construction, construction and operational phases of the project.

Targeted surveys consisted of the following components:

- Baseline glider surveys which determine the presence or absence of gliders and provide a basic indication of site occupancy and activity (specific abundance has not been measured). This data will form the baseline data for the on-going monitoring program post-construction. Survey methods are described in detail in **Section 8**.
- Tree surveys at each of the widened medians (and associated road verges) to gather information on tree heights and ensure the tree heights are suitable for threatened glider crossings. The gliding capacity or distance that a Squirrel Glider or Yellow-Bellied Glider can achieve is largely determined by the height at which they launch and their angle of decent or glide angle. The average glide angle for Squirrel Glider is reportedly 29° and the Yellow-Bellied Glider closer to 31°. This suggests that a Squirrel Glider and Yellow-Bellied Glider will achieve approximately 1.7-1.9 m horizontally for the loss of each meter of height during a glide. Assessment of widened median locations and installation of crossing structures have considered minimum tree heights and/or pole heights following the calculation of glide angles to ensure that gliders can safely glide across the road, in both directions, with a minimum clearance above truck height. At locations identified for road mitigation, if the roadside tree heights are insufficient to enable a safe glide in both directions, either a rope bridge or roadside and/or median strip glide poles will be required; and

- Detailed hollow bearing tree surveys were undertaken across the entire W2B alignment to inform the NBMP required by MCoA D6. These surveys estimated the number of hollows and size classes within each area allowing the number and type of boxes required to be determined. Monitoring and management of nest boxes are detailed in the NBMP.

5.3.2 Minimise areas for clearing

In all cases defining the limits of clearing to give priority to maintaining as much threatened glider habitat as possible. Methods in reducing clearing requirements will include; consideration of construction methods, alterations to batter slope, utilisation of existing cleared areas, location of stockpiles and lay-down areas and location of ancillary facilities to avoid where practicable fauna habitat. For example, ancillary facility sites (e.g. temporary sites for construction related activities) will be sited in cleared land or sites with low ecological value to avoid unnecessary clearing of habitat (Roads and Maritime 2013).

The limits of clearing will also consider retaining remnant vegetation along road verges and in widened median strips to enhance the proposed crossing structures. Strategic revegetation will be undertaken adjacent to crossing structures in disturbed areas to guide threatened gliders to crossing structures or away from the road.

5.3.3 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 will be documented in the CEMP and implemented along the entire construction corridor for all threatened species and endangered ecological communities.

Habitat exclusion zones and limits of clearing will include consideration of threatened glider habitat that has been informed by the targeted surveys. Exclusion zones will be established prior to the commencement of clearing and construction to ensure that any activities do not unnecessarily remove protected vegetation within the project, proposed widened median areas, and roadside vegetation that would be retained in and/or near threatened glider habitat areas and crossing structures.

The identification of exclusion zones will 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.

5.4 Mitigation goals and corrective actions

The pre-construction mitigation measures for threatened gliders that are to be completed prior to the commencement of construction and corrective actions should mitigation 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
Targeted glider surveys completed to inform the detailed design, monitoring program and nest box strategy.	Targeted glider surveys undertaken during detailed design and crossing structure locations refined. Identification of ongoing monitoring sites (impact, control and reference) from targeted survey findings.	During detailed design prior to construction.	Targeted surveys for gliders have not been completed prior to commencement of construction. Crossing structure designs for gliders have not been finalised prior to commencement of construction. Monitoring sites for threatened gliders have not been finalised prior to commencement of construction.	Do not commence vegetation clearing or construction until actions have been completed.
	Tree habitat survey to quantify number of hollows to be removed for input into the Nest Box Management Plans.	During detailed design and prior to clearing hollows.	Tree habitat surveys have not been completed prior to commencement of construction. Nest Box Management Plans have not been finalised and approved prior to the commencement of construction.	Tree habitat surveys have now been completed for all sections. The Nest Box Management Plans have been approved.
Limiting damage to threatened glider habitat through minimisation of areas required for clearing for road and ancillary facility sites	Road and construction related infrastructure to be planned and sited within cleared / disturbed areas or minimised, where possible. Particularly away from water sources and known glider habitat and movement areas. Development of UDLP to outline areas for revegetation. Revegetation to include native vegetation that provides foraging resources for gliders.	During detailed design	Detailed plans showing the proposed location of construction related infrastructure have not been produced and signed off prior to commencement of construction. The amount of threatened glider habitat to be cleared has not been integrated into the UDLP or offset strategy (as required).	Delay clearing / construction activities near identified threatened glider habitat until detailed design plans have been completed and approved. Any removal of glider habitat is either mitigated by revegetation or offset.
Identify habitat exclusions zones prior to construction	Temporary and permanent exclusion zone identification informed by the targeted glider surveys.	Pre-construction and marked on detailed design plans (to be implemented prior to commencement of clearing).	Exclusions zones have not been identified on detailed design plans.	Delay clearing and construction until exclusions zones have been identified on detailed design plans and approved.

6. Construction management measures

6.1 Potential impacts during construction

- Direct mortality of threatened gliders from construction activities
- Loss of habitat including potential den sites and foraging resources
- Fragmentation and loss of connectivity during construction; and
- Dust, noise and light impacting on adjacent areas of habitat.

6.2 Mitigation goals

- Establish procedures and training to ensure mitigation is incorporated into construction, through implementation of a CEMP
- Glider mortalities recorded and all injured gliders returned to health for release back to the proximate habitats to their capture (where possible, the EPA should be consulted on release locations of threatened gliders). All threatened gliders recovered from hollows or habitat trees successfully relocated to habitats proximate to their capture
- Construction of crossing structures targeted for threatened gliders completed as soon as practical to allow for daily movements by gliders
- Methods and designs for rehabilitation of glider habitat adjacent to the road is included within the UDLP
- Early installation of 70 per cent of nest boxes prior to the removal of any vegetation to assist in potential glider and other fauna habituation prior to construction as per the W2B NBMP; and
- Implement noise, dust and light mitigation identified in the CEMP to mitigate edge effects.

6.3 Management measures

6.3.1 Construction work method statements

Construction work method statements will be prepared for specific activities to ensure sound environmental practices have been implemented and to minimise the risk of environmental incidents or system failures, in accordance with the CEMP. This management plan would be included as an annexure to the project CEMP.

Construction work method statements will be prepared to address all construction threatened glider management requirements in consultation with relevant agencies, Roads and Maritime and the relevant project environmental manager prior to the commencement of identified activities.

6.3.2 Construction induction and training

Induction training will be conducted with all contractors and other staff that would be working in the areas of known and potential habitat for threatened gliders within the project. This training will highlight to staff the threatened glider habitat, crossing zones and key threats as identified above. 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 Pre-clearing and clearing procedures

Pre-clearing and clearing procedures would be outlined in the project specific CEMPs and FFMP. The procedure would adopt a consistent approach across all project sections in accordance with the Biodiversity Guidelines: Protecting and managing biodiversity on RTA Projects (RTA 2011).

In summary, prior to the commencement of clearing operations (pre-clearance), a licensed ecologist would identify exclusion zones where vegetation and habitat would be retained (refer to **Section 5.3.2**). Where practicable, remnant vegetation in widened medians will be retained throughout construction. This will focus on the retention of trees which are of suitable height in relation to the surrounding topography to assist in facilitating safe glider crossing and reduce the likelihood of vehicular strike, in particular with higher vehicles such as trucks. These trees would not be cleared and exclusion fencing erected around individual trees within the widened medians and in nearby habitat within the construction corridor.

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 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 of their own volition. A licensed ecologist/fauna spotter catcher will be present to supervise the felling of each habitat tree. The ecologist would inspect each felled tree and record habitat/hollow characteristics and evidence of habituation.

Threatened glider species found within the clearing footprint would be relocated to areas which are likely to be within their individual home range (similar habitat adjacent to the project) in accordance with the Biodiversity Guidelines: Protecting and managing biodiversity on RTA Projects (RTA 2011). Release sites for threatened gliders will be identified prior to the commencement of clearing and informed by the additional targeted surveys described in **Section 5.3.1**. Where possible and time permits, the EPA should be consulted regarding the release location of threatened gliders.

6.3.4 Fauna rehabilitation protocol

A licensed ecologist/spotter catcher will be present on site during all vegetation clearing and habitat removal activities to capture and relocate threatened gliders (and other fauna species) that may be encountered. Identified habitat will be left for at least 48 hours after removing non-habitat vegetation to allow fauna to escape. If necessary, fauna will be trapped or captured and relocated to pre-determined habitat or denning site (e.g. appropriate nest box) 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 gliders.

All incidences of threatened glider mortality (resulting from construction activities) will be recorded as well as the number of gliders injured and placed in care or returned to the wild. Injured gliders 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 is 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. Where possible and time permits, the EPA should be consulted regarding the release location of threatened gliders.

6.3.5 Arboreal crossing structures and widened medians

Road crossing structures have been shown to reduce the habitat fragmentation impacts of linear infrastructure in areas proximate to their installation. However the extent to which population viability can be maintained subsequent to installing the structures remains unclear.

As noted in **Section 4.4**, studies have shown Squirrel Gliders use glider poles and rope bridges to cross minor and major roads (Veage and Jones 2007, Ball and Goldingay 2008, Goldingay, Taylor and Ball 2011, Soanes *et. al.* 2013, Goldingay, Rohweder and Taylor 2013). Less is known about Yellow-bellied Glider use of fauna connectivity structures.

Arboreal crossing structures and widened medians will be provided to maintain landscape connectivity between habitat areas on the eastern and western sides of the project. Structures targeting threatened gliders include:

- Canopy (rope) bridges
- Glider poles
- Vegetated overpasses (land bridges) with glider poles
- Widened medians with retained trees; and
- Strategic vegetation plantings.

The location of all arboreal fauna connectivity structures included in the relevant Fauna Connectivity Strategy (GHD 2014) for Section 1 and 2 are detailed in **Table 6.1**. The locations for these crossing structures are illustrated in **Figure 2.1**. The final exact location of glide poles and proximity to retained trees can only be established at the time of construction due to a number of variables that may occur. Where practicable, glide poles and retained trees proximate to the project and vegetated medians will be established no greater than 50 m apart to allow safe glide spaces for threatened gliders. The final location of glide poles will be determined in consultation with the EPA.

Table 6.1 Arboreal crossing structures for Sections 1 and 2

Project Section	Chainage	Connectivity structure	Functionality	Target species
1	1800	Rope bridge (75m) plus glider pole	Arboreal	Possums and gliders
1	5200-6620	N/A – 1,420m	Vegetated median	Gliders
1	7100	Rope bridge – 65m	Arboreal	Possums and gliders
1	13040	Rope bridge – 61m	Arboreal	Possums and gliders
1	16060 - 16430	Glider poles in median	Arboreal	Yellow-bellied Glider Squirrel Glider
2	22900-23640	Vegetated median	Vegetated median	
2	24600	Rope Bridge	Arboreal	Possums and gliders

Detailed assessments of each proposed crossing structure for Sections 3-11 were undertaken by Sandpiper Ecological (2014) to determine the appropriateness of each crossing type and its proposed location in relation to threatened glider populations. The results and recommendations of this survey are detailed within **Appendix D**. A summary of the recommended crossing structures adopted for Sections 3 - 11 is outlined in **Table 6.2** with the location of each structure illustrated in **Figure 2.1.** Three of the proposed crossing structures assessed by Sandpiper Ecological were not recommended and have been subsequently omitted from the TGMP.

One supplementary crossing may be established within the New Italy area of Section 7. The inclusion of this crossing structure will be subject to subsequent threatened glider surveys to identify the presence of Yellow-bellied Glider within proximity to this location. Surveys are to be undertaken by Sandpiper Ecological in late 2014 and early 2015 which will then confirm whether the additional crossing structure is required. It will then be incorporated into the Fauna Connectivity Strategy for Sections 3 - 11.

Table 6.2 Arboreal crossing structures for Sections 3 – 11

Project Section	Proposed Chainage	Recommended Chainage	Connectivity structure	Functionality	Target species
3	35540	35540	Rope Bridge	Arboreal	Yellow-bellied Glider Squirrel Glider
3	37500	37230	Glide poles	Arboreal	Possums and gliders
3	48100	48100	Rope Bridge	Arboreal	Yellow-bellied Glider Squirrel Glider
3	50500	50470	Rope bridge	Arboreal	Possums and gliders
3	53850	53850	Glide poles	Arboreal	Possums and gliders
4	75880	75880	Rope bridge	Arboreal	Possums and gliders

Project Section	Proposed Chainage	Recommended Chainage	Connectivity structure	Functionality	Target species
6	99550	99290-99375	Glide poles	Arboreal	Yellow-bellied Glider Squirrel Glider
7	111550	111315	Glide poles	Arboreal	Yellow-bellied Glider Squirrel Glider
7	112500	112345	Rope bridge	Arboreal	Possums and gliders
7	116400	116030	Rope bridge	Arboreal	Possums and gliders
7	116300-118000	116300-118300	Vegetated median	Vegetated median	Yellow-bellied Glider Squirrel Glider
7	116320	116320	Rope bridge	Arboreal	Brush-tailed Phascogale, Gliders
7	118620	118645	Glide poles	Arboreal	Yellow-bellied Glider Squirrel Glider
7	124610	124680	Rope bridge	Arboreal	Possums and gliders
9	140620	140550	Rope bridge	Arboreal	Possums and gliders
10	147600	146460	Glide poles	Bridge – Combined	Yellow-bellied Glider Squirrel Glider
10	150016	147330	Rope bridge	Arboreal	Possums and gliders

*Crossing structure to be incorporated into the Fauna Connectivity Strategy should the presence of Yellow-bellied Glider be detected in supplementary surveys to be conducted in late 2014 and early 2015

6.3.6 Habitat revegetation

An 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.

