APPENDIX B2

Flora and Fauna Management Sub Plan

Warrell Creek to Nambucca Heads

June 2018

Contents

Tables

Appendices

Document control

File name	WC2NH-EN-MPL- Appendix B2 Flora and Fauna Management Sub-plan
Report name	Appendix B2 Flora and Fauna Management Sub-Plan, Warrell Creek to Nambucca Heads
Revision number	8

Plan approved by:

[signed]	[signed]	[signed]
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11/12/14	11/12/14.	
AFJV Project Director	AFJV Environmental Manager	RMS representative

Revision history

Revision	Date	Description	Approval
0		Issued for RMS review	
1		Issued for stakeholder review	
2		Amendments to accommodate authority and stakeholder comments	
3	16/09/13	Updated following additional authority and stakeholder comments on NH2U CEMP	
4	12/09/14	Updated by AFJV for WC2NH Project	
5	27/10/14	Updated with comments from Roads and Maritime and ER	
6	18/11/14	Updated with final Species Specific Management Plans	
7	03/12/14	Updated to incorporate comments from EPA and DPE	
8	11/12/14	Finalised and Approved	
9	1/6/2018	Updates to various Plans	

Distribution of controlled copies

Copy no.	Issued to	Version
1	RMS	4
2	ER	4
3	Roads and Maritime and ER	5

4	Agencies	5
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Glossary / Abbreviations

CEMP	Construction Environmental Management Plan
CoA	Condition of Approval
DPI	Department of Primary Industries (Fisheries, Conservation and Aquaculture)
EA	Environmental Assessment
EEC	Endangered Ecological Community
EPA	Environment Protection Authority
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPBC Act	*Environmental Protection and Biodiversity Conservation Act 1999*
EWMS	Environmental Work Method Statements
FFMP	Flora and Fauna Management Plan
FM Act	*Fisheries Management Act 1994*
NPW Act	*National Parks and Wildlife Act 1974*
NW Act	*Noxious Weeds Act 1993*
OEH	Office of Environment and Heritage
RMS	Roads and Maritime Services
SoC	Revised Statement of Commitments included in the Submissions Report
TSC Act	*Threatened Species and Conservation Act 1995*

1 Introduction

1.1 Context

This Flora and Fauna Management Sub Plan (FFMP or Plan) forms part of the Construction Environmental Management Plan (CEMP) for the upgrade of the Pacific Highway between Warrell Creek and Nambucca Heads (the Project). The WC2NH Project is Stage 2 of the Warrell Creek to Urunga (WC2U) Project, approved by the Minister for Planning and Infrastructure in 2011.

The WC2NH section of the WC2U Project involves the upgrade of approximately 19km of the Pacific Highway from the northern end of the Allgomera deviation south of Warrell Creek to Old Coast Road, west of Nambucca Heads. The WC2NH Project is being constructed by ACCIONA Ferrovial Joint Venture (AFJV).

This FFMP has been prepared to address the requirements of the Minister's Conditions of Approval (CoA), the RMS Statement of Commitments (SoC), the mitigation and management measures listed in the Warrell Creek to Urunga Environmental Assessment (EA) and all applicable legislation.

1.2 Background

The *Warrell Creek to Urunga – Upgrading the Pacific Highway - Environmental Assessment* (RTA 2010) assessed the impacts of construction and operation of the Project on flora and fauna.

As part of EA development, a detailed flora and fauna assessment was prepared to address the Environmental Assessment Requirements issued by the then Department of Planning. The flora and fauna assessment was included in the EA as Working Paper 1 – Flora and Fauna.

The EA proposed the implementation of the mitigation and management measures, including further survey and monitoring.

1.3 Environmental management systems overview

The overall Environmental Management System for the Project is described in the Construction Environmental Management Plan (CEMP).

The FFMP is part of the AFJV environmental management framework for the Project, as described in Section 4.1 of the CEMP. In accordance with CoA B.31(b), this Plan has been developed in consultation with the Environment Protection Authority (EPA). The Department of Primary Industries (Fisheries, Conservation and Aquaculture) has also been consulted. Ongoing consultation would be in accordance with Chapter 6 of the CEMP.

Mitigation and management measures identified in this Plan will be incorporated into site or activity specific Environmental Work Method Statements (EWMS).

EWMS will be developed and signed off by environment and management representatives prior to associated works and construction personnel will be required to undertake works in accordance with the identified mitigation and management measures.

Used together, the CEMP, strategies, procedures and EWMS form management guides that clearly identify required environmental management actions for reference by AFJV personnel and contractors.

The review and document control processes for this Plan are described in Chapter 10 of the CEMP.

2 Purpose and objectives

2.1 Purpose

The purpose of this Plan is to describe how construction impacts on ecology will be minimised and managed.

2.2 Objectives

The key objective of the FFMP is to ensure that impacts to flora and fauna are minimised. To achieve this objective, the following will be undertaken:

- Ensure controls and procedures are implemented during construction activities to avoid, minimise or manage potential adverse impacts to flora and fauna within and adjacent to the Project corridor.
- Ensure appropriate measures are implemented to address the relevant EPBC Approval outlined in Table 3.3 and mitigation measures as outline in Table 3.4-1.
- Ensure measures are implemented to address the relevant CoA and SoC outlined in Table 3.1 and Table 3.2, and the management measures detailed in the EA.
- Ensure measures are implemented to comply with all relevant legislation and other requirements as described in Section 3.1 of this Plan.

2.3 Targets

The following targets have been established for the management of flora and fauna impacts during the project:

- Ensure full compliance with the relevant legislative requirements, CoA and SoC.
- No unapproved disturbance to flora and fauna outside the proposed construction footprint and associated access tracks and site compounds.
- No increase in distribution of weeds currently existing within the project areas.
- No new weeds introduced to the project areas.
- No transfer of plant diseases or pathogens to or from the project work areas.
- No net loss of significant habitat resources including hollow logs and tree nesting hollows, with materials cleared from the construction area re-used in adjacent areas where possible.
- Effective rehabilitation / revegetation that ensures different successional stages of rehabilitation are achieved.
- No fauna mortality during construction.
- Not facilitate spread of feral animals as a result of construction.
- No pollution or siltation of aquatic ecosystems, wetlands, endangered ecological communities or threatened species habitat.
- Minimise barriers to fauna movement and fish passage.

3 Environmental requirements

3.1 Relevant legislation and guidelines

3.1.1 Legislation

Legislation relevant to flora and fauna management includes:

- *Environmental Planning and Assessment Act 1979* (EP&A Act).
- *National Parks and Wildlife Act 1974* (NPW Act).
- *Threatened Species and Conservation Act 1995* (TSC Act).
- *Fisheries Management Act 1994* (FM Act).
- *Native Vegetation Act 2003*
- *Noxious Weeds Act 1993* (NW Act).
- *Pesticides Act 1999.*
- *Animal Research Act 1985.*
- *Environmental Protection and Biodiversity Conservation Act 1999* (Commonwealth) (EPBC Act).

Relevant provisions of the above legislation are explained in the register of legal and other requirements included in Appendix A1 of the CEMP.

3.1.2 Additional approvals, licences, permits and requirements

Refer to Appendix A1 of the CEMP.

3.1.3 Guidelines

The main guidelines, specifications and policy documents relevant to this Plan include:

- RMS QA Specification G36 – Environmental Protection (Management System).
- RMS QA Specification G40– Clearing and Grubbing.
- RMS QA Specification R176 – Native Seed Collection.
- RMS QA Specification R178 – Vegetation.
- RMS QA Specification R179 – Landscape Planting.
- RMS Environmental Direction No.25 - Management of Tannins from Vegetation Mulch (January 2012).
- RMS *Practice Note: Clearing and Fauna Management – Pacific Highway Projects* (May 2012).
- RMS *Biodiversity Guidelines* (September 2011).
- NSW Fisheries, *Why Do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings*, Fairfull and Witheridge, 2003;
- *Fishnote – Policy and Guidelines for Fish Friendly Waterway Crossings* – November 2003;
- NSW Department of Primary Industries, *Policy and guidelines for fish habitat conservation and management*, (2013 upate);

- NSW National Parks & Wildlife Service. 2001. *Policy for the Translocation of Threatened Fauna in NSW: Policy and Procedure Statement No. 9* Threatened Species Unit, Hurstville NSW;
- Australian Network for Plant Conservation. 2004. *Guidelines for the Translocation of Threatened Plants in Australia*, 2nd Edition.
- DECCW. 2008. *Hygiene protocol for the control of disease in frogs*.
- Relevant recovery plans, priority action statements and best practice guidelines.

3.2 Minister's Conditions of Approval

The CoA relevant to this Plan are listed Table 3-1 below. A cross reference is also included to indicate where the condition is addressed in this Plan or other Project management documents.

Table 3-1 Conditions of Approval relevant to the FFMP

CoA No.	Condition Requirements	Document Reference
CoA B1	The Proponent shall implement the fauna and waterway crossings identified in the documents listed under condition A1(d) at the locations and in accordance with the minimum design dimensions identified in the documents listed under condition A1(d), unless otherwise agreed to by the Director General.	RMS correspondence dated 25 May 2011 RMS correspondence dated 1 June 2011 (as referenced in CoA A1(d))
CoA B2	As part of detailed design, the Proponent shall further investigate design refinements to improve fauna connectivity between Chainages 19150 and 19820.	*A Fauna Infrastructure Report will be prepared following detailed design refinements.*
CoA B3	All investigations into fauna crossings design undertaken during detailed design (with respect to the crossing design and locations identified in conditions B1 and B2 shall be undertaken with the input of a qualified and experienced ecologist and in consultation with EPA and DPI (Fisheries) through a process of workshops and on-site ground verification. Where detailed design refinements are made, the Proponent shall prior to the commencement of construction of the relevant crossings, submit a report to the Director General identifying the final design of the fauna crossings and demonstrating consistency with the locations and minimum design parameters identified in the documents listed under condition A1(d) or where there have been changes, how the new location and/ or design would result in a better biodiversity outcome. The report shall also clearly identify how the fauna crossings structures will work in conjunction with complementary fauna exclusion fencing measures to be implemented for the project. The report must be accompanied by evidence of consultation with EPA and DPI (Fisheries) in relation to the suitability of any changes to the crossings design.	*A Fauna Infrastructure Report will be prepared following detailed design refinements,*
CoA B4	The Proponent shall in consultation with EPA, ensure that the design of the project as far as feasible and reasonable, incorporates provision for glider crossings (such as widened medians and maintenance or enhancement of habitat within the medians and corresponding carriageway boundaries) where the alignment crosses areas of recognised glider habitat.	*A Fauna Infrastructure Report will be prepared following detailed design refinements,*
CoA B5	The Proponent shall in consultation with DPI (Fisheries) ensure that all waterway crossings are designed and constructed consistent with the principles of the *Guidelines for Controlled Activities Watercourse Crossings* (DWE), *Fish Note: Policy and Guidelines for Fish Friendly Waterway Crossings* (NSW Fisheries) and *Policy and Guidelines for Design and Construction of Bridges, Roads, Causeways, Culverts and Similar Structures* (NSI4/ Fisheries). As far as feasible and reasonable, culvert replacements as part of the project shall incorporate naturalised	*A Fauna Infrastructure Report will be prepared following detailed design refinements,*

CoA No.	Condition Requirements	Document Reference
	bases and where multiple cell culverts are proposed for creek crossings, shall include at least one cell for fish passage, with an invert or bed level that mimics creek flows.	
CoA B6	Prior to the commencement of any construction work that would result in the disturbance of any native vegetation (or as otherwise agreed to by the Director General), the Proponent shall in consultation with EPA prepare and submit for the approval of the Director General a Nest Box Plan to provide replacement hollows for displaced fauna consistent with the requirements of SoC F7. The plan shall detail the number and type of nest boxes to be installed which must be justified based on the number and type of hollows removed (based on detailed pre-construction surveys), the density of hollows in the area to be cleared and adjacent forest, and the availability of adjacent food resources. The plan shall also provide details of maintenance protocols for the nest boxes installed including responsibilities, timing and duration.	Appendix A - Nest Box Plan of Management
CoA B7	Prior to the commencement of any construction work that would result in the disturbance of *Amorphospermum whitei* and *Marsdenia longiloba*, the Proponent shall in consultation with the OEH develop a management plan for these species which: (a) investigates the potential for the translocation of plants impacted by the project; (b) if investigation under Condition B7(a) reveals translocation of impacted plants is feasible, includes details of a translocation plan for the plants consistent with the Australian Network for Plant Conservation 2nd Ed 2004: *Guidelines for the Translocation of Threatened Species in Australia*, including details of ongoing maintenance such as responsibilities, timing and duration; (c) identifies a process for incorporating appropriate compensatory habitat for the impacted plants in the Biodiversity Offset Strategy referred to in Condition B8 should the information obtained during the investigation referred to in Condition B7(a) find that translocation is not feasible or where the monitoring undertaken as part of condition B10 finds that translocation measures have not been successful (as identified through performance criteria); and (d) includes detail of mitigation measures to be implemented during construction to avoid and minimise impacts to areas identified to contain these species, including excluding construction plant, equipment, materials and unauthorised personnel. Unless otherwise agreed to by the Director General, the Plan shall be submitted for the Director General's approval prior to the commencement of any construction work that would result in the disturbance of *Amorphospermum whitei* and *Marsdenia longiloba*.	Appendix B - Threatened Flora Management Plan (Amorphospermum whitei is now known as Niemeyera whitei).
CoA B8	The Proponent shall, in consultation with the EPA and DPI (Fisheries), develop a Biodiversity Offset Strategy that identifies available options for offsetting the biodiversity impacts of the project in perpetuity, with consideration to EPA's *Principles for the Use of Biodiversity Offsets in NSW* (EPA Website, June 2011). Unless otherwise agreed to by EPA, offsets shall be provided on a like-for-like basis and at a minimum ratio of 4:1 for areas of high conservation value	The Biodiversity Offset Strategy will be prepared by Roads and Maritime and submitted to DP&I at least 6 weeks prior to the commencement of Construction that would disturb native vegetation.

CoA No.	Condition Requirements	Document Reference
	(including EEC and threatened species or their habitat identified in the Environmental Assessment to be impacted by the project and poorly conserved vegetation communities identified as being more than 75% cleared in the catchment management area) and 2:1 for the remainder of native vegetation areas (including mangroves, seagrass, salt marsh and riparian vegetation). The Strategy shall include, but not necessarily be limited to: (a) confirmation of the vegetation communities/ habitat (in hectares) to be offset and the size of offsets required (in hectares); (b) details of the available offset measures that have been identified to compensate for the biodiversity impacts of the project, such as (but not necessarily limited to): suitable compensatory land options and/ or contributions towards biodiversity programs for high conservation value areas on nearby lands (including research programs). Where the use of State Forest land managed in accordance with an Integrated Forestry Operations Approval is proposed to offset biodiversity impacts, the Proponent shall clearly demonstrate how this would provide the biodiversity outcomes required under this condition including any additional offset requirements to cover residual impacts; (c) the decision-making framework that would be used to select the final suite of offset measures to achieve the aims and objectives of the Strategy, including the ranking of offset measures; (d) a process for addressing and incorporating offset measures for changes to impact (where these changes are generally consistent with the biodiversity impacts identified for the project in the documents listed under condition A1, including: i. changes to footprint due to design changes; ii. changes to predicted impacts resulting from changes to mitigation measures; iii. identification of additional species/habitat through pre-clearance surveys; and iv. additional impacts associated with ancillary facilities; and (e) options for the securing of biodiversity options in perpetuity. The Biodiversity Offset Strategy shall be submitted to, and approved by, the Director General prior to the commencement of any construction work that would result in the disturbance of any native vegetation, unless otherwise agreed by the Director General. Unless otherwise agreed, the Biodiversity Offset Strategy shall be submitted to the Director General for approval no later than 6 weeks prior to the commencement of any construction that would result in the disturbance of any native vegetation. The Proponent may elect to satisfy the requirements of this condition by implementing a suitable offset package which addresses impacts from multiple Pacific Highway Upgrade projects (including the Warrell Creek to Urunga Project) within the North Coast Bio-region. Any such agreement made with the EPA must be made in consultation with the Department and approved	

CoA No.	Condition Requirements	Document Reference
	by the Director General within a timeframe agreed to by the Director General.	
CoA B9	Within two years of the approval of the Biodiversity Offset Strategy, unless otherwise agreed by the Director General, the Proponent shall prepare and submit a Biodiversity Offset Package which identifies the final suite of offset measures to be implemented for the project for the approval of the Director General. The Package shall be developed in consultation with EPA, and shall provide details of: (a) the final suite of the biodiversity offset measures selected for the project demonstrating how it achieves the requirements and aims of the Biodiversity Offset Strategy (including specified offset ratios); (b) the final selected means of securing the biodiversity values of the offset package in perpetuity including ongoing management, monitoring and maintenance requirements; and (c) timing and responsibilities for the implementation of the provisions of the package over time. The requirements of the Package shall be implemented by the responsible parties according to the timeframes set out in the Package	The Biodiversity Offset Package will be prepared and submitted to the Director General within two years of the approval of the Biodiversity Offset Strategy.
CoA B10	Prior to the commencement of any construction work that would result in the disturbance of any native vegetation, the Proponent shall develop an Ecological Monitoring Program to monitor the effectiveness of the mitigation measures implemented as part of the project. The program shall be developed in consultation with EPA and prepared by a suitably qualified ecologist and shall include but not necessarily be limited to: (a) an adaptive monitoring program to assess the effectiveness of the mitigation measures identified in condition 81 to 86, B7(b), B7(d), 821(c) and B3'1(b)and allow amendment to the measures if necessary. The monitoring program shall nominate appropriate and justified monitoring periods and performance targets against which effectiveness will be measured. The monitoring shall include operational road kill surveys to assess the effectiveness of fauna crossing and exclusion fencing implemented as part of the project; (b) mechanism for developing additional monitoring protocols to assess the effectiveness of any additional mitigation measures implemented to address additional impacts in the case of design amendments or unexpected threatened species finds during construction (where these additional impacts are generally consistent with the biodiversity impacts identified for the project in the documents listed under condition A1; (c) monitoring shall be undertaken during construction (for construction-related impacts) and from opening of the project to traffic (for operation/ongoing impacts) until such time as the effectiveness of mitigation measures can be demonstrated to have been achieved over a minimum of five successive monitoring periods (i.e. 5 years) after opening of the project to traffic, unless otherwise agreed to by the Director General. The monitoring period may be reduced with the agreement of the Director General in consultation with EPA, depending	Appendix C - Ecological Monitoring Program

CoA No.	Condition Requirements	Document Reference
	on the outcomes of the monitoring; (d) provision for the assessment of the data to identify changes to habitat usage and if this can be attributed to the project; (e) details of contingency measures that would be implemented in the event of changes to habitat usage patterns directly attributable to the construction or operation of the project; and (f) provision for annual reporting of monitoring results to the Director General and EPA, or as otherwise agreed by those agencies. The Program shall be submitted for the Director General's approval prior to the commencement of any construction work that would result in the disturbance of any native vegetation. Unless otherwise agreed, the Program shall be submitted to the Director General for approval no later than 6 weeks prior to the commencement of any construction that would result in the disturbance of any native vegetation.	
CoA B31	As part of the Construction Environment Management Plan for the project required under condition B30 of this approval, the Proponent shall prepare and implement the following sub plan(s): … (b) a Construction Flora and Fauna Management Plan to detail how construction impacts on ecology will be minimised and managed. The Plan shall be developed in consultation with the OEH and shall include, but not necessarily be limited to: i. details of pre-construction surveys undertaken to verify the construction boundaries/ footprint of the project based on detailed design and to confirm the vegetation to be cleared as part of the project (including tree hollows, threatened flora and fauna species, mangroves and riparian vegetation). The surveys shall be undertaken by a qualified ecologist and include surveys of existing bridges and culverts for the presence of micro-bat roosting at least 6 months prior to the planned disturbance of such structures and targeted surveys for the Giant Barred Frog within and in the vicinity of the project corridor undertaken during suitable conditions;	Section 4.3 Appendix C - Ecological Monitoring Program [Appendix G – Pre-clearing Checklist Appendix D - Giant Barred Frog Management Strategy
	ii. updated sensitive area / vegetation maps based on B31(b)(i) above and previous survey work;	Appendix A6 of the CEMP
	iii. a Giant Barred Frog management plan, in the case that this species or its habitat is identified to occur in the project corridor or its vicinity, based on surveys undertaken as part of B31(b)(i);	Appendix D - Giant Barred Frog Management Strategy
	iv. a micro-bat management strategy, in the case that micro bats or evidence of roosting are identified during pre-construction surveys. The strategy shall detail measures to avoid, minimise and mitigate impacts to these species and identified roost sites,	Appendix F - Microchiropteran Bat Management Strategy

CoA No.	Condition Requirements	Document Reference
	including short and long term management measures;	
	v. details of general work practices to minimise the potential for damage to native vegetation (particularly EECs) not proposed to be cleared as part of the project and native fauna during construction, including (but not necessary limited to): fencing of sensitive areas, a protocol for the removal and relocation of fauna during clearing, presence of an experienced ecologist to oversee clearing activities and facilitate fauna rescues and re-location, clearing timing with consideration to breeding periods, measures for maintaining existing habitat features (such as bush rock and tree branches etc), seed harvesting and appropriate topsoil management, construction worker education, weed management, erosion and sediment control and progressive re-vegetation;	Section 5 Appendix H – Working Around Trees Guideline Appendix I – Fauna Handling and Rescue Procedure Appendix K – Weed Management Plan
	vi. specific procedures to deal with EEC/ threatened species anticipated to be encountered within the project corridor including re-location, translocation and/or management and protection measures;	Section 5 Appendix B – Threatened Flora Management Plan Appendix D - Giant Barred Frog Management Strategy Appendix E – Green-thighed Frog Management Strategy Appendix F - Microchiropteran Bat Management Strategy
	vii. a procedure for dealing with unexpected EEC/ threatened species identified during construction including stopping works and notification of EPA, determination of appropriate mitigation measures in consultation with EPA (including relevant relocation measures) and update of ecological monitoring and/ or biodiversity offset requirements consistent with conditions B8 and B10; and	Section 5 Appendix J – Unexpected Threatened Flora Find Procedure Appendix I – Fauna Handling and Rescue Procedure
	viii. mechanism for the monitoring, review and amendment of this plan;	Section 7

3.3 Statement of commitments

Relevant SoC are listed Table 3-2 below. This includes reference to required outcomes, the timing of when the commitment applies, relevant documents or sections of the environmental assessment influencing the outcome and implementation.

Table 3-2 Statement of commitments relevant to this FFMP

Outcome	Ref #	Commitment	Timing	Reference Document	FFMP Reference
Minimise impacts on flora and fauna	F1	Clearing of native vegetation (including endangered ecological communities (EECs)) will be restricted to the minimum area necessary for construction.	Pre-construction and construction	Chapter 10 of the EA. DWE (2008) *Guidelines for Controlled Activities 2008*	Table 5-1
	F2	A qualified ecologist will identify any vegetation (including *Marsdenia longiloba*) to be retained and to be clearly delineated on work plans within the construction corridor. Erection of flagging/fencing on-site prior to any construction works, which is to remain in place for the full construction period, will clearly delineate this vegetation.	Pre-construction and construction	Chapter 10 of the EA. DECC (2004) *Threatened species survey and assessment: Guidelines for developments and activities* (working draft). *Australian Network for Plant Conservation 2004 guidelines.*	Table 5-1
	F3	A threatened flora survey will be undertaken prior to clearing to identify individuals to be translocated and to confirm the extent of clearing.	Pre-construction	*Section 3.1 of The response to Submissions and Preferred Project Report*	Table 5-1 Appendix B
		Threatened species directly impacted by the Proposal will be translocated to a suitable location outside the impact zone.	Pre-construction		Table 5-1 Appendix B Appendix D Appendix E Appendix F
		A further visual inspection will be conducted post clearance to identify threatened species which may be indirectly impacted outside the cleared zone.	Construction		Table 5-1 Appendix B
		Landscape planting to commence along the road	Construction		

Outcome	Ref #	Commitment	Timing	Reference Document	FFMP Reference
		boundary as soon as possible during construction.			
	F4	Plantings of rusty plum (*Amorphospermum whitei*) in areas of suitable habitat adjacent to the Proposal will follow from seed collection and propagation.	Pre-construction	*Australian Network for Plant Conservation 2004 guidelines.*	Table 5-1 Appendix B
	F5	Site induction of construction workers will inform and instruct them of vegetation to be retained and on the identification of threatened species	Pre-construction and construction	DECC (2004) *Threatened species survey and assessment: Guidelines for developments and activities* (working draft).	Table 5-1
Maintain fauna habitat and connectivity	F6	A suitably qualified ecologist will undertake pre-clearance surveys for threatened species including frogs. Searches will include nests and hollow bearing trees. Re-location of fauna species at risk of injury found in pre-clearance surveys or during construction will be in suitable habitat as close as possible to the area in which they were found. Immediately prior to clearing an inspection will confirm that the sites subject to pre-clearance surveys remain free of fauna.	Pre-construction and construction	*National Parks and Wildlife Act* 1979. *RTA QA Specification G36 Environmental Protection.*	Table 5-1 Appendix I
	F7	Where feasible and reasonable the identification and distribution of natural and artificial habitat features and resources (such as hollow-bearing trees, hollow logs, nest boxes and bush rocks) will occur along the Proposal. This relocation will limit injury to fauna and damage to existing vegetation. A nest box plan will be developed for the Proposal.	Pre-construction and construction	Section 10.5 of the EA. *Australian Network for Plant Conservation 2004 guidelines*. *Warrell Creek to Urunga Nest Box Plan of Management*	Table 5-1 Appendix A
	F8	Retention of mature trees in the median at locations identified in the environmental assessment will provide a stepping stone for gliders. Protection of these trees will occur (F2), and lopping and pruning is not to occur without expert advice.	Pre-construction and construction	Table 10-12 of the EA.	Table 5-1
	F9	Provision of fauna crossings will be as identified in the environmental assessment. All fauna crossings will be confirmed with the DECCW and I&I (Fisheries) during the detailed design phase.	Pre-construction	Table 3-1 of the Response to Submissions and Preferred Project Report.	Table 5-1

Outcome	Ref #	Commitment	Timing	Reference Document	FFMP Reference
Minimise adverse impacts on aquatic habitat and fish species	F10	Design and construction of waterway crossings will be in accordance with the fish habitat classification of each waterway and in consultation with the Department of Industry and Investment. All fauna crossings will be confirmed with the DECCW and I&I (Fisheries) during the detailed design phase.	Pre-construction	*Fish note: Policy and Guidelines for Fish Friendly Waterway Crossings* (NSW Fisheries). *Policy and Guidelines for Design and Construction of Bridges, Roads, Causeways, Culverts and Similar Structures* (NSW Fisheries 1999).	Table 5-1
Minimise fauna road injuries and mortalities during operation	F11	Erection of fauna exclusion fencing (e.g. floppy-top fencing) along the Proposal at appropriate locations will direct fauna movement towards fauna-crossing structures.	Construction and operation	Figure 10-6 to 10-9 of the EA *Giant Barred Frog Management Strategy* *Green-thighed Frog Management Strategy* *Fauna fencing locations will be discussed with the EPA during the detailed design phase.*	Table 5-1
Offset residual impacts of the proposal on key habitat	F12	Development of an offset strategy will occur in consultation with the Department of Environment, Climate Change and Water.	Pre-construction and construction	RTA *Compensatory Habitat Policy and Guideline* (draft).	Section 5.2 Offset Strategy and Package
Effective flora and fauna management and mitigation measures	F13	A targeted, adaptive monitoring program will be undertaken for a minimum of 12 months to assess the effectiveness of fauna and flora impact mitigation measures. After 12 months a report will be completed to assess the need for additional measures and/or further targeted monitoring.	Operation	Section 10.5.11 of the EA.	Table 5-1 Appendix C
	F14	The RTA will set bed levels for culverts and ledges for combined fauna passage in consultation with the Department of Environment, Climate Change and Water.	Pre-construction and construction	Section 10.4.3 of the EA	Table 5-1

3.4 EPBC Act Approval Conditions

The EPBC Act approval conditions relevant to this Plan are listed in Table 3-3 below. A cross reference is also included to indicate where the condition is addressed in this Plan or other Project management documents. Where conditions are not specifically addressed in this Plan, the relevant document is referenced.

Table 3-3 EPBC Act Approval Conditions relevant to this CEMP

Condition No.	Condition Requirements	Document Reference
	Impacts	
1	The approval holder must not clear more than:	
	a) 17.80 hectares 9ha0 of Slender Marsdenia/Clear milkvine and Wooll's Tylophora/Cryptic Forest Twiner habitat	Appendix A6 of the CEMP (Sensitive Area Plans)
	b) 106.60 ha of Koala habitat, including 86.50 ha critical to the survival c) 106.6 ha of Grey-headed Flying fox habitat, comprised of 103.5 ha of foraging habitat critical to survival and 3.1 ha of roosting habitat critical to survival d) D 113.30 ha of Spotted-tail Quoll habitat e) 0.7ha of Giant Barred Frog habitat f) 0.4 ha of Australian Painted Snipe ((Rostratula australis) wetland habitat g) 5.30 ha of Regent Honeyeater (*Anthochaera phrygia*) and Swift Parrot (*Lathamus discolour*) wintering habitat, comprising dry sclerophyll forests containing Swamp Mahogany; and h) 24.30 ha of Parsonsia dorrigoensis (*Milky Silkpod*) habitat, comprising Mixed Floodplain Forest, Flooded Gum Open Forest and White Mahogany/Grey Gum/Ironbark Open Forest	Incorporated into Detailed Design drawings and reports.
2	Within 30 days of the **completion of construction**, the **approval holder** must: a) notify the **Minister** in writing of the **completion of construction**; and b) provide a report (supported by maps) that clearly shows the location of all **threatened species**, including the number of individuals of threatened flora and their **habitat cleared** as a result of **action**, which demonstrates compliance with Condition 1.	Incorporated into Detailed Design drawings and Reports.
	Management Plans	

Condition No.	Condition Requirements	Document Reference
3	The **approval holder** must undertake the **action** and implement all mitigation measures in accordance with the **Koala Management Plan**, **Grey-headed Flying-Fox Management Plan**, **Spotted-tail Quoll Management Plan** and **Giant Barred Frog Management Plan**. These **Plans** must be implemented.	Appendix D – Giant Barred Frog Management Strategy Appendix L – Koala Management Plan Appendix M – Spotted Tailed Quoll Management Plan Appendix N – Grey Headed Flying Fox Management Plan
4	To mitigate impacts to **threatened species**, the **approval holder** must submit the Flora and Fauna Management Sub Plan and Construction Environment Management Plan to the **Department** for approval prior to **commencement**. The Plans must include the additional mitigation measures not included in the **management plans** and as described in the **Biodiversity Offset Strategy**. The approved **plans** must be implemented.	Table 3.4-1 of this Plan
5	In the event of any inconsistency, ambiguity or discrepancy between the **management plans** and the Flora and Fauna Management Plan or the Construction Environmental Management Plan, the **management plans** have precedence.	
6	Prior to **commencement,** the **approval holder** must amend the monitoring program proposed in the **Threatened Flora Management Plan** to: a) include detailed monitoring methodology designed to monitor the success of the management and mitigation measures proposed for pre-construction, construction and operations; and b) ensure all performance thresholds, corrective actions and monitoring/timing frequency are specific, measurable, auditable, enforceable and time-bound to monitor the success of the management and mitigation measures proposed.	Appendix B – Threatened Flora Management Plan
7	The **approval** holder must not **commence** the **action** until the **Threatened Flora Management Plan** has been approved by the **Minister.** The approved **Threatened Flora Management Plan** must be implemented.	Appendix B – Threatened Flora Management Plan
	All Management Plans	
8	The **approval holder** must monitor all mitigation measures until they are demonstrated to be successful, and with written agreement from the **Department**.	Table 3.4-1 of this Plan

Condition No.	Condition Requirements	Document Reference
9	If **MNES** not previously identified and reported to the **Department**, are found in the **action** area, the **approval holder** must notify the **Department** in writing within five business days of finding the **MNES**, and within a further 30 business days, the **approval holder** must outline in writing how **impacts** to these **MNES** will be avoided, mitigated and/or **offset**.	Appendix J Unexpected Threatened Species_EEC Finds Procedure
10	Prior to **commencement**, all **management plans** must be made publicly available on the **approval holder's website**, for 10 years following **commencement**. The monitoring results must also be made available on request for the duration of the **approval**.	
11	The **approval** holder must make all monitoring results required by the **management plans** publicly available on the **approval holder's website** within two months of the monitoring event, for 10 years following **commencement**. The monitoring results must also be made available on request for the duration of the **approval.**	
	Offsets Biodiversity Offset Package	
12	To compensate for the loss of **threatened species habitat**, within 12 months of the approval of the **action**, the **approval holder** must submit to the **Minister** for approval a Biodiversity Offset Package. The Package must: a) provide known **habitat** and compensate for the residual significant **impacts** on the **threatened species** and their **habitat** in Condition 1a) to e); b) demonstrate consistency with and meets the requirements of the **EPBC Act Environmental Offsets Policy**; c) detail the **offset attributes** (including maps in electronic Geographic Information System (GIS) format with accompanying **shapefiles**), site descriptions environmental values relevant to **threatened species** being **offset**, connectivity with other **habitat** and biodiversity corridors;	Biodiversity Offset Strategy prepared by Roads and Maritime Services.

Condition No.	Condition Requirements	Document Reference
12 (cont)	d) include detailed surveys and quantitative and qualitative descriptions of any proposed **offset areas** which clearly identify **baseline** conditions. This must include: i. a **baseline** description (prior to any management activities) of the current **quality** of the **habitat** for each relevant **threatened species** in each **offset area**, including the location of survey points (GPS reference); ii. the quantity (in hectares) of suitable **habitat** present within the **offsets areas** for the **threatened species** the **quality** of the **habitat** for the relevant **threatened species** found within the **offset areas**; iii. vegetation condition mapping; and iv. photo reference points. e) be prepared by a **suitably qualified ecologist**; f) include conservation and management measures for long-term protection and adaptive management of the **offsets** to improve **habitat** for **threatened species** within the **offset areas** from **baseline** conditions, including but not limited to: i. a map showing **offset areas** to be managed; ii. conservation management actions for each **offset area** and the details of methods to be used; iii. **offset** management must be consistent with **threat abatement plans** for **threatened species**; iv. the timing of management activity for each **offset area** and anticipated timeframes for achieving performance objectives; v. clear performance measures and performance indicators for each **offset area** including contingency actions, criteria for triggering contingency actions and a commitment to the implementation of these actions in the event that performance objectives are not met that will enable maintenance and enhancement of **habitat** within the **offset area**, as well as contribute to the better protection of individuals and/or populations of **threatened species** and their **habitat**;	

Condition No.	Condition Requirements	Document Reference
12 (cont)	vi. a monitoring program to assess the effectiveness of the management actions measured against the **baseline** condition. This must include, but not be limited to, control sites and periodic ecological surveys to be undertaken by a **suitably qualified ecologist**; vii. a risk assessment and a description of the contingency measures that would be implemented to mitigate these risks; viii. details of the various parties responsible for the management, monitoring and implementing the management activities, including their experience and qualifications and employment or engagement status; and ix. details of qualifications and experience of persons responsible for undertaking monitoring, review, and implementation of the Biodiversity Offset Package, including the role of the **independent expert** in preparing, reviewing, and implementing the Biodiversity Offset Package; and x. a description of protection and funding arrangements or agreements including	
13	The **approval holder** must implement the approved Biodiversity Offset Package within 24 months of the date of this **approval**.	Biodiversity Offset Strategy prepared by Roads and Maritime Services.
14	If an **offset** site proposed as a part of the Offset Package is already required to be protected as a result of a separate **EPBC Act** approval, only the management actions which can be demonstrated to be additional to those required for the separate approval, can be considered as an **offset** for this project. The legal protection of the site and management action required for separate approvals cannot be considered a part of the **offsets**, in accordance with the **Environmental Offsets Policy**.	Biodiversity Offset Strategy prepared by Roads and Maritime Services.
15	The **approval holder** must, within 12 months of the **approval** of the Biodiversity Offset Package, register a legally binding conservation mechanism to provide long-term protection to the **offsets** approved by the **Minister** in the Biodiversity Offset Package, which prohibits any activities that are not conservation activities from being undertaken in the **offsets**	Biodiversity Offset Strategy prepared by Roads and Maritime Services.

Condition No.	Condition Requirements	Document Reference
16	If the results of the monitoring required in the **Grey-headed Flying-fox Management Plan**, shows that the Macksville Grey-headed Flying-fox Camp is abandoned from September to May for two or more consecutive years within a six year period after **impacts** to **Grey-headed Flying-fox habitat** occurs, the **approval holder** must then **offset** the entire 23.50 ha roosting habitat critical to survival, rather than 3.10 ha required by Condition 1. Note: The provision of the additional offset, if required, would be additional to the requirements of Condition 13-16.	Biodiversity Offset Strategy prepared by Roads and Maritime Services.
	General	
17	Within 14 days after the **commencement** of the **action**, the person taking the **action** must advise the **Department** in writing of the actual date of **commencement**.	
18	The **approval holder** must notify the **Department** in writing of potential non-compliance with any condition of this **approval** as soon as practical and within no later than two business days of becoming aware of the non-compliance. The notice provided to the **Department** under this condition must specify: a) the condition which the **approval holder** has potentially breached; b) the nature of the non-compliance; and c) when and how the **approval holder** became aware of the non-compliance. Further to providing any such notice, the **approval holder** must provide the following information within 10 business days of becoming aware of a potential non-compliance: a) how the non-compliance will affect the anticipated impacts of the **approved action**, in particular how the non-compliance will affect the impacts on the **MNES**; b) the measures the **approval holder** will take to address the impacts of the non-compliance on the **MNES** and rectify the non-compliance; and c) the time by when the **approval holder** will rectify the non-compliance.	Section 8.6 of the CEMP Appendix A7 of the CEMP – Environmental Incident Classification and Reporting Procedure

Condition No.	Condition Requirements	Document Reference
19	Within three months of every 12 month anniversary of the **commencement** of the **action**, the **approval holder** must publish a report on its **website** addressing compliance with each of the conditions of this **approval**, including implementation of any **management plan, package** as specified in the conditions. **Documentary** evidence providing proof of the date of publication must be included in the published **compliance report**. The **compliance report** must remain on the **website**, for 10 years following **commencement**. The monitoring results must also be made available on request for the duration of the **approval**. Reports of any non-compliance must also be included in the annual **compliance report.**	Section 8.5 of the CEMP
20	The **approval holder** must maintain accurate **compliance records** substantiating all activities associated with or relevant to the conditions of **approval**, including measures taken to implement the **management plans, package** required by this **approval**, and make them available upon request to the **Department**. Such **compliance records** may be subject to audit by the **Department** or an independent auditor in accordance with section 458 of the **EPBC Act**, or used to verify compliance with the conditions of **approval**. Summaries of audits will be posted on the **Department's website**. The results of audits may also be publicised through the general media.	Section 10 of the CEMP
21	Upon the direction of the **Minister**, the **approval holder** must ensure that an independent audit of compliance with the conditions of **approval** is conducted and a report submitted to the **Minister**. The audit must not commence unless and until the **Minister** has approved the independent auditor and audit criteria. The audit report must address the criteria to the satisfaction of the **Minister.**	Section 8.3 of the CEMP
22	If the **approval holder** wishes to carry out any activity otherwise than in accordance with a **management plans, strategy, package** as specified in the conditions, the **approval holder** must submit to the **Department** for the **Minister's** written approval a revised version of that **management plan, package**. The varied activity must not commence until the **Minister** has approved the varied **management plan, package** in writing. The **Minister** will not approve a varied **management plan, package** unless the revised **management plan, package** would result in an equivalent or improved environmental outcome over time. If the **Minister** approves the revised **management plan, package** that **management plan, package** must be implemented in place of the **management plan, package** originally approved.	Section 9 of the CEMP.

Condition No.	Condition Requirements	Document Reference
23	If the **Minister** believes that it is necessary or convenient for the better protection of **MNES** to do so, the **Minister** may request that the **approval holder** make specified revisions to a **management plan, package** required by the conditions and submit the revised **management plan, package** for the **Minister's** written approval. The **approval holder** must comply with any such request. The revised **management plan, package** must be implemented. Until the **Minister** has approved a revised **management plan, package**, the **approval holder** must continue to implement the previously approved **management plan, package**, as specified in the conditions.	Section 9 of the CEMP
24	If, at any time after five years from the date of this **approval**, the **approval holder** has not **commenced** the **action**, then the **approval holder** must not **commence** the **action** without the written agreement of the **Minister.**	
25	Unless otherwise agreed to in writing by the **Minister**, the **approval holder** must publish the **management plans, package**, monitoring data in these conditions of **approval** on its **website**. Each **management plans, package**, monitoring data must be published on the **website** within one month of being approved (unless otherwise specified in these conditions) or within one month of data collection.	
26	The **approval holder** must notify the **Department** within 5 business days of publishing the **management plan, package**, monitoring data on their website and the **management plan, package**, monitoring data must remain on the website for the life of this **approval**.	

3.4.1 Management Measures under Condition 2 of EPBC approval EPBC 2013/7101

Relevant conditions under EPBA approval EPBC 2013/7101 have been identified in Table 3-3. Of particular note is the requirement to comply with condition 2, a Flora and Fauna Management Plan (this plan). The plan whilst developed to satisfy both federal and state requirements must clearly identify how matters of national environmental significance (NES) will be managed during construction.

Dedicated measures in relation to matters of NES are outlined in Table 3-4. Where the requirements are too detailed to include in this section, a clear link to the relevant chapter of an Appendices is outlined. Measures under the State approval (MP 07_0112) are identified in Table 5-1.

