Roads & Maritime

Threatened Frog Management Plan

Woolgoolga to Ballina Pacific Highway upgrade

April 2015

Contents

Glossary and Abbreviations

Term	Definition
BACI	Before and After Control Sites (BACI) is a form of monitoring methodology being used to assess impacts on the nominated threatened species of frog. The adopted approach focuses on a paired sampling strategy that allows for comparing populations that could be subject to impacts from the project and compares them to other nearby populations that occur in adjacent areas unaffected by the project. This method allows for the assessment of the success of mitigative measures.
BMF	Biodiversity Mitigation Framework
CEMP	Construction Environmental Management Plan
CoA	Conditions of Approval
Construction footprint	The direct area of the design alignment (also referred to as the clearance limits)
Direct impact	An impact that causes direct harm within the project boundary (i.e. clearing of vegetation)
DoE	Commonwealth Department of the Environment (formally 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
EIS	Environmental Impact Statement
EPA	NSW Environment Protection Authority
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EIS	Environmental Impact Statement (Biodiversity Assessment Working Paper)
EWMS	Environmental work method statement
FFMP	Flora and Fauna Management Plan
Hydro-period	The period in which a soil area is waterlogged
Indirect impact	An impact that causes harm outside of the project boundary as a result of a direct impact (i.e. edge effects, erosion, changes in water quality etc.)
LES	Lewis Ecological Surveys
MCoA	Ministers Condition of Approval
NSW	New South Wales
OEH	Office of Environment and Heritage
Offset	An offset may be an area of land that is protected and managed to improve biodiversity values or an action that compensates for adverse impacts to biodiversity. Requirements for offsets are determined using an objective assessment of predicted loss of biodiversity at the development site and expected gain in biodiversity to be achieved at the offset site.
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 the implementation of appropriate corrective action.
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.
Revegetation	The planting of native species post construction to stabilise areas and restore bushland in areas that were required to be cleared as a result of construction, but not required for ongoing highway operations.
Roads and Maritime	NSW Roads and Maritime Services
SAP	Sensitive Area Plans
SPIR	Submissions / Preferred Infrastructure Report
Suitably qualified and experienced persons	A person with a tertiary degree in a related field (e.g. Environmental Science / Ecology) with a minimum five years of experience conducting targeted frog surveys, and for projects of a similar scale and complexity as the W2B project.
Targeted surveys	Field surveys completed post SPIR between 2013-2015 that included targeted surveys for threatened frog species currently listed under the provisions of the EPBC Act and TSC Act.
TFMP	Threatened Frog Management Plan
Threatened frogs	Frog species covered by this plan; Wallum Sedge Frog (*Litoria olongburensis*), Green-

Term	Definition
	thighed Frog (*Litoria brevipalmata*), Giant Barred Frog (*Mixophyes iteratus*)
Threatened species	Any organism listed as vulnerable, endangered or critically endangered under state and/or Commonwealth legislation.
TSC Act	*Threatened Species Conservation Act 1995*
TSS	Total suspended solids
UDLP	Urban Design and Landscape Plan
W2B	Woolgoolga to Ballina Pacific Highway Upgrade
W2G	Woolgoolga to Glenugie Project
WQMP	Water Quality Management Program

1. Introduction

1.1 Project overview

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

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

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

Key features of the upgrade include:

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

Construction and delivery of the project will be undertaken in a number of separate stages. These stages are detailed in the Staging Report prepared to satisfy NSW Government Approval – Minister's Condition of Approval (MCoA) A7.

The 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 (as illustrated in **Figure 1-1** Woolgoolga to Ballina project sections). These are separate projects, with both of these additional projects now complete. Altogether, these three projects will total to an upgrade of 164 kilometres of the Pacific Highway. The project does include a partial upgrade of the existing dual carriageways at Halfway Creek.

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

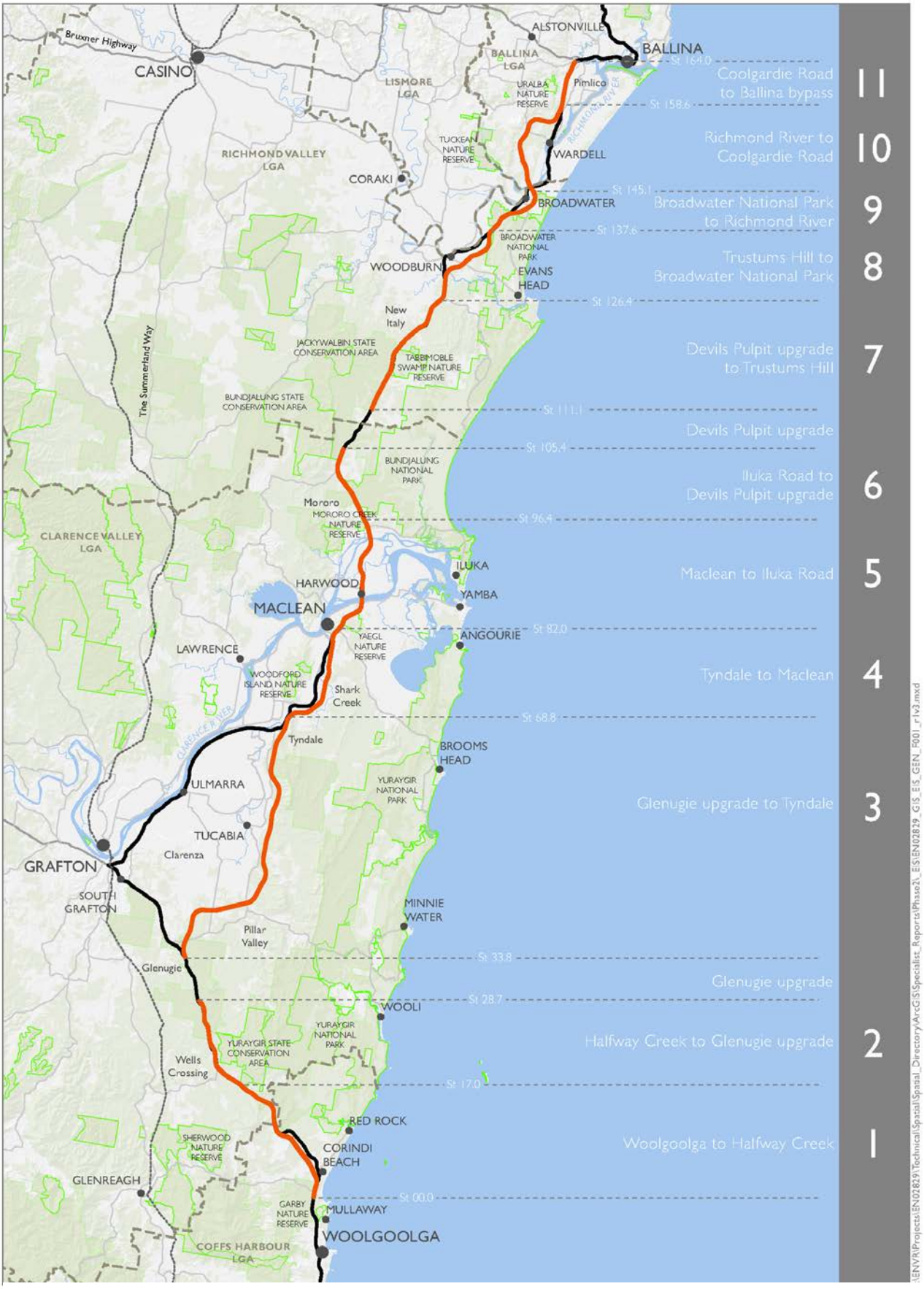

Figure 1-1 Woolgoolga to Ballina project sections

1.2 Purpose of the plan

This Threatened Frog Management Plan (TFMP) has been developed to meet the requirements of the NSW Government Approval – Ministers Condition of Approval D8, and Commonwealth EPBC Act Approval CoA 4 and 14. The requirements of this approval and where it is addressed in this report are detailed in **Table 1-1**.

Table 1-1: Project Approval requirements and where addressed.

Approval requirement		

Approval requirement		Where addressed
	ancillary facilities, rest areas or service roads, or local roads (servicing over 100 vehicles per day) that are realigned as part of the SSI or experience an increase in traffic volumes during operation of the SSI; (g) commitment to implement the landscaping of vegetation leading to connectivity structures; (h) a fencing strategy, describing the location, design and length of fencing, which must extend beyond the edges of habitat for threatened species; (i) the maintenance of connectivity measures and fencing for the life of the impact of the action, including the timing and frequency; (j) an assessment of the flooding risk for proposed structures, and measures to confirm and provide for flood immunity of those structures in light of this assessment. The agreement of the OEH on flood immunity levels shall be obtained prior to the commencement of construction of the relevant stage; (k) commitment that all bridges in identified wildlife corridors, or adjacent to threatened species habitat, or are likely to provide connectivity for threatened species based on surveys undertaken in accordance with the Mitigation Framework required in condition D1, shall provide a minimum three metre wide dry passage from toe of the scour protection to the top of the bank, with natural substrate and refuge features. Where this criteria cannot be achieved and with the agreement of the OEH, consideration shall be given to the use of suitable materials in, and the final form of, the scour protection to provide for the safe and effective passage of fauna; (l) detailed consideration of the effects of connectivity structures on the maintenance or improvement of population viability and gene flow; and (m) incorporate the outcomes of the Mitigation Framework required under condition D1. 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.	(f) Fauna Connectivity Strategy (g) Section 7.3.1 (h) Fauna Connectivity Strategy and Section 2, Section 4.4.3, Section 5.3.9. (i) Section 7.3.2. (j) Not part of this document. (k) Section 2 and Section 5.3.10 (l) Section 4.4 and Section 5.3.10 (m) Mitigation Framework describes surveys that have been completed and changes that have occurred to the Frog Plan since project approval. These changes are found throughout this document including habitat mapping, fencing locations and monitoring program. Additional details associated with these conditions can be found in the final Fauna Connectivity Strategy (GHD, 2014). Public authority comments and responses are summarised in Appendix A.
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	The requirements of this condition in the context of threatened frog species are addressed in this plan in the following sections: (a) Section 2 and Appendix C (Lewis, 2014), Appendix D (Lemckert and Senior, 2014) and Appendix E (Lewis and Smith, 2014). (b) Section 3.2 and 3.4 (c) Section 3.5, 3.7, 4, 5, 6 and 7.

Approval requirement		
	connectivity for the relevant species; (d) an adaptive monitoring program to assess the use of the mitigation measures identified in conditions B10 and D2. The monitoring program shall nominate appropriate and justified monitoring periods, performance parameters and criteria against which effectiveness of the mitigation measures will be measured and include operational road kill and fauna crossing surveys to assess the use of fauna crossings and exclusion fencing implemented as part of the SSI; (e) monitoring methodology for threatened flora and fauna adjacent to the SSI footprint, (f) goals and performance indicators to measure the success of mitigation measures, which shall be specific, measurable, achievable, realistic and timely (SMART), and be compared against baseline data; (g) methodology for the ongoing monitoring of road kill, the species densities, distribution, habitat use and movement patterns, and the use of fauna crossings during construction and operation of the SSI, including the proposed timing, and duration of that monitoring; (h) provision for the assessment of monitoring data to identify changes to habitat usage and whether this can be attributed to the SSI; (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.	(d) Section 4.5 and Section 7. (e) Section 7. (f) Section 4.5, Section 5.4 and Section 7. (g) Monitoring is described in Section 7. Frog road kill monitoring has been removed and justification provided in Appendix A. (h) Section 7.1. (i) Section 4.5, Section 5.4 and Section 7. (j) Section 7.6. (k) Section 7 and 8. (l) Section 7.6. Expert and agency recommendations regarding the TFMP are summarised and details as to how they have been addressed in this plan are provided in Appendix A.
Commonwealth approval		
CoA 4	In order to minimise impacts to the Giant Barred Frog, the approval holder must undertake the action in accordance with the requirements of NSW approval condition B39.	As per NSW approval condition B39.
CoA 14	In order to minimise impacts to threatened species and communities, and migratory species, the approval holder must develop and implement frameworks, strategies and plans or programs in accordance with the requirements of the following NSW approval conditions: c) Threatened Species Management Plans required by NSW approval condition D8 and D9.	This entire document.
SPIR Environmental Management Measure		
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 Frog Management Plan. Expert recommendations, conditions of approval and baseline surveys have been considered and addressed in this plan. Agencies including DP&E, EPA and DoE have been consulted in finalising 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	Details of the pre-construction surveys conducted for threatened frog species are detailed in Appendix C, D and E. Mapping of frog records

Approval requirement		Where addressed
	roosting (eg Southern Myotis) or cave dwelling bats in trees or existing culvert/bridge structures. If the species is present in or directly adjacent to the project footprint (including ancillary facilities), measures to manage any species including buffer and exclusion zones, translocation of nests or establishment of adjacent nesting platforms would be considered, if required. Mapping the location of any threatened flora and/or fauna species, Threatened Ecological Communities and habitat.	and habitats are provided in this plan.
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 frog species are addressed in Section 4.4.3, 4.4.4 and Section 5.3.3, 5.3.9.
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 frog species are addressed in Section 5.3.6.
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 4.4.2.

The TFMP identifies the potential impacts of the upgrade on threatened frog species listed under the EPBC Act and NSW *Threatened Species Conservation Act 1995* (TSC Act) which were considered to be directly impacted or at greatest risk of impact from the project. This version of the plan relates to all sections of the project.

This TFMP identifies proposed mitigation measures that will be applied to populations of threatened frogs and a program for monitoring the effectiveness of these measures to ensure the long-term viability of these species within the area associated with the project. The plan focuses on three species identified in the EIS as at greatest risk from the project (referred to in this plan as 'threatened frogs'), being:

- Wallum Sedge Frog (*Litoria olongburensis*)
- Green-thighed Frog (*Litoria brevipalmata*)
- Giant Barred Frog (*Mixophyes iteratus*).

This plan is intended to provide:

- An effective threatened frog management plan which addresses the concerns of main stakeholders, including expert review
- An overarching management framework for the Wallum Sedge Frog, Green-thighed Frog and Giant Barred Frog for the project
- A summary of the locations where threatened frog populations were detected during pre-construction targeted surveys along with the proposed BACI monitoring sites identified for pre-construction baseline monitoring, construction and post construction monitoring
- Management and mitigation measures to be implemented during pre-construction, construction and operation of the project to minimise impacts on threatened frog populations
- A monitoring program to be implemented during pre-construction, construction and operation of the project to assess the effectiveness of the mitigation measures proposed, evaluate any changes in frog populations and inform an adaptive management approach.

1.3 Management structure and plan updates

1.3.1 Management structure

This plan is intended to provide an overarching threatened frog management framework for all proposed upgrades between Sections 1 to 11 of the Project. This plan provides up-to-date information based on the results of targeted surveys which have identified the occurrence of threatened frogs within the project area, and those that are likely to be impacted, or at a greater risk of impact. This plan identifies known populations of threatened frog species, the likely impacts to frogs as a result of project activities, and specifies mitigation measures that are to be put in place.

This plan also provides for monitoring and reporting programs, by describing the final monitoring sites, methods, variables and timing of this program (detailed in **Section 7)**. Details have also been provided for the parameters of site selection for the final monitoring sites (impact and control/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), Urban Design and Landscape Plan (UDLP) and aspects associated with updates and delivery incorporated into the Biodiversity Mitigation Framework. An overview of how this TFMP relates to other project documentation is provided in

Plate 1-1.

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

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

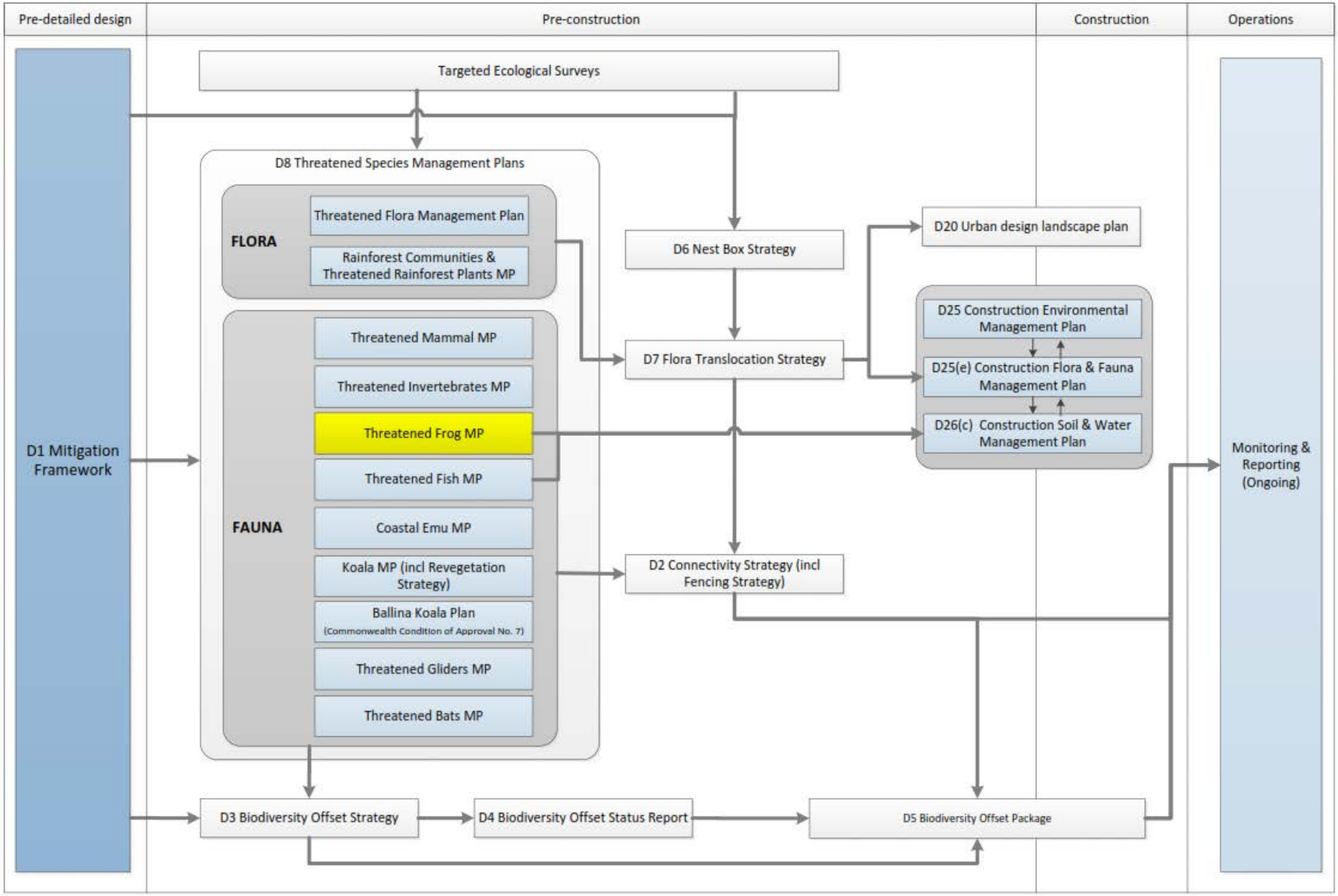

Plate 1-1 Project documentation overview

1.3.2 Plan updates

This plan is intended to be a dynamic document subject to continual improvement. This TFMP has been updated to ensure it incorporates the results of targeted threatened frog 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 TFMP) incorporated the majority of independent expert review and comments. This was completed in November 2013 and was included with the submission of the SPIR documentation. The expert comments are summarised in **Appendix A**.

The second update (Version 2 of the TFMP) has been undertaken to address the approval conditions received, agency comments provided, subject matter expert comments, and to incorporate results of targeted threatened frog surveys completed to date and pre-construction baseline surveys. Connectivity structures for frogs have also been finalised for Sections 1 and 2 which are now reflected in this plan and in the Fauna Connectivity Strategy for these sections (GHD, 2014). A summary as to how the independent expert and agency comments have been addressed is detailed in **Appendix A**.

The administering authorities (EPA, DP&E and DoE) have now reviewed the updated TFMP (Version 2) and approval will be granted prior to construction commencing for Sections 1 and 2 and early works.

A summary of the process for updating the plan is illustrated in **Plate 1-2.**

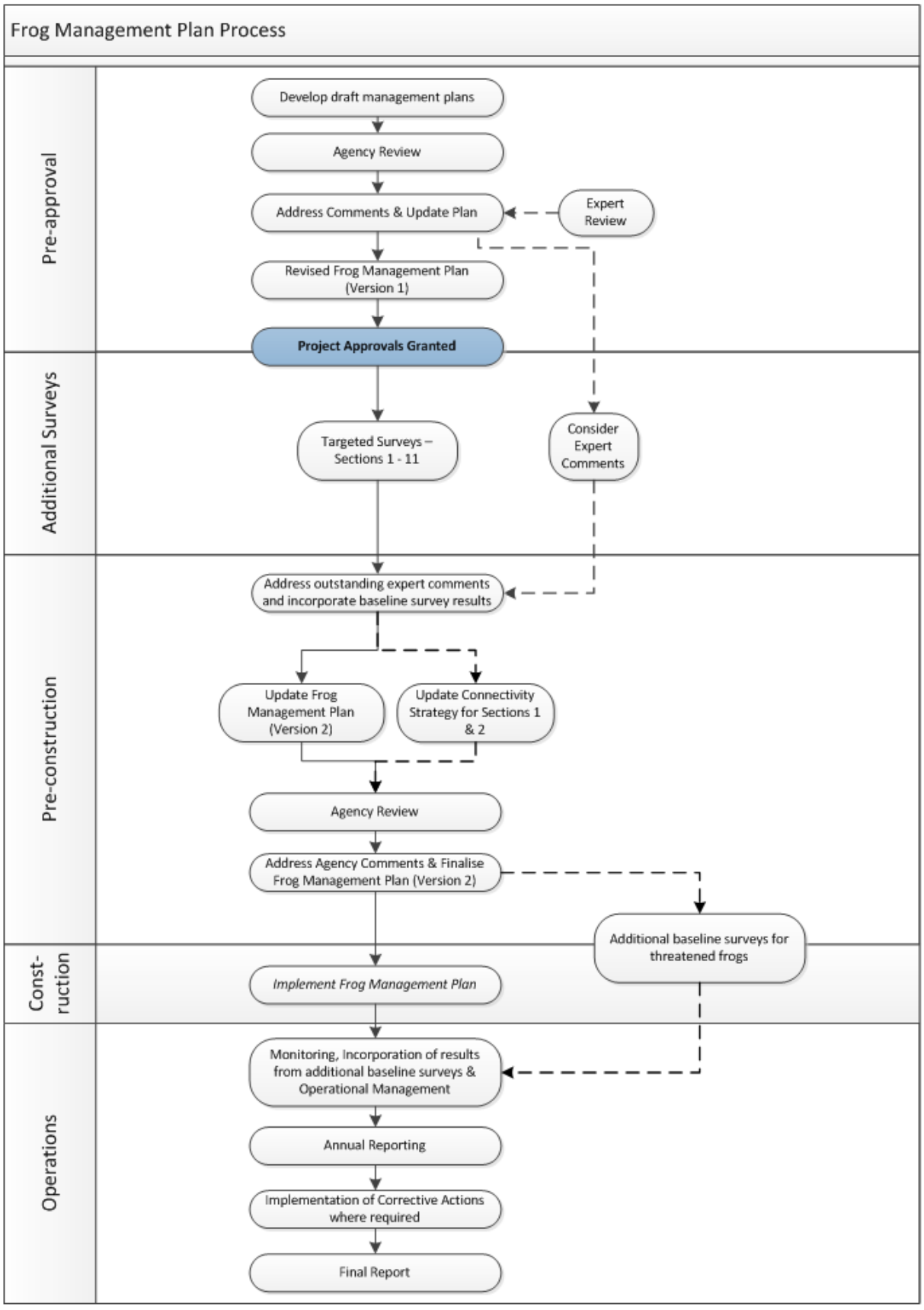

Plate 1-2 Process to update and finalise the management plan

1.4 Plan authors and expert review

1.4.1 Authors

Version 1

The first version of the TFMP was prepared by Chris Thomson and Dr Josh Hale of Jacobs (formerly Sinclair Knight Merz (SKM)) and addressed expert reviewer comments from Dr Frank Lemckert (as outlined in **Appendix A** and **Appendix B**). A summary of personnel involved including their experience and qualifications are summarised in **Table 1-2.**

Version 2

Supplementary targeted frog surveys and pre-construction baseline studies have been undertaken by Lewis Ecological Surveys Pty Ltd for the Wallum Sedge Frog and Giant Barred Frog. Ben Lewis was the ecologist to lead these surveys and his experience and qualifications are summarised in **Table 1-2**. Niche Environment and Heritage undertook surveys for the Green-thighed Frog. Revisions to this TFMP (Version 2) to incorporate the results of targeted surveys and address expert and agency comments have been prepared by Berlinda Ezzy and Richard Floyd of Amec Foster Wheeler with input from Ben Lewis from Lewis Ecological Surveys Pty Ltd as required. This included Ben preparing habitat mapping for the three threatened frog species. Lewis Ecological Surveys Pty Ltd has also been engaged to provide pre-construction baseline monitoring information on the Green-thighed Frog for Sections 3-8 and to update information on the pre-construction baseline data for this species from Sections 1-2. 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 is a group practice leader for ecology with a Bachelor of Applied Science and Graduate Certificate in Natural Resources and seventeen years professional experience managing biodiversity assessments and scientific reporting. He is a highly experienced field ecologist with extensive experience on major road projects with the Roads and Maritime, having worked widely throughout NSW as the technical lead on a range of environmental assessments including several Pacific Highway upgrades, the Hume Highway, Great Western Highway, Princes Highway and New England Highway along with numerous large and small arterial road projects including the M5, M4, Westlink M7 and Westconnex. Chris has comprehensive knowledge of Commonwealth and NSW threatened species legislation, policies and guidelines and has extensive experience in the design of avoidance and mitigation measures for minimising impacts on threatened species. Chris also has a high level of experience on infrastructure projects including the development of compensatory habitat and offset strategies, biodiversity connectivity strategies, mitigation and monitoring strategies and threatened species management plans.
Josh Hale Jacobs		Josh Hale completed a PhD in 2011 on the conservation genetics of a range of south eastern Australian frogs, including the EPBC listed Growling Grass Frog (*Litoria raniformis*). In particular, Josh investigated the impacts of roads and other infrastructure on movement dynamics of frogs. Josh has experience developing and implementing frog monitoring programs in south-eastern Australia. These include a large scale program to assess the impacts of the Black Saturday bushfires on frogs in the Victoria and another investigating the impact of urban development on a range of species around Melbourne. Josh has also completed extensive frog monitoring on Lord Howe Island.
Ben Lewis Lewis Ecological	Bachelor of Applied Science (Honours)	Ben has 20 years professional experience working as a freelance ecologist throughout eastern Australia. He has a comprehensive knowledge of frog populations in north east NSW, particularly in relation to his long term monitoring of the Wallum Sedge Frog (*Litoria olongburenisis*) and investigations into the distribution and habitat requirements of the Giant Barred Frog (*Mixophyes iteratus*) presented in reputable scientific journals. Moreover, Ben has firsthand knowledge of the entire Woolgoolga to Ballina project corridor having performed numerous surveys along and adjacent to it for more than 20 years, canvasing both extreme dry and wet periods. This knowledge has enabled him to

Personnel	Qualifications	Experience
		develop a sound understanding of the enigmatic Green-thighed Frog and its distribution and breeding requirements across the Project. Ben has combined his knowledge on frog fauna with considerable experience working on frog mitigation on other highway programs including but not limited to developing work processes for the removal and recreation of Wallum Sedge Frog habitats for the Tugun Bypass, designed and developed what now appears to be the first effective Green-thighed Frog breeding ponds during the construction of the Kempsey Bypass and been involved in developing several frog fence designs now attributed to reducing road strike or providing effective management of chytrid fungus during construction programs.
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.
Richard Floyd Amec Foster Wheeler	Bachelor of Science Grad Dip Nat Resources and Ecosystem Management	Richard Floyd has more than 17 years' experience undertaking and managing ecology studies throughout Australia. Richard's experience has primarily been with mining and linear infrastructure such as roads, rail and pipelines. He has coordinated aquatic and terrestrial ecology studies for numerous major projects and is familiar with environmental legislation and approvals triggers across several states (Queensland, Western Australia, Victoria and New South Wales) and at the Commonwealth level. Richard has experience designing and undertaking aquatic and terrestrial surveys to assess potential impacts of mining and infrastructure projects. He is familiar with current best practice methodologies and techniques and has experience developing practical mitigation measures for inclusion in Environmental Management Plans.

1.4.2 Expert review

An expert review of the plan was undertaken in August 2013 by Dr Frank Lemckert. Frank has been a professional scientist since 1992, specialising in the ecology and management of frogs and the management of threatened species. Frank has conducted ecological work throughout eastern Australia (NSW, Victoria, Queensland) establishing long-term research and monitoring programs into the management of forest fauna and developing strategies to mitigate the impacts of human disturbances on threatened fauna. He has worked extensively with the NSW state and Federal Governments on varying issues of fauna management and written reports and recovery plans. He is experienced in the application of state and federal legislation which relates to the conservation of threatened species and communities, having been directly involved in the assessment of major Environmental Impact Statements and Fauna Impact Assessment.

Frank also has a long and ongoing interest in education and wildlife training, heading the Forests NSW Wildlife School Training Program, which he continues at Niche. He coordinates all of the courses as well as providing large elements of the teaching program. He continues to have regular involvement in teaching senior biology students at several universities.

Frank has been the author on over 100 scientific publications and reports including invited authorships for chapters in international book series. He has also undertaken more than 50 presentations at National and International conferences.

A curriculum vitae which contains a list of published work on frogs for Dr Frank Lemckert is provided in **Appendix B**. All recommendations have now been assessed and where appropriate incorporated into the TFMP. A summary of the expert recommendations and responses that have incorporated into this version are summarised in **Appendix A**.