Landscaping around crossing structures targeted for gliders will look to retain as many existing large trees as possible and revegetate in proximity to the structure with suitable trees and shrubs. Strategic revegetation would be undertaken to enhance connectivity through revegetation of lands within the road reserve prioritising the glider crossing zones, and targeted structures. Strategic planting will also guide threatened gliders to appropriate crossing points or discourage them away from the road (whichever is more suitable). Specific locations identified for revegetation around arboreal crossing structures as identified in the Fauna Connectivity Strategy (Roads and Maritime 2012) include Section 9 of the project (chainage 140.620) where a canopy bridge would be combined with revegetation of an area of crown land adjacent to Broadwater National Park. The UDLP will also detail where and how disturbed adjacent areas are to be revegetated. Revegetation will also replace glider food sources to encourage usage on both sides of the structure and encourage gliders to the structure and away from the road. Species used will include summer and winter feed trees for threatened gliders and be guided by advice from a suitably qualified ecologist involved in pre-clearance surveys to ensure those species removed are replaced. Known feed tree species for Squirrel Glider have been listed in **Appendix F**. Feed tree species for Yellow-bellied Glider from the Approved Recovery Plan for the Yellow-bellied Glider (NSW NPWS 2003) are listed in **Appendix G.**

6.3.7 Nest boxes

To mitigate impacts from the loss of hollow-bearing trees from the project, nest boxes will be installed to compensate for this loss. Detailed hollow bearing tree surveys have been completed across the entire W2B alignment to inform the NBMP as required by MCoA D6. These surveys estimated the number of hollows and size classes within each project section allowing the number and type of boxes required to be determined.

Guidance regarding the dimensions of nest boxes, installation and maintenance is provided in the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA Projects* (RTA 2011). The more detailed procedures for nest box management on this project is detailed in the NBMP which has been developed to meet MCoA D6 and approved by the relevant agencies. The NBMP identifies the number, type, location and dimensions of nest boxes required based on the number, quality and size of the hollows lost, and specifies installation and maintenance requirements. Roads and Maritime have committed to installing 70 per cent of required nest boxes as soon as practicable prior to the removal of any vegetation to assist with glider habituation.

6.4 Mitigation goals and corrective actions

The construction mitigation measures for threatened glider species, and their associated corrective actions, are summarised in **Table 6.3**.

Table 6.3 Mitigation goals and corrective actions – construction

Mitigation goals	Proposed mitigation measure	Monitoring/timing frequency	Triggers for corrective actions	Corrective actions
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 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 must stop work until they have completed their inductions.
No glider injuries or mortalities resulting from clearing activities.	Pre-clearing and clearing procedures conducted as per protocol outlined in the FFMP • Injured gliders are transferred to wildlife carers or vet. • Refer to FFMP for wildlife carer and vet details. • All threatened glider mortalities reported to EPA within 24 hours.	Monitoring to occur daily as part of routine site inspections. A weekly fauna incident log to be maintained as per FFMP during clearing works. .	A single glider is injured or killed during clearing activities.	Review the clearing procedures and mitigation approach between ecologists and contractor and modify the techniques if found to be ineffective. Injured gliders are transferred to wildlife carer or vet. All glider mortalities are reported to EPA within 24 hours.
All threatened gliders recovered from hollows or habitat trees are successfully relocated.	• 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. Identify and retain all habitat trees for 48 hours post underscrubbing and general clearing to ensure fauna have time to vacate the area.	Daily monitoring of retained habitat trees and exclusion zones. Daily monitor procedures to ensure effectiveness.	Less than 70% of nest boxes have been installed prior to vegetation removal. Habitat trees aren't being successfully identified. Identified habitat trees are not appropriately under scrubbed and retained for 48 hours.	Cease clearing until nest boxes have been installed. Review cause for mortality or injury against existing procedures and processes. Re-evaluate risks and modify pre-clearance activities accordingly to ensure habitat trees are retained for the 48 hour period and where possible gliders relocated to suitable habitats within their home range.
Construction of crossing structures for threatened gliders completed to maintain daily movements.	Installation of connectivity structures at pre-defined locations (based on targeted survey findings).	Monitor installation of connectivity structures during construction. All crossing structures installed at the correct locations and as per specifications prior to operation.	Connectivity structures not installed prior to operation.	Operational phase not to commence until crossing structures installed. If an issue arises where a crossing structure can't be installed as per specifications Roads and Maritime will consult with applicable agencies to identify appropriate action.

Mitigation goals	Proposed mitigation measure	Monitoring/timing frequency	Triggers for corrective actions	Corrective actions
Methods for rehabilitation of glider habitat adjacent to the road included in the completed UDLP.	Implementation of the UDLP that considers threatened glider population, 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 plantings is not undertaken in completely constructed sections of the project. Appropriate native species are not used in revegetation to enhance glider habitats and foraging resources.	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.
Installation of 70% of nest boxes prior to the removal of any vegetation in that section.	Installation of 70% of planned nest boxes prior to the removal of vegetation of a particular section to increase likelihood of habituation by gliders in the local area.	Review of the number of next boxes installed prior to vegetation removal.	Less than 70% of nest boxes have been installed prior to vegetation removal for that section.	Install required number of nest boxes prior to any further vegetation removal.
Implement noise, dust and light mitigation identified in the CEMP to mitigate edge effects.	Implement relevant sections of the CEMP.	Implement noise, dust and light monitoring as outlined in the CEMP.	Exceedance of pre-defined limits for noise, dust or light recorded.	Implement corrective actions as per CEMP

7. Operational management measures

7.1 Potential impacts during operational phase

- Direct mortality of gliders from vehicle strike on the highway
- Loss of connectivity and access to important habitats; and
- Continued degradation of habitat values in habitats adjoining the road in identified important areas.

7.2 Mitigation goals

- Glider mortality caused by vehicle strike monitored
- Targeted glider crossing structures implemented to allow for regular movement of gliders, and structures monitored for effectiveness
- Glider habitat restoration (revegetation and strategic planting) monitored and maintained; and
- Nest boxes found to be used by threatened and/or other gliders species at three years post-construction.

7.3 Management measures

7.3.1 Monitoring of operational glider mortality

Gliders that attempt to cross the road at locations where there are no crossing structures, may become victims of vehicle strike. This is likely to be the result of an unsuccessful attempt to glide across the road, but may also relate to an attempted terrestrial crossing. The installation of fauna exclusion fencing is not thought to be effective for gliders as they are generally able to move through the canopy and over or through a fence. The most effective way of mitigating this impact is to provide opportunities for safe road crossings (through provision of crossing structures) and to create a landscape that guides animals to these structures and away from danger (through retaining trees and strategic plantings near structures). Both these measures are discussed in **Sections 5** and **6**. It is also important that boundary fencing does not include barb wire (top two strands) in the areas of known glider habitat.

Other mitigation may focus on monitoring of glider mortality caused by vehicle strike and identification of hot-spots where additional glider crossings may potentially be installed (post-construction). Road kill records being collected as part of RMS maintenance activities would assist in this regard as well as road kill data gathered as part of the overall glider monitoring program as described in **Section 8**.

7.3.2 Maintenance of arboreal crossing structures

Roads and Maritime will maintain fauna crossing structures as part of the standard maintenance requirements for the project to ensure stability of the structure and to rectify any damage. This will occur for the life of the project. Regular monitoring of the integrity of crossing structures will be undertaken.

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

7.3.3 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 one month 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.

7.3.4 Maintenance of nest boxes

Nest boxes will be installed to compensate for the loss of hollow-bearing trees from the project. Installation and maintenance will be in accordance with the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA Projects* (RTA 2011) and the NBMP prepared for the project.

Monitoring will be required to assess the usage of nest boxes by the target species and other fauna and any maintenance requirements. Monitoring requirements for nest boxes is outlined in the NBMP and **Section 8.6**.

7.4 Mitigation goals and corrective actions

The mitigation measures for threatened gliders and their associated corrective actions are summarised in **Table 7.3**.

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Table 7.3 Mitigation goals and corrective actions – operation

Main goals for mitigation	Proposed mitigation measure	Monitoring/timing frequency	Triggers for corrective actions	Corrective actions
Monitoring of operational glider mortality	Record glider road kill as part of RMS road maintenance activities and as per targeted monitoring surveys outlined in Section 8.4.	Occurs throughout the year Refer to Section 8.4	Hot-spots for glider mortality are identified (significantly higher numbers of glider vehicle strikes recorded).	Consider implementation of additional crossing structure at identified hot-spot or other methods to reduce mortality (e.g. signage, review design of structure in that locality, additional plantings to encourage gliders away from road and to crossing structure).
Maintenance of arboreal crossing structures to allow daily movement	• Connectivity structures installed • Maintenance of widened medians and crossing structures. • Conduct threatened glider connectivity structure survey and monitoring of glider populations at regular intervals as detailed in Section 8.	• Connectivity structures completed prior to operation. • Evaluate effectiveness of crossing structures and widened medians as per monitoring program as detailed in Section 8. • Annual monitoring report.	No evidence of use of arboreal crossings and widened medians by threatened gliders post-construction. High visitation/usage rates by exotic predators.	Review location and type of connectivity structures installed and implement additional controls or provisional measures where appropriate and in consultation with EPA. Unless connectivity measures can be demonstrated to be effective at successfully mitigating the barrier and fragmentation impact to glider species, the residual impact to connectivity shall be offset. This is in accordance with MCoA D2.
Glider habitat revegetation monitored and maintained.	Revegetation of areas outlined in the UDLP for threatened glider 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 two years, then annually up to year 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 and plant more feed and habitat trees as required. Increase monitoring period.
Nest boxes found to be used by gliders at three years post-construction.	Inspection of nest boxes and confirmation that nest boxes have been used by the target species. Nest boxes to be maintained as per the Nest Box Management Plan.	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 for five consecutive monitoring periods. Annual monitoring report.	Threatened gliders are not found to be using nest boxes.	Re-evaluate nest box strategy if boxes continue not to be used by target species or are used by pest species. Upgrade maintenance schedule. Replace nest boxes as required.

8. Monitoring program

Monitoring sites have been confirmed for threatened gliders. Pre-construction baseline information has been gathered at all monitoring sites throughout the project area, which are focused on known glider populations or where they potentially occur. Monitoring will be conducted before, during and after construction 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.

The monitoring program has been developed in consultation with relevant expert ecologists (**Appendix A**) and government authorities (EPA and OEH) and subsequently further refined by Sandpiper Ecological (Dr Taylor and Dr Rohweder – **Appendix C** & **E** following completion of the baseline glider surveys for the project). The program developed includes monitoring at impact, control and reference sites using a BACI approach (Before versus After / Control versus Impact) comparing before and after data with impact versus control sites. Baseline glider surveys have been completed for all project sections.. Ongoing surveys are being undertaken at all monitoring sites to assist in evaluating changes to glider populations, occupancy levels and activity levels in the area.

Monitoring will focus on areas of known and potential habitat for the target glider species throughout the project area, including locations where management measures such as crossing structures and land bridges are proposed. The majority of records for threatened gliders are from Sections 1 to 3 and 6 to 8 of the project. The Halfway Creek area in Section 2 is considered to be a hotspot for Yellow-bellied Glider, and there is also a high proportion of Squirrel Glider records that occur around Halfway Creek (Section 2), Pillar Valley to Tyndale (Section 3), and Mororo to Broadwater (Section 6 to 8).

Monitoring will assist Roads and Maritime to evaluate the success of mitigation measures implemented to address the impacts of the project to gliders. Secondly, the monitoring program will look for opportunities to address gaps in current knowledge such as Yellow-bellied Glider usage of crossing structures, arboreal fauna use of single rope crossings, the efficacy of aerial crossings across large road gaps (i.e. >80 m), and distances threatened gliders will travel to access aerial structures. It is acknowledged that there is limited information on the use of crossing structures by the Yellow-bellied Glider. Thus, a thorough review of the usage of crossing locations by Yellow-bellied Glider combined with other monitoring results will be undertaken after three years of monitoring. The intent of this review is to redress adaptive connectivity measures for this species.

It is acknowledged the monitoring program has been developed in consultation with OEH representatives.

8.1 Aims and goals

Monitoring will be conducted before, during and after construction 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. This time-frame is based on previous studies that suggest at least two years monitoring of crossing structures to assess their use by gliders (Soanes et al 2013) and the recommended five year time-frame for monitoring revegetation (**Section 8.7**). The monitoring data aims to provide data to identify changes to levels of habitat usage and determine if this can be attributed to the project. It will provide robust information to draw sound conclusions around the effectiveness of mitigation measures for the target species. The goals of the monitoring program include:

- To provide an adaptive monitoring program to assess the effectiveness of the mitigation measures proposed, and allow corrective measures to be implemented. To develop contingency measures that would be implemented in the event of changes to habitat usage patterns or evidence that mitigation measures are ineffective and directly attributable to the construction or operation of the road; and
- To provide annual reporting of monitoring results.

Each monitoring program is associated with its own objective as described in the following sections.