Table 3-4.1 EPBC Act Management Measures

ID	Management Action	Performance Indicator/Target	Monitoring/Timing	Responsibility
General Measures				
EPBC 1 FF 1	Training will be provided to all project personnel, including relevant sub contractors on matters of NES as identified in section 3.4.2.	**Performance indicator:** Induction of staff on NES matters prior to commencement of works on site. **Performance target:** 100% of all staff inducted on NES matters prior to commencement of work on site.	Site induction prior to work on-site	Environmental Manager
EPBC 2	Sensitive Area Plans showing site constraints (including matters of NES) shall be prominently displayed across the site. Sensitive Areas Plans form Appendix A6 of the CEMP.	**Performance indicator:** Display of Sensitive Area Plans at all primary and satellite compounds. **Performance target:** 100% of primary and satellite compounds have Sensitive Areas Plans displayed.	Prior to construction and for duration of construction.	Environmental Coordinators
EPBC 3 FF 7	Protective fencing to mark the limits of clearing (i.e. 'no-go' areas) surrounding the construction footprint will be installed and routinely inspected and maintained where required until the completion of construction. The limits of clearing will be consistent with those verified in accordance with CoA B31(b)(i). The limits of clearing will be marked in accordance with Guide 2 of the RMS Biodiversity Guidelines. These surveys will be	**Performance indicator:** Completion of pre-clearing survey including mark-out of clearing extents and identification of weed infestation prior to construction. **Performance target:** Completion of pre-clearing survey prior to construction including mark-out of clearing extents and identification	No later than 20 days prior to commencement of clearing.	Environmental Manager Project Ecologist Environmental Coordinators

ID	Management Action	Performance Indicator/Target	Monitoring/Timing	Responsibility
	completed no later than 20 working days prior to the commencement of clearing and will be limited to the time required to complete these surveys.	of weed infestation in 100% of clearing areas.		
EPBC 4 FF4	A project ecologist will be appointed prior to construction where matters of NES are involved.	**Performance indicator:** Appointment of project ecologist/suitably qualified expert. **Performance target:** Appointment of project ecologist/suitably qualified expert prior to commencement of works.	Prior to the commencement of construction	Environmental Manager
EPBC 5 FF 5	The Ecological Monitoring Program will be implemented for matters of NES during the construction phase as stipulated within the Ecological Monitoring Program.	**Performance indicator:** Completion of construction ecological monitoring requirements. **Performance target:** Completion of construction ecological monitoring requirements in accordance frequency stipulated in the EMP.	Timing and roles identified as per table 3.1 of the Ecological Monitoring Program found in Appendix C.	Environmental Manager/ RMS
EPBC 6 FF 6	The limits of clearing are to be clearly marked on all relevant work plans and protective fencing erected to mark these limits (i.e. 'no-go' areas).	**Performance indicator:** Inclusion of sensitive areas on Sensitive Area Plans and limits of clearing on clearing drawings AND Completion of pre-clearing survey including mark-out of clearing extents and identification of weed infestation prior to construction. **Performance target:** 100% Sensitive Area Plans identify sensitive areas and 100% of clearing drawings identify clearing extents. AND Completion of pre-clearing survey	Limits of clearing will be marked out prior to clearing commencing in that area. Fencing installed prior to vegetation clearing activities commencing in that area. Fencing and no-go signage inspected weekly, Until construction completion.	Project / Site Engineers Foreman / Leading Hands Environmental Coordinators

ID	Management Action	Performance Indicator/Target	Monitoring/Timing	Responsibility
		prior to construction including mark-out of clearing extents and identification of weed infestation in 100% of clearing areas.		
Measures to avoid, supress and control spread of weeds, plant pathogens and invasive species				
EPBC 7 FF13	Weeds will be managed in accordance with the management actions detailed in Section 4 of the weed and pathogen management plan (Appendix K)	**Performance indicator:** Completion of weed management actions outlined in Appendix K. **Performance target:** Completion of all weed management actions outlined in Appendix K in the timeframes specified.	As outlined in Appendix K.	Project / Site Engineers Foreman / Leading Hands Environmental Coordinators
EPBC 8 FF39	Washing procedures for plant and equipment will be in accordance with the process described for machinery in Table 4.5 of Appendix K.	**Performance indicator:** Wash down of plant and equipment before entering site. **Performance target:** 100% of plant and equipment are washed down before entering site.	All plant prior to use on site.	Project / Site Engineers Foreman / Leading Hands Environmental Coordinators
EPBC 9 FF40	The spread of bacteria, viruses and diseases such as Myrtle rust, *Phytophthora cinnamomi*, amphibian chytrid fungus and beak and feather disease will be addressed through washing of equipment. The washing procedure will be undertaken in accordance with the process described in Table 4.5 of Appendix K. Monitoring and management measures for retained vegetation will be carried out in a way that minimizes the risk of plant pathogen spread.	**Performance indicator:** Wash down of plant and equipment before entering site. AND Implementation of Chytrid Fungus wash down procedure in Appendix K. **Performance target:** 100% of plant and equipment washed down before entering site. AND Chytrid Fungus washdown procedure is implemented prior to the commencement of work in all areas required in the procedure.	All plant during construction prior to use on site. As outlined in Appendix J.	Project Engineers Foreman / Leading Hands Environmental Coordinators

ID	Management Action	Performance Indicator/Target	Monitoring/Timing	Responsibility
EPBC 10	Weed management training will be provided to key staff on-site.	**Performance indicator:** Provision of weed management training to key staff on site. **Performance target:** 100% of key staff provided with weed management training during construction.	Induction for all personnel prior to commencing work on site.	Environmental Manager
EPBC 11 FF 9 FF10 FF12	Revegetation/rehabilitation of the site will be conducted progressively during the construction phase to ensure the use of collected topsoil and seed and to develop different successional stages of rehabilitation Where vegetation is to be retained, vegetation management measures will be implemented, including weed removal, native plantings, broadcasting of collected native seed and relocation of specific habitat resources such as bush rocks, hollow logs, hollow tree trunks and branches. Seed collection of native plant species to be removed from the construction footprint will be undertaken prior to commencement of clearing and during clearing and seed will be stored for use in revegetation works. The Landscaping Plan and CEMP for the WC2NH project are to identify that specific revegetation measures are required as per points a) to d) below for roadside threatened flora to ensure these sites are adequately buffered with fast growing native species and weeds do not become dominant. The Landscaping Plan and CEMP are to contain an implementation schedule with actions for areas adjacent to in-situ threatened species. Specific revegetation measures for areas adjacent to in-situ threatened species:- a) Topsoil salvaged from weed free	**Performance indicator:** Direct seeding (hydromulch) of disturbed areas following completion of all construction activities. AND Completion of rehabilitation works in accordance with the approved Landscape design. AND Use in landscaping works seed mix representative of the vegetation community adjacent to the works. **Performance target:** Direct seeding (hydromulch) of disturbed areas within 14 days of completion of all activities required to finalise and rehabilitate disturbed areas, including the placement of topsoil. AND Completion of all rehabilitation works in accordance with the approved Landscape design prior to Construction Completion. AND 100% of landscaping works use seed mix representative of the	Direct seeding will be completed 14 days from completion of works (completion of all activities required to finalise and rehabilitate disturbed areas, including placement of topsoil). Rehabilitation works will be completed prior to construction completion. Seed mixes will be selected prior to commencement of revegetation works in each area. Revegetation/rehabilitation areas will be assessed Six-monthly; during construction period and 36 month landscape maintenance period. As required by Landscape Review.	Project / Site Engineers Foreman / Leading Hands Environmental Manager

ID	Management Action	Performance Indicator/Target	Monitoring/Timing	Responsibility
	forest during clearing to be stored and used to top-dress batters and bare areas. b) Alternatively, plant around threatened flora sites with tubestock of hardy, locally occurring native ground-covers, shrubs and small tree trees. c) Carry out revegetation of bare/disturbed ground surrounding in-situ threatened species locations as soon as earthworks are completed. Use of forest topsoil with native species seedbank is recommended to ensure hardy, locally occurring species (gound-covers, shrubs and small trees) are established. d) A plant ecologist/horticulturalist to identify/advise on areas of forest within the clearing footprint suitable for salvage of weed free topsoil for use in revegetation/landscaping and appropriate methods of storage and use. .	vegetation community adjacent to the works.		
Measures to minimise other indirect impacts including erosion and sedimentation				
EPBC 12 FF11	Native vegetation cleared from the construction footprint will be mulched and used along with retained topsoil for reuse in rehabilitation works and erosion control. Mulch and topsoil will not be stockpiled in ‘no-go’ areas and cleared vegetation will not be pushed into ‘no-go’ areas.	**Performance indicator:** Use of mulch in accordance with landscaping plans and erosion and sediment control plans. AND Storage of mulch and topsoil within approved stockpile areas outside no-go areas. **Performance targets:** Mulch is utilised in all areas nominated in landscaping plans and erosion and sediment control.	Use of mulch for landscaping and erosion and sediment control will be monitored progressively. Locations of stockpiles will be checked as part of weekly inspections.	Project / Site Engineers Foreman / Leading Hands Environmental Coordinators
EPBC 13 SW1	Progressive erosion and sediment control plans (ESCPs) will be prepared and implemented in advance of construction, including earthworks and stockpiling. ESCPs and will be updated as required.	**Performance indicators:** Erosion control measures within the ESCPs are in accordance with the Blue Book.	Prior to the commencement of construction in that area, or prior to changed work	Construction Manager Environmental Coordinators

ID	Management Action	Performance Indicator/Target	Monitoring/Timing	Responsibility
		AND Controls inspected and poorly operating/damaged controls repaired. **Performance targets:** All erosion control measures nominated in the ESCPs are in accordance with the Blue Book. AND All controls inspected weekly and all poorly operating/ damaged controls repaired.	activities in that area. Weekly.	
EPBC 14 SW7	• EWMS will be prepared for construction activities and implemented to manage soil and water impacts. EWMS for activities identified as having high environmental risk will undergo a period of consultation with EPA and DPI (Fisheries Conservation and Aquaculture).	**Performance indicators:** Preparation of EWMS for nominated activities. AND Construction activities undertaken in accordance with EWMS and staff tool boxed on requirements. **Performance targets:** No works commencing in these areas until an EWMS has been prepared for the activity. AND All construction activities conducted in accordance with the EWMS. AND 100% of staff toolboxed on EWMS requirements before starting work in those areas.	Prior to the commencement of the activity. Ongoing.	Superintendent/Environment Manager/Foreman
EPBC 15 SW19	Catch drains, contour and diversion drains across exposed areas will be installed immediately following clearing, and re-established and	**Performance indicators:** Installation of controls in	Within 24 hours of the	Superintendent Foreman

ID	Management Action	Performance Indicator/Target	Monitoring/Timing	Responsibility
	maintained during topsoil removal and earthwork operations.	accordance with the ESCP. AND Inspection of controls and identification of poorly operating/damaged controls. **Performance target:** 100% of controls in ESCP installed within 24 hours of completion of clearing in that area. AND All controls inspected weekly and all poorly operating/ damaged controls repaired.	completion of clearing in that area. Weekly.	
EPBC 16 SW16	All disturbed areas would be progressively stabilised and/or rehabilitated as they are completed. Rehabilitation would aim to achieve at least 70% cover (i.e. C-factor of 0.05 or less) within 60 days on cut and fill batters or other disturbed areas, or 10 days in concentrated flow paths.	**Performance indicators:** Installation of temporary erosion and sediment controls in accordance with ESCP. AND Inspection of controls at least weekly to identify operating/damaged controls. AND Removal of controls following consultation with suitably qualified professional. **Performance targets:** 100% of controls are installed as per the ESCP. AND All controls inspected weekly and all poorly operating/ damaged controls repaired. AND	Ongoing during construction Weekly Ongoing	Superintendent Foreman

ID	Management Action	Performance Indicator/Target	Monitoring/Timing	Responsibility
		No controls are removed until suitably qualified professional has been consulted.		
EPBC 17 SW11	Works will be programmed to minimise the extent and duration of disturbance to vegetation. This will include leaving clearing (unless undertaken by manual means) and initial earthworks in intermittent and permanent watercourses until subsequent works are about to commence.	**Performance indicator:** Clearing in all watercourses. **Performance target:** 100% of clearing in all watercourses left until works are about to commence unless all vegetation is felled manually / with minimal disturbance.	Prior to construction commencing in watercourses.	Superintendent Foreman
EPBC 18 SW29	Where temporary crossings are required, these shall be designed, constructed and maintained in accordance with Managing Urban Storm water Soils and Construction Volumes 2A and 2D Main Road Construction (DECC 2008) and section 5.3.4 of the guideline Managing Urban Storm water 4th edition March 2004, Volume 1 Soils and Construction (the 'Blue Book') and subject to the preparation of an EWMS identified in SW10 and SW33. Temporary crossings will: • Be 'fish friendly' with a lower section of the temporary crossing provided to act as an emergency spillway. Including the use of the adequate size and number of pipes set at bed level to facilitate fish passage in Class 1 -3 waterways. • Be used for the shortest time required to complete their designed operational function and affected riparian vegetation will be rehabilitated as soon as possible where the permanent design footprint does not overlay the temporary crossing location. • Use material that will not result in fine sediment material entering the waterway. Where rock crossings are used, the rock will be of	**Performance indicators:** Design of temporary crossings. AND Construction and maintenance of temporary crossings. AND Rehabilitation of temporary crossings **Performance targets:** 100% of temporary crossings designed in accordance with the Blue Book. AND 100% of temporary crossings constructed and maintained as per design. AND 100% of temporary crossings rehabilitated within 24 hours of removal.	Prior to construction of temporary crossing Ongoing Within 24 hours of the removal of the temporary crossing.	Environment Manager Superintendent Engineers

ID	Management Action	Performance Indicator/Target	Monitoring/Timing	Responsibility
	suitable size to reduce the likelihood of the material being washed away in a storm or flood event, with large sized rock on the lower side of crossings where water velocity increases.			
EPBC 19 SW 30	Scour protection shall be installed at the base of permanent and temporary drainage outlets, and will be integrated where feasible into existing banks to minimise impacts.	**Performance indicator:** Installation of scour protection installed at the base of all drainage outlets. **Performance target:** Scour protection installed at 100% of drainage outlets prior to commissioning.	Prior to commissioning these structures.	Engineers
EPBC 20 SW 31	Drainage works shall be stabilised against erosion by appropriate selection of channel dimensions, slope and lining, and the inclusion, if necessary, of drop structures and energy dissipaters. Where feasible and reasonable, removal of frog habitat along drainage lines would not be undertaken during periods of wet weather;	**Performance indicators:** Preparation of ESCPs inclusive of erosion control measures. AND Erosion controls installed and maintained as per ESCPs. **Performance targets:** All erosion and sediment control measures installed are in ESCPs. AND 100% of erosion and sediment control plans prepared prior to works commencing in that area. AND 100% of erosion and sediment controls installed and maintained as per ESCPs.	Prior to commencing works in that area. Ongoing.	Engineers
EPBC 21 SW 32	Culverts and permanent stream protection measures shall be installed as early as possible where the construction program permits, to facilitate transverse drainage during the early	**Performance indicator:** Timing of culvert construction. **Performance target:** Where traffic staging permits,	Within 12 months of clearing in that location.	Superintendent Foreman Engineers

ID	Management Action	Performance Indicator/Target	Monitoring/Timing	Responsibility
	stages of construction. Bridge structures will be designed to mitigate potential impacts on creek geomorphology;	100% of culverts are constructed within the first 12 months of the construction programme.		
EPBC 22 SW 39	Sediment basins will be retained for a minimum of six months or until a 70% vegetative cover is achieved in its catchment, or other satisfactory controls are in place, or the basin is otherwise redundant.	**Performance indicator:** Retention of sediment basin. **Performance target:** No sediment basins are removed until management action criteria are achieved.	Minimum of six months or until management action criteria achieved.	Environmental Manager
EPBC 23 SW 56	Erosion and sediment controls will be inspected at least daily (with maintenance and/or modifications made as necessary). Inspections and/or maintenance during rainfall that causes runoff from the premises maybe increased where necessary.	**Performance indicators:** Completion of informal and formal inspections. AND Completion of maintenance of erosion and sediment controls. **Performance targets:** Informal inspection conducted on 100% of work days. AND Formal inspections undertaken every week during construction. AND 100% of maintenance actions in inspection reports are undertaken.	Informal inspections daily and formal inspections weekly for the duration of construction. Ongoing.	Environmental Coordinators
EPBC 24 SW 57	A project soil conservation specialist will inspect the work areas, assess drainage and riparian conditions, prepare erosion and sediment control plans and provide advice to the project team to maintain a high standard of erosion and sediment practices on site. Inspections will be undertaken	**Performance indicators:** Engagement of project soil conservation specialist. AND Preparation and review of ESCPs	Prior to the commencement of construction. Prior to the commencement of work in that area.	Soil Conservation Specialist Environment Manager

ID	Management Action	Performance Indicator/Target	Monitoring/Timing	Responsibility
	typically on a fortnightly basis, or as required where high-risk activities are proposed, or where sensitive areas have the potential to be affected eg SEPP 14 wetland, heritage sites. Inspections and timing will be reviewed regularly by the Environmental Manager in response to site conditions, risk profile and stage of the project.	by soil conservationist. AND Completion of inspections by soil conservationist. **Performance targets:** No construction works commence until soil conservation specialist engaged. AND 100% of ESCPs are prepared or reviewed by the soil conservationist prior to the commencement of work in that area. AND Soil conservationist inspections conducted every fortnight during construction. AND No high risk activities commence until soil conservation inspection has been conducted.	At least fortnightly.	
Measures to manage impacts to Threatened Flora Species				
EPBC 25 Appendix B	The following measures will be implemented for the translocation of Slender Marsdenia as follows: • Pre-clearance surveying for individuals • Directly impacted plants to be transplanted to adjoining State Forest, road reserve and RMS owned property, whichever is closest, provides suitable habitat and is in a location/tenure suitable for long-term conservation. • Methods for appropriate translocation are provided in the Threatened Flora Management Plan.	**Performance indicators:** Number of directly impacted plants transplanted to adjoining suitable land. AND Transplanted and propagated plants ID correctly. AND Experimental work incorporated into translocation process.	• Translocation to occur prior to clearing. • Experimental work incorporated into translocation process during pre-construction and construction phases • Monitoring of the translocation including the experiments would be conducted during	Flora Specialist Ecologist

ID	Management Action	Performance Indicator/Target	Monitoring/Timing	Responsibility

	• Rhizome pieces dislodged during transplanting (soil breaks up easily) to be used to for propagation of population enhancement plants.
	• All transplants to be tagged with its donor ID number throughout the translocation process; all propagated plants to be labelled with the parent donor ID number throughout the propagation and introduction process.
	• Experimental work to be incorporated in the Slender Marsdenia translocation including:-
	  • study of genetic variation within and between sub-populations using shoot material taken during transplanting (stems to be pruned).
	  • study of flowering and seed production in transplants under pot cultivation
	  • study of plant response to translocation introduction treatments - i.e. direct transplanting vs. planting after initial pot stabilisation; fertiliser/mulch vs. no fertiliser treatment; disturbed vegetation vs undisturbed vegetation.
	  • Ongoing maintenance of the translocated populations for a minimum of five years or until the translocated populations are well established and habitat has been restored to good condition. Maintenance activities are listed in the Threatened Flora Management Plan.
	  • Unexpected impacts on retained or translocated Marsdenia individuals must be addressed immediately, appropriate mitigation measures are to be discussed and agreed with Roads and Maritime/ Environmental Representative and DoE.
		Performance targets:
		100% of directly impacted plants transplanted to adjoining suitable land.
		AND
		100% of transplanted / propagated plants to be tagged with its donor ID number / parent donor ID number.
		AND
		100% of experimental work incorporated into translocation process.
			construction and after construction for a minimum of 5 years, a total of approximately 8 years.
			• Monitoring of other roadside specimens	

ID	Management Action	Performance Indicator/Target	Monitoring/Timing	Responsibility
EPBC 25b Appendix B	• **Monitoring and reporting** - Monitoring would be every three months for the first year; every six months in the second year and once a year thereafter. An annual translocation monitoring report would be prepared at the end of each year of the monitoring program (starting from the completion of translocation) • **Evaluation** - The progress and outcomes of the translocation Project would be evaluated to assess whether the aims of the program have been achieved, and to identify the reasons for success/failure that can be used to inform future translocation Projects (ANPC, 2004).	**Performance Targets:** 100% monitoring undertaken; AND Monitoring results are compared with the experimental hypothesis of the Threatened Flora Management Plan	• Every three months for the first year; every six months in the second year and once a year thereafter. An annual translocation monitoring report would be prepared at the end of each year of the monitoring program.	Flora Specialist
Measures to manage impacts to Giant Barred Frog (GBF), Grey Headed Flying Fox (GHFF), Koala and Spotted Tailed Quoll (STQ) during Pre-construction Phase				
EPBC 26 Appendix D Appendix L Appendix M Appendix N	To ensure no loss of known habitat of above mentioned EBPC listed fauna species from pre-construction activities, the following measures will be implemented: • Minimise areas of vegetation habitat, including Swamp Mahogany, *Melaleuca quinquenervia, Banksia integrifolia and Eucalyptus tereticornis* and others to be cleared where feasible and reasonable during the detailed design phase; • No areas of habitat to be cleared during preconstruction; • All ancillary sites to be located outside of exclusion zone for mapped habitat; • Ecological assessments to be prepared for ancillary sites to verify minimal impacts to species; • Constraints maps to include species habitat mapping; • Prior to any clearing taking place during pre-	**Performance indicators:** Area of EBPC listed fauna species habitat cleared during preconstruction. AND Number of ancillary sites located within mapped EBPC listed fauna species habitat. AND Sensitive areas and clearing extents identified on Sensitive Area Plans and clearing drawings. AND Pre-clearing inspections / permits completed by the Project Ecologist prior to the clearing of areas of vegetation. AND	Detailed design and pre-construction Pre-construction Pre-construction Pre-construction Pre-construction Prior to clearing	Environmental Manager Project Ecologist

ID	Management Action	Performance Indicator/Target	Monitoring/Timing	Responsibility
	construction works, he Project Ecologist will undertake an inspection of vegetation, to be cleared, to determine if works are in accordance with planning approval (Construction definition and Referral ‘excluded work’); • Pre-clearing permits to be completed by the Project Ecologist prior to the clearing of areas of vegetation. • The limits of clearing are to be clearly marked on all relevant work plans and protective fencing erected to mark these limits (i.e. ‘no-go’ areas); • Limits of clearing will be marked out prior to clearing commencing in each works area; • Identify exclusion zones and install exclusion fencing / no-go fencing will be installed prior to vegetation clearing activities commencing in each works area; and • Areas for habitat restoration/ connectivity are to be identified and included in the detailed design.	Clearing limits and no-go fencing marked out/installed prior to clearing commencing. **Performance targets:** No EPBC listed fauna species habitat cleared during preconstruction. AND No EPBC listed fauna species habitat impacted by the ancillary facilities. AND 100% of sensitive area plans identify EPBC listed fauna species. AND 100% of pre-clearing inspections / permits completed by the Project Ecologist prior to the clearing of areas of vegetation. AND 100% of clearing limits and exclusion / no-go zones erected prior to clearing.	Prior to clearing, Prior to clearing, Prior to clearing, Prior to clearing, Detailed Design	
EPBC 27 Appendix D Appendix L Appendix M Appendix N	To ensure no injury/mortality to individuals of above mentioned EBPC listed fauna species from pre-construction activities, the following measures will be implemented: • No areas habitat to be cleared during preconstruction; • All ancillary sites to be located outside of exclusion zones for mapped habitat; • Preparation of an EWMS would be undertaken for all work activities and would include where	**Performance indicator:** Number of injuries/ mortalities to EPBC listed fauna species as a consequence of pre-construction activities. **Performance target:** No injuries/ mortalities to EPBC listed fauna species as a consequence of pre-construction activities.	Pre-construction Pre-construction Pre-construction	Project / Site Engineers Foreman / Leading Hands Environment Manager Environmental Coordinators

ID	Management Action	Performance Indicator/Target	Monitoring/Timing	Responsibility
	necessary measures to minimise risk; • Induction of all personnel involved with pre-construction activities would be undertaken to advise on management requirements; • For any area of vegetation to be cleared during the pre-construction stage of the Project, a suitably qualified ecologist will undertake a search for native fauna in the vicinity of clearing immediately prior to clearing commencing; • In the event that a Koala is identified within 50 metres of a works area, works will be rescheduled until the construction stage of the Project. in the event that a STQ is identified no works would be undertaken within a 200 metre radius of this sighting until the construction stage of the Project. • For all Koalas and STQ's detected on/ near the site the protocol as shown in Table 4.1 of Appendix L (Koala) and Appendix M (STQ) is to be implemented.		Pre-construction Prior to clearing Pre-construction Pre-construction Pre-construction	
EPBC 28 Appendix D Appendix L Appendix M Appendix N	To minimise vehicle strike of above mentioned EBPC listed fauna species during pre-construction activities, the following measures will be implemented: • Koala and STQ Management Protocol to be implemented requiring all personnel to report Koalas and STQ's (including roadkill). • Assessment of future roadkill risk including adaptive management actions to be provided by ecologist where Koala and STQ roadkill is detected.	**Performance indicator:** Number of EPBC listed fauna species injuried/killed due to road strike. **Performance target:** No roadkill of EPBC listed fauna species resulting from the Project.	Roadkill monitoring to be undertaken in accordance with Koala (Appendix L) and STQ (Appendix M) Management Plan.	Project / Site Engineers Foreman / Leading Hands Environmental Coordinators

ID	Management Action	Performance Indicator/Target	Monitoring/Timing	Responsibility
EPBC 29 Appendix D Appendix L Appendix M Appendix N	To minimise the spread of Chytrid fungus during pre-construction activities the following measures will be implemented: • No areas of Giant Barred Frog habitat to be accessed during preconstruction • All ancillary sites to be located outside of mapped GBF habitat.	**Performance indicators:** Area of GBF accessed during preconstruction. AND Number of ancillary sites located within mapped EBPC listed fauna species habitat. **Performance targets:** No GBF habitat accessed during preconstruction. AND No GBF habitat impacted by the ancillary facilities.	Preconstruction Preconstruction	Project / Site Engineers Foreman / Leading Hands All Staff
EPBC 30 Appendix D Appendix L Appendix M Appendix N	To ensure that appropriate habitat offsets have been identified for the above mentioned EBPC listed fauna species the following measures will be implemented: • Appropriate habitat offsets to be identified by including targeted surveys using recognised survey approaches to confirm usage of potential offset properties. • Roads and Maritime will further investigate opportunities to plant preferred food trees in offset properties that are proposed for purchase following the offset selection process.	**Performance indicator:** Suitable offset area for EPBC listed fauna species habitat identified. **Performance target:** Suitable offsets identified in accordance with the EPBC Environmental Offsets Policy (2012) and Biodiversity Offset Strategy	Offset properties are currently being investigated by RMS.	Roads and Maritime
Measures to manage impacts to Giant Barred Frog (GBF), Grey Headed Flying Fox (GHFF), Koala (K) and Spotted Tailed Quoll (STQ) during Construction Phase				
EPBC 31 Appendix D Appendix L Appendix M	To minimise habitat loss of the above mentioned EBPC listed fauna species during construction the following measures will be implemented: • Provide for habitat offsets as per the Biodiversity Offset Strategy; • Implement the Nest Box Plan of Management;	**Performance indicator:** Area of EPBC listed fauna species habitat cleared AND Sensitive areas and clearing extents identified on Sensitive	Clearing limits to be checked prior to the commencement of clearing by survey and environmental team.	Environment Manager Ecologist

ID	Management Action	Performance Indicator/Target	Monitoring/Timing	Responsibility
Appendix N	• Any design changes required during the construction stage would minimise clearing of habitat where feasible and reasonable; additionally to maximise separation between alignment and GHFF camp. • Ecological Assessments to be prepared for additional areas to be cleared to verify minimal impacts; • The limits of clearing are to be clearly marked on all relevant work plans and protective fencing erected to mark these limits (i.e. 'no-go' areas) including 5m clearing limit outside of Project Boundary of GHFF Swamp Sclerophyll. • Fencing and marking monitored with breaches repaired. • Fauna habitat resources for EPBC species to be marked by the ecologist and retained within areas adjacent to the clearing footprint and within the Project boundary where appropriate.	Area Plans and clearing drawings. **Performance target:** Clearing limit does not exceed approved limits for each species AND 100% Sensitive Area Plans identify sensitive areas and 100% of clearing drawings identify clearing extents. AND Completion of pre clearing survey prior to construction including mark out of clearing extents. AND Suitable habitat features for STQ relocated into appropriate areas.		
EPBC 32 Appendix D Appendix L Appendix M Appendix N	To ensure no injury/mortality to the above mentioned EBPC listed fauna species from construction activities, the following measures will be implemented: • Preparation of an EWMS would be undertaken for all construction activities to clearly communicate relevant measures within this plan to work crews; • Ongoing induction of all personnel involved with construction activities would be undertaken to advise of species management requirements; • Establish Site Controls (Temporary Frog Fencing) in Upper Warrell Creek for GBF in	**Performance indicator:** Number of EPBC listed fauna species injured / mortalities as a consequence of construction activities **Performance target:** No EPBC listed fauna species injured / mortalities as a consequence of construction activities.	• Pre-clearing permits/checklists to be completed by the Project Ecologist with Giant Barred Frog experience prior to the clearing of any vegetation. • Post-clearing inspections of recently cleared areas (<1 day) in known Giant Barred Frog habitat to identify any individuals injured or killed during clearing • The detection of chytrid	Project / Site Engineers Foreman / Leading Hands Environmental Manager Environmental Coordinators

ID	Management Action	Performance Indicator/Target	Monitoring/Timing	Responsibility

	accordance with Section 4.4.2. of Appendix D;
	• Undertake pre-clearing Survey for GBF in accordance with Section 4.5.3 of Appendix D;
	• Clearing supervision in GBF areas to be undertaken in accordance with section 4.5.4 of Appendix D;
	• Undertaken dewatering procedures in GBF areas in accordance with section 4.5.5 of Appendix D;
	• Install permanent frog fencing in GBF areas in accordance with section 4.5.6 of Appendix D
	• If GBF are detected during pre-clearing surveys, clearing operations or dewatering works the unexpected finds procedure, detailed in Section 4.5.7 of Appendix D must be followed.
	• Undertake pre-clearing surveys for other EPBC fauna species (including Koala, STQ and GHFF) prior to any clearing commencing.
	  • For Koalas these are to include spotlighting surveys within suitable habitat on the night prior to clearing operations commencing in a given area.
	  • For the STQ these would focus on dens, large hollow-bearing trees, scats and any other potential habitat features such as rock formations.
	• During the proposed clearing works, an experienced wildlife handler will be present to retrieve any displaced fauna and release the fauna into adjacent habitats safe from construction work. Contact details for the local OEH Officers, WIRES and other wildlife care
			fungus 'sick and dying' frogs;
			• Dewatering permit/checklist to be completed by the Project Ecologist with Giant Barred Frog experience prior to any water bodies being dewatered in Giant Barred Frog habitat
			• Daily inspections of temporary frog exclusion fencing following completion of pre-clearing survey until the installation of the permanent Giant Barred Frog Fencing
			• Pre-clearing permits to be completed by the Project Ecologist prior to the clearing of any vegetation.
			• Post-clearing inspections to be undertaken of areas cleared to identify any animal (including Koalas) injured or killed during clearing.
			• Pre-clearing permits to be completed by the Project Ecologist prior to the clearing of any vegetation.
			• Within 24 hours after the completion of clearing within a given area, post-clearing inspections to be	

ID	Management Action	Performance Indicator/Target	Monitoring/Timing	Responsibility
	groups will be maintained and used if required; • Immediately prior to clearing an additional ecologist inspection is to be undertaken to confirm that clearing areas remain free of fauna (including Koalas). • Where Koalas are identified no works would be undertaken within 50 metres of the animal and the measures within the Fauna Management Protocol for Koalas (refer to Table 4.1) would be implemented. • In the event that a STQ is identified, no works would be undertaken within 200 metres of the animal and the measures within the Fauna Management Protocol for STQs (refer to Table 4.1) would be implemented. • Should relocation of Koalas be required, a Koala Relocation Strategy included in Appendix C would be implemented. • Implement contingency plan for moving flying-fox out of the clearing corridor during vegetation clearing/construction, refer to Appendix C of GHFF Management Plan; • To minimise the risk of flying-fox vehicle strike during take-off from roosting/foraging, road corridor revegetation and ornamental planting is not to include plants that flower prolifically and produce nectar food sources likely to attract flying-foxes.		undertaken of areas cleared to identify any animal (STQs) injured or killed during clearing.	
EPBC 33 Appendix D Appendix L Appendix M	To minimise roadkill of above mentioned EBPC listed fauna species from construction activities, the following measures will be implemented: • Prior to the construction of fauna passage locations and installation of fauna fence, where continuous lines of jersey barriers are to be	**Performance indicator:** Number of roadkill of EPBC listed fauna species resulting from the Project. **Performance target:**	• Roadkill vac to be undertaken in accordance with species specific management plans.	Project / Site Engineers Foreman / Leading Hands Environmental Manager Environmental Coordinators

ID	Management Action	Performance Indicator/Target	Monitoring/Timing	Responsibility

Appendix N	installed, gaps are to be provided to allow escape of any animals off the highway or a suitable material is to be placed over the barrier to provide access over the barrier. Fauna crossings and fencing to be reviewed and maximise their suitability and efficiency in reducing road kills and enhancing habitat connectivity. Type F concrete barriers to be used in a way to allow Koalas to move off from highway. Material to be used to allow Koalas to climb over barriers at strategic locations.
	• Giant Barred Frog road kill to be reported to the Project Ecologist during daily/weekly monitoring.
	• Koala and STQ Management Protocols to be implemented requiring all personnel to report Koalas (including roadkill).
	• An assessment of future roadkill risks including adaptive management actions is to be provided by the Project Ecologist where:
	  • A GBF / Koala / STQ is detected within/ near the site; or GBF / Koala / STQ roadkill is detected.
	  • Temporary fauna exclusion fencing may be required if at specific sites as nominated by the Project Ecologist in consultation with Roads and Maritime Services.
		No roadkill of EPBC listed fauna species resulting from the Project.		Ecologist

EPBC 34 Appendix D Appendix L Appendix M Appendix N	To minimise disturbance to the flying-fox camp from vegetation removal, surface water drawdown, noise, vibration and lighting; • Pre-clearing and clearing surveys of all vegetation within the clearing footprint conducted as per protocol. • Impacts to the flying-fox camp from	**Performance indicators:** Maintenance of exclusion zone buffers and fencing. AND Types of construction activities undertaken within the exclusion	 As required during construction. During period from mid-September to the following	Foreman / Leading Hands Ecologist Appropriately qualified flying fox handler Environmental Manager

ID	Management Action	Performance Indicator/Target	Monitoring/Timing	Responsibility
	construction noise, vibration and light would be managed through maintaining 300m exclusion zone buffers and fencing. 500m buffer zone around perimeter of camp to apply to ancillary facilities. If heavily pregnant female GHFF or female GHFF with dependent young are present, clearing or construction within buffer to halt. Other construction activities to halt if heavily pregnant female GHFF or GHFF with dependent young present from 31 August. If monitoring demonstrates no GHFF present, construction activities may be undertaken within buffer zone. Temporary access road constructed between existing highway and Project north of the camp to reduce impacts to colony. At its closest, road will be approx. 500m from the perimeter of the camp. The existing highway, the temporary construction access road between the highway and alignment and the Bald Hill Road interchange / cutting would be excluded from the 300 metre construction buffer zone. • Measures implemented to facilitate opening of Project close to the GHFF camp when population is at or close to minimum (winter). Potential extension of working hours extension to be further considered in Flying Fox Management Plan. • Only low noise / low disturbance construction activities to occur within the exclusion zone buffer during mid-September to the following April. • Low noise pavement will be utilised from the brige over Warrell Creek to the north of Macksville to manage road traffic noise levels. • Roadside lighting will be limited to lighting required for the interchange at Bald Hill Road	zone buffer during mid-September to the following April. AND Cross drainage installed and a permeable, free draining rock platform provided AND Relocation of captured Grey-headed flying-fox outside the clearing corridor and 100m buffer. **Performance targets:** No breach in exclusion zone/fencing by construction vehicle or unauthorised construction activities. AND 100% of construction activities during mid-September to the following April will comprise of low noise / low disturbance activities only, subject to monitoring results. AND 100% of cross drainage installed and a permeable, free draining rock platform provided AND 100% of Grey-headed flying-fox captured are relocated out of the clearing corridor and 100m buffer during vegetation clearing/ construction	April. Prior to commencement of construction. Prior to commencement of construction. •	

ID	Management Action	Performance Indicator/Target	Monitoring/Timing	Responsibility
	south of the camp. • Measures implemented to ensure no change to surface water levels to GHFF camp and using appropriate expertise to monitor and ID changes within, upstream and downstream of construction corridor. This includes utilization of cross drainage and the provision of a permeable, free draining rock platform in the vicinity of the camp. Erosion sediment control measures also utilised to minimize impacts to camp water quality. • Experienced ecologist present during clearing and pre-clearing, implement pre-clearing and clearing procedures in Section 4 and 5 of Flying Fox MP. Implement contingency plan for moving flying-fox out of the clearing corridor and 100 metre buffer during vegetation clearing/ construction, refer to Appendix C. • The Flying Fox MP would be updated as required in consultation with Roads and Maritime, the Contractor, flying fox ecologist and the Environmental Protection Authority (EPA) and DoE.			
EPBC 35 Appendix D Appendix L Appendix M Appendix N	The following measures will be implemented to manage Impacts to flying-foxes during clearing, in accordance with fauna handling protocol: • implement exclusion zone and fencing strategy. • Fauna exclusion fencing through forest to be located within cleared area and connected to boundary outside forest to avoid need to clear for fencing through forest. • Pre-clearing and clearing surveys conducted as per protocol outlined. Implementation of flying-fox handling procedure.	**Performance indicators:** Exclusion zone and fencing strategy implemented. Pre-clearing and clearing surveys conducted as per protocol outlined. Flying-fox handling procedure implemented for all handling of Flying-foxes. **Performance targets:** 100% of all pre-clearing and clearing surveys conducted as per	Prior to commencement of construction. Prior to commencement of construction. Prior to and during construction.	Ecologist Appropriately qualified flying fox handler Environmental Manager

ID	Management Action	Performance Indicator/Target	Monitoring/Timing	Responsibility
		protocol outlined in Appendix N. AND 100% of all flying-foxes that require handling / relocation during clearing managed in accordance with fauna handling and rescue procedure..		
EPBC 36 Appendix D Appendix L Appendix M Appendix N	Implement water quality procedures from the CEMP to ensure no contamination or isolation of water.	**Performance indicator:** Water quality procedures implemented. **Performance target:** No contamination or isolation of water supplies.	Prior to and during construction.	Project / Site Engineers Foreman / Leading Hands Environmental Coordinators
EPBC 37 Appendix D Appendix L Appendix M Appendix N	The following habitat rehabilitation works will be undertaken within identified areas associated with the Project Site for to create additional GBF, Koala STQ and GHFF habitat. • Progressive rehabilitation of identified areas during the construction stage using collected topsoil and seed at specific sites and to develop different successional stages of rehabilitation. Key rehabilitation measures would include: • Implement fauna crossing structures and fauna fencing to maintain connectivity for Koalas while minimising road kill, in accordance with consultation with government agencies such as EPA, NPWS and NSW Department of Primary Industries (Fisheries) and independent experts for crossings within regional corridors in preparation for the operational phase of the Project	**Performance indicator:** GBF, Koala and STQ habitat. established in nominated areas. **Performance target:** Successful establishment of GBF, Koala and STQ habitat in nominated areas.	• Monitoring and maintenance of rehabilitation areas to be undertaken regularly as part of the Project landscaping contract. • Weed monitoring would be undertaken on the site.	Project / Site Engineers Foreman / Leading Hands Environmental Manager Environmental Coordinators

ID	Management Action	Performance Indicator/Target	Monitoring/Timing	Responsibility
	• Key rehabilitation measures will include: • Progressive revegetation/ rehabilitation during the construction phase using collected topsoil and seed at specific sites and to develop different successional stages of rehabilitation. • Planting of locally occurring species, including plants representative of groundcover, understorey and canopy strata. • Planting of preferred food trees for native fauna, including appropriate eucalypt species for the Koala and preferred food trees including winter-flowering plants for GHFF. • Plantings are to be undertaken around fauna crossing structures to optimise utilisation of these structures. • Monitoring and maintenance of revegated areas, including disturbed section of Swamp Sclerophyll Forest occupied by flying-fox camp. • A range of other treatments will also be provided including placement of hollow logs and course woody material, fauna furniture, fauna pathways and plantings over large scour rock. • Managing and controlling weeds.			
Monitoring Program to establish baseline (prior to construction) and changes in response to construction of Giant Barred Frog (GBF), Grey Headed Flying Fox (GHFF), Koala (K) and Spotted Tailed Quoll (STQ)				
EPBC 38 Appendix D	Undertake population monitoring to establish baseline data relating to densities, distribution and current usage of habitats by the Giant Barred Frog,	**Performance indicator:** Population monitoring completed.	Giant Barred Frog: • Pre-construction baseline	Project Ecologist

ID	Management Action	Performance Indicator/Target	Monitoring/Timing	Responsibility
Appendix L Appendix M Appendix N	Koala and STQ.	**Performance target:** Accurate/ robust survey design and information interpretation.	surveys completed between spring 2013 and autumn 2014. • Continuation of the pre construction field survey program on an annual basis in spring, summer and autumn in Years 4-8 (operational stage of the Project) Koala • Pre-construction baseline surveys completed (autumn and spring). • Ongoing established transect surveys annually (spring) at years 1 and 3 during construction, and years 4, 6 and 8 during operational as per KMP. Spotted Tailed Quoll • Pre-construction baseline surveys completed (winter 2014).	
EPBC 39 Appendix D Appendix L Appendix M Appendix N	The following monitoring measures will be implemented for the flying fox camp and provide data for any required refinements to mitigation measures. • Continuation of the systematic program of monthly flying-fox monitoring introduced in Winter 2013 (as discussed in Section 2.2) during the pre-construction and construction stages of the Project.	**Performance indicator:** Population monitoring completed. **Performance target:** Significant reduction in reproductive output (measured as mean percentage of females with young in target trees) relative to control site.	• Continuation of the fortnightly monitoring program introduced in January 2014 during the preconstruction stage of the Project. • During construction of the Project fortnightly monitoring would start 1 August and extend until	Project Ecologist

ID	Management Action	Performance Indicator/Target	Monitoring/Timing	Responsibility
	• During the pre-construction stage of the Project continuation of the fortnightly monitoring program introduced in January 2014. • During construction of the Project fortnightly monitoring would start 1 August and extend until end of April the following year. Initiation of a quarterly monitoring program of the quality of the habitat adjacent to the Project for the first year after the opening of the Project to traffic unless otherwise agreed with P&I, EPA and DOE. • Roads and Maritime would develop and implement a strategy for the management of new Grey-headed Flying-fox camps that may become established within 5 kilometres of the Macksville camp site. The strategy would be developed in consultation with EPA, DoE, the relevant local council and affected landholders. The strategy would include camps which become established within 12 months of the permanent opening of the full length of the Project to traffic. Roads and Maritime would provide the resources and funding required to implement the agreed reasonable and feasible mitigation measures identified in the strategy – no mention of new camps	Zero flying-fox mortality within 300 metres of the camp footprint. Should the annual road kill monitoring reports identify a significant difference between the road kill numbers of the different treatments (transect types).	the end of April the following year. • Road kill monitoring would commence one month of opening the Project to traffic. Surveys would be targeted 500 metres either side of the Macksville flying-fox camp (chainage 8,000 / 49,765). Subsequent surveys will be conducted weekly during October (spring), January	
EPBC 40 Appendix D Appendix L Appendix M Appendix N	Undertake road kill monitoring	**Performance indicator:** Roadkill monitoring completed. **Performance target:** Lower rates of road kill in proximity to fauna fencing (i.e. areas of the main carriageways within areas adjacent to installed	Koala / STQ • During clearing operations (up until one month after clearing is completed) – daily. • Duration of construction (weekly).	Project Ecologist / Traffic Manager / Environmental Manager

ID	Management Action	Performance Indicator/Target	Monitoring/Timing	Responsibility
		fauna fencing) than in sections of the upgrade not near fauna fencing All fauna fencing is installed at the minimum of locations as identified in the EPBC approval prior to the operational phase of the WC2NH Upgrade.		

3.4.2 Training in matters of NES

All employees, contractors and utility staff working on site will undergo induction training prior to the individual commencing work on-site relating to flora and fauna management issues including matters of NES. The induction training will address elements related to flora and fauna management including:

- Existence and requirements of this sub-plan.
- Relevant legislation.
- Presence of matters of NES in the corridor and how these species can be recognised.
- Fauna rescue requirements.
- Weed control measures.
- Specific responsibilities for the protection of flora and fauna.

In addition to the above, daily pre-start/toolbox training will also serve to inform employees of developments in the corridor including ongoing reminder of measures in place. Examples include sightings of matters of NES adjacent to work areas and fauna rescues.

Inspections of sensitive areas and activities with the potential to impact flora and fauna will occur for the duration of the Project. Frequency and responsibilities are detailed in Table 3.4.1 in respect of matters of NES.

3.4.3 Auditing matters of NES

Audits will be undertaken to assess the effectiveness of environmental controls, compliance with this sub plan (specifically Table 3.4.1) on matters of NES and the EPBC approval. External audits are generally completed by Roads and Maritime or a third-party engaged by Roads and Maritime. These are undertaken in six monthly intervals.

In addition, should the Minister direct an independent audit of the project in accordance with condition 21 of EPBC approval 2013/7101 (*information to be inserted once EPBC Approval received*), an independent auditor will be engaged and approved by the Minister prior to the commencement of the audit. Further, audit criteria must be approved by the Minister.

3.4.4 Corrective and preventation action for NES matters

Where non-conformance with the performance targets identified in Table 3.4.1 are identified, the following procedure will be implemented:

1. Immediate stop work of all activities relevant to the non-conformance until close out of identified corrective and preventative action,
2. Initiation of a hold point on these activities within the project quality assurance system,
3. Initiation of a preliminary investigation by Roads and Maritime and AFJV into the non-conformance to identify root cause factors, assessment of extent of impacts on NES matters, and identification of corrective/contingency measures specifically to address the root cause of the non-conformance or non-conforming works,
4. Where non-conformances are identified that result in a non-compliance with the approval conditions of EPBC Approval 3012/7101 the non-compliance will be reported to the Federal Department of the Environment within 2 business days and an Incident Cause Analysis Method (ICAM) investigation initiated.
5. Implementation of identified corrective/contingency actions followed by release of hold point relating to the activities relevant to the non-conformance.

Non-conforming activities may be stopped, if necessary, by the Environmental Manager, Environmental Coordinator/Advisor(s) or Project/Site Engineer following consultation with the Construction Manager or delegate. The works will not commence until a corrective/preventative action has been closed out. The Environmental Representative may also stop works in these circumstances. In such circumstances, a non-conformance report must be prepared in accordance with the Quality Plan.

3.4.4 Reporting matters of NES

Under condition 19 of EPBC approval 2013/7101, reporting of measures identified in Table 3.4.1 will occur within three months of the twelve month anniversary of the commencement of the action. Reporting will be published on the project website. A copy of this compliance report will also be sent to the Department of the Environment at that time.

3.4.5 FFMP update and amendment for matters of NES

Any revisions to the FFMP will be in accordance with the process outlined in Section 1.6 of the CEMP. Where such revisions do not have an equal or better outcome for Slender Marsdenia, Koala, Grey-headed Flying-fox, Spotted-tail Quoll and the Giant-Barred Frog, the plan will be provided to the Minister for the Environment for written approval prior to implementation of those changes.

A copy of the updated plan and changes will be distributed to all relevant stakeholders in accordance with the approved document control procedure.

4 Environmental aspects and impacts

The following sections summarise existing flora and fauna within and adjacent to the project area including species, communities and habitats. Identified impacts are reviewed. The key reference documents are Chapter 10 and Working Paper 1 of the EA. The project boundary and relevant ecological data is shown on the sensitive area maps included in Appendix A6 of the CEMP.

4.1 Environmental aspects

4.1.1 Endangered ecological communities

EECs listed in NSW under the TSC Act have been located in the study area and are listed below:

- Subtropical Coastal Floodplain Forest of the NSW North Coast Bioregion
- Lowland Rainforest of the NSW North Coast and Sydney Basin Bioregion
- Swamp Sclerophyll Forest on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregion
- Swamp Oak Floodplain Forest of the NSW North Coast, Sydney Basin and South East Corner Bioregion
- Freshwater Wetlands on Coastal Floodplains of the NSW North Coast, Sydney Basin and South East Corner Bioregion
- Coastal Saltmarsh of the NSW North Coast, Sydney Basin and South East Corner Bioregion

The location of these EECs in relation to the project is shown on the Sensitive Area Plans included at Appendix A6 of the CEMP.

No Commonwealth EPBC Act listed endangered ecological communities (EEC) were identified in the study area.

4.1.2 Threatened or otherwise significant plant species

Threatened flora species identified, or with the potential to occur within the project corridor, and their conservation status, are listed in Table 4-1. These species listed are the result of the EA findings and subsequent surveys conducted by Benwell (2010) and Brown (2010).

Table 4-1 Threatened or otherwise significant plant species

Common name	Scientific name	EPBC Act	TSC Act	Occurrence
Slender Marsdenia	*Marsdenia longiloba*	Vulnerable	Endangered	Identified
Rusty Plum	*Niemeyera whitei*	-	Vulnerable	Identified
-	*Maundia triglochinoides*	-	Vulnerable	Identified
Cryptic Forest Twiner	*Tylophora woollsii*	Endangered	Endangered	Identified
Koala Bell	*Artanema fimbriatum*	-	-	Identified
-	*Goodenia fordiana*	-	-	Identified
Floyd's Grass	*Alexfloydia repens*	-	Endangered	Identified
-	*Eucalyptus ancophila*	-	-	Identified
Great Climbing Orchid	*Psuedovanilla foliata*	-	-	Identified
Spider Orchid	*Dendrobium*	-	Endangered	Identified

Common name	Scientific name	EPBC Act	TSC Act	Occurrence
	melaleucaphilum			
Newry Golden Wattle	*Acacia chrysotricha*	-	Endangered	Potential
Scented acronychia	*Acronychia littoralis*	Endangered	Endangered	Potential
Red Bopple Nut	*Hicksbeachia pinnatifolia*	-	Vulnerable	Potential
Milky Silkpod	*Parsonsia dorrigoensis*	Endangered	Vulnerable	Potential
Brown Fairy-chain Orchid	*Peristeranthus hillii*	-	Vulnerable	Potential
Eastern Underground Orchid	*Rhizanthella slateri*	Endangered	Vulnerable	Potential

Following changes to the project alignment subsequent to the Environmental Assessment exhibition, the proposal is also expected to impact on approximately one hectare of potential habitat for the vulnerable flora species *Rhizanthella slateri* (Eastern underground orchid), compared to the 4.3 hectares of potential habitat originally affected.

The location of flora species identified in the project corridor are shown on the Sensitive Area Plans included at Appendix A6 of the CEMP

4.1.3 Fauna habitats

Five fauna habitat types were identified by the EA. These are listed below and shown on the Sensitive Area Maps included at Appendix A6 of the CEMP.

Table 4-2 Fauna habitat types

Name	Habitat features
Dry open forests	Diversity of canopy plant species which provide seasonal food and shelter resources for nectarivorous and foliovorous birds and mammals. Abundance of logs and dense understorey providing sheltering and breeding opportunities for reptiles and small ground dwelling mammals.
Moist closed forests	Higher floristic diversity than dry open forests and may comprise a greater percentage of fruiting and flowering resources which are particularly important for specialist frugivorous fauna. Larger percentage of dead standing trees or mature trees were found to occur in moist gullies where fire has been suppressed.
Swamp forests	Provide dense cover for ground-dwelling mammals and birds. Swamp mahogany is a winter flowering eucalypt and important food resource for nectarivorous fauna. Other important habitat features include large trees, tree hollows and logs, and persistent surface water providing important refuge habitat for frogs.
Aquatic / estuarine habitats	Permanent and ephemeral creeks, freshwater wetlands and farm dams provide habitat for frogs, some reptiles and several common wader and waterbird species. The Nambucca River and Kalang River provide significant estuarine fauna habitats including open water, intertidal sandflats, sandy shores and oyster leases for bird groups such as waders, waterfowl, cormorants, pelicans, herons, oystercatchers and their allies.
Modified habitats	Provide few important habitat features for fauna and generally comprise lower faunal diversity as a result of the degree of disturbance

4.1.4 Threatened fauna

Threatened fauna species identified during survey (confirmed) and those which have been previously recorded in the area are listed in Table 4-3.

Table 4-3 Threatened fauna

Common name	Scientific name	EPBC Act	TSC Act	Occurrence Likelihood
Black-necked Stork	*Ehippiorhynchus asiaticus*	-	Endangered	Confirmed
Spotted-tailed Quoll	*Dasyurus maculatus*	Vulnerable	Vulnerable	Potential
Brush-tailed Phascogale	*Phascogale tapotafa*	-	Vulnerable	Potential
Yellow-bellied Glider	*Petaurus australis*	-	Vulnerable	Confirmed
Koala	*Phascolarctos cinereus*	Vulnerable	Vulnerable	Confirmed
Glossy Black-Cockatoo	*Calyptorhynchus lathami*	-	Vulnerable	Confirmed
Square-tailed Kite	*Lophiotinia isura*	-	Vulnerable	Confirmed
Emu	*Dromaius noveahollandia*	-	Endangered population	Unlikely
Black Bittern	*Ixobrychus flavicollis*	-	Vulnerable	Potential
Green and Golden Bell Frog	*Litoria aurea*	Endangered	Endangered	Unlikely
Green-thighed Frog	*Litoria brevipalmata*	-	Vulnerable	Confirmed
Giant Barred Frog	*Mixophyes iteratus*	Endangered	Endangered	Confirmed
Swift Parrot	*Lathamus discolour*	Endangered	Endangered	Potential
Regent Honeyeater	*Xanthomyza phrygia*	Endangered	Endangered	Potential
Little Bentwing-bat	*Miniopterus australis*	-	Vulnerable	Confirmed
Eastern Bentwing-bat	*Miniopterus schreibersii*	-	Vulnerable	Confirmed
Common Blossom bat	*Syconycteris australis*	-	Vulnerable	Potential
Greater Broad-nosed Bat	*Scoteanax rueppellii*	-	Vulnerable	Confirmed
Eastern Freetail-bat	*Mormopterus norfolkensis*	-	Vulnerable	Potential
Eastern False Pipistrelle	*Falsistrellus tasmaniensis*	-	Vulnerable	Confirmed
Grey-headed Flying-fox	*Pteropus poliocephalus*	Vulnerable	Vulnerable	Confirmed
Yellow-bellied Sheathtail bat	*Saccolaimus flaviventris*	-	Vulnerable	Confirmed

4.1.5 Aquatic fauna

Species recorded in freshwater and estuarine habitats during investigations for the EA are shown in Table 4-4.