1.5 Consultation

Roads and Maritime have consulted with the Commonwealth DoE and the NSW DP&E and EPA during the development of this plan. Each agency was provided a copy of the Draft TFMP on 23 December 2014. The feedback received along with Roads and Maritime responses to the issues raised have been included in **Appendix A** of the TFMP. A summary of the consultation undertaken 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	Summary of Comments	Section of Report Addressing Comments
Commonwealth Department of the Environment			
Version 2	March 2015	Given the new information about specific occurrences of these species, the Department notes that the plan still includes relatively general information about site specific mitigation measures proposed and still defers some of the key mitigation measures to other sub plans (e.g. location of fencing, ponds, and erosion and sedimentation measures to be implemented). The Department considers that if key mitigation measures are to be deferred to sub plans, this plan needs to set the standards that these sub plans must meet and should include key commitments the sub plans must adhere to. This would then provide confidence that mitigation measures will effectively reduce the level of impacts to threatened frogs.	We note key mitigation measures for frogs pertain to: • Frog fencing • Compensatory ponds • Water Quality Management • Connectivity structures Where more detailed information on a mitigation measure is available, and where it will be applied, this has been added to the plan. For example more detailed information has been included in Section 4 and 5 regarding the location of frog exclusion fencing. We have retained references to the other relevant sub plans where this information is more detailed e.g. crossing structures are detailed in the Fauna Connectivity Strategy for Sections 1 and 2. If a sub plan is still to be finalised then a summary of information that is to be included in that sub plan has been added.
		The Department requests that maps identifying the location of potential/known habitat be included as part of this document. This is particularly relevant for the Wallum Sedge frog, where the location and distribution of suitable habitat in the vicinity of the highway for the species is unclear based on the textual descriptions only. Impact area also needs to be clearly stated now that the additional surveys have been undertaken.	Habitat maps have been prepared by Lewis Ecological, with habitat for Wallum Sedge Frog and the Green-thighed Frog classified into two categories; breeding habitat and foraging/dispersal habitat. The basis of this habitat mapping has been previously defined and discussed in Lewis and Goldingay 2005 (i.e. habitat preference). Mapping for the Giant Barred Frog has been prepared by Lewis Ecological. Habitat for this species has not been segregated into breeding habitat and foraging/dispersal habitat on the basis both life cycle aspects take place within the riparian zone of the mapped stream habitats (i.e generally within 50 m of the edge of stream). Direct impacts to frog habitat have now been included in Section 3.4 based on extent of habitats identified in proximity to the construction footprint.
		There seems to be confusion in the plan between performance thresholds and triggers for corrective actions. Performance thresholds are thresholds that are trying to be met and for which deviation from these thresholds would result in corrective actions being implemented (as is written in the headings of tables within the document). On the other hand triggers for corrective actions are negative outcomes which would trigger corrective actions. Currently the majority of the actions/statements under the	Clarification has been made for both headings and the wording regarding performance thresholds and corrective actions to ensure the intent of the performance indicator and corrective action tables is clear and consistent.

Document Version	Review Date	Summary of Comments	Section of Report Addressing Comments
		performance measures heading are actually triggers for corrective actions. Therefore, as currently written, deviation from these measures, which would trigger corrective actions, would in effect result in corrective actions being implemented when the desired outcome is being achieved. The actions under the heading or the terminology used in the heading needs to be amended to address this inconsistency. For example, in table 5.2, a performance threshold is "temporary exclusion fence not installed prior to construction commencing". Should the performance threshold be deviated from (i.e. the fence is installed), the plan recommends that the following corrective action be implemented "Delay construction until temporary fencing has been installed". Either the threshold should reworded to be "temporary exclusion fence installed prior to construction commencing", or modify the headings of the table to trigger for corrective action and corrective action.	
		The Department notes that this plan is proposed to meet some of the requirements of condition D2 (as per the table in the beginning of the document). The Department notes that the justification for the location and design of connectivity measures, based on the results of the further surveys is not provided. Rather, the connectivity measures as originally proposed in the EIS are presented. This is of particular relevance to the Wallum Sedge Frog, which has now been identified on either side of the proposed highway (see comments below). If this plan is to meet the requirements, it must be updated to address this. Sub condition e regarding service roads is not addressed; sub condition h, location of proposed fencing not provided. A discussion and/or commitment to further offsets should connectivity be lost in key locations is required. This is relevant to Dirty Creek for the Giant Barred frog and areas where Wallum Sedge frog is located on either side of the proposed highway.	Connectivity measures are now finalised for Sections 1 and 2, the locations are supported by results of additional baseline surveys. Wallum Sedge Frog does not occur in Sections 1 and 2. Reference to the Fauna Connectivity Strategy is made in the plan for final locations of frog connectivity structures in Section 1 and 2. Fencing locations for frogs in Section 1 and 2 is also provided. Connectivity structures and frog fencing for Sections 3-11 are provided as indicative locations. Exclusion fencing is in Section 4.4.3, 5.3.3 and 5.3.9. Crossing structures are in Section 5.3.10. Proposed fencing locations are based around areas of identified breeding habitats. Final locations of crossing structures and fencing for Sections 3-11 will be confirmed post detailed design and during development of the next Fauna Connectivity Strategy. An additional commitment to provide offsets has been added should it be demonstrated that connectivity is lost after three consecutive monitoring periods. As discussed in Section 5.3.10, the location of service roads will be taken into account during the detailed design phase and will not conflict with connectivity.
		As targeted surveys have now been undertaken, the location of proposed fencing should now be known. The Department requests that this information be included as part of this plan. A stronger commitment to fence design is also required. For example, the document currently describes the design requirements as recommendations, with the use of words such as "should" rather than "must".	Further detail regarding the location and design of temporary and operational frog exclusion fencing has been added to Section 4.4.3, Section 5.3.3 and Section 5.3.9. Temporary and permanent frog exclusion fencing will be focused around areas of breeding habitats and known frog populations. Wording has been updated to say 'will' and 'must'.
		Currently, no measures are proposed to mitigate water quality impacts, including those from erosion and sedimentation as a result of the vegetation clearance to be undertaken within the vicinity of key habitat area (including Corindi River, Dirty Creek and Wallum Sedge Frog occurrences). This plan needs to include these measures, and key commitments, particularly as they relate to key habitat areas.	Further detail has been included in Section 5 of the plan to define targets and mitigation measures regarding water quality and erosion and sediment control.

Document Version	Review Date	Summary of Comments	Section of Report Addressing Comments
		A discussion is also required as to the likelihood of the Wallum Sedge Frog using a land bridge, based on the ecology and known habitat use of the species, including the measures that are proposed to make the habitat on the land bridge suitable (while also addressing the requirements of other species targeted to use this structure). Based on current information, the Department considers that further connectivity measures that are known to be effective for frogs (i.e. a bridge under the highway) are required in these areas. Alternatively, this area must be considered as an area where connectivity for the Wallum Sedge Frog is likely to be lost, and this loss will require an offset. This issue needs to be addressed in the Plan.	A brief discussion about the use of land bridges by the Wallum Sedge Frog has been included in Section 5.3.10. It has also been noted in this section that a proposed underpass will also provide connectivity for the Wallum Sedge Frog across this habitat.
Environmental Protection Agency			
Version 2	March 2015	The EPA does not support the proposal to review sediment basin locations which may have the potential to increase the pH of receiving waters. Alternatively, rather than relocating basins, Stu Murphy (EPA Regional Operations Officer) and James Sakker (Fisheries NSW) have suggested that sensitive water management that complements Oxleyan Pygmy Perch management requirements will likely produce the desired water quality outcomes for the Wallum Sedge frog. Please refer to the floodplain infiltration/perched turkeys nest system successfully employed on the Devils Pulpit Upgrade project. However bear in mind that this approach necessitates an accurate map of known Wallum Sedge Frog habitat.	Sediment control measures, such as those used for the Oxleyan Pygmy Perch in the fish management plan, have been included in Section 5.3.12. This includes the capture and testing of run-off water prior to releasing into areas of habitat for the Wallum Sedge Frog.
		Frog toe clipping is not supported by the EPA. The EPA understands that population persistence on opposite sides of the upgrade may provide a long term answer in cases where the population is dependent on the structure for survival or in a closed system/population.	Due to the difficulties associated with the mark and recapture of smaller frogs (<50 cm), toe clipping is considered the best option to be able to monitor the migration patterns of individuals. As per Section 7.3.1 appropriately qualified and licensed ecologists have been provided approval previously to undertake this methodology. This method has been approved by ethics committees for previous projects and is considered standard practice for smaller frog species.
		The proposed measure in decline of 25% after 5 years appears arbitrary. The EPA suggests a biostatistician is engaged by the RMS to confirm whether this represents the most feasible and meaningful measure of change. It appears that the proposed trigger does not account for population growth and decline patterns prior to the 5th year. Consider the possibility that the population could undergo a growth phase for the prior 4 years then rapidly decline. The EPA believes it is more efficient and meaningful to measure impacted population stability relative to the paired reference sites and determine whether there is a pattern of decline or growth. If there is a general pattern of decline over the monitoring period this could then trigger corrective actions and further monitoring. Bear in mind that data captured and analysed is limited to the relative population size within study area and larger population estimates may be grossly inaccurate. Population sizes can also be highly variable and	The context of this measure of 25% was not made clear previously. Wording has been changed to illustrate that this decline in abundance is to be measured relatively between impact and control sites, not as a standalone decline in the impact population. This measure of decline has been recommended as part of the expert review and adopted by Ben Lewis in undertaking pre-construction baseline surveys to establish the monitoring program for frog populations. More detail on the monitoring program and thresholds is provided in Section 7.

Document Version	Review Date	Summary of Comments	Section of Report Addressing Comments
		respond quickly to climatic conditions (rendering any percentile measure as meaningless when used for comparisons between years). The EPA suggests that a measure of relative density at the study site using the proposed methodology will provide a replicable and quick measure of the overall population dynamic for comparison.	

2. Supplementary targeted frog surveys

The body of data collected for the W2B Project has been gathered over a period of nine years (2005 - 2014). In line with the objectives of the Biodiversity Mitigation Framework (BMF), this TFMP draws on the information from seasonal surveys undertaken during the preparation of the EIS, and refines the avoid/mitigate/offset measures of the EIS through the inclusion of data from targeted surveys for threatened frogs completed between 2013 and 2015. The methods and results of the recent targeted frog surveys have provided more detail on the location of key threatened frog habitat and informed the design of the primary mitigative strategies including exclusion zones and connectivity structures. The details of the recent survey efforts are described within this section. A summary of all relevant data collected to date is provided in **Table 2-1**.

Table 2-1 Summary of relevant ecological surveys undertaken to date

Project section	Survey Period	Purpose
1-2	16 - 21 Oct 2006 18 - 24 Feb 2007	• Mapping of vegetation communities • Surveys for arboreal and terrestrial mammals, reptiles, frogs, microchiropteran bats, nocturnal birds and mammals and birds
	Nov 2011	• Habitat surveys
	5-9 Dec 2011	• Vegetation mapping in areas not covered in previous surveys.
	Dec 2012 Jan – Feb 2013 16 May 2013 Feb – April 2014	• Targeted threatened frog surveys for Wallum Sedge Frog, Wallum Froglet, Green and Golden Bell Frog, Southern Barred Frog and Giant Barred Frog • Giant Barred Frog targeted surveys
	5-7 Feb 2014 12-14 Mar 2014	• Targeted habitat and tadpole surveys for the Green-thighed Frog
	28 Mar 2014	• Targeted aural/visual surveys for the Green-thighed Frog
	Feb-May 2014	• Spotlighting surveys for Green-thighed Frog
	Jan – March 2015	• Site selection surveys for establishment of Green-thighed Frog BACI sites 6-10
3 - 5	July – Aug 2005	• Surveys for arboreal and terrestrial mammals, frogs, microchiropteran bats, nocturnal birds and mammals, birds and reptiles
	2-7 July 2007 6-11 Aug 2007 14-19 Oct 2007	• Mapping of vegetation communities • Surveys for arboreal and terrestrial mammals, microchiropteran bats, birds (including emus), nocturnal birds and mammals, frogs and reptiles
	12-16 Dec 2011	• Targeted surveys for frogs, reptiles and Koalas • Habitat survey (including identification of hollow bearing trees).
	5-7 Feb 2014 12-14 Mar 2014	• Targeted habitat and tadpole surveys for the Green-thighed Frog
	28 Mar 2014	• Targeted aural/visual surveys for the Green-thighed Frog
	Feb - Apr 2014	• Giant Barred Frog targeted surveys and spotlighting survey for Green-thighed Frog
	Jan – March 2015	• Site selection surveys for establishment of Green-thighed Frog BACI sites 6-10
6-8	March 2005	• Habitat survey (including identification of hollow bearing trees).
	May-June 2005	• Mapping of vegetation communities • Surveys for arboreal and terrestrial mammals, microchiropteran bats, nocturnal birds and mammals, birds, frogs and reptiles
	20th and 25th February 2006	• Targeted frog surveys for entirety of Section 6 and 7
	16-20 Jan 2012	• Targeted surveys for arboreal and terrestrial mammals, reptiles and frogs.

Project section	Survey Period	Purpose
	28 Mar 2014	• Targeted aural/visual surveys for the Green-thighed Frog
	Feb - Apr 2014	• Giant Barred Frog targeted surveys
	Feb 2014 18 Mar 2014 11-13 Apr 2014 31 May – 4 Jun 2014	• Targeted survey and habitat assessment for the Wallum Sedge Frog
	Jan – March 2015	• Site selection surveys for establishment of Green-thighed Frog BACI sites 6-10
	14-25 March 2005	• Mapping of vegetation communities
	11-16 March 2006	• Survey for arboreal and terrestrial mammals, microchiropteran bats, nocturnal birds and mammals, birds, frogs, reptiles and invertebrates • Habitat survey (including identification of hollow bearing trees).
	15-18 Aug 2006	• Mapping for vegetation communities.
	Jan 2007	• Surveys for arboreal and terrestrial mammals, microchiropteran bats, nocturnal birds and mammals, birds, frogs and reptiles • Habitat survey (including identification of hollow bearing trees).
	Aug-Sept 2010	• Mapping of vegetation communities
	5-7 Feb 2014 12-14 Mar 2014	• Targeted habitat and tadpole surveys for the Green-thighed Frog
	28 Mar 2014	• Targeted aural/visual surveys for the Green-thighed Frog
	Feb 2014 18 Mar 2014 11-13 Apr 2014 31 May – 4 Jun 2014	• Targeted survey and habitat assessment for the Wallum Sedge Frog
	Feb-April 2014	• Giant Barred Frog targeted surveys

2.1 Wallum Sedge Frog

Lewis Ecological Surveys (LES) was commissioned by Roads and Maritime to undertake pre-construction surveys for the Wallum Sedge Frog to fulfil requirements specified in the Version 1 of the TFMP. The purpose of these pre-construction surveys was to enable preparation works along Sections 6-11 within the W2B program. Data gathered during these surveys was used to present baseline information and inform the design of a Wallum Sedge Frog monitoring program which will be employed throughout the duration of works, and post construction.

LES was also commissioned by the PB-Arup Joint Venture during the development of the road design package for Section 1 and 2. As part of these works, targeted surveys were performed in areas that provided potential habitat for this species.

2.1.1 Survey Methods

The entire route between Sections 6 and 11 was subject to a foot and vehicle traverse in February 2014 to assess areas of potential habitat. This resulted in 31 sites being selected for further survey, comprising 27 impact and four control sites. For the purposes of this study, impact sites were defined as any location within 500 m of the project boundary as most of the impacts associated with this species will be secondary and linked to potential changes in water quality (i.e. increased pH). Consequently, control or reference sites were located at least 500 m away from the project boundary and where possible more than 1 km away.

Field surveys were originally scheduled to occur in January and again in March 2014, however, ongoing dry conditions prevented this from occurring. Following some substantial rainfall in late March (>100 mm) the field sampling schedule was amended to the following:

- Survey 1 - Autumn surveys whilst conditions were still similar to a late summer sampling period with field surveys conducted between 18 March and 13 April 2014; and
- Survey 2 - Late autumn / early winter surveys with the objective to sample at a time when juvenile and sub adult frogs could be expected (i.e. around 10 weeks after major rainfall event in March). These surveys were performed between 31 May and 4 June 2014.

Surveys were performed within 7 days of a notable rainfall event (>10 mm in 24 hrs) using the Bureau of Meteorology (BoM) weather stations at Evans Head (058212). At other times, the BoM website and radar images from Grafton were used to determine more fine scale survey requirements post rainfall. Surveys commenced 30 minutes after dark, with the latest surveys being performed up to 01:30 hrs. A 50 m transect was installed at sites where possible to do so, and where this was not feasible due to the small size of the habitat, a timed 20 minute search was undertaken. All surveys involved the use of active search with a head lamp (Led Lenser H14R rated 850 lumens). Call broadcast was used at only those sites which necessitated its use for assessing presence, not for obtaining baseline frog count data. For example, call broadcast was not used at the control sites as these were already known to contain frogs; the objective at such sites was to minimise disturbance whilst obtaining a count of frogs over a standardised 100 m^2 area of habitat.

For all frogs observed, their age class was determined using the following classification:

- Adults defined as being >16 mm;
- Sub adult <16 mm; and
- Juvenile showing some form of a tail from recent metamorphosis.

2.1.2 Survey Results

Wallum Sedge Frogs were recorded from 11 of the 31 sites surveyed with known occurrences confirmed in Sections 8, 9 and 10 (**Figure 3-1**). Seven of the 11 sites have been assigned as impact sites and four as control sites. Despite the lack of detection at some sites during the surveys, Wallum Sedge Frogs are likely to occur at several other locations where suitable habitat is present. Examples include the northern parts of Section 8 and parts of Section 9 with Wallum Sedge Frogs likely to inhabit these areas during seasons with average to above average rainfall or at least when the groundwater table is recharged. For example, Site 6 (ch. 136000) was surveyed in 2008 and was found to contain Wallum Sedge Frogs with count data of 5 adults per 100 m^2 (Lewis, 2008). This pattern of habitat occupancy was studied by Lewis and Goldingay (2005) at nearby Lennox Head where they found Wallum Sedge Frogs would quickly move from sedge swamps during periods of extended rainfall presumably in an effort to colonise other areas of suitable habitat[1].

Wallum Sedge Frog abundance ranged from 1 adult per 100 m^2 of habitat through to 11 adults per 100 m^2 of habitat with an overall survey mean of 3.1 adult Wallum Sedge Frogs per 100 m^2 (SD= 3.5). The highest numbers of Wallum Sedge Frogs were recorded from a control site in Broadwater National Park with 11 adults and at an impact site adjacent to ch. 148300 with 10 adults. The remaining sites recording fewer than 5 Wallum Sedge Frogs per 100 m^2. No other age classes were recorded and this has been attributed to the ongoing dry seasonal conditions and the overall lack of recruitment over the past 12 months.

[1] This area is subsequently being surveyed in April 2015 and will become the 5thBACI Site, as shown in **Figure 3-1**.

All Wallum Sedge Frogs were observed on sedges growing in free standing water and were not heard calling, nor were any recorded from areas of dry heath. This was attributed to the dry seasonal conditions when most adult frogs are expected to remain in these refuge habitats. Lewis and Goldingay (2005) found sedge frogs frequently occurred in areas of sedge swamp habitat (46%) in preference to dry heath (9%) and to a lesser extent wet heath (22%). They concluded that sedge swamp habitat accounted for 84% of all frog records in comparison to dry heath with 5%. Surveys during wet weather found frogs shifted their pattern of habitat use to include drier habitats. For example, their two surveys in Tyagarah Nature Reserve showed a shift in habitat use with a higher number of frogs detected in dry heath on the wet survey night.

Given the prevailing dry conditions, Wallum Sedge Frogs are unlikely to be attempting to colonise new areas of habitat nor inhabiting those areas which periodically dry out. Unlike other frogs, Wallum Sedge Frogs have been observed to retreat into areas of sedge swamp, wet heath or paperbark forest habitat, or seek refuge in areas that will reduce moisture loss. For example, individuals can be found by removing exfoliating bark from *Melaleuca* spp. growing in swamps but this alone is unlikely to prove a reliable survey technique. In this way, any records of Wallum Sedge Frog during these conditions could qualify as important refuge or source habitat and will be treated accordingly.

Based on survey findings, habitat suitability for the Wallum Sedge Frog within the W2B sections is summarised as follows:

- **Section 6**: No suitable habitat identified.
- **Section 7**: Ch. 122300 identified as low likelihood of supporting sedge frogs. No Wallum Sedge Frogs were recorded during both surveys and this data combined with previous surveys of this site in February 2006 (Lewis 2006) suggest they do not occur at this location.
- **Section 8**: Wallum Sedge Frogs identified around 500 m east of ch.135800 in Broadwater National Park and considered an important source population for areas closer to the Project. Known habitat confirmed in areas adjacent to ch.135800-136400 and ch.136500-136800 but too dry at the time of Survey 1. However, Wallum Sedge Frogs were detected at Site 2 (Broadwater West) during Survey 2 and surveys performed during more suitable conditions are likely to yield frogs closer to the project boundary[2].
- **Section 9**: Wallum Sedge Frogs recorded within project boundary at ch.139500 west and likely to use areas to the east. Wallum Sedge Frogs are considered likely to use habitat on either side of ch.139900 during more favourable seasons and were recorded within 100 m of ch.142500 on Broadwater Beach Road with suitable habitat identified close to the eastern project boundary.
- **Section 10**: Wallum Sedge Frogs recorded approximately 450 m west of ch.146750 and considered an important record. Wallum Sedge Frogs also recorded using a number of disturbed ponds on Ballina Shire Council land to the east of ch. 148250-148650.
- **Section 11**: Some marginal habitat identified to the south of Coolgardie at ch.157400. Wallum Sedge Frogs are considered unlikely to occur in this section.

The locations of records for the Wallum Sedge Frog found during targeted surveys are illustrated in **Figure 3-1**.

Four Before-After-Control-Impact (BACI) paired sites were identified, the location data and baseline population counts at these sites are outlined in **Table 2-2**. A fifth BACI site has been recently identified and this site along with the other four BACI sites are currently subject to wet season pre construction baseline monitoring surveys scheduled for completion in mid-April 2015.

[2] Confirmed during the 2015 surveys and now the BACI Site 5

Table 2-2 Baseline pre-construction monitoring counts for the four paired BACI sites. Coordinates in GDA94.

Pairing	Site No	Site name	Impact/ Control	W2B Section	Easting	Northing	Chainage Location	Western/ Easting Side of Carriageway	Frog count	
									Survey	Adults
1	12	Broadwater National Park 139500 West	Impact	9	539561	6788469	140000–139000	Western	1	2
									2	1
	2	Broadwater West	Control	8	538261	6783101	133000–132000	Eastern	1	0
									2	1
2	17	Broadwater Beach Road	Impact	9	542794	6788915	143000–142000	Eastern	1	2
									2	1
	10	Broadwater East	Control	9	541562	6786687	138000–137000	Eastern	1	11
									2	11
3	21	Melino 1	Impact	10	542125	6793092	147000–146000	Western	1	2
									2	2
	30	Wardell Road	Control	10	544007	6797989	152000–151000	Eastern	1	0
									2	1
4	25	Ballina Shire Council 2	Impact	10	542557	6794651	149000–148000	Eastern	1	7
									2	10
	27	Ballina Shire Council Control	Control	10	543040	6794707	149000–148000	Eastern	1	4
									2	3

The following six recommendations have been derived from the findings of the pre-construction survey:

- The four BACI sites detailed in **Table 2-2** are to be implemented as part of the TFMP.
- An additional opportunistic survey should be undertaken in early summer 2014/15 to try and establish a fifth BACI site[3] at a suitable location in Section 8-10. This survey has now been commissioned by Roads and Maritime and is expected to occur in mid April 2015.
- A process for monitoring and advising ground water table levels between Sections 8-10 is developed with the RMS and their contractors to ensure any additional field surveys are performed during an optimal survey period.
- An additional opportunistic survey should be undertaken in early summer 2014/15 to obtain baseline data counts for sub adults and juvenile frogs during a season of average to above average rainfall.

[3] This survey is currently being undertaken and is expected to be completed in April 2015. The location of the fifth BACI site is shown in **Figure 2-2**.

- Consideration should be given to temporary construction and operational frog exclusion fencing in W2B Section 9 in the vicinity of Site 12 (~ch. 139500) to reduce impacts associated with road mortality during the operation phase of the project.
- Consideration should be given to temporary construction and operational frog exclusion fencing in W2B Section 10 (ch148300–148750) for the eastern side of the carriageway due to the close proximity of populations in this area.
- The location of water quality / sediment basins used during construction is reviewed to assess potential management actions or conflicts with any Environmental Protection Licence (EPL) issued for the project. The aim of this is to ensure that any water being released off site does not adversely impact on the habitat requirements of Wallum Sedge Frog. Typically, this species occurs in pH waters ranging from 2.8–5.5 and the ongoing release of higher pH waters will result in other pond dwelling species (*Crinia signifera, Limnodynastes peroni, Litoria fallax, Litoria tyleri, Litoria peronii*) colonising Wallum Sedge Frog habitats.

2.2 Giant Barred Frog

LES was commissioned by Roads and Maritime to fulfil pre-construction survey requirements for the Giant Barred Frog as specified in the Version 1 of the TFMP. The purpose of these pre-construction surveys was to enable preparation works along Sections 1-3 and Section 7 of the W2B program whilst gathering data to inform the design of a Giant Barred Frog monitoring program to continue throughout the duration of works and as part of post construction monitoring.

2.2.1 Survey Methods

Desktop surveys were used to update existing records of Giant Barred Frog within 10 km of the Project. This was combined with a review of recent ecological studies and some consultation with local ecologists with expertise on the subject species. The objective of this was to guide the field sampling program and to identify the most suitable sites for monitoring. Field surveys were undertaken over 21 nights summarised as follows:

- Summer sampling over 6 nights in December 2012 and in January and February of 2013 for Sections 1 and 2 (Lewis 2013a,b). Some diurnal surveys focused on tadpole sampling was were performed at a specific location (ch. 8400) on 16 May 2013 (Lewis 2013c); and
- Summer and autumn sampling was undertaken over 15 nights between February 2014 and April 2014.

Frog surveys were performed in the manner outlined in Version 1 of the TFMP (RMS 2013). This involved:

- 500 m transect with 250 m either side of the Project corridor with the start and finish extent recorded using a hand held GPS in GDA94
- At sites where a transect could not be achieved (i.e. dams) a timed 60 minute search was undertaken
- Field surveys comprised spotlighting and call broadcast during the nocturnal transect followed by a timed 30 min search for tadpoles using a dip net during daylight hours
- For each frog, the following information was collected:
    - Distance from the stream edge measured to the nearest 0.1 m
    - Position within the microhabitat (i.e. under litter, above litter, exposed, on rock/log)
    - Sex (male, female, unknown) based on size of frog and inspection of nuptial pads present in male frogs
    - Age class (adult = >60 mm; sub adult = 40-60 mm; juvenile = <40 mm)
    - Snout-vent length (mm)
    - Weight (grams); and
    - Breeding condition:
        - males assessed on the colouration of their nuptial pads (i.e. no colour, light, moderate, dark) in accordance with a classification developed by Lewis Ecological Surveys (Table 2-1)
        - females based on whether they were gravid (i.e. typically adult weighing > 100 grams) or not gravid (egg bearing); and
        - frogs with a snout vent length of <60 mm were classified as immature.

All handling procedures were undertaken in accordance with the *Hygiene Protocols for the Control of Disease in Frogs* (DECW 2008).

2.2.2 Survey Results

Database, literature searches and consultation with peer ecologists revealed the following:

- **Section 1**: Thirteen records with most of these originating from the upper Corindi Creek and the Orara River catchments several kilometres upstream or in adjacent catchments to the Project. There are two records from close to the Project at Arrawarra Creek and Corindi Creek. An additional five records were obtained from monitoring surveys associated with the Sapphire to Woolgoolga Upgrade immediately to the south (Benchmark Environmental Management 2012).
- **Section 2**: Seven records from areas adjacent to Section 2 along with some additional records obtained from the headwaters of the Coldstream River in the Calmania area, a known local population of this species (Russell Jago pers. comm).
- **Section 3**: A single historic record from the Bookram Creek Catchment and Candole State Forest areas which form part of the Wooli River and Sandon River catchments, not catchments associated with the Project.
- **Section 5**: Two records from the Warregah Island area, around 4 km west of the Project. The Project bisects cultivated agricultural land in this area and there is no potential risk of primary (i.e. habitat removal) nor secondary impacts (i.e. changes in water quality or habitat degradation downstream).
- **Section 7**: One record from the Moonem area approximately 3-4 km west of ch. 119000. Several confirmed records are associated with the eastern watershed of the Bungawalbin Catchment (i.e. Jackybulbin Creek) presented in Lewis and Rohweder (2005).

No Giant Barred Frog records were recorded for Sections 4, Section 6 and Sections 8-11. Similarly, no historic records were obtained following literature searches and reviews of numerous frog surveys performed in this area between1995 and 2014.

Giant Barred Frogs were recorded from six locations within and adjacent to the following W2B Sections:

- **Section 1**: Corindi Creek (ch. 4000) where 10 adults were recorded as a pre-construction baseline count with individuals observed on both sides of the proposed construction footprint. At this location, a 90 m bridge is proposed to maintain both hydrological and biodiversity fauna connectivity. A second population was recorded at Dirty Creek (ch. 8500) with surveys recording 2 adults, 3 juveniles and a single tadpole as a pre-construction baseline count. Although all of the suitable habitat has been identified on the downstream side of the proposed construction footprint, a 3x3 m reinforced box culvert and neighbouring 1200 mm round concrete pipe culvert provides opportunities for both hydrological and biodiversity fauna connectivity. Control or reference sites have been paired to both of these locations with the preconstruction baseline monitoring recording the following mean counts:
  - Madmans Creek with a mean count of 4.5 adults, 2 sub adults and 0.5 juveniles as a pre-construction baseline count and paired with Corindi Creek;
  - Pigeon Gully with 1.5 adults as a pre-construction baseline count and used as the paired reference site for Dirty Creek.
- **Section 2:** Halfway Creek (ch. 20800) where 0.5 adults were recorded as a pre-construction baseline count. At this location, a 57 m long bridge is proposed to maintain both hydrological and biodiversity fauna connectivity. A control or reference site was paired to the Wooli River (Yellow Cutting Road) with 21.5 adults, 5.5 sub adults and 2.5 juveniles as the pre-construction baseline count.