8.2 Glider population monitoring

8.2.1 Objective

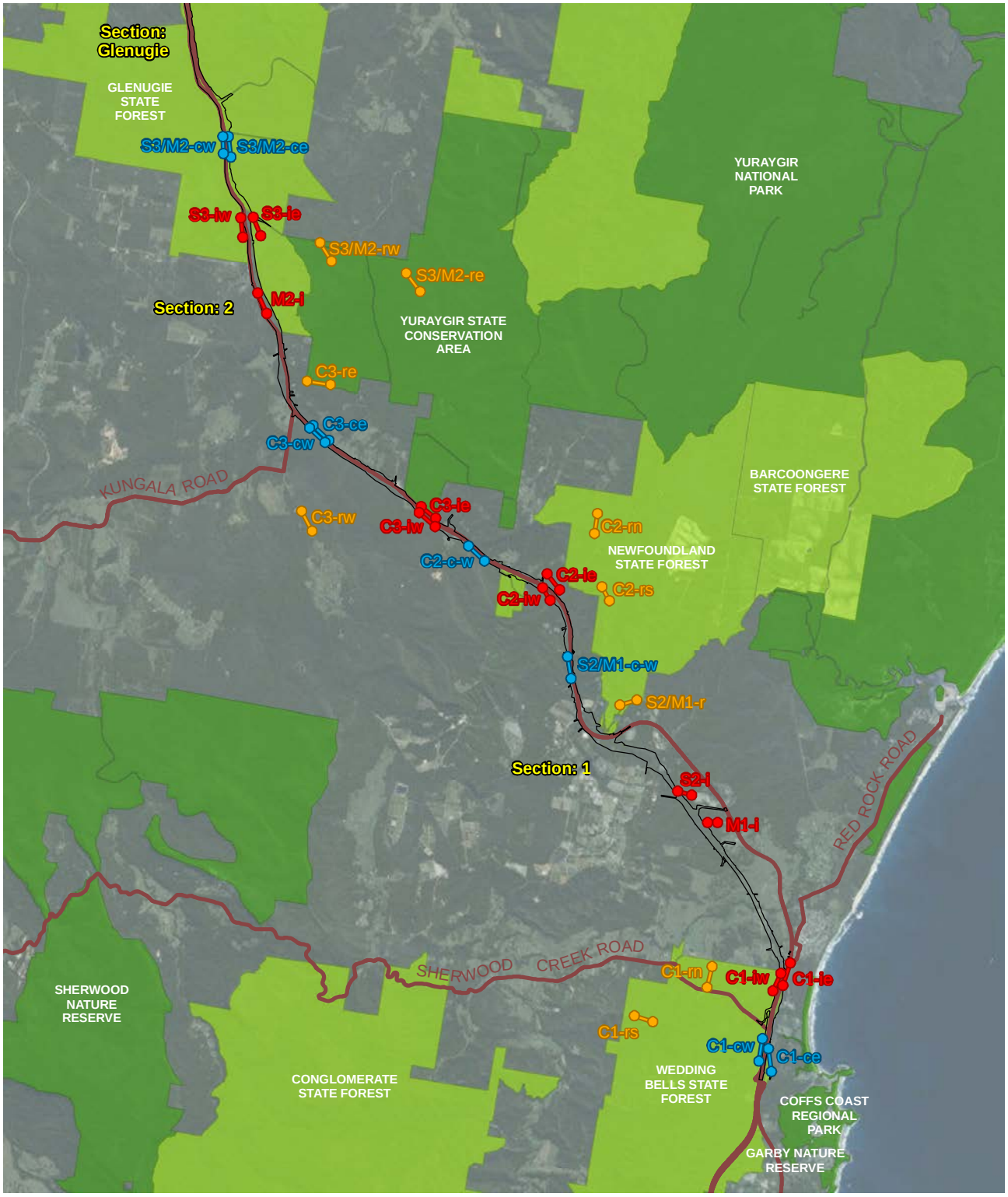
To establish if there is a difference in occupational abundance of threatened gliders or activity levels before, during and after the project.

8.2.2 Selection of monitoring locations

Targeted surveys for the threatened gliders have been undertaken (pre-construction) to confirm the presence of populations and finalise the impact, control and reference monitoring sites. Confirmed populations and monitoring sites are in Sections 1-7. Continual monitoring for threatened glider populations during construction and operation of the project will be conducted at the site locations discussed in **Section 8.5**, listed in **Table 8.5** and illustrated in **Figure 8.1**. The surveys targeted known and potential habitats identified in the EIS with the aim of establishing a set of monitoring sites that meet the following criteria:

- Impact sites (mitigated sites such as widened medians and near crossing structures within 100 m of the road edge or both sides of the road).
- Control sites (unmitigated sites within 100 m of the road edge on both sides of the road).
- Reference sites (>300 m from the project).

Figure 8.1 Threatened glider population monitoring site locations Sections 1-7



JACOBS NSW SPATIAL - GIS MAP file : J:\IE\Projects\04_Eastern\IA136900\22 Spatial\Directory\Templates\Figures\IA136900_TGMP_F001_MonitoringLocations_r1v3.mxd | 2/11/2017

Legend

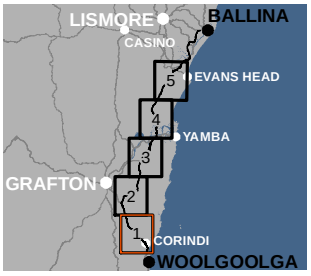
- Approved Project Boundary (Draft v11)
- NPWS Reserve
- State Forest

Glider transect location

- Control transect
- Impact transect
- Reference transect

1:160,000 @ A4

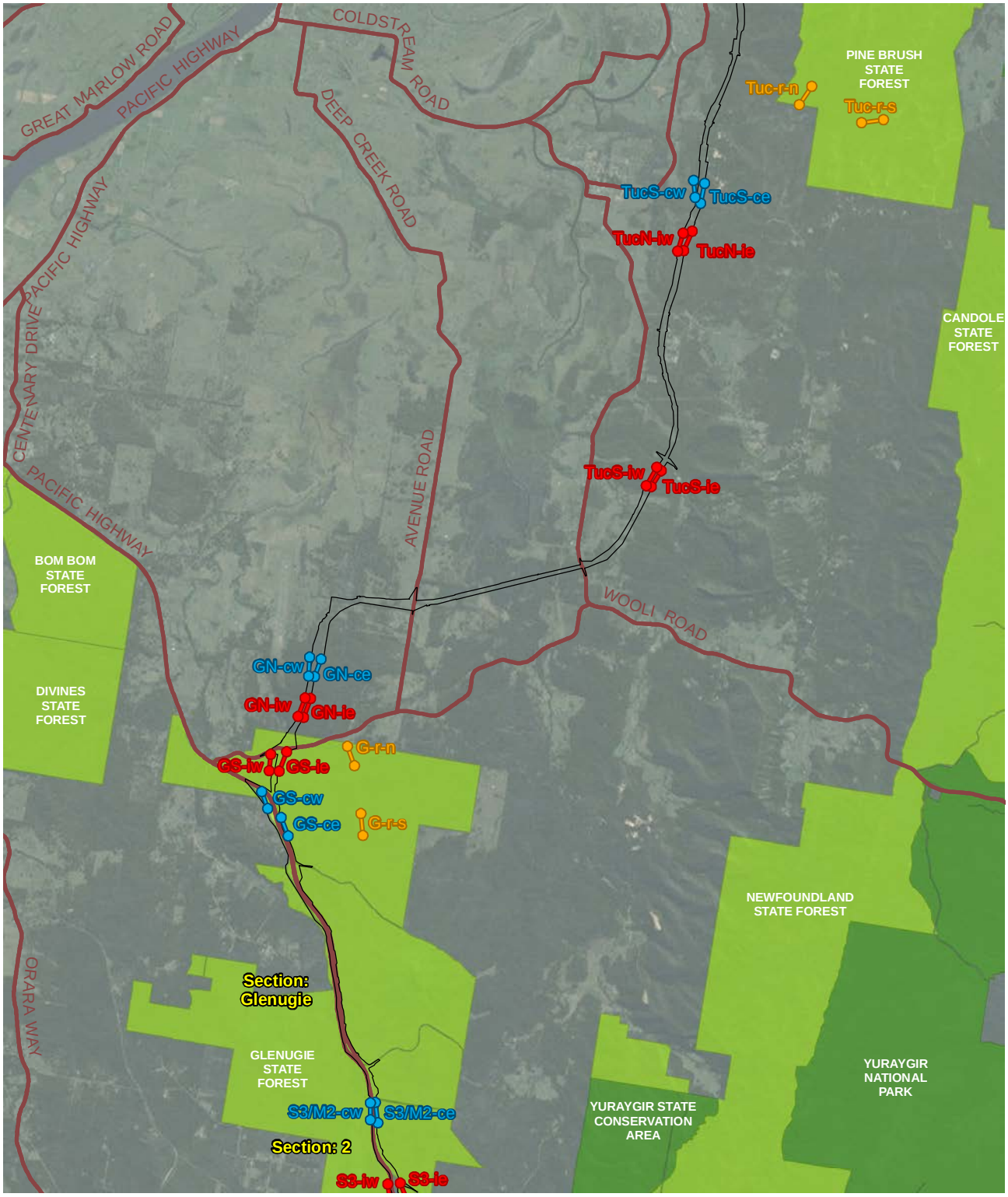
0 4 8 km



Data sources

Jacobs 2017, Pacific Complete 2017, LPI 2017, Imagery Service Layer Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 8-1 | Threatened glider monitoring site locations (Page 1 of 5)



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Legend

- Approved Project Boundary (Draft v11)
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- State Forest

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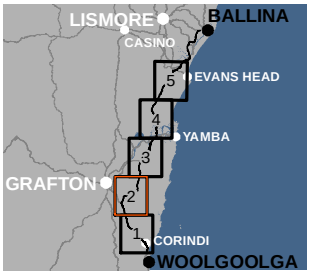
- Control transect
- Impact transect
- Reference transect

1:160,000 @ A4

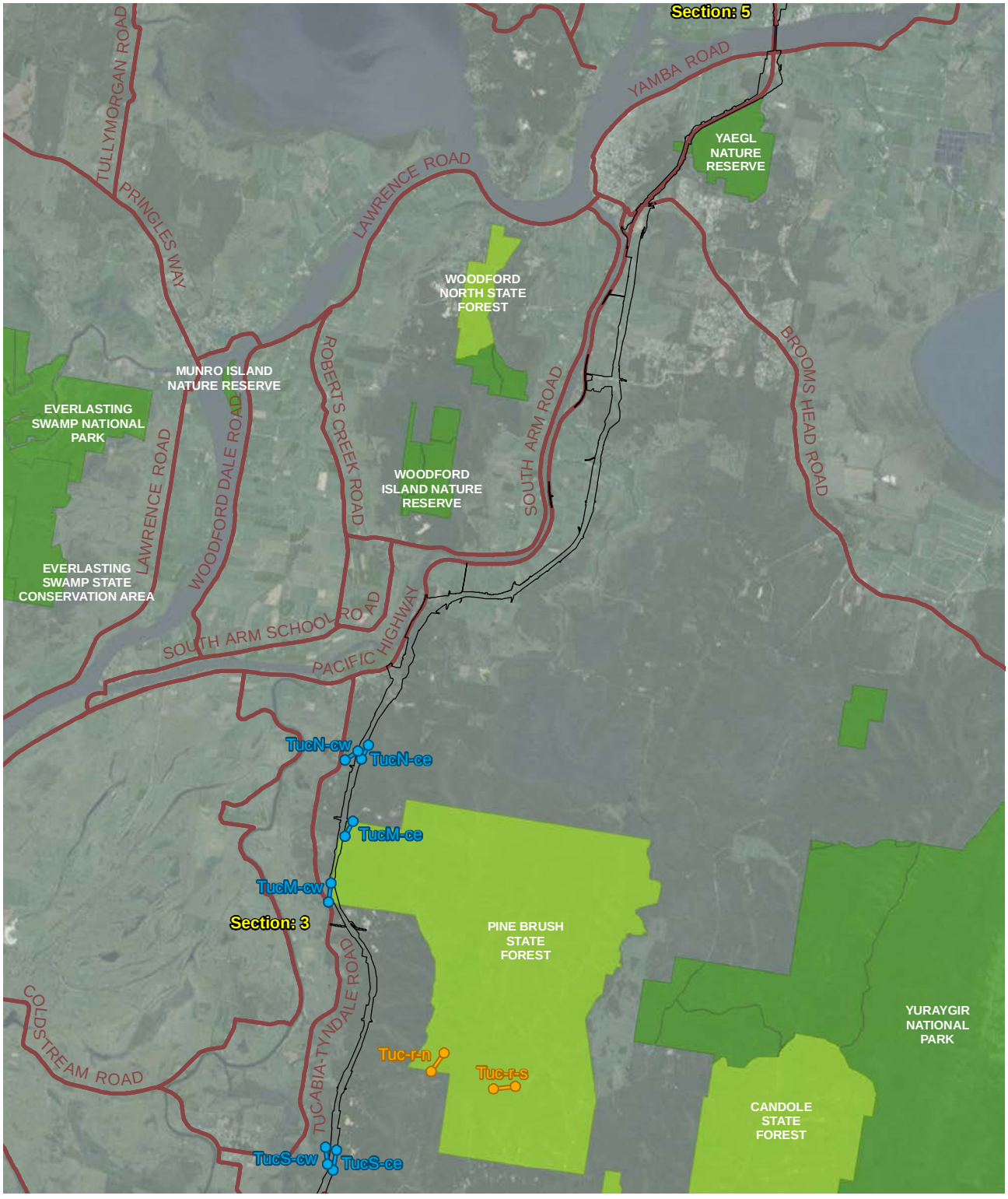
0 4 8 km



Data sources

Jacobs 2017, Pacific Complete 2017, LPI 2017, Imagery Service Layer Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 8-1 | Threatened glider monitoring site locations (Page 2 of 5)