Table 4-4 Aquatic fauna

Habitat	Species
Freshwater Butchers Creek, Rosewood Creek, Stony Creek, Williamson Creek.	273 fish were caught from 12 species. The most widely distributed was the Striped Gudgeon (*Gobimorphus australis*) and the Empire Gudgeon (*Hypseleotris compressa*). No state or nationally threatened species were present. One exotic species, the Mosquito Fish (*Gambusia holbrooki*) was identified.
Estuarine Warrell Creek, Nambucca	4836 fish were caught from 17 species. The most widely distributed species at all sites was the Grass Shrimp (*Macrobrachium intermedium)*. The Estuary

River,	Perchlet (*Ambassis marianus*), Estuary Perch (*Macquaria colonorum*), Flathead Gudgeon (*Philypnodon grandiceps*) and Sea Mullet (*Mugil cephalus*) were also widely distributed across the sites. No state or nationally listed species were recorded.

The fisheries habitat classification for each of the waterways referred to above is provided in Table 4-5.

Table 4-5 Fisheries habitat classifications

Waterway	Classification #	Description
Butchers Creek	Class 2 – Moderate Fish Habitat	Named permanent or intermittent stream, creek or waterway with clearly defined bed and banks with semi-permanent to permanent waters in pools or in connected wetland areas. Marine or freshwater aquatic vegetation is present. Known fish habitat and/or fish observed inhabiting the area.
Rosewood Creek	Class 2 – Moderate Fish Habitat	
Stony Creek	Class 2 – Moderate Fish Habitat	
Williamson Creek	Class 2 – Moderate Fish Habitat	
Warrell Creek	Class 1 – Major Fish Habitat	Major permanently or intermittently flowing waterway (e.g. river or major creek), habitat of a threatened fish species.
Nambucca River	Class 1 – Major Fish Habitat	

Classification in accordance with NSW DPI Fisheries Guidelines - Why Do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings, Fairfull and Witheridge. January 2003.

4.2 Construction activities

Key aspects of the project that could result in impacts to terrestrial and aquatic flora and fauna include:

- Clearing of native vegetation (including habitat). The Scope of Works and Technical Criteria (SWTC) for the WC2NH Project identifies clearing of approximately 87.4 hectares of native vegetation.
- Works around and within watercourses.
- Removal of dead wood, in-stream woody debris and dead trees.
- Noise impacts.
- Disturbance of soils, consequential erosion and the mobilisation of sediment.
- Use of chemicals / fuels (potential for spills).

Refer also to the Aspects and Impacts Register included in Appendix A2 of the CEMP.

4.3 Ecological impacts

Likely and/or potential impacts associated with the Project are discussed in Chapter 10 of the EA and include:

- Loss of threatened plant species and endangered ecological communities.
- Direct and indirect impacts to fauna.
- Loss of habitat.
- Fragmentation of habitats and wildlife corridors.
- Barrier effects on wildlife and riparian corridors (such as the erosion of genetic stock, impacts on home ranges, territorial disputes, increased competition etc).
- Spread of plant diseases.

- Spread of feral animals.
- Physical, chemical and biological changes to aquatic environments, wetlands etc.
- Edge effects (such as weed invasion, pests and disease).
- Disturbance to aquatic and riparian habitats potentially resulting in contamination and siltation of waterways.
- Cumulative impacts in association with the Pacific Highway Upgrade Program.

Notwithstanding, mitigation and management measures provided in Table 5-1 aim to minimise the above likely and potential impacts on those threatened plant species identified in Table 4-1.

In the absence of appropriate mitigation measures, there is the potential for significant impacts on those threatened flora and fauna species identified in as occurring, or with the potential to occur, within the project corridor.

Based on the proposed Tender Design and refined Detailed Design the Project is expected to result in the loss of less than approximately 87.4 hectares of native vegetation and 10 hectares of Endangered Ecological Communities (EEC) this includes approximately 0.1475 hectares of mangroves and approximately 0.086 hectares of Saltmarsh (as defined under the Fisheries Management Act only)

4.3.1 Pre-construction surveys

Surveys of all areas within the project boundary (including the detailed design footprint) were undertaken by a team of ecologists between 21 and 28 July with subsequent inspections of the site undertaken in August 2014. The following activities were undertaken:

- Previously identified HBTs as recorded by Lewis (2013) were remarked with red and white flagging tape and white spray paint.
- Additional HBTs were marked as above with the locations recorded on iPads (using IGIS software).
- Vegetation communities were mapped using iPads and IGIS software in accordance with the vegetation classification systems used in the Project Environmental Assessment (EA) (SKM, 2010). This included determining and mapping any Endangered Ecological Communities (EECs) or Threatened Ecological Communities (TECs) listed under the Threatened Species Conservation Act 1997 (TSC Act) or Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). Mangroves, saltmarsh, sea grass and riparian vegetation was also determined.
- Weed Mapping was undertaken of areas of noxious/ environmental weeds, the results of which are included in the Weed and Pathogen Management Plan (GeoLINK, 2014).
- Searches of the project site for additional threatened flora species listed under the TSC Act or EPBC Act and ground-truthing the location of previously detected threatened flora as recorded within the WC2NH Threatened Flora Management Plan (TFMP). The ground-truthing of previously recorded threatened flora has not been completed as the TFMP is currently being finalised. Further details will be provided as an addendum to this report once the TFMP has been completed.

Updated mapping showing the revised vegetation communities is provided in the Sensitive Area Maps attached to the CEMP. Updated vegetation mapping generally conformed to previous mapping undertaken as part of the Project EA (SKM, 2013). A small number of discrepancies were identified which are summarised in **Table 4.6**. Where minor and arbitrary changes to mapping line work only were identified, (e.g. areas of Moist Open Forest

Flooded Gum occurring in Nambucca State Forest) previous mapping is considered to reflect vegetation communities adequately and has been presented.

Based on the revised vegetation communities mapping, updated EEC mapping is also included in the Sensitive Area Plans. No additional EECs/ TECs were detected within the project site. The following previously recorded EECs (listed under the TSC Act only) were detected on the site in generally similar areas as to that previously recorded:

- Freshwater Wetland.
- Swamp Sclerophyll Forest.
- Subtropical Coastal Floodplain Forest.
- Swamp Oak Forest.

Areas for vegetation communities and EECs recorded within the project boundary are summarised in **Table 4.6.**

Table 4.6 Vegetation Communities/ EECs Recorded within the Project Boundary

Vegetation Community	*Area within Project Boundary (ha)*
Camphor Laurel Forest	1.69
Freshwater Wetland (EEC)	4.36
Garden Plantings	0.77
Hardwood Plantation	3.57
Mangrove Forest	0.12
Mixed Floodplain Forest (EEC)	3.78
Moist Open Forest-Flooded Gum	16.05
Moist Open Forest – White Mahogany – Grey Gum	9.35
Open Forest - Blackbutt	77.16
Regrowth Acacia/ Weeds	0.95
Regrowth Swamp Oak	1.61
Swamp Sclerophyll Forest – Swamp Mahogany Paperbark (EEC)	4.33
Swamp Oak Forest (EEC)	0.43

Freshwater Wetland mapping was recently reassessed after recent rainfall. Updated areas have been provided in Table 4.6 above.

Areas previously mapped as Lowland Rainforest EEC (listed under the TSC Act and the EPBC Act) were found to be more representative of Camphor Laurel Forest due to being largely dominated by Camphor Laurel and Privet with very few, if any species indicative of the lowland rainforest community.

No additional threatened flora species were recorded and no additional threatened flora occurrences were confirmed. A number of potential Maundia (*Maundia triglochinoides*) plants were located although were unable to be confirmed due to lacking flowering material. These will be confirmed in spring 2014 with details to be provided within an addendum to this report.

A number of additional HBTs were recorded within the project site. Revised HBT mapping is included in the Sensitive Area Plans.

Table 4.7 Vegetation Mapping Varying from EA Mapping (SKM, 2013)

Chainages	Previous Mapping	Updated Mapping	Justification
450 - 700	Included in areas of cleared grazing land.	Additional linear areas of freshwater wetland which would typically hold water after rain events.	Potential Maundia located in areas and other species indicative of freshwater wetland.
1,300-1,700	Flooded Gum Moist Open Forest along Butchers Creek.	Logged plantation extends over most of the vegetated area.	Lack of mature Flooded Gums and recently logged areas.
3,020 – 3,200	Lowland Rainforest (EEC)	Camphor Laurel Forest	Predominantly Camphor Laurel with few natives present.
3,400 - 3,600	Areas previously mapped as Lowland Rainforest (EEC)	Moist Open Forest – Flooded Gum.	No rainforest species present. Tallowwood, Flooded Gum and Camphor Laurel present.
5,200 - 5,420	Lowland Rainforest (EEC)	Camphor Laurel Forest	Areas within project boundary contain predominantly Camphor Laurel and Privet. Area offsite (to the east) is more indicative of lowland rainforest/ mixed floodplain forest.
5,420 - 6,250	Open Forest - Blackbutt	Moist Open Forest – White Mahogany Grey Gum, Ironbark	Presence of Tallowwood, White Mahogany and Ironbark
7,900 – 8,020	Row of Swamp Oaks not previously mapped	Swamp Oak forest EEC	Mature Swamp Oaks and likelihood of this vegetation type previously have been in the area.
8,900 – 9,600	Areas of cleared grazing land adjacent to areas of Freshwater Wetland.	Extensions to areas of Freshwater Wetland (EEC)	Areas contain suite of flora species indicative of this community and appropriate hydrology.

An additional survey targeting potential occurrences of Maundia identified would be undertaken in spring/ summer to confirm any additional occurrences of this species.
Ground-truthing of previously identified threatened flora records subject to the TFMP would be undertaken after this plan has been finalised and prior to clearing commencing.

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5 Environmental mitigation and management measures

5.1 Flora and fauna mitigation and management measures

A range of environmental requirements and control measures are identified in the various environmental documents, including the EA, Statement of Commitments, Conditions of Approval and other RMS documents. Specific measures and requirements to address impacts on flora and fauna are outlined in Table 5-1.

5.2 Biodiversity offsets

Biodiversity offsets are proposed as required by CoA B8 and B9. These are documented separately in the Biodiversity Offset Strategy.

Table 5-1 Flora and fauna management and mitigation measures

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
GENERAL					
FF1	Training will be provided to all project personnel, including relevant sub-contractors on flora and fauna requirements from this plan through inductions, toolboxes and targeted training. Flora and fauna training requirements will be as per Section 6.2 of this plan.	Training resources such as threatened species fact sheets.	Construction Pre-construction	Environmental Manager	EA CoA B31(b)(v) G36
FF2	Any works required outside the construction footprint verified in accordance with CoA B31(b)(i) will be referred to the Environment Manager for advice on further assessment and approval requirements in accordance with Section 3.7 of the CEMP.		Construction	Project / Site Engineers Environmental Manager	CoA B31(b)(i) G36
FF3	In the event that threatened species or endangered ecological communities are unexpectedly identified during construction the Unexpected Threatened Species /EECs Procedure will be followed.		Construction	Environmental Manager	CoA B31(b)(vii) Appendix J of this FFMP
FF4	A project ecologist will be appointed prior to the commencement of construction		Pre-construction	Environmental Manager	SoC F2 and F6 CoA B31(b)(i)(v)
FF5	The Ecological Monitoring Program will be implemented.		Pre-Construction Construction Operation	Environmental Manager	CoA B10 Appendix C of this FFMP
VEGETATION CLEARING, PROTECTION AND MANAGEMENT					
FF6	Protective fencing to mark the limits of clearing (i.e. 'no-go' areas) surrounding the construction footprint will be installed and routinely inspected and maintained where required until the completion of construction. The limits of clearing will be consistent with those verified in accordance with CoA B31(b)(i). The limits of clearing will be marked in accordance with Guide 2 of the RMS *Biodiversity Guidelines*.	RMS *Biodiversity Guidelines* *RMS Practice Note: Clearing and Fauna Management – Pacific Highway Projects (May 2012)*	Pre-construction Construction	Project / Site Engineers Forman / Leading Hands Environmental Manager	SoC F2 and F3 CoA B31(b)(5) G36 G40
FF7	Before clearing and grubbing commences a joint inspection with the Project Ecologist and RMS Representative would be undertaken to inspect the		Pre-construction	Environmental Manager	G40

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	clearing limits and temporary exclusion fencing and to identify opportunities to preserve habitat trees that fall within or are likely to be affected by the clearing limits.			Project Ecologist	
FF8	During the proposed clearing works, an experienced wildlife handler will be present to retrieve any displaced fauna and release the fauna into adjacent habitats safe from construction work. Fauna handling and rescue will be in accordance with the Fauna Handling and Rescue Procedure.	RMS *Biodiversity Guidelines*	Construction	Project Ecologist Environmental Manager	Appendix I of this FFMP
FF9	Where vegetation is to be retained, vegetation management measures will be implemented, including weed removal, native plantings, broadcasting of collected native seed and relocation of specific habitat resources such as bush rocks, hollow logs, hollow tree trunks and branches.		Construction	Project / Site Engineers Forman / Leading Hands Environmental Manager	EA CoA B31(b)(5)
FF10	Seed collection of native plant species to be removed from the construction footprint will be undertaken prior to commencement of clearing and during clearing and seed will be stored for use in revegetation works.		Pre-construction Construction	Environmental Manager	EA CoA B31(b)(5)
FF11	Native vegetation cleared from the construction footprint will be mulched and used along with collection of topsoil for reuse in rehabilitation works and erosion control. Mulch and topsoil will not be stockpiled in 'no-go' areas and cleared vegetation will not be pushed into 'no-go' areas.	*RMS Environmental Direction No.25 – Management of Tannins from Vegetation Mulch*	Construction	Project / Site Engineers Forman / Leading Hands Environmental Manager	EA G36
FF12	Revegetation/rehabilitation of the site will be conducted progressively during the construction phase to ensure the use of collected topsoil and seed and to develop different successional stages of rehabilitation.		Construction	Project / Site Engineers Forman / Leading Hands	EA G38
FF12b	Erosion and sediment control measures are to be installed in accordance with the Soil and Water Management Sub-plan to reduce the impact of sedimentation on retained vegetation.		Construction	Environmental Manager Forman / Leading Hands	CoA B31 (b) (5) SWMP

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
FF13	Weeds will be managed in accordance with the Weed and Pathogen Management Plan.		Construction	Project / Site Engineers Forman / Leading Hands Environmental Manager	EA G36 CoA B31(b)(v) Appendix K of this FFMP
FF14	Clearing will be undertaken consistent with the process described in Guide 4 of the RMS *Biodiversity Guidelines*.	RMS *Biodiversity Guidelines*. *RMS Practice Note: Clearing and Fauna Management – Pacific Highway Projects (May 2012)*	Pre-Construction Construction	Project / Site Engineers Forman / Leading Hands Environmental Manager	EA CoA B31(b)(v) G40
FF15	Prior to clearing any vegetation within and adjacent the widened median locations (Chainages 19150 and 19820) the Project Ecologist will undertake a survey to identify the taller healthy glider launching trees to be retained. A joint inspection of these trees and the marked limits of clearing will be conducted by the Project Ecologist and relevant government agencies.		Pre-Construction	Project Ecologist Environmental Manager Project / Site Engineers	CoA B2 and B4
THREATENED FLORA					
FF16	The Project Ecologist must undertake flora pre-clearing surveys for threatened flora, in accordance with Environmental Documents and the SWTC (Appendix 5),		Pre-construction	Project Ecologist Environmental Manager	G40 SWTC (Appendix 5)
FF17	Threatened flora within and immediately adjacent to the limits of clearing will be located and tagged.		Pre-construction	Project Ecologist	EA Appendix B of this FFMP
FF18	In the event that threatened species or endangered ecological communities are unexpectedly identified during construction the Unexpected Threatened Species /EECs Procedure will be followed.		Construction	Environmental Manager	CoA B31(b)(vii) Appendix J of this FFMP

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
FF19	The measures identified in the Threatened Flora Management Plan will be implemented, including translocation procedures and monitoring during construction and procedures for the management of roadside threatened flora during construction.		As specified	Environmental Manager Project Ecologist	CoA B7 Appendix B of this FFMP
THREATENED FAUNA					
FF20	The measures identified in the Giant Barred Frog Management Plan will be implemented.		As specified	Environmental Manager Project Ecologist	CoA B31(b)(iii) Appendix D of this FFMP
FF21	The measures identified in the Green-thighed Frog Management Strategy will be implemented.		As specified	Environmental Manager Project Ecologist	Appendix E of this FFMP
FF22	The measures identified in the Microchiropteran Bat Management Strategy will be implemented.		As specified	Environmental Manager Project Ecologist	CoA B31(b)(iv) Appendix F of this FFMP
FF23	The measures identified in the Flying Fox Management Plan will be implemented (available in Appendix N of this Plan and referenced in Table 3.4-1)		As specified	Environmental Manager Project Ecologist	Appendix N of this FFMP EPBC Approval
FF24	The measures identified in the Koala Management Plan will be implemented (available in Appendix L of this Plan and reference in Table 3.4-1) .		As specified	Environmental Manager Project Ecologist	Appendix L of this FFMP EBPC Approval
FF25	The measures identified in the Spotted-tailed Quoll Management Plan will be implemented (available in Appendix M of this Plan and reference in Table 3.4-1).		As specified	Environmental Manager Project Ecologist	Appendix M of this FFMP EBPC Approval
FF26	The Nest Box Plan of Management will be implemented incorporating the additional requirements outlined in the SWTC		Pre-construction As specified	Environmental Manager	EA CoA B6 SWTC (Appendix 4 and 14) Appendix B of this FFMP
FF27	In the event that threatened species or endangered		Construction	Environmental	CoA B31(b)(vii)

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	ecological communities are unexpectedly identified during construction the Unexpected Threatened Species /EECs Procedure will be followed.			Manager	Appendix J of this FFMP
WILDLIFE PROTECTION					
FF28	A suitably qualified ecologist will undertake searches in the construction footprint for native fauna immediately prior to clearing activities. Searches will include nests and large hollow-bearing trees and target habitats of hollow dwelling species, Koalas and frogs. During the proposed clearing works, an experienced wildlife handler will be present to retrieve any displaced fauna and release the fauna into adjacent habitats safe from construction work.	*RMS Practice Note: Clearing and Fauna Management – Pacific Highway Projects (May 2012)*	Pre-construction Construction	Project Ecologist	EA Appendices D,E,F,G,I of this FFMP
FF29	Fauna exclusion fencing (e.g. floppy-top fencing) will be erected along the project corridor at appropriate locations to direct fauna movement towards fauna-crossing structures. This fencing will be subject to routine monitoring to check for damage and overhanging vegetation and maintained as required.		Construction Operation	Project / Site Engineers Forman / Leading Hands Environment Manager	EA Section 10.3.3.2 SoC F11
FAUNA HABITATS AND CONNECTIVITY					
FF30	Habitat features and resources for native fauna (such as hollow logs and bush rocks) will be distributed along the route of the project where feasible and reasonable. Such relocation will be undertaken so as to limit damage to existing vegetation and would not occur in good condition remnant vegetation. This measure will be implemented consistent with Guide 5 of the RMS *Biodiversity Guidelines*.	RMS *Biodiversity Guidelines*.	Construction	Forman / Leading Hands Environmental Manager	EA SoC F7
FF31	Fauna connectivity measures will be finalised during detailed design in consultation with relevant government agencies through a process of workshops and on-site ground verification.		Construction	Environmental Manager	CoA B1, B2, B3, B4 and B5

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
FF32	Glider crossings and widened medians will be provided in accordance with the requirements of Section 14.3 of the SWTC (Appendix 14)		Construction	Environmental Manager Project Ecologist	CoA B3 SWTC (Appendix 4 and 14) SOC F8
FF33	Where detailed design refinements are made, prior to the commencement of construction of the relevant crossings, AFJV will prepare and submit a report to the Director General identifying the final design of the fauna crossings and demonstrating consistency with the Project approval.		Pre-Construction Construction	Environmental Manager	CoA B3
AQUATIC HABITATS					
FF34	Construction activities over Warrell Creek, Nambucca River, Deep Creek and the Kalang River will be minimised during the Bass and Perch spawning season between June and August, unless mitigation measures are developed in consultation with DPI (Fisheries).		Construction	Project / Site Engineers Environmental Manager	EA
FF35	Riparian and aquatic habitat would be protected during construction works with fencing and any mangroves or areas of riparian vegetation impacted by construction would be rehabilitated.		Construction	Project / Site Engineers Forman / Leading Hands Environmental Manager	EA
FF36	Large woody debris within watercourses would be retained where possible. Any removal or relocation of large woody debris within watercourses will be undertaken in consultation with DPI (Fisheries).		Construction	Project / Site Engineers Forman / Leading Hands Environmental Manager	EA
FF37	An aquatic ecologist would be engaged to undertake capture/ relocation of aquatic fauna from waterbodies being dewatered including farm dams, creek realignments and temporary creek diversions.		Construction	Environmental Manager	DPI (Fisheries) James Saker
FF38	Prior to the commencement of Construction the Project		Construction	Environmental	SWTC (Appendix 4)

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	Ecologist must assess waterways impacted by the Contractor's Work for potential platypus habitat. Where potential habitat is identified the AFJV will develop in consultation with EPA and implement a strategy to mitigate platypus fatalities/injuries during the performance of the Contractor's Work.			Manager Project Ecologist	
PESTS AND DISEASES					
FF39	Washing procedures will be implemented to ensure that insect pests and their eggs/larvae are not present on equipment.		Construction	Project / Site Engineers Forman / Leading Hands Environmental Manager	EA
FF40	The spread of bacteria, viruses and diseases such as *Phytophthora cinnamomi*, amphibian chytrid fungus and beak and feather disease will be addressed through the implementation of the best practice measures included in Table 7.1 of the RMS Biodiversity Guidelines and the Weed and Pathogen Management Plan – Appendix K	RMS *Biodiversity Guidelines*.	Construction	Project Engineers Forman / Leading Hands Environment Manager	EA Appendix K of FFMP
FF41	Pathogens will be managed in accordance with the Weed and Pathogen Management Plan.		Construction	Project / Site Engineers Forman / Leading Hands Environmental Manager	EA G36 CoA B31(b)(v) Appendix K of this FFMP

6 Compliance management

6.1 Roles and responsibilities

The Project Team's organisational structure and overall roles and responsibilities are outlined in Section 4.2 of the CEMP. Specific responsibilities for the implementation of environmental controls are detailed in Chapter 5 of this Plan.

6.2 Training

All employees, contractors and utility staff working on site will undergo site induction training relating to flora and fauna management issues. The induction training will address elements related to flora and fauna management including:

- Existence and requirements of this sub-plan.
- Relevant legislation.
- Specific species likely to be affected by the construction works and how these species can be recognised.
- Mulch stockpile location and management measures.
- Fauna rescue requirements.
- Weed control measures.
- General flora and fauna management measures.
- Specific responsibilities for the protection of flora and fauna.

Further details regarding staff induction and training are outlined in Chapter 5 of the CEMP.

6.3 Inspections

Inspections of sensitive areas and activities with the potential to impact flora and fauna will occur for the duration of the project.

Requirements and responsibilities in relation to inspections are documented in Section 8.2 of the CEMP.

6.4 Auditing

Audits (both internal and external) will be undertaken to assess the effectiveness of environmental controls, compliance with this sub plan, MCoA and other relevant approvals, licenses and guidelines.

Audit requirements are detailed in Section 8.4 of the CEMP.

6.5 Reporting

Reporting requirements and responsibilities are documented in Section 8.4 of the CEMP. There are specific reporting requirements associated with additional survey work and monitoring including:

- Results of pre-clearing surveys.
- Threatened Flora Management Plan
- Giant Barred Frog and Green-thighed Frog Management Strategies.
- Microchiropteran Bat Management Strategy.

- Nest Box Plan of Management.
- Grey Headed Flying-Fox Management Plan
- Koala Management Plan.
- Spotted-Tail Quoll Management Plan.

The Ecological Monitoring Program (as required by CoA B10) will assess and report on the effectiveness of mitigation measures implemented as part of the project. Details of the Ecological Monitoring Program are included in Appendix C of this Plan.

7 Review and improvement

7.1 Continuous improvement

Continuous improvement of this plan will be achieved by the ongoing evaluation of environmental management performance against environmental policies, objectives and targets for the purpose of identifying opportunities for improvement.

The continuous improvement process will be designed to:

- Identify areas of opportunity for improvement of environmental management and performance.
- Determine the cause or causes of non-conformances and deficiencies.
- Develop and implement a plan of corrective and preventative action to address any non-conformances and deficiencies.
- Verify the effectiveness of the corrective and preventative actions.
- Document any changes in procedures resulting from process improvement.
- Make comparisons with objectives and targets.

7.2 FFMP update and amendment

The processes described in Chapter 8 and Chapter 9 of the CEMP may result in the need to update or revise this Plan. This will occur as needed.

Any revisions to the FFMP will be in accordance with the process outlined in Section 1.6 of the CEMP and as required, be provided to relevant stakeholders for review and comment and forwarded to the Director General of DP&I for approval.

A copy of the updated plan and changes will be distributed to all relevant stakeholders in accordance with the approved document control procedure – refer to Section 10.2 of the CEMP.

Appendix A
Nest Box Plan of Management

NEST BOX MANAGEMENT PLAN

Warrell Creek to Urunga upgrade

FEBRUARY 2013

WARRELL CREEK TO URUNGA:

NEST BOX PLAN OF MANAGEMENT

FEBRUARY 2013

PREPARED FOR THE ROADS AND MARITIME SERVICES BY:

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…14th February 2013……
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ACKNOWLEDGEMENTS

Ben Lewis (LES): Field surveys and report author.

Kristy Harvey (RMS) – Project management and supply of background information.

Brett Hoffman (RMS) – Project management and logistics.

Tim Gooley (RMS) – Project management and review process.

Belinda Bock (RMS) – Project management and logistics.

Craig Harre (EPA) – Document review.

Photography: Ben Lewis T/A Lewis Ecological Surveys and Alan and Stacey Franks T/A Hollow Log Homes ©

Top Left– Hollow bearing tree number 285 from Burkes Lane area (section K).
Bottom Left to Right – Squirrel Gliders (*Petaurus norfolcensis*) inhabiting a nest box shortly after its installation in the Hunter Valley.
Gould's Wattled Bat (*Chalinolobus gouldi*) a common inhabitant of the project study area, juvenile Sugar Glider (*Petaurus brevipes*).

Report to be cited: Lewis, B.D. (2013). Warrell Creek to Urunga: Nest Box Plan. Report prepared by Lewis Ecological Surveys © for Roads and Maritime Services.

Revision History:

Rev.	Project Number	Date	Description	Prepared By	Reviewed By
A	2071112e	7.5.2012	Draft for comment	Ben Lewis (Lewis Ecological Surveys)	Craig Harre (EPA)
B	2071112e	19.6.2012	Final	Ben Lewis (Lewis Ecological Surveys)	Kristy Harvey
C	2071112e	13.2.2013	Final	Ben Lewis (Lewis Ecological Surveys)	Belinda Bock

Distribution History:

Rev.	Date	Issued To	Position	Name
A	20.04.2012	Roads and Maritime Services	Environmental Officer	Kristy Harvey
B	18.06.2012	Roads and Maritime Services with just EPA comments/review	Environmental Officer	Kristy Harvey
B	20.06.2012[1]	Roads and Maritime Services with EPA and KH review	Environmental Officer	Kristy Harvey
C	2.11.2012	Roads and Maritime Services	Environmental Officer	Belinda Bock/Tim Gooley
D	14.2.2013	Roads and Maritime Services	Environmental Officer	Belinda Bock

[1] Late submission from RMS on the 19.6.2012 after the final document was issued. Revision and distribution to remain at version B at that point in time.

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1.0 INTRODUCTION

1.1 Background

This Nest Box Plan of Management (NBPoM) forms part of the overall management of fauna for the Upgrading of the Pacific Highway to a four lane divided carriageway from the existing Allgomera deviation, south of Warrell Creek to the Waterfall Way, Raleigh by constructing the Warrell Creek to Urunga Upgrade (the Project). The primary objective of this plan is to implement nest boxes as a compensatory mechanism for the loss of den, roost and nest resources and thereby satisfying Minister Condition of Approval B6 "*prior to the commencement of any construction work that would result in the disturbance of any native vegetation (or as otherwise agreed to by the Director General), the Proponent shall in consultation with OEH prepare and submit for the approval of the Director General a Nest Box Plan to provide replacement hollows for displaced fauna consistent with the requirements of SoC F7. The plan shall detail the number and type of nest boxes to be installed which must be justified based on the number and type of hollows removed (based on detailed pre-construction surveys), the density of hollows in the area to be cleared and adjacent forest, and the availability of adjacent food resources. The plan shall also provide details of maintenance protocols for the nest boxes installed including responsibilities, timing and duration".*

Among those hollow dependant fauna previously recorded in the Warrell Creek to Urunga area are a number of threatened species including the Yellow-bellied Glider (*Petaurus australis*), Glossy Black Cockatoo (*Calyptorhynchus lathami*), Powerful Owl (*Ninox strenua*) and microchiropteran bats such as the Greater Broad-nosed Bat (*Scoteanax rueppellii*) and Eastern False Pipistrelle (*Falsistrellus tasmaniensis*). The project application report prepared by SKM (2010) highlighted a number of ecological impacts including but not limited to the loss of suitable and/or potential foraging habitat and hollow bearing trees (HBT's) which represent potential den, roost or nest sites for the species above.

1.2 Why Provide Nest Boxes

The removal of HBT's has the potential to impact upon the population processes of a species requiring tree hollows. For example, the removal of hollows can expose individuals to greater levels of predation, reduced reproductive success of that species and can increase inter-specific and intra-specific competition for resources (Carbery 2004). For these reasons, the removal of HBT's is currently listed as a key threatening process (KTP) pursuant to the *Threatened Species Conservation* Act (NSW Scientific Committee 2006). The provision of nest boxes can ameliorate these processes, and is the focus of increased research efforts (*see review in* Goldingay and Stevens 2009).

1.3 Structure of this Plan

This NBPoM identifies the fauna which are likely to utilise tree hollows along the construction/clearing footprint and provides an indication as to the number, type, location, installation heights, aspect and density of nest boxes required to compensate for this whilst addressing the implications of land tenure and maintenance considerations. As part of preparing this plan, a monitoring and maintenance program has also been developed to ensure that nest boxes are functioning appropriately and to assess their effectiveness over the life of this plan (2013-2017). For the purposes of this plan, the term effectiveness refers to whether or not the identified fauna groups outlined in this plan utilise the provided nest boxes.

2.0 FAUNA SPECIES USING TREE HOLLOWS IN THE LOCALITY

Fifty-seven (57) species of animal that use natural tree hollows for nesting/roosting or as den sites were recorded as part of pre-approval surveys for the Pacific Highway upgrade, notwithstanding a number of other fauna that potentially inhabit the area (SKM 2010). Among those previously recorded fauna were 25 mammals, 23 hollow-dependent birds, three reptiles and six species of hylid frog with 12 of these currently listed as threatened fauna pursuant to the NSW *Threatened Species Conservation Act* 1995 (Appendix A). Perusal of the Bionet Wildlife Atlas data for the area suggest there are a few other hollow dependant species that may utilise tree hollows in this area, namely other hylid frogs (i.e. *Litoria chloris*), Stephens Banded Snake (*Hoplocephalus stephensii*), some bats (i.e. East Coast Free-tail Bat *Mormopetrus norfolkensis*) and birds including Masked Owl (*Tyto novaehollandiae*). Habitat descriptions including natural tree hollow characteristics for each of these species or species groups is provided in Appendix B.

3.0 DISTRIBUTION, CHARACTERISTICS AND SUITABILITY OF EXISTING TREE HOLLOWS

The use of tree hollows by fauna may depend on a number of factors including hollow characteristics (diameter, height, depth), the number of hollows in a tree, tree health, size, location, density and the resulting thermoregulatory capabilities of the hollows themselves (Gibbons and Lindenmayer 2003). A more detailed discussion of these factors in provided in Section's 4-6 with relevance to the species considered in this plan. This section describes the characteristics of tree hollow resources present within the RMS road corridor during a ground based observation survey between the 6th December 2011 and 12th October 2012. The actual delineation of clearing limits for construction is not yet known (Kristy Harvey pers. comm. 4.4.2012). Some additional information has been obtained on the extent of tree hollows in the adjacent landscape, as this information will determine the locations where nest boxes will be installed.

3.1 Areas Not Accessed

The following areas were not accessed as part of the field surveys:

- Ch. 43365-44365 which includes retained mature Coastal Blackbutt vegetation associated with MR J. F. McInnes property;
- A few properties scattered across the Nambucca Floodplain Investigation area including Ch. 50165-50665 (Hunt property), some smaller land parcels on the southern part of Old Coast Road (i.e. Farrawell and Browne properties) and Ch. 55765-56565 (Sheather and Clarke properties);
- Ch. 62665-62865 (Boggy Creek) where access could not be obtained at the time of the survey; and
- Ch. 69315-69765 but only the eastern side of existing carriageway which is more than 100 m from any likely construction works and contains a prominent incised drainage line.

Cumulatively, the above areas amount to approximately 3 km of the 40.8 km upgrade with most of this area occurring on the Nambucca River floodplain. To address this shortfall, the contractor should perform tree hollow surveys for the remaining areas as part of their pre-clearing inspection works prior to clearing and then calculate the required numbers of nest boxes in accordance with this plan (refer to Section 4.0).

3.2 Within the Clearing Footprint

3.2.1 Distribution

Five hundred and nineteen (519) HBT's providing an estimated 2942 tree hollows have been identified between Warrell Creek (south) and the Waterfall Way/Pacific Highway interchange at Repton (Figure 3-1; Appendix C). Each of these trees have been assigned a designated number for reference (i.e. H01-H551[2]) and marked with white paint and pink or orange flagging tape.

The survey identified a number of areas as containing a high density (>6 hbt/ha) of tree hollow resources. They included:

- 15 HBT's along Albert Drive, Donnellyville (ch.46165);
- 25 HBT's growing within Old Coast Road reserve and adjacent crown land between ch. 53680-54050;
- 14 HBT's growing partly on Hartman property and Old Coast Road reserve between ch. 55300-55700;
- 13 HBT's where the carriageway first traverses Nambucca State Forest (Old Coast Road and Jacks Ridge Road, ch. 56965);
- 10 HBT's to the south of Old Coast Road in the central part of Nambucca State Forest (ch. 60065);
- 13 HBT's to the south of Cow Creek, Valla (ch. 63415);
- 24 HBT's to the south of Deep Creek, Valla (ch. 64335-64735);
- 38 HBT's at Blackbutt Drive, Valla Beach (ch. 66365);
- 50 HBT's in the vicinity of Burkes Lane, Oyster Creek (ch. 68565);
- 12 HBT's in the Mines Road, Pickett Hill (ch. 70765);
- 14 HBT's to the south of Ainsworth Road Cut, Newry (ch. 74065); and
- 13 HBT's at Raleigh South (ch. 80665).

[2] Nine of the mapped trees now occur adjacent to the clearing footprint.

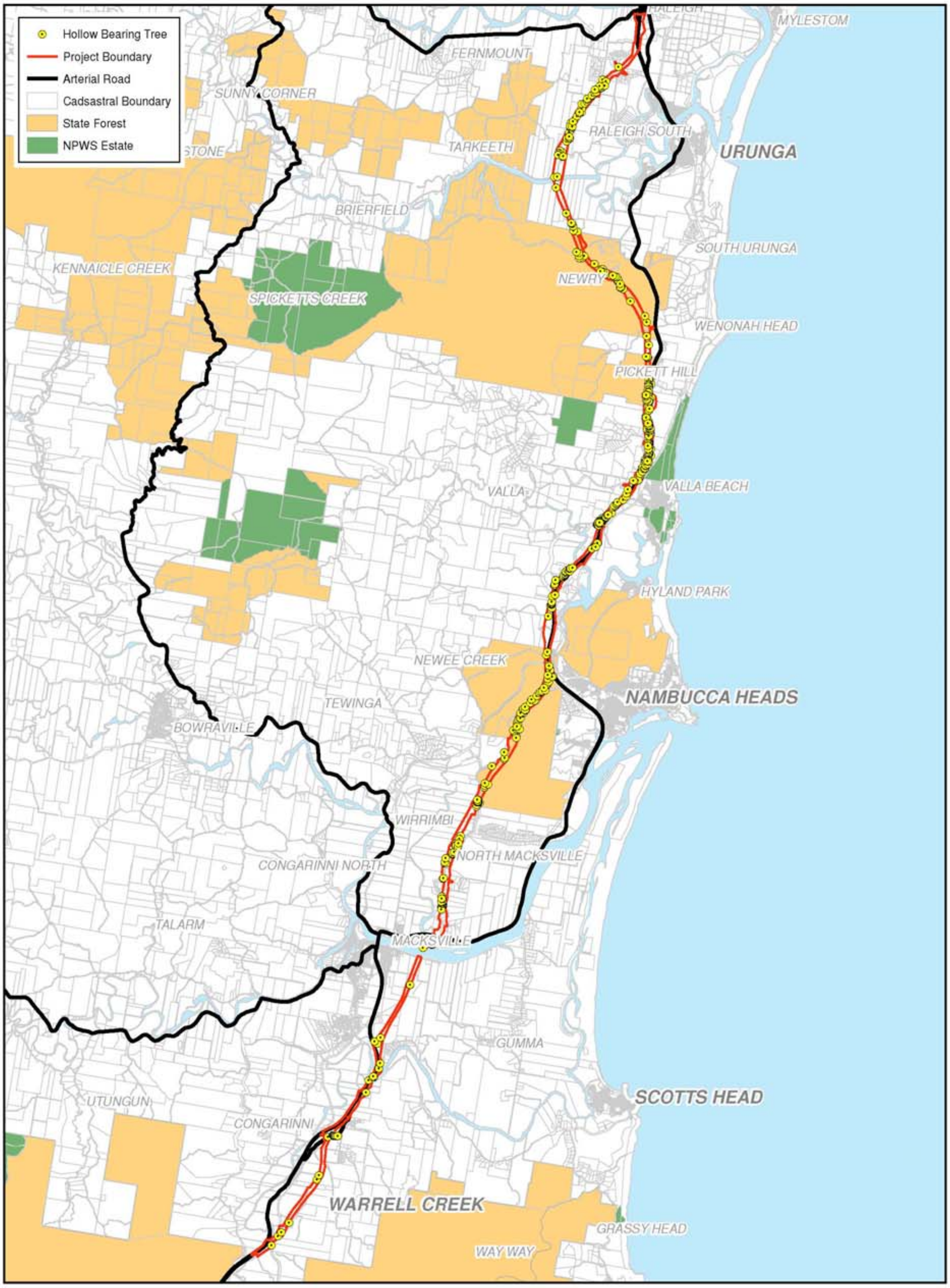

Figure 1 : LOCATION OF HOLLOW BEARING TREES

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009

Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2008

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Meters
A4 Scale 1:140,887

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File: Figure_1_RTA_Grafton_HBT_Survey Date: 14-04-2012

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Figure 3-1. Overview of hollow bearing tree resources for the Warrell Creek to Urunga Upgrade.

3.2.2 Tree Hollow Characteristics

Of the 2942 identified tree hollows, 321 (11%) were trunk hollows, 2611 (89%) were limb hollows, and 10 (<1%) were basal trunk hollows (i.e. butt of the tree trunk). The size of each hollow was assigned into three size classes based on their estimated size of their entrance. This approach identified:

- 1542 small hollows (<50 mm);
- 960 medium hollows (50 – 150 mm);
- 394 large hollows (>150 mm);
- 36 trees had prominent fissures (narrows splits predominantly in tree trunk); and
- 10 basal/butt hollows.

Most of the identified 519 HBT's contained more than one hollow with an average of 5.7 functional hollows per tree (S.D =4.1). Around 12% of the identified HBT's contained ≥10 tree hollows with up to 32 hollows recorded in a large Coastal Blackbutt adjacent to Burkes Lane, Oyster Creek (ch. 26900).

3.2.3 Suitability of the Tree Hollow Resources to Fauna

The suitability of each tree hollow to specific fauna groups was assigned primarily on the basis of the entrance size, tree species, status (live, dead), height above the ground and the size of the tree based on an estimated diameter at breast height (DBH). The spatial arrangement of hollows and their location within the landscape was also considered. For example, an isolated paddock tree containing hollows was considered unsuitable for gliders due to the canopy gap being beyond their normal volplane (i.e. gliding) capability. Similarly, a medium to large open hollow in dense vegetation away from water was not considered suitable for hollow nesting ducks (i.e. Maned Duck, *Chenonetta jubata*). The status of hollow using fauna is documented in Appendix A making reference as to whether the species has been previously recorded from or near (i.e. < 1km) the RMS road corridor. For example, the environmental assessment prepared by SKM (2010) identifies that higher levels of arboreal fauna diversity were recorded within the state forests. Caution should be exercised in this instance following the discovery of numerous tree hollow resources within the road corridor at locations where little or no survey effort had been employed for the EA. For example, Blackbutt Drive (ch. 24500) contains numerous senescent Coastal Blackbutt and to a lesser extent White Mahogany and Pink Bloodwood. This area provides habitat for species such as the threatened Yellow-bellied Glider and < 1km top the north some consideration should be given toward the presence of the threatened Squirrel Glider. Other common arboreal fauna including possums and smaller marsupial gliders probably also occur in this area. Other examples include the Oyster Creek area, the south end of Little Newry State Forest abutting private land and the existing Pacific Highway, and the southern part of Nambucca State Forest.

Perusal of Figure 3-2 illustrates:

- Most of the identified habitat trees provide hollows suitable for:
  - Arboreal herpetofauna including *Eulamprus* and *Egernia* skinks, arboreal snakes (i.e. Green Tree Snake) along with most of the hylid tree frogs known from the area.
  - Scansorial mammals such as the Brown Antechinus;
  - Microchiropteran bats;
  - Small gliding marsupials including the Feather-tail Glider (*Acrobates pygmaeus*) and Sugar Glider;
  - Larger Gliders including Greater Glider, Yellow-bellied Glider and Squirrel Glider (*Petaurus norfolcensis*); and
  - Parrots, particularly Scaly-breasted Lorikeet, Rainbow Lorikeet and Eastern Rosella.
- Two hundred and thirty-one (231) HBT's provide den resources for possums;
- One hundred and fifty-five (155) HBT's provide suitable retreat and overwintering sites for Lace Monitor;
- Fifty-six (57) HBT's provide suitable nest resources for black cockatoos and Australian King Parrot (*Alisterus scapularis*);
- Eighty-six (86) HBT's provide potential nest resources for smaller owls such as the Southern Boobook (*Ninox novaehollandiae*) and Barn Owl (*Tyto alba*); and
- Seven of the recorded HBT's were considered suitable for large forest owls including Masked Owl (*Tyto novaehollandiae*), Powerful Owl (*Ninox strenua*) and to a limited extent Sooty Owl (*Tyto tenebriscosa*).

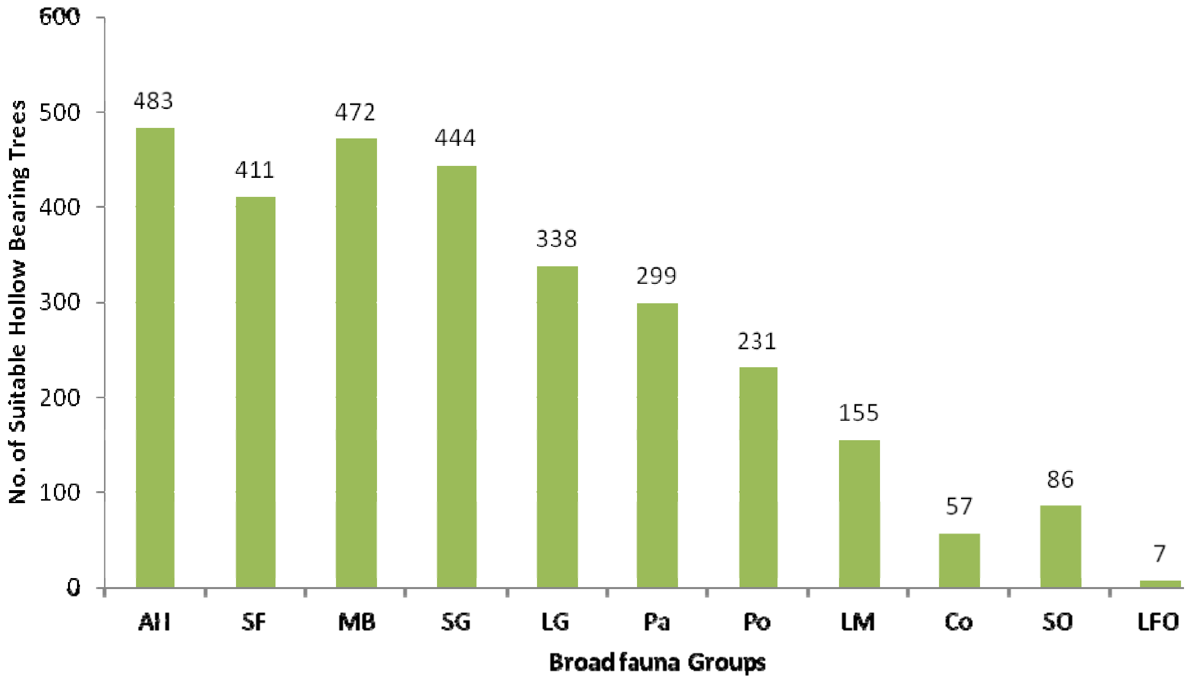

Figure 3-2. Suitability of the identified tree hollows to broad fauna groups from the 519 HBT's identified within the road corridor.

SF = Scansorial mammals (e.g. Antechinus), MB = Microchiropteran bats, SG = Small gliders (Feather-tail Glider, Sugar Glider), LG = Larger Gliders (Squirrel, Yellow-bellied, Greater), Po = Possums (Common Ring-tail Possum, Common Brushtail Possum and Short-eared Brush-tail Possum), PA = Parrots (i.e. Eastern Rosella, Lorikeets), LP = Large Parrot (i.e. King Parrot), Co = Cockatoos (Sulphur-crested Cockatoo, Yellow-tailed Black Cockatoo, Glossy Black Cockatoo), SO = Smaller Owls (Southern Boobook, Barn Owl), LFO = Large Forest Owl (Powerful Owl, Masked Owl, Sooty Owl), LM = Lace Monitor, AH = Arboreal herpetofauna (*Egernia*, *Eulamprus*, Tree Frogs)

3.3 A Look at Tree Hollow Resources Adjacent to the Clearing Footprint

Field surveys employing 1 hectare quadrats were established at 35 locations immediately adjacent to the road corridor to collect data on the density of HBT's and to estimate the number of functional tree hollows accordingly to the aforementioned size classes (Table 3-1). A range of broad fauna habitats were surveyed including:

- Riparian habitats of Upper Warrell Creek, Rosewood Creek, Warrell Creek and the Kalang River;
- Moist Sclerophyll Forests bordering riparian habitats (i.e. Warrell Creek) or within sheltered gullies in Nambucca and Newry State Forests;
- Swamp Forests on the southern side of the Nambucca River Floodplain, Hyland Park, Deep Creek area and further north at Raleigh (i.e. north of Short Cut Road); and
- Dry Sclerophyll Forests broadly distributed across the project.

In addition to broad fauna habitats some surveys were undertaken in:

- Forest types that had been recently logged (<6 months) by Forests NSW; and
- Plantation forest types in Newry State Forest to provide a snapshot look at habitat tree retention.

This survey identified most of the forested lands adjacent to the road corridor contain <4 HBT's per hectare. The exceptions were lands adjacent to chainages:

- North east of ch. 55800 (within Old Coast Road Reserve and boundary of Hartman Private Property);
- South of ch. 60365 (Allan's Trail in Nambucca State Forest);
- West of ch. 63965 (opposite Auld Close, Hyland Park);
- North west of Blackbutt Drive ch. 66565 (Valla); and
- East of ch. 79265 (Raleigh South).

Cursory surveys at Oyster Creek (Burkes Lane) indicate the high density of HBT's (~6 HBT/ha) continues beyond the RMS Road Corridor boundary and over an area of ~ 8 ha.

The majority of the HBT's occur within close proximity to roads, property boundaries or drainage lines. In a number of instances there is a disproportional density of HBT's within the road corridor when compared to the surrounding environs as these areas have historically been treated as "buffer" zones.

After reviewing the HBT data it was considered necessary to critique other specific tree hollow characteristics in assessing the need for nest boxes within a given area. At those localities where HBT's exceeding 4/ha they were assessed to see whether they contained a:

- High proportional of stags as opposed to senescent trees (i.e. >70%) indicating a reduced life expectancy of hollow resources;
- An adequate amount of tree hollows to accommodate displaced fauna during clearing operations;
- Were in close proximity to specific mitigation devices such as fauna underpasses and vegetated medians adopted for the project; or
- Form part of previously mapped key habitats and corridors linking important coastal lowlands with upland areas (Scotts *et al.* 2000).