The locations of records for Giant Barred Frog are illustrated in **Figure 3-2**.

No Giant Barred Frogs were recorded in the remaining Sections 3-11 and a likelihood of occurrence at each site was provided in the pre-construction targeted survey report. Importantly, only Boneys Creek (ch. 13300) in Section 1 was given a moderate likelihood of supporting Giant Barred Frogs on the eastern side of the existing carriageway. At the remaining sites close to the Project they were considered to have a ‘low’ or ‘very low’ likelihood of supporting a Giant Barred Frog population.

All Giant Barred Frogs recorded during the surveys were observed within 25 m of the water's edge and most occurred within 10 m. Frogs were most often observed sitting above the leaf litter and were expected to have been foraging given that conditions were not conducive for breeding. This hypothesis was supported by the fact that none of the females captured were assessed as being in a gravid state (i.e. egg bearing condition). In contrast, a number of the captured male frogs displayed some reproductive scoring with individuals from Madman's Creek, Corindi Creek and Wooli River (Yellow Cutting Road) assigned as having 'light' coloured nuptials, and 'moderate' coloured nuptials. The two male frogs captured at the downstream site on Dirty Creek both exhibited 'dark' coloured nuptials as had a few of the males captured along Corindi Creek in December 2012. Tadpoles were only captured at the Dirty Creek site following the record flood events some four months earlier in late January 2013. It is expected that tadpoles would occur at all of the known sites but each site has their own difficulties with sampling (i.e. either too deep, or detritus layer and large woody instream debris making dip-netting difficult).

Giant Barred Frogs were recorded from a range of land use types including private land used for beef cattle grazing, forestry land, private natural vegetation and conservation estate. The broad range of vegetation classes present include both disturbed and intact forms of coastal eucalypt forest with a developed rainforest mid stratum at Halfway Creek, Corindi Creek and Wooli River or sub-tropical rainforest patches within wet sclerophyll forests at Pigeon Gully. At Dirty Creek, the lower part of thetransect contained Swamp Forest associations with rainforest elements which have been previously described as lowland sub-tropical rainforest. Giant Barred Frogs were not detected within open forms of eucalypt forest and woodland, or where swamp forest habitat lacked defined drainage channels. The targeted survey concluded that land use and broad vegetation types were not a reliable predictor of occurrence.

The vegetation on top of the primary or main stream bank was continuous at the three control/reference sites of Madman's Creek, Wooli River and Pigeon Gully apart from the small unpaved vehicle tracks which bisect these transects. The overstorey foliage project cover at these sites was estimated at between 75-85% with the higher levels obtained from within the Bangalow Palm forests at Pigeon Gully. The impact sites scored lower overall foliage projection covers due in part to their location being within more disturbed landscapes. In this context, the cover values ranged from 45-70% with most of this more openness attributed to canopy breaks from clearing up to within the riparian canopy zone (i.e. Corindi Creek) or as the result of more unstable stream bank structure and associated tree falls.

Shrub cover was relatively consistent across all six sites ranging from 5-17%; there was no significant variation between the control/reference and the impact sites. In contrast, there was a marked variation in the recorded groundcover between impact and control/reference sites with impact sites containing on average 35-40% vegetative cover compared to 9% at the control/reference sites. Sites without Giant Barred Frogs ranged from 5-95%. The extent of litter cover was calculated at 55% across all sites with frogs, but this varied between impact and control/reference, being 38% and 73% respectively. At sites without frogs, the extent of litter varied with values ranging from close to 0 - 80%, indicating this variable alone is not a reliable predictor. Litter depth was recorded as descriptive bands with all sites containing frogs having at least a moderate depth present (20-100mm). The stream bank profile at sites with frogs was predominantly benched and steep as most channels were incised in the landscape. The exception to this was Dirty Creek which most often had a gradual bank incline and only occasional benching around the heads of pools.

Sites with frogs had an average stream width of between 2-9 m. Stream width was related to stream order, for example lower 4th and 5th order streams tended to have a stream width of 5-9 m whilst higher order drainages tended to be less than 5 m in width. Sites without frogs were highly variable due to the cross section of watercourses that were surveyed and ranged from being dry and <1 m to >30 m on the Coldstream River in Section 3. Water depth at sites with frogs ranged from 0.3 m at Pigeon Gully up to >1.5 m at Corindi Creek, Halfway Creek and the Wooli River. The stream bed characteristics at each site were highly variable with frogs being recorded at sites with a rocky and clay substrate with deep areas of detritus, and sandy soiled sites which appear susceptible to erosion and sedimentation of pools (i.e. Halfway Creek).

Based on the results obtained during the survey the following recommendations were made:

- The monitoring framework for this species should be based on the following paired BACI survey design:
  - Corindi Creek impact site continue to be paired with Madman's Creek. Although Madman's Creek forms an upper part of the Corindi Creek catchment it is difficult to access and consumes a lot of logistical resourcing to accomplish these surveys. A more suitable location would be somewhere around Corindi itself but access to a private holding would need to be negotiated. Overall, it would align with the Corindi Creek site in that it is a semi degraded larger order stream with agricultural landuses.
  - Dirty Creek be paired with Pigeon Gully as both have rainforest components and the creeks are small spring feed systems.
  - Halfway Creek be paired with Wooli River (Yellow Cutting Road). Both sites feature a deeply incised channel prone to erosion and the deep sided banks support Lomandra and act as suitable and likely calling sites for male frogs. Both sites have a Eucalypt overstorey with rainforest plants in the lower and mid stratum.
- To ensure consistent frog population monitoring, the monitoring program will adopt the following procedures:
  - A mark recapture program that uses microchips (PIT tagging) to permanently mark individual frogs.
  - All frogs captured during the pre-clearing surveys would be PIT tagged in order to gauge the success of specific management actions during the construction phase of the project and inform post construction monitoring efforts. For example, the capture of a frog during a pre clearing survey would be PIT tagged and its subsequent recapture during construction or post construction monitoring would demonstrate that relocating individuals has been successful.
  - Chytrid monitoring be undertaken prior to construction followed by at least one post construction Chytrid monitoring event.
  - Any water quality data collected as part of pre-construction and during construction monitoring is made readily available to the persons engaged in delivering the Giant Barred Frog monitoring program.
- All records of this species will be confirmed with supporting photographs and/or visual confirmation to avoid confusion between the Great Barred Frog (*Mixophyes fasciolatus*) and the Giant Barred Frog.
- Temporary frog fencing is installed before any construction works take place within 50 m of sites known to provide habitat for Giant Barred Frog.
- No further targeted pre-construction survey work is required for Giant Barred Frog in Sections 3-11.

2.3 Green-thighed Frog

Niche Environment and Heritage Pty Ltd (Niche) was commissioned by Roads and Maritime to fulfil pre-construction survey requirements for the Green-thighed Frog. The purpose of these pre-construction surveys was to enable preparation works along the length of the W2B project and to gathering data to inform the design of a Green-thighed Frog monitoring program to continue throughout the duration of works and post construction.

More recently, the Roads and Maritime have engaged Lewis Ecological Surveys to select some additional BACI monitoring sites in Sections 3-8 of the Project with the objective of locating an additional five paired sites. This follows sightings of Green-thighed Frog across all 10 of the Rufous Bettong pre construction monitoring sites located in and adjacent to Section 2 and 3 (Lewis 2014; unpublished data) and some historic records for this species from Section 7 (Lewis 2006). In this way, these later surveys from January-April 2015 represent the adaptive approach currently being adopted by the Roads and Maritime.

2.3.1 Survey Methods

Three separate field surveys were conducted as part of baseline data acquisition for the Green-thighed Frog along all sections of the project. The first of these was a habitat survey at known and potential breeding sites conducted between 5 and 7 February 2014.

This resulted in 76 out of 100 sites visited assessed as likely to provide habitat for Green-thighed Frog. The second survey involved a visual and aural survey to look for breeding frogs on the night of 28 March 2014 following predictions from the Bureau of Meteorology for widespread rainfall of between 50 mm and 150 mm of rain along the length of the project. During this survey, 27 sites were visited to locate calling/breeding Green-thighed Frogs. A third survey was conducted at 69 sites between 12 and 14 May 2014 to survey potential breeding sites for the presence of Green-thighed Frog tadpoles or metamorphosing froglets and thus identify new breeding sites for monitoring. This time was also used to assess which sites retained free standing water and so could represent suitable breeding sites based on a sufficient hydroperiod to allow successful tadpole development. Habitat data was also collected at those breeding sites nominated in the ongoing monitoring program through the construction of the project.

2.3.2 Survey Results

The survey recorded a single Green-thighed Frog at one location in Section 5 near the Iluka Road turnoff as illustrated in **Figure 3-3**. Consequently, desktop assessments were relied upon to describe their current extent with:

- Sections 1 & 2; known populations occur in these sections as listed in **Table 3-2** as survey by Lewis Ecological Surveys in January 2013 (Lewis 2013a,b).
- Sections 3-8; nine populations were confirmed in close proximity to the Project during surveys in January and February 2015 with their extent shown in **Figure 3-3**. Habitat associated with these areas has been noted for this species during pre-construction surveys and the habitat will be protected with mitigation options proposed in this TFMP.
- Sections 9-11; the Green-thighed Frog has been assessed as absent from these sections and no further pre construction targeted surveys have been proposed.

3. Threatened frog populations

3.1 Background

3.1.1 Conservation status and preferred habitats

Threatened frog species relevant to and referred in this plan, their status under the NSW TSC Act and the Commonwealth EPBC Act, and brief outline of the habitat requirements is provided in **Table 3-1**. Further detail is provided within the species profiles in **Appendix F**.

Table 3-1 Threatened frogs species conservation status and habitat requirements

Species	Status		Preferred habitats
	EPBC Act	TSC Act	
Wallum Sedge Frog (*Litoria olongburensis*)	Vulnerable	Vulnerable	The Wallum Sedge Frog is an "acid" frog confined to the coastal sandplain wallum swamps. Their life-cycle is adapted to the acidic pH (2.8-5.5) of these wetlands. Frogs are highest in abundance in relatively undisturbed wallum swamps. Breeding habitat is characterised by the presence of emergent sedges, with upright species such as *Baumea* spp., *Restio* spp., *Lepironia articulata* and *Schoenus* spp. preferred by adult frogs for perching. Frogs can be found in breeding habitat throughout the year although there appears to be some localised movements during or shortly after rainfall (Lewis and Goldingay 2005). Breeding occurs mainly in spring, summer and autumn after rain. Eggs are laid singly in water at the base of sedges (OEH 2014).
Giant Barred Frog (*Mixophyes iteratus*)	Endangered	Endangered	The Giant Barred Frogs forage and live amongst deep, damp leaf litter in rainforests, moist eucalypt forest and nearby dry eucalypt forest, at elevations below 1000 m. Whilst it has been observed to prefer a closed forest canopy with a relatively light cover of vegetation at ground level (Aland and Wood 2013), they have been found in cleared or disturbed areas, for example cattle farms with vegetated riparian strips and regenerated logged areas (Ingram and McDonald 1993; Hero and Shoo undated and cited in Hines *et al.* 2004; Lemckert and Brassil 2000; Lewis and Rohweder 2005). Many sites where the Giant Barred Frog is known to occur are the lower reaches of streams which have been affected by major disturbances such as clearing, timber harvesting and urban development in their headwaters (Hines *et al.* 1999). Giant Barred Frogs breed around shallow, flowing rocky streams as well as deeper slower moving rivers from late spring to summer. Females lay eggs onto moist creek banks or rocks above water level, from where tadpoles drop into the water when hatched. Tadpoles grow to a length of 80–100 mm and take up to 14 months before changing into frogs. When not breeding, the frogs remain within 50 m of the stream edge (Streatfield 1999).Other studies have shown they are usually found within 20 m of the stream edge (Lemckert and Brassil 2000).
Green-thighed Frog (*Litoria brevipalmata*)		Vulnerable	Found in a in a variety of habitats including coastal woodlands, dry and wet sclerophyll forests, rainforests, swamp forests and shrubland with a healthy understorey (Anstis 2002; reviewed in Lemckert *et al.* 2006). It has been occasionally recorded in wallum related communities that fringe swamp forests (B. Lewis pers. obs). Breeding takes place following periods of heavy rainfall often in excess of 50-75 mm in 24 hours with individuals congregating around flooded ephemeral depressions (Lemckert *et al.* 2006).

3.1.2 Known and expected occurrence within the project

Details of the known and expected distributions of each of the threatened frog species covered in this TFMP is summarised in **Table 3-2**. The distribution data presented in **Figure 3-1, Figure 3-2** and **Figure 3-3** has been derived from results of targeted frog surveys, pre-construction baseline monitoring and Atlas of NSW Wildlife data collated from the database on the 10th December 2014. Further detail of threatened frog records and habitat within the project is provided in Section 2.

Table 3-2 Known and expected distributions of threatened frog species within the Project area

Species	Identified records and project section	Potential habitat
Wallum Sedge Frog	Recorded during targeted surveys within the Project or adjacent to it in Sections 8, 9 and 10. Potential habitat was originally identified from Section 7 and 11, however, repeated surveys of some discreet locations suggested it is most likely absent.	Section 7 - 11
Giant Barred Frog	Recorded at Corindi River, Dirty Creek (Section 1) and Halfway Creek (Section 2) (Lewis 2013a; Lewis 2014a). Suitable habitat was also identified along the lower reaches of Boneys Creek (Ch. 13300) downstream of the existing Pacific Highway carriageway. In most cases, the remainder of the study area provides limited habitat for the Giant Barred Frog largely because it requires permanent creeks with adequate riparian vegetation often comprising moist sclerophyll or lowland riparian rainforest species (Lemckert and Morse 1999; Lewis and Rohweder 2005)	Section 1 and 2
Green-thighed Frog	One Green-thighed Frog was recorded during the 2014 targeted surveys in Section 5, at the Iluka turnoff on the Pacific Highway (Niche 2014). Known populations also occur in Sections 1 & 2, as per survey by LES in January 2013 (Lewis 2013a,b). Following continual sightings of this species during Rufous Bettong surveys in Section 3 (Lewis 2014; unpublished data) Roads and Maritime have commissioned further targeted surveys for Green-thighed Frog in Sections 3-8. The preliminary findings show nine populations scattered between the start of Section 3 (ch. 35230) north to Section 7 (ch. 118400). Sections 9-11; the Green-thighed Frog has been assessed as absent from these sections and no further preconstruction surveys are required.	Section 1 - 8

Figure 3-1 Wallum Sedge Frog habitat, records and monitoring locations

Richmond River
Richmond River
PACIFIC HIGHWAY
Bridge
142000
141000
Overpass
140000
Section 9
Underpass
139000
Overpass
Underpass
138000
137000
Bridge
136000
135000
Culvert
134000
Section 8
133000
132000
Bridge
L. olongburensis
L. olongburensis
L. olongburensis
Site 2
L. olongburensis
L. olongburensis
L. olongburensis
Site 5
L. olongburensis
Site 5
L. olongburensis
L. olongburensis
Site 1
L. olongburensis
L. olongburensis
L. olongburensis

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Figure 3-1
Wallum Sedge Frog
Litoria olongburensis
Records, Monitoring Sites and Habitat

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Topographic Vector Series 3 © Commonwealth of Australia (Geoscience Australia) 2006

LEGEND

- Chainage (metres)
- Alignment
- Project boundary
- Section excluded from plan
- Combined fauna and drainage structure

Litoria olongburensis

- Control site (BACI Site Label)
- Impact site (BACI Site Label)
- Targeted survey record
- Atlas of NSW Wildlife record
- Breeding Habitat
- Foraging/Dispersal Habitat

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02/12/2014	JH	BL	BE	A	Issued for Review

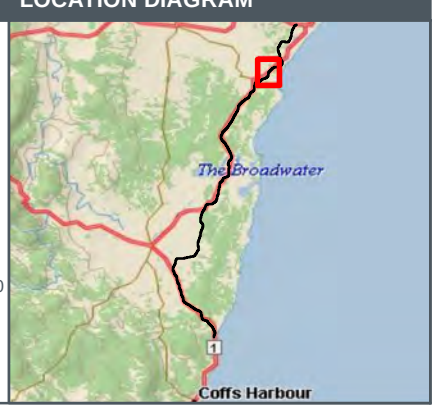
amec foster wheeler

N

0 500 1,000
Metres

(A3) GCS GDA 1994

LOCATION DIAGRAM



Bridge
152000
Section 10
151000
Culvert
Culvert
Culvert
150000
149000
148000
147000
146000
145000
144000
Culvert
Culvert
143000
Section 9
Bridge
142000
Bridge
141000
Overpass
140000
Underpass
139000
Overpass
Site 3
Site 4
Site 4
Site 3
Site 2
L. olongburensis
L. olongburensis
L. olongburensis
Wardell
Richmond River
PACIFIC HIGHWAY
Broadwater
Bridge
Bridge

ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 3-1
Wallum Sedge Frog
Litoria olongburensis
Records, Monitoring Sites and Habitat

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Topographic Vector Series 3 © Commonwealth of Australia (Geoscience Australia) 2006

LEGEND

- Chainage (metres)
- Alignment
- Project boundary
- Section excluded from plan
- Combined fauna and drainage structure

Litoria olongburensis

- Control site (BACI Site Label)
- Impact site (BACI Site Label)
- Targeted survey record
- Atlas of NSW Wildlife record
- Breeding Habitat
- Foraging/Dispersal Habitat

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N

0 500 1,000
Metres

(A3) GCS GDA 1994

LOCATION DIAGRAM

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Figure 3-2 Giant Barred Frog habitat, records and monitoring locations

11000
10000
Site 2
Site 2
9000
Dirty Creek
8000
PACIFIC HIGHWAY
Culvert
7000
Underpass
Section 1
6000
Culvert x2
5000
Bridge
Bridge
Bridge
4000
Site 1
Corindi Creek
Site 1
Corindi River
3000
Culvert
2000
Combined culvert
1000
Arrawarra Creek
0

ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 3-2
Giant Barred Frog *Mixophyes iteratus* Records, Monitoring Sites and Habitat

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Topographic Vector Series 3 © Commonwealth of Australia (Geoscience Australia) 2006

LEGEND

- Chainage (metres)
- Alignment
- Project boundary
- Section excluded from plan
- Combined fauna and drainage structure

Mixophyes iteratus

- Control site
- Impact site (BACI Site Label)
- Targeted survey record
- Dedicated fauna structure
- Habitat Area

ISSUE DATE	AUTHOR	QA CHECK	APPROVED	MAP REV.	REVISION NOTE
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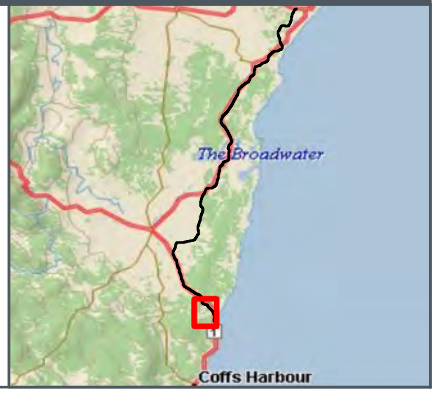
02/12/2014	JH	BL	BE	A	Issued for Review

amec foster wheeler

0 500 1,000
Metres

(A3) GCS GDA 1994

LOCATION DIAGRAM



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M. iteratus

19000

Section 2

18000

17000

16000

15000

14000

Culvert

Boneys Creek

13000

Culvert

Section 1

Culvert

12000

11000

10000

Site 2

Site 2

PACIFIC HIGHWAY

Wooli Wooli River

Wooli Wooli River

ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 3-2
Giant Barred Frog *Mixophyes iteratus* Records, Monitoring Sites and Habitat

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Topographic Vector Series 3 © Commonwealth of Australia (Geoscience Australia) 2006

LEGEND

- Chainage (metres)
- Alignment
- Project boundary
- Section excluded from plan
- Combined fauna and drainage structure

Mixophyes iteratus

- Control site
- Impact site (BACI Site Label)
- Targeted survey record
- Atlas of NSW Wildlife record
- Dedicated fauna structure
- Habitat Area

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N

0 500 1,000
Metres

(A3) GCS GDA 1994

LOCATION DIAGRAM

The Broadwater

Coffs Harbour

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31000
30000
PACIFIC HIGHWAY
29000
28000
27000
26000
25000
Culvert
24000
Section 2
23000
Bridge
22000
21000
Site 3
Halfway Creek
Site 3
Bridge
20000
19000
M. iteratus
The Broadwater
Coffs Harbour

ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 3-2
Giant Barred Frog
Mixophyes iteratus
Records, Monitoring Sites and Habitat

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Topographic Vector Series 3 © Commonwealth of Australia (Geoscience Australia) 2006

LEGEND

- Chainage (metres)
- Alignment
- Project boundary
- Section excluded from plan
- Combined fauna and drainage structure

Mixophyes iteratus

- Impact site (BACI Site Label)
- Targeted survey record
- Atlas of NSW Wildlife record
- Dedicated fauna structure
- Habitat Area

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N

0 500 1,000
Metres

(A3) GCS GDA 1994

LOCATION DIAGRAM

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Figure 3-3 Green-thighed Frog habitat, records and monitoring locations

Culvert
12000
11000
Combined culvert
10000
9000
Dirty Creek Range
8000
PACIFIC HIGHWAY
Culvert
7000
Underpass
6000
Section 1
Redbank Creek
5000
Bridge
Bridge
Bridge
4000
Bridge
Bridge
3000
Culvert
2000
Combined culvert
1000
0

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

ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 3-3
Green-thighed Frog
Litoria brevipalmata
Records, Monitoring Sites and Habitat

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Topographic Vector Series 3 © Commonwealth of Australia (Geoscience Australia) 2006

LEGEND

- Chainage (metres)
- Alignment
- Project boundary
- Section excluded from plan
- Combined fauna and drainage structure
- Dedicated fauna structure

Litoria brevipalmata
- Impact site
- Targeted survey record
- Breeding habitat
- Foraging/Dispersal habitat

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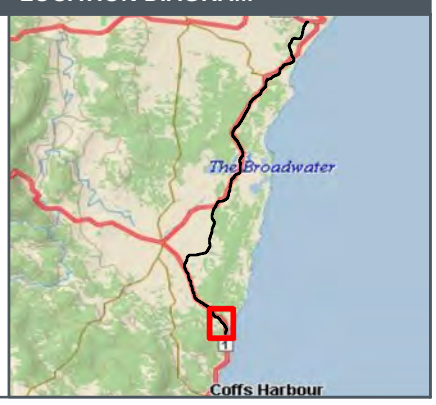
N

0 500 1,000
Metres

(A3) GCS GDA 1994

LOCATION DIAGRAM



20000
Combined culvert
19000
Section 2
18000
L. brevipalmata
17000
16000
15000
Combined culvert
14000
Boneys Creek
Section 1
Combined culvert
13000
Culvert
12000
11000
Combined culvert
10000
PACIFIC HIGHWAY

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Figure 3-3
Green-thighed Frog *Litoria brevipalmata* Records, Monitoring Sites and Habitat

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Topographic Vector Series 3 © Commonwealth of Australia (Geoscience Australia) 2006

LEGEND

- Chainage (metres)
- Alignment
- Project boundary
- Section excluded from plan
- Combined fauna and drainage structure
- Dedicated fauna structure

Litoria brevipalmata

- Control site
- Impact site
- Targeted survey record
- Atlas of NSW Wildlife record

- Breeding habitat
- Foraging/Dispersal habitat

amec foster wheeler

N

0 500 1,000
Metres

(A3) GCS GDA 1994

LOCATION DIAGRAM

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02/12/2014	JH	BL	BE	A	Issued for Review

31000
PACIFIC HIGHWAY
30000
Glenugie Creek Bebo arch
29000
28000
27000
26000
25000
Combined culvert
Culvert
L. brevipalmata
Wells Crossing bridge
24000
Section 2
23000
Bridge
22000
21000
Culvert
Bridge
20000
Combined culvert
19000

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Figure 3-3
Green-thighed Frog *Litoria brevipalmata* Records, Monitoring Sites and Habitat

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Topographic Vector Series 3 © Commonwealth of Australia (Geoscience Australia) 2006

LEGEND

- Chainage (metres)
- Alignment
- Project boundary
- Section excluded from plan
- Combined fauna and drainage structure
- Dedicated fauna structure

Litoria brevipalmata

- Control site
- Impact site
- Targeted survey record
- Atlas of NSW Wildlife record
- Breeding habitat
- Foraging/Dispersal habitat

amec foster wheeler

N

0 500 1,000
Metres

(A3) GCS GDA 1994

LOCATION DIAGRAM

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PACIFIC HIGHWAY

40000
41000
Culvert
39000
38000
Culvert
37000
Section 3
36000
L. brevipalmata
35000
34000
33000
32000
31000

ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 3-3
Green-thighed Frog
Litoria brevipalmata
Records, Monitoring Sites and Habitat

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Topographic Vector Series 3 © Commonwealth of Australia (Geoscience Australia) 2006

LEGEND

- Chainage (metres)
- Alignment
- Project boundary
- Section excluded from plan
- Combined fauna and drainage structure

Litoria brevipalmata

- Control site
- Targeted survey record
- Atlas of NSW Wildlife record
- Breeding habitat
- Foraging/Dispersal habitat

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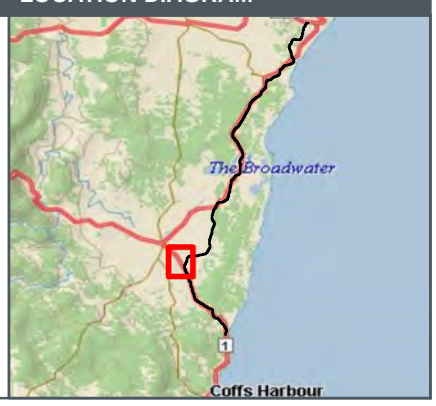
amec foster wheeler

N

0 500 1,000
Metres

(A3) GCS GDA 1994

LOCATION DIAGRAM



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Bridge
50000
49000
Overpass
48000
Bridge
47000
Bridge
Bridge
Bridge
46000
Section 3
45000
Overrpass
Bridge
44000
Bridge
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40000
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Pillar Valley

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ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 3-3
Green-thighed Frog *Litoria brevipalmata* Records, Monitoring Sites and Habitat

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Topographic Vector Series 3 © Commonwealth of Australia (Geoscience Australia) 2006

LEGEND

- Chainage (metres)
- Alignment
- Project boundary
- Section excluded from plan
- Combined fauna and drainage structure

Litoria brevipalmata

- Control site
- Targeted survey record
- Breeding habitat
- Foraging/Dispersal habitat

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Clarence River

PACIFIC HIGHWAY

Section 4

Section 3

70000
Bridge
71000
69000
68000
67000
Drainage
66000
Drainage
65000
Overpass
64000
Overrpass
63000
62000
Underpass
61000
Drainage
60000
59000
Bridge
58000
Bridge
57000

Figure 3-3
Green-thighed Frog *Litoria brevipalmata* Records, Monitoring Sites and Habitat

WORK REQUEST NUMBER: RMS

DATA SOURCES:
Topographic Vector Series 3 © Commonwealth of Australia (Geoscience Australia) 2006

ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

LEGEND

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Metres

(A3) GCS GDA 1994

LOCATION DIAGRAM

The Broadwater

Coffs Harbour

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101000
Culvert
100000
Underpass
99000
Section 6
98000
PACIFIC HIGHWAY
97000
96000
L. brevipalmata
ILUKA ROAD
95000
94000
93000
92000
Section 5
91000
90000
89000
88000
Clarence River

ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 3-3
Green-thighed Frog
Litoria brevipalmata
Records, Monitoring Sites and Habitat

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(A3) GCS GDA 1994

LOCATION DIAGRAM

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Section 7

111000

110000

109000

108000

PACIFIC HIGHWAY

107000

106000

105000

104000

103000

102000

Bridge

101000

Culvert

Section 6

100000

Underpass

99000

98000

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ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

Figure 3-3
Green-thighed Frog
Litoria brevipalmata
Records, Monitoring Sites and Habitat

WORK REQUEST NUMBER: RMS

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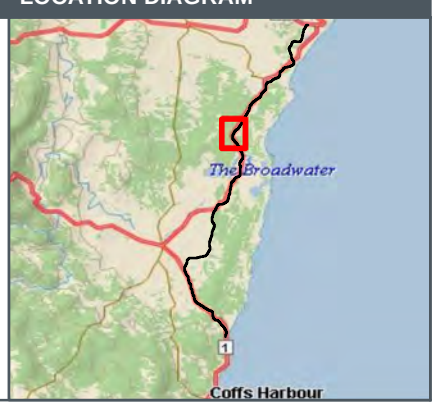

Culvert
122000
121000
120000
119000
Overpass
118000
L. brevipalmata
117000
PACIFIC HIGHWAY
Section 7
116000
L. brevipalmata
115000
Bridge
114000
Bridge
113000
112000
111000
110000
109000

Figure 3-3
Green-thighed Frog
Litoria brevipalmata
Records, Monitoring Sites and Habitat

ROADS & MARITIME SERVICES - 651570 - W2B Species Management Plans

WORK REQUEST NUMBER: RMS

DATA SOURCES:
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3.2 Key threats

3.2.1 Wallum Sedge Frog

Threats to the persistence of the Wallum Sedge Frog include:

- Destruction and degradation of coastal wetlands due to sandmining, coastal developments and road works.
- Reduction of water quality and acidification and de-acidification of coastal wetlands. De-acidification may open habitats to species that compete with Wallum Sedge Frogs.
- Impacts due to grazing and associated frequent burning of coastal wetlands.
- Impacts from pest vertebrate species including Cane Toads (*Rhinella marina*), European Fox (*Vulpes vulpes*), Pigs (*Sus scrofa*) and Mosquito Fish (*Gambusia holbrooki*).