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Legend

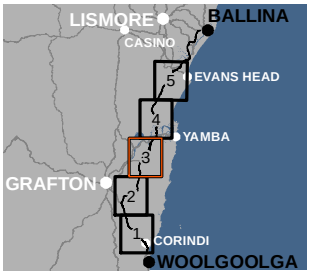
- Approved Project Boundary (Draft v11)
- NPWS Reserve
- State Forest

Glider transect location

- Control transect
- Impact transect
- Reference transect

1:160,000 @ A4

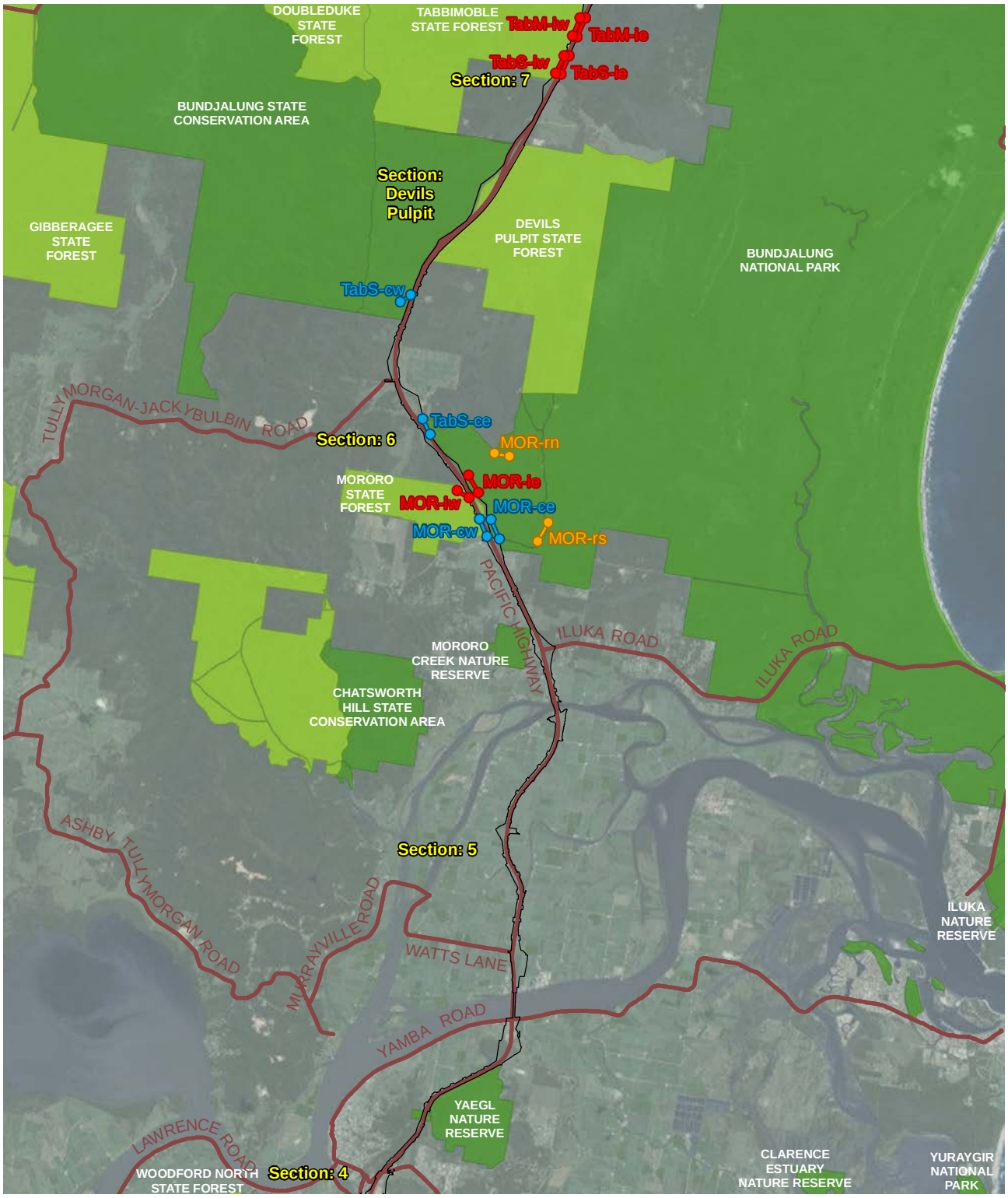
0 4 8 km



Data sources

Jacobs 2017, Pacific Complete 2017, LPI 2017, Imagery Service Layer Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 8-1 | Threatened glider monitoring site locations (Page 3 of 5)



JACOBS NSW SPATIAL - GIS MAP file : J:\IE\Projects\04_Eastern\IA136900\22 Spatial\Directory\TemplatesFigures\IA136900_TGMP_F001_MonitoringLocations_r1v3.mxd | 2/11/2017

Legend

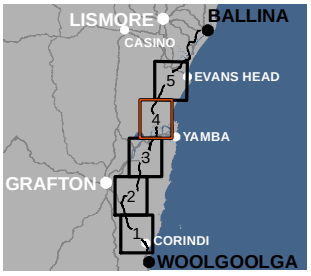
- Approved Project Boundary (Draft v11)
- NPWS Reserve
- State Forest

Glider transect location

- Control transect
- Impact transect
- Reference transect

1:160,000 @ A4

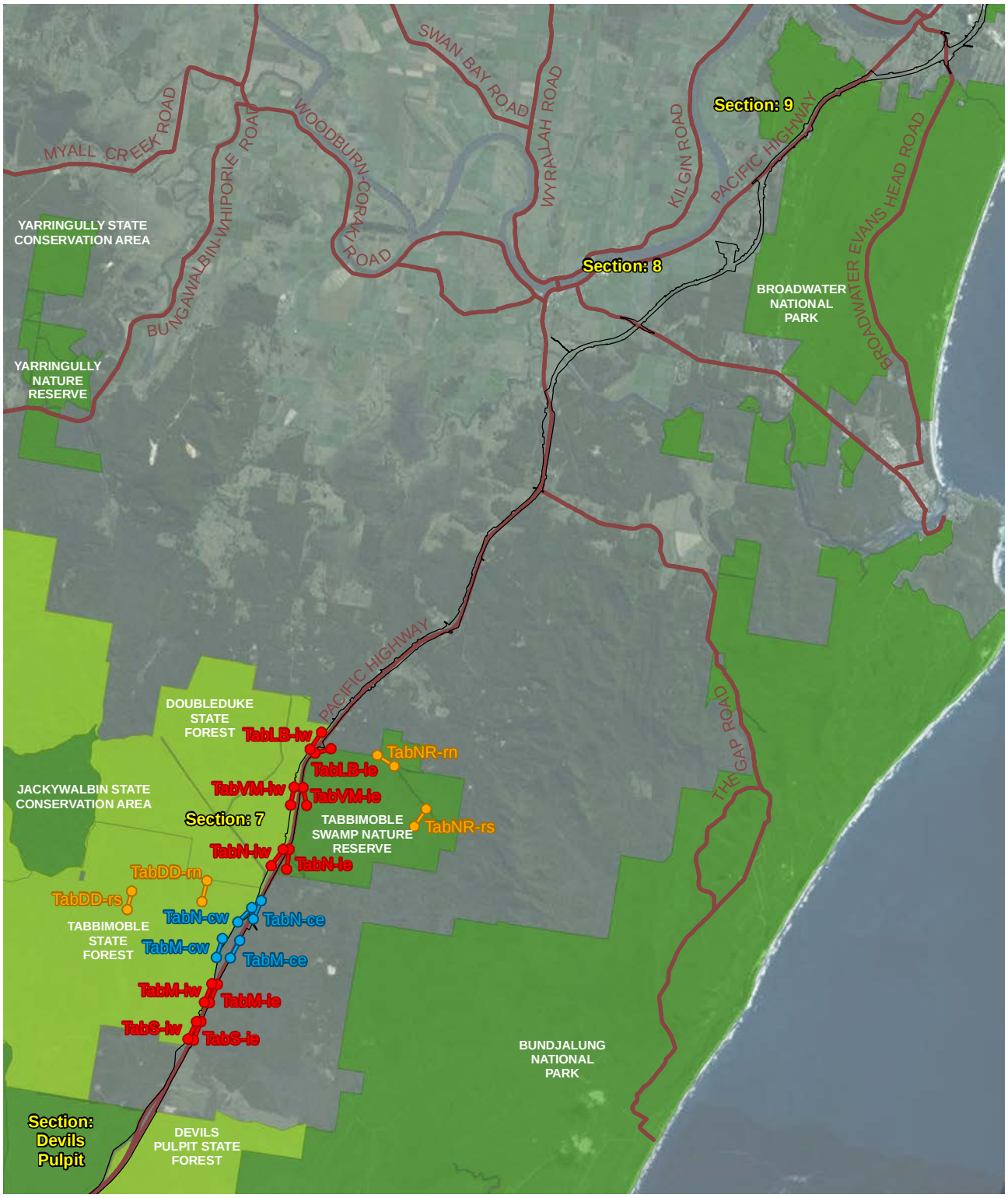
0 4 8 km



Data sources

Jacobs 2017, Pacific Complete 2017, LPI 2017, Imagery Service Layer Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 8-1 | Threatened glider monitoring site locations (Page 4 of 5)



JACOBS NSW SPATIAL - GIS MAP file : J:\IE\Projects\04_Eastern\IA136900\22 Spatial\Directory\Templates\Figures\IA136900_TGMP_F001_MonitoringLocations_r1v3.mxd | 2/11/2017

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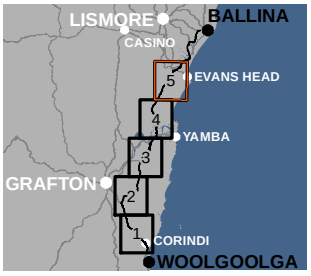
1:160,000 @ A4

0 4 8 km



Data sources

Jacobs 2017, Pacific Complete 2017, LPI 2017, Imagery Service Layer Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Figure 8-1 | Threatened glider monitoring site locations (Page 5 of 5)

8.2.3 Timing and methods

The monitoring program will compare the 'before' construction data with 'during' and 'after' construction data and for each monitoring location, compare the impact sites with control sites and reference sites (i.e. there is a control, impact and reference site for each monitoring location). Monitoring will be conducted every three months (four times annually) to sample for seasonal variability with time as a factor in assessing the impacts on glider occupational abundance and activity.

The monitoring program will aim to compare species occupational abundance at each location and each site (impact, control and reference) to be estimated based on spotlight transects. Goldingay and Sharpe (2004) found spotlighting under suitable condition by experience personnel was equally effective as trapping in detecting and providing population index of Squirrel Gliders. This technique has also proven effective for Yellow-bellied Glider (Davey 1990), and other glider species (refer to Taylor and Goldingay 2009).

Spotlight transects will be located at each site in each monitoring location and will be 200 m in length and placed to sample the same habitat. The spotlighting program (encompassing all locations) will be conducted over several nights by a single operator with a 50 watt spotlight aimed at sampling the same time period (e.g. 25 minutes per transect). Gliders will be recorded within 40 metres of the spotlight transect (as per Taylor and Goldingay 2009). For each glider observation, the species, behaviour, time and location would be recorded. It should be noted that other survey techniques such as the use of audio detection (e.g. Song Meter use) should be considered however, are not compulsory as they have not been used during the baseline surveys nor would be appropriate to determine relative abundance.

The occupancy rate of gliders on each transect will be calculated for comparison between before and after impact and impact versus control and reference sites.

8.2.4 Performance indicators and contingency measures

Reliability of these performance indicators will rely on being able to take into account population fluctuations due to changing availability of food sources, hence the use of control and reference sites. Squirrel Glider populations are very susceptible to reduced food availability during poor flowering seasons (Sharpe 2004). The main performance indicators and corrective actions are outlined in **Table 8.1.**

Table 8.1 Performance indicators and corrective actions – monitoring of threatened glider population

Triggers for corrective actions	Corrective actions
Decline in the after construction occupancy rates of Squirrel Glider or Yellow-bellied Glider at impact sites over 3 consecutive monitoring sessions.	Review monitoring methods, considering further monitoring and assessment should there be a decline in population abundance. Consider potential for natural variation to be responsible for decline in population numbers/density. Review location of the arboreal crossing structures and consider adding new structures. Investigate habitat adjoining the highway and consider improving habitat condition and connectivity. Post three years of monitoring and implementation of corrective actions, if connectivity measures cannot be demonstrated to be effective at successfully mitigating the barrier and fragmentation impact to glider species, the residual impact to connectivity shall be offset. This is in accordance with MCoA D2.

8.3 Arboreal crossing structures and widened medians

8.3.1 Objectives

Establish the level of use of various crossing structures (i.e. glider poles, widened medians and rope bridges) by Squirrel Glider and Yellow-bellied Glider.

8.3.2 Selection of monitoring locations

Monitoring locations will include the connectivity structures targeted for threatened gliders listed in **Table 8.4**, including rope crossings, targeted land bridges and widened medians.

8.3.3 Timing and methods

Monitoring of the arboreal crossing structures and widened medians will be undertaken to assess their level of use by threatened gliders across the project. Provision for ongoing monitoring during operation of the SSI (for operation/ongoing impacts) will continue until such time as the use and effectiveness of mitigation measures for Gliders can be demonstrated to have been achieved over a minimum of three successive monitoring periods, or until such time as agreed by EPA. This is consistent with MCoA D8(k).