With respect to this latter point, the EPA Key Habitats and Corridors Project identifies the Oyster Creek/Valla as forming a critical part of a regional habitat corridor known as the Oyster Creek Urunga Corridor. This corridor links large areas of coastal vegetation from Deep Creek in the south to the Bellinger River in the north, providing potential key linkages for threatened forest fauna.

Using the secondary consideration described above it was deemed necessary to provide nest boxes in the vicinity of:

- North east of ch. 55800 (within Old Coast Road Reserve and boundary of Hartman Private Property) given the number of tree hollows within a particular few trees (>12 per tree);
- South of ch. 60365 (Allan's Trail in Nambucca State Forest);
- Burkes Lane, Oyster Creek (ch. 68765); and
- Moyles Road area (ch. 73765).

The proposed recipient areas for nest boxes have been presented in Section 6.0 of this plan.

Table 3-1. Comparison between the numbers of HBT's identified for removal and the extent and characteristics of HBT's in adjacent forested land.
Note – omitted chainages reflect cleared lands or areas where field surveys could not be undertaken (i.e. Nambucca River Floodplain investigation area).
SoC = Side of Carriageway; No. = Number, M = Metres, ha = hectare, S = Small (<50mm), M = Medium (51-150 mm), L = Large (>150 mm), nd = no data, SC = Secondary Consideration as per text on page 7.

Plot No	Chainage	No HBT Removed from 400 m section of carriageway	SoC	Fauna Habitat	Tree Hollows in Adjacent Forest: No. Stags	No. Senescent Trees	Density ha	Estimated No. Functional Hollows				Nest Boxes Required	Nest Box Zone (Figure 3-1)
								S	M	L	Total		
1	42765	2	West	Riparian with Flooded Gum, Tallowwood, White Mahogany, Weeping Lilly Pilly and Water Gum.	0	2	**2**	5	0	0	**5**	Yes	A
2	43265	1	East	Mixed Dry and Moist Sclerophyll Forest with Coastal Blackbutt, Pink Bloodwood, tallowwood and White Mahogany	0	0	**0**	0	0	0	**0**	No	-
3	44665	2	East	Riparian (weedy) with emergent Flooded Gum and weedy Camphor Laurel and Privet	0	1	**1**	2	0	0	**0**	Yes	B
4	48365	6	West	Mixed Riparian and Moist Sclerophyll Forest with Swamp Oak, Flooded Gum, Tallowwood, Grey Ironbark)	0	2	**2**	4	2	0	**0**	Yes	C
5	56965	13	East	Dry Sclerophyll Forest with Coastal Blackbutt, Red Mahogany and White Mahogany	1	2	**3**	10	5	6	**21**	Yes	D
6	58165	0	West	Dry Sclerophyll Forest with Coastal Blackbutt, Red Mahogany and White Mahogany	0	2	**2**	5	0	0	**5**	No	-
7	58765	3	East	Dry Sclerophyll Forest (Coastal Blackbutt, Pink Bloodwood) on ridges running down to Moist Sclerophyll Forest (Flooded Gum, Turpentine, Tallowwood) in gullies.	0	0	**0**	0	0	0	**0**	Yes	E
8	59665	7	West	Moist Sclerophyll Forest (Coastal Blackbutt, Flooded Gum, Red Mahogany, Turpentine)	0	3	**3**	8	4	0	**12**	Yes	F
9	60365	12	South	Dry Sclerophyll Forest (Coastal Blackbutt, Pink Bloodwood, Grey Gum, White Mahogany)	1	3	**4**	14	6	3	**23**	Yes	G (SC)
10	61165	6	East	Dry Sclerophyll Forest (Coastal Blackbutt, White Mahogany, Pink Bloodwood, Scribbly Gum, Red Mahogany)	0	0	**0**	0	0	0	**0**	No	-
11	61315	7	West	Dry Sclerophyll Forest (Coastal Blackbutt, White Mahogany, Tallowwood, Pink Bloodwood, Red Mahogany)	1	2	**3**	6	1	0	**7**	Yes	H
12	61965	2	West	Dry Sclerophyll Forest (Coastal Blackbutt, White Mahogany, Pink Bloodwood, Tallowwood, Red Mahogany)	0	0	**0**	0	0	0	**0**	No	-
13	63865	5	West	Dry Sclerophyll Forest (Coastal Blackbutt, White Mahogany, Pink Bloodwood, Red Mahogany, Tallowwood)	1	4	**5**	11	6	2	**19**	No	-

14	64565	20	West	Swamp Forest (Red Mahogany, Swamp Mahogany, Coastal Blackbutt, Turpentine with Callicoma and occasionally Banksia	0	3	**3**	6	3	1	**10**	Yes	I
15	66615	24	West	Dry Sclerophyll Forest (Coastal Blackbutt, White Mahogany, Pink Bloodwood with dense Callicoma understorey in parts)	0	~4	**~4**	nd	nd	nd	**nd**	Yes	J (SC)
16	68315	41	West	Dry Sclerophyll Forest (Coastal Blackbutt, White Mahogany, Tallowwood, Pink Bloodwood, Flooded Gum)	1	1	**2**	6	3	1	**10**	Yes	K (SC)
17	70215	15	West	Dry Sclerophyll Forest (Coastal Blackbutt, White Mahogany, Tallowwood, Pink Bloodwood, Grey Ironbark)	1	1	**2**	4	1	0	**5**	Yes	L
18	70865	16	West	Dry Sclerophyll Forest (Coastal Blackbutt, White Mahogany, Pink Bloodwood, Grey Ironbark)	0	0	**0**	0	0	0	**0**	Yes	M
19	71945	1	West	Riparian Moist Sclerophyll Forest (Sydney Blue Gum, Grey Ironbark, Flooded Gum, Tallowwood with Water Gum)	1	0	**1**	2	0	0	**0**	No	-
20	72415	2	West	Dry Sclerophyll Forest (Coastal Blackbutt, Tallowwood, White Mahogany, Pink Bloodwood, Stringybark)	0	1	**1**	3	1	0	**4**	No	-
21	72965	1	East	Dry Sclerophyll Forest (Coastal Blackbutt, White Mahogany, Pink Bloodwood, Grey Ironbark, Turpentine)	0	0	**0**	0	0	0	**0**	No	-
22	73565	2	west	Dry Sclerophyll Forest (Coastal Blackbutt, Pink Bloodwood, Grey Ironbark, White Mahogany, Tallowwood)	1	1	**2**	7	2	0	**9**	Yes	N
23	74565	7	West	Moist Sclerophyll Forest in gullies (Red Mahogany, Small-fruited Grey Gum, Tallowwood) with Dry Sclerophyll Ridges (Coastal Blackbutt, Pink Bloodwood, Grey Ironbark, White Mahogany, Small-fruited Grey Gum, Tallowwood)	0	0	**0**	0	0	0	**0**	Yes	O
24	75365	2	West	Moist Sclerophyll Forest in gullies (Red Mahogany, Small-fruited Grey Gum, Tallowwood, Coastal Blackbutt) with Dry Sclerophyll Ridges (Coastal Blackbutt, Pink Bloodwood, Grey Ironbark, White Mahogany, Small-fruited Grey Gum, Tallowwood)	2	0	**2**	4	3	2	**9**	No	-
25	75765	0	East	Forest NSW Plantation (Coastal Blackbutt) with neighbouring gullies native regeneration of Red Mahogany, Turpentine, Tallowwood, Coastal Blackbutt)	0	0	**0**	0	0	0	**0**	No	-
26	76765	1	West	Dry Sclerophyll Forest (Coastal Blackbutt, White Mahogany, Pink Bloodwood, Red Mahogany, Tallowwood, Turpentine)	1	0	**1**	3	1	0	**4**	Yes	P
27	77765	2	West	Riparian Sclerophyll Forest with mix of dry	1	0	**1**	2	1	0	**3**	No	-

				and moist elements (Grey Ironbark, Flooded Gum) with estuarine components (Swamp Oak, Grey Mangrove)									
28	79265	9	East	Dry Sclerophyll Forest upslope (Tallowwood, Small-fruited Grey Gum, Pink Bloodwood, Coastal Blackbutt, White Mahogany) with Swamp Forest on lower slopes (Broad-leaved paperbark, Swamp Mahogany)	1	5	**6**	26	11	5	**32**	Yes	Q (SC)
29	80165	5	West	Moist Sclerophyll Forest (Tallowwood, Flooded Gum, White Mahogany, Pink Bloodwood, Grey Ironbark)	1	1	**2**	7	1	0	**8**	Yes	R
30	81665	1	West	Swamp Forest (Swamp Mahogany, Swamp Oak, Cheese Tree) rising into Moist Sclerophyll Forest (Coastal Blackbutt, Tallowwood)	0	0	**0**	0	0	0	**0**	No	-
31	49815	0	West	Broad-leaved Paperbark and Swamp Oak Swamp Forest with surrounding cleared land	0	0	**0**	0	0	0	**0**	No	-
32	50965	3	East	Broad-leaved Paperbark and Swamp Oak Swamp Forest	0	3	**3**	4	2	0	**6**	No	-
33	53915	25	West	Under scrubbed moist sclerophyll forest (Tallowwood, Pink Bloodwood, White Mahogany, Coastal Blackbutt) perched above Swamp Forest	1	2	**3**	8	3	0	**11**	Yes	S
34	55065	7	East	Dry sclerophyll forest (Coastal Blackbutt, Pink Bloodwood, Tallowwood, Turpentine)	1	2	**3**	7	2	1	**10**	Yes	T
35	55800	10	East	Dry sclerophyll forest (Coastal Blackbutt, Pink Bloodwood, Tallowwood)	1	4	**2**	7	2	0	**9**	Yes	U

4.0 NUMBER OF NEST BOXES REQUIRED

This section presents the proposed number of nest boxes required and the types of fauna the nest boxes should accommodate during stage one (ground based tree hollow survey) of a two stage assessment (i.e. recalculation once clearing of detailed design is completed). The final (i.e. second stage) will be an appraisal once the clearing works have been completed and a final tally of the actual numbers of hollow bearing trees and tree hollows has been tallied based on the detailed design (numerical data substituted back into the formulas provided below). At this point in the time the nest box plan will be updated to reflect the final number of nest boxes required and re submitted to the EPA for approval.

4.1 The Proposed Number of Nest Boxes Required

A condition for this project's approval was to compensate for the loss of HBT's by using nest boxes, however, it did not provide any scope as to the ratio or what defines when compensation is necessary. In this absence, those areas adjacent to the RMS road corridor that support fewer than 4 HBT's per hectare require nest boxes. Secondary considerations have also resulted in two initially exempt areas (i.e. ch. 60365, ch. 68765 and ch. 73765) being re classified as areas requiring nest boxes. This approach is consistent with the nest box plan prepared for the Kempsey Bypass project (Lewis 2010).

In this context 467 nest boxes of various sizes are required for the Warrell Creek to Urunga project with:

- 152 nest boxes required for the Warrell Creek to Nambucca Heads (ch. 61265); and
- 315 nest boxes required for the Nambucca Heads (ch. 61265) to Urunga Upgrade.

A two stage formula has been used to derive the number of nest boxes required for each area identified in Table 3-1.

Stage 1:

A x B x 1.3 = Proposed Number of Nest Boxes Required

Where:

A = $\frac{\text{Number of identified HBT's within the clearing footprint of a specified zone}}{\text{Area (ha) of vegetated land identified for removal}}$ = Density HBT/ha

B = $\frac{\text{Total number of tree hollows identified}}{\text{Total number of HBT's within the zone}}$ = Mean number of functional hollows per HBT

1.3 = 30% error factor built in to accommodate for the difficulties associated with identifying tree hollows in habitat with one or more of the following factors:

- Dense lower or mid stratum (i.e. Callicoma);
- Particular tree species (i.e. Broad-leaved Paperbark) that are difficult to accurately critique for tree hollows;
- Adverse weather conditions when surveys had to be completed. For example, more difficult to identify tree hollows on cloudy days as the opportunities to utilise shadowing is not available.

As an example, using this formula at Zone I (ch. 64265-64865) can be summarised as follows:

- 4.5 ha has been identified for removal;
- 23 HBT's have been identified within the RMS road corridor; which contain
- 165 functional tree hollows.

Applying the base formula of:
5.11 (A) x 7.17 (B) = 36.7 nest boxes followed by the introduction of the 30% error/compensatory factor: 1.3 x 36.7 = 47.7. This number is then rounded up to the nearest whole number to show 48 nest boxes are required

for Zone I. This number is then reviewed in stage 2 and for every cockatoo/owl nest box required within a given zone an additional possum nest box is required to reduce competitive interactions for nesting/denning resources. Four additional possum boxes are required bring this total to 52. Stage 2 below is used to determine the types of nest boxes required.

Stage 2:

Within each zone, the number and specific designs of nest boxes have been tailored to best accommodate for the loss of hollow resources. This has been done on a proportional basis, so if for example 20% of the tree hollows being removed are considered suitable for small gliders, then 20% of the nest boxes should be specifically designed for gliders such as Sugar Glider and Feathertail Glider. Using the Zone I example again:

- 52 nest boxes are required and these will comprise:
  - 6 microchiropteran bats;
  - 8 scansorial fauna (Antechinus/Phascogale) boxes;
  - 9 small gliders;
  - 6 larger gliders;
  - 9 possums;
  - 6 parrots/lorikeets;
  - 4 cockatoos, larger parrots or small owls with an additional 4 possum boxes to reduce competition.

Some specific fauna groups have been omitted from the nest box schedule given they have generalist habits (i.e. arboreal herpetofauna) which suggest they will utilise most of the current nest box designs or their nesting habits are synonymous with other widely scattered resources found adjacent to the footprint (i.e. termitaria for kingfishers). Moreover, the number of bat nest boxes has been reduced in a number of instances given their highly mobile habits compared to other fauna considered in this plan and the relatively low uptake rates recorded during monitoring for the Kempsey Bypass project (Lewis 2012 in prep).

4.2 Type of Nest Boxes to be Supplied

Most of the HBT's identified for removal contain small and medium sized limb and to a lesser extent trunk hollows which are considered suitable for smaller fauna including scansorial marsupials such as *Antechinus*, small gliders including the Feather-tail Glider and Sugar Glider, some larger species of glider (i.e. Yellow-bellied Glider), microchiropteran bats, possums, and smaller hollow dependant birds up to the size of lorikeets and rosella's. It therefore seems appropriate that the nest boxes themselves be designed with these fauna groups in mind. Ultimately, this equates to fewer large nest boxes capable of providing roosting and nesting habitat for cockatoos and owls.

Nest boxes considered suitable for the following fauna groups have been proposed:

- Scansorial fauna (*Antechinus*)
- Small gliders (Feather-tail Glider and Sugar Glider);
- Larger gliders (Squirrel Glider, Yellow-bellied Glider, Greater Glider)
- Possums (Common Brushtail Possum, Short-eared Possum and to a lesser extent Common Ringtail Possum);
- Microchiropteran bats (fluttering and direct flying species that utilise tree hollows);
- Medium sized parrots/lorikeets;
- Cockatoo (Black Cockatoos);
- Small Owls (Southern Boobook and Barn Owl); and
- Large Forest Owls (Masked Owl, Sooty Owl, Powerful Owl).

No specific nest box designs have been proposed for arboreal herpetofauna given they are considered to have generalist habits and likely to use a number of the designs proposed in this plan. For example, a juvenile python would be capable of using the bat and scansorial fauna nest boxes whilst a larger adult may be more inclined to seek refuge within a possum, cockatoo or small owl nest box.

Microchiropteran bats have been considered here as a single group and include only those species which utilise tree hollows (i.e. cave roosting species such as *Miniopterus spp* not considered). The target species range in size from the small (4 g) Little Forest Bat (*Vespadelus vulturnus*) through to the medium sized bats including the Chocolate Wattled Bat (*Chalinolobus morio*) and Gould's Wattled Bat (*Chalinolobus gouldi*) up to the relatively large Greater Broad-nosed Bat (*Scoteanax rueppellii*) and White-striped Mastiff Bat (*Tadarida australis*) which attain weights of 25-38 g. Whilst these and other species were recorded during the pre approval field surveys there is no evidence to suggest they actually utilise tree hollows within the clearing footprint which probably forms only a fraction of their home range (*see* Van Dyke and Strahan 2008). Moreover, roost site selection can be highly variable with entrances often larger than what may normally be required. For example, Gould's Wattled Bat is known to use roost sites with entrances of 100 mm whilst Lessor Long-eared Bat (*Nyctophilus geoffroyi*) may also use similarly large roosts as times, even where smaller tree hollows are spatially abundant (Dixon and Lumsden 2008; B. Lewis unpub. data). Given these unknowns and the fact that most of the bats being considered are relatively small (i.e. <20 g; *see* Churchill 2008) they have been considered here as a single group.

When providing nest boxes for microchiropteran bats, an important consideration is the thermoregulatory[3] properties of the nest box as this is thought to be a significant factor in bat roost site selection (Gibbons and Lindenmayer 2002; Lourenco and Palmeirim 2004). Even when the requirements are met for a single species or size guild there may also be seasonal requirements in relation to migratory habits or breeding biology. For example, Bechstein's bats (*Myotis bechsteinii*) in Germany tend to prefer sun-exposed boxes during lactation whereas shaded boxes were preferred pre-lactation (Kerth *et al*. 2001).

Attempting to successfully compensate for the larger more mobile species may also result in a reduction of nest box use or effectiveness of this plan. For example, there is limited evidence to suggest black cockatoos will readily use artificial nest boxes. Given that both the Yellow-tailed Black Cockatoo and Glossy Black Cockatoo have been recorded in the area on a number of occasions, it is appropriate that an equitable number of nest boxes be constructed for these species. This is partly due to the relatively low number of suitable tree hollows located throughout the adjacent forests, particularly Nambucca, Little Newry and Newry State Forests (pers. obs). Whilst herpetofauna have not been specifically accounted for it is expected that at least some of the nest boxes will provide amicable refuge habitat.

In relation to the Large Powerful Owl evidence indicates they can typically inhabit tracts of forests in the vicinity of 500-1000 ha so there are a lot of potential nest sites in this area. It should be noted that this report is based on a preliminary ground based assessment and will be updated following clearing works. Hence this would allow for the possibility of an increase in the number of nest boxes for the Large Powerful Owl, should the post clearing survey justify it.

[3] Thermoregulation relates to the ability of an animal to keep its body temperature within certain boundaries, even when the surrounding temperature is very different. This process is one aspect of homeostasis, a dynamic state of stability between an animal's internal environment and its external environment.

Table 4-1. Proposed number of nest boxes for each of the identified nest box zones.
Note - Flexibility should be permitted to change the placement of nest boxes as currently proposed if landholder agreement is not reached. Contractor's Project Ecologist to perform.
Ha = Hectare, No. = Number, HBT = Hollow Bearing Tree. SoC = Side of Carriageway, RMS = Roads and Maritime Services, SF NSW = State Forests NSW.
Specific Designs: MB = Microchiropteran bats, SF = Scansorial mammals (e.g. Antechinus, Phascogale), SG = Small gliders (Feather-tail Glider, Sugar Glider), Po = Possums (Common Ring-tail Possum, Common Brushtail Possum and Short-eared Brush-tail Possum), P/L = Parrots (i.e. Eastern Rosella, Lorikeets), Co = Cockatoos/Large Parrot (Sulphur-crested Cockatoo, Yellow-tailed Black Cockatoo, Glossy Black Cockatoo, King Parrot), SO = Smaller Owls (Southern Boobook, Barn Owl). C = Cockatoo, S = Small Owls
Add. Poss refers to the number of possum boxes required in the vicinity of Cockatoo/King parrot/Small Owl/Large Forest Owl nest boxes to discourage their uptake of these nest boxes.

Zone	Chainages	Area removed ha	No. HBT Removed	No. Functional Hollows	No. Nest Boxes required	Specific Designs									Position		
						MB	SF	SG	LG	Po	P/L	Co/SO	LFO	Add. Poss	SoC	Tenure	Comment
WC2NH																	
A	42565-43015	5.2	2	22	**6**	0	2	0	2	2	0	0	0	0	East	Private	Install on eastern side of ch. 42865. Note - glider incisions tentatively identified in this area and connects with contiguous vegetation to the east.
B	44765-44965	0.75	2	7	**14**	3	2	0	0	3	4	1	0	1	Either	Private	Install either side of the drainage line. Property owner specifically requested nest boxes. RMS will continue to consult and negotiate with property owners.
C	48265-48765	6.1	6	23	**5**	2	1	0	0	2	0	0	0	0	East	RMS	Install within RMS road corridor on eastern side bordering Warrell Creek. Contributes into dry fauna corridor crossing structure for northern side of Warrell Creek.
D	56865-57465	5.8	13	62	**15**	2	2	3	2	2	2	1	0	1	East	RMS/SFNSW	Install on the RMS/Nambucca SF boundary with final location to be determined by project ecologist. Note – this area may need to be reviewed as part of redesign with the Nambucca Floodplain investigation area.
E	58565-59065	7.0	3	11	**3**	0	1	1	0	1	0	0	0	0	East	RMS/SFNSW	Retain HBT64 and install nest boxes on RMS/Nambucca SF boundary ch. 58515. Ties into combined culvert/fauna underpass.
F	59465-60015	7.2	12	50	**10**	0	3	2	2	2	1	0	0	0	West	RMS/SFNSW	Install on the RMS Nambucca SF boundary. Must consider Yellow-bellied Gliders and any potential crossing points. Adjacent to proposed vegetated median.
G	60115-60915	9.2	19	110	**17**	1	3	3	4	3	1	1	0	1	South	RMS/SFNSW	Install on the RMS Nambucca SF boundary. Must consider Yellow-bellied Gliders and any potential crossing points around Allan's Fire Trail.
S	53680-54100	2.7	25	101	**49**	10	6	13	6	6	6	2	0	0	West	RMS/Crown/Private	Ideally there should be sufficient tree retention to provide amenity improvements on western side thus retaining a number of hollow bearing trees. Nest boxes should also be placed in this area. At the interface with RMS/private/crown tenures.
T	55000-55400	8	9	53	**9**	0	2	3	2	1	1	0	0	0	East	RMS/Private	Position boxes on the eastern side of the Old Coast Road service road within RMS retained vegetation.
U	5550055750-	4	9	73	**24**	3	2	5	5	5	3	1	0	0		RMS/Private/Old Coast Road reserve	Construction contractor should make efforts to retain HBT in this area in particular HBT551. Nest boxes should be positioned on eastern side north of ch. 55700 at the discretion of the Project Ecologist.
				WC2NH Total	**152**	**21**	**24**	**30**	**23**	**27**	**18**	**6**	**0**	**3**			
NH2U																	
H	61265-61865	15.3	10	33	**3**	0	1		1		1	0	0	0	West	RMS/SFNSW	Ch. 61365 install on boundary within retained vegetation or alternatively within riparian zone of Cedar Creek.
I	64265-64865	4.5	23	165	**52**	6	8	9	6	9	6	4	0	4	Both	Private and RMS	Seek landholder support for installation. Ensure at least half of nest boxes occur within swamp forest habitat. May need to considered adjacent vegetation to the south bordering Valla Road.
J	66165-66765	10.2	40	259	**36**	4	5	6	5	5	5	3	0	3	West	Private	Give due consideration to retaining as much remnant vegetation as possible. Specialist surveys for Yellow-bellied Glider warranted here. RMS will continue to consult and negotiate with property owners.
K	68165-68815	5.7	60	427	**109**	12	15	15	15	15	15	9	2	11	West	Private	Negotiate with private landowners to west of ch. 68765. Forest through here contains old growth elements and specialist surveys should be undertaken to quantify the presence of threatened hollow dependant fauna including large gliders and large forest owls. Ties in with combined culvert fauna underpass. RMS will continue to consult and negotiate with property owners.
L	70065-70565	10.4	19	106	**14**	2	3	3	2	2	2	0	0	0	East	RMS	Install within RMS corridor on eastern side of ch. 65565-70065 to increase security over tenure and maintenance. Ties in with combined culvert fauna underpass.
M	70565-71065	5.1	21	145	**41**	4	7	5	7	4	6	4	0	4	Both	RMS, SFNSW, Private	Install a cross section of boxes in each tenure. Consult with SF NSW, to seek support for the installation of nest boxes within drainage lines (Forest Management Zones).
N	73465-74065	10.8	9	40	**5**	0	2		2	1	0	0	0	0	Both	RMS	Install boxes in areas to tie in with areas adjacent to the vegetated

Zone	Chainages	Area removed ha	No. HBT Removed	No. Functional Hollows	No. Nest Boxes required	Specific Designs									Position		
						MB	SF	SG	LG	Po	P/L	Co/SO	LFO	Add. Poss	SoC	Tenure	Comment
																	medians being used to maintain glider connectivity.
O	74365-74865	7.1	8	31	**6**	0	2	2	2	0	0	0	0	0	Either	RMS	Project ecologist to advise once clearing limits defined on refined design. Installation should occur within the RMS/SF interface. Ties in with dedicated fauna underpass.
P	76165-76765	6.6	5	24	**10**	2	2	3	2	0	1	0	0	0	West	RMS	Increased the error factor to 100% after considering the structure of the existing Swamp Mahogany forest (i.e. likely to contain more hollows then documented) and its local importance for seasonal foraging resources. All nest boxes to be installed within or close to this community (ch. 76290-76565).
Q	79065-79765	8.75	13	63	**11**	0	2	1	2	2	2	1	0	1	Either	RMS	Install nest boxes within retained vegetation within the RMS road corridor. Occurs within an area identified for retained vegetated median.
R	80065-80765	9.1	17	96	**16**	2	3	2	3	2	2	1	0	1	Either	RMS	Install on both sides but ensure the swamp forest vegetation on eastern side is given due consideration. For example, retain vegetation to the east of ch. 80565 or move boxes south into the vegetated median zone.
				NH2U Total	**303**	**32**	**50**	**46**	**47**	**40**	**40**	**22**	**2**	**24**			

5.0 DESIGN AND CONSTRUCTION OF NEST BOXES

5.1 Some Design Considerations

The recommended dimensions of nest boxes for fauna known or considered likely to occur in the vicinity of the carriageway has been summarised in Table 5-1. Whilst recognising that different fauna require different nest box dimensions the constructed box should take the following design considerations into account:

- Consideration for the target species or fauna group so that:
    - The entrance hole is no larger than for the intended recipient;
    - The entrance hole is positioned toward the top of the nest box so the area remains dark;
    - Rear entrances may be used for some species, namely gliders and bats to avoid competition from non target species (see below); and
    - Rough sawn timber to allow animals to grip the exterior of the nest box.
- Should consider the need for anti competition devices such as:
    - Rear openings for scansorial fauna, bats and gliders to avoid uptake by Common Myna (*Acridotheres tristis*) or common generalist birds such as Rainbow Lorikeets (*Trichoglossus haematodus*);
    - Anti pest devices should be considered. For example, Buffalo Fly ear tags are considered a suitable deterrent for the European Bee (*Apis mellifera*) when positioned close to the nest box entrance.
- Specific furniture needs of the intended recipient fauna such as:
    - Lining the floor with ≥20 mm of non-toxic wood shavings, or in the event they conceal the opening of the nest box, an alternative material such as decayed wood or shredded bark should be selected; and
    - Provision of toe holds to enable young to climb from the nest box.

- A number of weather associated variables including:
    - The use of ≥30 mm thick timber to insulate against heat and cold;
    - All joins and gaps should be sealed with a non toxic glue;
    - The lid of the nest box should overhang by ≥25 mm like an awning to reduce moisture damage;
    - Small drain holes should be placed in the bottom front section of the nest box; and
    - The exterior should be preferably painted with a dark coloured outdoor water-based acrylic paint or oil, and the internal surfaces left unpainted.
- Whilst considering the above, the thermoregulatory capabilities of the nest box need to be considered, particularly for bats as this is thought to significantly influence roost use (*see* Gibbons and Lindenmayer 2002; Lourenco and Palmeirim 2004). This may be achieved using one or more variables including but not limited to the thickness of the nest box walls, external colour of the box (white versus black or an intermediate colour such as grey) or aspect in its positioning. Whilst this has been the focus of little research effort in Australia several overseas studies support this (*see review in* Goldingay and Stevens 2009). For example, Soprano Pipistrelles (*Pipistrellus pygmaeus*) in Portugal preferred the high temperatures (~40^{o}C) associated with black roost boxes over white or grey coloured boxes (Lourenco and Palmeirim 2004). Seasonally, Bechstein's bats (*Myotis bechsteinii*) in Germany seem to prefer sun-exposed boxes during lactation whereas shaded boxes were preferred pre-lactation (Kerth *et al*. 2001).
- Given that monitoring is often proposed there should be allowances for routine maintenance included in the overall nest box design. For example, a hinged lid to allow visual inspection and maintenance access.
- Where monitoring is proposed, the labelling of the nest boxes should be in such a way so as to easily identify them from other nest boxes. For example, a box number and code for each fauna group be stamped or riveted onto the bottom or side of each nest box to enable easier identification, preferably from the ground.
- There should be no sharp edges such as protruding nails or staples.
- Where nest boxes are being designed specifically for gliders they should have a good landing surface close to the nest box such as a large branch.
- The design of the positioning and fastening mechanism should be sturdy and stable and preferentially with a slight forward lean to assist with drainage whilst allowing for growth in the host tree. It is recommended that bracketing use the Habisure™ system (Hollow Log Homes Pty Ltd) where possible as this has the added advantage of allowing at least one metre growth in the diameter of the host tree before adjustment is required, is non-invasive to the tree and provides the required security (Figure 5-1).

Table 5-1. Summary of specifications for nest boxes targeting specific species or fauna groups (Grant 1997; Franks and Franks 2006; McNabb and Greenwood 2011).

Dimen = Dimension.

1 = Nest boxes are to be installed as close to the canopy as possible, thus in the first instance the upper limit of the height range is to be adopted. The lower limit should only be referred to where a series of constraints are present and be approved by the RMS Project Ecologist or Environment Manager. Note – designs 6 and 7 culminate into the required 25 boxes for cockatoos/owls/larger parrots.

Nest Box Type	Total No Required	Fauna Group	Nest Box Dimensions (Grant 1997; Franks and Franks 2006)				Comments
			Inner Dimen. (mm)	Depth (mm)	Entrance Width (mm)	Height Above Ground [1] (m)	
1	64	Scansorial mammals (i.e. Antechinus, Brush-tailed Phascogale)	180 x 180	300	35 – 40	5-8	Timber should be at 30 mm thick for insulation. Choose a tree with no side branches for predator avoidance. Flap of carpet over the entrance to prevent a draft. Drill 5 mm drainage holes at the base of the box.
2	40	Microchiropteran bats (fluttering and direct flying species)	200 x 200	400	10 – 30	5-8	Wedge shaped design reduces build up of guano. PVC design can also be used. Entrance should be a slit at the bottom of the box and heavily grooved to promote grip.
3	55	Small Gliders (i.e. Sugar Glider)	200 x 200	300	40-45	5-8	Recent research would suggest 5 m is sufficient positioning height (R. Goldingay pers. comm.).
4	57	Larger Gliders (i.e. Yellow-bellied Glider)	250 x 300	400	70-90	8-10	Use rear entry design to reduce uptake by possum and other non specific fauna.
5	55	Possums (Brush-tails)	250 x 300	400	85-100	5-8	A ladder of wire mesh or cut steps on the inside will allow the young to climb out.
6	12	Small Owls (Boobook Owl, Barn Owl)	250 x 300	500	100	8-10	Make spout entrance short and horizontal.
7	13	Black Cockatoos/Large Parrots (King Parrot)	300 x 400	1200	200	8-10	A large piece of timber should be attached to the lid for chewing. Layer of sawdust will attract cockatoos and 5mm drainage holes should be placed in base of box. Angled spout entrance.
8	48	Medium-sized Parrots (Lorikeets/Rosellas)	200 x 200	400	65	5-8	Layer of sawdust will attract parrots such as Rosellas. Place 5 mm drainage holes in the base of the box.
9	2	Large forest owls	550 x 550	800	200	12-20	May have to be custom build and installed using an elevated work platform (EWP) or specialist tree climbers.

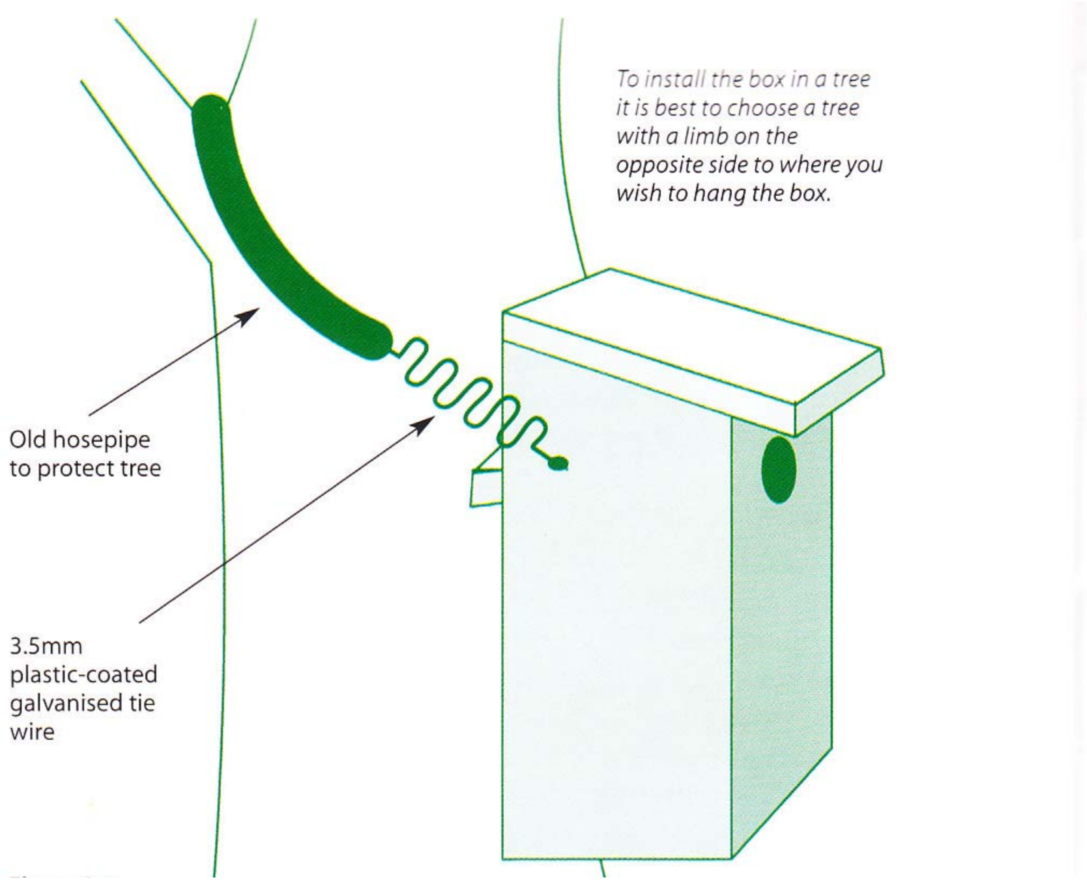

Figure 5-1. Diagrammatic sketch of the Habisure system. Courtesy of Alan and Stacey Franks (Hollow Log Homes ©)

5.2 Dealing with Non Target or Pest Species

A number of pest species both native and exotic are relevant to this plan and are known to utilise both natural hollows and nest boxes. The most relevant ones to this plan are:

- European Bee;
- Exotic birds including Common Myna and Common Starling (*Sturnus vulgaris*); and
- Termites and ants.

These species may construct hives or nests in boxes that exclude the target groups of hollow dependant fauna. Six European Bee hives have been recorded within the RMS road corridor including a:

- Stag (HBT 3) at ch. 42885;
- Dead stag (HBT 14) at ch. 46165;
- Coastal Blackbutt (H226) at ch. 67415;
- Coastal Blackbutt (H263) at ch. 68365;
- Tallowwood (H244) at ch. 68565;
- Tallowwood (HBT 395) at ch. 74215; and
- Turpentine (HBT 526) at ch. 53985.

This is undoubtedly an underestimate as conditions were often unsuitable for conducting hive surveys (i.e. often raining).

Termites can similarly invade nest boxes and eventually consume them, whilst ants although not known to prevent nest box use, can cause maintenance problems. Natural hollows frequently used by exotic birds can out compete native species for nesting resources. The introduction of nest boxes may further facilitate habitat availability for exotic birds resulting in an increase of the local population and in some instances may contribute to key threatening processes pursuant to the *TSC* Act. For example, inadvertently providing habitat for European

Bees. Therefore, a number of recommendations have been suggested to eliminate pest species from nest boxes including the use of:

- Rear openings for glider and bat boxes to reduce uptake by non target species;
- Replacement of a perch with a router-grooved ladder. Nest boxes without a visible entrance hole are less likely to be used by birds (Birds Australia 2001);
- Pest strips or Buffalo Fly ear tags attached and passed into the nest box on a long pole when a colony of ants, termites or honeybees are inactive so as to destroy established colonies; and
- Talcum powder, Coupex ® and other domestic agents can be applied to the entrance of a nest box to deter ants.

It is recommended these later strategies form part of the monitoring and maintenance schedule.

6.0 DISTRIBUTION AND POSITION OF NEST BOXES

This section extends on from the discussion in Section 3.0 which set out to determine broad areas where nest boxes were required. The selected location and positioning of nest boxes is a fundamental component of this plan given that it will ultimately determine the effectiveness of this as a mitigation tool. The use of nest boxes may also be affected by the availability of tree hollows in the surrounding area which varies in this context from nil to 6 HBT's per hectare in the measured 1 ha quadrats and estimates of 8 HBT's per hectare in an area to the west of Burkes Lane (*see* Table 3-1).

As a general rule nest boxes should be installed on large (>400 mm dbh), mature trees close to or on the main trunk. Taking this into account the proposed locations shown in Table 4-1 have also considered:

- The number of tree hollows identified for removal in that part of the construction corridor;
- The residual number of tree hollows on those lands adjacent to the clearing footprint;
- The suitability of those tree hollows to fauna adjacent to the clearing footprint;
- Availability and suitability of other key life cycle components such as foraging resources for displaced fauna including but not limited to autumn-winter flowering Swamp Mahogany (*Eucalyptus robusta*) and Broad-leaved Paperbark (*Melaleuca quinquenervia*), late winter-spring spring flowering Forest Red Gum (*Eucalyptus tereticornis*) or the presence of *Allocasuarina spp* in the case of the Glossy Black Cockatoo;
- Habitat connectivity in the context to those area's identified for removal and the intended recipient fauna; and
- Other fauna mitigation devices and their locations along the carriageway. For example, fauna underpasses and vegetated medians.

Preference has also been given to:

- Areas that contained mixed aged stands of trees, some of which have started to produce tree hollows albeit in low densities or are likely to in the short-medium term (20-40 yrs); and
- Where preferably within RMS's managed road reserve or have been endorsed by landholders during initial consultations.

In addition to those points raised above, the behavioural ecology of the target species must also be considered along with site specifics including aspect, positioning height above the ground, installation techniques and the spatial arrangement or density of nest boxes. This latter point is required to meet the territorial needs of some species that will vigorously defend a territory, attacking individuals of the same species, and occasionally destroying rival nests. Others species are more gregarious, tolerating overlapping home ranges. Therefore an understanding on the individual territorial requirements of a species' can be used as a guide to the density of nest boxes within any given area. Lindenmayer *et al.* (2003) suggested there is a spatial trend in the occupancy pattern of nest box use where nest boxes used for arboreal marsupials placed in a clump of four had greater occupancy rates over time. This would suggest the occupancy of nest boxes by fauna would depend on the density of other roosting/nesting habitat resources within the localised area. Tables 4-1 and 6-1 have been used as a guide in selecting the location and density of nest boxes within the nominated areas.

The position of the nest box on the host tree has also been considered in the context of predominant weather patterns, along with light and noise disturbances arising from the carriageway. It is proposed that nest boxes be installed with their entrances facing away from the lights of traffic and from a north west to south east position on the tree trunk to provide additional shelter from rain and wind (i.e. dominant rainfall from the south west). If this is not always possible, an alternative, particularly for glider nest boxes is to have the entrance facing into the tree. This would necessitate a maintained gap between the nest box entrance and the tree of around 100 mm.

Another important consideration is the height at which nest boxes are placed in the host tree. It has often been recommended that nest boxes be placed as high as possible to protect the occupants from predation and low enough to allow monitoring and maintenance. After considering the preferred height of nest box placement for each of the fauna groups it is recommended that nest boxes be positioned at heights of 5-8 m and possibly a little higher for specific fauna such as black cockatoos (8-10 m) and higher again for the two large forest owl nest boxes. The recommended height has taken into account the surrounding structure of the vegetation where the overstorey ranges from 11-16 m in the Swamp Forest communities to more than 25 m in the taller moist sclerophyll forest found around throughout the state forests. After considering the heights proposed for the installation of the nest boxes a suitable extension ladder with the necessary safety equipment and training would be sufficient to install and subsequently monitor them or alternatively a portable Elevated Work Platform (EWP). In the cases of the large forest owl nest boxes it may be necessary to have them installed by specialist tree climbers.

Table 6-1. Breeding territory and distance required between nest boxes for native fauna that utilise tree hollows and were either recorded, or considered likely to occur along the carriageway.

Bold type denotes vulnerable fauna pursuant to the NSW *TSC* Act. NS = No nest boxes supplied for these species.

Common Name	Scientific Name	Territorial at any stage of life-cycle? (y/n)	Breeding territory (ha) or distance between nests (m)	Distance between nest boxes (m)	Nest Box Type (see Table 5-1)
Birds					
Australian Wood Duck	*Chenonetta jubata*	Y[1]	unknown[1]	-	NS
Grey Teal	*Anas gracilis*	Y[1]	1 pair per 0.25 ha[1]	-	NS
Chestnut Teal	*Anas castanea*	Y[1]	unknown[1]	-	NS
Glossy Black Cockatoo	***Calyptorhynchus lathami***	**N[2]**	**-**	**-**	**7**
Yellow-tailed Black Cockatoo	*Calyptorhynchus funereus*	N[2]	-	-	7
Galah	*Cacatua roseicapilla*	N[2]	-	-	6
Long-billed Corella	*Cacatua tenuirostris*	N[2]	5 nests per tree[2]	2-3 m	NS
Sulphur-crested Cockatoo	*Cacatua galerita*	N[2]	-	-	7
Rainbow Lorikeet	*Trichoglossus haematodus*	N[2]	Several pairs in same tree[2]	2-3 m	8
Scaly-breasted Lorikeet	*Trichoglossus chlorolepidotus*	N[2]	Several pairs in same tree[2]	2-3 m	8
Musk Lorikeet	*Glossopsitta concinna*	N[2]	Several pairs in same tree[2]	2-3 m	8
Little Lorikeet	***Glossopsitta pusilla***	**N[2]**	**Several multiple species in same tree[2]**	**2-3 m**	**NS**
Australian King Parrot	*Alisterus scapularis*	Y[2]	100 m[2]	100 m	7
Eastern Rosella	*Platycercus eximius*	Y[2]	90 m[2]	90 m	8
Powerful Owl	***Ninox strenua***	**Y[2]**	**300-1500 ha[2]**	**3.8 km**	**9**
Sooty Owl	***Tyto tenebricosa***	**Y[2]**	**200-800 ha[2]**	**2.5 km**	**9**
Masked Owl	***Tyto novaehollandiae***	**Y[2]**	**200-800 ha[2]**	**2.5 km**	**9**
Southern Boobook	*Ninox novaeseelandiae*	Y[2]	37 ha[2]	600 m	6
Barn Owl	*Tyto alba*	Y[2]	300 m[2]	300 m	6
Australian Owlet-Nightjar	*Aegothesles cristatus*	Y[2]	<80 ha[2]	750-900 m	8
Laughing Kookaburra	*Dacelo novaeguineae*	Y[2]	25 ha[2]	500 m	NS
Sacred kingfisher	*Todiramphus sanctus*	Y[2]	4 ha[3]	200 m	NS
Dollarbird	*Eurystomus orientalis*	Y[2]	14 ha[3]	300 m	NS
White-throated Treecreeper	*Cormobates leucophaeus*	Y[3]	3-7 ha[3]	170-250 m	NS
Striated Pardalote	*Pardolotus striatus*	Y[3] immediate area	Pairs up to 100's pairs	2 m	NS
Starling [I]	*Sturnus vulgaris* [I]	Y[4]	2.3 territories/ha	100 m	NS
Common Myna [I]	*Acridotheres tristis* [I]	Y[4]	0.8-2.0 ha	125 m	NS
Reptiles					
Southern Leaf-tailed Gecko	*Phyllurus platurus*	N[5]	-	-	NS
Tree Skink	*Egernia mcpheei*				NS
Lace Monitor	*Varanus varius*	Unknown[5]	-	-	NS
Diamond Python	*Morelia spilota spilota*	Unknown[5]	-	-	NS
Carpet Python	*Morelia spilota*	Unknown[5]	-	-	NS
Frogs					
Bleating Tree Frog	*Litoria dentata*	N[6]	-	-	NS
Perons Tree Frog	*Litoria peronii*	N[6]	-	-	NS
Tyler's Tree Frog	*Litoria tyleri*	N[6]	-	-	NS

Common Name	Scientific Name	Territorial at any stage of life-cycle? (y/n)	Breeding territory (ha) or distance between nests (m)	Distance between nest boxes (m)	Nest Box Type (see Table 5-1)
Mammals					
Brown Antechinus	*Antechinus stuartii*	N[7]	1-2 ha[8]	-	1
Brush-tailed Phascogale	***Phascogale tapofata***	**Y[8]**	**5-60 ha[8]**	**-**	**1**
Mountain Brushtail Possum	*Trichosurus caninus*	Y[8]	0.2-4 ha[8]	100 m	5
Common Brushtail Possum	*Trichosurus vulpecular*	Y[8]	0.2-4 ha[8]	100 m	5
Feather-tail Glider	*Acrobates pygmaeus*	N[9]	0.15-2.1 ha[10]	~2-4[9]	1/2
Sugar Glider	*Petaurus breviceps*	Unknown[11]	0.89-1.54 ha[11]	100-125 m	3
Squirrel Glider					**3/4**
Yellow-bellied Glider	***Petaurus australis***	**Y[14]**	**30-60 ha**	**125 m**	**4**
Greater Glider					4
Common Ringtail Possum	*Pseudocheirus peregrinus*	Unknown[8]	-	-	5
White-striped Mastiff Bat	*Tadarida australis*	N[15]	-	-	2
Eastern Free-tail Bat	***Mormopterus norfolkensis***	**N[15]**	**-**	**-**	**2**
Gould's Wattled Bat	*Chalinolobus gouldi*	N[15]	-	-	2
Chocolate Wattled Bat	*Chalinolobus morio*	N[15]	-	-	2
Eastern Forest Bat	*Vespadelus pumilus*	N[15]	-	-	2
Little Forest Bat	*Vespadelus vulturnus*	N[15]	-	-	2
Southern Forest Bat	*Vespadelus regulus*	N[15]	-	-	2
Greater Broad-nosed Bat	***Scoteanax rueppellii***	**Y[16]**	**Regional if maternity site**	**-**	**2**
Eastern Broad-nosed Bat	*Scotorepens orion*	N[15]	-	-	2
Lesser Long-eared Bat	*Nyctophilus geoffroyi*	N[15]	-	-	2
Gould's Long-eared Bat	*Nyctophilus gouldi*	N[15]	-	-	2

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7.0 NEST BOX MANAGEMENT

The management of nest boxes forms part of the overall management of fauna for the Upgrading of the Pacific Highway from just south of Warrell Creek (Allgomera deviation) north the Waterfall Way, Raleigh.

7.1 When will the Nest Boxes be Installed?

The contractor will install 60% of the nominated nest boxes will be installed prior to or during the clearing works with the objective of providing temporal refuge habitat for those hollow dependent fauna displaced during clearing operations. The remaining 40% of nest boxes will be installed by the contractor once a final tally of functional tree hollows has been compiled and reviewed as a result of the data collected during the clearing supervision. Occupancy rates of tree hollows during the clearing supervision will also facilitate the final number and types of nest boxes being installed. Ultimately, the Project Ecologist will be responsible for determining these values as they will be performing the clearing supervision.

7.2 Monitoring and Maintenance

Roads and Maritime Services have committed to developing a suitable monitoring and maintenance strategy to evaluate the effectiveness of the nest boxes with this summarised in Table 7-1. As such, it will be important to assign each nest box a number and ensure its location is recorded using a GPS. It is proposed that summer and winter monitoring would take place shortly after the installation period (i.e. Year 3 and 4 of this plan) and this would continue in Year 6 and Year 8. An annual maintenance program will align with this monitoring program after which a pre handover maintenance inspection will be undertaken at Year 8 (Table 7-1).