3.2.2 Giant Barred Frog

Threats to the persistence of the Giant Barred Frog include:

- Sedimentation and pollution leading to a reduction in water quality.
- Changes in flow patterns (either decreased or increased flow).
- Burning leading to reduction in leaf litter and fallen logs which provide cover.
- Timber harvesting.
- Vegetation clearance.
- Predation by introduced fish on eggs and tadpoles.
- Chytrid fungus.
- Weed spraying close to streams.
- Impacts from pest vertebrate species (including Cane Toads, Foxes, Pigs, Mosquito Fish).

3.2.3 Green-thighed Frog

Threats to the persistence of the Green-thighed Frog include:

- Reductions in local flooding due to changes to drainage.
- Degradation of semi-permanent and ephemeral ponds and damage to flood-prone vegetation.
- Habitat clearing for agriculture and development.
- Timber harvesting leading to habitat disturbance.
- Grazing and pasture fertilisation leading to a reduction in water quality.
- Grazing and associated burning leading to reduction in leaf litter.
- Impacts from pest vertebrate species (including Cane Toads, Foxes, Pigs, Mosquito Fish).

3.3 Potential impacts and management approach

The following chapter provides a brief overview of the potential impacts to the threatened frog populations with reference to the more detailed impact assessment presented in the Biodiversity Working Paper. It describes the potential impacts to the species at specific locations along the upgrade and during the pre-construction, construction and post-construction (operational) stages of the project. The mitigation approach presented in the EIS and documented in Chapters 4 to 6 of TFMP target the predicted impacts.

3.4 Potential impacts associated with the project

Specific impacts on the Giant Barred Frog and Green-thighed Frog are discussed in Section 4.3.2 (pp 368-369) of the Biodiversity Working Paper (Roads and Maritime 2012). Details of impacts on the Wallum Sedge Frog are reviewed in Table 4-16 (p 375) of the Biodiversity Working Paper (Roads and Maritime 2012).

During the EIS, SPIR process, and supplementary targeted surveys significant survey effort was applied to the project area to determine known habitat of threatened frog species so that potential impacts and associated mitigation measures could be identified.

There are a number of known and potential impacts associated with the project including:

- Direct loss of habitat over small discrete areas through crossing freshwater aquatic habitats (drainage and creek habitats)
- Indirect edge effects on habitat remaining adjacent to the road (primarily changed hydrological patterns in 'greenfield' areas and the encroachment of weeds)
- Detrimental changes to drainage patterns in known or potential habitats
- The reduction of water quality and acidification and de-acidification of coastal wetlands
- The impacts of changes to water pH leading to more neutral waters and competition from non-wallum frog fauna
- Altered water quality associated with polluted water from runoff and overflow of sediment basins in drainage areas
- Sediment runoff during construction into known and potential habitat
- Impacts from increasing the barrier effects of the existing highway including fragmentation of habitats and potential disruption to movement
- Creation of habitat for the Mosquito Fish, a known predator of tadpoles
- Creation of breeding habitat for the Cane Toad (road side depressions) and increased dispersal opportunities within the road corridor, particularly at roadside rest areas
- Transference of chytrid fungus.

The areas of habitat for each threatened frog species to be directly impacted (i.e within the construction footprint) by the project are detailed in **Table 3-3** and **Figure 3-1**, **Figure 3-2** and **Figure 3-3**.

Table 3-3 Threatened frog habitat impact

Species	Breeding habitat (ha)	Foraging / dispersal habitat (ha)	Total (ha)
Giant Barred Frog	4.85 ha*		4.85 ha
Green-thighed Frog	24.6 ha	214.31 ha	238.91 ha
Wallum Sedge Frog	2.35 ha	10.4 ha	12.75 ha

* This species performs all of its life cycle functions within the riparian zone and as such the different life cycle traits was not differentiated.

3.5 Detailed design considerations

Factors to be addressed in the detailed design phase for each section to minimise impacts of the project on frogs are listed below. Detailed design has been completed for Sections 1 and 2 therefore mitigation measures such as connectivity structures are now finalised.

Factors for consideration include:

- Avoiding and minimising vegetation / habitat removal wherever possible
- Consideration of water quality and altered hydrology
- Detention basins to reduce sediment loads and pollutants
- Provisioning of compensatory ponds at location informed by targeted surveys and expert knowledge
- Refinement of connectivity mitigation measures including the design and location of bridges, culverts, overpasses (i.e. land bridges) and frog exclusion fencing commensurate to the target species.

3.6 Mitigation and monitoring approach

A number of measures to mitigate and monitor the impact of the project on threatened frogs during construction and operation of the project were identified in the EIS (Biodiversity Working Paper) and SPIR. In general, these measures related to:

- Provision of exclusion fencing; both temporary, to exclude frogs from construction activities, but also permanent frog fencing, to prevent frogs from accessing the road during the operation of the road and often strategically aligned to fauna underpasses capable of facilitating movement and maintaining habitat connectivity.
- Using of sediment and erosion control measures.
- Water quality controls.
- Provision of crossing structures including bridges and culverts.
- Pest and pathogen management.
- Re-establishment of threatened frog habitat at approaches to crossing structures.
- Compensatory habitat (ponds) where habitat has been removed by construction activities and is considered locally important as recognised by a frog expert.
- Development of a monitoring program to monitor impacts on the populations of threatened frogs and assess the effectiveness of mitigation measures, incorporating adaptive management actions where impacts are recorded.

To minimise the impact of runoff during the operational phase of the Project, runoff would be treated prior to being discharged to drains and then local waterways. Ensuring water quality is maintained during construction would help to prevent any increase in the numbers of the aquatic pest species Mosquito Fish (*Gambusia holbrooki*) which thrive in disturbed aquatic habitats and prey on tadpoles (Webb and Joss 1997). Impacts would be expected to be minimal due to implementation of measures such as ensuring appropriate design of water storage areas and temporary drainage systems, controlling runoff from construction areas, and the implementation of routine water quality monitoring.

3.7 Effectiveness of mitigation measures

A summary of the proposed threatened frog mitigation measures and evaluation of their effectiveness based on past experience with other highway upgrades is described in **Table 3-4**.

3.8 Adaptive management approach

The management plan has been presented using an adaptive management approach based on firstly identifying specific goals for management and 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 against the defined triggers for corrective actions and implement the prescribed corrective actions to improve mitigation where required.

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

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

Table 3-4 Mitigation measures and evaluation of their effectiveness

Issue	Mitigation measure	History of success	Effectiveness rating
Direct loss of habitat over small discrete areas through crossing freshwater aquatic habitats (drainage and creek habitats).	Threatened frog fencing and compensatory pond strategy. Identification and clear marking of habitat exclusions zones via the use of temporary and permanent frog exclusion fencing. Installation and maintenance of fauna connectivity structures. Maintenance of constructed compensatory ponds.	Roads and Maritime has developed and implemented frog fencing and compensatory ponds for a number of road projects. Specifically as part of these strategies monitoring the effectiveness of frog crossings through culverts, bridges and arches for the Bonville, Karuah to Bulahdelah, Bulahdelah to Coolongolook and Yelgun to Chinderah projects has been undertaken. Roads and Maritime has also constructed compensatory ponds for the Tugun Bypass and Kempsey Bypass projects. The long term success of compensatory ponds is uncertain. Initial monitoring of ponds designed and constructed under the supervision of Lewis Ecological Surveys showed Green-thighed Frogs returning to a site to breed within 18 months of their construction (Lewis, 2014c). The creation of earth fill zones was also attributed to a record of a new breeding site immediately adjacent to this upgrade. Road crossing structures have been shown to reduce fauna mortality rates and to reduce the habitat fragmentation impacts of linear infrastructure (Taylor and Goldingay 2010). This is supported by the results of monitoring surveys undertaken for threatened frog species at underpass sites along the Tugan Bypass project. During these surveys, Wallum Sedge Frogs were observed inside and around the entrances of underpasses suggesting movement between the east and the west of the structure (SMEC 2011).	Moderate, monitor effectiveness and implement contingencies where appropriate
Indirect edge effects on habitat remaining adjacent to the road (primarily the encroachment of weeds).	Management of edge effects particularly weed invasions, around known and likely threatened frog habitat. Weed management plan developed and implemented to control weeds.	Roads and Maritime has developed standard weed management procedures that are implemented during construction and are reported as part of the FFMP process. This includes pre-clearing surveys to identify weeds and noxious species and map their location for on-going monitoring and control during construction. Weed monitoring during construction is a routine procedure for road upgrades with a long history of success in NSW. Operational monitoring of weeds is conducted around *in situ* populations of threatened frogs and control undertaken where required. Reporting for on-going weed impacts and controls around important habitats adjacent to the road have varied greatly in their success. The results suggest they are reliant on persistent effort, with on-going follow-up actions until such time as the population is proven to remain viable.	Moderate, monitor against performance and implement weed management actions
Detrimental changes to drainage patterns in known or potential frog habitats	Rainfall monitoring. Assessment of drainage performance, in particular flow rates through identified ponds and water bodies that are known to support frogs.	Typically drainage is dealt with on road upgrades using engineered solutions to slow surface flow and capture and treat run-off from roads. Standard designs have been developed and are affective for the purposes of reducing run-off impacts. However there has been no monitoring of the impacts of road run-off on the Pacific Highway in terms of impacts on frog habitat and populations. The threatened subject species are known to occur in locations adjacent to the existing highway suggesting some tolerance of road run-off impacts however this has not been tested.	Moderate, monitor success and implement corrective actions

Issue	Mitigation measure	History of success	Effectiveness rating
Altered water quality associated with polluted water from runoff and overflow of sediment basins in drainage areas	Water quality managed in accordance with the Blue Book principles. Specifically, pH monitoring would be undertaken as part of the frog population monitoring.	Roads and Maritime has successfully used water quality controls across a number of Pacific Highway projects. Procedures for water quality management on construction sites have been developed in accordance with the Blue Book principles and form part of the CEMP process. However as stated previously there has been no monitoring of the impacts of road run-off on the Pacific Highway in terms of impacts on frog habitat and populations. The threatened subject species are known to occur in locations adjacent to the existing highway suggesting some tolerance of road run-off impacts however this has not been tested.	Moderate, monitor success and implement corrective actions
Sediment runoff during construction into know and potential habitat	Sediment and erosion control managed in accordance with the Blue Book principles.	Roads and Maritime has successfully used erosion and sediment controls across a number of Pacific Highway projects. Procedures for sediment and erosion management on construction sites have been developed in accordance with the Blue Book principles and form part of the CEMP. However as stated previously there has been no monitoring of the impacts of road run-off on the Pacific Highway in terms of impacts on frog habitat and populations. The threatened subject species are known to occur in locations adjacent to the existing highway suggesting some tolerance of road run-off impacts however this has not been tested.	Moderate, monitor success and implement corrective actions
Identification of Chytrid fungus	Any dead frogs found during monitoring surveys will be collected for determination of presence of Chytrid fungus	Roads and Maritime has successfully used frog hygiene protocols across a number of Pacific Highway projects. Department of Environment and Climate Change (Now Office of Environment and Heritage) Hygiene protocol for the control of disease in frogs. Information Circular Number 6 (Appendix C). This includes the use of a disinfecting solution, containing benzalkonium chloride as the active ingredient, being sprayed on footwear and vehicle tyres in areas known to or suspected of containing the Chytrid. Guidance has also been provided in the RTA Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects.	Moderate, monitor for presence of disease and ensure the strict use of control actions during ongoing management operations

4. Pre-construction management measures

4.1 Potential impacts during pre-construction phase

- Location of infrastructure within ancillary facility sites including heavy vehicle access may impact on frog habitat, movements, foraging and behaviour. However, this is probably unlikely due to the Roads and Maritime separation distance requirements for ancillary facilities from watercourses.

4.2 Mitigation goals

- Establish baseline information on habitat condition, location and status of threatened frog populations within the project.
- Protection of threatened frog habitat by accurately identifying important habitats for planning of appropriate exclusion zones.
- Installing temporary frog fencing prior to clearing works.
- Capture and relocation of frogs prior to clearing.

4.3 Targeted baseline surveys

The objectives of the targeted frog surveys were:

- To inform the design and management measures for threatened frogs on each stage of the upgrade including the locations of temporary and permanent frog exclusion fencing and provisions for compensatory breeding habitat.
- To collect baseline population and habitat data to monitor impacts to populations and the effectiveness of mitigation measures as part of an adaptive management approach.

The aim of the targeted surveys was to firstly identify the location of threatened frog populations for each section, and identify and map known and potential habitat for each species. A subset of known locations was selected for ongoing population monitoring whilst some adjacent areas also known to contain the target species were selected as control or reference sites. The details of the monitoring program are provided in Section 7, and the following information summarises the timing, methods and parameters for the targeted surveys which are intended to be repeated as part of the post-construction monitoring program.

It should be noted that no permanent marking of frogs was performed for this stage of the monitoring program as the duration between the pre-construction surveys and any subsequent post construction monitoring is predicted to be beyond the life expectancy of the target species. For example, the Wallum Sedge Frog and Green-thighed Frog are expected to live for between 3-5 years (Lemckert 2003, Meyer *et al.* 2006; DoE 2014) which is either at or slightly beyond the expected time frames between the pre-construction field surveys and any subsequent post construction monitoring. Although Giant Barred Frogs are expected to live to between 5-8 years it is expected that only a reduced number of frogs would be potentially present at the monitoring site once post construction monitoring commences and it was therefore decided that marking frogs at this time would be minimally useful.

4.3.1 Wallum Sedge Frog

Timing of Surveys: Wallum Sedge Frog surveys were intended to occur in early summer 2013 and again in late summer or early autumn 2014. Dry seasonal conditions and the absence of a widespread rainfall event which is required to provide suitable sampling conditions, meant that surveys were postponed until late March 2014. The study area received in excess of 100 mm at this time. In the weeks preceding this rainfall event, the first round of sampling was initiated and subsequent scattered falls around 6-8 weeks thereafter enabled the second sampling event to occur. The adequacy of this sampling period was supported by past long term monitoring of this species in north east NSW which showed that rainfall within seven days of monitoring had a positive influence on frog abundance rather than a seasonal effect of sampling being performed in spring, summer or autumn (Lewis and Goldingay 2005). Winter surveys were often attributed the highest counts along their monitoring transects as individuals climbed higher into the sedges making their detection easier.

Survey Method: A 50 m transect was installed in each area of suitable habitat with the observer walking this transect whilst listening for calling frogs or observing non calling individuals. An abundance measure was obtained by counting frogs within 1 m of this transect to derive a standard unit of measure expressed in the pre-construction monitoring as the number of frogs per 100 m^2 of habitat. The age class of frogs was classified as adults >16 mm, sub adults <16 mm and juveniles as showing some evidence of a tail stub. All transect count surveys commenced at least 30 minutes after dark when sedge frogs have had an adequate amount of time to emerge from their diurnal retreat sites (*see* Lewis and Goldingay 2005). Performing surveys in this way allowed for some direct comparison with long term monitoring of this species performed by Lewis and Goldingay (2005) across the broader region, notwithstanding the fact the surveys were also being performed by the same individual (Ben Lewis). In areas where a 50 m transect could not be established a timed 30 min search was used as an adequate substitute.

Site Selection: Impact sites were located at distances up to 500 m from the construction footprint. Making an allowance to include impact distances of up to 500 m from the construction footprint enabled secondary impacts associated with potential changes in water pH levels and interspecific interactions with competitor species to be evaluated against proposed management actions. Control sites on the other hand were located at least 500 m from the construction footprint and where possible at least 1 km away.

4.3.2 Giant Barred Frog

Timing of Surveys: Giant Barred Frog surveys were performed in spring, summer and autumn between 2012 and 2014. Within this survey period, field sampling focused on performing surveys when the ambient air temperature was above 18^{o}C and there had been a suitable rainfall event exceeding 10 mm in 24 hrs in the previous 7 days. In some instances, sampling was undertaken opportunistically during heavy rainfall events or when ambient air temperatures were below 18^{o}C. Where this occurred, the site was either surveyed again or the species was detected. The term heavy rainfall and localised flooding was defined as rainfall that resulted in the normal flow line rising more than 1 m above the normal flow line of the stream.

Survey Method: A 500 m transect was installed with surveys involving a minimum of 60 minutes per person at each site. Each survey employed an active visual and aural search using call broadcast within 50 m of the stream edge with effort concentrated within 20 m of the stream edge where most frogs are likely to occur. All captured frogs were sexed and assigned to an age class based on the following; adults >60 mm snout-vent length, sub adults 40-60 mm and juveniles <40 mm. Where possible their respective reproductive state was determined either by the colouration of the nuptial pads for male frogs (no colour, light colour, moderate colour, dark colour) or the presence of eggs in females (i.e. gravid).

Site Selection: Impact sites were selected based on the known habitat and micro-habitat requirements of this species, namely damp leaf litter of a suitable depth situated within areas of moist eucalypt or rainforest. These sites are located both in close proximity to the project (within the footprint) and adjacent to the proposed mitigation measures. Control sites were located a minimum of 100 m from the project footprint and preferably 500 m to ensure the site remains unaffected by drainage patterns resulting from the project. All sites were separated by at least 200 m to avoid spatial confounding effects.

4.3.3 Green-thighed Frog

Timing of Surveys: Green-thighed Frog surveys were performed in January 2013 in Sections 1 and 2 of the Project and more comprehensively across the entire corridor between February and May with the main sampling occurring in March 2014. Sampling was triggered by a rainfall event which exceeded 50 mm within a 24 hour period with a preference given to rainfall events which exceeded 75 mm in 24 hours or an accumulated total of 150 mm over a 72 hr period. The magnitude of these rainfall events enabled any potential breeding sites to fill with water. Follow up or post breeding surveys were performed in May 2014 around 50 days after a suitable rainfall event in late March.

Survey Method: Breeding and calling surveys consisted of an initial five minute listening period at each suitable site to identify calling individuals. This was followed by a search of any flooded habitat to visually identify any non-calling individuals present in and around the flooded areas. At each site, the following were recorded: time at start and end of survey for each survey site, conditions during the survey (including temperature, humidity, cloud cover, relative wind intensity and rainfall) and species of frogs calling.

The post breeding surveys were comprised of tadpole surveys using a fine scale mesh net (250 mm diameter) to sweep any of the residual water body. A minimum of 10 sweeps was undertaken per 25 m^2 of water body. Any tadpoles captured were examined to determine if they were hylids representative of Green-thighed Frogs. If so, a sample was taken for further identification. If no tadpoles were seen, water bodies and the bank area within five metres were traversed to visually search for metamorphosed froglets.

Site Selection: Impact sites were selected in close proximity to the project (within the footprint) and adjacent to the proposed mitigation measures. Control sites were located a minimum of 100 m from the project footprint and preferably 500 m to ensure the site remains unaffected by drainage patterns resulting from the project. All sites were separated by at least 200 m to avoid spatial confounding effects.

4.4 Management measures

Details on the site specific mitigation measures for threatened frogs to be implemented during the pre-construction phase are detailed within this section and summarised in **Table 4-1** along with performance thresholds and corrective actions.

4.4.1 Design considerations

The design of the carriageway has taken into account the locations of populations of threatened frog populations. This was demonstrated during the designs of Sections 1 and 2 when targeted threatened frog surveys were commissioned by the PB-ARUP alliance with the findings documented in the following reports:

- Lewis, B.D (2013). *Pacific Highway Upgrade: Arrawarra Interchange to Chainage 16500: Targeted Frog Surveys*. Report prepared for ARUP-PB Joint Venture by Lewis Ecological Surveys.
- Lewis, B.D (2013). *Pacific Highway Upgrade between Halfway Creek and Glenugie: Targeted Frog Surveys*. Report prepared for ARUP-PB Joint Venture by Lewis Ecological Surveys.

During the design phase, a workshop was held to discuss various frog mitigation measures including fencing, breeding ponds and general habitat requirements for riverine frogs around sites where the design of the carriageway necessitated the construction of a bridge. For example, the extent and proximity of earth abutments, the landscaping treatments that may reduce frogs from accessing the carriageway (i.e. dense planting of ground covers such as Lomandra) and the opportunities to integrate frog fencing into boundary fencing designs.

4.4.2 Locating of ancillary facilities outside of known habitat for threatened frogs

The siting of ancillary areas including stockpiles and construction infrastructure (i.e. batch plants, compound sites) will occur within previously cleared areas where possible and at appropriate distances to water bodies and known threatened frog habitats. This would occur across all ancillary sites for each stage of the project and would be documented in the CEMP.

4.4.3 Frog exclusion fencing

The results of targeted field surveys and pre-construction baseline monitoring were used to inform the location of temporary frog fencing. This temporary fencing will be erected prior to construction commencing and will be replaced with operational frog fencing in proximity to known breeding habitat areas once the project is nearing the completion of construction and before it is opens to traffic. The design and extents of frog fencing will differ between each species but the fencing strategy for all aspects of the project will be designed to be adaptive and require a reduced maintenance schedule. The general location of temporary exclusion fencing used during construction will be defined based on the breeding habitat areas mapped in **Figure 3-1**, **Figure 3-2** and **Figure 3-3,** and as described in **Table 5-1**. The locations of operational frog fencing, including general fauna fencing with design considerations for frogs, is detailed in **Table 5-2**. Fencing locations are finalised for Sections 1 and 2 as detailed design has been completed. However for Sections 3 to 11 these are only proposed locations and will be confirmed during detailed design and will form part of the Fauna Connectivity Strategy. Both temporary and operational fencing requirements for the project are discussed in further detail in **Section 5**.

4.4.4 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 will be conducted where appropriate along the entire construction corridor prior to construction commencing. The location of threatened frog species and habitats will be identified in the documentation and exclusion zones clearly marked on the ground prior to construction by the project ecologist.

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

Ancillary infrastructure will also be planned and sited in disturbed areas where possible, minimising the need for any vegetation removal, in particular keeping clear from water sources and known fauna movement areas.

4.4.5 Constructed or augmented breeding ponds

Constructed or augmented breeding ponds would be used as a compensatory mechanism to reduce impacts for the Wallum Sedge Frog and Green-thighed Frog. The locations of these ponds will be carefully selected during pre-clearance surveys to ensure that their placement causes no unnecessary damage to existing habitat (i.e outside the clearance footprint) while ensuring their success as mitigative instruments. Ponds that are known to provide habitat for sedge frogs, but are limited in their extent of emergent sedges growing in freestanding water, may be augmented by the planting of suitable sedge species. An example of this is shown in **Plate 4-1**, a site known to support Wallum Sedge Frogs during the preconstruction baseline monitoring surveys but only within the clumps of *Leperonia articulata* rendering the habitat as patchily distributed within a broader expanse of free standing water.

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Plate 4-1 Disturbed wallum habitat adjacent to Ballina Shire Council Quarry at ch.148600 showing the extent of lowered water levels. This site has been identified as an impact site for future monitoring. (Photograph: Ben Lewis).

Some previous road upgrades have developed pond design criteria including the Tugun Bypass:

- *Tugun Bypass, Stewart Road to Kennedy Drive: Compensatory Habitat, September 2005* (DTMR 2005) for the Wallum Sedge Frog.

This project proposed a number of recommendations based on observations during field and laboratory work on Wallum Sedge Frog including:

- Ponds will generally be shallow and constructed in areas of high groundwater.
- Water quality will exhibit the following characteristics:
  - pH <5 (as influenced by humic acids) (for Wallum Sedge Frog only).
  - Hardness <100 ppm.
  - Salinity <350 µS/cm.
- Ponds will be ephemeral to prevent habitation by fish
- Pond fringes will be densely planted with emergent species to minimise their uptake by Cane Toads (*Rhinella marina;* Semeniuk *et al.* 2007) and therefore reduce predation on native species.

The following four performance criteria were developed as part of the Compensatory Habitat Report (DTMR 2005) to provide a means to determine success of the compensatory ponds based upon monitoring results:

- Ponds are to contain surface water for a period of >10 weeks per annum, for at least two of the three year monitoring periods.
- Waters within ponds are to have a pH <5 (for Wallum Sedge Frog only) and an electrical conductivity (EC) <350 µS/cm.
- Ponds are to contain a margin of emergent macrophytes >200 mm thick and bank vegetation; and
- Ponds are not to contain fish.

As part of detailed design for Section 1 and Section 2, Green-thighed Frog compensatory ponds have been finalised where the project will significantly impact on known breeding habitat. The location of compensatory or augmented ponds for the Green-thighed Frog and Wallum Sedge Frog in Sections 3 – 11 will be finalised during the detailed design of these areas of the project. These will be constructed where breeding habitat will be directly impacted by the project (**Figure 3-1** and **Figure 3-3**) or changed hydrological patterns have the potential to affect the suitability of breeding habitat areas adjacent to the corridor.

The following locations have been identified as sites for Green-thighed Frog ponds for Section 1 and 2:

> **Section 1**: Redbank Creek area between ch. 5500 to ch. 6700 and Dirty Range at a suitable location preferably adjacent to a fill section between ch. 11500 to ch. 12900.
>
> **Section 2**: Halfway Creek (ch. 19000-19500) providing ponds on both sides of the project corridor; Bald Knob Tick Gate Road area (ch. 25000) providing ponds on the eastern side of the project corridor; and Franklins Road (ch. 28000) providing ponds on the eastern side of the project corridor if this area is impacted by means of ground disturbance or changed hydrological regimes.

At each of these locations, the positioning of ponds will ideally be within retained areas of vegetation which support deep leaf litter and occur within low lying areas more likely to support their preferred habitat (i.e. swamp forest, moist forest associations). A critical component in the design of these ponds is to ensure the water body periodically dries out. This provides two important advantages for this species; firstly, it reduces competitive interactions with pond dwelling frogs (i.e. Tyler's Tree Frog, *Litoria tyleri*) which are common in the study area, and secondly, it reduces predatory interactions associated with the exotic Mosquito Fish (*Gambusia holbrooki*). Based on site specific data and surveys of breeding sites on the mid north coast including monitoring of constructed Green-thighed Frog ponds at Kempsey, a temporary water body should hold surface water for between 40-50 days at sunny exposed sites and for between 60-70 days at more shaded locations following a suitable summer rainfall event of 100-150 mm in 24-36 hours.

With the above in mind, the shallow excavated ponds will be similar to those illustrated in **Plate 4-2** and have the following attributes:

- Each pond will cover and area of at least 12 m^2;
- Maximum depth of 400 mm;
- Batters no steeper than 1:4;
- Construct 3-5 with each one staggered out from a drainage line thus ensuring they will be flooded at differing rainfall events; and
- Vegetated via assisted planting techniques with low naturally occurring ground covers obtained from the site (i.e. *Carex* spp., *Fimbristylis* spp.).

Another key message in the design of the breeding ponds is to not over design the pond and replicate features from other known nearby breeding locations and thus provide the best opportunity for a successful breeding event. The design and construction of breeding ponds will be supervised by the Project Ecologist and this will occur within 12 months of the clearing and grubbing operations and thus enable sufficient rehabilitation time before the ponds themselves can be considered operational.

The above approach has been used successfully during the construction of the Kempsey Bypass whereby Green-thighed Frogs returned to a constructed pond within 18 months of its construction (Lewis 2014c).

September 2011 **September 2011** **March 2012**

Plate 4-2 Green-thighed Frog ponds at Fill 6 Kempsey Bypass project (September 2011-March 2012).

Additional information can be found within:

- *Pacific Highway Upgrade: Arrawarra Interchange to Chainage 16500 targeted frog survey, April 2013* for the Green-thighed Frog breeding ponds.
- *Section 1 - Woolgoolga to Half Creek targeted frog survey, Lewis Ecological Surveys, July 2013.*
- *Section 2 - Half Creek to Glenugie targeted frog survey, Lewis Ecological Surveys, July 2013.*

4.5 Mitigation goals and corrective actions

The pre-construction mitigation goals and measures for threatened frogs that are to be completed prior to the commencement of construction are summarised in **Table 4-1.**

Table 4-1 Mitigation goals and corrective actions – Pre-construction

Mitigation goals	Proposed mitigation measure	Monitoring/timing frequency	Trigger for corrective actions	Corrective actions
Establish baselines about the habitat condition, location and status of threatened frog populations within the project.	Targeted surveys and baseline monitoring including habitat condition and population locations and abundance estimates.	Prior to construction as outlined in Section 4.3.	Targeted surveys and baseline monitoring have not been completed during the appropriate season prior to construction in the section for construction.	Delay construction of project sections until targeted surveys and baseline monitoring have been undertaken in the appropriate season.
Protection of threatened frog habitat by accurately identifying exclusion zones, and installing temporary frog fencing and compensatory ponds.	Identify exclusion zones, frog fencing and compensatory pond locations. Install exclusion zones, temporary frog fencing prior to clearing. Install compensatory ponds after clearing complete.	Exclusion zones mapped and frog fencing installed 1 week prior to clearing activities commencing. Frog ponds to be installed within 12 months of clearing.	Exclusion zones have not been mapped and/or frog fencing has not been installed 1 week prior to clearing activities commencing. Frog ponds have not been installed within 12 months of clearing being completed.	Delay construction in relevant area until exclusion zones and frog fencing have been installed. Compensatory ponds to be installed within 3 month of trigger. Non-conformance reported to the Environmental Representative for follow up.

5. Construction management measures

5.1 Potential impacts during construction

- Impacts during clearing of vegetation and clearing adjacent to frog habitat.
- Frogs entering the construction corridor and becoming trapped in the corridor.
- Frogs being killed by construction traffic and activities.
- Disturbance and degradation to adjoining habitat including loss of aquatic plants and reduction in water quality.
- Contamination or changes to water quality of water bodies used by threatened frogs.
- Dewatering of wetlands to construct fill areas.
- Pathogen (chytrid) transported during construction.
- Change in pH of waterbodies due to discharge of water from basins.
- Opening of habitats allowing entry of feral predators and competitors.