The monitoring locations will occur at each of the proposed structures and locations identified in **Table 8.4** and follow a similar design to other studies on the Pacific Highway (example Goldingay *et al* 2013) as described:

- A digital camera activated by an infrared motion sensor and infrared flash installed at each end of the rope crossing (at the top of support poles) with the objective to record successful crossings of threatened gliders from one side of the highway to the other. Installing a camera at each end of the rope bridge will aid in the confirmation of complete crossing by an individual.
- Cameras are to be set to record between 1930 and 0600 hours for the monitoring period. Data will be downloaded and batteries changed as required.
- Camera set up will be standardised to allow comparison between structures and with subsequent monitoring events.
- Hair funnels will be placed along three transects within and either side of the widened medians. Funnels will be baited with a mixture of peanut butter, honey, oats and pistachio nut oil for 14 consecutive nights per monitoring period. Hair samples will be sent to an appropriately qualified/experienced specialist for identification.

This methodology will allow for the assessment of use of crossing structures by Yellow-bellied Gliders, as they will be identified in photographs and hair samples if present. This information will add to the current knowledge on the species. In addition, placement of camera'sat crossing locations exceeding 75m will allow data collection of the willingness of arboreal animals to cross voids greater than 75m.

Monitoring of wildlife road crossing structures by Soanes *et al.* (2013) found the rate of glider crossing increased over several years as animals habituated to the structure. They suggest monitoring periods of at least two years to allow gliders adequate time to habituate to the crossing structures.

As different Sections of the W2B upgrade are being constructed independently, crossing structure installation and deployment has/is/will occur at different times during the construction phase. It is intended to schedule monitoring for all arboreal crossing structures within a project section at the same time, rather than individually, this will enable meaningful and robust data comparisons, particularly with the population monitoring data. This approach will also reduce the potentially confounding effects of differing stages of construction. As such, monitoring of arboreal crossings will commence six months after installation of all structures within a project Section. This approach has been agreed through consultation with OEH. Monitoring will then continue once every three months timed to coincide with the population monitoring described in **Section 8.2** until the effectiveness of each crossing site has been proven over three consecutive monitoring periods, unless otherwise agreed by the Secretary in consultation with the OEH, DPI (Fisheries) and DoE), after which the need for further monitoring would be reviewed in consultation with EPA. Additional monitoring may be required in the event the monitoring data suggests any of the crossings have been ineffective (i.e. recording no crossings) and modification/treatments are required.

8.3.4 Performance indicators and contingency measures

The use of crossing structures by threatened gliders would be monitored to identify the effectiveness of mitigation measures and to inform the need for corrective and adaptive actions. The main performance indicators and corrective actions for arboreal crossing structures and widened medians are outlined in **Table 8.2**.

Table 8.2 Performance indicators and corrective actions – monitoring of arboreal crossing structures and widened medians

Triggers for corrective actions	Corrective actions
No evidence of use of arboreal crossings and widened medians by threatened gliders post-construction.	Review location and type of connectivity structures installed and implement provisional measures in consultation with EPA which may include but not limited to the installation of more glide poles or rope bridges, particularly were known mortality hotspots occur. Consider more strategic planting of habitat or the installation of additional glider poles, informed by the long-term population monitoring data. Post three years of monitoring and implementation of corrective actions, if connectivity measures cannot be demonstrated to be effective at successfully mitigating the barrier and fragmentation impact to glider species, the residual impact to connectivity shall be offset. This is in accordance with MCoA D2.

8.4 Road mortality monitoring

8.4.1 Objectives

Record the incidence of glider / vehicle collisions at mitigated (impact) and unmitigated (control) sites, to establish if there is a positive effect (i.e. decrease in glider mortality) associated with crossing structures. This is to meet MCoA D8(g).

8.4.2 Timing and methods

Monitoring of threatened glider mortalities on the road will occur adjacent to all arboreal crossing structures and the widened medians in relevant project sections and also at control sites established as per **Section 8.2**. Threatened glider mortality monitoring will occur every three months and coincide with the glider population monitoring program. The threatened glider mortality monitoring will involve an ecologist walking a 500 m transect either side of the crossing on both sides of the upgraded highway. For widened medians this will include an additional transect within the median. The number of road mortalities will be collated per monitoring event and geographic coordinates recorded for each road kill specimen to be assessed in relation to the closest fauna crossing structure.

Detection of threatened glider road kill is 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. 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 contingency measures

The correlation between connectivity structures and glider road mortalities will be measured by the monitoring program and a higher or non-significant difference in mortality (between impact and control sites) will indicate that the mitigation measure is ineffective for road mortality. This information will add to the level of current knowledge and indicate whether other mitigation measures (e.g. clearance of vegetation to decrease proximity of habitat to the road) need to be considered to lower threatened glider road mortalities.

A high number of incidental observations in locations away from crossing structures may identify hotspots for threatened glider road mortality, indicating a need for additional mitigation (such as a new crossing structure).

The main performance indicators and corrective actions for road mortality monitoring are outlined in **Table 8.3**.

Table 8.3 Performance indicators and corrective actions – monitoring of threatened glider road mortality

Triggers for corrective actions	Corrective actions
Higher mortality rate at impact sites or no significant difference in mortality rates	Review reported usage level of crossing structure by threatened gliders. Corrective actions may include but not limited to the installation of more glide poles or rope

Triggers for corrective actions	Corrective actions
for threatened gliders between impact and control sites.	bridges to known mortality hotspots. Crossing structures also serve as 'insurance' in the case of stochastic events such as fire or disease which may occur at long time intervals. Further the cost of decommissioning and relocating a rope bridge or glide pole array is likely to be comparable to the cost of installing a new structure. Therefore existing glide poles/rope bridges will be retained. Should road kill data indicate a road-kill hot spot for gliders where there is limited crossing structures RMS will investigate the feasibility of installing additional crossing structures. Post three years of monitoring and implementation of corrective actions, if connectivity measures cannot be demonstrated to be effective at successfully mitigating the barrier and fragmentation impact to glider species, the residual impact to connectivity shall be offset. This is in accordance with MCoA D2.
High number of incidental records of threatened glider mortality away from crossing structures.	Identify a hot spot. Review options for mitigation, i.e. crossing structure, signage, lowering speed limit. Consider implementation of crossing structure at identified hot-spot or other methods to reduce mortality (e.g. signage, review design of structure in that locality, additional plantings to encourage gliders away from road and to crossing structure).

8.5 Selection of monitoring locations for gliders, arboreal road crossings and road mortality

In order to address these objectives, baseline monitoring activities have focused on:

- Sites that feature highest threatened glider activity and suitable habitats; and
- A combination of aerial crossing types and gap widths, particularly in known Yellow-bellied Glider habitats.

In light of the above directives, the eight crossing structures surveyed within Sections 1 & 2 will be subjected to ongoing monitoring and are detailed within **Table 8.4**. Within Sections 3 - 7, the 18 aerial crossing locations have been prioritised (high, medium or low) for population monitoring, aerial crossing monitoring and road mortality monitoring according to their perceived importance and likelihood of providing new insights. Of the 18 proposed monitoring sites, only those identified as high or medium priority (with two low priority sites included to provide sufficient replication) these were subject to further baseline surveys in winter 2015, summer 2015/16 and autumn 2016 to confirm glider presence adjacent to the structure site. Ongoing monitoring will occur during the construction and operational phases (**Table 8.4**). Four of the high priority population monitoring sites (8mile-nth/8mile-sth; C9/C9-nth) are paired both spatially (i.e. in close proximity to each other) and as a contrast of structures (i.e. poles versus rope bridge).

Pairing in such a way would assist in controlling for confounding factors which may affect interpretation of population and crossing use data. A land bridge with poles/rope (C11) and the vegetated median (M3) are also included as high priority because they are relatively new crossing types for which there is little data in a highway setting, particularly for Yellow-bellied Gliders. Aerial crossing monitoring and road mortality monitoring should be conducted concurrent with population monitoring because they provide complementary insights on the efficacy of an aerial structure and possible population impacts.

The location of impact, control and reference glider population monitoring sites for all Sections are detailed within **Figure 8.1, Table 8.5** and **Appendices C & D**.

Table 8.4 Monitoring Locations for arboreal crossing structures

Section	Chainage	Structure
1	1800	Rope bridge and glide pole
1	5200-6620	Vegetated median
1	7100	Rope bridge
1	13040	Rope bridge
1	16060	Glide pole in median
1	16430	Glide pole in median
2	22900-23640	Vegetated median

Section	Chainage	Structure
2	24800	Rope bridge
3	35540	Glide pole
3	37230	Rope bridge
3	48100	Glide pole
3	53850	Rope bridge
6	99550	Glide pole
7	111550	Glide pole
7	112500	Rope bridge
7	115880	Rope bridge
7	114100-121100	Vegetated median
7	118800 (or 118620)	Land bridge with glide poles (or Glide poles)

Table 8.5 Glider Population Monitoring Locations (Impact, Control and Reference sites)

Impact site monitoring locations			
Section	Transect Name	Easting	Northing
1	C3ab Impact [west]	509850	6687547
1	C3ab Impact [east]	509906	6687795
1	S2 Impact	515883	6681363
1	C2 Impact [west]	512679	6685922
1	C2 Impact [east]	512851	6686077
1	M1 Impact	516570	6680519
1	C1 Impact [east]	518322	6676929
1	C1 Impact [west]	518030	6676650
2	M2 Impact	505995	6692694
2	S3 Impact [east]	505841	6694435
2	S3 Impact [west]	505481	6694379
3	TucN-ie	512595	6716859
3	TucN-iw	512402	6716841
3	TucS-ie	511823	6711239
3	TucS-iw	511679	6711293
3	GN-ie	503577	6705891
3	GN-iw	503440	6705889
3	GS-ie	503004	6704630
3	GS-iw	502783	6704623
6	MOR-ie	522418	6756590
6	MOR-iw	522276	6756457
7	TabM-ie	525033	6767369
7	TabS-ie	524651	6766470
7	TabLB-ie	527582	6773203
7	TabVM-ie	527232	6772031
7	TabN-ie	526826	6770530
7	TabN-iw	526550	6770577
7	TabLB-iw	527452	6773308
7	TabVM-iw	526888	6772045
7	TabM-iw	524907	6767395
7	TabS-iw	524533	6766500
Control site monitoring locations			
Section	Transect Name	Easting	Northing
1	S2/M1 Control	513141	6684370

1	C2 Control	511076	6686737
1	C1 Control [west]	517730	6675298
1	C1 Control [east]	517957	6674864
2	S3/M2 Control [east]	505283	6696376
2	C3ab Control [east]	507390	6689699
2	C3ab Control [west]	507291	6689520
2	S3/M2 Control [west]	505073	6696423
3	TucS-cw	512812	6718078
3	GN-ce	503802	6706855
3	GN-cw	503680	6706878
3	TucS-ce	512932	6717966
3	TucN-cw	513342	6727435
3	TucN-ce	513756	6727507
3	TucM-ce	513240	6725830
3	TucM-cw	512830	6724245
3	GS-ce	503049	6703073
3	GS-cw	502577	6703722
6	MOR-ce	522970	6755546
6	TabS-ce	521327	6757919
6	MOR-cw	522700	6755572
6	TabS-cw	520905	6760849
7	TabM-cw	525151	6768474
7	TabM-ce	525557	6768428
7	TabN-cw	525803	6769255
7	TabN-ce	526094	6769344

Reference site monitoring locations			
Section	Transect Name	Easting	Northing
1	S2/M1 Reference	514580	6716859
1	C1 Reference [north]	516489	6676888
1	C1 Reference [south]	514930	6675917
1	C2 Reference [north]	513857	6687516
1	C2 Reference [south]	514153	6685728
2	C3ab Reference [west]	507052	6687564
2	C3ab Reference [east]	507419	6690817
2	S3/M2 Reference [east]	509572	6693192
2	S3/M2 Reference [west]	507516	6693900
3	Tuc-r-n	515344	6720259
3	Tuc-r-s	516956	6719676
3	G-r-n	504645	6704742
3	G-r-s	504872	6703121
6	MOR-rn	523152	6757392
6	MOR-rs	524147	6755441
7	TabDD-rs	523057	6769560
7	TabNR-rs	529960	6771525
7	TabDD-rn	524826	6769767
7	TabNR-rn	529178	6772891

8.6 Nest boxes

The procedures for installation and monitoring of nest boxes relate to a range of fauna species and would be consistently applied across all project sections and are documented in the NBMP.

8.7 Habitat revegetation

8.7.1 Objective

Evaluate the success of habitat revegetation and strategic plantings at locations adjacent to connectivity structures and widened medians.

8.7.2 Timing and methods

After the first year of maintenance of habitat revegetation (**Section 7.3.3**), 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.

8.7.3 Performance indicators and corrective actions

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.Performance indicators and corrective actions.

The monitoring program, performance indicators and corrective actions if monitoring finds poor outcomes as measured by performance indicators are outlined in **6**.

Table 8.6 Performance indicators and corrective actions – monitoring for habitat revegetation

Triggers for corrective actions	Corrective actions
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.

8.8 Evaluation, project review and reporting

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

8.8.1 Responsibility

The contractor employed to undertake the threatened glider monitoring is responsible for the evaluation of the monitoring information collected. Reports will be submitted to Roads and Maritime after each monitoring event. Monitoring of threatened glider crossing structures, widened medians and habitat restoration has been anticipated to be undertaken separately for each relevant project section.

8.8.2 Timing

A brief annual report will be prepared by the contractor for distribution to the Roads and Maritime and relevant government agencies regarding the annual population counts. This may include a separate monitoring report per target species or a combined report for one or more species.

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

A final report will be prepared at the conclusion of the monitoring period. This report will incorporate all the results of the monitoring and recommend any additional measures (if deemed necessary) to facilitate the long-term survival of Squirrel Glider and Yellow-bellied Glider populations in the locality.