During each monitoring event, the following information should be collected for each nest box using a field proforma:

- Inspection dates, weather conditions (i.e. rain, wind, cloud cover, ambient temperature) and time each box was inspected;
- Nest box number;
- Is the nest box currently occupied by native fauna;
- If yes, what species;
- If no, are there signs of use and can the species be identified or assigned to a group (i.e. bats, birds);
- Has the nest box been used by a pest species (i.e. European Bees, Common Myna, Termites);
- Is there any deterioration of the nest box;
- Is there any maintenance required; and
- Has the surrounding landscape changed (i.e. clearing, partial clearing).

Factors to be considered as part of the maintenance schedule include:

- The need to remove exotic pests species such as Common Mynas, Common Starling and European Bees;
- Replacement of fallen, damaged or degraded nest boxes;
- Repositioning or relocation of dysfunctional[4] nest boxes;
- Checking each box is not holding water or leaking; and
- Removing excess nesting material[5] as this may impede access over time.

[4] Dysfunctional for the purposes of the nest box monitoring program shall mean nest boxes that are showing no signs of use during the latter stages of the monitoring program (i.e. after 3 monitoring episodes).

[5] Build-up of nest material that threatens to block nest box entrance or create management problems as determined by the qualified zoologist undertaking the monitoring program.

Table 7-1. Timing of key actions for this nest box plan of management, responsibilities and documentation requirements.

Management Action / Year Number	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Responsibility	Documentation Requirements
Pre Construction										
Prepare Nest Box Plan	√								RMS	Construction Environmental Management Plan
Construction										
Commission Construction of Nest Boxes	√	√							Contractor	-
Install Nest Boxes		√	√						Contractor	Construction Environmental Management Plan
Monitoring										
Summer			√	√		√		√	Contractor	Yearly reporting
Winter			√	√		√		√	Contractor	Yearly reporting
Maintenance										
Maintenance of boxes			√		√		√		Contractor	
Pre Handover Maintenance Inspection								√	Contractor	Nest Box Reporting

7.3 Performance Measures

The performance of the nest box program would be assessed against the following parameters:

- Use of nest boxes by a wide range of native fauna;
- Use of nest boxes designed for specific species by those species (i.e. Brush-tailed Phascogale nest box being used by this species);
- Low rates of exotic fauna using nest boxes; and
- Reduced maintenance requirements.

7.4 Contingency Measures

A number of contingency measures have been proposed to overcome potential problems associated with using nest boxes as a mitigation device. These have been summarised in Table 7-2.

Table 7-2. Potential problems encountered when using nest boxes as a mitigation tool to offset tree hollow losses.

Problem	Contingency / Correction Action
Nest box being used by non target species.	Review the selection and number of nest box designs.
Nest boxes become occupied by exotic or invasive fauna (i.e. European Bees, Termites).	Review/modify nest box design to exclude undesirable species, treat if applicable (i.e. Buffalo Fly ear tags for bees) or relocate those nest boxes to another location.
Poor uptake/usage rate by native fauna.	Review the types and numbers of nest box designs.
Nest boxes deteriorating rapidly and requiring maintenance.	Identify causes of nest box failure, modify design and construct accordingly.

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APPENDIX A

Hollow Dependant Fauna Recorded along the RMS Road Corridor

Table A. Summary of hollow dependant fauna recorded on or near to the Warrell Creek to Urunga.

Bold type denotes species currently listed as vulnerable pursuant to the NSW *Threatened Species Conservation* Act (1995).

* denotes introduced species.

Family Name	Common Name	Scientific Name
FROGS		
HYLIDAE	Common Green Tree Frog	*Litoria caerulea*
HYLIDAE	Bleating tree Frog	*Litoria dentata*
HYLIDAE	Eastern Dwarf Frog	*Litoria fallax*
HYLIDAE	Graceful Tree Frog	*Litoria gracilenta*
HYLIDAE	Peron's Tree Frog	*Litoria peronii*
HYLIDAE	Red-eyed Tree Frog	*Litoria chloris*
HYLIDAE	Tyler's Tree Frog	*Litoria tyleri*
REPTILES		
GECKONIDAE	Southern Leaf-tailed Gecko	*Saltuarius swaini*
VARANIDAE	Lace Monitor	*Varanus varius*
SCINCIDAE	Tree Skink	*Egernia mcpheei*
SCINCIDAE	Bar-sided Skink	*Eulamprus martini*
PYTHONIDAE	Carpet Python	*Morelia spilota*
COLUBRIDAE	Green Tree Snake	*Dendrelaphis punctulata*
MAMMALS		
DASYURIDAE	**Brush-tailed Phascogale**	***Phascogale tapoatafa***
DASYURIDAE	Brown Antechinus	*Antechinus stuartii*
PETAUROIDEA	**Yellow-bellied Glider**	***Petaurus australis***
PETAUROIDEA	**Squirrel Glider**	***Petaurus norfolcensis***
PETAUROIDEA	Sugar Glider	*Petaurus breviceps*
PETAUROIDEA	Greater Glider	*Petauroides volans*
PSEUDOCHEIRIDAE	Common Ringtail Possum	*Pseudocheirus peregrinus*
ACROBATIDAE	Feather-tail Glider	*Acrobates pygmaeus*
PHALANGERIDAE	Common Brushtail possum	*Trichosurus vulpecula*
PHALANGERIDAE	Short-eared Brushtail possum	*Trichosurus caninus*
VESPERTILIONIDAE	Chocolate Wattle Bat	*Chalinolobus morio*
VESPERTILIONIDAE	Gould's Wattled Bat	*Chalinolobus gouldi*
VESPERTILIONIDAE	**Hoary Wattled Bat**	***Chalinolobus nigrogriseus***
VESPERTILIONIDAE	Eastern Broad-nosed Bat	*Scotorepens orion*
VESPERTILIONIDAE	Undescribed Broad-nosed Bat	*Scotorepens sp*
VESPERTILIONIDAE	Eastern Forest Bat	*Vespadelus pumulis*
VESPERTILIONIDAE	Southern Forest Bat	*Vespadelus regulus*
VESPERTILIONIDAE	Southern Forest Bat	*Vespadelus vulturnus*
VESPERTILIONIDAE	**Little Bent-wing Bat**	***Miniopterus australis***
VESPERTILIONIDAE	**Southern Myotis**	***Myotis macropus***
VESPERTILIONIDAE	**Greater Broad-nosed Bat**	***Scoteanax rueppellii***
VESPERTILIONIDAE	**Eastern False Pipistrelle**	***Falsistrellus tasmaniensis***
VESPERTILIONIDAE	Lesser long-eared Bat	*Nyctophilus geoffroyi*

Family Name	Common Name	Scientific Name
VESPERTILIONIDAE	Gould's Long-eared Bat	*Nyctophilus gouldi*
MOLOSSIDAE	Little Free-tail Bat	*Mormopterus sp. 2*
MOLOSSIDAE	White-striped Mastiff Bat	*Tadarida australis*
BIRDS		
ANATIDAE	Hardhead	*Aythya australis*
ANATIDAE	Pacific Black Duck	*Anas superciliosa*
ANATIDAE	Wood Duck	*Chenonetta jubata*
ANATIDAE	Grey Teal	*Anas gracilis*
ANATIDAE	Chestnut Teal	*Anas castanea*
CACATUIDAE	**Glossy Black Cockatoo**	*Calyptorhynchus lathami*
CACATUIDAE	Yellow-tailed Black Cockatoo	*Calyptorhynchus funereus*
CACATUIDAE	Galah	*Cacatua rosicapilla*
PSITTACIDAE	Rainbow Lorikeet	*Trichoglossus haematodus*
PSITTACIDAE	Scaly Breasted Lorikeet	*Trichoglossus chlorolepidotus*
PSITTACIDAE	**Little Lorikeet**	***Glossopsitta pusilla***
PSITTACIDAE	Musk Lorikeet	*Glossopsitta concinna*
PSITTACIDAE	Australian King Parrot	*Alisterus scapularis*
PSITTACIDAE	Eastern Rosella	*Platycercus eximius*
STRIGIDAE	Southern Boobook	*Ninox novaeseelandiae*
STRIGIDAE	**Powerful Owl**	***Ninox strenua***
TYTONIDAE	**Masked Owl**	***Tyto novaehollandiae***
TYTONIDAE	**Sooty Owl**	***Tyto tenebricosa***
TYTONIDAE	Barn Owl	*Tyto alba*
AEGOTHELIDAE	Australian Owlet Nightjar	*Aegotheles cristatus*
CAPRIMULGIDAE	White-throated Nightjar	*Eurostopodus mystacalis*
ALCEDINIDAE	Laughing Kookaburra	*Dacelo novaeguineae*
ALCEDINIDAE	Sacred Kingfisher	*Todiramphus sanctus*
ALCEDINIDAE	Forest Kingfisher	*Todiramphus macleayii*
CORACIIDAE	Dollarbird	*Eurystomus orientalis*
CLIMACTERIDAE	White-throated treecreeper	*Cormobates leucophaeus*
PARDALOTIDAE	Striated Pardalote	*Pardolotus striatus*
PARDALOTIDAE	Spotted Pardalote	*Pardolotus punctatus*
STURNIDAE	Common Starling *	*Sturnus vulgaris* *
STURNIDAE	Common Myna *	*Acridotheres tristis* *

APPENDIX B

Ecology of Relevant Hollow Dependant Fauna

Table B. Summary of hollow dependant fauna species known from the lower foothills and coastal plans of the Nambucca and Kalang Valley.

M = Metres, MM = Millimetre, DBH = Diameter at breast height.

Fauna Group Common Name (Latin Name)	Habitat	Tree hollow characteristics (Gibbons and Lindenmayer 2003)					Comment
		Den tree type	Height (m)	Entrance diameter (mm)	Depth (mm)	Density of hollow use within home range	
Mammals							
Scansorial mammals							
Brush-tailed Phascogale (*Phascogale tapoatafa*)	Largely an arboreal inhabitant of dry sclerophyll forests and woodlands with little/sparse ground cover. It uses multiple den sites usually a tree hollow but also known to use rotted stumps and bird nests. Forages on arthropods and small vertebrates over variable home range of 5-100 ha depending on habitat quality (Soderquist and Rhind 2008).	Rough barked trees of ≥250 mm DBH					Large tree cavities with small secure entrances are preferred (Soderquist and Rhind 2008).
Brown Antechinus (*Antechinus stuartii*)	Widespread in a variety of forested and heathland habitats reaching its highest density in habitats with dense groundcover and abundant logs. Nests are constructed in hollow log or tree hollow when young reach 5 weeks old (Crowther and Braithwaite 2008)						Likely to use a range of nest box types.
Small Gliders							
Feather-tail Glider (*Acrobates pygmaeus*)	Widely distributed throughout tall forests and woodlands of eastern Australia with home range of up to 2.1 ha (Ward and Woodside 2008). Normally den in groups of 3-5 individuals with observations of up to 25 individuals.	400-2000 mm DBH	25	120	920		Known for utilising any available enclosed space including tree hollows, telephone interchange boxes, bird boxes, old bird nests or abandoned possum drays Ward and Woodside 2008).

Fauna Group Common Name (Latin Name)	Habitat	Tree hollow characteristics (Gibbons and Lindenmayer 2003)					Comment
		Den tree type	Height (m)	Entrance diameter (mm)	Depth (mm)	Density of hollow use within home range	
Sugar Glider (*Petaurus breviceps*)	Found in variety of habitats including rainforest, sclerophyll forests and woodland habitats of eastern and northern Australia (Suckling 2008). Highest densities tend to occur in open forest habitats where animals have access to dense patches of *Acacia* (Suckling 2008).	>300 mm DBH	8 -31	35-50	60-700	<5	It seems to tolerant some level of habitat fragmentation being often road in linear strips of vegetation and has been successfully introduced in rehabilitated habitats augmented with nest boxes.
Large Gliders							
Squirrel Glider (*Petaurus norfolcensis*)	Inhabitant of dry sclerophyll forest and woodland but usually absent from dense coastal ranges of NSW. Such habitats tend to have *Eucalyptus*, *Corymbia*, *Angophora* species with a shrubby understorey of Acacia or Banksia with at least one winter flowering species providing an important nectar source (van der Ree and Suckling 2008)	Rough barked trees including Ironbarks and Swamp Mahogany 900mm DBH					Usually select multiple tree hollows with a tight fitting entrance.
Yellow-bellied Glider (*Petaurus australis*)	Generally restricted to tall, mature eucalypt forest and coastal woodlands in high rainfall areas of temperate to sub-tropical eastern Australia (NPWS 2003; Menkhorst and Knight 2003). A family group of two to six individuals usually occupy a home range of 30-60 ha (Goldingay 2008). Tree hollows are used for denning and these are changed periodically throughout the year.	800-2000 mm DBH	44	110 - 140	1300	6 - 13	These gliders require large hollows because family groups share den sites (Gibbons and Lindenmayer 2003).
Greater Glider (*Petauroides volans*)	An inhabitant of Eucalypt, *Corymbia* and *Angophora* dominated habitats from low open forests on the coast to tall closed forest of the coastal ranges and along riparian corridor and woodlands west of the dividing range (McKay 2008).	>1m DBH	11	180		2 - 14	
Possums							
Common Ringtail Possum (*Pseudocheirus peregrinus*)	Occupant of usually dense vegetation types including rainforest where shrubs form dense tangled foliage although inhabitant riparian woodland vegetation west of the dividing range. Spherical nests lined with shredded bark or grass are made in a hollow limb or dense undergrowth (McKay and Ong 2008).	100 - 1430 DBH	4	66-80	> 200	8	Ringtail possums inhabiting areas with dense understorey vegetation are more likely to build drays from sticks and vegetative matters as a shelter in preference to tree hollows (McKay and Ong 2008).

Fauna Group Common Name (Latin Name)	Habitat	Tree hollow characteristics (Gibbons and Lindenmayer 2003)					Comment
		Den tree type	Height (m)	Entrance diameter (mm)	Depth (mm)	Density of hollow use within home range	
Common Brushtail Possum (*Trichosurus vulpecula*)	Widely distributed throughout Australia, however, sclerophyll forests tend to be the preferred habitat (Kearle and How 2008). Although tree hollows are the usually den location in either tree limb or trunk individuals have been recorded using termite mounds, hollow logs and rabbit warrens (Kearle and How 2008).	550-1150 mm DBH	6	> 100	90-120	4 - 8	The generalist denning habits of this species suggest alternative nesting resources should be an effective substitute for the loss of tree hollow habitat.
Short-eared Brushtail Possum (*Trichosurus caninus*)	An inhabitant of moist forests north from about Newcastle (How 2008). It reaches its peak density of 1 individual per 10 ha in forest gullies with abundant tree hollows in north eastern NSW (Martin 2008). Den site selection is normally in a live or dead tree although it has been known to utilise epiphytes.	550-1150 mm DBH	6	> 100	90-120	4 - 8	
Flying Mammals							
Microchiropteran bats (i.e. East Coast Free-tail Bat, Greater Broad-nosed Bat, Large-footed Myotis)	No preferred hollow characteristics are apparent among bats and both natural and man-made structures are used. However some species of microchiroptera are partly heterothermic suggesting that their selection of roost sites is strongly influenced by microclimatic conditions (Gibbons and Lindenmayer 2003). Bat species have been known to show fidelity to a roost area, rather than a single roost (Gibbons and Lindenmayer 2003) which may indicate the substitution of natural hollows with nest boxes will not greatly influence local populations of this fauna group.	Mature, senescent or dead trees > 800 mm DBH.					Been recorded using roost trees as small as 25 mm.
Birds							
Ducks							
Australian Wood Duck (*Chenonetta jubata*)	An inhabitant of grasslands, open woodlands, wetlands, flooded pastures and coastal inlets and bays. Also common on farmland with dams, as well as around rice fields, sewage ponds and in urban parks. Often be found around deeper lakes that may be unsuitable for other waterbirds, as it prefers to forage on land (Pizzey and Knight 2008).	Live or dead tress above or near water	3		400		Often re-using the same site.

Fauna Group Common Name (Latin Name)	Habitat	Tree hollow characteristics (Gibbons and Lindenmayer 2003)					Comment
		Den tree type	Height (m)	Entrance diameter (mm)	Depth (mm)	Density of hollow use within home range	
Grey Teal (*Anas gracilis*)	Common inhabitant of all sheltered watered areas ranging from freshwater to saltwater. It preferred habitat tends to be timbered pools and river systems of the inland areas, where large aggregations numbers thousands are not uncommon (Marchant and Higgins 1993).	Usually tall tree along watercourse	3.5		1300		Rarely on ground, under shrubs or bushes.
Chestnut Teal (*Anas castanea*)	Inhabitant of wetlands and estuaries in coastal regions, and is one of the few ducks able to tolerate hyper saline waters, although it still needs fresh water for drinking. It will also use open freshwater lakes, reservoirs and sewage ponds during dry seasons. It mainly breeds in coastal areas, needing hollow trees in water or short grasslands near water for nesting, and it will readily take to suitably constructed nest boxes (Marchant and Higgins 1993; Pizzey and Knight 2008).	Close to water	1-10.5				Nest sites tend to be lower in mangrove communities
Cockatoos							
Glossy Black Cockatoo (*Calyptorhynchus lathami*)	In coastal parts of NSW the preferred habitat for Glossy Black Cockatoo is dry open forest or woodland with a plentiful supply of *Allocasuarina* species for foraging, and large hollows for nesting (Pepper *et al.* 2000). Glossy Black Cockatoos are selective in their choice of foraging sites and chose stands that produce the highest seed to cone ratio (Pepper *et al.* 2000). Typically nest sites occur close (<2 km) to areas with a plentiful supply of *Allocasuarina*.	Live or dead Eucalypt >700mm DBH usually <1km from feeding area.	5-28	210	400-1200		Known to use nest boxes constructed from hollow logs.
Yellow-tailed Black Cockatoo (*Calyptorhynchus funereus*)	The Yellow-tailed Black Cockatoo inhabits temperate rainforest, sclerophyll forests, woodlands and coastal heaths throughout eastern Australia (Pizzey and Knight 2008). It has a varied diet of grubs, seeds from *Pinus*, *Hakea*, *Banksia* and other plants, fruits and plant shoots. Breeding usually takes place in a large senescent eucalypt of considerable age (Nelson and Morris 1994).	Hollow in mature senescent tree	5-56	460	600-2400		Mean estimated age of nest trees used by Yellow-tailed Black Cockatoo 221 years (Nelson and Morris 1994)
Sulphur Crested Cockatoo (*Cacatua galerita*)	Inhabitant of most forested and wooded areas including urban areas (Pizzey and Knight 2008). Tend to display sedentary habits.	Hollow in limb or trunk of dead or living tree often near water	1-35	220	200-1800		

Fauna Group Common Name (Latin Name)	Habitat	Tree hollow characteristics (Gibbons and Lindenmayer 2003)					Comment
		Den tree type	Height (m)	Entrance diameter (mm)	Depth (mm)	Density of hollow use within home range	
Galah (*Cacatua roseicapilla*)	Inhabitant of most forested and wooded areas including urban areas often close to water (Pizzey and Knight 2008). Seeds of grasses and cultivated crops are eaten, making these birds agricultural pests in some areas where they are often described as abundant. Birds may travel large distances in search of favorable feeding grounds.	Hollow in limb or trunk of dead or living tree often near water	1-19	250	700-2000		
Forest Owls							
Powerful Owl (*Ninox Strenua*)	An inhabitant of sclerophyll forests and occasionally woodlands of eastern and south-eastern Australia (Pizzey and Knight 2008). Studies suggest it is highly mobile species occupying large home ranges of approximately 1000-3000 ha in tall sclerophyll forests with pairs of birds holding territories are rarely found within 4-5 kilometres of another territory. The Powerful Owl often nests in trees growing near creeks along drainage lines (McNabb 1996; Kavanagh 1997) and have occasionally been recorded nesting in parkland next to forest (Pavey *et al.* 1994). Roost sites are traditional and used year after year but the number of roost sites can vary considerably (e.g. McNabb 1996, Kavanagh 1997). Kavanagh (1997) found the most important roost sites are trees in the roost or nest-grove which can be used for many months of the year. Prey are generally hollow dwelling (Garnett and Crowley 2000).	> 1m DBH located on steep slopes	12 - 45	450 -750	2000		Feather identified as belong to this species off this species was recorded in the vicinity of chainage 8420 during the hollow bearing tree survey. There has been no record of this species utilising artificial nest boxes (Carbery 2004).
Masked Owl (*Tyto novaehollandiae*)	Inhabitant of dry sclerophyll forests and woodlands generally with a low sparse understorey but is known to utilise open and partially cleared habitat (Kavanagh and Peake 1993). This species is mainly encountered in coastal areas and tablelands but can extend far inland along riparian habitats. Nest and roost sites are often associated with large hollows in wet sclerophyll gullies where hollows may be used for several years.		10 - 30	450 - 550	400-5000		The Masked Owl may also roost in caves and rock crevices (Gibbons and Lindenmayer 1997). There has been no record of this species utilising artificial nest boxes (Carbery 2004).

Fauna Group Common Name (Latin Name)	Habitat	Tree hollow characteristics (Gibbons and Lindenmayer 2003)					Comment
		Den tree type	Height (m)	Entrance diameter (mm)	Depth (mm)	Density of hollow use within home range	
Sooty Owl (*Tyto tenebricosa*)	Occurs in wet eucalypt forest and rainforest on fertile soils with tall emergent trees. Typically found in old growth forest with a dense understorey, however, it is known to utilise younger forests if suitable nesting trees occur nearby. Nest site selection is normally within a large eucalypt hollow (Garnett and Crowley 2000).	Smooth barked eucalypts 400-600 mm DBH	16 - 30		400- 3000		The Sooty Owl may also roost in caves, rock overhangs and dense gully vegetation (Gibbons and Lindenmayer 1997). There has been no record of this species utilising artificial nest boxes (Carbery 2004).
Small Owls							
Southern Boobook (*Ninox novaeseelandiae*)	Inhabits most vegetated landscapes from heathlands to dense forest and open deserts where it often feeds on insects, small mammals (such as the House Mouse, *Mus musculus* and small dasyurids) along with other small animals including frogs (Pizzey and Knight 2008).	Vertical hollow in live or dead tree	3-30	200-300	300-2500		
Barn Owl (*Tyto alba*)	This species is found throughout Australia where its distribution is limited only by habitat and food availability (Pizzey and Knight 2008). Its preferred habitat is open, often arid landscapes, fragmented farming landscapes, heath and lightly wooded forest.	Hollow in live or dead tree	0-20	200-250	600-2000		
Australian Owlet Nightjar (*Aegothesles cristatus*)	Most treed habitats that support tree hollows and nearby adjacent areas. During the day this species roosts in a limb or trunk hollow (Pizzey and Knight 2008).	Hollow in live or dead tree	0.2-30	70-250	200-3500		May use multiple roost hollows over short periods (Brigham *et al.* 1998)
Parrots/Lorikeets & Rosellas							
Australian King Parrot (*Alisterus scapularis*)	An inhabitant of rainforests, sclerophyll forests and woodlands particularly near riparian habitats where it forages for seeds and fruits (Pizzey and Knight 2008).	Deep vertical hollow in trunk of large Eucalypt	6-25	600	50-18000		
Rainbow Lorikeet (*Trichoglossus haematodus)*	This species inhabits a range of treed landscapes from heathlands to woodlands, sclerophyll forests and rainforests (Pizzey and Knight 2008). It is largely sedentary although some nomadic movements are undertaken in response to seasonal flowering and fruiting of plants.	Live or dead tree	3-30	220	300-600		Will readily use artificial sites

Fauna Group Common Name (Latin Name)	Habitat	Tree hollow characteristics (Gibbons and Lindenmayer 2003)					Comment
		Den tree type	Height (m)	Entrance diameter (mm)	Depth (mm)	Density of hollow use within home range	
Musk Lorikeet (*Glossopsitta concinna*)	A nomadic species following the flowering and fruiting of trees in tall, open and dry forest or woodlands dominated by eucalypts and *Corymbia*. Treed suburban areas, parks and landscaped street trees are also used. This species may also feed upon the seeds, fruits and insects and their larvae found within its preferred habitat.	Live or dead tree often close to water	3-8	40	500		
Scaly-breasted Lorikeet (*Trichoglossus chlorolepidotus*)	This species inhabits lowland eucalypt forests, woodlands heathlands and well-treed urban areas, including parks and gardens (Pizzey and Knight 2008). Numbers within any particular area often fluctuate in response to seasonal flowering of eucalypts, *Melaleuca*, *Callistemon* and *Banksia*.	Live or dead tree with an inclined hollow	3-20	50-150	200-1980		
Little Lorikeet (*Glossopsitta pusilla*)	A nomadic species that mostly occurs in dry, open eucalypt forests and woodlands (Pizzey and Knight 2008). They have been recorded from both old-growth and logged forests in the eastern part of their range, and in remnant woodland patches and roadside vegetation on the western slopes.	Hollows and knot holes usually in senescent trees	6-18	29-32	180-500		Very small entrance used.
Eastern Rosella (*Platycercus eximius*)	An inhabitant of open woodlands, grasslands, farmlands and remnant bushland. May also occur in urban habitats such as parks, gardens and golf courses (Pizzey and Knight 2008).Within these habitats it forages on the ground, especially amongst grasses in lawns, pastures and other clearings.	Hollow in any part of usually large Eucalypt	1-30	60-410	180-2440		Will utilise artificial structures.
Kookaburra/Kingfishers							
Laughing kookaburra (*Dacelo novaeguineae*)	Open Sclerophyll forest or woodland, with open or sparse understorey or grass ground cover (Pizzey and Knight 2008).	Live or dead tree often a Eucalypt	2-60	80-400	200-1500		Often utilises burrows and termitaria as well as artificial sites.
Sacred Kingfisher (*Todiramphus sanctus*)	An inhabitant of woodlands, mangroves and paperback forests, tall open eucalypt forest and *Melaleuca* forest. Sacred Kingfishers spend the winter in the north of their range and return south (including NSW) in the spring to breed (Pizzey and Knight 2008).		0.5-35				Often utilises burrows and termitaria.

Fauna Group Common Name (Latin Name)	Habitat	Tree hollow characteristics (Gibbons and Lindenmayer 2003)					Comment
		Den tree type	**Height (m)**	**Entrance diameter (mm)**	**Depth (mm)**	**Density of hollow use within home range**	
Dollarbird (*Eurystomus orientalis*)	An inhabitant of open wooded areas, normally with mature, hollow-bearing trees suitable for nesting (Pizzey and Knight 2008).	Mostly in senescent Eucalypt	6-35				May occasionally use termitaria.
White-throated Treecreeper (*Cormobates leucophaeus*)	An inhabitant of sclerophyll forests, rainforests, woodlands and timbered watercourses where it maintains permanent territories (Pizzey and Knight 2008).		4-5				
Striated Pardalote (*Pardolotus* striatus)	Striated Pardalotes are found in almost any habitat with trees or shrubs, but favor eucalypt forests and woodlands where they forage in the tops of trees, occasionally coming close to the ground in low shrubs (Pizzey and Knight 2008).	Maybe a burrow in a termite mound, hollow branch or river bank.					Often nests in burrows constructed in roadside cuttings, riverbanks and steep hillsides.
Reptiles							
Southern Leaf-tailed Gecko (*Phyllurus platurus*)	Sclerophyll forests, rainforests often with exposed rock and/or abundant fallen timber and old growth trees.	Under rock or exfoliating bark or tree hollow					Nothing known of its hollow habits.
Tree Skink (*Egernia mcpheei*)	Arboreal inhabitant of sclerophyll forests, rainforest margins and woodlands from coastal floodplains to upland areas of the Great Dividing Range (Wilson and Swan (2004).	Under rock or exfoliating bark or tree hollow, particularly fissures on dead stags					Little known on its hollow habits.
Lace Monitor (*Varanus varius*)	Arboreal inhabitant of sclerophyll forests, rainforest margins and woodlands (Wilson and Swan (2004).	Hollows with nearby large limbs for sunning	1->10m	>150	>300		
Frogs							
Bleating Tree Frog (*Litoria dentata*)	Coastal swamps and lagoons, rainforests, wet and dry sclerophyll forests and urban bushland. During the day it often hides beneath stones and bark (Barker *et al.* 1995).	Any hollow form but particular those that hold water					

Fauna Group Common Name (Latin Name)	Habitat	Tree hollow characteristics (Gibbons and Lindenmayer 2003)					Comment
		Den tree type	Height (m)	Entrance diameter (mm)	Depth (mm)	Density of hollow use within home range	
Common Green Tree Frog (*Litoria caerulea*)	Inhabitant of forests, woodlands, shrublands and open areas. Tends to take refuge in tree hollows, cracks and beneath exfoliating bark and occasionally under rocks (Barker *et al.* 1995).	Any hollow form but particular those that hold water					
Eastern Dwarf Frog (*Litoria fallax*)	Inhabitant of sclerophyll forest and occasionally rainforest and coastal heaths and woodlands where it normally occurs in permanent dams, swamps and ponds (Barker *et al.* 1995).	Mainly foliage but known to use tree hollows					
Graceful Tree Frog (*Litoria gracilenta*)	Inhabitant of mainly moist forest associated along coastal seaboard where it normally selects permanent dams, swamps and ponds for breeding (Barker *et al.* 1995).	Mainly foliage but known to use tree hollows					
Perons Tree Frog (*Litoria peronii*)	Inhabitant of forests, woodlands, shrublands and open areas. Tends to take refuge in tree hollows, cracks and beneath exfoliating bark (Barker *et al.* 1995).	Any hollow form but particular those that hold water	Ground level to >10 m	20-400	50-750		
Tyler's Tree Frog (*Litoria tyleri*)	Inhabitant of sclerophyll forest and occasionally rainforest and coastal heaths and woodlands where it normally occurs a short distance from permanent dams, swamps and ponds (Barker *et al.* 1995).	Any hollow form but particular those that hold water					

APPENDIX C

Hollow Bearing Tree Locations and Tree Hollow Field data

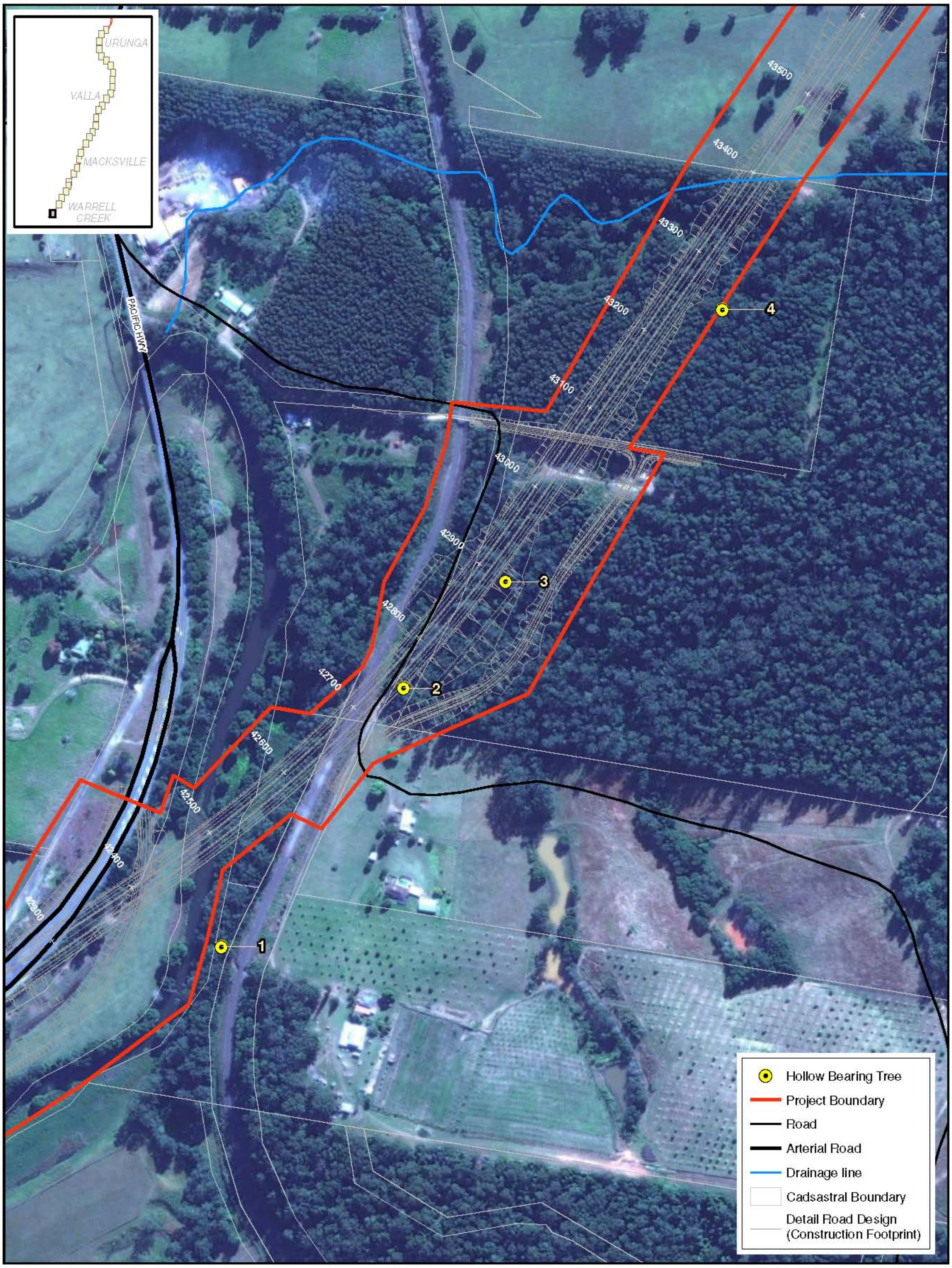

Figure 2 : HOLLOW BEARING TREES

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009

Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2008

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0 50 100 150 200 250
Meters

A4 Scale 1:5,000

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File: Figure_2-30_RTA_Grafton_HBT_Survey_121102
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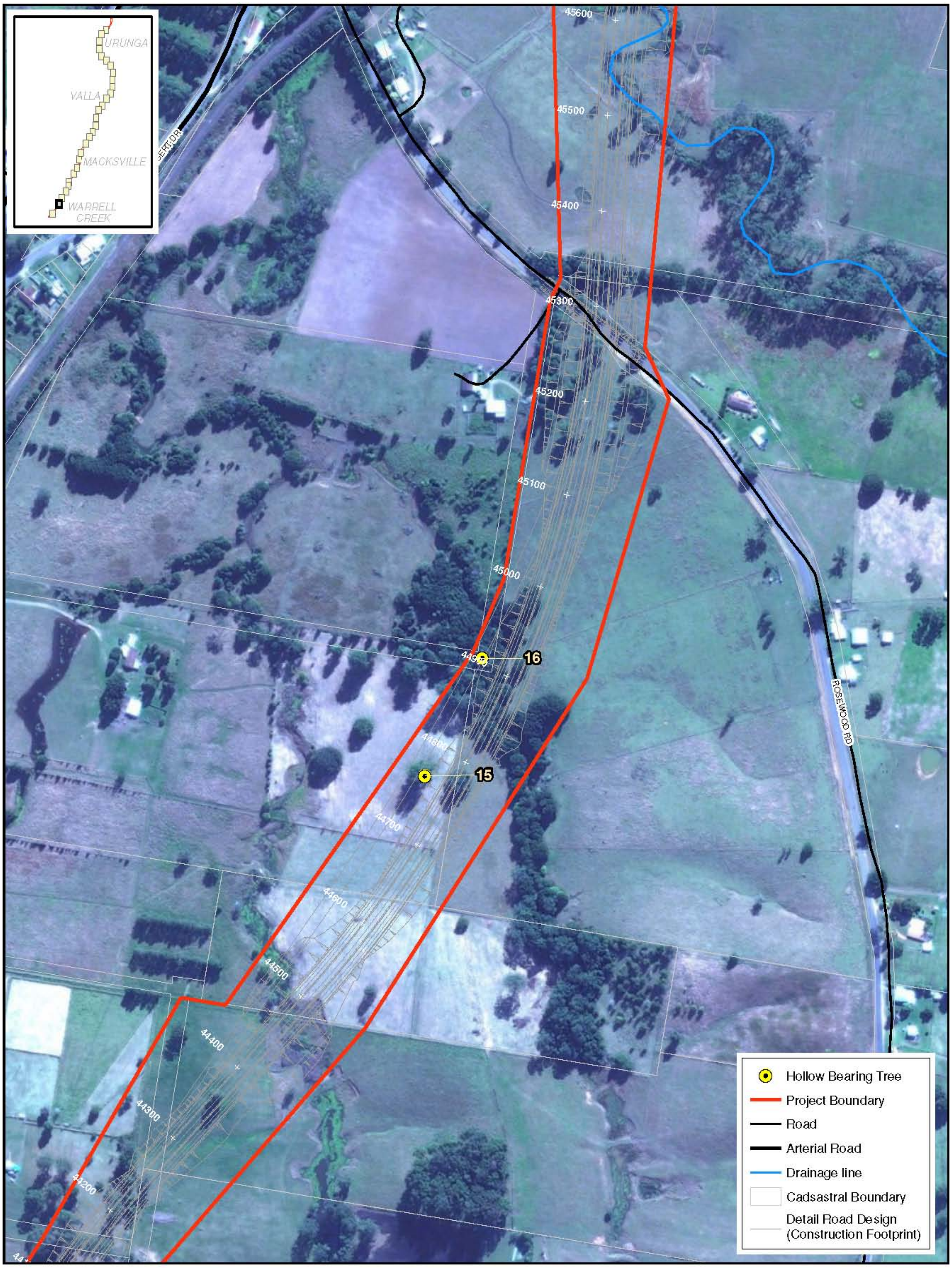

Figure 3 : HOLLOW BEARING TREES

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009

Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2008

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0 50 100 150 200 250
Meters
A4 Scale 1:5,000

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File: Figure_2-30_RTA_Grafton_HBT_Survey_121102
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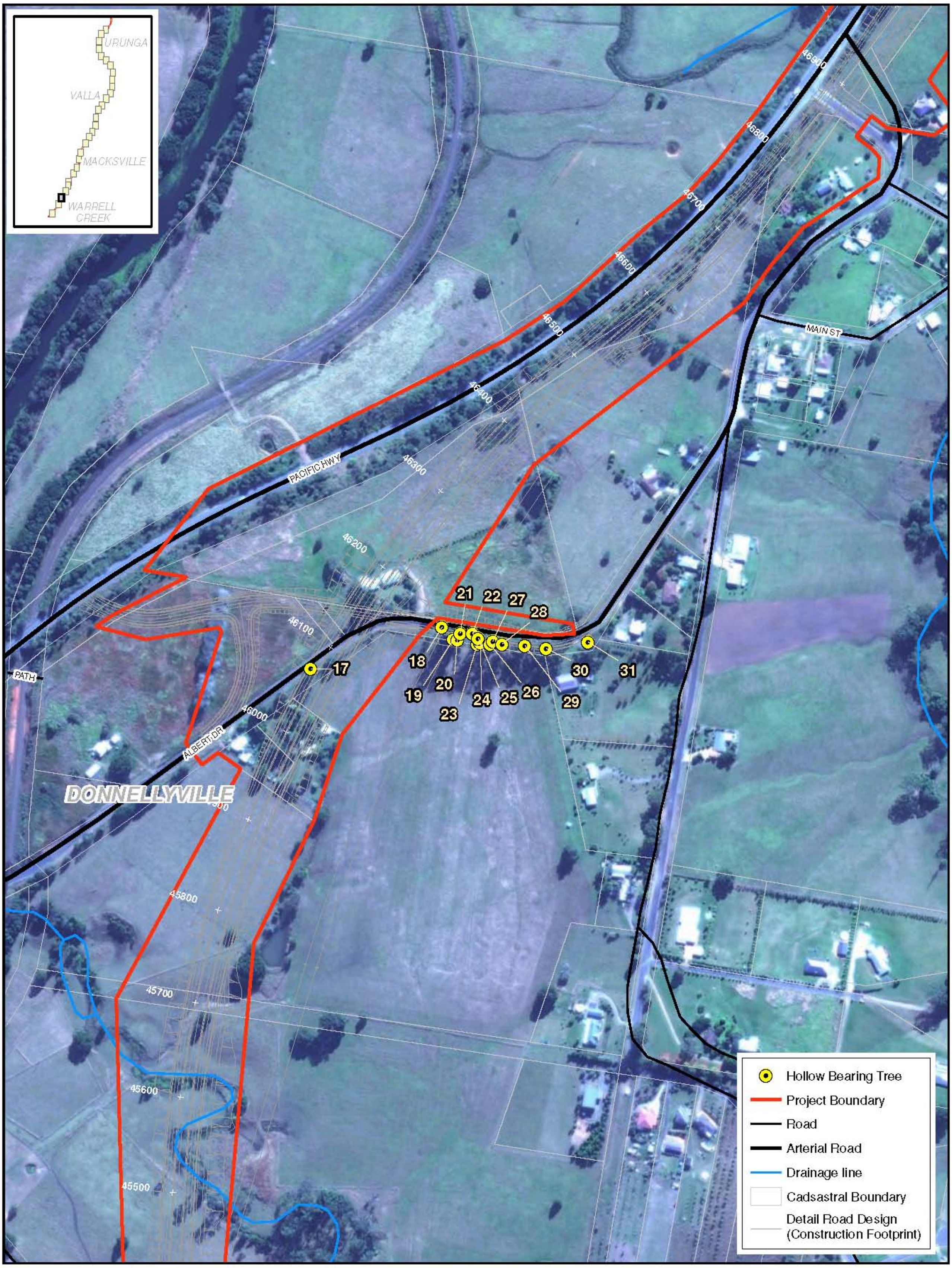

Figure 4 : HOLLOW BEARING TREES

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009
Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2008

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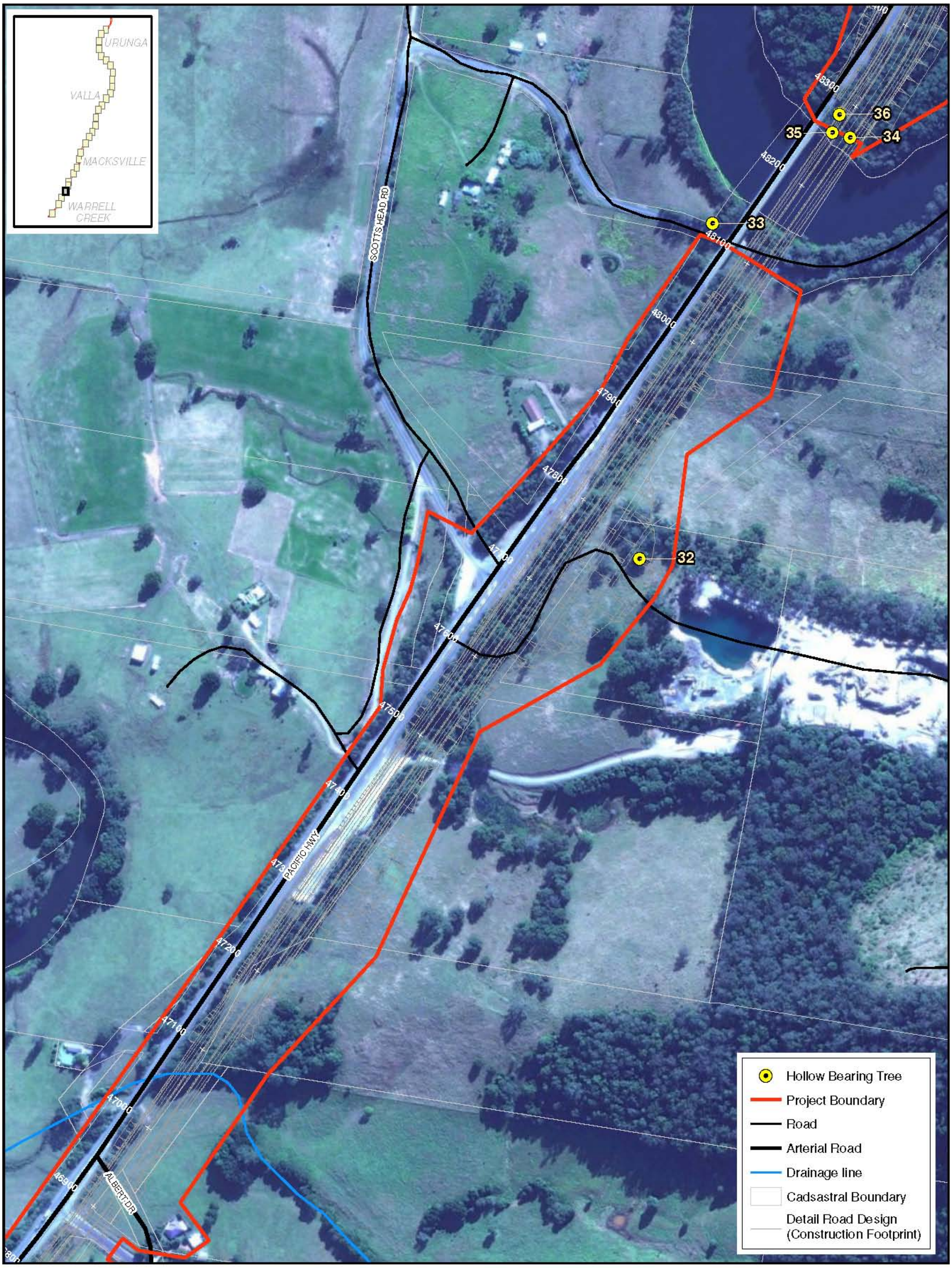

Figure 5 : HOLLOW BEARING TREES

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009

Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2008

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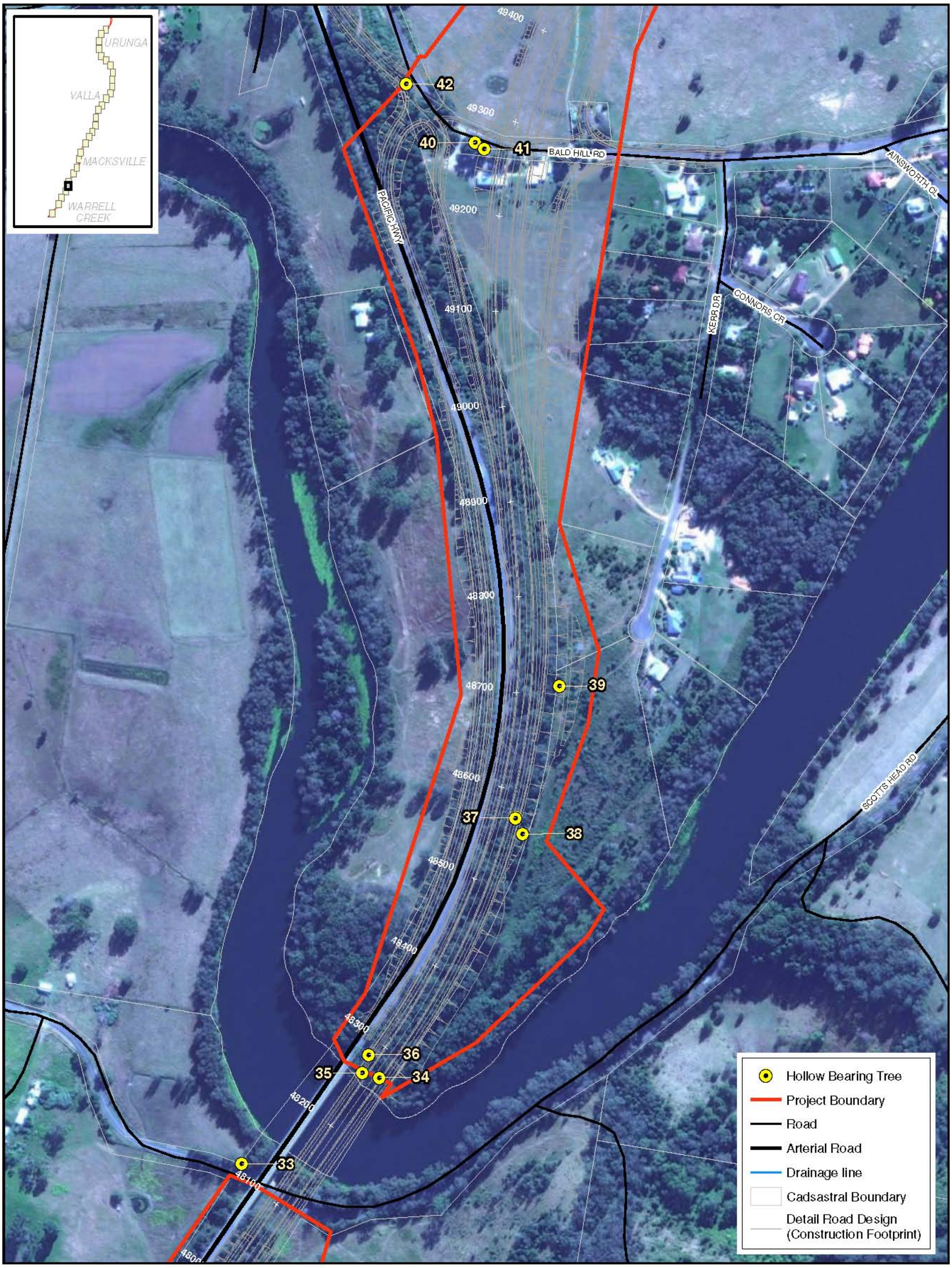