5.2 Mitigation goals

- Low rate of injuries to threatened frogs during clearing works.
- No injuries to threatened frogs during construction as a result of vehicle collisions.
- No injuries to frogs that need to be handled.
- No movement of chytrid fungus between sites.
- No injuries or mortality of threatened frogs as a result of dewatering activities.

5.3 Management measures

5.3.1 Work method statements

Environmental work method statements (EWMSs) would be prepared for specific activities that pose particular environmental risks, including risks to threatened frogs. EWMS's would ensure sound environmental practices are implemented to minimise the risk of environmental incidents or system failures, in accordance with the CEMP.

EWMSs covering activities with the potential to impact on threatened frogs would address all relevant management measures and be prepared in consultation with agencies, Roads and Maritime and the relevant project environmental manager prior to the commencement of identified activities.

5.3.2 Induction and training

Induction and training would be conducted with all contractors and other staff that would be working in the areas of known and potential threatened frog habitat. This training would identify threatened frog habitat, and crossing zones and key threats, with all personnel shown pictures of the species. The importance of following the clearing, and rehabilitation protocols would be made clear for any personnel that require access to the site.

5.3.3 Temporary frog exclusion fencing

As noted in **Section 4.3.3**, the location of temporary frog fencing has been informed by the identification of breeding habitat in targeted surveys and pre-construction baseline monitoring surveys (Lewis 2014). These habitat areas for each species are shown in **Figure 3-1**, **Figure 3-2** and **Figure 3-3**. The extent of proposed temporary exclusion fencing to be erected for each species is summarised in **Table 5-1**. The locations of fencing for Sections 1 and 2 have been confirmed (GHD 2014) whereas fencing locations for Sections 3 – 11 will be finalised as a part of the connectivity strategy for these sections. An adaptive management approach will be applied to the implementation of temporary exclusion fencing, therefore the need for additional fencing will be assessed if additional frog species are identified during pre-construction or construction activities as per the unexpected finds procedures.

Table 5-1 Locations of temporary exclusion fencing

Target species	Project section			
Giant Barred Frog	1	3400	3600	200
Green-thighed Frog	1	5200	6000	800
Giant Barred Frog	1	8500	9100	600
Giant Barred Frog	1	13200	13400	200
Giant Barred Frog	1	15800	1600	200
Green-thighed Frog	2	18850	19800	500
Giant Barred Frog	2	19000	19400	400
Giant Barred Frog	2	20500	21000	500
Green-thighed Frog	2	25000	25300	300
Green-thighed Frog	3	34200	35200	1000
Green-thighed Frog	3	36100	38300	2200
Green-thighed Frog	3	64200	65100	900
Green-thighed Frog	5	95200	95800	600
Green-thighed Frog	6	102100	102600	500
Green-thighed Frog	7	111800	112100	300
Green-thighed Frog	7	118100	118600	500
Wallum Sedge Frog	9	139400	139600	200
Wallum Sedge Frog	9	139900	140100	200
Wallum Sedge Frog	10	148300	148750	450

Temporary frog exclusion fencing will have the following design considerations:

- Installed for up to 200 m either side of known threatened frog habitat including streams and breeding sites. Where the terrestrial habitat borders a stream that contains cleared land this could be reduced to 100 m.
- Fence height will extend to at least 900 mm above the ground (or > 500 mm if just for the Green-thighed Frog or the Wallum Sedge Frog) and buried to a depth of between 50 and 100 mm.

- A return of wing of 3 to 5 m to minimise breaches.
- Constructed using UV resistant shade cloth which is permeable to water. Geotextile materials may also form an adequate substitute.
- Posts/pegs placed on the works side of the exclusion fence to prevent frogs using these structures to climb the fence.
- Include relevant signage to identify the area and inform construction personnel.

Temporary frog exclusion fencing will be installed at least 7 days prior to the clearing and grubbing works commencing in the areas of known threatened frog habitat. The objective of this is to prevent frogs from entering the works areas (including roads and lay down areas) and to minimise direct mortality as a result of the construction/disturbance activities. The clearing footprint required to install the temporary frog fence (maximum of 5 m width) would be inspected/searched by an ecologist immediately prior to installing the temporary fencing. This search would use active techniques such as raking the leaf litter and inspections around tussocks and logs. A nocturnal survey may be required the night before and include the use of call broadcast, aural and observation surveys. Once installed, the frog fence will be inspected and signed off by a suitably qualified herpetologist/ecologist. The temporary frog fence will be maintained to ensure it remains effective or until the operational frog fencing is completed.

5.3.4 Constructed and augmented ponds

As noted in **Section 4.3**, the targeted frog surveys and pre-construction baseline monitoring surveys have informed the location and design requirements of constructed and augmented ponds for Sections 1 and 2 and will inform locations for Sections 3 to 11 during detailed design. Examples of design criteria and specific locations are provided in **Section 4.4.5**. Ponds will be constructed during the relevant construction stages of each upgrade and typically these occur around the end of the bulk earthworks treatments in Year 2-3 of the construction program. Compensatory ponds will not be constructed in areas that will impact on existing frog habitats.

5.3.5 Frog hygiene protocol

The chytrid fungus (*Batrachochytrium dendrobatidis*) is a water borne pathogen that has been previously implicated in frog declines and disappearances both in Australia and around the world (Berger *et al*. 1998; Skerratt *et al.* 2007). It can be spread readily between wetlands and catchments with both personnel and equipment acting as inadvertent vectors. Consequently, it is widespread in eastern Australia (Kriger *et al.* 2007) but management controls still form part of combating its spread via the adoption of procedures outlined in the Office of Environment and Heritage *Hygiene protocol for the control of disease in frogs. Information Circular Number 6* which is provided in **Appendix G**. This includes the use of a disinfecting solution, containing benzalkonium chloride as the active ingredient, being sprayed on footwear and vehicle tyres in areas known to or suspected of containing the chytrid. Guidance has also been provided in The *RTA Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* also provide guidance with regard to frog hygiene protocols which include:

- Have water suspected of containing chytrid tested by a NATA accredited laboratory before release.
- Minimising work during excessively wet or muddy conditions.
- Programming of works will always move from uninfected areas to infected areas.
- Set up of exclusions zones with fencing and signage to restrict access into contaminated areas.
- Induction of all personnel (including visitors) on chytrid management measures for the site.
- Providing vehicle washdown facilities.
- Restricting vehicles to designated tracks and trails and parking areas.
- Providing parking and turn around points on hard, well drained surfaces.
- Providing boot wash facilities.
- Disinfecting with cleaning products containing benzalkonium chloride or 70 per cent methylated spirits in 30 per cent water.

- Disinfecting hands or change gloves between handling of individual frogs and between each site.
- Only handling frogs when necessary, using the one bag, one frog approach.
- To avoid cross contamination, avoid transferring water between two or more separate water bodies.

These guidelines also outlined frog handling protocols that would be implemented during construction.

5.3.6 Pre-clearing and clearing surveys

Pre-clearing surveys for threatened frogs will occur where threatened frog habitat has been identified for removal or where the construction/clearing footprint occurs within 50 m of either known or potential habitat. These surveys would occur in the locations of threatened frog habitat illustrated in **Figure 3-1**, **Figure 3-2** and **Figure 3-3** after temporary frog exclusion fencing has been installed to delineate the work site and nocturnal frog surveys have been performed under suitable conditions. Any pre-clearing surveys must employ techniques suitable for each target species, with at least 1 hour of survey per hectare.

All captured threatened frogs will have the following information recorded; species, age class, sex, breeding condition and snout-vent length. For larger species, the use of PIT tags (i.e. micro-chipping) will facilitate in the understanding of the successes of such relocations during any subsequent construction and post construction monitoring.

The relocation process of any captured frogs must be as follows:

- Frogs relocated into habitat immediately adjacent to the clearing footprint which is considered suitable for the captured species;
- Frogs are not to be relocated for distances of more than 100 m.

For example, a Giant Barred Frog captured from the middle of the clearing footprint at Corindi Creek could be relocated on either side of the footprint given both upstream and downstream is known Giant Barred Frog habitat. The clearing footprint in this area is unlikely to exceed 70 m so the likely relocation distance is less than 50 m and arguably still within an individual's home range (see Streatfield 1999; Lemckert and Brassil 2000).

All frogs would be handled in accordance with the *NSW Frog Hygiene Protocols* (DECC 2008 – Information Circular Number 6) noted in **Chapter 5.3.5**. The main points from this protocol include:

- Wear disposable gloves when handling frogs.
- Place only one frog in each plastic bags.
- Do not re-use plastic bags.
- Disinfect any handling equipment and boots when moving between waterbodies.
- Wash hands thoroughly with disinfectant after handing frogs from one waterbody.
- Frogs or tadpoles /spawn will not be moved between catchments.

In addition to the pre-clearing survey, immediately prior (within two hours) to the clearing/disturbance activities adjacent to identified populations, an ecologist will conduct active searches. At least 15 minutes of searching per hectare will be undertaken. Searching would be undertaken under rocks, logs, debris and in low vegetation around drainage lines and in depressions.

An ecologist/herpetologist for each relevant section of the project would supervise clearing activities until such as time that they are confident that no threatened frog species remain within the works area.

5.3.7 Unexpected finds procedure

The Roads and Maritime *Biodiversity Guidelines: unexpected finds procedure* will be adopted as part of the CEMP during construction. This will be required as field surveys are not exhaustive and some frogs can move relatively large distances in short time periods. For example, although the Giant Barred Frog generally has a small home range (Streatfield 1999, Lemckert and Brassil 2000), in some circumstances, such as dispersal events, it has the capacity to move hundreds of metres over one to two nights.

In general, the unexpected finds procedure includes stopping relevant construction activities, recording details of find and removing the unexpected find from within the construction area. At this time, Roads and Maritime in consultation with the project ecologist or a recognised frog expert, will review the finding in relation to the existing TFMP and the relevant management provisions. These may include:

- The protection of existing habitat.
- The creation of additional compensatory ponds.
- The installation of temporary and/or permanent fencing.
- The assessment of the relevance of the record with regard to the overall BACI monitoring program.

The discovery of retained habitats within 50 m of where new populations of known threatened frog species were found will result in the unexpected finds procedure being implemented. As a part of this procedure the following actions will then be initiated:

- Relevant construction activities will stop while a suitably qualified person identifies the extent of the population and habitat.
- Further management requirements, designed in consultation with the EPA, DP&E and in accordance with the relevant biodiversity guidelines, will be implemented to identify options for facilitating connectivity, temporary/permanent fencing and proposed monitoring protocols for where the new population was discovered.

5.3.8 De-watering protocols

Dewatering would be required where any ponded waterbody is located within the construction footprint. Waterbodies requiring dewatering will be identified during pre-clearance surveys as seasonality will be a factor. It is the goal of de-watering protocols to see no loss of threatened frog habitat, beyond the construction footprint, that is attributed to dewatering activities. In circumstances which require the dewatering of waterbodies within threatened frog habitat, the following process will be adopted:

- The dewatering process must be conducted in accordance with an EWMS and with the Frog Hygiene Protocols (refer to **Appendix G**) for the control of disease in frogs.
- The water body will be waded through by the project ecologist and dip netting must be undertaken to remove as many aquatic fauna as possible. If the water body is too deep to effectively do this prior to pumping, then pumping will be ceased once the water body is shallow enough to allow effective wading and intensive dip netting conducted at this time.
- The intake pipe must be placed in the deepest part of the water body if the water body is to be pumped dry.
- A screen must be installed over the pump intake (at least 5 mm mesh size) to prevent tadpoles being sucked into the intake pipe.
- All tadpoles would be identified, to species level where possible, and placed into separate holding containers.
- All tadpoles must be released in nearby pools in adjacent habitat. Tadpoles must be acclimatised to the water temperature in the new location by immersing bags or holding containers for a minimum of 30 minutes.

- In instances where there are numerous tadpoles from a wide range of species, preferential treatment would be given to threatened species.
- Pest species / Cane toad tad poles will be humanly euthanized

5.3.9 Operational frog exclusion fencing

Operational frog fencing will be installed in proximity to known frog breeding habitat areas and where there is a high chance of threatened frogs accessing the carriageway. The design and location of operational exclusion fencing has been presented as part of the Fauna Connectivity Strategy for Sections 1 and 2 of the W2B project. The detailed design is currently still being refined for Sections 3-11 for the W2B project. The final locations for Sections 1 and 2 and proposed locations for 3-11 relating to threatened frogs is detailed in **Table 5-2**.

Operational fencing for Green-thighed Frog has been proposed in areas where constructed breeding ponds have been proposed because there will be a long term attempt to attract frogs to an area close to the newly constructed carriageway. The extent of operational fencing for Green-thighed Frog will extend at least 100 m beyond the edge/s of identified habitat. This distance is expected to cover the movement distances of most post-breeding frogs and address any concerns with attracting frogs close to the carriageway. The use of operational frog fencing at other locations will be informed by the unexpected finds procedure and after considering the overall importance of the location to the local Green-thighed Frog population. For example, an observation of a foraging non-breeding individual will not be deemed important habitat requiring operational frog fencing because the species is thought to be widely distributed in Section 3 (*see* Lewis 2014).

Operational frog fencing for the Wallum Sedge Frog is focused on an area of Section 9 where both sides of the carriageway require fencing (900 mm high and a minimum of 100 m beyond the edge of identified habitat). Section 10 has been nominated for operational fencing only on the eastern side of the carriageway due to the close proximity of sedge frog populations in this area. Habitat on the western side of the highway is not considered sedge frog habitat given it is comprised of shale deposits with cleared land or sclerophyll forests rather than sand plains and heath communities.

Operational fencing for the Giant Barred Frog has been proposed where this species is present and there is a high risk of frogs accessing the carriageway. A high risk has been defined as earth embankments/batters with a batter profile of less than 2:1 and within 200 m of the stream. The fence must provide the required protection for between 100 - 200 m either side of the stream. A fence return of 5 m must be installed if the frog fencing does not extend for at least 50 m into unsuitable habitat (i.e. cleared land or non-riparian habitat) at the above mentioned sites. Consequently, the final design will be reviewed by an experienced ecologist to determine the requirement of operational frog fencing for Giant Barred Frog.

Table 5-2 Frog operational exclusion fencing

Target species	Project section	Fencing chainage range		Total length of fenced area (m)
Giant Barred Frog	1	3400	3600	200
Green-thighed Frog	1	5200	6000	800
Giant Barred Frog	1	8500	9100	600
Giant Barred Frog	1	13200	13400	200
Giant Barred Frog	1	15800	16000	200
Green-thighed Frog	2	18850	19800	950
Giant Barred Frog	2	19000	19400	400

Target species	Project section	Fencing chainage range		Total length of fenced area (m)

Examples of the types of operational frog exclusion fencing are provided in **Plate 5-1** and **Plate 5-2** with the former figure being designed specifically for Green-thighed Frog but considered effective for other small hylid and myobatrachid frogs up to 50 mm in snout vent length. It was also identified for the W2G project that the standard fauna fence would be adequate for the Giant Barred Frog provided the mesh size was suitably small enough (see **Plate 5-1**).

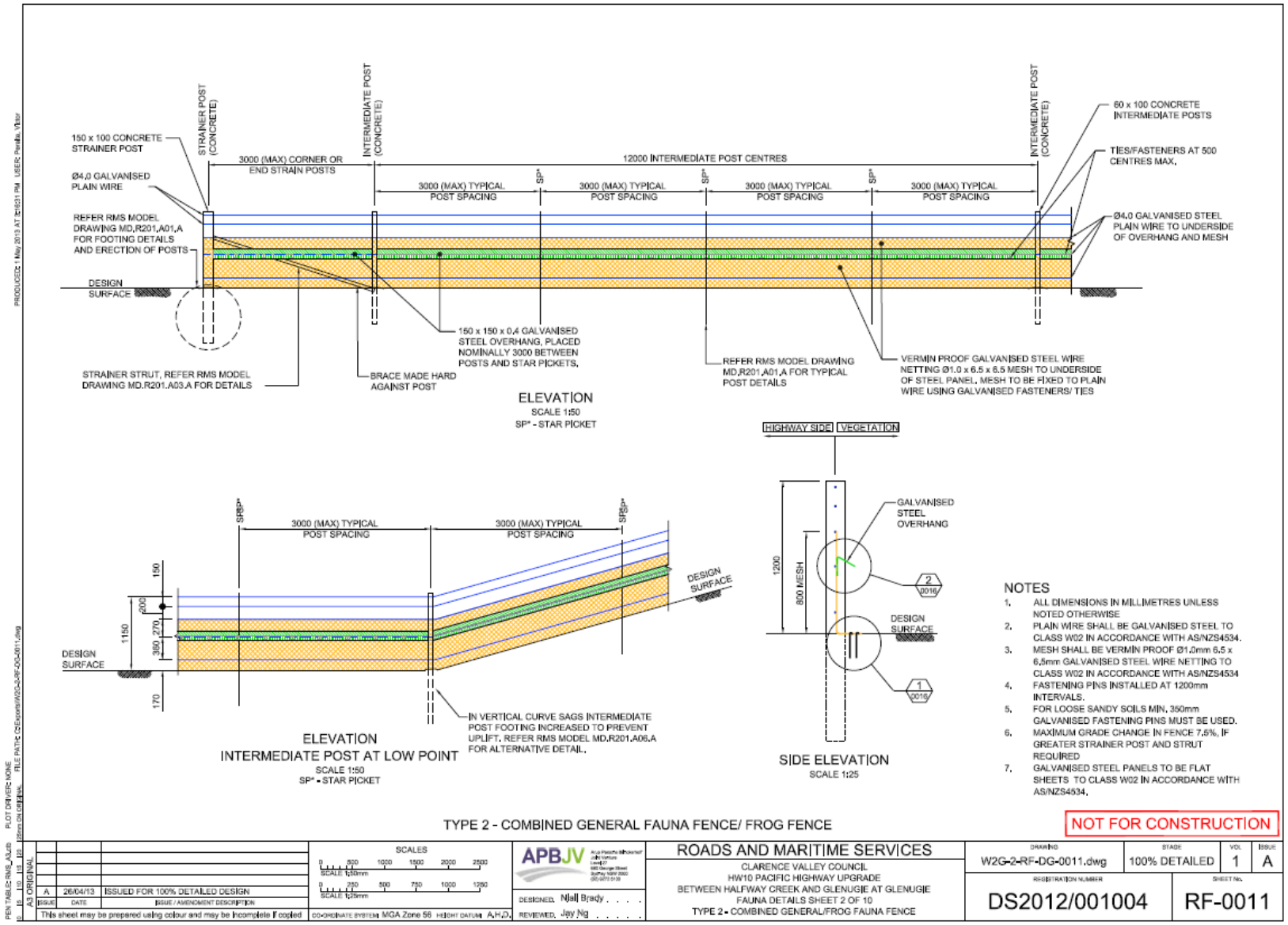

Plate 5-1 Example Type 2 general fauna/frog exclusion fence design (as per W2G detailed design)

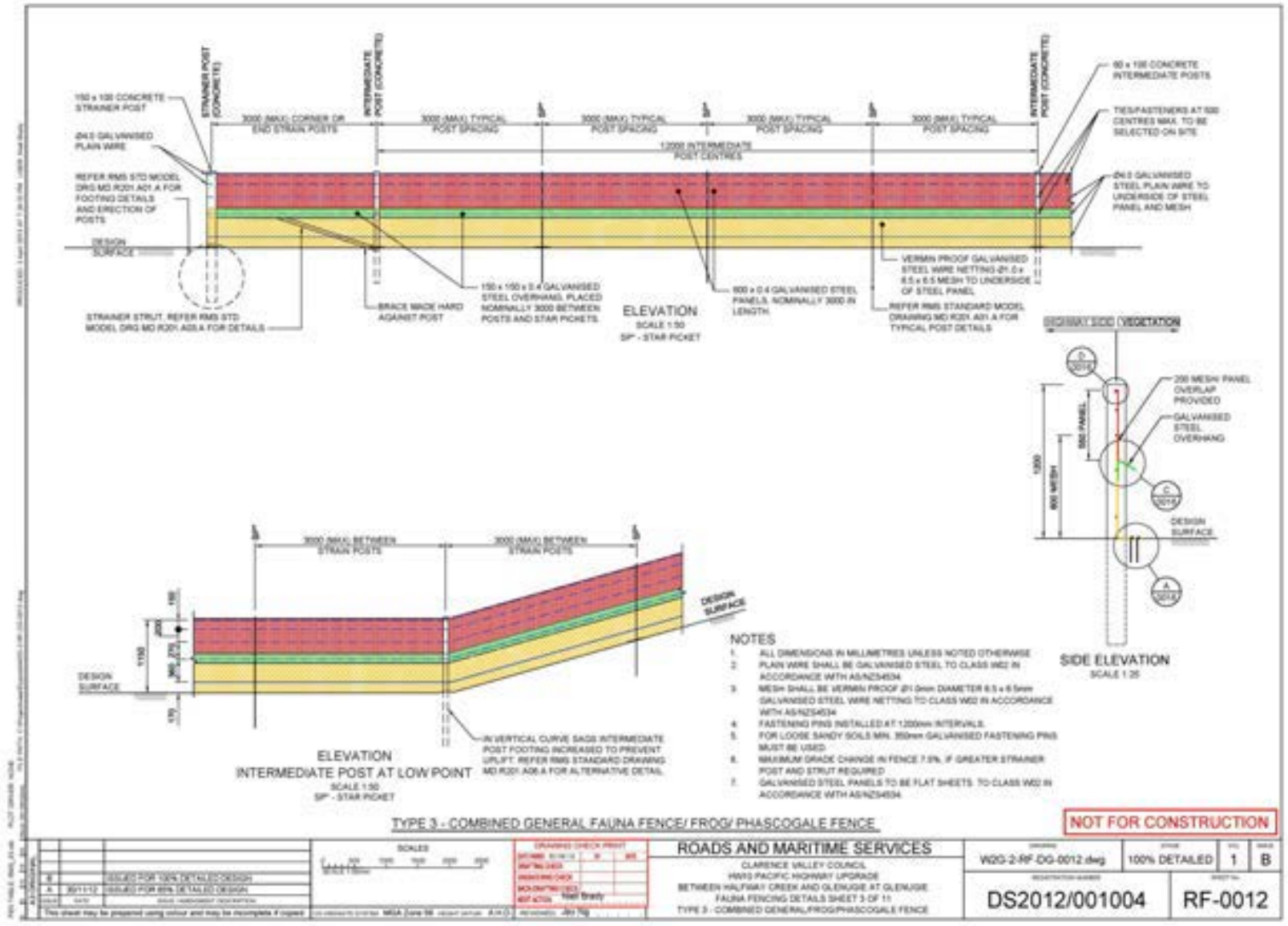

Plate 5-2 Example Type 3 general fauna/frog exclusion fence design (as per W2G detailed design)

5.3.10 Connectivity structures

Road crossing structures have been shown to reduce fauna mortality rates and to reduce the habitat fragmentation impacts of linear infrastructure (Taylor and Goldingay 2010). This is supported by the results of monitoring surveys undertaken for threatened frog species at underpass sites along the Tugan Bypass project. During these surveys, Wallum Sedge Frogs were observed inside and around the entrances of underpasses suggesting movement between the east and the west of the structure (SMEC 2011). Structures such as bridges and underpasses have been included in the design to target a range of fauna species. Many of these general crossing structures are combined drainage and fauna crossing structures in areas known to support threatened frogs. Additional targeted frog surveys and baseline monitoring undertaken for Section 1 and Section 2 have identified areas of important habitat, and connectivity structures for frogs that occur within these sections have been refined and finalised. Connectivity structures are shown in mapping in **Figure 3-1**, **Figure 3-2** and **Figure 3-3**. The location of these structures are summarised below.

Green-thighed Frog at 14 locations including:

- ch. 2000 - combined culvert
- ch. 3600 – bridge
- ch. 4150 - bridge
- ch. 4750 – bridge
- ch. 5660 (Redbank Creek) - bridge
- ch. 8470 (Dirty Creek Tributary) - combined culvert
- ch. 10750 - combined culvert
- ch. 12880 - combined culvert
- ch. 13310 (Boneys Creek) - bridge
- ch. 14280 - combined culvert
- ch. 19180 - combined culvert
- ch. 24400 (Wells Crossing) - bridge
- ch. 24570 - combined culvert
- ch. 29360 (Glenugie Creek) - bebo arch.

Giant Barred Frog at eight locations including:

- ch. 320 (Arrawarra Gully) - incidental culvert
- ch. 2000 combined culvert
- ch. 3600 (Corindi Creek)- 62 m long bridge is proposed
- ch. 4150 - bridge
- ch. 4750 - bridge
- ch. 8470 (Dirty Creek tributary) - 3x3 m reinforced box culvert is proposed with an inline basin to provide habitat
- ch. 13310 (Halfway Creek) tributary combined culvert; and
- ch. 20780 (Halfway Creek) where a 57 m long bridge is proposed.

As detailed design has not been completed for the areas where Wallum Sedge Frog habitat has been identified, connectivity structures for this species are yet to be confirmed. Proposed connectivity structures that may be used by the Wallum Sedge Frog are a land bridge at ch.140000 and an underpass at ch.139500. Although the success of land bridges as a connectivity structure for this species is relatively unknown, research suggests that on wet nights this species tends to radiate out from the sedge swamps with free standing water in into dry heath areas. Design features such as small ponding areas and associated vegetation will therefore be considered during design to enhance usability. The use of this land bridge will be closely monitored during the standard frog monitoring schedule. The locations of connectivity structures for this species will be finalised after detailed design of Sections 3-11 and detailed in a future Fauna Connectivity Strategy for agency approval.

Additional descriptions for fauna connectivity structures and design principles, proposed locations and target species are summarised in **Table 5-3** (Tables A-3 and A-4) (Roads and Maritime 2012).

Table 5-3 Fauna crossing structures targeted for threatened frogs

Project section	Proposed fauna crossing structures
1-2	A combination of dedicated and combined fauna crossing structures were designed in key habitat and corridor locations, which included the following. • Five bridges with fauna passage beneath and retained along river banks • Twenty combined drainage / fauna passage culverts in wet areas • One dedicated underpass in swamp forest
3-5	A combination of dedicated and combined fauna crossing structures have been designed in key habitat and corridor locations which include the following. • Thirteen bridges with fauna passage beneath and retained along river banks • Eleven combined culverts in wet areas designed for combined drainage and fauna crossing capabilities
6-7	A combination of dedicated and combined fauna crossing structures have been designed in key habitat and corridor locations, which included the following: • Three bridges including two across identified major waterways and potential habitat for Oxleyan Pygmy Perch. • Three combined culverts in wet areas designed for combined drainage and fauna capabilities
8-11	• Two frog and small mammal underpasses (1.2 x 1.2 m) near to paperbark swamp and wetland vegetation within Broadwater National Park corridor • Four viaducts about 20 m long between the Richmond River and Coolgardie Road • Three bridges with fauna passage beneath and retained along river banks • Twelve drainage culverts minimum 1.2 m high between the Richmond River and Coolgardie Road (with a further six culverts minimum 0.9 m high)

5.3.11 Weed management

Weed management measures will be developed for each staged section of the upgrade, as part of the FFMP to provide guidance for preventing or minimising the spread of noxious and environmental weed species during pre-construction, construction and operation. The FFMP plan will outline weed management measures to be implemented during construction.

The FFMP will include descriptions and mapping of major weed populations identified during pre-clearing surveys, with appropriate management actions outlined to be implemented for each infestation. The details in the weed management plans would most likely vary for each section of the project but will include:

- Taxa and potential sources of the weed species.
- Weed management priorities and objectives.
- Sensitive environmental areas within or adjacent to the site.
- Location of weed infested areas.
- Treatment and removal methods for all weed species of national significance.
- Mechanical weed control methods such as slashing or mowing, as well as where suitable a range of herbicides to avoid the development of herbicide resistance.
- The use of herbicides must be carefully considered near populations of threatened frogs as some herbicides are harmful to the species.
- Measures to prevent the spread of weeds.
- A monitoring program to measure the success of weed management.
- Strategic management with adjacent landowners.
- Appropriate disposal of weed infested materials and soils to be identified in the CEMP.
- Communication strategies to improve contractor awareness of weeds and weed management.

Details on monitoring the performance of weed management as well as corrective actions to be implemented in instances of change from performance measures are provided in the Weed Management Plan.

5.3.12 Hydrology and water quality

To manage potential impacts associated with water quality, erosion and sediment; management considerations have been incorporated into the project design and will be further detailed in the CEMP, a process that will include consultation with the DoE. Experiences and findings from Devils Pulpit have been used to inform the plan for the project as initial monitoring for Devils Pulpit has demonstrated no notable change in water quality during construction. These designs have taken into account the guidelines, principles and design standards as defined in *Managing urban stormwater: soils and construction volume 1* (Landcom, 2004), and *Managing urban stormwater: soils and construction – main road construction (*DECC, 2008). These documents describe RMS's commitment on how soils and water quality are to be managed during road construction, and during the ongoing operation of the NSW state road network, so as to prevent environmental pollution.

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

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

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

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

Water quality monitoring, particularly following rainfall events, would identify if the hydrology and water quality has been adversely impacted by the project. Standard project water quality objectives criteria that are applicable project wide, and are relevant to areas of Green-thighed Frog and Giant Barred Frog habitat, are as follows:

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

Water quality requirements within Wallum Sedge Frog breeding habitat vary slightly from those of other species and therefore runoff from construction sites within mapped areas of Wallum Sedge Frog breeding habitat would be treated using a sedimentation basin. The required water quality parameters for the basins discharging into this area are detailed below.. During construction, direct discharge to waterways of water from sediment basins that does not meet the water quality requirements for Wallum Sedge Frog habitat would not be permitted, but rather this water would be used for beneficial purposes (i.e., sprayed into adjacent open grass areas or used for construction purposes such as dust suppression). Discharge by diffuse method of land irrigation would be allowed only if a minimum of 50 m from a waterway, within the project boundary, and subject to negotiations with the landholder. If diffuse discharge is not feasible then water would be pumped to a proposed storage facility.