9. Summary table and implementation schedule

An overall summary of the actions proposed in the above plan, including identification of the person responsible for the actions and the estimated timing of the project is provided in **Table 9.1**.

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 glider surveys, tree surveys and hollow bearing tree 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	Arboreal crossing structures and widened medians implemented	Contractor		X																				
2.6	Habitat revegetation – UDLP	Contractor		X																				
2.7	Nest box installation (remaining)	Contractor		X																				
2.8	Threatened glider monitoring	Roads and Maritime		X																				
2.9	Arboreal crossing structure and widened median monitoring (within competed sections even if not operational)	Roads and Maritime		X																				
3. Operational management																								
3.1	Monitoring of operational glider mortality	Roads and Maritime			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3.2	Maintenance of arboreal 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			
4. Operational monitoring																								
4.1	Threatened glider monitoring*	Roads and Maritime			X	X	X	X	X	X	X	X	X	X	X	X								
4.2	Arboreal crossing structure	Roads and			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
	and widened median monitoring*	Maritime																						
4.3	Road mortality monitoring	Roads and Maritime			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
4.5	Habitat revegetation monitoring (until performance objectives are achieved)*	Contractor						X				X				X								
4.6	Evaluation and reporting	Roads and Maritime				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, unless otherwise agreed by EPA.

10. References

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Appendix A – Response to Expert and Agency Comments

Expert Comments				
ID No	Recommendation	Recommendation has been addressed (Version 1)	How recommendation has been addressed (Version 2)	How recommendation has been addressed (Version 3)
TGMP1	The goals for mitigation need to be clearly articulated. They should include general goals (e.g. maintain connectivity for daily movements or maintain natural rates of gene flow across the road) and specific goals that are measurable (i.e. using the SMART approach).	Adopted- plan to be updated prior to implementation	The major aim for the project has been identified as ensuring the continued viability of Squirrel Gliders and Yellow-bellied Gliders in the project area. Specific goals for mitigation have been identified and relate to the impacts being managed. SMART goals have also been developed and the monitoring program built around these goals to measure performance. These are articulated for each phase of the project in Sections 5, 6, 7 and 8.	
TGMP2	Daily movements should be a goal of mitigation, therefore one major goal of mitigation must be to allow regular movement of gliders.	Adopted- plan to be updated prior to implementation	Identified as a goal in Section 3.3.	
TGMP3	I recommend that the objectives and methods of the monitoring program for threatened gliders be further developed through a workshop with glider experts and monitoring design experts in order to develop a monitoring program that answers the most important and necessary questions. The current monitoring program will conclude: yes, squirrel gliders use crossing structures and yes/no – YBG use crossing structures.	To be reviewed	The monitoring program has been refined by Sandpiper Ecological (Dr Taylor and Dr Rohweder). The monitoring program includes population monitoring at impact, control and reference sites. Baseline targeted surveys have been completed by Sandpiper Ecological in 2013/2014. Surveys aimed at prioritising crossing structures as high, medium and low priorities for monitoring based on the crossing type, perceived importance and likelihood of providing new insights for threatened gliders. 18 monitoring sites will be subject to further baseline surveys in summer 2014/15 and	

Expert Comments				
ID No	Recommendation	Recommendation has been addressed (Version 1)	How recommendation has been addressed (Version 2)	How recommendation has been addressed (Version 3)
			winter 2015 and ongoing monitoring during construction and operational phases.	
TGMP4	Developing and finalising a comprehensive, scientifically robust and useful monitoring program can not be completed before the goals for mitigation are revised and the targeted surveys are finalised. I recommend that the monitoring program be developed with relevant experts, as per RECC 3.	Adopted- plan to be updated prior to implementation	Monitoring objectives have been refined to be clearer about the goals of mitigation and monitoring. The monitoring program has now taken into consideration results of targeted surveys completed.	
TGMP5	"Monitoring will continue until mitigation is proven effective" revise this based on the recommendations above.	Adopted- plan to be updated prior to implementation	In accordance with project approval condition MCoAD8(k) the TGMP now states "Monitoring will be conducted before, during and after construction 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".	
TGMP6	Ensure that the effects of mortality and reduced connectivity are clearly differentiated in the TGMP and ensure that the mitigation measures are appropriate for the impact.	Adopted- plan to be updated prior to implementation	This comment is pertaining to the main objectives of crossing structures being to convey glider movement, rather than decrease mortality (although that is a positive side-effect). Fencing of roads does not limit road mortality for gliders because they are arboreal and simply travel over fences. Other mitigation measures to assist reduce glider mortality could be considered, such as signage to alert motorists to be aware of fauna on roads/roadsides, and use fencing that is traversible by gliders (in case of an unsuccessful attempt to glide across the road) i.e. avoid use of barbed wire on top	

Expert Comments				
ID No	Recommendation	Recommendation has been addressed (Version 1)	How recommendation has been addressed (Version 2)	How recommendation has been addressed (Version 3)
			two strands of boundary fencing.	
GMP7	A greater number of crossing structures for gliders will be required.	To be reviewed prior to implementation	The number and location of crossing structures have been finalised for the project in relation to gliders. These were informed by the results of targeted surveys. One arboreal crossing structure is subject to further assessment post additional baseline surveys in 2015. Sandpiper Ecological will advise Roads and Maritime of survey results and crossing structure requirements. There are now 18 proposed crossing structures for gliders. An updated map showing the latest information pertaining to crossing structures is included as Figure 6-1 and Figure 6-2. The location, design and number of arboreal crossing structures is also detailed in the Fauna Connectivity Strategy.	
TGMP8	There is confusion around pre-clearing surveys, Clarify the role / purpose of the different surveys.	To be reviewed prior to implementation	Terminology around surveys has been inconsistent. Targeted surveys will be undertaken pre-construction and are summarised in Section 3 and full reports are Appendix C and E of this plan. Targeted surveys include: baseline population assessments, den sites and tree heights. The targeted surveys occur pre-construction. The pre-clearance surveys referred to in some sections refers to spotter-catcher and translocation immediately prior to clearing. Pre-clearing surveys are yet to occur. The monitoring program has its own set of	

Expert Comments				
ID No	Recommendation	Recommendation has been addressed (Version 1)	How recommendation has been addressed (Version 2)	How recommendation has been addressed (Version 3)
			surveys as well. This has now been clarified throughout the document.	
TGMP9	To what extent is this plan a stand-alone document; please Clarify how this plan is to be used in the introduction section.	Adopted- plan to be updated prior to implementation	Integration of a diagram (Figure 1.2) showing how the plan fits in with other higher or lower level documents has been included. Some information on biology/ecology has been added to Section 2.	
TGMP10	Acknowledge in the TGMP that the only way to funnel gliders is with strategic tree planting and that gliders are likely to attempt to cross the highway wherever there are trees on both sides of the road, including in places where trees are too distant to successfully make the glide	Adopted- plan to be updated prior to implementation	The removal of the reference to fencing to funnel gliders has been completed and replaced with reference to strategic plantings and revegetation in areas adjacent to crossing structures and in disturbed areas to enhance habitat.	
TGMP11	Ensure glide angle calculations are completed for every set of glider poles and for treed medians and that minimum clearances can be achieved.	Adopted- plan to be updated prior to implementation	This requirement was included in targeted surveys aimed at locating the glider crossings. Information regarding glide angle requirements is included in Section 5.3.1. Further, Section 3 outlines survey methods for pre-construction targeted surveys including an assessment of tree heights and adequacy for glider use.	
TGMP12	There is no detail of amount of time available before construction. The amount of time required for pre-clearing baseline surveys will depend on the goals of monitoring and the monitoring questions being asked. 12 months would likely be the minimum time required, but this should be reviewed when the monitoring program is properly finalised.	To be reviewed prior to implementation	The planning horizon for the project is until the end of 2015 which provides just over 1 year to conduct additional baseline targeted surveys. This is adequate to achieve the minimum 12 months of monitoring recommended by the expert. Section 4.3 has been amended.	
TGMP13	There is insufficient acknowledgment of gliders in fragmented areas. The mitigation proposed for highly cleared and fragmented areas be reviewed for adequacy.	To be reviewed prior to implementation	Acknowledgement added to Section 2. Potential additional mitigation measure to address these areas is suggested in TGMP10 above (re strategic	

Expert Comments				
ID No	Recommendation	Recommendation has been addressed (Version 1)	How recommendation has been addressed (Version 2)	How recommendation has been addressed (Version 3)
			planting). Revegetation of glider habitat is also outlined in Section 6.3.6 and UDLP.	
TGMP14	Use crossing zones with multiple crossing structures when crossings are few and far between. If crossings are spaced at shorter distances (e.g. one per average home range length), then crossing zones are not required.	To be reviewed prior to implementation	Targeted surveys have been undertaken by glider experts from Sandpiper Ecology to assess the adequacy of the crossing structures and locations as well as recommend where further mitigations are required. Recommendations and changes are described within Section 3.1 and Section 3.2 (method for crossing sections) and Section 6.3.5. These expert recommendations have been adopted by the project where practicable.	
TGMP15	Change arboreal crossing monitoring approach to occur once the installation of all structures across a particular section of the project is complete. Glider population monitoring location tables need to be updated.			Monitoring approach wording has been changed to reflect the recommendation, see Section 8 (specifically Sections 8.2.2, 8.3.3 and 8.5) Tables 8.4 and 8.5 have been updated to include all glider population monitoring locations.
TGMP16	Hair funnels should not be installed on crossing structures (glide poles & rope bridges) as this may be regarded as an attractant & distort any assessment to determine use of the structures by arboreal mammals. Determining use of a crossing structure should not be biased by use of an attractant. We know from numerous locations that cameras on the structures provide definitive evidence of use. Hair funnels do not provide any additional information in such a context and present the risk of distorting any assessment of use of the structures. (Mr B Taylor, Sandpiper Ecological Surveys, email 19 December 2017)			Reference to the installation of hair funnels on crossing structures has been removed. Changes were made in Section 8.3.3 'Timing and Methods'

Agency Comments			
Date	Section	Recommendation	How recommendation has been addressed (Version 2)
EPA - 11/02/15	Page 33 - 6.3.3	Where time permits, please consult with the EPA prior to confirming release sites for captured gliders. It is important that individuals are released within their likely home range and in suitable habitat. The RMS Biodiversity Guidelines commits to identifying these release areas prior to clearing.	Section 6.3.3 updated to reflect where possible and time permits, the EPA will be consulted regarding the release location of threatened gliders. Wording also states they will be released within their likely home range and in suitable habitats.
EPA - 11/02/15	Page 34 – Table 6.1	Please provide an indicative glide distance between glide poles/nearest launch tree in this table. This is an important consideration and may require further EPA input into pole location.	This will not be possible to determine until (as a minimum) the time of clearing. This has been confirmed by Sandpiper ecologists based on previous experience. Clearing activities may require the removal of trees due to safety concerns or other construction requirements thus glide poles and proximate trees locations/distances can't feasibly be detailed at this stage of the project. RMS and project ecologists will work with the construction contractors to retain as many suitable trees as possible around identified crossing structures. Where practical glide poles and retained trees will have a maximum glide distance of no more than 50m.
EPA - 11/02/15	Page 39 – Table 6.3	The performance threshold is stated as Low (<5). This may be considered low in the context of the entire project, i.e. W2B sections 1-11, however in a single section of project with a low density of gliders this would be a poor outcome. Please clarify whether the measure (<5) is to be used for each project section or does it refer to a clearing front or the entire project? The EPA recommends a lower mortality rate depending on the geographic area. The section on Monitoring/timing frequency is referring to the retention period of habitat trees (that may house gliders). Please clarify if the suggested timing range (24 – 48 hours) represents the retention period and if so please maintain a 48 hour retention period.	Wording has been updated to now state that any mortality of a threatened glider is reported to the EPA within 24 hours. Baseline studies have recorded a relatively small number of gliders therefore after further consideration an acceptable mortality rate cannot be reliably determined. Any mortality should be considered significant and evaluated. Table 6.3 has been updated. Amend the retention of habitat trees for a minimum of 48 hours.
EPA - 11/02/15	Page 48 – 8.2.3	Given the recent positive results from the use of a Song Meter by Dr Goldingay at Nambucca Heads State Forest, has the RMS considered utilising this technology in combination with spotlighting to establish glider population density?	This has not been considered as a mandatory survey option however additional wording has now been included to state Song Meters can be incorporated into future surveys as an additional survey method.
EPA - 11/02/15	Page 49 – 8.3.3	In this section and in a number of places throughout this document the monitoring period is suggested to continue until effectiveness is established or for a maximum period of 5 years. This is inconsistent with MCoA (D8)(k) which states that monitoring shall continue until effectiveness is established over three monitoring periods, or until such time as agreed by EPA. Please amend the plan to reflect the MCoA.	Monitoring section 8.3.3 has been updated to state "monitoring shall continue until effectiveness is established over three monitoring periods, or until such time as agreed by EPA" and a reference to the condition MCoA (D8) (k) has been added.
EPA - 11/02/15	Page 50 – Table 8.3	If monitoring reveals a glider road kill hot spot, rather than mitigating this by clearing roadside vegetation the EPA would prefer to see the installation of additional crossing poles or rope bridges. This could be justified readily if arboreal crossing structures in the vicinity have proven to be ineffective. If after a period of say 3 - 5 years, any non-utilised structures could be considered for shifting to these road kill	Crossing structures serve as 'insurance' in the case of stochastic events such as fire or disease which may occur at long time intervals. Further the cost of decommissioning and relocating a rope bridge or glide pole array is likely to be comparable to the cost of installing a new structure. Accordingly, RMS does not