Figure 6 : HOLLOW BEARING TREES

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009
Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2008

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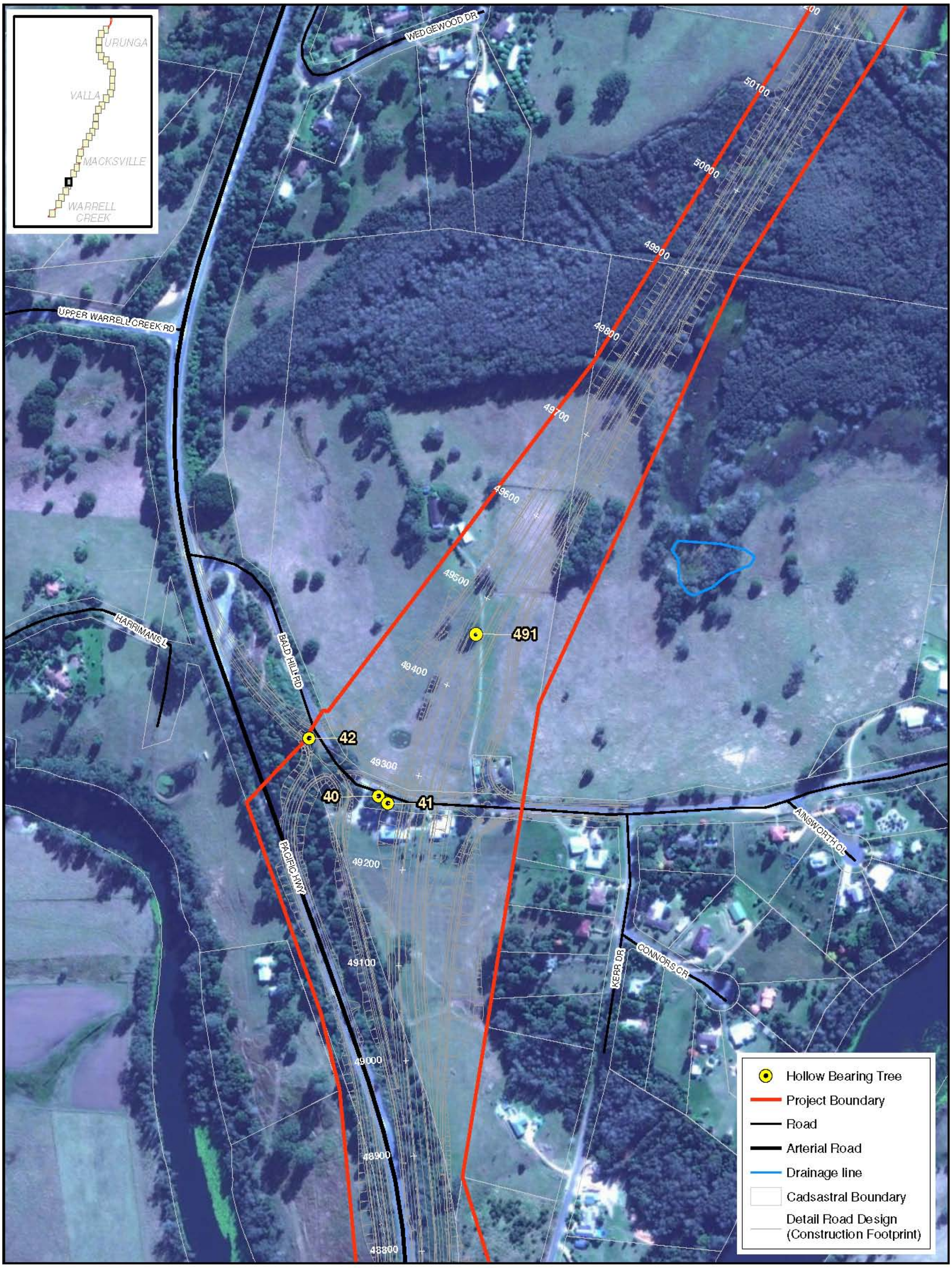

Figure 7 : HOLLOW BEARING TREES

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009

Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2008

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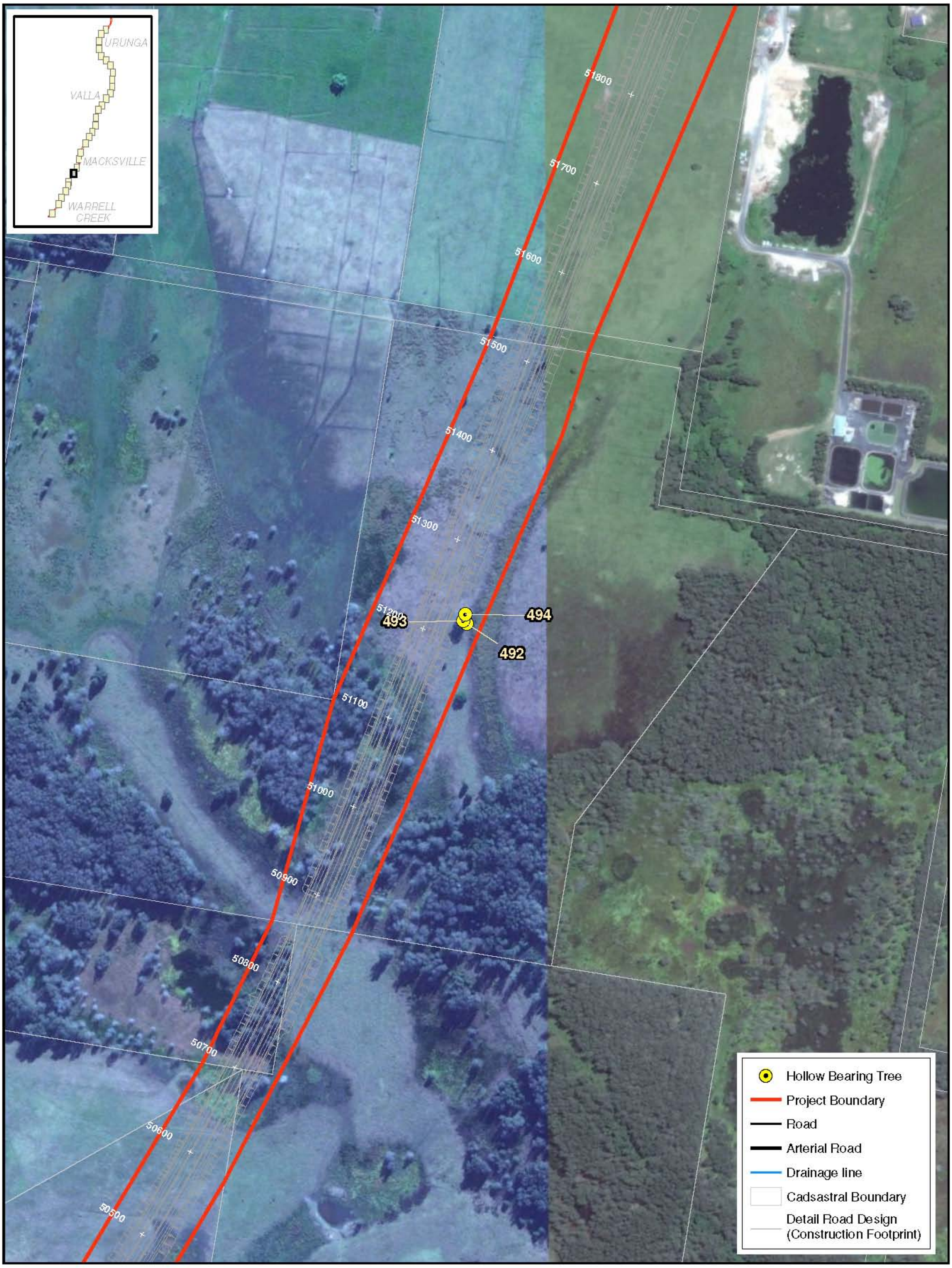

Figure 8 : **HOLLOW BEARING TREES**

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009

Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2008

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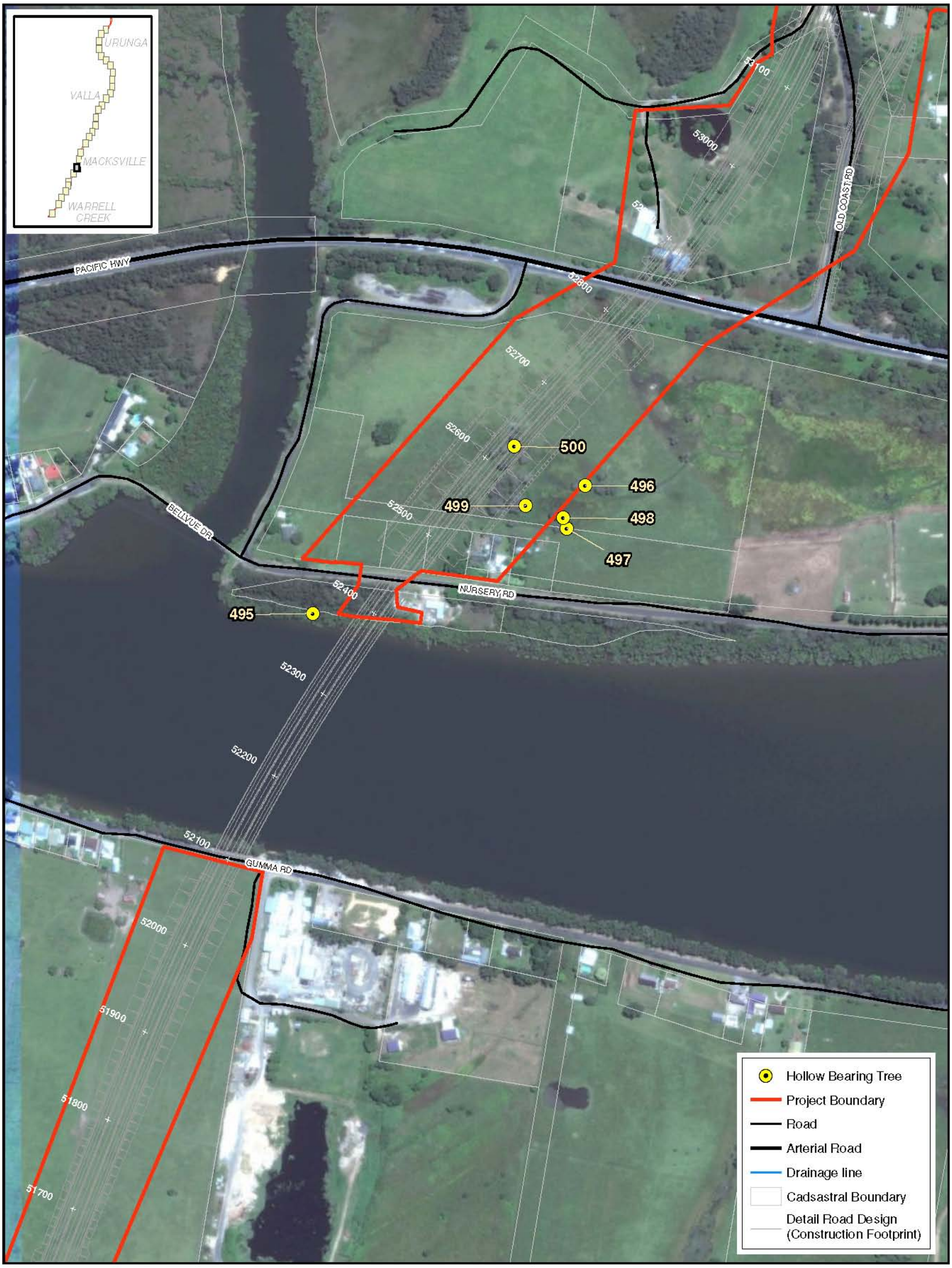

Figure 9 : HOLLOW BEARING TREES

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009
Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
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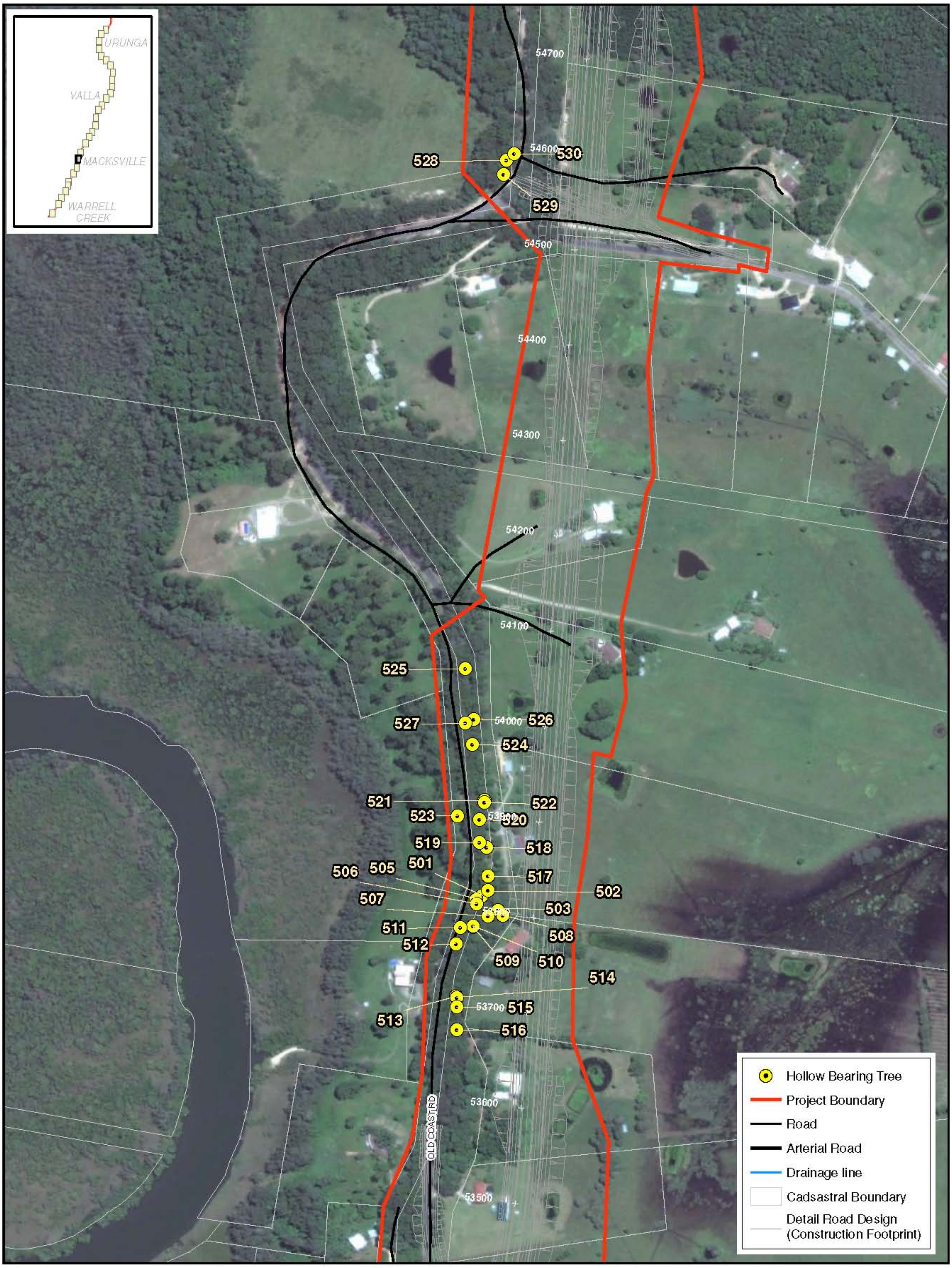

Figure 10 : HOLLOW BEARING TREES

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009

Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
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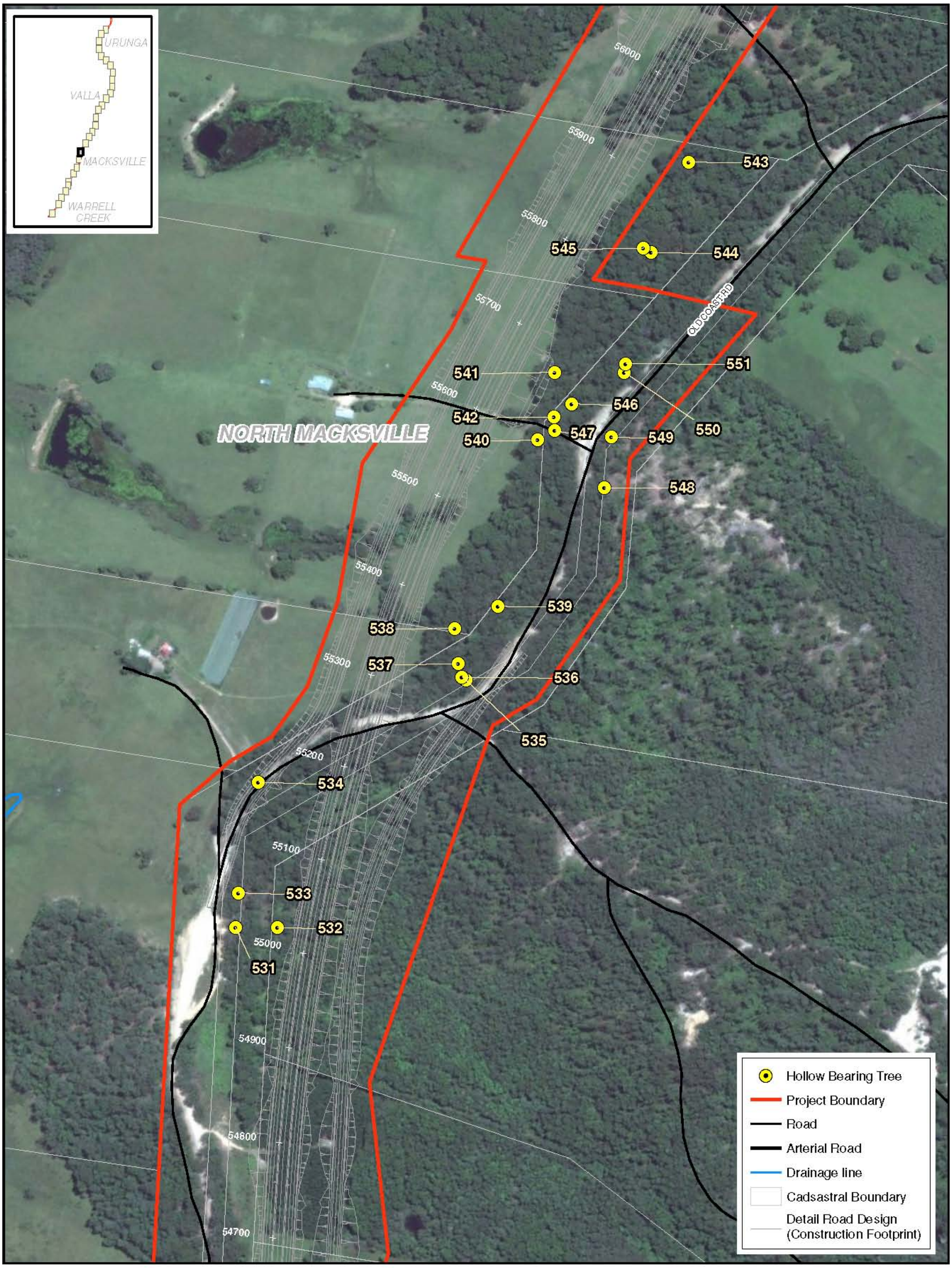

Figure 11 : HOLLOW BEARING TREES

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009

Highway Design (footprint): RTA 2011
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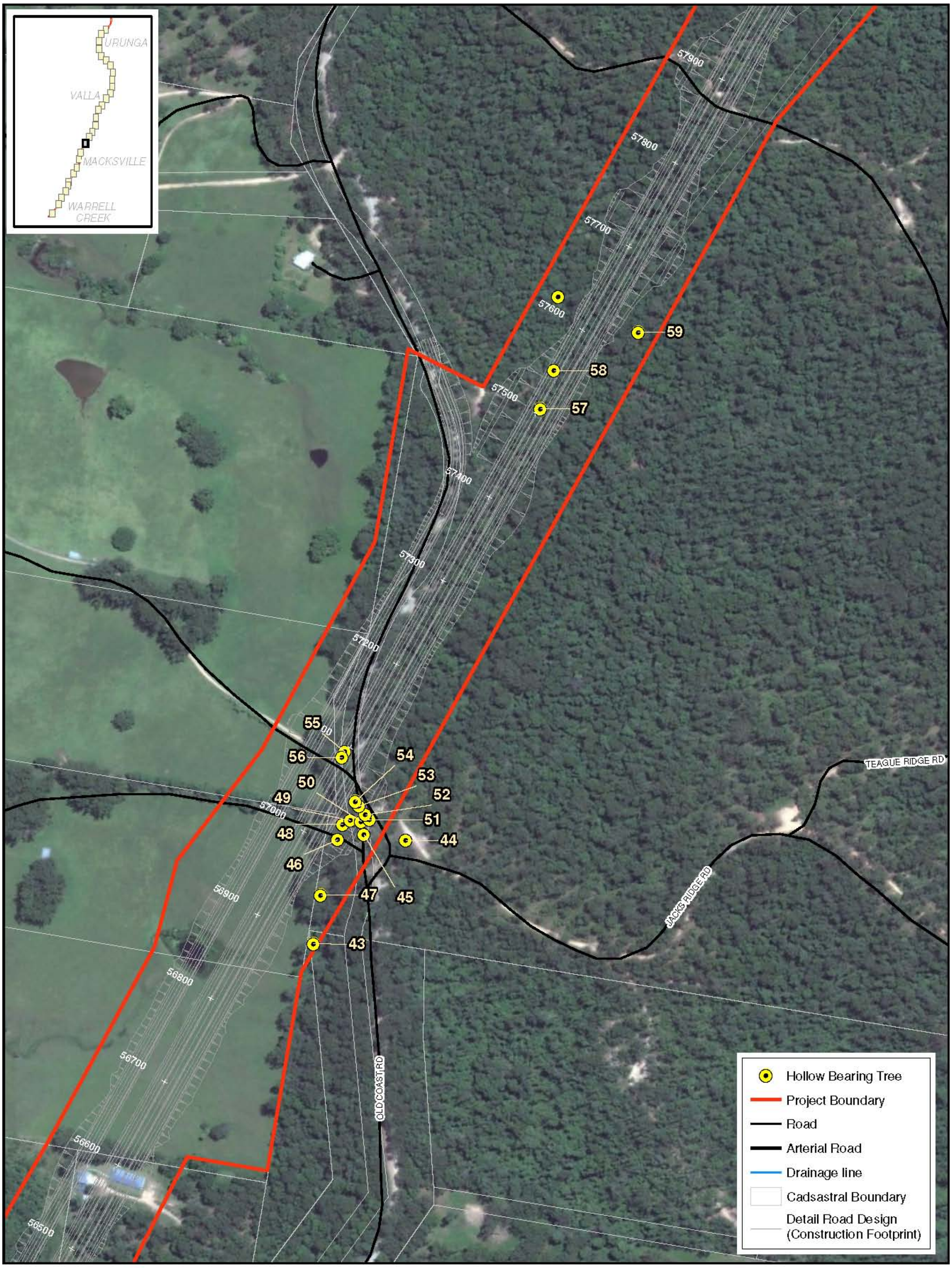

Figure 12 : HOLLOW BEARING TREES

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009
Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
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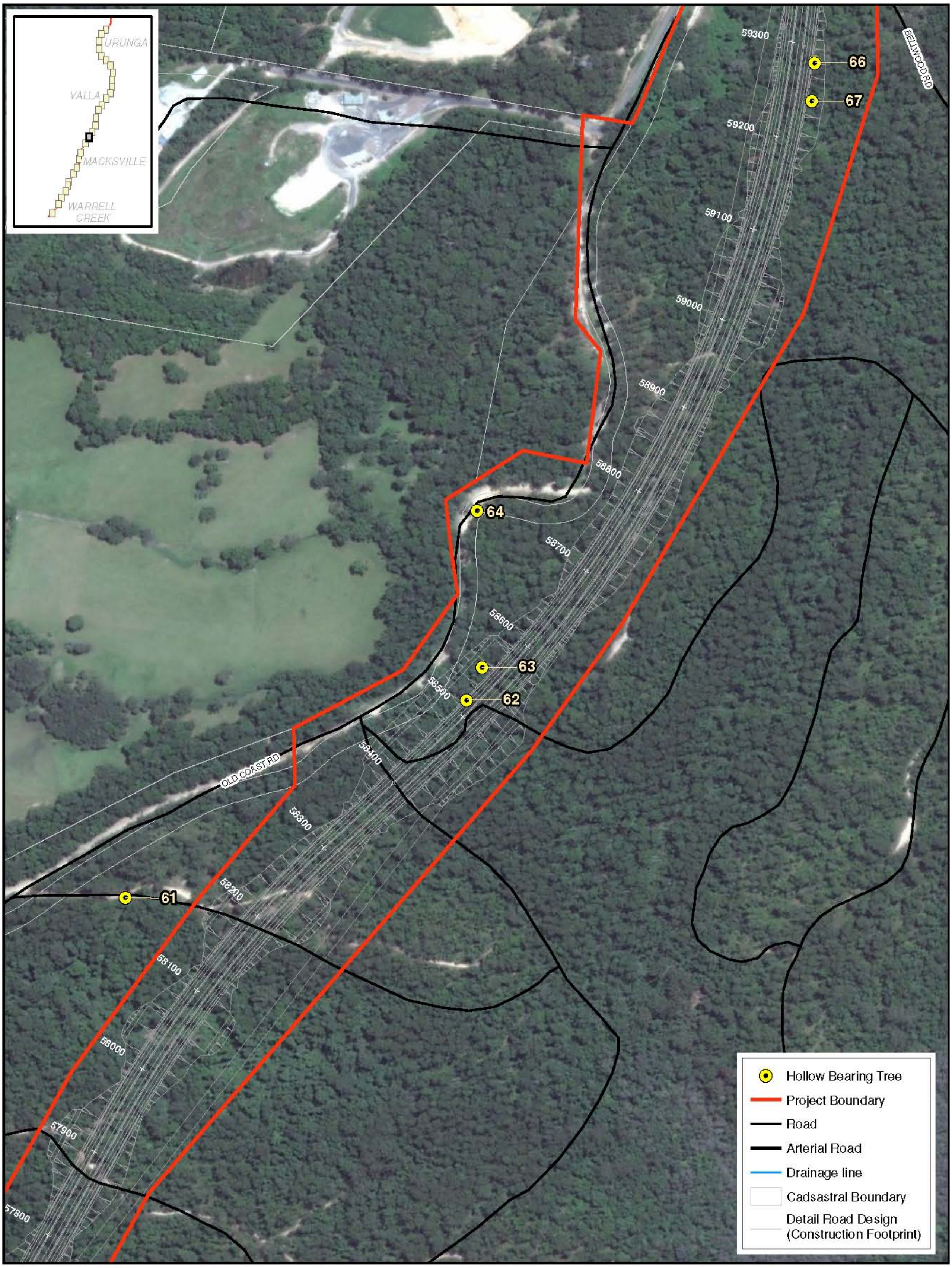

Figure 13 : HOLLOW BEARING TREES

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009

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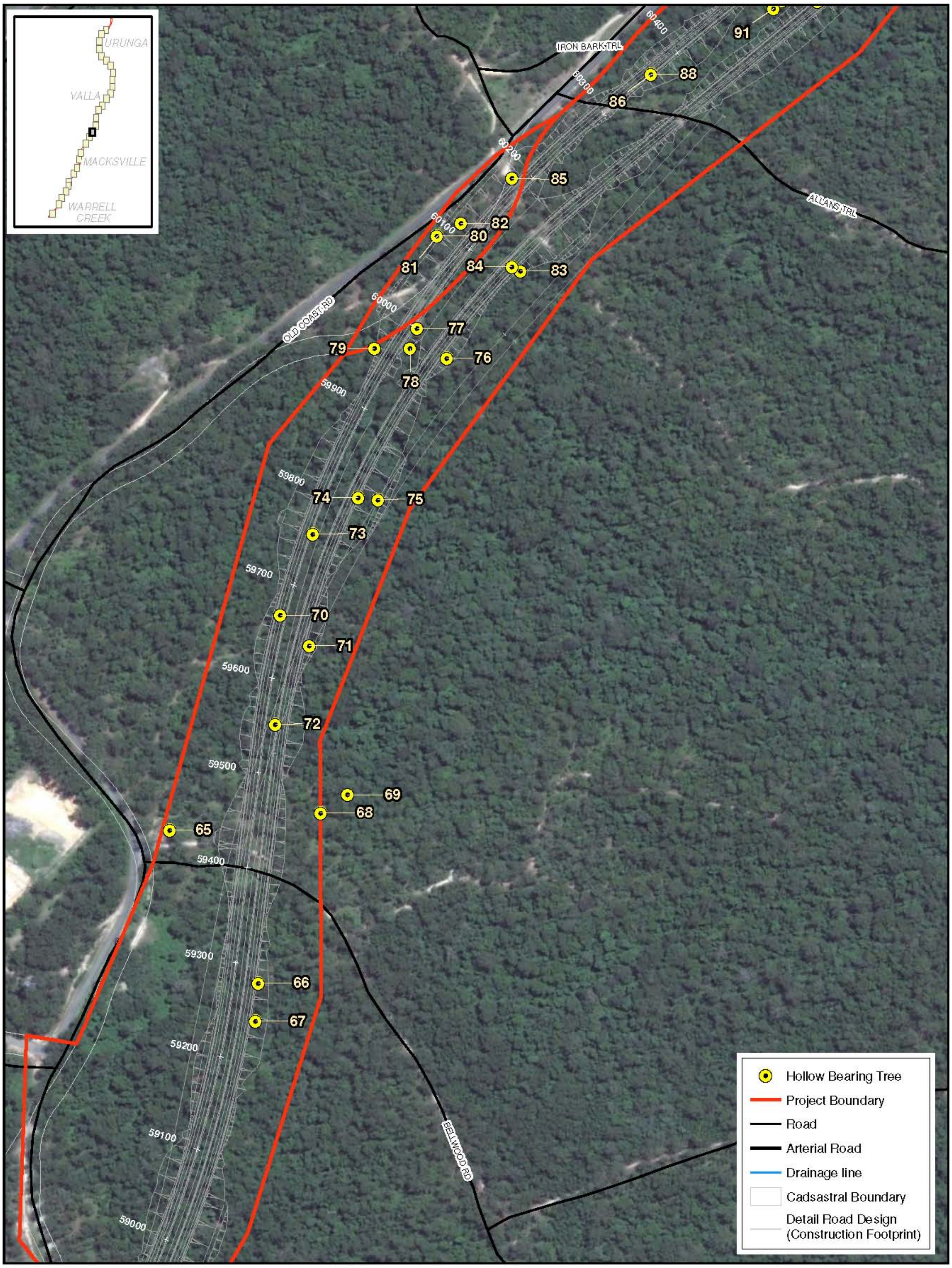

Figure 14 : **HOLLOW BEARING TREES**

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009

Highway Design (footprint): RTA 2011
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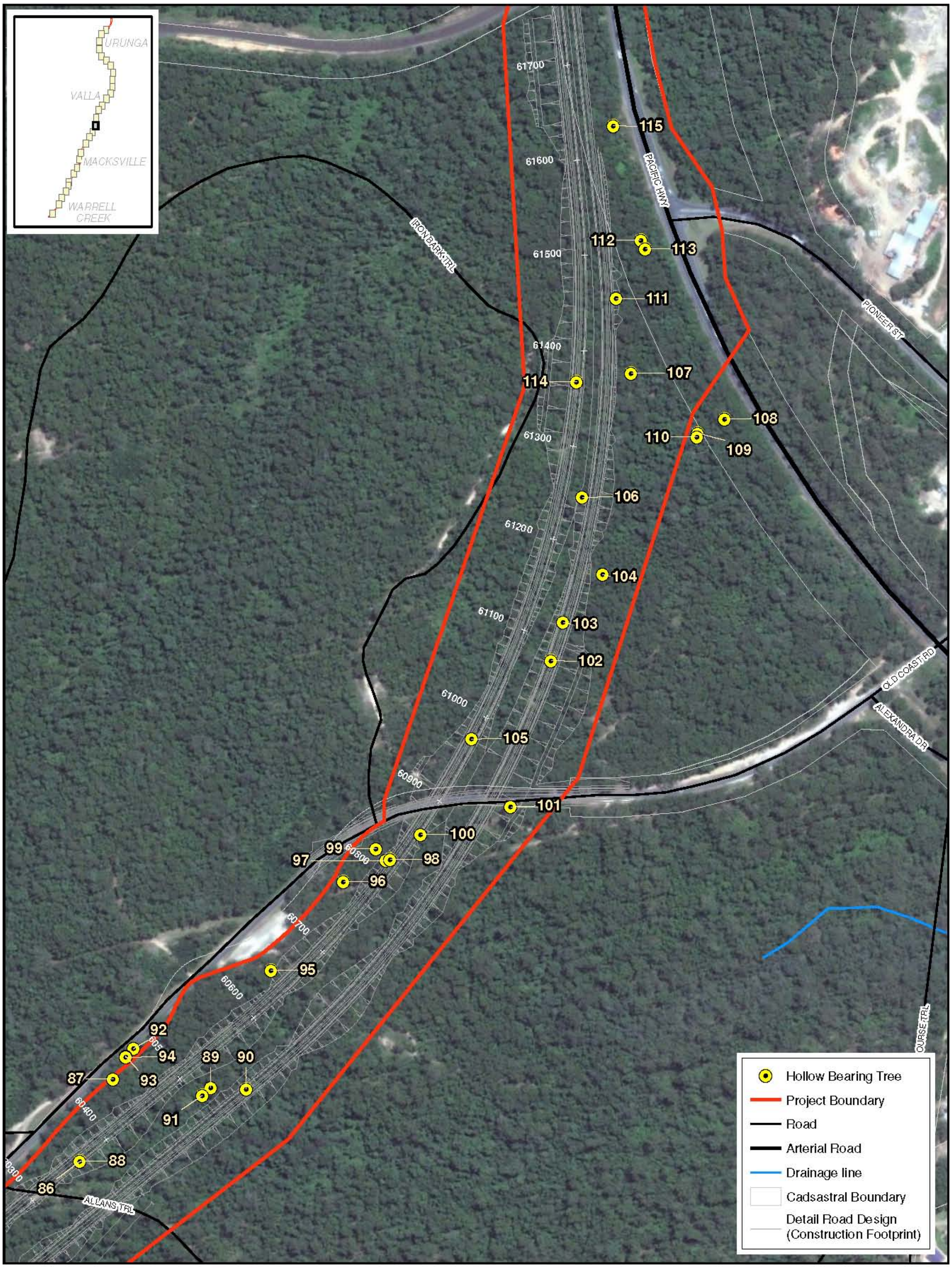

Figure 15 : HOLLOW BEARING TREES

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009

Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
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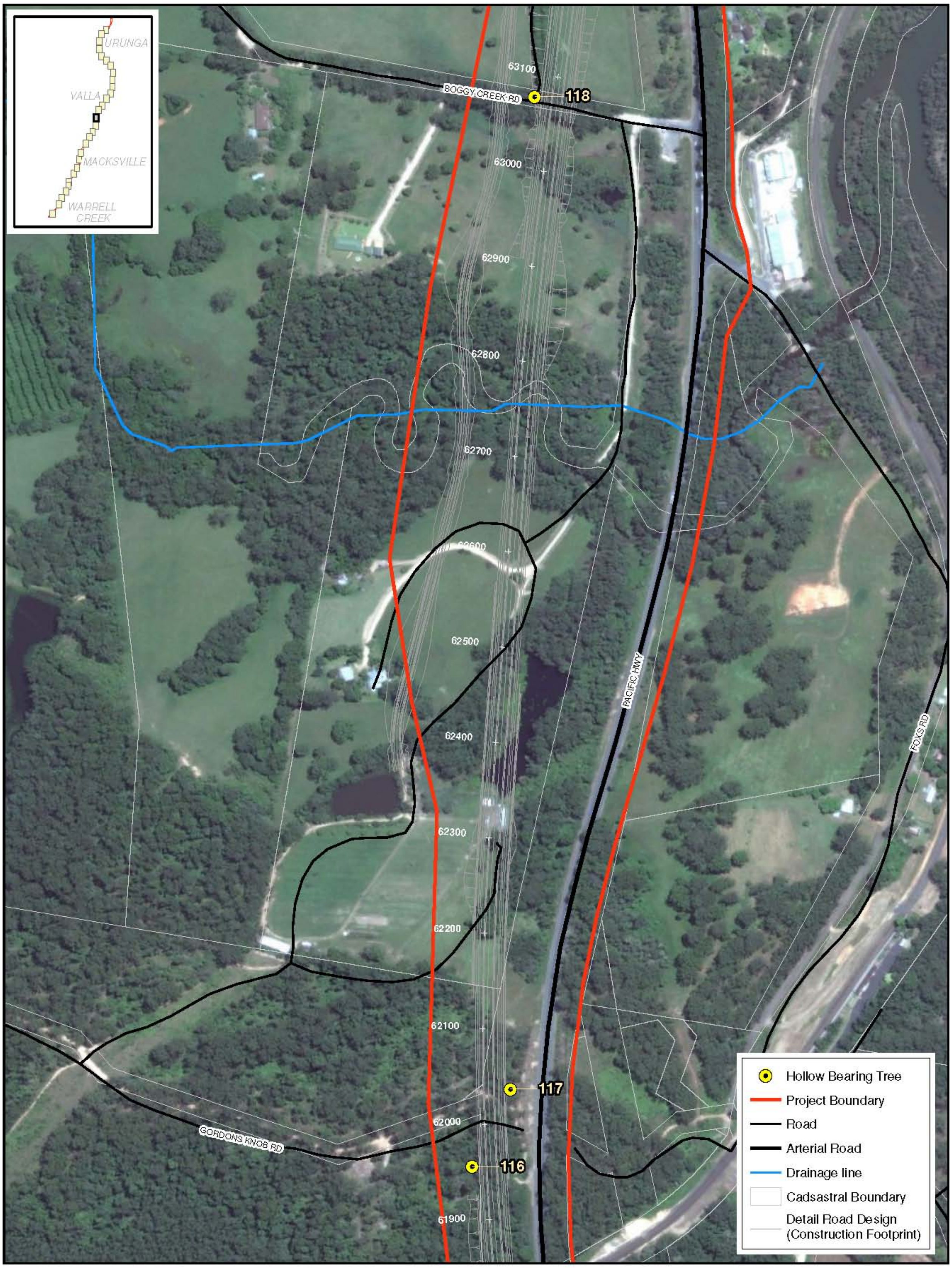

Figure 16 : **HOLLOW BEARING TREES**

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009

Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
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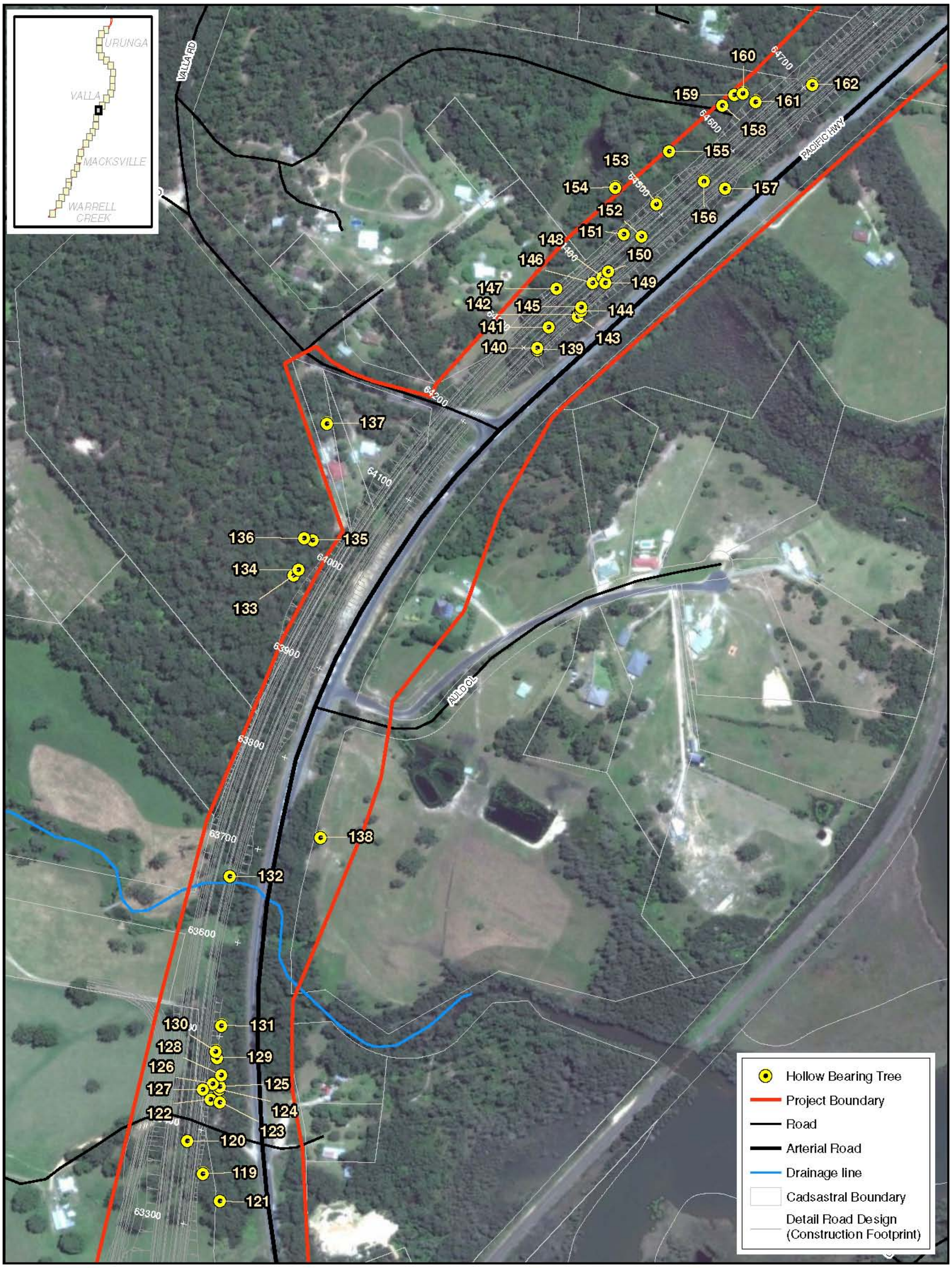

Figure 17 : HOLLOW BEARING TREES

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009

Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
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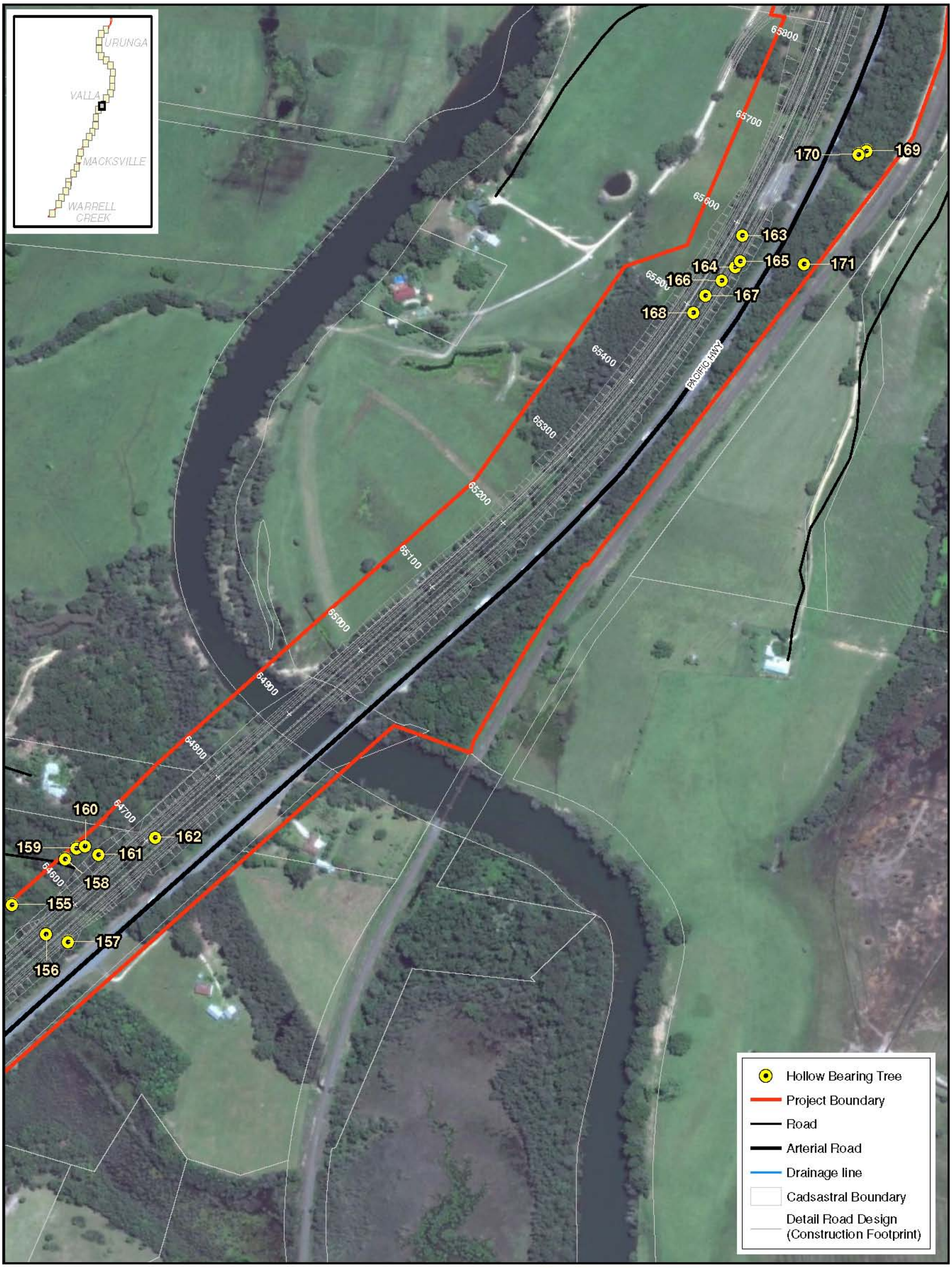