Water quality objectives criteria that are applicable to areas of Wallum Sedge Frog habitat and the associated augmented ponds are as follows:

- Total suspended solids: <50mg/L
- pH: <5.5
- Oil and grease: no visible trace.

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

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

5.4 Mitigation goals and corrective actions

The construction mitigation goals and mitigation measures for threatened frog species, and their associated corrective actions, are summarised in **Table 5-4**.

Table 5-4 Mitigation goals and corrective actions - construction

Mitigation goals	Proposed mitigation measure	Monitoring/timing frequency	Trigger for corrective actions	Corrective actions
No injuries or mortality to threatened frogs during clearing works.	• Installation of temporary fencing. • Active frog searches five days prior to clearing activities as detailed in Section 5.3.6. • Ecologist present during clearing activities.	Prior to and during clearing works	A single threatened frog suffering an injury or mortality during clearing works.	• Stop clearing works and check temporary fencing for breaches immediately. If breaches found, commence repair activities within five days and report to the project Environmental Representative. • If breach is severe, and results in the injury or mortality of >10 individuals, report breach to the relevant government agencies. • Conduct additional active searches for frogs within five days of incident. • Review sampling procedures before commencement of further clearing • Ensure pre-clearing surveys were performed in relation to suitable abiotic conditions for the target species.
No injuries to or mortality of threatened frogs during construction as a result of vehicle collisions.	• Temporary frog exclusion fencing in place during construction. • Unexpected finds procedure.	Weekly inspection of exclusion fencing.	• Temporary exclusion fencing not installed prior to construction commencing. • A single injured or dead threatened frog found during construction. • Unexpected finds procedure triggered.	• Delay construction in area of concern until temporary exclusion fencing has been installed. • Stop works immediately, investigate and review the exclusion fencing requirements, repair breaches and update as appropriate. • Conduct additional active searches for frogs. • Initiate unexpected find procedure.
No injuries to frogs that need to be handled.	Fauna handling procedure.	Event based. During clearing works.	Frog mortalities resulting from handling noted during clearing works.	• Investigate incident immediately and identify cause for mortality if possible. • If correct procedure was followed, review fauna handling procedure within one week and update as required. • Ensure all relevant personnel are trained on correct amphibian handling techniques.
No movement of chytrid fungus between sites.	Frog hygiene protocol.	Measures to minimise the spread of chytrid fungus to be implemented during construction where personnel and/or equipment are required to enter threatened frog areas within project sections.	Non-compliance with hygiene protocols by construction vehicle operators.	• Stop works in threatened frog areas until chytrid fungus mitigation measures have been implemented. • Ensure all staff have been trained in frog hygiene protocol. • Evaluate and change methods/protocols, consider testing water to identify source.

Mitigation goals	Proposed mitigation measure	Monitoring/timing frequency	Trigger for corrective actions	Corrective actions
Low rate injuries or mortality of threatened frogs as a result of dewatering activities. No loss of habitat beyond what is identified in construction footprint as a result of dewatering activities	• De-watering protocol. • Frog hygiene protocol.	Event based.	• Fauna handling procedure not developed and implemented. • De-water protocol not developed and implemented. • Injured or dead frogs and tadpoles found during dewatering activities.	• Delay dewatering activities until a fauna handling procedure and de-watering protocol have been developed. • Ensure all relevant staff are trained in the de-watering protocol and fauna handling procedure. • Evaluate dewatering protocol if effectiveness is low (greater than approximately 1% of frogs and tadpoles from the site dying during dewatering).
No adverse effects to Wallum Sedge Frog populations resulting from impacts to water quality.	Monitoring of constructed compensatory ponds	Bi- Weekly	• pH for Wallum Sedge Frog ponds > 5.5. • Total suspended Solids >50mg/L. • Visible oil and grease.	• Stop works in the immediate area and investigate the reasons for the change in water quality to determine appropriate mitigation measures for Wallum Sedge Frog ponds. • Before continuing works, inspect and rectify water quality ponds and grassed swales in areas where adverse impacts are identified.
No adverse effects to Giant Barred Frog and Green-thighed Frog populations resulting from impacts to water quality.	Monitoring of constructed compensatory ponds	Bi Weekly	• pH for waters within Giant Barred Frog and Green-thighed Frog habitat is outside acceptable range of 6.5 - 8.5. • Total suspended Solids >50mg/L. • Visible oil and grease.	• Stop works in the immediate area and investigate the reasons for the change in water quality to determine appropriate mitigation actions. • Before continuing works, inspect and rectify water quality ponds and grassed swales in area where adverse impacts are identified.

6. Operational management measures

6.1 Potential impacts during operational phase

- Direct mortality from vehicle strike.
- Degradation of habitat values due to edge effects, predominantly an increase in weeds, loss of riparian or aquatic plants.
- Changes in hydrology or water quality as a result of road construction leading to a degradation of habitat.
- Loss of connectivity and access to important habitats.
- Increased dispersal opportunities or habitats for feral species, in particular Cane Toads.

6.2 Mitigation goals

- No ongoing degradation of known threatened frog habitat adjacent to the project.
- No mortality of threatened frogs from vehicle strike adjacent to known habitat areas.
- Maintenance of frog access to important habitats, demonstrated use of connectivity structures.
- Use of constructed compensatory ponds by threatened frogs.

6.3 Management measures

6.3.1 Habitat revegetation

Revegetation works would be incorporated into the landscape plans and would be undertaken following construction in any areas disturbed within the road corridor that are adjacent to identified important threatened frog habitats or beyond if the habitat is located within properties owned by Roads and Maritime. This may include ponds, ephemeral areas, creek riparian areas, culvert and bridge locations to restore connectivity, and wetlands within the road corridor to minimise edge effects. This may also include sediment and water treatment ponds and immediate surrounds where these occur adjacent to identified important threatened frog habitats. It would also include any compensatory ponds constructed that were revegetated.

Consideration of the threatened frog species located adjacent to revegetation areas is required to ensure suitable plant species are used to revegetate the areas suited to the particular threatened frog species (i.e. wallum flora species for the Wallum Sedge Frog and riparian flora species for the Green-thighed Frog). The flora species to be used in revegetation will then be incorporated into the UDLP.

Ongoing maintenance of habitat revegetated areas adjacent to threatened frog habitats will be undertaken. Inspection, monitoring and maintenance is specified within the Roads and Maritime specifications including R178 and R179. The recommended maintenance and monitoring schedule for the habitat revegetated areas in the first year is outlined in **Table 6-1** and for years two and three in **Table 6-2**. 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. Monitoring of revegetation will continue for at least three years to ensure the successful establishment of propagules and beyond that until the health of the revegetated areas are demonstrated for three consecutive monitoring periods.

Maintenance activities would include watering if necessary, removal of damaging debris after storms, plantings to replace mortalities, maintenance of mulch cover and weed control as necessary.

Table 6-1 Recommended monitoring and maintenance schedule (Year 1)

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

Table 6-2 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 m 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.

6.3.2 Weed management

Weed management would be undertaken as part of the Roads and Maritime ongoing maintenance of landscaped areas. Weed management in areas with threatened frog habitat will be undertaken by suitably qualified and experienced contractors that are familiar with the threatened species of the area. Weed control measures would be implemented for threatened frog habitat and revegetated areas adjacent to threatened frog habitat.

The monitoring program would monitor weeds adjacent to threatened frog habitat with corrective actions to be implemented if the abundance of weeds is above the performance thresholds. Monitoring and performance measures are provided in **Chapter 7**.

6.3.3 Maintenance of frog exclusion fencing

Roads and Maritime would conduct regular monitoring of frog exclusion fencing in conjunction with population monitoring events twice per year, as well as periodic inspections and maintenance of frog exclusion fencing as part of general road corridor asset maintenance. The fence monitoring program would include ongoing inspections of the structures as part of the standard maintenance requirements for frog usage, stability, damage and replacement where necessary.

6.3.4 Maintenance of fauna connectivity structures

Roads and Maritime would conduct periodic inspection (twice per annum) and maintenance of dedicated and combined underpasses. The program would include ongoing inspections of the structures as part of the standard maintenance requirements for stability and damage and replacement where necessary. Refer to **Chapter 7.3** for details on how the periodic monitoring would be undertaken.

6.3.5 Maintenance of compensatory ponds

Maintenance of Green-thighed Frog ponds may be required following rainfall events. Ponds may require additional earth works in terms of excavation or improving drainage of the pond to achieve a suitable hydroperiod (as specified in **Chapter 5.3.4**) for the target frog species. In some instances, incorrect positioning of the ponds around revegetated areas may require additional vegetation management.

The requirements for maintenance will be driven from the results of the routine monitoring. Monitoring will be performed by experienced persons with adequate experience able to make informed decisions on how to make the ponds suitable for sedge frogs.

Following monitoring surveys, where corrective actions are deemed to be required, appropriate measures will be agreed with Roads and Maritime and where practicable the mitigation action will be undertaken within 60 days of the monitoring event.

6.4 Mitigation goals and corrective actions

The operational mitigation goals and mitigation measures for threatened frogs and their associated corrective actions are detailed in **Table 6-3**.

Table 6-3 Mitigation goals and corrective actions –operation

Mitigation goals	Proposed mitigation measure	Monitoring/timing frequency	Triggers for corrective actions	Corrective actions
No ongoing degradation of known threatened frog habitat adjacent to the project. Maintain habitat revegetation until evidence of performance objectives being reached.	Habitat revegetation / landscaping design. Weed control.	As per Section 6.3 maintenance measures. For the first twelve months monitoring of revegetation will be monthly. It will then go to every 6 months for years two and three. Monitoring will occur in Spring/Summer to evaluate the success of revegetation against performance objectives.	Monitoring and maintenance activities not being undertaken. More than 10% of plants have died after year one, and more than 20% have died after three years.	Review maintenance schedule for revegetated areas within one month of trigger being identified and plant more feed and habitat trees as required. Increase monitoring period as advised by landscape designer. Review weed control strategy if vegetation fails over three consecutive monitoring periods.
Functionality of frog exclusion fencing maintained.	Maintenance of permanent frog exclusion fencing. Checking of fences after floods to ensure integrity and during population monitoring.	Routine (i.e. twice annually) monitoring of permanent exclusion fencing.	Any damage to frog exclusion fencing.	Check permanent frog exclusion fencing for breaches immediately. Repair breaches within three days of inspection.
No reduction of frog access to important habitats and demonstrated use of connectivity structures.	Maintenance of frog connectivity structures or corridors to allow connectivity between populations.	Monitoring (i.e. twice annually) of culverts and corridor structures within the first three years.	Connectivity structures are identified as not being used by threatened frogs during monitoring. Number of sightings necessary to determine if structures are being successful. <1% of estimated population within 250 m of structure using the device. Routine monitoring/maintenance find high sediment or debris build-up in culverts.	Commence works to remove any obstructions within one week of issue identification. Re-evaluate connectivity strategy if threatened frogs continue to avoid structures for three consecutive years. If connectivity structures are deemed ineffective over three consecutive monitoring periods (refer to Section 7.2.2), offsets for associated frog habitat will be assessed.
Quality of retained habitat is maintained to a functional level.	Regular monitoring of paired BACI sites to identify any changes in comparative population density.	Routine (i.e. twice annually) monitoring of BACI sites.	A 25% decline in an impact population that is not concurrently observed in the associated BACI control population.	Increase maintenance time and frequency immediately after decline is observed to confirm. If decline is confirmed, assess environmental and biotic characteristics of habitat to identify any issues. If habitat is deemed unsuitable, assess the possibility of additional offsets to address lost habitat.

Mitigation goals	Proposed mitigation measure	Monitoring/timing frequency	Triggers for corrective actions	Corrective actions
Use of constructed compensatory ponds by threatened frogs.	Provision of compensatory frog ponds.	Monitoring (i.e. twice annually) of compensatory ponds to ensure that vegetation is in good condition, and water quality and hydro-period are suitable, as per Chapter 7.	Revegetation failing (more than 10% of plants have died after year one, and more than 20% have died after three years). Water quality is identified as being not within recognised limits at sites naturally known to support the target species. Hydro-period is deemed unsuitable to enable the target species to breed successfully (i.e. dries too quickly). Alternatively the hydro-period is too long and does not provide suitable breeding conditions for the Green-thighed Frog (i.e. permanent water body). A minimum of 20% of the original number of frogs at the impacted pond using the compensatory pond for at least 3 years and that successful reproduction in the form of tadpoles reaching metamorphosis be recorded.	Complete site specific investigation immediately to ensure that water quality and hydro-period is suitable. Increase maintenance time and frequency. Replace lost vegetation within one month of trigger. Review monitoring program, consider conditions during surveys and re-evaluate within one month of trigger. Check water quality and vegetation condition immediately. Revegetate if required. Provisional measures such as additional ponds should be considered. Undertake mitigation actions within 60 days of the monitoring event where practicable.
No increase in the proliferation of invasive species in key frog habitat areas.	Implementation of a weed monitoring and management strategy. Educate all project personnel on the identification of key weed species.	All vehicles are to be washed down before entering the project area on project related business and vehicle weed hygiene to be checked fortnightly for ongoing work such as monitoring and maintenance. Records are to be maintained.	An observation of >1 individual of a weed species controlled under state or federal legislation is observed growing in an area of the project during or after construction.	Immediately identify the area in which the weed species was observed with marking tape/paint or similar. Initiate the weeds removal under the guidance of the project environmental representative, in a manner that minimises any chance of further propagation.

7. Monitoring program

7.1 Aims and goals

The objectives of the monitoring program are to:

- Evaluate the success of mitigation measures (i.e. pre-clearing procedures, frog exclusion fencing, crossing structures, constructed ponds and habitat revegetation) for threatened frogs.
- Further understand the habitat requirements of the threatened frog species in the locality.
- Confirm the extent of secondary impacts on populations of threatened frog species including changes in water quality and the resulting interspecific competition in wallum habitats and identify any additional mitigation measures that may minimise these impacts.

The monitoring program has been designed to continue until the mitigation measures are proven to be effective over three consecutive post-construction monitoring periods. It is an adaptive monitoring and management program.

7.2 Population monitoring survey design frog population monitoring

7.2.1 Treatment design

Population monitoring for each of the three species is based on a BACI (Before-After-Control-Impact) design in an attempt to measure the effectiveness of the mitigation measures being used to manage *in situ* populations of threatened frogs. It follows a mitigation-construction BACI design, with populations compared at two treatment levels:

Treatment 1 (Impact Sites): Sites known to contain the target species at or close to the construction footprint which are likely to be impacted by the Project.

Treatment 2 (Control/Reference Sites): Sites located in adjacent areas unaffected by the Project. Due to the differing habitat requirements of the target species this is considered at different scales. For example, Wallum Sedge Frog control/reference sites have been set at >500 m from the project and at this distance they are unlikely to be affected by either primary (habitat removal) or secondary (changes in pH reducing habitat quality and improving conditions for competitive species). For Giant Barred Frog a control/reference site is located at least 1 km upstream or in a neighbouring sub catchment or catchment unaffected by the Project but the area is still subject to similar prevailing abiotic conditions and occurs within a similar broad riparian vegetation type. Control sites for the Green-thighed Frog were located a minimum of 100 m from the Upgrade footprint and preferably 500 m to ensure the site remains unaffected by drainage patterns resulting from the Project.

All sites were separated by an appropriate distance, at least 200 m, to avoid spatial compounding effects and where possible this was increased to a number of kilometres because the metapopulation structures of all three species is not well known.

Using this treatment design the minimum number of replicates has been set at three paired sites which comprise an impact and a control/reference site (n=6) and allow for some statistical evaluation albeit at a minimal statistical power. In instances where it is possible to increase this further to a maximum of 10 paired BACI sites (n=20) this will be adopted but based on present pre-construction baseline surveys it is summarised as follows:

- Green-thighed Frog with five paired sites from Sections 1 and 2
- Giant Barred Frog with three paired sites from Section 1 and 2
- Wallum Sedge Frog with five paired sites from Sections 8-10.

7.2.2 Methods and duration

The survey methodology for each species is described in **Section 4.3** and is based on a standardised transect or time area counts performed twice annually, once in winter and once in summer, during suitable detection periods for each of the three frog species. Construction and post-construction monitoring would be undertaken twice annually using the methods described in **Section 4** and compared with pre-construction data at control and impact sites. The performance of the mitigation measures would be assessed against the thresholds described in **Section 7.2.3** and corrective measures implemented where population declines can be demonstrated as being attributable to the project.

The success or effectiveness of the mitigation measures employed for each species will be measured over three consecutive post-construction monitoring periods. Conversely, in the event that population declines are detected the monitoring program may need to extend a further two or three years and up to five years after which the need for future monitoring or other provisional measures would be evaluated in consultation with the relevant regulatory authorities.

The monitoring program must be sufficient to give a reasonable confidence of the condition of relevant frog populations (although it is important that the methodology outlined in **Section 4** is followed, in particular in relation to the timing of surveys). Although comparisons of presence/absence data between pre-construction monitoring and post-construction monitoring form critical indicators of the impacts of construction activities on threatened frog populations it will be the population count or abundance data that will be compared to determine if there has been any declines at those impacted populations. Where a decline in frog abundance is identified at impact sites and not at control sites, then the decline must be attributed to the highway, unless it can be demonstrated otherwise.

7.2.3 Performance indicators and corrective actions

Should it become clear that sites that were occupied prior to road construction (i.e established impact monitoring sites) have become unoccupied, or abundance (estimated using the transect counts) has declined beyond the identified thresholds (i.e. 25%) relative to control/reference sites, corrective actions must be implemented in accordance with those provided in **Table 7-1**.

Table 7-1 Performance indicators and corrective actions – population density monitoring

Triggers for corrective actions	Corrective actions
The absence of threatened frogs at impact sites identified as occupied in the baseline monitoring surveys. A relative decline in abundance of 25% or more at an impact site than its relative control site over 3 consecutive monitoring periods. Frog abundance determined by standardised transect counts: • Number of Wallum Sedge Frogs per 100 m2 of habitat; • Number of Giant Barred Frogs per 500 m of habitat; • Number of adult male Green-thighed Frogs per Stage 1 survey (breeding survey) (as outlined in Section 4.3).	Review monitoring methods immediately, considering further monitoring and assessment if there is a decline in population abundance. Investigate effectiveness of frog exclusion fencing immediately. Closely monitor habitat conditions over a period of three months to ensure they are suitable, in particular hydrology (hydro-period), water quality and vegetation. Assess the requirement for additional offsets where a threatened frog population is no longer present in a previously occupied area, and this habitat is deemed unsuitable for the target species.

7.3 Connectivity structures

7.3.1 Methods, timing, intensity and duration

Monitoring would be conducted by an experienced frog ecologist to confirm the efficacy of connectivity structures. A more detailed summary of frog connectivity structures is provided in **Section 5.3.10**.

Surveying connectivity structures and fauna exclusion fencing would be conducted as part of the population monitoring during the construction (i.e. as the structures are built and become operational but only with operational frog fencing installed) and post construction phases of the project. These population monitoring efforts will link directly with the broader BACI survey design whilst introducing mark recapture techniques to enable frogs to be clearly identified. For larger species like the Giant Barred Frog this will include the use of PIT tagging whilst the smaller species may be more reliant on some basic form of toe clipping. Toe clipping is a commonly used method of marking individuals of smaller species of frog and appropriately qualified ecologists that are experienced in its use have received ethics approval from governing bodies previously. Through having a simplified approach and adhering to special conditions, such as the use of antiseptic on PIT tag and toe clipped sites, this method will minimise harm to individuals and inequitably provide the necessary information to confirm frog movements between the two areas. An acceptable measure of its overall success will be set at >1% of the estimated population size for that area and this could be simply based on the total number of frogs captured and marked versus the number recorded as recaptures that have moved across the carriageway. Monitoring and inspection of frog exclusion fencing will coincide with population monitoring and continue through until population monitoring has ceased.

7.3.2 Performance indicators and corrective actions

In the event the monitoring is not able to clearly demonstrate >1% of the estimated population uses the structure or alternatively the recorded thresholds of frog mortality are breached, the corrective actions outlined in **Table 7-2** must be considered.

Table 7-2 Performance thresholds and corrective actions – underpass structure monitoring

Triggers for corrective actions	Corrective actions
The use of the structure by less than 1% of the estimated population size. Connectivity structures not maintained (i.e. culverts clogged with debris or sedimentation). Frog exclusion fencing damaged or ineffective.	Review monitoring methods where goals are not achieved, by increasing frequency, intensity and duration, to ensure individuals are identified. Survey habitat adjoining the connectivity structures and undertake landscape improvement (planting, weed removal) to improve habitat functionality. Survey and monitor crossing structures and frog fencing to ensure they are functional (i.e. are adequately maintained, including fencing is not damaged, and connectivity structure is operating correctly). Monitor twice per year. Assess the need for offsets if connectivity structures are identified as ineffective over three consecutive monitoring periods.

7.4 Compensatory ponds

7.4.1 Methods, timing, intensity and duration

Compensatory ponds in the form of constructed breeding ponds be monitored as part of the overall monitoring program. Monitoring of these ponds will commence immediately after their construction to ensure their initial stability and continue twice a year, until their success is confirmed over three consecutive monitoring periods. These sites would be visited during the monitoring of the BACI sites using the same standardised approach as described in **Section 4.3.** Other data to be collected during each monitoring event would include:

- A photograph taken during daylight hours of the pond at an installed photo-point.
- A visual and quantitative assessment on the extent of fringing vegetation and aquatic vegetation to assess the status of the rehabilitation efforts.
- Dip-netting to determine the presence of Mosquito Fish or any other exotic fish.
- The depth of water from a permanently installed water staff.

- Obtaining rainfall data from the preceding month to facilitate in describing the hydroperiod of Green-thighed Frog and the Wallum Sedge Frog ponds.

7.4.2 Performance indicators and corrective actions

Where compensatory ponds have been constructed or augmented in some way, monitoring would be undertaken to confirm if the ponds have been used by threatened frogs as breeding habitat by Green-thighed Frogs or used at all by Wallum Sedge Frogs. Performance indicators and corrective actions are outlined in **Table 7-3**.

Table 7-3 Performance indicators and corrective actions – constructed pond monitoring

Triggers of corrective actions	Corrective actions
Absence of threatened frogs and metamorphs at the compensatory ponds after three years since construction.	Investigation be undertaken to determine why there may be a lack of success and, as where recommended, changes be made to the habitat and monitored for effectiveness (i.e. 3 more years of monitoring) Review monitoring methods, considering timing and weather conditions to ensure individuals are identified. Review location of the compensatory pond and consider moving, and/or modifying or constructing additional ponds. Investigate habitat adjoining the upgraded highway and consider improving habitat condition and connectivity.
Water pH exceeds 5.5 for Wallum Sedge Frog	Investigate ways to reduce pH of water.
Visual water quality of the compensatory pond is not similar to nearby unimpacted and/or similar wetlands or is unsuitable for frog occupation. No persistent water present in ponds (negative hydroperiod) despite recent rainfall.	Complete site specific investigation to identify the causes of the unsuitable hydrological conditions or water quality. Assess possible causes for water draining from the pond and apply physical corrective actions
Mosquito Fish present and threatened frogs / tadpoles absent.	Draining pond to remove Mosquito Fish and allow pond fill at the next rain event.
Constructed habitat un-suitable for frogs (e.g. wetlands have un-suitable hydro-period (as determined from monitoring events), water quality or associated vegetation) as detailed in section 5.4.4. Revegetated native habitat in poor condition (e.g. >30% cover died, plant dieback). Frog absence confirmed following monitoring surveys (it should be noted that a pond may be suitable for frogs, but not colonised).	Undertake revegetation maintenance, i.e. replanting, erosion control, weed control. Ensure wetlands are functioning as designed and present suitable habitat in terms of water quality and hydro-period.

7.5 Riparian habitat revegetation

7.5.1 Methods, timing, intensity and duration

Any stream or wetland areas or other critical habitats identified in the pre-construction surveys that have known threatened frogs and are to be disturbed during construction (for example areas next to culverts or bridges) would need to be suitably revegetated. The objective of the monitoring program would be to ensure that those revegetation measures have been effective over time. It may be unsuitable to have a 'before' or 'control' comparison with rehabilitated or revegetated wetlands. In these cases, monitoring would be conducted to ensure that habitats become or remain suitable for frogs following their construction/rehabilitation.

Quantitative habitat surveys would be undertaken at each of the threatened frog monitoring sites identified during the targeted surveys. To complete the survey, transects would be established perpendicular to the channel or wetland at each site. The number and location of these transects would be identified on a site by site case and may include dividing the site into even segments and then randomly selecting a point in each segment. Wetted width and average water depth would be measured along each transect.

Four 0.5 m^2 quadrats would be randomly positioned along each transect. Fewer quadrats may be used in channels that have a wetted width of less than 2.5 m or small wetlands adjacent to the project corridor. Substrate composition, woody debris cover and vegetation cover would be estimated within each quadrat and pooled for each transect. Aquatic plants in each quadrat would also be identified and recorded.

Transects would also be randomly positioned along each stream bank to estimate the amount of root masses, undercut bank, vegetation overhang and riparian vegetation cover at each site. The total length of the transect would equal approximately 20 per cent of the wetted perimeter at each site.

Photo points would be established at each site with a GPS and repeat photographs would be taken from the same location on each survey. Biannual surveys would be undertaken until such time as it can be established that the habitat has been restored effectively. Habitat surveys would be conducted at the same time as population surveys.

7.5.2 Performance indicators and corrective actions

Any habitat changes that have been identified at construction sites or downstream of the construction area that was not also evident at sites immediately upstream of the project would be attributed to the construction or operation of the project. Such results would trigger immediate investigation into the specific cause so that appropriate remedial action can be taken such as replanting, replacing lost trees, weeding and physical modification.

The main performance indicators and corrective actions have been outlined in **Table 7-4**.

Table 7-4 Performance indicators and corrective actions – riparian habitat revegetation monitoring

Triggers for corrective actions	Corrective actions
Greater than 10% of riparian plants have died after first 12 months of maintenance. Greater than 20% of riparian plants have died after three years of maintenance. Total weed coverage is more than 30% in revegetation areas. Bank erosion causes unforseen revegetation area instability.	Review maintenance schedule for revegetated areas immediately after trigger. Replace dead plants within one month of issue being identified. Increase weed control if required as soon as practicable or review control methods being used. Install physical measures to halt bank erosion within one month of issue being identified.

7.6 Evaluation, project review and reporting

Reports would include:

- The results of the population surveys for detailed design of each project including mapping the location and extent of habitats and populations and baseline data for inclusion in the project monitoring program.
- Annual reporting include an analysis of the data to determine if change has taken place and/or demonstrate if there is enough power to detect the specified levels of unacceptable change.
- Reporting annual results during the construction phase including the results of the monitoring program of a minimum of two night sampling per site for all species, except for the Giant Barred Frog, which requires a minimum of four nights sampling per site (DEWHA 2010).

- Reporting any change to performance indicators and how these were addressed in terms of actions implemented.

7.6.1 Responsibility

The ecologist/herpetologist employed to undertake the threatened frog species monitoring for each relevant project section would be responsible for the evaluation of the monitoring information collected. The definition of a suitably qualified ecologist requires "a person with a tertiary degree in a related field (e.g. Environmental Science / Ecology) with a minimum five years of experience conducting targeted frog surveys, and for projects of a similar scale and complexity as the W2B project."

7.6.2 Timing

A brief annual report would be prepared by the contractor for distribution to the Roads and Maritime and other relevant government agencies (DP&E, EPA and DoE) regarding the annual population counts.

A final report would be prepared at the conclusion of the monitoring period. This report would incorporate all the results of the monitoring and recommend any additional measures (if deemed necessary) to facilitate the long-term survival of the Green-thighed Frog, Wallum Sedge Frog and Giant Barred Frog populations in the locality.

8. Summary table and implementation schedule

Table 8-1 provides an overall example summary of the actions proposed in the above plan. It also identifies the person responsible for the actions and the estimated timing of the project.

Table 8-1 Summary table and implementation schedule of management plan

	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
	Targeted surveys and establish control and impact sites	Ecologist	X																					
	Identify frog exclusion fencing locations	Ecologist	X																					
	Identify frog compensatory pond locations	Ecologist	X																					
	Ancillary facilities	Contractor	X																					
	Work method statements	Contractor		X																				
	Inductions and training	Contractor		X																				
	Install temporary frog fencing prior to clearing	Contractor		X																				
	Construction of compensatory ponds	Contractor		X																				
	Monitoring of compensatory ponds post construction	Ecologist		X																				
	Frog hygiene protocol	Contractor		X																				
	Pre-clearing and clearing surveys	Contractor		X																				
	Unexpected finds procedure	Contractor		X																				
	De-watering protocols	Contractor		X																				
	Install permanent frog exclusion fencing post-construction	Contractor		X																				
	Connectivity structures	Contractor		X																				
	Weed management	Contractor		X																				
	Sedimentation fencing	Contractor		X																				
	Water quality	Contractor		X																				
	Habitat revegetation	Roads and Maritime			X		X		X		X		X											
	Maintenance checks of frog exclusion fencing	Roads and Maritime			X		X		X		X		X											
	Maintenance of connectivity structures	Roads and Maritime			X		X		X		X		X											
	Maintenance checks of compensatory ponds	Roads and Maritime			X		X		X		X		X											
	Threatened frog population monitoring#	Ecologist	X	X	X		X		X		X		X											
	Crossing structure monitoring#	Roads and Maritime		X	X		X		X		X		X											
	Compensatory pond	Ecologist		X	X		X		X		X		X											

No.					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
	monitoring#																							
	Riparian habitat revegetation#	Roads and Maritime		X	X		X		X		X		X		X									
	Monitoring of permanent exclusion fencing#	Ecologist		X	X		X		X		X		X		X									
	Evaluation	Roads and Maritime	X	X			X				X				X				X				X	

as per MCOA condition D8(k), ongoing monitoring during operation of the SSI (for operation/ongoing impacts) is to be undertaken 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 (years).