Agency Comments			
Date	Section	Recommendation	How recommendation has been addressed (Version 2)
		hot spots.	intend to remove/relocate structures. However, should road kill data indicate a road-kill hot spot for gliders where there are limited crossing structures RMS will investigate the feasibility of installing an additional crossing structure as per Table 7.3 and Table 8.3.
EPA - 11/02/15	Yellow-bellied Gliders	Whilst this plan proposes all probable mitigation measures to facilitate YBG connectivity across the highway barrier, it remains unknown whether this species will utilise these structures, including the widened medians. The EPA is therefore seeking an adaptive approach to possible contingency measures as monitoring and population results become available over time. It is difficult to predict how this will manifest, however the EPA is seeking a commitment to review the effectiveness of mitigation and impacts to YBG populations 3 years after highway operation.	Updated to reflect EPA comments. Wording has been updated in Section 8 (third paragraph) to state a review of the effectiveness of connectivity structures for YBG and other monitoring results will occur after 3 years of monitoring post highway operation. During monitoring an adaptive approach will be taken by RMS and corrective actions will be implemented where appropriate to improve the effectiveness of mitigation measures. With the intent of this review to take an adaptive approach and vary mitigation measures if these measures aren't proven to be effective and there is a residual impact to connectivity for yellow-bellied glider then this impact shall be offset. This is in accordance with MCoA D2.
DP&E - 13/02/2015	Glossary	Three separate definitions are listed for the conditions of project approval being CoA, MCoA, and NSW CoA. Provide just one consistent abbreviation and ensure consistent cross-referencing throughout the Plan. As there are no Commonwealth conditions of approval, the abbreviation 'NSW CoA' should be deleted.	The plan has been updated to reference MCoA consistently through the document.
DP&E - 13/02/2015	Glossary	Provide the full title and reference for the definition of 'EIS', including author, date etc. Should the definition of EIS be limited to the Biodiversity Assessment Working Paper only or the whole Environmental Impact Statement?	This has been updated with the name and date of the EIS.
DP&E - 13/02/2015	Glossary	Remove RTA abbreviation as this is out of date if this refers to the NSW RMS.	This has not been removed. This abbreviation is used to reference a historic plan the RTA developed – Biodiversity Guidelines. (http://www.rms.nsw.gov.au/documents/about/environment/biodiversity_guidelines.pdf)
DP&E - 13/02/2015	Section 1.1	The figure that precedes the contents page should be instead inserted into Section 1.1 for clear reference. Add a Figure number and title. The current cross-referencing "The location of the project is shown in the figure above" is confusing because it is not directly above. This figure will be referred to many times through the Plan.	Updated. It is now Figure 1.1.

Agency Comments			
Date	Section	Recommendation	How recommendation has been addressed (Version 2)
DP&E - 13/02/2015	Section 1.1 Page 3	"Key features of the upgrade include" should instead say "Key features of the project include". It is important to be clear about the upgrade meaning the whole Pacific Highway Upgrade and this project being W2B, because this Plan relates only to the project.	Updated.
DP&E - 13/02/2015	Section 1.1	Provide date and full title of the W2B Staging Plan. This should say W2B Staging Report and not that it hasn't yet been approved under CoA A7.	Updated.
DP&E - 13/02/2015	Section 1.3 Page 8	Add to this explanation that the TGMP has been prepared in accordance with the requirements of MCoA D8.	Updated.
DP&E - 13/02/2015	Section 1.3.2 Page 10	Who is the administering authority in the last paragraph? Please provide the name of this authority to avoid confusion.	Updated to reflect administering authority being EPA and DPE.
DP&E - 13/02/2015	Figure 1.2	Can dates be added to this Figure? The current project status blue line should be moved to Agency Review dated Feb 2015.	No dates will be added to this component. The blue line has been removed. The figure will be about the steps and process to be followed. If dates were added they are likely to become out of date due to a number of variables in project implementation.
DP&E - 13/02/2015	Section 1.5 Page 15	Insert date of consultation when each agency was provided with a copy of the Draft TGMP. Table 1.3 is to be completed.	Updated. Table 1.3 has now been completed to summarise key agency comments and responses. All agency comments and responses are detailed in Appendix A.
DP&E - 13/02/2015	Section 2.1	Photos of the Squirrel Glider and Yellow-bellied Glider species would be helpful here. Insert a figure of the project route showing the locations of glider populations to reflect the information provided on page 17.	No other plans within the suite of threatened species management plans incorporate photos of animals/plants. Photos require copyright approval from the originator of the photo. To keep consistent no photos have been included. Figure 2.1 has been created illustrating glider records in proximity to the project.
DP&E - 13/02/2015	Section 2.1 Pages 16 & 17	Confirm the information that states 'Squirrel Gliders have been recorded throughout the project corridor in sections 1-10', and specific locations have been identified where intersected by the project, as explained in the three bullet points at the top of page 17. This is confusing. What is the source of this information? Same question for the Yellow-bellied Glider.	This has been outlined in greater detail with regards to known glider records (e.g. Sandpiper records and NSW Atlas records). Figure 2.1 has been created illustrating glider records in proximity to the project. As above.

Agency Comments			
Date	Section	Recommendation	How recommendation has been addressed (Version 2)
DP&E - 13/02/2015	Section 3.1 and Figure 6.1	Figure 6.1 does not show the survey results for the two glider species which are described in Section 3.1. Consistency with the proposed measures should be shown. Otherwise add a separate figure showing the survey results in Section 3 for all surveys conducted to date.	Figure has been created highlighting the survey results (Figure 2.1). Figure 3.1 illustrates survey locations.
DP&E - 13/02/2015	Section 3.1	Provide the chainages of the December 2014 survey results to illustrate changes from the 2013 survey and to determine if the proposed measures shown in Figure 6.1 are appropriate.	Updated Figure 3.1 to show surveys undertaken – no glider surveys were undertaken in 2013 between sections 3-11 by Sandpiper for the project.
DP&E - 13/02/2015	Section 3.2	The 2013 survey results for Section 3-11 are not reported here. Again it would be useful to show the 2013 and December 2014 survey results for Section 3-11 for the two species on Figure 6.1.	No surveys were conducted in 2013 by Sandpiper for sections 3-11 for the project. Figure updated with survey results for all surveys.
DP&E - 13/02/2015	Table 4.1	Can approximate dates be added to this table for each task?	Updated
DP&E - 13/02/2015	Section 5	Add a figure or map to show the location of the ancillary facility sites being discussed.	RMS has made a committed to locating these facilities outside of potential habitat areas where practicable. Their final location will not be determined until the time of clearing. (Table 4.1, Section 5.2.3 and Table 5.1)
DP&E - 13/02/2015	Section 5.3.1	Did the 2013 and/or December 2014 survey include the ancillary facility sites and if so, what did the results show in terms of glider species at the ancillary facility sites? It isn't clear from the information provided in Section 3.	These areas will be determined closer to construction and will be sited outside of glider habitat (Table 4.1, Section 5.2.3 and Table 5.1).
DP&E - 13/02/2015	Section 6.2	Nest box management measures should include a reference to the separate Nest Box Management Plan to ensure consistency across the various management plans.	Updated to reflect NBMP correct references.
DP&E - 13/02/2015	Table 6.1	The location of crossing structures must be consistent with the structures proposed in Appendix A – Connectivity Structure Register of the Fauna Connectivity Strategy Woolgoolga to Glenugie (December 2014).	Crossing structures for gliders have been finalised for Sections 1&2 and are detailed in the Fauna Connectivity Strategy and Table 6.1 of the TGMP. Sections 3-11 have not been finalised as yet. Proposed crossing locations have been based on those developed through RMS and Sandpipers targeted surveys and are listed in Table 6.2 in the TGMP. These will be updated after the final targeted and baselines assessments have been completed by Sandpiper. A Fauna Connectivity Strategy will also be finalised at a later date for Sections 3-11.

Agency Comments			
Date	Section	Recommendation	How recommendation has been addressed (Version 2)
DP&E - 13/02/2015	Table 6.2	Confirm that Table 6.2 is consistent with the measures in the other Management Plans (for mammals etc). The Department is unable to provide comments on the proposed structures in Sections 3-11 of the project. No formal request has been made for approval of these structures (see Conditions B11 and D2).	Table 6.2 has been developed through the Sandpiper targeted species report. These glider crossings are not finalised as yet and don't necessary correlate with all mammal crossings as some are specific to gliders (i.e. glider poles). Second comment is noted.
DP&E - 13/02/2015	Section 8	Confirm that monitoring will occur along the whole project corridor where the glider species are known to occur and where management measures are proposed. The second paragraph on page 45 focuses on hot spots.	Updated to highlight monitoring will be conducted along the whole project corridor where glider species are known or have potential to occur.
DP&E - 13/02/2015	Section 8	Monitoring and reporting requirements needs to be determined in consultation with OEH, DPI (Fisheries) and DoE in accordance with MCoA D8(l). Has this consultation been conducted? It doesn't appear to be reflected in the text in Section 8.	Commonwealth department is not relevant to this plan as the gliders are not EPBC Act listed. A proposal for monitoring of crossing structures within sections 3-11 was presented by SES at a meeting with RMS & OEH representatives (23/5/2014) and agreed to in principle. The proposal is detailed in W2B Threatened Glider Targeted surveys Sections 3-11 (SES 2014).
DP&E - 13/02/2015	Appendix A	Have agency comments been sought from all required agencies: OEH, DPI (Fisheries), & DoE? Comments need to be adequately addressed and added to this table. This includes consultation regarding ongoing monitoring requirements.	EPA and DPE have been consulted regarding the TGMP. DoE have not been consulted as these species are not MNES species.

Appendix B – Dr Rodney van der Ree CV

PERSONAL DETAILS

Dr Rodney van der Ree
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EDUCATION

1995 – 2000 Ph.D. School of Ecology and Environment, Deakin University "Ecology of arboreal marsupials in a network of remnant linear habitats".

1994 Bachelor of Science (1st Class Honours), Deakin University. "The distribution and abundance of mammals in 1939 and 1983 regrowth *Eucalyptus regnans* (Mountain Ash) forests in the Central Highlands of Victoria".

1991 – 1993 Bachelor of Applied Science, Deakin University, with majors in Biology, Terrestrial Ecology, Earth Sciences and Environmental Science.

EMPLOYMENT HISTORY

2009-present: Deputy Director and Manager, Ecological Sciences: Australian Research Centre for Urban Ecology (ARCUE)

Employment history at ARCUE:
2001 – 2004 Post-Doctoral Research Fellow
2004 – 2006 Ecologist
2006 – 2008 Senior Ecologist

ARCUE is a research division of the Royal Botanic Gardens Melbourne and is also part of the School of Botany at The University of Melbourne. I am responsible for conducting high quality scientific research on the impacts of human activities on wildlife as well as managing the commercial and collaborative research partnerships and consultancies between ARCUE and our clients. My research projects are diverse, and broadly cover the effects of habitat loss and fragmentation due to the construction of cities and towns as well as other infrastructures, such as roads, and agricultural activities. For example, I am leading a team of scientists and postgraduate students researching the effects of roads and traffic on flora, fauna and ecological processes. This is an 8-year project with initial support from the ARC via the Linkage Projects scheme, with VicRoads and the NSW Roads and Maritime Service as major industry partners. I am also leading a team of scientists, postdocs and postgraduate students on another ARC Linkage Project to understand the impacts of urbanisation on insectivorous bats. In addition, I am responsible for the day to day management of all aspects of numerous small research and consulting projects.

In my role as Deputy Director I am responsible for the recruitment and supervision of staff and students on my projects (i.e. setting tasks, reviewing progress, managing expectations), as well as the management of multiple projects (up to 20) - including setting and monitoring budgets, liaison with clients, report writing - and co-ordinate the often competing demands on equipment, staff time and other resources. I supervise multiple students and postdoctoral fellows, write scientific papers, grant applications and review student theses, papers and reports. An important part of my role is engaging with project partners to financially and logistically support projects.

Throughout the year I frequently undertake higher duties when the ARCUE Director is on leave or travelling. In this capacity, I am fully responsible for all the functions and operations of ARCUE, including approval of expenditure, signing contracts, project management and staff supervision.

2001 – 2004 **Consultant Ecologist**
I have successfully undertaken consultancy projects for a range of clients in Victoria and New South Wales, including the New South Wales National Parks and Wildlife Service, VicRoads, and the Albury-Wodonga Development Corporation. The research included studies of the distribution and abundance of Squirrel Gliders in New South Wales and Victoria and the development of mitigation measures to facilitate the crossing of major roads by fauna. I have contributed to the design of a strategy to conserve biodiversity in the Thurgoona district of Albury, an agricultural area being rapidly developed for housing. As an environmental consultant, I was required to establish my own business, undertake field research and literature reviews, be responsible for budgeting and accounting, report writing and working to deadlines.

1994 – present **Lecturer, Tutor and Demonstrator - Deakin University, The University of Melbourne**
I regularly lecture and in undergraduate ecology classes at Melbourne Uni and have taught classes in Biology, Environmental Management and Conservation Biology at Deakin University.

1999 **Ecologist - Department of Natural Resources and Environment**
Consultancy to investigate the spatial organisation of the endangered Brush-tailed Phascogale within a highly fragmented and cleared agricultural landscape in northern Victoria. The consultancy involved project planning and budgeting, fieldwork (trapping, radiotracking), data analysis and report writing.

Supervision of postdoctoral fellows and students

Current

Dr Fiona Caryl (Post Doc). Australian Research Centre for Urban Ecology and University of Melbourne. Habitat models of insectivorous bats in urban Melbourne.