Figure 18 : **HOLLOW BEARING TREES**

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009

Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
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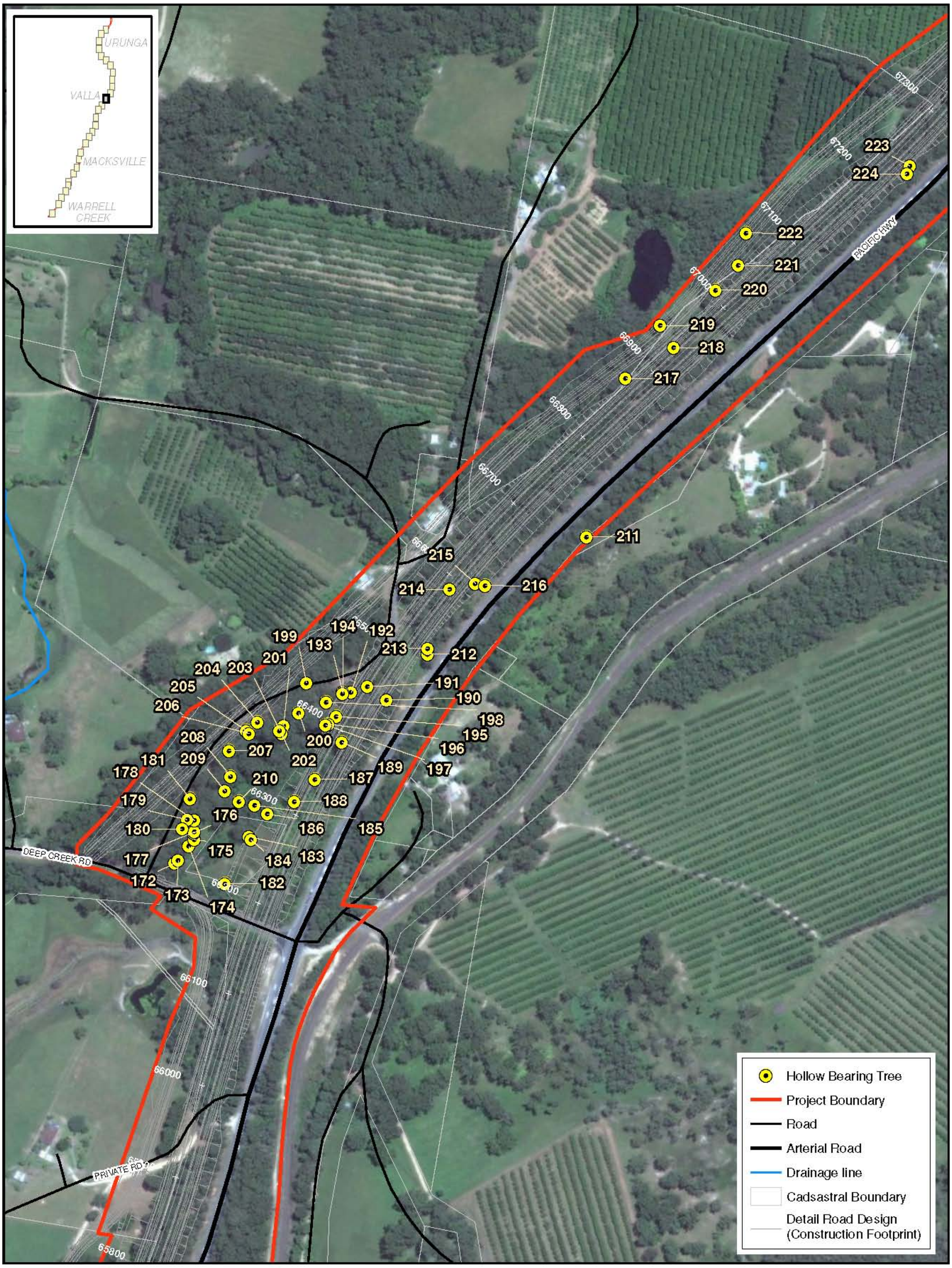

Figure 19 : **HOLLOW BEARING TREES**

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009

Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
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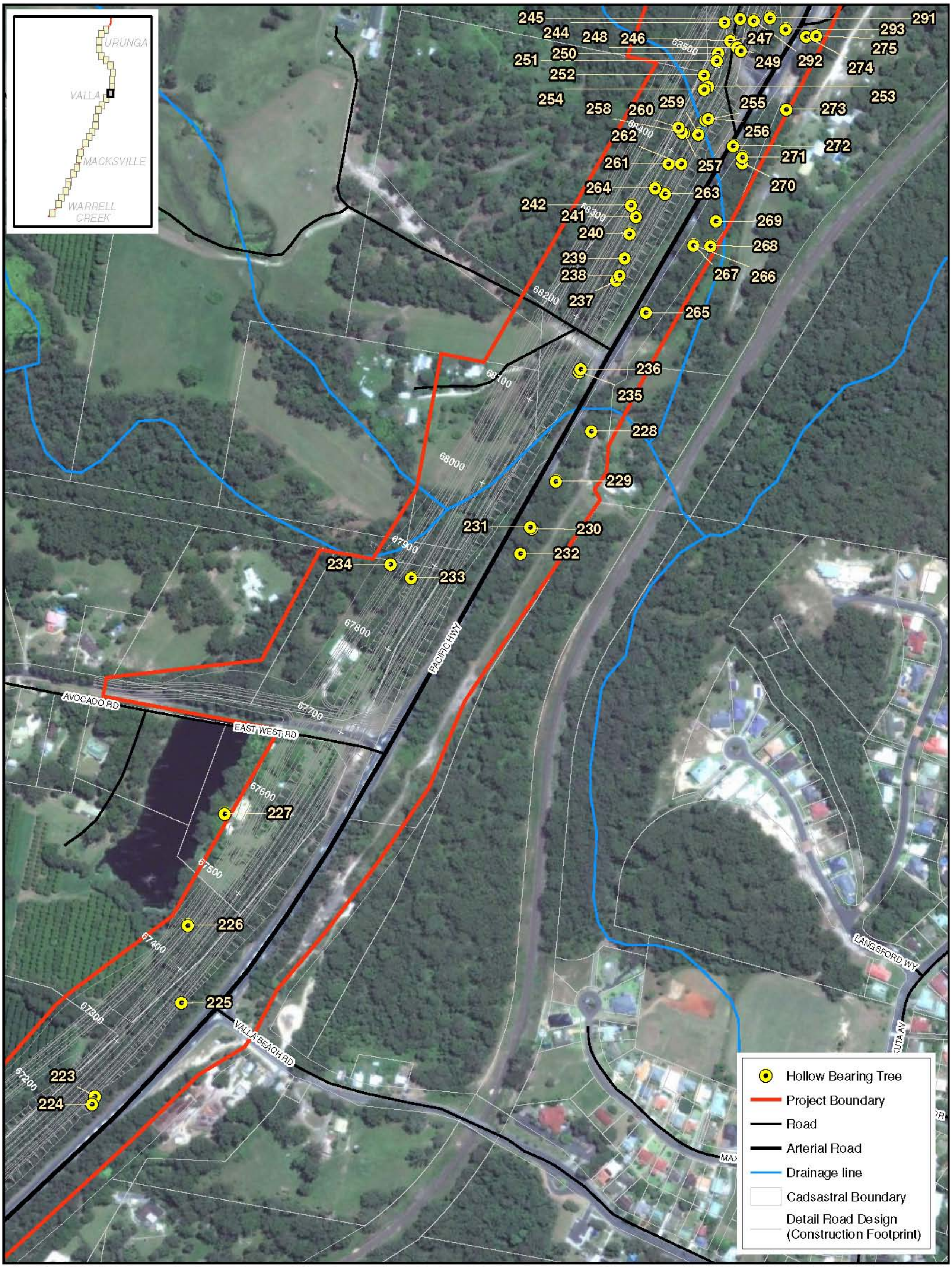

Figure 20 : HOLLOW BEARING TREES

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009

Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
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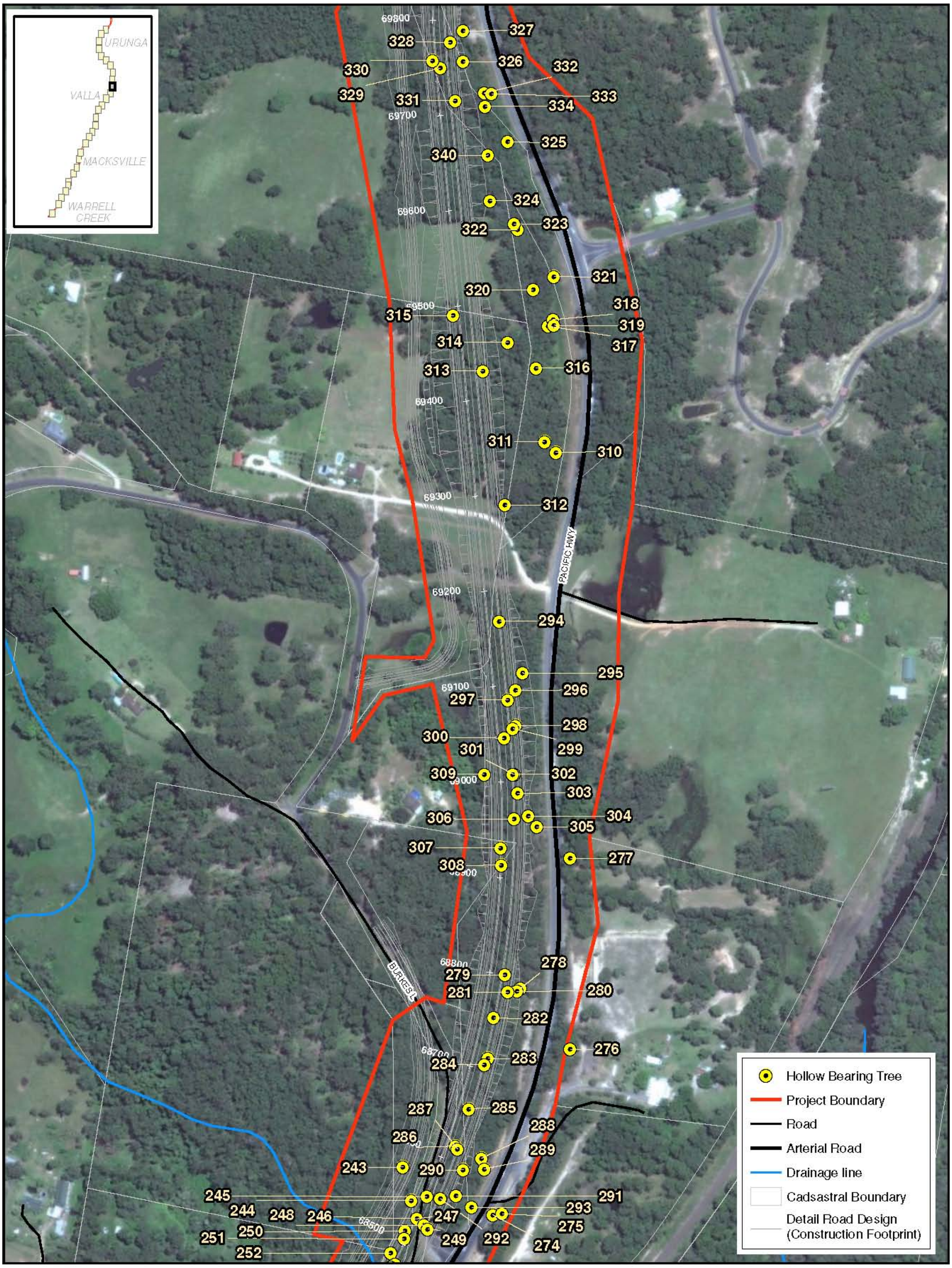

Figure 21 : HOLLOW BEARING TREES

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009

Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2008

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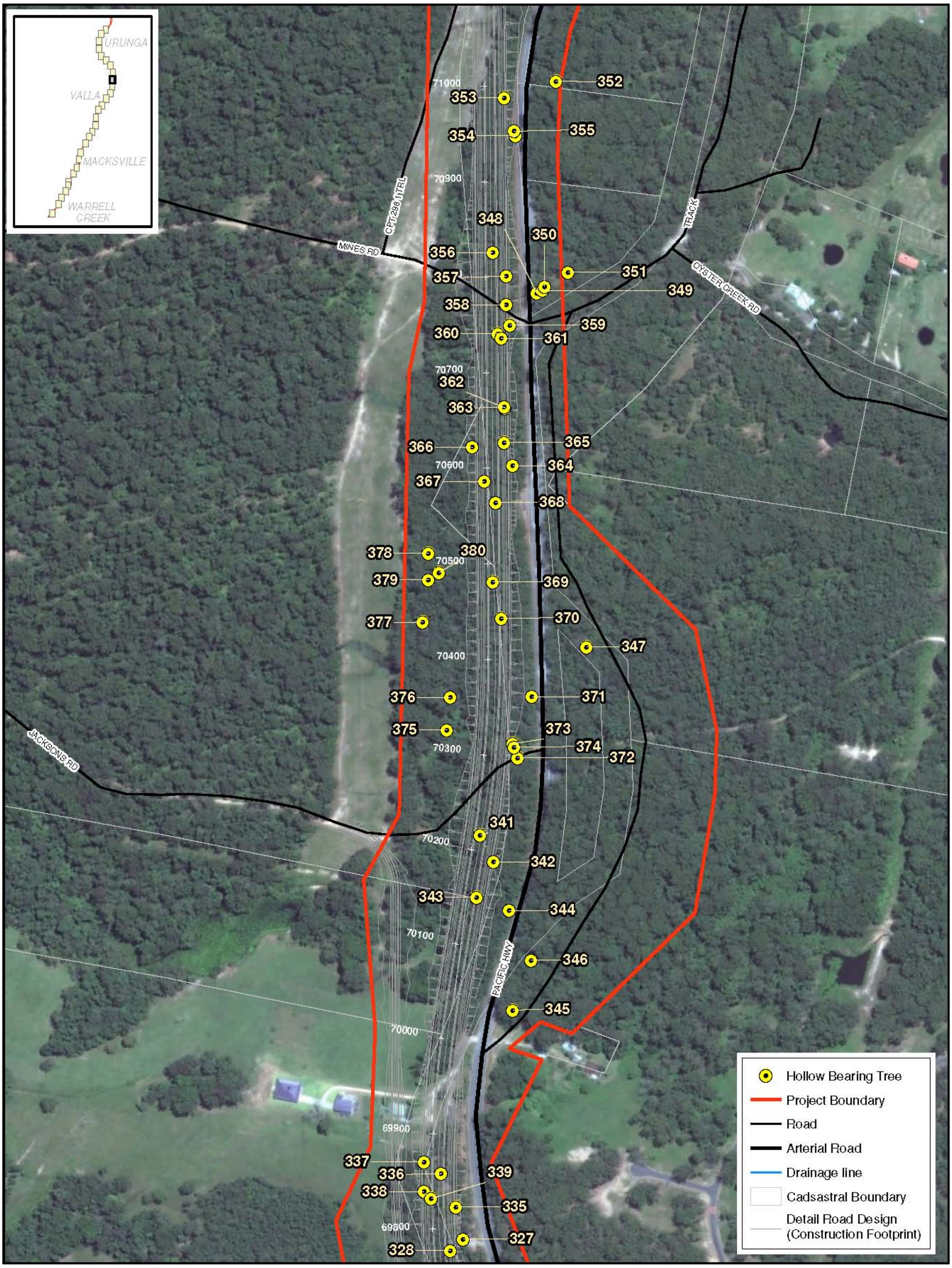

Figure 22 : **HOLLOW BEARING TREES**

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009

Highway Design (footprint): RTA 2011
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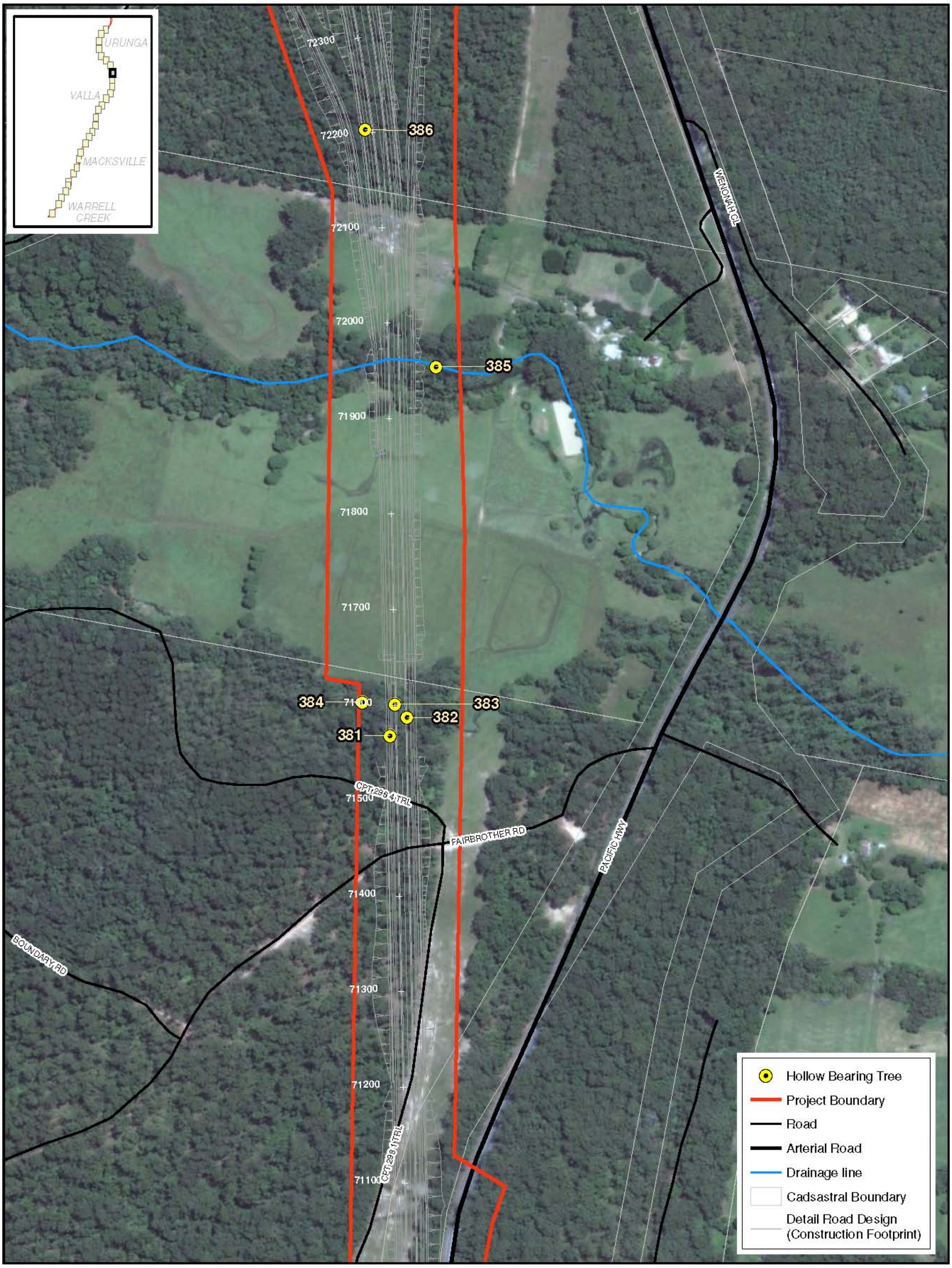

Figure 23 : HOLLOW BEARING TREES

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009
Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2008

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0 50 100 150 200 250
Meters
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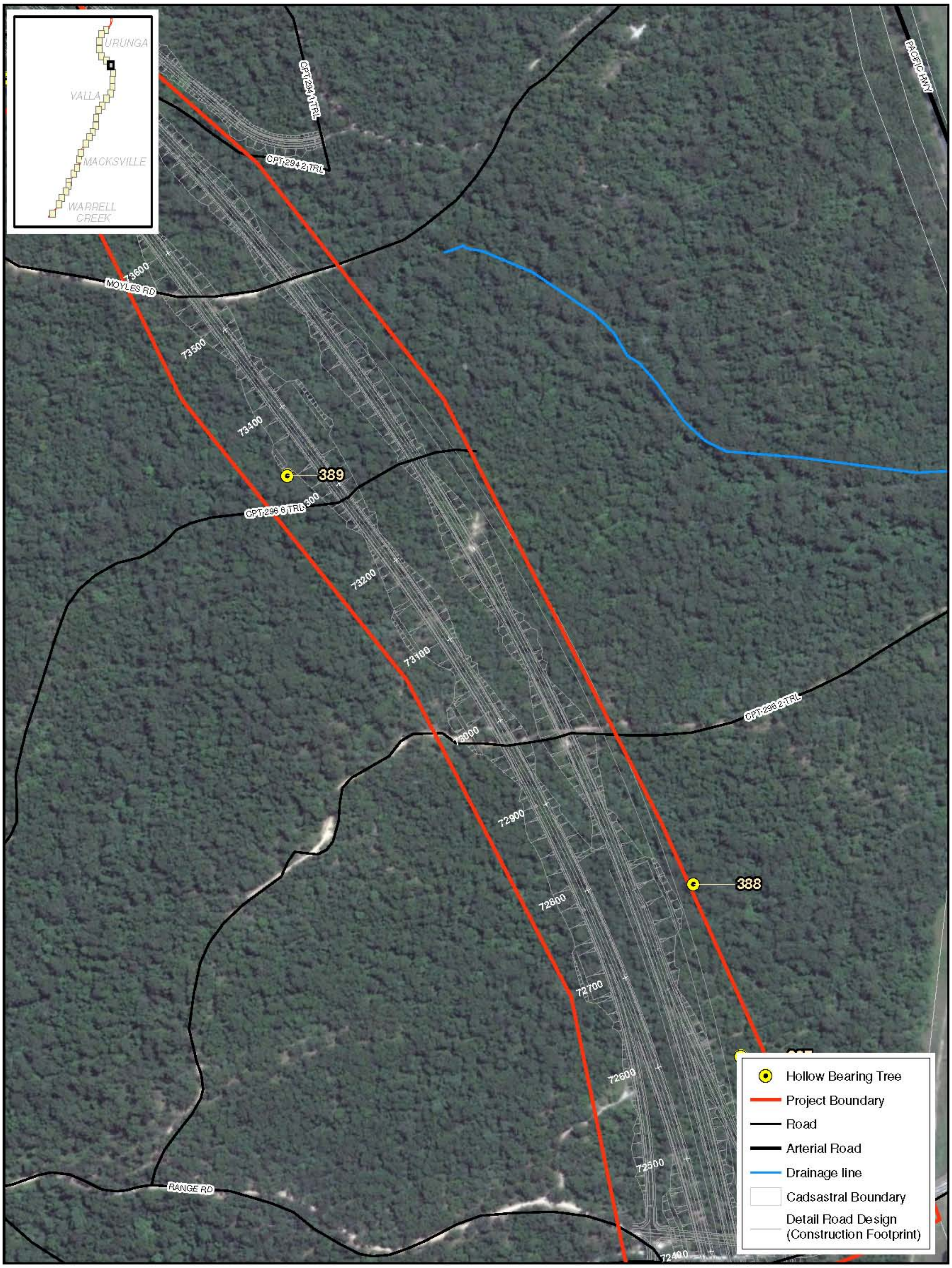

Figure 24 : HOLLOW BEARING TREES

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009

Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2008

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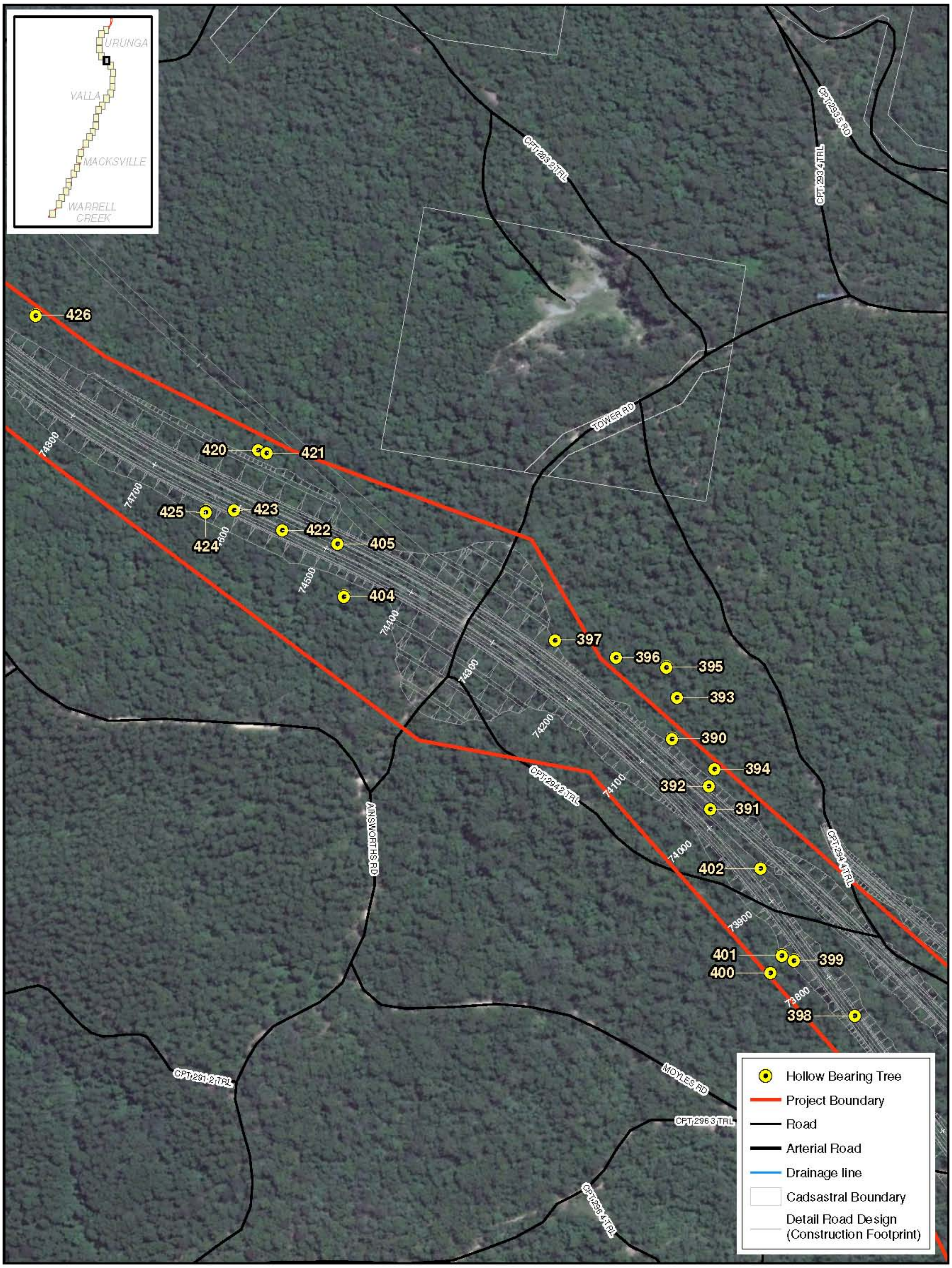

Figure 25 : **HOLLOW BEARING TREES**

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009

Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2008

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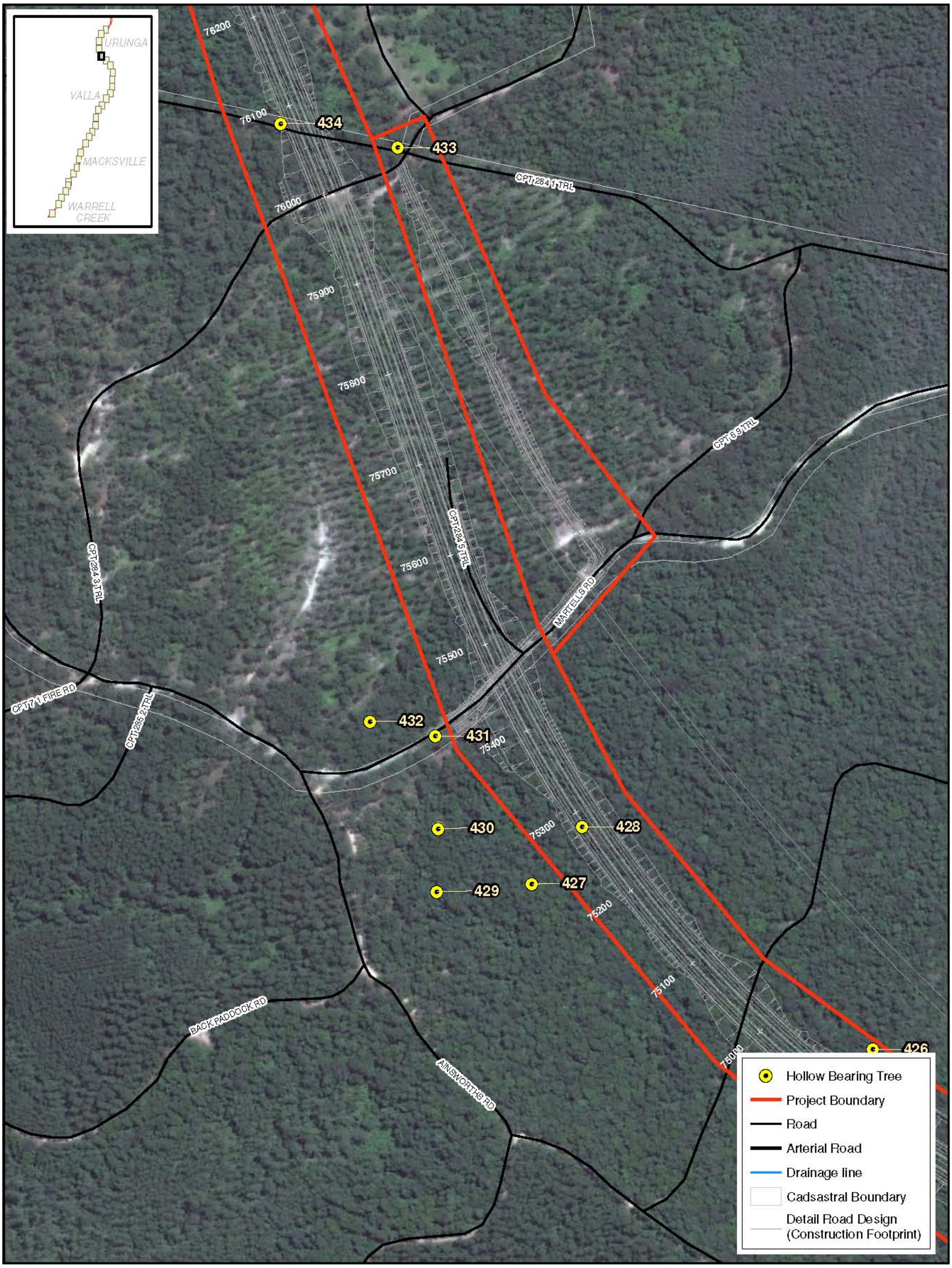

Figure 26 : HOLLOW BEARING TREES

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009

Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2008

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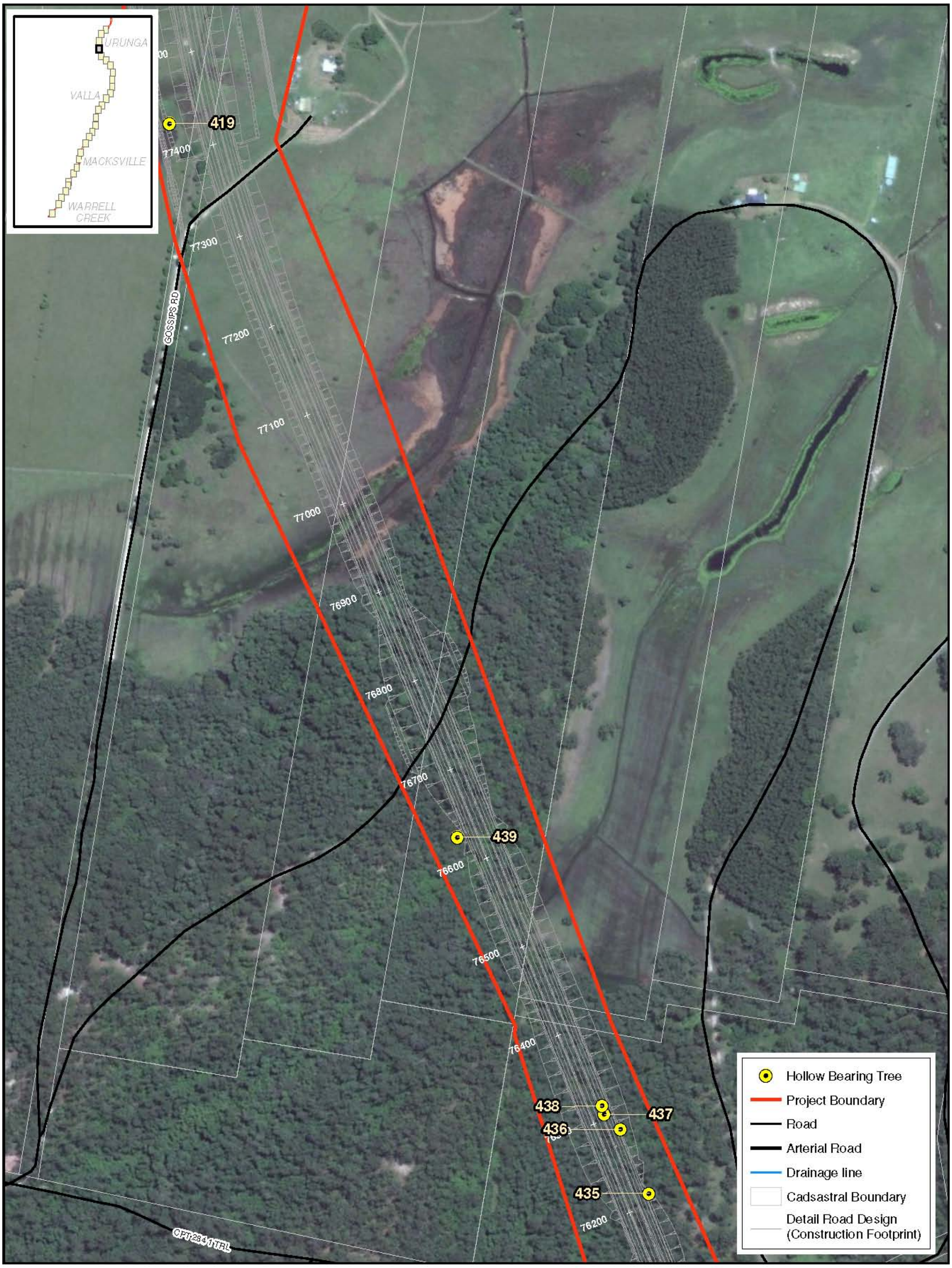

Figure 27 : HOLLOW BEARING TREES

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009

Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2008

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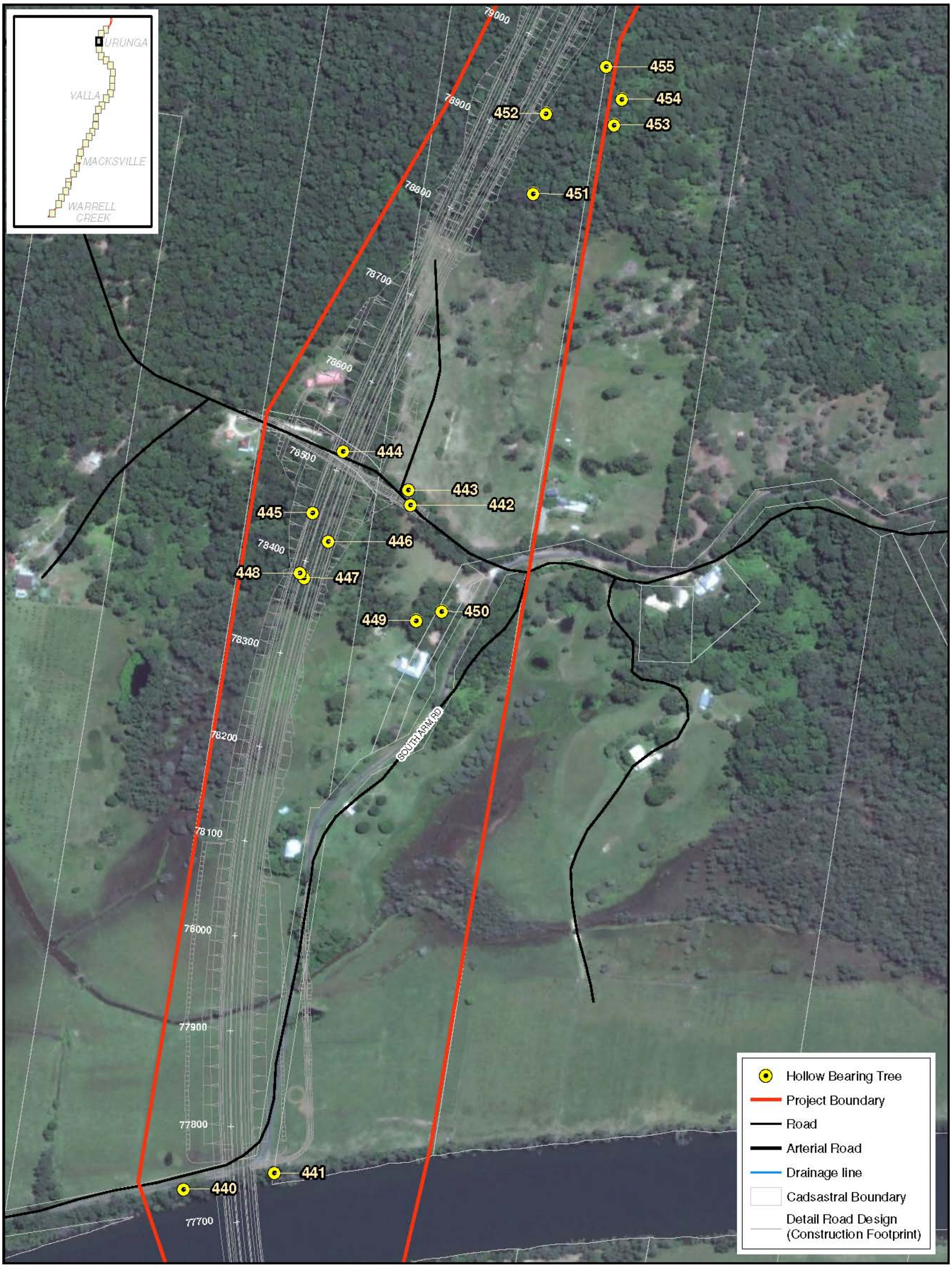

Figure 28 : **HOLLOW BEARING TREES**

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009

Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2008

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0 50 100 150 200 250
Meters
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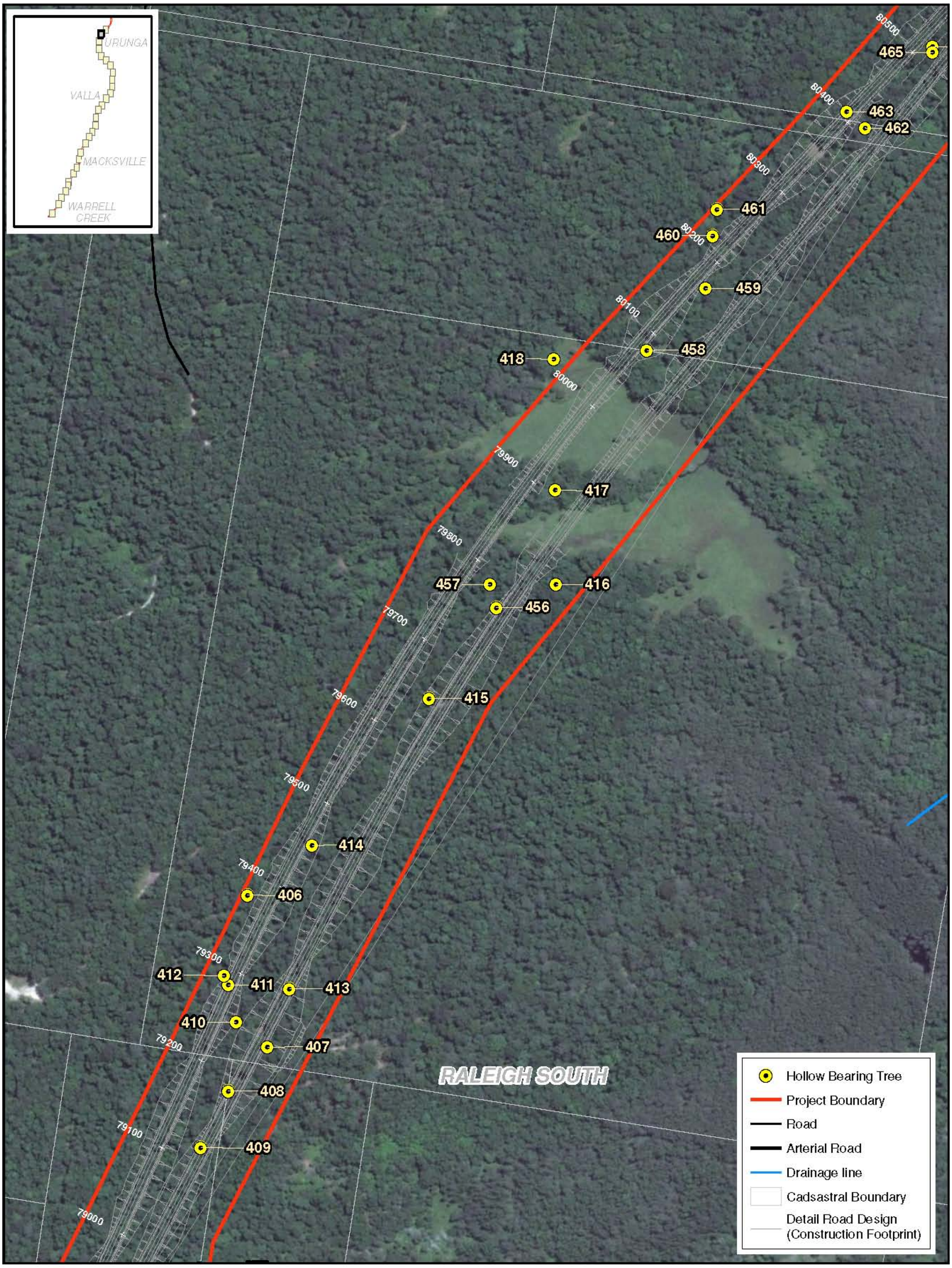

Figure 29 : **HOLLOW BEARING TREES**

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009

Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2008

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0 50 100 150 200 250
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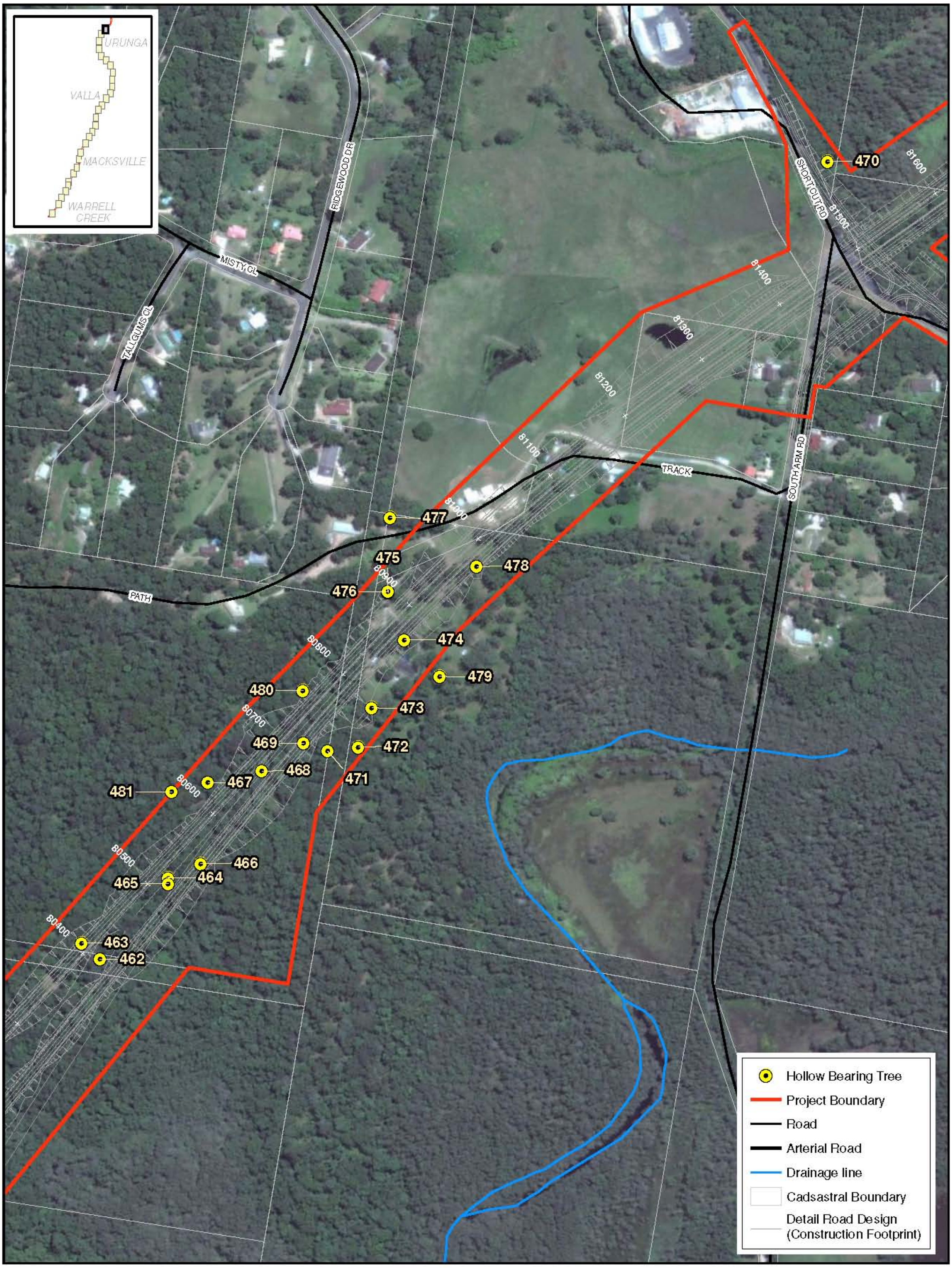

Figure 30 : **HOLLOW BEARING TREES**

Source:
Cadastre: Roads and Traffic Authority 2007
HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009

Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2008

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0 50 100 150 200 250
Meters
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Table C. Summary data from the hollow bearing tree survey conducted on those accessible properties for the Warrell Creek to Urunga Pacific Highway Upgrade between December-March 2012.

HBT = Hollow bearing tree and reference number, ~ = approximate or estimate, No. Func. Holl. = Number of function hollows SF = Scansorial fauna, MB = Microbats, Small gliders, LG = Larger Gliders, Po = Possums, Pa = Parrots, Lorikeets, Treecreeper, SO = Small owls, LFO = Large forest owls, EB = European Bees, LM = Lace Monitor, AH = Arboreal herpetofauna.