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Appendix A – Response to expert and agency comments

Expert Comments				
ID No	Section	Recommendation	Recommendation has been addressed (Version 1)	How recommendation has been addressed (Version 2.1)
TFrMP1	1.2	*Crinia tinnula* will not be adequately covered by many of the management actions for frogs documented in the plan. Recommendation: Remove all specific information on *Crinia tinnula* to be consistent.	Adopted- plan updated	*Crinia tinnula* (Wallum froglet) was assessed during the EIS and findings concluded there would not be a 'significant' impact on the species as a result of the project. Therefore the species has not been included specifically in this TFMP. It is noted the species shares similar habitat requirements as the Wallum Sedge Frog. Therefore those mitigation measures (such as frog exclusion fencing, crossing structures, compensatory ponds and habitat revegetation) to be adopted for the Wallum Sedge Frog will also provide a benefit to the Wallum froglet.
TFrMP2	3.1.1	The information on habitats for Giant Barred Frogs is incorrect. Recommendation: This information is corrected to accurately reflect the consensus of available information.	Adopted- plan updated	
TFrMP3	3.1.1	For the Green-thighed Frog, I would have thought quoting Lemckert et al (2006) would have been obvious in regards to habitat and general biology as it is a summary paper for this species. Recommendation: This information is corrected to accurately reflect the consensus of available information.	Adopted- plan updated	
TFrMP4	4.1	Recommendation: The impacts of changes to pH leading to more neutral waters needs to be discussed in this MP.	Adopted- plan updated	
TFrMP5	Table 4.1	Amphibians are the one group that have not been demonstrated to widely use over and underpass structures and this has support from a published study. There are instances of frog tunnels being of some use in some places overseas, but nothing in Australia. Similarly, the provision of compensatory ponds is widely used as a mitigation measure, yet there are almost no indications of any long-term success in using such a system. Recommendation: Change the rating to uncertain.	Adopted- plan updated	
TFrMP6	5.3.1	I believe that the stated preferred window of frog surveys of late spring and summer is too narrow and restrictive, at least for the Green-thighed Frog, and suggesting a seasonal approach to monitoring is potentially quite misleading if setting survey and monitoring programs.	Adopted- plan updated	

Expert Comments				
ID No	Section	Recommendation	Recommendation has been addressed (Version 1)	How recommendation has been addressed (Version 2.1)
		Recommendation: That the information on the Giant Barred Frog and Green-thighed Frog is changed to reflect the published information that is based on a synthesis of all available data and not just a few points.		
TFrMP7	5.3.1	Recommendation: Note that surveys for Giant Barred Frogs should not be undertaken immediately after heavy rains.	Adopted- plan updated	
TFrMP8	5.3.1	In Paragraph 5 of Timing, Site-selection and Methods the distances advocated for the control and impact sites are not appropriately far enough apart. Recommendation: That the distances between Control and Impact sites be a minimum of 200m apart, unless physically not possible to do, in which case they need to be as far apart as it possible.	Adopted- plan updated	
TFrMP9	Section 5.3.1 and 10	Should be Lemckert and Morse 1999. I note that this reference is not in the reference section at the back, along with a few others. Recommendation: Complete and make accurate the reference list.	Adopted- plan updated	
TFrMP10	5.3.1	It is possible that some Wallum Sedge Frog breeding sites will be less than 50m in diameter/length (recent studies from Simpkins and Cat). Would be worth saying that transects for the Wallum Sedge Frog should be 50m in length unless the area is too small the achieve this. This would then need to be taken into account when analysing monitoring data. As per the Giant Barred Frog, this may mean a time-constrained search. Recommendation: That all transects be kept to the specified size unless otherwise impossible. This is not negotiable.	Adopted- plan updated	
TFrMP11	5.3.1	Recommendation: Transects of Giant Barred Frogs be 20m wide and cover both sides of the stream. Transects for Green-thighed Frogs be 20m wide and cover the bank of the breeding site.	Adopted- plan updated	

Expert Comments				
	Section	Recommendation	Recommendation has been addressed (Version 1)	
	6.3.4	For the Wallum Sedge Frog, the extent of vegetation planted inside the pond is the key point, not that next to the pond. They live in emergent sedges not around the edges of ponds and so monitoring surrounding vegetation appears to have little relevance. Recommendation: The extent of emergent vegetation is measured as well as bank vegetation.	Adopted- plan updated	

Expert Comments				
	Section	Recommendation	Recommendation has been addressed (Version 1)	How recommendation has been addressed (Version 2.1)
				from these projects will be used to inform pond construction for the W2B Project.
	6.3.4	The planting of densely packed emergent vegetation on pond fringes will minimise Cane Toad predation, not prevent it. They still use this habitat to some degree (See Semeniuk et al 2007).	Adopted- plan updated	
	6.3.4	Green-thighed Frog compensatory ponds need to be ephemeral because otherwise they will not use them. Recommendation: That it is recorded that compensatory ponds for this species cannot be permanent ponds.	Adopted- plan updated	
	6.3.4	Recommendation: That the design of Green-thighed Frog compensatory ponds be changed to state that they be created as large as is practically possible under the circumstances, be temporary pools and be placed, as far as is possible, within the most typically used habitats: wet sclerophyll or swamp forest with a dense understorey and deep leaf litter.	Adopted- plan updated	
	6.3.4	I would note that the water quality parameters presented are fine for the Wallum Sedge Frog, but are not likely to be useful for the Green-thighed Frogs. They are not a Wallum species. I would strongly suggest that water quality requirements for Green-thighed Frogs be included as a well, with limits on what is and is not acceptable. I do not know specifically what they should be, but they should not be acid. Ledlin (1997) has some information on this. Recommendation: Include a table that notes the water quality parameters that should be achieved in compensatory ponds for each frog species, including minimum and maximum variation points that are acceptable.	Adopted- plan to be updated prior to implementation.	The plan has been updated to include separate design elements for the construction of compensatory ponds for Wallum Sedge Frog and Green-thighed Frog in Section 4. The proposed designs are based on those employed successfully within the Tugun Bypass and Kempsey Bypass Projects, for Wallum Sedge Frog and Green-thighed Frog respectively. Section 5.3.12 details design elements and references to water quality measures.
	6.3.3	I would just like to see it clarified that fall broadcast surveys should not be carried out during the day. Recommendation: Call surveys are noted as not to be undertaken during the day.	Adopted- plan updated	
	6.3.3	The plan should provide a specific definition of a person experienced in frog exclusions. Recommendation: A specific level of experience is included for a qualified person to ensure consistency through the program. I would recommend a minimum 2 years or 1000 trap-nights as a starting point for consideration.	Adopted- plan updated	
	6.3.9	The plan states that fences should installed for up to 200m either side of potential or known threatened frog habitat. This makes it okay to be only 20m as this falls into the criteria of up to 200m. I believe that a table would be most useful that specifically defines what are correct distances for different species and different habitats and why they should be that size. For example, Giant Barred Frog fencing need be no more than 50m wide based on the research of	Adopted- plan to be updated prior to implementation.	Species-specific wording has been added within Sections 5.3.3 and Section 5.3.9 which specifies lengths and locations of proposed exclusion fencing for temporary and operational

Expert Comments				
ID No	Section	Recommendation	Recommendation has been addressed (Version 1)	How recommendation has been addressed (Version 2.1)
		the movements of these frogs (Lemckert et al, Streatfield, Koch). Green-thighed Frogs probably need more, although there is little to base this on. I have done only a very limited study of this species that cannot say much as it was too short term to say anything about distances. Would be better applying a general approach as advocated by Semlitsch and Bodie (2003) or Lemckert (2004) which would fit in with the idea of a minimum 200m for smaller frogs, although a recent paper on the Wallum Sedge Frog (Meyer et al) indicates that they may move much further. Recommendation: A table is included that defines the correct distances of fencing for different species and different habitats and locations and why they should be that size.		fencing respectively.
TFrMP22	6.3.6	Recommendation: Define what "where is reasonable and feasible" means.	Adopted- plan updated	
TFrMP23	6.3.6	Recommendation: The TFMP should list rules on the maximum distances that frogs can be translocated.	Adopted- plan to be updated prior to implementation.	Plan updated to include maximum distances for frog relocation i.e. no more than 100m.
TFrMP24	6.3.6	The TFMP information should be altered to reflect the general information available on the movements of this species.	Adopted- plan to be updated prior to implementation.	Information has been included and informed design of mitigation measures such as fencing.
TFrMP25	6.3.8	How long should they be acclimatised for? 5 minutes? One hour? I am sure the former is not anywhere near long enough. Recommendation is that this needs to be specified: a minimum of 30 minutes.	Adopted- plan updated	
TFrMP26	6.3.9	Does the frog fencing for the Woolgoolga to Glenugie project work? No point in including it in other works if it does not. Similarly, does the frog fencing in Figure 5-1 that was designed specifically for the Green-thighed Frog actually work to stop the Green-thighed Frog? Recommendation: The TFMP include a table that includes the type of fencing that is suitable for use for each species and what the evidence is that demonstrates it is suitable.	To be reviewed prior to implementation	Roads and Maritime are still completing monitoring studies for Woolgoolga to Glenugie in relation to the effectiveness of frog fencing. The frog fencing design proposed is consistent with that on previous Roads and Maritime projects and effectiveness will be reviewed through the proposed monitoring program. An adaptive approach is proposed and should fencing be determined not to be effective for some species then the design will be altered to improve outcomes during the construction and operational phase.
TFrMP27	Table 6-2	The TFMP must define what a high rate of injury during clearing works is? Recommendation: The TFMP defines the type and extent of injuries which leads to a classification of a high injury rate.	Adopted- plan updated	
TFrMP28	Table 6-2	What does Chytrid affected frogs found mean? As noted previously, it is not possible to guarantee that a frog carrying Chytrid can be identified as such by a visual inspection.	Adopted- plan updated	The management of chytrid has been retained in the TFMP as it is a potential

Expert Comments				
	Section	Recommendation	Recommendation has been addressed (Version 1)	How recommendation has been addressed (Version 2.1)
		Recommendations: That this form of Chytrid sampling be dropped from the MP.		threat to native frogs within the project area. It is agreed that it is not effective to test frogs for Chytrid or undertake visual surveys. The proposed approach is to presume that Chytrid is present and to adopt appropriate mitigation measures to minimise the spread of this fungus. The chytrid fungus (*Batrachochytrium dendrobatidis*) is a water borne pathogen that has been previously implicated in frog declines and disappearances both here in Australia and around the world (Berger *et al*. 1998; Skerratt *et al.* 2007). It can be spread readily between wetlands and catchments with both personnel and equipment acting as inadvertent vectors. Consequently, it is widespread in eastern Australia (Kriger et al. 2007) but management controls still form part of combating its spread via the adoption of procedures outlined in the Department of Environment and Climate Change (Now Office of Environment and Heritage) *Hygiene protocol for the control of disease in frogs. Information Circular Number 6* which is provided in Appendix G. This includes the use of a disinfecting solution, containing benzalkonium chloride as the active ingredient, being sprayed on footwear and vehicle tyres in areas known to or suspected of containing the Chytrid. Further information regarding the proposed management of Chytrid is detailed in Section 5.3.5.
	Table 6-2	How many is multiple tadpole deaths? I presume that two is enough. If that is 2 out of 10000, will that be a problem. This needs defining given the document has raised tadpole deaths as a	Adopted- plan updated	

Expert Comments				
	Section	Recommendation	Recommendation has been addressed (Version 1)	How recommendation has been addressed (Version 2.1)
		significant problem that is a performance criteria. Recommendation: The TFMP defines the type and extent of injuries that are considered to be associated with de-watering and the number of tadpoles that should be considered too many. I would suggest 1%.		
	7.3.4	Maintenance of compensatory ponds. What does "be maintained routinely" mean? Recommendation: Define accurately the term routinely.	Adopted- plan updated	
	Table 7-1	Taking three days to clear a breach seems a rather long time. How few sightings of frogs are required to decide that connectivity structures are not being used successfully or appropriately by frogs? If one or two frogs use it in a year, would this be deemed sufficient to consider it successful? I would assume not, but the plan seems to say yes. It needs a proper definition. Recommendation: The TFMP defines the number of sightings necessary to conclude a structure is working. I would recommend 1% of the approximate population size of the frogs per year. This would maintain genetic diversity.	Adopted- plan updated	
	Table 7-1	How much would constitute activity at a pond would be required before it is determined that a pond is being used successfully after 2 years? Recommendation: I would recommend a definition of a successful pond must include that a minimum 20% of the original number of frogs located at the previously used pond must use that pond for at least 3 years and that successful reproduction in the form of tadpoles from a minimum of three separate clutches reaching metamorphosis be included as the final performance criteria.	Adopted- plan updated	
	Table 7-1	The TFMP needs to define specifically the levels of water quality variation that are not acceptable for the breeding sites. Recommendation: Covered previously.	Adopted- plan updated	
	8.1	In the first full paragraph it is stated that at least two control sites should be selected per relevant project section. Recommendation: The number of control sites should be the same as the number of impact sites to get a balanced design, which makes analysis much simpler and more effective. Preferably there should also be a minimum of five independent samples within each category of sites. This would provide a minimum of statistical robustness under a normal Analysis of Variance analysis.	Adopted- plan updated	
				for each frog species.

Expert Comments				
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				Monitoring program proposed includes: Population monitoring for each of the three frog species is based on a BACI (Before-After-Control-Impact) design in an attempt to measure the effectiveness of the mitigation measures being used to manage *in situ* populations of threatened frogs. It follows a mitigation-construction BACI design, with populations compared at two treatment levels: Treatment 1 (Impact Sites): Sites known to contain the target species at or close to the construction footprint which are likely to be impacted by the Project. Treatment 2 (Control/Reference Sites): Sites located in adjacent areas unaffected by the Project. Due to the differing habitat requirements of the target species this is considered at different scales. Based on present pre-construction baseline surveys it is summarised as follows: • Green-thighed Frog with five paired sites from Sections 1 and 2; • Giant Barred Frog with three paired sites from Section 1 and 2; and • Wallum Sedge Frog with five paired sites from Sections 8-10. The monitoring performance trigger is using a relative decline in abundance of 25% or more at an impact site than its relative control site over 3 consecutive monitoring periods.

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				Frog abundance will be determined by standardised transect counts: • Number of Wallum Sedge Frogs per 100 m2 of habitat; • Number of Giant Barred Frogs per 500 m of habitat; • Number of adult male Green-thighed Frogs per Stage 1 survey (breeding survey) (as outlined in Section 4.3). Three monitoring periods has been used as this is a requirement of the projects condition of approval. If a decline of this magnitude is found to occur then corrective actions are described.
TFrMP36	8.2.1	Monitoring programs that do not undertake specific experimental manipulations are not likely to be able to determine the causes of any decline, just that there has been a decline. Specific tests will be required after that to assess what caused it. Similarly one of the critical failures of so many monitoring programs is the lack of definition of what an acceptable change in populations is and what is not. They usually say just that to monitor for a decline. Given the variability in frog numbers under natural circumstances and that there is likely a pattern of mostly declines with occasional increases under natural population processes (see Alford and Richards 1999), it is both very difficult to detect a decline statistically without a good program and it is not clear what it means even if a decline is detected where a drop in numbers in one year is all that is needed to trigger a response. I highly recommend that a standard monitoring strategy is provided in the TFMP to be used in subsequent MPs. It would be very useful to have a fully worked up and scientifically based template as to how monitoring should take place for each species – what methods, when, how long for and what are acceptable changes. This would ensure a uniform program is used across the remaining areas of Upgrade and significantly improve the quality of monitoring compared to what has been achieved previously. One of the other main values of providing such clear guidelines is that the same approach can	Adopted- plan updated	

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		be repeated accurately and consistently across all of the sections of road to be covered, which will provide valid comparisons between sections and data that can be pooled to provide a more sensitive meta-analysis of mitigation success across the range of Upgrades. That ultimately will give the Roads and Maritime a lot more power and confidence to say that mitigation is working or which mitigation works and which does not. This should be very useful in the long-term for overall frog management.		
TFrMP37	8	It is stated that there is a preference for a BACI style monitoring program. However, using presence/absence as a means of defining change is not used in BACI studies because such an approach is not sensitive enough. Recommendation: A BACI program is used and it is based on population count data.	Adopted- plan updated	
TFrMP38	8.2.2	I am not sure what "noticeable change in calling males or populations" means and it is not a useful measure of frog abundance. Frogs are notorious for their variation in calling activity between nights and so using this as fine-scale means of determining changes in population size is highly unadvisable under most circumstances, unless there are a lot of sampling points to account for this variation. Visual population counts or, much more preferably, mark-recapture studies generally are much more useful if carried out well. Recommendation: The Giant Barred Frogs and Wallum Sedge Frog should be monitored using a combination of counts of calling and visually identified animals. This is suitably based around the suggested transects.	Adopted- plan updated	
TFrMP39	8.2.2	Green-thighed Frogs are an unusual exception to this rule as it seems that all males call at the same time over a very short period and individuals otherwise, are very difficult to locate. Recommendation: Total counts of adult males Green-thighed Frogs are used to monitor this species.	Adopted- plan updated	
TFrMP40	8.2.2	The term "noticeable change in populations" needs to be defined appropriately if there is going to be any valid monitoring comparisons. As before, I did suggest a 25% decline in populations over 5 years, but there is dependence on how long the Roads and Maritime intends to monitor for. A best level of change may be determined through a detailed review of the literature. Recommendation: Already noted in regards to extent of change.	Adopted- plan updated	
TFrMP41	8.3.1	The TFMP needs to define what is a suitably qualified and experienced ecologist is to be used for frog monitoring? In regards to frogs, it is far better to say a suitable qualified and experienced herpetologist and define what a suitable level of qualification and experience is. For the Nowra Upgrade of the Princes Highway, a suitably qualified expert for the Green and Golden Bell Frog was defined as someone with at least 5 years' experience working with that frog. This is a good starting point. Recommendation: As noted before, define the minimum level of experience for each action. I would suggest an expert is someone who has had at least 5 years of experience working with the targeted frog. I would also suggest as an addition or an alternative including the requirement to have successfully detected the target species on at least 10	To be reviewed prior to implementation	A definition of a 'suitably qualified ecologist' has been included to provide further clarity around the minimum experience an ecologist should have to complete the required frog monitoring. The definition has been updated to be "a person with a tertiary degree in a related field (e.g. Environmental Science / Ecology) with a minimum five years of experience conducting targeted frog

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		occasions. The latter will clearly demonstrate that the herpetologist is capable of finding these often hard to locate species.		surveys, and for projects of a similar scale and complexity as the W2B project."
TFrMP42	8.1	As before, why would you choose 3 impact sites and 2 control sites? This is unbalanced and so statistically already a poor design. It should be at least 3 and 3 and preferably 5 and 5. The TFMP states that monitoring of control sites should try to follow the same approach in using transects. Recommendation: the control sites MUST be sampled in the same way as the impact sites. Otherwise they are not control sites and the monitoring program and analysis is invalid.	Adopted- plan updated	
TFrMP43	8.3	Why should the evidence of the effectiveness of exclusion fencing be clear? I have already noted that hylid frogs climb fences of any type very well when they want to. I would not expect to see no frogs vs. lots of frogs. However, if the monitoring program is carried out effectively and the data collected adequately, the evidence for the effectiveness of the exclusion fencing should be statistically clear. Recommendation: The TFMP notes that there should be no detectable change in the numbers of frogs associated with areas controlled by frog fencing.	Adopted- plan updated	
TFrMP44		When will the surveys of frogs occur for road kills? Surveying frogs for road kills is very hard to do and dangerous. Dead bodies are rapidly crushed and scavenging birds remove them usually relatively quickly. This monitoring needs to be carefully planned and managed. Is there a guide as to how this will be done? The TFMP should include a standard protocol for carrying out road kill surveys such that it will be safe for those carrying out the work. Recommendation: Remove the monitoring of Road kills as a requirement in the MP.	Adopted- plan updated	
TFrMP45	8.3.2	Recommendation: Corrective actions must be undertaken if the performance criteria or are not met or set thresholds are breached. This is essential to demonstrate compliance.	Adopted- plan updated	
TFrMP46	8.4.1	Recommendation: Do not use pitfall traps or motion sensitive cameras as a means of monitoring connectivity.	Adopted- plan updated	
TFrMP47	8.4.1	Recommendation: State that time-lapse cameras be used as a minimum monitoring method for connectivity structures.	Adopted- plan updated	
TFrMP48	8.4.2	Again define what would be considered to be effective use of the underpasses. One frog? Ten frogs? 5% of the known population number. A 50% drop in road mortality? I am not sure the best method without doing a detailed literature review and consideration of each species. The ultimate aim would be to maintain sufficient connectivity between both sides of a road to ensure long-term genetic integration of the overall population. This is not well known for Australian frogs but a level may be justifiable with a detailed review of the available scientific literature. Recommendation: As previously advised, the use of the structure by a minimum 1% of the estimated population size.	Adopted- plan updated	
TFrMP49	8.4.2	How will increasing the monitoring program actually be a corrective measure for use of connectivity structures or, more critically, road kill? It is not a corrective measure. It is just a	To be reviewed prior to implementation	It is not possible for Roads and Maritime to add in new crossing structures for

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		means to determine if the connectivity structures appear to be working. The corrective measure would be to add additional structures or change the structure or stop frogs using the road in some other way. Recommendation: Change the table to read to change/add to the structures and monitor.		frogs once the highway has been constructed. Crossing structures need to be finalised during detailed design. If crossing structures aren't proving to be used by frogs then an increase to the monitoring will firstly assist to provide greater certainty that frogs are in fact using or not using the structure. For example by increasing frequency, intensity and duration of monitoring, to ensure individuals are being identified. Additional corrective actions are also stated as: Survey habitat adjoining the connectivity structures and undertake landscape improvement (planting, weed removal) to improve habitat functionality. Survey crossing structures to ensure they are functional (i.e. are adequately maintained, including fencing is not damaged, and connectivity structure is operating correctly). Assess the need for offsets if connectivity structures are identified as ineffective over three consecutive monitoring periods. Frog road kill is not proposed to be monitored.
TFrMP50	8.5.2	What will happen if frogs are present at compensatory breeding sites, but are not breeding at them? There is no corrective measure identified. I would assume it would mean that a review be undertaken of the created habitat to see if it was not created properly and measures taken to either alter the current pond or create new ones that will provide better habitat and that are again monitored to determine if they are more and suitably effective. That is adaptive monitoring and management and represents an actual corrective action. This should be changed. Recommendation: That if compensatory breeding habitat does not produce metamorphs within 3 years, that an investigation be undertaken to determine why there may be a lack of success and, as where recommended, changes be made to the habitat and monitored	Adopted- plan updated	

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		for effectiveness (ie 3 more years of monitoring).		
TFrMP51	8.6.1	Why up to four 0.5 m^2 quadrats. Should not the sampling be standardised for all sites to allow proper comparisons? Recommendation: The TFMP should simply state that four 0.5 m^2 quadrats will be undertaken at each site to provide replicate data sets.	Adopted- plan updated	
TFrMP52	8.6.2	Define what good quality habitat restoration requires. At what point is it restored? We know that 30% loss of revegetation is bad, but at what time does restoration become adequate. Recommendation: Define what good quality habitat is so that it can be measured against.	Adopted- plan to be updated prior to implementation.	Additional criteria have been included to describe what constitutes good quality compensatory frog habitat. This has been included in Section 4.4.4, 4.4.5, 5.3.4. These criteria include water quality parameters such as pH, salinity and conductivity as included within Section 5.3.12 with performance indicators for breeding ponds outlined in Table 7-3. They also cover aquatic plant and fringing plant requirements. In relation to revegetation additional performance criteria have been included such as weed cover percentage and survival rate of individual plants.
TFrMP53	8.6.2	What is "evidence of threatening processes being controlled or eradicated"? This suggests that one person maintaining a fence or removing a weed means that the threshold has been reached and all is good. I doubt this is what is meant. Again, state what is the minimum allowable level of maintenance to be undertaken each year? Recommendation: Define what appropriate evidence is.	Adopted- plan updated	
TFrMP54	8.7	Recommendation: Annual reporting include an analysis of the data to determine if change has taken place and/or demonstrate if there is enough power to detect the specified levels of unacceptable change.	Adopted- plan updated	
TFrMP55	8.7	Recommendation: Defining suitable levels of experience has already been covered.	To be reviewed prior to implementation	A definition of a 'suitably qualified ecologist' has been included to provide further clarity around the minimum experience an ecologist should have to complete the required frog monitoring.
TFrMP56	Appendices	Profiles. Make sure that the same types of information are included in each of the profiles, providing a consistent approach to their management. As an example, some of the profiles contain specific information on the breeding season of the target species and some don't. Recommendation: The categories in each of the profiles are standardised.	Adopted- plan updated	
TFrMP57	Appendices	The Giant Barred Frog has not been found south of the Hawkesbury River despite Cogger	Adopted- plan updated	

Expert Comments				
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		(2000) saying so. The Giant Barred Frog is not known to disperse hundreds of metres from breeding sites on any regular basis. Recommendation: Include in the information presented the above information.		
TFrMP58	Appendices	The Green-thighed Frog is only found north of the Hawkesbury. Records south of this are erroneous. I do not know where this information comes from as it is not in the typical field guides. Recommendation: Change range to north of the Hawkesbury.	Adopted- plan updated	

Department of Environment Consultation Comments			
ID No.	Section	Recommendation	How recommendation has been addressed (Version 2.1)
1.	General	The Department recognises the additional surveys now undertaken and the substantial amount of work that has been undertaken to apply the BACI methodology, and the information now available on likely occurrences of the threatened frog species.	Noted.
2.	General	Given the new information about specific occurrences of these species, the Department notes that the plan still includes relatively general information about site specific mitigation measures proposed and still defers some of the key mitigation measures to other sub plans (e.g. location of fencing, ponds, and erosion and sedimentation measures to be implemented). The Department considers that if key mitigation measures are to be deferred to sub plans, this plan needs to set the standards that these sub plans must meet and should include key commitments the sub plans must adhere to. This would then provide confidence that mitigation measures will effectively reduce the level of impacts to threatened frogs.	We note key mitigation measures for frogs pertain to: • Frog fencing • Compensatory ponds • Water Quality Management • Connectivity structures Where more detailed information on a mitigation measure is available, and where it will be applied (e.g. frog fencing) this has been added to the plan. We have retained references to the other sub plans where this information is detailed (e.g. crossing structures in the Fauna Connectivity Strategy for Sections 1 and 2). If a sub plan is still to be finalised then information that is to be included in that sub plan will be added.

Department of Environment Consultation Comments			
ID No.	Section	Recommendation	How recommendation has been addressed (Version 2.1)
3	General	The Department requests that maps identifying the location of potential/known habitat be included as part of this document. This is particularly relevant for the Wallum Sedge frog, where the location and distribution of suitable habitat in the vicinity of the highway for the species is unclear based on the textual descriptions only. Impact area also needs to be clearly stated now that the additional surveys have been undertaken.	Habitat maps have been prepared by Amec Foster Wheeler and Lewis Ecological, with habitat for Wallum sedge frog and the Green-thighed Frog classified into two categories; breeding habitat and foraging/dispersal habitat. The basis of this habitat mapping has been previously defined and discussed in Lewis and Goldingay 2005 (i.e. habitat preference). Mapping for the Giant Barred Frog has been prepared by Lewis Ecological Surveys. Habitat for this species has not been segregated into breeding habitat and foraging/dispersal habitat on the basis both life cycle aspects take place within the riparian zone of the mapped stream habitats (i.e generally within 50 m of the edge of stream). The extent of direct impacts to frog habitat have now been included into the plan in Section 3.4.
4.	General	Key sections of the document, and mitigation measures proposed within, are currently worded as recommendations. The Department recommends that this wording be strengthened to clear commitments by RMS.	Terminology has been updated to imply a commitment not a recommendation throughout the document.
5.	General	There seems to be confusion in the plan between performance thresholds and triggers for corrective actions. Performance thresholds are thresholds that are trying to be met and for which deviation from these thresholds would result in corrective actions being implemented (as is written in the headings of tables within the document). On the other hand triggers for corrective actions are negative outcomes which would trigger corrective actions. Currently the majority of the actions/statements under the performance measures heading are actually triggers for corrective actions. Therefore, as currently written, deviation from these measures, which would trigger corrective actions, would in effect result in corrective actions being implemented when the desired outcome is being achieved. The actions under the heading or the terminology used in the heading needs to be amended to address this inconsistency. For example, in table 5.2, a performance threshold is “temporary exclusion fence not installed prior to construction commencing”. Should the performance threshold be deviated from (i.e. the fence is installed), the plan recommends that the following corrective action be	Clarification has been made for both headings and the wording regarding performance thresholds and corrective actions to ensure the intent of this table is clear and consistent.