Dr Pia Lentini (Post Doc). Australian Research Centre for Urban Ecology and University of Melbourne. Population viability of insectivorous bats under different urbanisation scenarios.

Dr Cheryl Krull (Post Doc). University of Auckland, New Zealand. Is the grass greener on the other side? Applying road ecology to invasive species management in New Zealand.

Kylie Soanes (PhD). Australian Research Centre for Urban Ecology and University of Melbourne. Assessing the use and effectiveness of wildlife crossing structures for the endangered Squirrl Glider.

Caroline Wilson (PhD). Australian Research Centre for Urban Ecology and University of Melbourne. The foraging and roosting requirements of insectivorous bats in an urban environment.

Tanja Straka (PhD). Australian Research Centre for Urban Ecology and University of Melbourne. The role of waterbodies and perceptions of the public to urban bats.

Chris Stewart (PhD). Australian Research Centre for Urban Ecology and University of Melbourne. Investigating the effects of roads on wildlife populations using simulation modelling.

Jody Taylor (PhD) Monash University. Landscape connectivity in fragmented habitat: Lizard-eyed views of remnant vegetation in Victoria.

2007 Silvana Cesarini (PhD). Monash University. Quantifying and mitigating the barrier effect of roads on the Squirrel Glider, *Petaurus norfolcensis.*

2007 Natasha Kreitals (1st Class Hons). Australian Research Centre for Urban Ecology and University of Melbourne. Using stable isotopes to identify food sources for Spectacled Flying-foxes.

2006 Micaela Main (1st Class Hons). Australian Research Centre for Urban Ecology and University of Melbourne. Living life on the edge: abundance and diversity of lizards on roadsides.

2006 Nadine Gulle (1st Class Hons). Australian Research Centre for Urban Ecology and University of Melbourne. The effects of roads on the movement patterns of the Common Brushtail Possum.

2006 Shannon Troy (1st Class Hons) Australian Research Centre for Urban Ecology and University of Melbourne. Quantifying source-sink dynamics in Yellow-footed Antechinus.

2006 Sarah McCall (1st Class Hons). Australian Research Centre for Urban Ecology and University of Melbourne. Modelling the survival of Squirrel Gliders adjacent to major roads.

2005 Ashley Herrod (1st Class Hons) Monash University. Quantifying a barrier effect of a major freeway to Yellow-footed Antechinus occurring in roadside habitat in northern Victoria, using genotypic analyses.

2005 Katrina Thompson (1st Class Hons). Australian Research Centre for Urban Ecology and University of Melbourne. Spatial organisation of the Sugar Glider in urban bushland remnants.

2005 Hayley Broecker (1st Class Hons). Australian Research Centre for Urban Ecology and University of Melbourne. Modelling detectability of small mammals during surveys.

2005 Michael Harper (PhD). Australian Research Centre for Urban Ecology and University of Melbourne. 'The distribution and development of tree hollows and the ecology of hollow-dependent fauna along an urbanisation gradient in Melbourne.'

2003 Carolina Cordeiro (H2A Hons). Australian Research Centre for Urban Ecology and University of Melbourne. 'Relationship between activity levels of predators and prey in patches of remnant Red Gum woodland along an urban-rural gradient.'

2001. Michael Harper (1st Class Hons). Australian Research Centre for Urban Ecology and University of Queensland. 'Assessing trees for tree hollows: a comparison of techniques.'

1999. Mark Venosta (3rd Year Research Project) Deakin University. 'Time budget and related aspects of the foraging and habitat use of the Brush-tailed Phascogale *Phascogale tapoatafa* within fragmented habitat near Euroa, Victoria.'

1998. Daniel Gilmore (3rd Year Research Project) Deakin University. 'The influence of isolation of the occurrence of arboreal marsupials in small patches of woodland in an agricultural landscape.'

1998. Greg Holland. (1st Class Hons) Deakin University. 'Time budget and related aspects of the foraging behaviour and habitat use of the Squirrel Glider *Petaurus norfolcensis.'*

1997. Luke Murphy (1st Class Hons) Deakin University). 'Ecology of the Common Brushtail Possum (*Trichosurus vulpecula* KERR, 1792) in roadside corridors in north east Victoria.'

ACADEMIC and PROFESSIONAL ACTIVITIES

I am an active member of the following professional organisations: Australasian Wildlife Management Society, Ecological Society of Australia, International Association for Landscape Ecology, Infra-Eco Network of Europe, International Conference of Ecology and Transportation and the Australian Mammal Society.

I have been invited to sit on a number of expert scientific committees across Australia. In 2004 I was a member of the Grey-headed Flying-fox Reference Group to provide advice to the Victorian Minister for the Environment on issues relating to the management of this nationally threatened species. In 2009-12 I advised the Royal Botanic Gardens Trust (Sydney) on management of the Grey-headed Flying-fox. In 2013 I was invited to be a scientific expert for the web-based company "MyRoadkill.com" who donate proceeds from their sales to wildlife conservation organisations. I have been appointed to expert committees for the International Conference on Ecology and Transportation (USA) and the Infra-Eco Network of Europe conferences in 2010, 2011 and 2012. In 2012 I was appointed to the Leadbeater's Possum Recovery Team. From 2005 – 2007 I was a member of the Environmental Advisory Committee for the City of Knox, advising them on a wide range of environmental issues. In 2001, I was invited to sit on the panel to judge applications for the National Banksia Environmental Awards. I have acted as a judge of student presentations at > 10 national and international conferences within Australia and overseas, including the 2004 meeting of the Society for Conservation Biology in the U.S.A. and the 2002 meeting of the Australian Mammal Society.

I have refereed manuscripts for numerous international scientific journals, including Journal of Applied Ecology, Acta Oecologia, Acta Theriologica, Austral Ecology, Animal Conservation, Ecological Management and Restoration, Journal of Environmental Management, Journal of Zoology, Wildlife Research, Landscape and Urban Planning, Landscape Ecology, Forest Ecology and Management, Biological Conservation, Urban Ecosystems, Australian Mammalogy, as well as manuscripts for various books. I have reviewed grant applications for the National Science Foundation (USA), Natural Sciences and Engineering Council (Canada), Killam Research Fellowship (Canada), and the Foundation for Research, Science and Technology (New Zealand). I have assessed four PhD, two Masters and >10 Honours theses from various universities across Australia and overseas.

I have made it a priority to give lectures and seminars about my research to a variety of audiences, including universities, research institutes, and special interest and community groups (see below for a selection of seminars). I have given Plenary lectures at the Infra-Eco Network of Europe Conference in Potsdam, Germany (October 2012), Society for Conservation Biology meeting in India (August 2012), International Conference on Ecology and Transportation, USA (May 2007). In 1999, I received a professional enhancement award from National Aeronautics and Space Administration (NASA) and Michigan State University to attend the Congress of the International Association of Landscape Ecology in Colorado, USA. In 2000, I received the Bolliger Award for the best spoken paper by a student at the annual conference of the Australian Mammal Society in Alice Springs.

I have organised numerous specialist symposia as part of national and international ecological conferences, as well chaired the organising committees for national conferences. The specialist symposia include:

- "Wildlife Management in Urban Areas", 3rd International Wildlife Management Congress, Christchurch, New Zealand, December 2003.
- "Ecological Effects of Roads, Traffic and Infrastructure Corridors", Ecological Society of Australia Adelaide, December 2004.
- "Effects of roads and traffic on wildlife populations and landscape function", International Association for Landscape Ecology Conference, The Netherlands, July 2007.

PUBLICATIONS (refereed)

Ascensao, F., S. LaPoint, van der Ree R. (in press). Roads and traffic: big problems for small mammals. Ecology of roads: an international practitioners guide. R. van der Ree, D. J. Smith and C. Grilo. London, Wiley.

D'Angelo, G. J. and R. van der Ree (in press). Use of wildlife reflectors and whistles to prevent wildlife-vehicle collisions. Ecology of roads: an international practitioners guide. R. van der Ree, D. J. Smith and C. Grilo. London, Wiley.

Jones, D., H. Bekker, van der Ree R (in press). Road ecology in an urbanising world. Ecology of roads: an international practitioners guide. R. van der Ree, D. J. Smith and C. Grilo. London, Wiley.

Milton, S. J., R. Dean, van der Ree R et al. (in press). The function and management of roadside vegetation. Ecology of roads: an international practitioners guide. R. van der Ree, D. J. Smith and C. Grilo. London, Wiley.

Reck, H. and R. van der Ree (in press). Insects, snails and spiders: the role of invertebrates in road ecology. Ecology of roads: an international practitioners guide. R. van der Ree, D. J. Smith and C. Grilo. London, Wiley.

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In addition, I have published more than 60 reports and popular articles, given in excess of 70 presentations at conferences, workshops, community groups and > 20 media appearances, including TV, radio, and newspaper.

Appendix C – Sandpiper Ecological Threatened Glider Baseline Surveys Sections 1 and 2 (Woolgoolga to Glenugie)

Appendix D – Sandpiper Ecological Threatened Glider Baseline Surveys Sections 3 and 11 (Glenugie to Ballina)

Appendix E – Sandpiper Ecological Threatened Glider Aerial Crossings Targeted Surveys Sections 3 to 11

Appendix F – Squirrel Glider feed trees in NSW to be targeted in revegetation

Source: Husbandry Manual For Squirrel Glider. *Petaurus norfolcensis* (Trudgeon 2006)

Scientific name	Common name	Food utilised	Time of year used	Distribution in Australia
Acacia concurrens	Curracabah	Nectar/pollen Seed arils	Autumn/winter Spring	NSW/QLD
Acacia irrorata	Green wattle	Gum	Autumn/winter	NSW/QLD
Acacia pycnantha	Golden wattle	Nectar/pollen Gun	Winter/spring Autumn/winter	NSW/VIC
Angophora	Smooth barked apple	Nectar/pollen Sap	Summer Autumn/winter	NSW/QLD
Banksia integrifolia	Coast banksia	Nectar	Summer/autumn	NSW/QLD
Banksia serrata	Saw banksia	Nectar	Spring/summer	NSW/VIC
Banksia spinulosa	Hairpin banksia	Nectar	Autumn/winter Spring	NSW/QLD/VIC
Corymbia glommifera	Red bloodwood	Nectar/pollen Sap	Summer Winter	NSW/QLD/VIC
Corymbia maculata	Spotted gum	Nectar/pollen Sap	Winter/spring Autumn/winter	NSW/QLD/VIC
Eucalyptus amplifolia	Cabbage gum	Nectar/pollen Sap	Summer Autumn/winter	NSW/QLD
Eucalyptus camaldulensis	River red gum	Nectar/pollen Sap	Variable Autumn/winter	NSW/QLD/VIC
Eucalyptus melliodora	Yellow box	Nectar/pollen	Summer	NSW
Eucalyptus paniculata	Grey ironbark	Nectar/pollen	Autumn/spring	NSW
Eucalyptus pilarus	Blackbutt	Nectar/pollen Sap	Winter	NSW/QLD
Eucalyptus punctata	Grey gum	Nectar/pollen	Summer/Autumn	NSW
Eucalyptus seeana	Narrow-leaved red gum	Nectar/pollen Sap	Spring/Summer Autumn/winter	NSW/QLD
Eucalyptus siderophloia	Grey ironbark	Nectar/pollen	Spring/Autumn	NSW/QLD
Lophostemon confertus	Brushbox	Nectar/pollen	Spring/Summer	NSW/QLD
Lophostemon suaveolens	Swamp terpentine	Nectar/pollen	Spring/Summer	NSW/QLD
Melaleuca nodosa	Tea tree	Nectar/pollen	Winter/spring Summer	NSW/QLD
Melaleuca alternifolia	Tea tree	Nectar/pollen	Spring/summer	NSW/QLD
Melaleuca stypholoides	Prickly leaved paperback	Nectar/pollen	Summer	NSW/QLD
Nototthixos species	Mistletoe	Fruit	Summer	NSW/QLD/VIC
Xanthorrhoea species	Grass tree	Nectar/pollen	Winter/spring	NSW/QLD/VIC

Appendix G – Yellow-bellied Glider Sap Feed Trees in north-east NSW to be targeted in revegetation

Scientific name	Common name	Region
Angophora subvelutina	Broad-leaved Apple	North-east
Corymbia henryi	Large-leaved Spotted Gum	North-east
Corymbia intermedia	Pink Bloodwood	North-east
Eucalyptus amplifolia	Cabbage Gum	North-east
Eucalyptus bancroftii	Orange Gum, Bancroft's Red Gum	North-east
Eucalyptus deanei	Mountain Blue Gum, Round-leaved Gum	North Coast and adjacent ranges
Eucalyptus dunnii	White Gum	North-east
Eucalyptus eugenioides (includes Eucalyptus nigra)	Thin-leaved Stringybark	North-east
Eucalyptus grandis	Flooded Gum, Rose Gum	North-east
Eucalyptus moluccana	Grey Box	North-east
Eucalyptus pilularis	Blackbutt	North-east
Eucalyptus propinqua	Grey Gum	North-east
Eucalyptus punctata	Grey Gum	Central Coast, South Coast, North Coast and adjacent ranges
Eucalyptus racemosa	Narrow-leaved Scribbly Gum	North Coast
Eucalyptus seeana *Eucalyptus signata*	Narrow-leaved Red Gum Scribbly Gum	North-east North-east
Eucalyptus tereticornis	Forest Red Gum	North Coast and adjacent ranges
Lophostemon confertus	Brush Box	North Coast

Source: Recovery Plan for the Yellow-bellied Glider (*Petaurus australis*) (NSW NPWS 2003)