Department of Environment Consultation Comments			
ID No.	Section	Recommendation	How recommendation has been addressed (Version 2.1)
		implemented "Delay construction until temporary fencing has been installed". Either the threshold should reworded to be "temporary exclusion fence installed prior to construction commencing", or modify the headings of the table to trigger for corrective action and corrective action.	
6.	General	The Department recommends that additional information regarding the methodology used in surveys, the location of surveys, and the data recorded be provided to ensure the robust replication of these surveys as part of the ongoing monitoring (see for example the water quality management plan). The description of the goals, performance measures, and corrective actions linked to the ongoing monitoring using the BACI methodology also needs to be clearly articulated to ensure that this monitoring achieves its intended outcomes. The Department also recommends that a discussion of the adequacy of the baseline data meeting the requirements of this monitoring is required.	Additional information has been included in Section 2 regarding details of the frog surveys. This includes a reference to the appropriate appendices for further details.
7.	Requirements of condition B39	As a culvert is proposed for Dirty Creek, the requirements of this condition would activate (as well as for any other tributaries where Giant Barred Frog is identified). This plan needs to demonstrate that the survey methodology proposed has been endorsed by NSW OEH/EPA, in accordance with this condition, and that the plan discuss/demonstrate that the surveys undertaken provide sufficient baseline data to meet the requirements of the condition. A corrective action of additional offsets needs to be included in the plan.	The Giant Barred Frog baseline surveys, the methods used, and proposed monitoring program are detailed in this Threatened Frog Management Plan. Frog survey methods are also described in the BMF. RMS are currently seeking EPA and DPE approval of this plan. Monitoring for the Giant Barred Frog where there is a crossing structure other than a bridge will need to demonstrate compliance with Condition B39. Should monitoring upstream and downstream of the crossing structure show an absence of Giant Barred Frogs, and it is likely to be as a result of the project, an additional corrective action has been included in the relative corrective action tables that offsets will be provided to compensate for this impact.
8.	Condition D2 - Connectivity	The Department notes that this plan is proposed to meet some of the requirements of condition D2 (as per the table in the beginning of the document). The Department notes that the justification for the location and design of connectivity measures, based on the results of the further surveys is not provided. Rather, the connectivity measures as originally proposed in the EIS are presented. This is of particular relevance to the Wallum Sedge Frog, which has now been identified on either side of the proposed highway (see comments below). If this plan is to meet the requirements, it must be updated to address this. Sub condition e regarding service roads is not addressed; sub condition h, location of proposed fencing not provided. A discussion and/or commitment to further offsets should connectivity be lost in key locations is required. This is relevant to Dirty Creek for the Giant Barred frog and areas where Wallum Sedge frog is located on either side of the proposed highway.	Connectivity measures are now finalised for Sections 1 and 2 which are described in Section 5.3.10 and are also detailed in the Fauna Connectivity Strategy. The locations have been supported by further pre-construction baseline surveys for frogs and habitat mapping. Fencing locations for frogs in

Department of Environment Consultation Comments			
ID No.	Section	Recommendation	How recommendation has been addressed (Version 2.1)
			Section 1 and 2 are now provided in Section 5.3.3 and Section 5.3.9 and have been informed by frog habitat mapping and location of known breeding habitats. Fencing for Sections 3-11 are provided as indicative locations based on frog habitat mapping. However final locations will be confirmed post detailed design and during development of the next Fauna Connectivity Strategy for Sections 3-11. The location of service roads will be taken into account during the detailed design phase and will not conflict with connectivity. Additional wording has been added regarding the use of offsets if connectivity is lost.
9.	Condition D8	Sub condition a - Reference to the mitigation framework is required, and how the additional surveys described in this plan meet these requirements Sub condition b – the impact area in hectares needs to be provided for the Wallum Sedge Frog. Sub condition f - Further updates are required ensure mitigation measures, thresholds and corrective actions are specific and time bound. Sub condition k – requires that monitoring be undertaken until such time as mitigation is demonstrated to be effective over three consecutive monitoring periods. This requirement has not currently been met for all monitoring proposed.	Mitigation Framework is referenced. Frog surveys have been summarised in Section 2. The Mitigation Framework outlines how surveys have complied with relevant guidelines. Information regarding habitat impact areas (Ha) has been added to Section 3.4 now that habitat mapping has been completed. Discussions about mitigation methods and corrective actions have been refined and strengthened.
10.	Page 15	As per other threatened species plans, the document could be updated to state that it has been prepared in consultation with DoE.	Wording updated to state this plan has been prepared in consultation with DoE.
11.	Page 31	The Department recommends that weed monitoring and management is also required during the operational phase.	Weed monitoring and management has been addressed in operational phase.
12.	Page 36	The minimum length of fencing proposed for the Wallum Sedge Frog and a justification for the basis of this decision is required.	Based on guidance from Ben Lewis, an indicative length of fencing has been determined for Wallum Sedge Frog by assessing mapped habitat areas. Information is provided on fence design for each species, and proposed length

Department of Environment Consultation Comments			
ID No.	Section	Recommendation	How recommendation has been addressed (Version 2.1)
			of fencing for each species in Section 4.4.3, 5.3.3 and 5.3.9.
13.	Page 39 Table 4.1	Please confirm that exclusion zones will be in place prior to clearing. Further information is also required regarding the basis for choosing the exclusion zones (for example, that these will cover all areas of suitable habitat within the vicinity of the highway but outside the clearance area).	We have included the requirement to confirm exclusion zones will be in place prior to clearing. Exclusion zones will be informed by habitat maps and pre-clearing surveys.
14.	Page 40	Reference is made to the detail of measures being included in EWMS. The Department recommends that key commitments and outcomes need to be included in this plan to meet the requirement of the conditions of approval, as discussed in comment 2 above.	Wording added stating that the EWMS will be prepared by the contractor to reflect the requirements as detailed within this Section of the Frog Management Plan. This covers the potential impacts associated with construction activities.
15.	Page 40, section 5.3.3	As targeted surveys have now been undertaken, the location of proposed fencing should now be known. The Department requests that this information be included as part of this plan. A stronger commitment to fence design is also required. For example, the document currently describes the design requirements as recommendations, with the use of words such as "should" rather than "must".	Text has been added to Section 5.3.3 and Section 5.3.9. Wording has been strengthened to state "will" and "must".
16.	Page 42. Section 5.3.6	Please define "adjacent to" in the sentence pre clearing surveys would be undertaken where the clearing footprint is adjacent to known or potential habitat to clarify what distance habitat would be considered adjacent to the highway. The recommendations in this section should be updated to reflect that these are commitments that have been adopted by RMS, not recommendations.	This has been defined as within 50m.
17.	Page 43	Unexpected finds procedure: please confirm that the procedures proposed when frogs are found within known habitat areas (e.g. maximum relocation distance etc) would apply to unexpected finds.	Have used 50 m as a default. Plan updated with the following: If any species is found, they should be relocated to similar habitat within 50 m of where they were found.
18.	Page 43	Please clarify in what circumstances dewatering would be required. Based on the surveys that have now been undertaken, the Department is of the understanding that the locations for dewatering would now be known, and requests that these are clearly identified in this plan, and the resulting loss of habitat included as part of the total impact, which should also be described in this plan.	Exact locations of sites to be dewatered will be identified during pre-clearance surveys as seasonality is a factor. Additional wording has been added to address this in Section 5.3.8.
19.	Page 44	Please include further information regarding the length, design and location of the Wallum sedge frog fencing, as well as a commitment to the proposed height for the Wallum Sedge Frog fencing.	This is detailed on Page 44 but has also been added to Wallum Sedge Frog paragraph.
20.	Page 44	Currently, no measures are proposed to mitigate water quality impacts, including those from erosion and sedimentation as a result of the vegetation clearance to be undertaken within the vicinity of key habitat area (including Corindi River, Dirty Creek and Wallum Sedge Frog occurrences). This plan needs to include these measures, and key commitments, particularly as they relate to key habitat areas.	Wording has been included in relevant sections to define targets and mitigation measures regarding water quality and

Department of Environment Consultation Comments			
ID No.	Section	Recommendation	How recommendation has been addressed (Version 2.1)
			erosion and sediment control.
21	Page 47	A statement is made that there are no occurrences of Wallum Sedge Frog on either side of the Highway. This is contradictory to the survey results described in this plan where the species has been located on either side of the proposed highway. Please amend and provide further discussion as to how the connectivity in these areas will be maintained.	The proposed structures that will maintain connectivity across the areas of Wallum Sedge Frog habitat have been discussed in more detail in Section 5.3.10.
22.	Page 47	A discussion is also required as to the likelihood of the Wallum Sedge Frog using a land bridge, based on the ecology and known habitat use of the species, including the measures that are proposed to make the habitat on the land bridge suitable (while also addressing the requirements of other species targeted to use this structure). Based on current information, the Department considers that further connectivity measures that are known to be effective for frogs (i.e. a bridge under the highway) are required in these areas. Alternatively, this area must be considered as an area where connectivity for the Wallum Sedge Frog is likely to be lost, and this loss will require an offset. This issue needs to be addressed in the Plan.	A brief discussion about the use of land bridges by the Wallum Sedge Frog has been included in Section 5.3.10. It has also been noted in this section that a proposed underpass will also provide connectivity for the Wallum Sedge Frog across this habitat as is supported by monitoring surveys of underpasses on the Tugun Bypass project (SMEC 2011).
23.	Page 48	Key commitments regarding erosion and sedimentation are required, particularly for the key habitat areas for the threatened frogs that have now been identified.	More detail surrounding erosion and sediment control measures has been included in Section 5.3.12.
24.	Page 50	The Department recommends that where temporary fencing is not installed as part of the plan's requirements and impacts to exclusion areas occur as a result, that this needs to be reported as an incident to the Environmental Representative. Depending on the severity of the impact that has occurred, this may then also need to be reported to the agencies.	Additional corrective actions included in Section 4.5.
25.	Page 50	The Department recommends that performance thresholds for water quality/erosion and sedimentation for key habitat areas be included in this table.	Specific water quality thresholds have been included in Section 5.4.
26.	Page 52	Re-vegetation – the monitoring period proposed for re-vegetation needs to include a justified timeframe, as is required by the conditions of approval. The timeframe must be sufficient to demonstrate the survival and establishment of the re-vegetated plants for three consecutive monitoring periods. It must also include a specific goal/performance measure regarding the level of survival of the re-vegetation. Stronger commitments are required.	Section 6.3.1 outlines the monitoring schedule for revegetation.
27.	Page 52 s.6.3.3	Further detail and justification is required regarding the monitoring and maintenance periods proposed for fencing, associated timeframes and corrective actions.	More detail has been added to Section 6.3.3 and 7.3.1.
28.	Page 54 Table 6.3	Performance thresholds: these are currently worded as triggers for corrective actions and should be amended as per comment 5 above. The corrective actions within this table should also be updated to have specific timeframes attached to them.	All corrective action tables have been updated to address this comment.
29.	Page 54 Table 6.3	The Department recommends that this table be updated to include a measure that ensures that if road kill is recorded in areas without fencing, that additional fencing will be installed in these areas – and that monitoring of such areas would be sufficient to identify the issue.	This comment is no longer applicable as RMS have assessed the undertaking of road mortality surveys for frogs to be impractical and unsafe. Frogs hit by vehicles are unidentifiable after a short period of time and it is unsafe to get out

Department of Environment Consultation Comments			
ID No.	Section	Recommendation	How recommendation has been addressed (Version 2.1)
			of a vehicle to check. Road mortality surveys have therefore been removed from the TFMP.
30.	Page 54 'maintenance of frog access'	The Department considers that further justification is required to demonstrate that the biannual monitoring proposed will be sufficient to identify whether or not frogs are using culverts. The methodology for the monitoring should also be provided in this document, or reference made to the document that describes the methodology. Further clarification is required as to what 're-evaluation of structures' means.	Based on lifecycle patterns of these species, biannual monitoring will be sufficient under the assumption that it is undertaken during suitable conditions. Re-evaluation of structure refers to the assessment of their suitability and success.
31.	Page 56, section 7.2.2	The document currently states that corrective actions would only be implemented where population declines can be attributable to the highway. The Department considers that should a decline be identified at impact sites and not at control sites, then the decline must be attributed to the highway, unless it can be demonstrated otherwise. This issue is addressed well in section 7.6.2 of the document, on page 59. Further justification is also required as to the numbers proposed in this section.	Updated Section 7.2.2 to reflect comment.
32.	Page 56	Please propose a corrective action should frogs vanish from a previously occupied area (but are still present at the control sites in accordance with comment above – i.e. offsets would be required as this habitat would be considered to be no longer suitable)	A corrective action has been included in the relevant table to address this.
33.	Page 57 7.3.2	Please define "high level of mortality"	This comment is no longer applicable as RMS have assessed the undertaking of road mortality surveys for frogs to be impractical and unsafe. Frogs hit by vehicles are unidentifiable after a short period of time and it is unsafe to get out of a vehicle to check frog road kill. Road mortality surveys have therefore been removed from the TFMP.
34.	Table 7.2	Please include timeframes regarding the additional information proposed.	Timeframes have been defined throughout the relevant sections.
35.	Table 7.3	The Department recommends that the corrective actions in this table be strengthened.	Corrective actions have been strengthened.
36.	Page 60 Table 7.5	Please update the corrective actions in this table to include specific timeframes; Suggest adding the word "install" in front of physical measures.	The word Install put in front of physical measures. Have included specific timeframes for corrective actions.
37.	Page 68 Expert recommendation s MP21	The expert's comments recommend a table be included that defines the distances of fencing for each species. The text that explains where and how this recommendation has been addressed refers to sections of the document that do not appear to exist within the document. The Department requests that this information be updated and the comment addressed.	References to Sections changed. Length of fencing and fence design has been included and refined.

Environmental Protection Agency Comments			
ID No.	Section	Recommendation	How recommendation has been addressed (Version 2.1)
1.	Page 21.	Points 2 and 3 suggest that there will be additional field surveys undertaken to establish baseline population data for sub adult and juvenile frogs (given the recent average to wet summer and previous dry year?). The EPA supports the additional survey if the ecologist believes it is necessary as the baseline data forms an important measure for mitigation evaluation and therefore should reflect population numbers established over as many survey periods and in as many conditions as possible, particularly for frogs. In addition please explain why the RMS dropped the recommendation from Appendix D to survey a fifth site?	This survey has been approved. The removal of the additional recommendation was an oversight due to its similarity with the comment above and has now been included.
2.	Page 21.	The EPA does not support the proposal to review sediment basin locations which may have the potential to increase the pH of receiving waters. Alternatively, rather than relocating basins, Stu Murphy (EPA Regional Operations Officer) and James Sakker (Fisheries NSW) have suggested that sensitive water management that complements Oxleyan Pygmy Perch management requirements will likely produce the desired water quality outcomes for the Wallum Sedge frog. Please refer to the floodplain infiltration/perched turkeys nest system successfully employed on the Devils Pulpit Upgrade project. However bear in mind that this approach necessitates an accurate map of known Wallum Sedge Frog habitat.	Sediment control measures such as those used in the Oxleyan Pygmy Perch management plan have been included in Section 5.3.12.
3	Page 23.	It is stated that no further survey work is required for the Giant Barred Frog (GBF) however the EPA is seeking clarification that pre-clearing survey will be undertaken.	This statement refers to the use of further targeted baseline surveys to attempt to identify more habitat. Pre-clearance surveys will continue as planned.
4.	Appendix E and Section 8.	Point 6 identifies the requirement for future GTF surveys and this is supported by the EPA given the previous year of dry weather and logistic problems associated with using non-local ecologists. However there are inconsistencies between Appendix E and the TFMP in this regard. Note that on page 4, page 25 and in the conclusions of Appendix E it is stated that "no further surveys are proposed in these locations (meaning sections 3-8?)." The EPA recommends further targeted survey for GTF at nominated habitat sites if conditions are appropriate (i.e. sufficient and ongoing rain). This view is supported by the recent GTF record by Lewis in Section 3, June 2014 whilst surveying for Rufous Bettong. It is important to establish 'known' habitat for this species as this will attract the appropriate level of construction and operational mitigation.	Additional surveys are planned for 2015. Green-thighed frog habitat mapping has been included in this TFMP version.
5.	Sections 4.2 and 4.3	It is clearly stated in these sections that a key outcome of this management plan is the identification of known and potential habitat for each species. The EPA therefore expects a series of maps that clearly illustrate the known and potential habitat of each frog species. The list of Figures illustrating vegetation types (from the EIS) is not sufficient for this purpose.	New maps have been created to show historical records, results of latest surveys and habitat areas for each species.
6.	Section 5.3.7	The unexpected finds procedure from the RMS Biodiversity Guidelines only applies to the discovery of additional threatened species (i.e. not assessed in the EIS) whereas the procedure in the TFMP and Appendix E is referring to the discovery of additional but previously assessed threatened frog individuals or populations. The EPA requires expansion of this section to list the steps that would be taken if additional threatened frog individuals or populations are discovered. This will need to include measures in addition to those already outlined in the TFMP and Biodiversity Guidelines i.e. cessation of construction and removal from construction area. For example the EPA expects an assessment of the extent of individuals and habitat, adequacy of connectivity, temporary and permanent fencing requirements, compensatory ponds, implementation of hygiene protocols and monitoring considerations. The GBF is also subject to further connectivity assessment.	Section 5.3.7 provides details of the unexpected finds procedure.
7.	Page 57.	Frog toe clipping is not supported by the EPA. The EPA understands that population persistence on opposite sides of the upgrade may provide a long term answer in cases where the population is dependent on the structure for survival or in a closed system/population.	Due to the difficulties associated with the mark and recapture of smaller frogs (<50 cm), toe clipping is considered the best option. Previous projects have

Environmental Protection Agency Comments			
ID No.	Section	Recommendation	How recommendation has been addressed (Version 2.1)
			gained ethics approval using this method. This method will be adopted to monitor use of crossing structures by threatened frog species.
8.	Page 56.	The proposed measure in decline of 25% after 5 years appears arbitrary. The EPA suggests a biostatistician is engaged by the RMS to confirm whether this represents the most feasible and meaningful measure of change. It appears that the proposed trigger does not account for population growth and decline patterns prior to the 5th year. Consider the possibility that the population could undergo a growth phase for the prior 4 years then rapidly decline. The EPA believes it is more efficient and meaningful to measure impacted population stability relative to the paired reference sites and determine whether there is a pattern of decline or growth. If there is a general pattern of decline over the monitoring period this could then trigger corrective actions and further monitoring. Bear in mind that data captured and analysed is limited to the relative population size within study area and larger population estimates may be grossly inaccurate. Population sizes can also be highly variable and respond quickly to climatic conditions (rendering any percentile measure as meaningless when used for comparisons between years). The EPA suggests that a measure of relative density at the study site using the proposed methodology will provide a replicable and quick measure of the overall population dynamic for comparison.	The context of this measure of 25% was not made clear previously. Wording has been changed to illustrate that this decline in abundance is to be measured relatively between impact and control sites, not as a standalone decline in the impact population. It was a recommendation by the expert and has been adopted by Ben Lewis in designing the BACI monitoring program. The monitoring performance trigger is using a relative decline in abundance of 25% or more at an impact site than its relative control site over 3 consecutive monitoring periods. Frog abundance will be determined by standardised transect counts: • Number of Wallum Sedge Frogs per 100 m2 of habitat; • Number of Giant Barred Frogs per 500 m of habitat; • Number of adult male Green-thighed Frogs per Stage 1 survey (breeding survey) (as outlined in Section 4.3). Three monitoring periods has been used as this is a requirement of the projects condition of approval. If this is found to occur then corrective actions are described.
9.	Page 57.	There are too many uncertainties associated with attempting to assess underpass use by evaluating success with crossing by >1% of the total estimated population. In the first instance, what is the stated objective of the structure? Is it to facilitate sufficient genetic dispersal to	This was a recommendation from the expert, as per expert comment

Environmental Protection Agency Comments			
ID No.	Section	Recommendation	How recommendation has been addressed (Version 2.1)
		maintain genetic diversity or is it to provide access to seasonal resources? How do we know if >1% of an estimated population will be enough movement to maintain viability or is it likely to be higher (for example could it be >5%?)? Also consider, as previously commented, that the population will likely be difficult to define and estimate. If the population estimate is low, a very small number of crossings will not trigger a failure. Also bear in mind that the drivers for movement may not be present over a period of time and therefore no movement in the study area would be expected and again would trigger a fail. It was previously stated in the EIS that the objective of the connectivity structures was to maintain access to habitat on either side of the highway. Therefore some movement is expected if the target frogs are present in suitable habitat on both sides of the road. As discussed in point 8 above, a suitable measure of success could be demonstrated by persistent population presence (using paired controls to compare fluctuations in population health and dynamics).	TFrMP31.
10.	Section 7.5	Compensatory ponds are supported as a useful mitigation tool however the monitoring period is critical for success given the uncertainties involved in locating the ponds and water depth etc. The RMS also needs to guarantee that good quality habitat is not removed for creation of any additional ponds.	Wording has been added to Section 4.4.5, Section 7.5 and monitoring periods are clearly defined in Table 8.1.

NSW Department of Planning and Environment Comments			
ID No.	Section	Recommendation	How recommendation has been addressed (Version 2.1)
1.	Definitions	Suitably qualified and experienced person – person to have minimum 2-years' experience conducting frog surveys for the target species and for projects of similar scale and complexity. Please justify the 2-year experience period given the independent expert recommended minimum of 5-years' experience.	The definition has been updated to be "a person with a tertiary degree in a related field (e.g. Environmental Science / Ecology) with a minimum five years of experience conducting targeted frog surveys, and for projects of a similar scale and complexity as the W2B project."
2.	Section 1	It is noted that the subsections within section 1 are numbered 2.1, 2.2, etc. This should be corrected.	Noted. Plan updated.
3	Section 2.1 (page 5)	Devils Pulpit was completed and opened to traffic in March 2014. Update reference to Devils Pulpit being under construction.	Reference to Devils Pulpit updated.
4.	Table 1.1	Comment (b) in relation to condition B39 states that Section 7.3.3 of the report addresses the requirements of the condition. There is no section 7.3.3.	Reference to Section 7.3.3 changed to 7.2.3 with respect to Performance indicators and corrective actions.
5.	Sections 2.1 and 2.2 (Page 18 -)	Explanation of paired BACI sites should be provided, including selection criteria and purpose. Are paired sites for monitoring of Green-thighed frog proposed? The ecologist conducting the pre-construction surveys for the Wallum Sedge Frog and Giant Barred Frog made a number of recommendations. The Management Plan should report the status of these recommendations.	Reference to this is made in Section 7.2.1. Defined in Glossary. Ecologist recommended additional surveys and survey sites are updated in Section 2 and 4.3.
6.	Figure 3-1	Figure 3-1 Page 10 should be inserted as Figure 3-1 Page 8 as this figure shows Section 7 of the project.	Noted. Plan updated.
7.	Table 3-3	The measures should include identification of Chytrid fungus as a key issue and proposed mitigation measure and likelihood of	The discussion of Chytrid as a key issue

		effectiveness.	and how it will be managed has been included in Sections 3.4, 3.8 and 5.
8.	Section 4.3.2	There is no discussion of site selection for the Giant Barred Frog monitoring sites. Details of the site selection process should be provided.	Information from survey reports has been included in Section 4.3.2.
9.	Section 4.4.4	Dot points following paragraph 5 on page 37 – replace deep with depth.	Noted. Plan updated.
10.	Section 5.3.10	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). Comparison of the crossing locations between the Frog Management Plan and the Fauna Connectivity Strategy is shown in the table below: Frog Management Plan — Fauna Connectivity Strategy Ch 12000 -dedicated — Ch 11710 and 12420 – dedicated Ch 25300 - dedicated — Ch 25850 – dedicated ch 3650 – 90 m bridge — Ch 3600 – 62 m bridge Ch 8550 – RCBC and RCP — Ch 8470 – dedicated RCBC Ch 8480 – incidental RCP Ch 20850 – bridge — Ch 20780 - bridge Please review the crossing locations above and amend as necessary. 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).	Amendments to the TFMP have been made in accordance with the latest Fauna Connectivity Strategy.
11.	Table 5-2	Include water quality impacts as a goal for mitigation, in particular water quality levels (eg. pH levels) of retained frog habitat and construction breeding/compensatory ponds.	Discussion of water quality characteristics and management have been added in Section 4.4.5 and Section 5.3.12.
12.	Tables 5-2, 5-3, and 7-2	Replace breeches with breaches.	Noted. Plan updated.
13.	Section 7.4.1	Toe clipping of smaller species may be used to identify frogs during surveys of connectivity structures. Is this an acceptable method of marking frogs? Should this method of marking not be endorsed by an Animal Care and Ethics Committee what alternative marking or identification method would be employed?	As per Section 7.3.1, appropriately qualified and licensed ecologists have been provided approval to undertake this methodology. This method has been approved by ethics committees for previous projects and is considered standard practice for smaller frog species.
14.	Condition B39	The requirements of Condition B39 in relation to the Giant Barred Frog (GBF) have not been addressed in full. In particular Condition B39(b) has not been addressed. The Management Plan must state that offsetting of GBF habitat is required should monitoring demonstrate that the presence of GBF has been adversely affected by the project.	Requirement for offsetting of GBF put into Table 7-1.

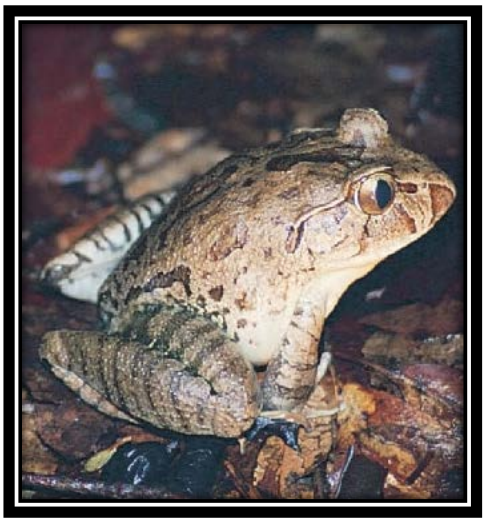
Appendix B - Dr F. Lemckert CV and expert review

Appendix C – Giant Barred Frog baseline monitoring

Appendix D – Wallum Sedge Frog baseline monitoring

Appendix E – Green-thighed Frog baseline monitoring

Appendix F - Species profiles



Giant Barred Frog

(*Mixophyes iteratus*)

Source:http://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10183

DESCRIPTION

Giant Barred Frogs are large frogs, up to 115 mm in length. They are olive to dark brown above with paler or darker blotches, and cream to pale yellow below. The skin is finely granular. The pupil of the eye is vertical and the iris is pale golden in the upper half and brown in the lower half. The call is a deep 'ork' breaking into a series of 'orks' and grunts. The Giant Barred Frog can be most easily distinguished from other barred frog species by the black thighs with smaller yellow spots, distinct barring on the limbs, dark blotches on the sides, absence of a creamy stripe on the upper lip and the distinctive eye colour.

LEGISLATIVE STATUS

TSC Act: ENDANGERED; EPBC Act: ENDANGERED.

DISTRIBUTION

Coast and ranges from south-eastern Queensland to the Hawkesbury River in NSW. North-eastern NSW, particularly the Coffs Harbour-Dorrigo area, is now a stronghold. Considered to have disappeared south of the Hawkesbury and there are no recent records from the Blue Mountains.

HABITAT

- Giant Barred Frogs forage and live amongst deep, damp leaf litter in rainforests, moist eucalypt forest and nearby dry eucalypt forest, at elevations below 1000 m.
- They breed around shallow, flowing rocky streams and deep and slow flowing streams and rivers without rocks, from late spring to summer.
- Females lay eggs onto moist creek banks or rocks above water level, from where tadpoles drop into the water when hatched.
- Tadpoles grow to a length of 80 mm and take up to 14 months before changing into frogs. They feed primarily on large insects and spiders.
- Adult frogs usually remain within 20m of their breeding stream

THREATS

- Reduction in water quality, from sedimentation or pollution.
- Changes in water flow patterns either increased or decreased flows.
- Reduction of leaf-litter and fallen log cover through burning.
- Timber harvesting and other forestry practices.
- Vegetation clearance.
- Predation on eggs and tadpoles by introduced fish.
- Weed spraying close to streams.
- Chytrid fungal disease.

Green-thighed Frog (*Litoria brevipalmata*)

Source: http://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10183

DESCRIPTION

Green-thighed Frogs are named for the bright green or blue-green colour on the groin and back of the thighs. They are small frogs (to 40 mm in length), rich brown to chocolate brown on the back, sometimes with smaller black flecks. A broad black stripe runs from the snout to the flank, ending as a series of blotches. The call is a continuous series of ‘quack’ or ‘wok’ sounds.

LEGISLATIVE STATUS

TSC Act: VULNERABLE.

DISTRIBUTION

Occurs in isolated localities along the coast and ranges from north of the Hawkesbury River to south-east Queensland.

HABITAT

- Green-thighed Frogs occur in a range of habitats from rainforest and moist eucalypt forest to dry eucalypt forest and heath, typically in areas where surface water gathers after rain. It prefers wetter forests in the south of its range, but extends into drier forests in northern NSW and southern Queensland.
- Breeding occurs following heavy rainfall from spring to autumn, with larger temporary pools and flooded areas preferred. Frogs may aggregate around breeding sites and eggs are laid in loose clumps among water plants, including water weeds. The larvae are free swimming.
- The frogs are thought to forage in leaf-litter.

THREATS

- Changes to drainage patterns which reduce periodic local flooding.
- Damage to semi-permanent and ephemeral ponds and flood-prone vegetation.
- Clearing of habitat for agriculture or development.
- Habitat disturbance through timber harvesting.
- Reduction in water quality through grazing and pasture fertilisation.
- Reduction of leaf-litter and cover of fallen logs through grazing and associated burning.

Wallum Sedge Frog
(*Litoria olongburensis*)

Source: http://www.environment.nsw.gov.au/threatenedspeciesapp/profile.aspx?id=10183

DESCRIPTION

Wallum Sedge Frogs are small, slender frogs up to 25 mm long. They are light green to light brown above, with a dark brown streak running from the nostril to the eye and down the flank and another cream-coloured stripe from below the eye to the flank. They can be distinguished from the similar but more common and widespread Eastern Dwarf Tree Frog (Litoria fallax) by their longer body, more pointed snout and brown-flecked throat. The call is an insect-like buzzing.

LEGISLATIVE STATUS

TSC Act: VULNERABLE; EPBC Act: VULNERABLE.

DISTRIBUTION

Occurs in coastal areas from Fraser Island in south-east Queensland to Woolgoolga in northern NSW.

HABITAT

- Paperbark swamps and sedge swamps of the coastal “wallum” country. Wallum is a Banksia dominated lowland heath ecosystem characterised by acidic waterbodies.
- Wallum Sedge Frogs are usually found amongst sedges and rushes in coastal wetlands.

THREATS

- Destruction and degradation of coastal wallum and coastal wetlands for road works, coastal developments and sand mining.
- Reduction of water quality and changes to acidity in coastal wetlands.
- Grazing and associated frequent burning of coastal wetlands.
- Impact by vertebrate pest species.

Appendix G – Frog hygiene protocol