HBT Ref No.	Species	Easting	Northing	DBH (cm)	~Tree Height (m)	No. Func. Holl.	Trunk Butt	Trunk Fissures	Trunk Small	Trunk Medium	Trunk Large	Limb Small	Limb Medium	Limb Large	SF	MB	SG	LG	Po	Pa	Co	SO	LFO	EB	LM	AH	Comments
		WGS84	WGS84						<5cm	5-15 cm	>15 cm	<5cm	5-15 cm	>15 cm													
1	Stag	489292	6594149	100	21	4		1				2	1		1	1	1									1	Several ringtail possum dreys in the area as associated with upper Warrell Creek
2	Stag	489482	6594420	130	9	2		1			1				1	1			1						1	1	
3	Stag	489589	6594531	230	30	20		1	2	2	4	4	4	3	1	1	1	1	1	1	1	1		1	1	1	European bees using small trunk hollow at 11 m
4	White Mahogany	489816	6594816	130	21	4						3	1		1	1	1									1	
15	White Mahogany	490637	6596069	180	22	4				1	1	2				1			1	1							Landowner states tree has been aged at 250 years. Brushtail possum probably using the large hollow
16	Sydney Blue Gum	490697	6596192	120	23	3						2	1		1	1			1							1	
17	Tallowwood	490973	6597308	110	22	5			1			4				1										1	Small birds such as Pardolotes probably use this tree. Start of Albert Road trees
18	Stag	491110	6597352	125	22	9						6	3			1	1			1				1			Scaly-breasted Lorikeets observed using medium hollow. European bees using base of stag to the north
19	Coastal Blackbutt	491122	6597339	120	23	4						4				1	1									1	
20	Coastal Blackbutt	491126	6597338	130	24	3						3				1	1									1	
21	Coastal Blackbutt	491129	6597345	120	17	7						4	3			1	1			1						1	Scaly-breasted Lorikeets observed using medium hollow.
22	Stag	491142	6597345	65	22	6		1				4	1			1	1			1						1	
23	Coastal Blackbutt	491147	6597334	170	24	7				1		4	2			1	1			1						1	twin trunk trees
24	Coastal Blackbutt	491150	6597335	75	20	2						2				1	1			1							
25	Coastal Blackbutt	491148	6597340	115	22	12						4	6	2		1	1		1	1							Small gliders doubtful in this Albert road area. Scaly-breasted Lorikeets using medium hollow
26	White Mahogany	491160	6597334	70	19	5			1	1		3				1				1						1	
27	Tallowwood	491163	6597337	90	22	2						2				1										1	
28	Coastal Blackbutt	491173	6597334	140	20	3						3				1										1	
29	Coastal Blackbutt	491197	6597332	105	18	4						2	2			1				1							
30	Coastal Blackbutt	491219	6597329	120	23	3						3				1											
31	Coastal Blackbutt	491263	6597336	190	17	5						5				1											Finish of trees in Albert Driver area
32	White Mahogany	492100	6598598	130	14	6		1	2			3			1	1	1									1	
33	Flooded Gum	492176	6598949	105	18	5						5			1	1	1									1	
34	Tallowwood	492320	6599039	95	16	5						3	2		1	1	1									1	Bald Hill Road area
35	Tallowwood	492302	6599044	110	17	5						3	2		1	1	1									1	
36	White Mahogany	492309	6599063	100	17	3						3			1	1	1									1	
37	Grey Ironbark	492462	6599311	75	13	1						1			1	1											
38	Coastal Blackbutt	492470	6599294	115	23	5						2	2	1	1	1	1	1	1	1						1	
39	Coastal Blackbutt	492508	6599449	135	20	4						2	2		1	1	1	1	1	1						1	
40	Flooded Gum	492420	6600018	55	23	1				1					1		1	1		1						1	Broken limb and decay
41	Flooded Gum	492430	6600011	80	18	3			1			2				1	1									1	
42	Coastal Blackbutt	492348	6600079	155	18	2						2				1	1									1	Nambucca State Forest
43	Pink Bloodwood	495362	6606905	80	22	6						3	2	1	1	1	1	1	1	1						1	
45	Coastal Blackbutt	495415	6607019	63	17	3						2	1			1	1									1	Jacks Ridge Road
46	Coastal Blackbutt	495388	6607014	115	18	3						3				1	1									1	
47	Coastal Blackbutt	495370	6606956	118	26	3						3				1	1									1	
48	Coastal Blackbutt	495393	6607030	60	18	2						2				1	1									1	
49	Coastal Blackbutt	495401	6607034	50	19	4			2			2				1	1									1	

HBT Ref No.	Species	Easting	Northing	DBH (cm)	~Tree Height (m)	No. Func. Holl.	Trunk Butt	Trunk Fissures	Trunk Small	Trunk Medium	Trunk Large	Limb Small	Limb Medium	Limb Large	SF	MB	SG	LG	Po	Pa	Co	SO	LFO	EB	LM	AH	Comments
		WGS84	WGS84						<5cm	5-15 cm	>15 cm	<5cm	5-15 cm	>15 cm													
50	Coastal Blackbutt	495412	6607033	75	17	4						2	2		1	1	1	1		1						1	
51	Coastal Blackbutt	495421	6607035	90	19	7						4	3		1	1	1	1	1	1						1	
52	Coastal Blackbutt	495417	6607040	80	19	10			1			5	3	1	1	1	1	1	1	1						1	
53	Coastal Blackbutt	495410	6607049	40	14	4			1			2	1			1	1									1	
54	Coastal Blackbutt	495406	6607054	85	20	6			1			3	2		1	1	1	1	1	1						1	
55	Coastal Blackbutt	495395	6607106	85	23	4				2		2			1	1	1	1	1	1						1	
56	Coastal Blackbutt	495392	6607100	115	23	6						3	3		1	1	1	1	1	1						1	
57	Stag	495600	6607465	115	20	3						3				1	1									1	
58	Stag	495614	6607505	80	15	20		1				5	8	6	1	1	1	1	1	1	1	1			1	1	
59	Coastal Blackbutt	495702	6607545	95	24	4						2	2			1	1	1		1						1	
60	Pink Bloodwood	495618	6607582	70	21	2						2				1	1									1	
62	Brushbox	496179	6608282	40	16	1					1				1				1						1	1	
63	Stag	496195	6608316	100	17	2					2					1			1						1	1	
64	Coastal Blackbutt	496190	6608480	220	27	8					1	4	3		1	1	1	1	1	1						1	
65	Coastal Blackbutt	496450	6609109	105	22	3						3			1	1	1										
66	Coastal Blackbutt	496543	6608949	120	27	2						1	1		1	1	1									1	**Potential Square-tailed Kite nest in this tree**
67	Coastal Blackbutt	496540	6608909	125	28	4						2	2		1	1	1	1		1						1	
68	Coastal Blackbutt	496608	6609127	125	26	8						5	3		1	1	1	1	1							1	
70	Stag	496566	6609334	80	21	5						3	2		1	1	1	1	1						1	1	
71	Coastal Blackbutt	496596	6609302	95	24	2						2				1	1										
72	Flooded Gum	496561	6609220	90	22	4						2	2		1	1	1	1								1	
73	Red Mahogany	496600	6609419	125	23	5						2	3		1	1	1	1		1						1	
74	Flooded Gum	496647	6609457	125	26	3						2	1		1	1	1	1		1						1	
75	Flooded Gum	496668	6609455	125	21	4						3	1		1	1	1	1		1						1	
76	Coastal Blackbutt	496740	6609603	85	25	3						3				1	1									1	
77	Coastal Blackbutt	496709	6609634	100	26	2						2				1	1									1	
78	Coastal Blackbutt	496702	6609613	130	28	8						6	2		1	1	1	1	1	1						1	
79	Coastal Blackbutt	496664	6609613	125	27	5						4	1		1	1	1	1	1	1						1	
80	Coastal Blackbutt	496730	6609731	135	25	5						4	1		1	1	1	1	1	1						1	
81	Coastal Blackbutt	496730	6609731	100	25	3						3			1	1	1									1	
82	Coastal Blackbutt	496755	6609744	115	19	5			2			3			1	1	1									1	
83	Stag	496817	6609694	90	15	11						4	4	3		1	1	1	1	1						1	
84	Coastal Blackbutt	496808	6609699	120	27	9						6	3		1	1	1	1	1	1						**1**	
85	Coastal Blackbutt	496808	6609791	85	20	4						4				1	1									**1**	
86	Red Mahogany	496954	6609900	100	25	3						3				1	1									1	
87	Coastal Blackbutt	496989	6609986	120	23	10						5	3	2	1	1	1	1	1	1	1	1			1	1	
88	Coastal Blackbutt	496954	6609900	120	26	4						4				1	1									1	
89	White Mahogany	497091	6609977	45	17	3			1			2				1	1									**1**	
90	Coastal Blackbutt	497128	6609976	120	26	7						5	2		1	1	1	1		1						**1**	
91	Coastal Blackbutt	497082	6609969	115	28	5						3	2		1	1	1	1		1						1	
92	Coastal Blackbutt	497010	6610018	95	25	5						3	2		1	1	1	1		1						**1**	
93	Coastal Blackbutt	497002	6610010	75	20	3						2	1		1	1	1	1		1						1	
94	Coastal Blackbutt	497002	6610009	95	24	5						3	2		1	1	1	1		1						1	
95	Coastal Blackbutt	497154	6610100	90	22	2						2			1	1	1									**1**	

HBT Ref No.	Species	Easting	Northing	DBH (cm)	~Tree Height (m)	No. Func. Holl.	Trunk Butt	Trunk Fissures	Trunk Small	Trunk Medium	Trunk Large	Limb Small	Limb Medium	Limb Large	SF	MB	SG	LG	Po	Pa	Co	SO	LFO	EB	LM	AH	Comments
		WGS84	WGS84						<5cm	5-15 cm	>15 cm	<5cm	5-15 cm	>15 cm													
96	Coastal Blackbutt	497230	6610193	125	27	6			1			3	2		1	1	1	1	1	1		1			**1**	**1**	
97	Coastal Blackbutt	497274	6610215	130	26	6						3	3		1	1	1	1	1	1		1			**1**	**1**	
98	Coastal Blackbutt	497279	6610216	125	27	10						6	3	1	1	1	1	1	1	1		1			**1**	**1**	
99	Coastal Blackbutt	497264	6610227	135	26	4						3	1		1	1	1	1								**1**	
100	Coastal Blackbutt	497311	6610242	70	23	3						2	1		1	1	1	1								**1**	
101	Coastal Blackbutt	497405	6610271	115	25	4						3	1		1	1	1			1						**1**	
102	Coastal Blackbutt	497447	6610424	110	27	3						3			1	1	1									**1**	
103	Coastal Blackbutt	497460	6610464	125	30	4						4			1	1	1									**1**	
104	Coastal Blackbutt	497501	6610514	105	20	3						3			1	1	1									**1**	
105	Coastal Blackbutt	497364	6610342	105	21	5						3	2		1	1	1	1		1						**1**	
106	Coastal Blackbutt	497480	6610595	125	30	3						3				1	1									1	
107	Coastal Blackbutt	497531	6610725	125	28	3						3			1	1	1	1	1	1						**1**	
111	Pink Bloodwood	497515	6610803	100	20	2						2				1	1									**1**	
112	Pink Bloodwood	497541	6610864	95	20	2						2				1	1									**1**	
113	White Mahogany	497546	6610855	85	19	5			2			2	1		1	1	1	1		1						**1**	
114	Coastal Blackbutt	497474	6610716	55	17	3						3				1	1									**1**	
115	Pink Bloodwood	497512	6610984	90	19	5			1			2	1	1	1	1	1	1	1	1		1				**1**	
116	Coastal Blackbutt	497428	6611302	115	26	3						3			1	1	1									**1**	
117	Coastal Blackbutt	497468	6611383	60	20	2						2			1	1	1									**1**	
118	Coastal Blackbutt	497494	6612422	115	23	4						2	2		1	1	1									**1**	
119	Coastal Blackbutt	497575	6612692	125	20	4						4				1	1	1	1	1						**1**	
120	Coastal Blackbutt	497559	6612726	190	20	10						7	2	1		1	1	1	1	1						**1**	
121	Coastal Blackbutt	497593	6612663	115	20	7						4	3			1	1	1	1	1						**1**	
122	Coastal Blackbutt	497583	6612770	100	20	5			1	1		3			1	1	1			1						**1**	
123	Coastal Blackbutt	497593	6612767	125	21	5						4	1		1	1	1	1		1						1	
124	Coastal Blackbutt	497592	6612780	95	21	3						2	1		1	1	1			1						1	
125	Coastal Blackbutt	497593	6612783	65	19	4			1			2	1		1	1	1			1						1	
126	Coastal Blackbutt	497585	6612786	70	15	2						2				1	1										
127	Coastal Blackbutt	497575	6612780	110	22	6						3	3		1	1	1	1	1	1						1	
128	Coastal Blackbutt	497594	6612795	105	22	6						3	3		1	1	1	1		1						1	
129	Coastal Blackbutt	497590	6612813	120	23	4						2	2		1	1	1	1		1						1	
130	Stag	497588	6612820	75	16	8				1	2	2	2	1	1	1	1	1	1	1		1			1	1	
131	Coastal Blackbutt	497594	6612847	135	24	3						2		1	1	1	1	1		1						1	
132	Stag	497603	6613003	40	10	2		1		1					1	1									1	1	
133	Coastal Blackbutt	497670	6613318	90	16	2						1	1		1	1	1	1		1					1	1	
134	Pink Bloodwood	497675	6613324	115	20	8						3	3	2	1	1	1	1	1	1		1			1	1	
135	Pink Bloodwood	497690	6613355	95	20	2						2				1	1									1	
136	Pink Bloodwood	497681	6613357	100	22	6						4	2		1	1	1	1								1	
137	Swamp Mahogany	497705	6613477	105	20	8			2	1		2	3		1	1	1	1		1						1	
138	Coastal Blackbutt	497698	6613044	115	21	3						2	1		1	1	1									1	
139	Smooth-barked Apple	497925	6613554	40	14	2				1		1			1	1	1	1	1							1	
140	Pink Bloodwood	497925	6613556	90	21	6			1	1		2	2		1	1	1	1	1							1	
141	Stag	497937	6613578	90	22	9						4	4	1	1	1	1	1	1	1		1			1	1	
142	Pink Bloodwood	497967	6613591	80	19	3							2	1	1		1	1								1	

HBT Ref No.	Species	Easting	Northing	DBH (cm)	~Tree Height (m)	No. Func. Holl.	Trunk Butt	Trunk Fissures	Trunk Small	Trunk Medium	Trunk Large	Limb Small	Limb Medium	Limb Large	SF	MB	SG	LG	Po	Pa	Co	SO	LFO	EB	LM	AH	Comments
		WGS84	WGS84						<5cm	5-15 cm	>15 cm	<5cm	5-15 cm	>15 cm													
143	Pink Bloodwood	497967	6613589	45	11	4			1			1	2			1	1	1								1	
144	Stag	497971	6613595	70	20	8		1				2	3	2		1	1	1	1	1						1	
145	Stag	497971	6613599	40	18	5			1	1		2	1		1	1	1	1								1	
146	Stag	497983	6613624	55	18	5			2	1		2			1	1	1	1								1	
147	Stag	497945	6613618	85	15	9						4	3	2	1	1	1	1	1	1		1			1		
148	Stag	497993	6613630	30	10	3							3		1	1	1	1								1	
149	Pink Bloodwood	497996	6613624	70	21	3						3			1	1	1									1	
150	Pink Bloodwood	497999	6613636	95	18	3				1		1		1	1	1	1	1	1							1	
151	White Mahogany	498016	6613675	110	22	7						3	3	1	1	1	1	1	1							1	
152	Stag	498034	6613673	75	18	11			1			4	2	4	1	1	1	1	1							1	
153	Coastal Blackbutt	498050	6613707	125	23	2						2				1	1									1	
154	White Mahogany	498007	6613724	90	18	3						2	1		1	1	1	1		1						1	
155	Coastal Blackbutt	498063	6613762	110	17	5					1	2	2		1	1	1	1	1	1		1			1	1	
156	Pink Bloodwood	498099	6613731	75	17	8				1		2	3	2	1	1	1	1	1	1		1			1	1	
157	Coastal Blackbutt	498122	6613723	145	19	14						6	5	3	1	1	1	1	1	1		1			1	1	
158	Coastal Blackbutt	498119	6613810	190	20	18						11	4	3	1	1	1	1	1	1		1			1	1	
159	White Mahogany	498131	6613821	95	18	4						2	2		1	1	1	1	1	1						1	
160	Coastal Blackbutt	498140	6613823	140	19	13				1	2	4	3	3	1	1	1	1	1	1	1	1			1	1	
161	Stag	498154	6613814	30	8	3						2	1		1	1	1									1	
162	Coastal Blackbutt	498213	6613832	120	23	13			1		1	7	4		1	1	1	1	1	1		1			1	1	
163	Swamp Mahogany	498827	6614462	110	17	6				2		2	2		1	1	1	1	1	1					1	1	
164	Swamp Mahogany	498820	6614429	75	18	4						2	2		1	1	1	1	1							1	
165	Swamp Box	498825	6614435	35	8	1								1	1				1						1	1	
166	Swamp Mahogany	498806	6614415	110	17	6						3	3		1	1	1	1	1							1	
167	Stag	498789	6614399	75	12	12						5	5	2	1		1	1	1						1	1	
168	Swamp Mahogany	498776	6614381	95	17	10			2			3	3	2	1	1	1	1	1	1					1	1	
169	Coastal Blackbutt	498957	6614551	95	17	4		1	1			2			1	1	1								1	1	
170	Coastal Blackbutt	498949	6614547	105	17	2						1	1		1	1	1									1	
171	Coastal Blackbutt	498892	6614432	150	22	14						5	7	2	1	1	1	1	1	1	1	1			1	1	
172	Coastal Blackbutt	498937	6615080	100	24	4						3	1		1	1	1	1								1	Start of Blackbutt Lane
173	Coastal Blackbutt	498941	6615083	130	27	5						3	2		1	1	1	1								1	
174	Coastal Blackbutt	498952	6615098	130	27	7						4	3		1	1	1	1								1	
175	Coastal Blackbutt	498958	6615105	115	28	7						3	3	1	1	1	1	1	1	1	1	1			1	1	
176	Coastal Blackbutt	498957	6615112	95	19	3						2	1		1	1	1									1	
177	Coastal Blackbutt	498958	6615113	100	25	4						2	2		1	1	1									1	
178	Coastal Blackbutt	498958	6615125	100	24	6						5	1		1	1	1									1	
179	Coastal Blackbutt	498950	6615126	125	25	6						4	2		1	1	1									1	
180	Coastal Blackbutt	498945	6615116	105	24	5						3	2		1	1	1									1	
181	Coastal Blackbutt	498953	6615148	105	27	5						2	3			1	1	1									
182	White Mahogany	498990	6615059	140	23	19			1		1	6	7	4	1	1	1	1	1	1	1	1			1	1	Rainbow Lorikeets using medium limb hollow
183	Coastal Blackbutt	499015	6615108	135	24	9						4	3	2	1	1	1	1	1	1						1	
184	White Mahogany	499017	6615105	100	22	5						3	2		1	1	1	1	1	1						1	
185	Pink Bloodwood	499021	6615141	105	18	4					1		2	1					1			1			1	1	
186	Pink Bloodwood	499034	6615132	80	13	4							2	2					1			1			1	1	

HBT Ref No.	Species	Easting	Northing	DBH (cm)	~Tree Height (m)	No. Func. Holl.	Trunk Butt	Trunk Fissures	Trunk Small	Trunk Medium	Trunk Large	Limb Small	Limb Medium	Limb Large	SF	MB	SG	LG	Po	Pa	Co	SO	LFO	EB	LM	AH	Comments
		WGS84	WGS84						<5cm	5-15 cm	>15 cm	<5cm	5-15 cm	>15 cm													
187	Coastal Blackbutt	499084	6615168	135	25	3						3				1	1									1	
188	White Mahogany	499062	6615145	140	22	14						7	4	3	1	1	1	1	1	1	1	1			1	1	
189	Pink Bloodwood	499112	6615207	95	20	16				1	1	7	3	4	1	1	1	1	1	1	1	1			1	1	
190	Coastal Blackbutt	499159	6615251	150	20	19						5	6	8	1	1	1	1	1	1	1	1			1	1	
191	Stag	499139	6615265	30	8	3				1			2		1										1	1	
192	Coastal Blackbutt	499122	6615259	100	21	2							1	1	1		1	1	1	1						1	
193	Coastal Blackbutt	499113	6615259	100	21	10						5	3	2	1	1	1	1	1	1						1	
194	Coastal Blackbutt	499113	6615258	105	22	4						2	2		1	1	1	1		1						1	
195	Coastal Blackbutt	499106	6615234	105	22	7						4	2	1	1	1	1	1	1	1						1	
196	Coastal Blackbutt	499098	6615226	85	23	4							3	1	1	1	1									1	
197	Coastal Blackbutt	499095	6615225	100	24	4						3	1		1	1	1									1	
198	Coastal Blackbutt	499096	6615249	135	24	5						3	2		1	1	1									1	
199	Coastal Blackbutt	499075	6615269	85	16	2					1		1		1		1	1	1						1	1	
200	Coastal Blackbutt	499067	6615238	115	23	3						2	1		1	1	1	1		1						1	
201	Coastal Blackbutt	499051	6615224	135	23	7						4	3		1	1	1	1		1						1	
202	Stag	499049	6615216	40	6	2		1			1				1										1		
203	Coastal Blackbutt	499047	6615219	110	23	2							2				1	1	1	1							
204	Coastal Blackbutt	499024	6615228	135	23	7						5	2		1	1	1	1								1	
205	Coastal Blackbutt	499012	6615219	165	23	19			3	2		4	6	4	1	1	1	1	1	1	1	1			1	1	Native bees using small limb hollow
206	Coastal Blackbutt	499015	6615216	105	25	8			2	3			2	1	1	1	1	1	1	1		1			1	1	
207	Coastal Blackbutt	498994	6615198	110	18	5						2	3		1	1	1	1	1							1	
208	Coastal Blackbutt	498996	6615171	90	21	5						3	2		1	1	1	1	1							1	
209	Coastal Blackbutt	498990	6615156	120	23	6						4	2		1	1	1	1	1							1	
210	Coastal Blackbutt	499005	6615145	105	23	7						5	2		1	1	1	1	1							1	End of Blackbutt Lane HBT's
211	Coastal Blackbutt	499368	6615422	95	20	2						1	1		1	1	1	1								1	
212	White Mahogany	499202	6615299	125	20	20				1	1	8	6	4	1	1	1	1	1	1	1	1			1	1	
213	Coastal Blackbutt	499202	6615305	60	19	3						2	1		1	1	1	1								1	
214	Coastal Blackbutt	499225	6615367	115	22	8			1			3	4		1	1	1	1								1	Scaly and Rainbows using hollows
215	Coastal Blackbutt	499252	6615373	105	20	7						3	4		1	1	1	1								1	
216	Coastal Blackbutt	499262	6615371	90	20	7						4	2	1	1	1	1	1	1	1						1	
217	Coastal Blackbutt	499409	6615588	125	23	4						3	1		1	1	1	1	1	1						1	
218	Coastal Blackbutt	499459	6615620	140	23	8						5	3		1	1	1	1	1	1						1	
219	Pink Bloodwood	499445	6615643	75	16	3						3			1	1	1									1	
220	Coastal Blackbutt	499503	6615680	140	21	8						5	2	1	1	1	1	1	1	1		1			1	1	
221	Coastal Blackbutt	499527	6615706	105	20	3						2	1		1	1	1	1		1						1	
222	Swamp Mahogany	499535	6615740	105	14	5				2	1	2			1	1	1	1	1	1						1	
223	Coastal Blackbutt	499706	6615810	90	17	3						3			1	1	1									1	
224	Coastal Blackbutt	499703	6615802	135	17	8						5	3		1	1	1	1		1						1	
225	Coastal Blackbutt	499796	6615908	130	17	6						3	3		1	1	1	1		1						1	
226	Coastal Blackbutt	499803	6615989	130	18	10						4	4	2	1	1	1	1	1	1	1	1		1		1	open hive in branch
227	Coastal Blackbutt	499842	6616106	130	22	9						4	3	2	1	1	1	1	1	1	1	1				1	tree not marked as beside house to east of large dam
228	Coastal Blackbutt	500225	6616506	190	19	5						3	2		1	1	1	1								1	
229	Coastal Blackbutt	500188	6616454	155	17	5						3	2		1	1	1	1								1	
230	Coastal Blackbutt	500163	6616404	115	17	7						4	2	1	1	1	1	1	1	1					1	1	

HBT Ref No.	Species	Easting	Northing	DBH (cm)	~Tree Height (m)	No. Func. Holl.	Trunk Butt	Trunk Fissures	Trunk Small	Trunk Medium	Trunk Large	Limb Small	Limb Medium	Limb Large	SF	MB	SG	LG	Po	Pa	Co	SO	LFO	EB	LM	AH	Comments
		WGS84	WGS84						<5cm	5-15 cm	>15 cm	<5cm	5-15 cm	>15 cm													
231	Stag	500161	6616406	35	9	3			1	1	1				1		1	1							1	1	
232	Coastal Blackbutt	500151	6616378	115	17	12						7	4	1	1	1	1	1	1	1					1	1	
233	Coastal Blackbutt	500037	6616353	95	16	6	1				1	2	2		1	1	1	1	1	1						1	Antechinus scats at base
234	Small-fruited Grey Gum	500015	6616367	85	19	3						3			1	1	1									1	
235	Swamp Mahogany	500213	6616568	90	14	5							2	3	1	1	1									1	
236	Swamp Mahogany	500214	6616571	70	14	4						3	1		1	1	1	1	1	1		1			1	1	
237	Stag	500251	6616664	135	13	10	1				1	3	3	2	1	1	1	1	1	1		1			1	1	Oyster Creek area from here
238	Tallowwood	500255	6616669	95	19	2						1	1		1	1	1	1								1	
239	Stag	500260	6616687	75	15	7						3	4		1	1	1	1		1						1	
240	Narrow-leaved Red Gum	500265	6616713	95	20	5				2		2	1		1	1	1	1		1						1	
241	Coastal Blackbutt	500272	6616731	105	21	4						2	1	1	1	1	1	1		1						1	
242	Stag	500267	6616743	40	18	9						2	7		1	1	1	1		1						1	
243	Coastal Blackbutt	500356	6616969	100	24	4						2	2		1	1	1	1		1						1	
244	Tallowwood	500365	6616934	220	28	21					3	5	4	9	1	1	1	1	1	1	1	1	1	1	1	1	using large limb hollow
245	Coastal Blackbutt	500381	6616938	95	26	4						2	2		1	1	1	1		1						1	
246	Coastal Blackbutt	500371	6616915	105	24	4						3	1		1	1	1	1		1						1	
247	Coastal Blackbutt	500371	6616915	85	21	5			2			2	1		1	1	1	1		1						1	
248	Coastal Blackbutt	500378	6616908	105	24	6	1		1		1	2	1		1	1	1	1		1					1	1	
249	Coastal Blackbutt	500382	6616904	80	19	2						2			1	1										1	
250	Coastal Blackbutt	500358	6616902	105	24	5	1					3	1		1	1	1	1		1						1	
251	Stag	500357	6616894	95	16	8						2	3	3	1	1	1	1	1	1		1			1	1	
252	Coastal Blackbutt	500343	6616879	110	24	6						3	3		1	1	1	1		1						1	lots of small black ants unknown if they using the canopy but tree may have low occupancy rates
253	Coastal Blackbutt	500348	6616867	130	24	5						3	2		1	1	1	1		1						1	
254	Coastal Blackbutt	500343	6616864	205	20	9					4	1	2	2	1	1	1	1	1	1	1	1	1		1	1	head of tree broken in recent storm
255	Coastal Blackbutt	500345	6616832	105	24	4						2	1	1	1	1	1	1	1	1					1	1	
256	Coastal Blackbutt	500348	6616833	100	21	4						2	2		1	1	1	1	1	1					1	1	
257	Stag	500322	6616818	105	20	9					1	3	3	2	1	1	1	1	1	1					1	1	
258	Pink Bloodwood	500320	6616819	105	22	4						1	1	2	1	1	1	1	1	1					1	1	
259	Coastal Blackbutt	500337	6616817	60	21	2							1	1	1	1	1	1								1	
260	Coastal Blackbutt	500316	6616824	115	22	5						2	1	2	1	1	1	1	1	1						1	
261	Stag	500306	6616786	95	22	11				1	1	4	3	2	1	1	1	1	1	1		1			1	1	
262	Coastal Blackbutt	500319	6616786	140	24	7						4	3		1	1	1	1		1						1	
263	Coastal Blackbutt	500302	6616755	140	23	19		1	2			7	8	1	1	1	1	1	1	1	1	1		1	1	1	bees using trunk fissure of dead leader
264	Stag	500292	6616761	90	23	9			1	1		1	1	5	1	1	1	1	1	1	1	1			1	1	
265	Flooded Gum	500282	6616630	85	26	7				2	2	3			1	1	1									1	eastern side of road
266	Stag	500332	6616701	70	11	0									1				1						1	1	
267	Coastal Blackbutt	500332	6616701	110	23	5						3	2		1	1	1	1		1						1	
268	Coastal Blackbutt	500350	6616700	95	23	3						3			1	1	1									1	
269	Coastal Blackbutt	500356	6616726	110	21	5						3	2		1	1	1	1		1						1	
270	Coastal Blackbutt	500383	6616787	100	21	6			1	1		2	2		1	1	1	1		1						1	
271	Coastal Blackbutt	500383	6616793	120	24	11						5	3	3	1	1	1	1	1	1	1	1			1	1	
272	Coastal Blackbutt	500374	6616805	110	23	3						3			1	1	1									1	
273	Coastal Blackbutt	500429	6616843	115	26	4						3	1		1	1	1	1		1						1	ref tree to south of driveway
274	Stag	500450	6616919	65	12	7		1				3	2	1	1	1	1	1	1	1	1	1			1	1	

HBT Ref No.	Species	Easting	Northing	DBH (cm)	~Tree Height (m)	No. Func. Holl.	Trunk Butt	Trunk Fissures	Trunk Small	Trunk Medium	Trunk Large	Limb Small	Limb Medium	Limb Large	SF	MB	SG	LG	Po	Pa	Co	SO	LFO	EB	LM	AH	Comments
		WGS84	WGS84						<5cm	5-15 cm	>15 cm	<5cm	5-15 cm	>15 cm													
275	Coastal Blackbutt	500460	6616920	65	21	2						1	1		1	1	1	1		1						1	
276	Coastal Blackbutt	500531	6617092	100	19	2						1	1		1	1	1	1		1						1	
277	White Mahogany	500531	6617292	105	20	4						3	1		1	1	1	1		1						1	
278	Coastal Blackbutt	500479	6617156	70	12	2	1				1				1	1	1	1		1						1	
279	Coastal Blackbutt	500463	6617170	135	23	13						4	5	4		1			1						1		
280	Turpentine Stag	500475	6617153	40	8	7		1		1		2	2	1	1	1	1	1	1	1	1	1			1	1	
281	Stag	500466	6617152	70	15	16		1		2	3	3	4	3	1	1	1	1	1	1		1			1	1	
282	Coastal Blackbutt	500451	6617125	135	19	11	1				3	3	2	2	1	1	1	1	1	1	1	1	1		1	1	roost grove of trees nearby for things like Powerful owl, Saltsaurus gecko skin in basal hollow
283	Coastal Blackbutt	500445	6617083	110	22	8				3		4	1		1	1	1	1		1						1	
284	Pink Bloodwood	500441	6617076	35	9	10			1			3	4	2	1	1	1	1	1	1		1			1	1	stag stage
285	Coastal Blackbutt	500425	6617030	230	23	32			1		1	10	11	9	1	1	1	1	1	1	1	1	1		1	1	very good tree for owls
286	Pink Bloodwood	500411	6616991	105	11	5							2	3	1				1						1	1	these hollows are low 3 and 6 respectively
287	Coastal Blackbutt	500413	6616988	110	22	6						3	2	1	1	1	1	1	1	1	1	1			1	1	
288	Coastal Blackbutt	500438	6616978	135	22	19						9	6	4	1	1	1	1	1	1	1	1			1	1	native bees using small limb hollow
289	Coastal Blackbutt	500441	6616967	150	24	18				1	1	8	5	3	1	1	1	1	1	1	1	1			1	1	on edge of highway
290	Coastal Blackbutt	500419	6616966	130	22	9						5	4		1	1	1	1		1						1	
291	Coastal Blackbutt	500412	6616939	100	21	4						2	1	1	1	1	1	1	1	1					1	1	
292	Pink Bloodwood	500395	6616936	100	18	6						3	2	1	1	1	1	1	1	1					1	1	
293	Coastal Blackbutt	500428	6616927	125	22	4						4				1	1									1	
294	Coastal Blackbutt	500457	6617540	105	21	4						2	2		1	1	1	1								1	
295	Swamp Mahogany	500481	6617486	95	20	5						2	2	1	1	1	1	1		1						1	
296	Swamp Mahogany	500474	6617468	60	17	2				1	1								1		1				1		
297	Coastal Blackbutt	500466	6617458	105	24	6						4	2		1	1	1	1		1						1	
298	Coastal Blackbutt	500474	6617431	105	23	6						4	2		1	1	1	1		1						1	
299	Coastal Blackbutt	500471	6617428	120	23	3						3				1	1									1	
300	Pink Bloodwood	500462	6617418	55	14	6						2	3	1	1	1	1	1	1	1					1	1	
301	Coastal Blackbutt	500472	6617380	110	23	3						2	1		1	1	1	1								1	
302	Turpentine	500471	6617380	50	14	1					1				1										1		very low at 2 mts
303	Coastal Blackbutt	500476	6617360	110	22	9		1		1		2	3	2	1	1	1	1								1	
304	Stag	500487	6617336	65	16	10					1	3	4	2	1	1	1	1	1	1					1	1	
305	Stag	500496	6617325	45	9	1						1				1			1						1		Broken at the base
306	Pink Bloodwood	500472	6617333	115	26	5						3	1	1	1	1	1	1	1	1							
307	Pink Bloodwood	500458	6617303	100	23	10						4	3	3	1	1	1	1	1	1	1	1			1	1	
308	Stag	500459	6617285	40	11	1					1								1						1		
309	Coastal Blackbutt	500441	6617380	115	26	7						5	2		1	1	1	1		1						1	Oyster Creek Finish
310	Coastal Blackbutt	500516	6617717	125	27	3						3			1	1	1									1	
311	Coastal Blackbutt	500504	6617728	125	24	8						3	3	2	1	1	1	1	1	1						1	
312	Turpentine	500463	6617662	115	20	3		1				2			1	1	1									1	
313	Coastal Blackbutt	500440	6617802	160	25	10						4	3	3	1	1	1	1	1	1	1	1			1	1	
314	Coastal Blackbutt	500466	6617832	145	22	9						3	4	2	1	1	1	1	1	1	1	1			1	1	
315	Coastal Blackbutt	500409	6617860	100	21	6						2	2	2	1	1	1	1	1	1	1	1			1	1	shallow large hollow
316	Coastal Blackbutt	500495	6617805	90	24	4						2	2		1	1	1	1	1	1					1	1	
317	Stag	500508	6617849	105	11	3					1			2		1			1						1	1	
318	Coastal Blackbutt	500513	6617856	110	24	3						1	1	1	1	1	1	1	1	1		1			1	1	

HBT Ref No.	Species	Easting	Northing	DBH (cm)	~Tree Height (m)	No. Func. Holl.	Trunk Butt	Trunk Fissures	Trunk Small	Trunk Medium	Trunk Large	Limb Small	Limb Medium	Limb Large	SF	MB	SG	LG	Po	Pa	Co	SO	LFO	EB	LM	AH	Comments
		WGS84	WGS84						<5cm	5-15 cm	>15 cm	<5cm	5-15 cm	>15 cm													
319	Coastal Blackbutt	500514	6617850	95	20	4						4			1	1	1									1	
320	Pink Bloodwood	500492	6617887	115	18	12					1	4	3	4	1	1	1	1	1	1	1	1			1	1	
321	Pink Bloodwood	500514	6617901	110	19	7						3	2	2	1	1	1	1	1	1	1	1			1	1	
322	Pink Bloodwood	500476	6617950	130	24	6			1			2	2	1	1	1	1	1	1	1	1	1			1	1	
323	Coastal Blackbutt	500472	6617956	100	24	6						3	3		1	1	1	1		1						1	
324	Swamp Mahogany	500447	6617980	130	21	4						2	2		1	1	1	1		1						1	
325	Pink Bloodwood	500466	6618042	90	16	7			1	2		3	1		1	1	1	1		1						1	
326	White Mahogany	500419	6618126	130	22	11						5	3	3	1	1	1	1	1	1						1	
327	Tallowwood	500419	6618158	170	21	28						13	11	4	1	1	1	1	1	1	1	1			1	1	
328	Stag	500406	6618146	50	11	7		1	2			3	1		1	1	1									1	
329	Coastal Blackbutt	500395	6618119	125	22	8						5	3		1	1	1	1		1						1	twin trunk tree
330	Coastal Blackbutt	500387	6618127	105	24	6						3	3		1	1	1	1		1						1	
331	Coastal Blackbutt	500411	6618085	120	25	5						3	2		1	1	1	1		1						1	
332	Coastal Blackbutt	500441	6618093	100	26	7			1			3	3		1	1	1	1		1						1	Sugar Glider at base of tree
333	Coastal Blackbutt	500449	6618092	115	25	14						5	7	2	1	1	1	1	1	1	1	1			1	1	
334	Coastal Blackbutt	500442	6618079	105	24	5						2	2	1	1	1	1	1	1	1	1	1			1	1	
335	Tallowwood	500412	6618192	95	22	2						2			1	1	1									1	
336	Coastal Blackbutt	500396	6618227	95	19	3						3			1	1	1									1	
337	Coastal Blackbutt	500378	6618239	125	21	4						2	1	1	1	1	1	1		1						1	
338	Coastal Blackbutt	500378	6618208	100	21	5						3	2		1	1	1	1		1						1	
339	Coastal Blackbutt	500386	6618201	105	21	6						4	2		1	1	1	1		1						1	
340	White Mahogany	500445	6618028	120	22	8			2			3	3		1	1	1	1		1						1	tree not flagged growing in swamp
341	Coastal Blackbutt	500437	6618581	125	29	4						2	2		1	1	1	1		1						1	
342	Coastal Blackbutt	500451	6618553	110	28	3						2		1	1	1	1		1	1						1	
343	Turpentine	500433	6618516	115	15	6		1	2	1		1		1	1	1			1						1	1	
344	Coastal Blackbutt	500467	6618502	85	23	4						2	2		1	1	1	1	1	1						1	
345	Coastal Blackbutt	500471	6618398	115	26	3						3			1	1	1									1	east of road
346	Coastal Blackbutt	500490	6618450	130	28	6						3	3		1	1	1	1		1					1	1	east of road
347	Coastal Blackbutt	500548	6618778	125	21	13	1				2	6	2	2	1	1	1	1	1	1	1	1			1	1	
348	Coastal Blackbutt	500496	6619148	85	22	4						3	1		1	1	1	1		1						1	
349	Coastal Blackbutt	500502	6619151	65	20	5						4	1		1	1	1	1		1						1	
350	Coastal Blackbutt	500504	6619155	105	20	7						5	2		1	1	1	1		1						1	
351	Coastal Blackbutt	500529	6619170	120	23	14						7	4	3	1	1	1	1	1	1	1	1			1	1	
352	Coastal Blackbutt	500516	6619370	60	17	2						2			1	1	1									1	eastern side on boundary so ref tree
353	Coastal Blackbutt	500462	6619353	110	24	7			1	1		4	1		1	1	1	1		1						1	
354	Coastal Blackbutt	500474	6619313	100	20	5						3	2		1	1	1	1		1						1	
355	Coastal Blackbutt	500472	6619318	110	26	7						4	3		1	1	1	1		1						1	
356	Pink Bloodwood	500450	6619191	110	25	5						2	2	1	1	1	1	1	1	1						1	
357	Coastal Blackbutt	500464	6619166	115	19	14	1					3	4	6	1	1	1	1	1	1	1	1	1		1	1	
358	Stag	500464	6619136	75	24	10						7	3		1	1	1	1								1	
359	Coastal Blackbutt	500468	6619115	105	24	6						3	2	1	1	1	1	1	1	1	1	1	1		1	1	
360	Coastal Blackbutt	500455	6619106	100	27	4						2	1	1	1	1	1	1	1	1			1		1	1	native bees using small limb leader
361	Coastal Blackbutt	500459	6619101	110	27	4						3	1		1	1	1	1								1	
362	Coastal Blackbutt	500463	6619028	105	21	8						4	4		1	1	1	1								1	

HBT Ref No.	Species	Easting	Northing	DBH (cm)	~Tree Height (m)	No. Func. Holl.	Trunk Butt	Trunk Fissures	Trunk Small	Trunk Medium	Trunk Large	Limb Small	Limb Medium	Limb Large	SF	MB	SG	LG	Po	Pa	Co	SO	LFO	EB	LM	AH	Comments
		WGS84	WGS84						<5cm	5-15 cm	>15 cm	<5cm	5-15 cm	>15 cm													
363	Pink Bloodwood	500462	6619029	45	19	1				1					1											1	medium trunk only 2.5 m above ground
364	Coastal Blackbutt	500471	6618968	130	24	17						9	5	3	1	1	1	1	1	1	1	1			1	1	
365	Coastal Blackbutt	500462	6618992	115	20	8						4	4		1	1	1	1		1						1	
366	Coastal Blackbutt	500429	6618987	125	25	6						4	2		1	1	1	1		1						1	
367	Coastal Blackbutt	500441	6618951	125	22	9						7	2		1	1	1	1		1						1	
368	Pink Bloodwood	500453	6618929	100	21	3				1		2			1	1	1	1		1						1	
369	Coastal Blackbutt	500450	6618846	125	26	8						2	4	2	1	1	1	1	1	1						1	
370	Stag	500459	6618808	95	13	2		1			1				1	1			1						1	1	
371	Flooded Gum	500491	6618726	85	21	3				1		2			1	1	1	1		1						1	
372	Coastal Blackbutt	500476	6618662	105	26	7						4	3		1	1	1	1		1						1	
373	Coastal Blackbutt	500471	6618677	110	28	4						2	2		1	1	1	1		1						1	
374	Stag	500472	6618673	85	23	14						4	7	3	1	1	1	1	1	1		1			1	1	
375	Coastal Blackbutt	500402	6618691	125	27	5						2	2	1	1	1	1	1	1	1		1			1	1	
376	Coastal Blackbutt	500406	6618725	130	28	4						3	1		1	1	1	1	1						1	1	
377	Flooded Gum	500377	6618804	70	21	2						1	1		1	1	1	1	1						1	1	
378	Coastal Blackbutt	500383	6618876	130	29	10						5	3	2	1	1	1	1	1	1	1	1			1	1	
379	Coastal Blackbutt	500383	6618848	140	29	4						4			1	1	1									1	
380	Coastal Blackbutt	500394	6618856	120	21	4						3	1		1	1	1	1		1						1	
381	Coastal Blackbutt	500424	6619933	125	28	5						3	2		1	1	1	1		1						1	
382	Flooded Gum	500442	6619952	70	24	1						1				1										1	
383	Flooded Gum	500429	6619966	115	32	6						4	2			1	1	1		1						1	
384	Flooded Gum	500395	6619968	135	31	9						5	3	1	1	1	1	1	1							1	
385	Stag	500472	6620319	35	9	1					1				1										1		
386	Stag	500398	6620567	80	28	2						2				1	1										
387	Tallowwood	500402	6620965	55	14	1					1				1										1	1	
388	Coastal Blackbutt	500352	6621145	125	26	4						3	1		1	1	1	1		1						1	potential glider crossing tree
389	Coastal Blackbutt	499927	6621573	105	23	13					1	7	4	1	1	1	1	1	1	1	1	1			1	1	
390	Coastal Blackbutt	499519	6622216	80	22	3						2	1		1	1	1	1		1							Ainsworth Cut area
391	Grey Ironbark	499559	6622142	135	30	8						4	2	2	1	1	1	1	1	1	1	1			1	1	gully
392	White Mahogany	499558	6622166	95	23	4						1	2	1	1	1	1	1	1	1	1	1			1	1	gully
393	Coastal Blackbutt	499524	6622259	100	24	5						3	2		1	1	1	1	1							1	
394	Grey Ironbark	499564	6622184	110	22	4					1	2		1	1	1			1						1		large hollow probably just a cavity
396	Stag	499461	6622301	35	6	1					1				1				1						1	1	
397	Coastal Blackbutt	499397	6622319	100	25	3						3				1	1									1	
398	Coastal Blackbutt	499711	6621926	80	23	3						2	1		1	1	1	1								1	
399	Small-fruited Grey Gum	499647	6621984	85	27	8						3	3	2		1	1	1	1	1						1	
400	Coastal Blackbutt	499622	6621971	85	25	4						3	1		1	1	1	1								1	
401	Tallowwood	499634	6621989	85	23	4						2	2		1	1	1	1								1	
402	Coastal Blackbutt	499612	6622080	95	29	5						3	2		1	1	1	1								1	
403	Stag	499156	5522360	50	13	5					1	1	2	1	1	1	1	1	1						1	1	
404	Stag	499176	6622365	60	19	9		1				3	3	2	1	1	1	1	1	1		1			1	1	
405	Stag	499169	6622420	75	11	3		1			1			1	1				1						1	1	
406	White Mahogany	498154	6626751	205	26	13						7	4	2	1	1	1	1	1	1	1	1			1	1	Significant habitat tree in immediate area
407	White Mahogany	498175	6626592	125	25	9				1	1	3	3	1	1	1	1	1	1	1	1	1			1	1	

HBT Ref No.	Species	Easting WGS84	Northing WGS84	DBH (cm)	~Tree Height (m)	No. Func. Holl.	Trunk Butt	Trunk Fissures	Trunk Small <5cm	Trunk Medium 5-15 cm	Trunk Large >15 cm	Limb Small <5cm	Limb Medium 5-15 cm	Limb Large >15 cm	SF	MB	SG	LG	Po	Pa	Co	SO	LFO	EB	LM	AH	Comments
408	Tallowwood	498134	6626546	115	25	7						3	2	2	1	1	1	1	1	1					1	1	
409	Pink Bloodwood	498105	6626487	90	21	5					1	2	2		1	1	1	1	1	1					1	1	
410	Tallowwood	498142	6626618	100	21	3						2	1			1	1	1		1						1	
411	White Mahogany	498134	6626657	85	20	3						2	1			1	1	1		1						1	
412	Pink Bloodwood	498130	6626667	105	21	1					1				1				1						1	1	
413	Pink Bloodwood	498198	6626653	105	22	6						2	2	2	1	1	1	1	1	1	1	1			1	1	
414	Pink Bloodwood	498222	6626803	110	25	16			1	1		7	5	2	1	1	1	1	1	1	1	1			1	1	
415	White Mahogany	498344	6626957	110	26	4						2	2		1	1	1	1		1						1	3 m north of station 47 with blue tape
416	Stag	498477	6627076	135	20	2		1			1				1	1			1						1	1	
417	Flooded Gum	498476	6627175	215	30	18						8	6	4	1	1	1	1	1	1	1	1			1	1	
418	Flooded Gum	498475	6627312	140	24	3						1	2			1	1	1	1							1	
419	Swamp Mahogany	497723	6624879	95	14	8			3	2		2	1		1	1			1	1		1				1	north side of dam in open paddock
420	stag	499086	6622518	115	14	4		1	2		1				1	1			1						1	1	2 m inside eastern road corridor boundary ring barked this stag and next 12 as stand improvement (i.e. forestry technique)
421	Stag	499095	6622515	75	22	5		1				3	1		1	1	1	1								1	
422	stag	499111	6622434	55	8	2		1			1								1						1	1	
423	stag	499061	6622455	90	19	2		1			1				1				1						1		Turpentine
424	Stag	499031	6622454	50	10	2						2			1		1									1	
425	Stag	499031	6622453	60	12	4		1				2	1		1	1	1	1								1	
426	Stag	498853	6622659	45	7	2		1			1				1				1						1		
427	Stag	498496	6622832	80	18	8	1	1				4	2		1	1	1	1		1						1	
428	stag	498549	6622892	100	18	3		1		1	1				1	1			1							1	
431	Coastal Blackbutt	498395	6622987	85	21	4						2	2		1	1	1	1		1						1	Southern bank of Martell's Road
433	Coastal Blackbutt	498356	6623603	100	24	4						2	2		1	1	1	1		1						1	
434	Coastal Blackbutt	498233	6623628	105	21	4						2	2		1	1	1	1		1						1	
435	Pink Bloodwood	498225	6623759	65	18	7						4	2	1	1	1	1	1	1	1					1	1	
436	Red Mahogany	498195	6623826	120	21	8						3	3	2	1	1	1	1	1	1					1	1	
437	Swamp Mahogany	498178	6623842	50	14	2							2		1		1	1								1	
438	Swamp Mahogany	498176	6623851	55	15	3				1		1	1		1		1	1	1						1	1	
439	Coastal Blackbutt	498024	6624132	90	18	4			1			2	1		1	1	1	1		1						1	
440	Stag	497662	6625186			3						2	1		1	1	1									1	
441	Grey Ironbark	497757	6625203	115	16	5						3	2		1	1	1									1	
442	Tallowwood	497899	6625902	65	19	5						2	3		1	1	1	1								1	
443	Tallowwood	497897	6625918	105	19	6			2		1	2	1		1	1	1	1	1							1	
444	White Mahogany	497829	6625958	90	21	5						4	1		1	1	1	1								1	
445	Stag	497797	6625894	80	12	2					1			1	1				1						1		
446	Stag	497813	6625864	65	10	1					1				1				1						1		
447	Stag	497788	6625826	60	11	1					1				1				1						1		
448	Stag	497784	6625831	40	16	2					1	1			1	1			1						1		
449	White Mahogany	497905	6625781	100	17	1					1								1						1		
450	White Mahogany	497932	6625791	110	18	4						3	1		1	1	1	1		1						1	
451	Grey Ironbark	498028	6626228	145	27	8					1	4	3		1	1	1	1	1	1	1	1			1	1	
452	Pink Bloodwood	498041	6626312	130	23	5						2	1	2	1	1	1	1	1	1	1	1			1	1	
453	Pink Bloodwood	498112	6626300	150	28	10						4	3	3	1	1	1	1	1	1	1	1			1	1	

HBT Ref No.	Species	Easting	Northing	DBH (cm)	~Tree Height (m)	No. Func. Holl.	Trunk Butt	Trunk Fissures	Trunk Small	Trunk Medium	Trunk Large	Limb Small	Limb Medium	Limb Large	SF	MB	SG	LG	Po	Pa	Co	SO	LFO	EB	LM	AH	Comments
		WGS84	WGS84						<5cm	5-15 cm	>15 cm	<5cm	5-15 cm	>15 cm													
455	Turpentine	498104	6626361	95	19	5			2	1		1	1		1		1	1	1						1	1	
456	Stag	498414	6627052	85	18	3			1	1		1			1	1										1	
457	Pink Bloodwood	498408	6627076	105	25	4						3	1		1	1	1	1		1						1	
458	Stag	498572	6627321	50	8	1				1					1	1			1						1	1	
459	Swamp Mahogany	498633	6627386	105	22	6						4	2		1	1	1	1								1	
460	Flooded Gum	498641	6627441	115	24	7			4			2	1		1		1	1								1	
461	White Mahogany	498645	6627469	105	30	4						3	1		1	1	1	1		1						1	in gully on creek line
462	Grey Ironbark	498800	6627554	190	35	6						4	2		1	1	1	1		1						1	
463	Stag	498781	6627571	45	11	2		1			1				1				1						1	1	
464	Pink Bloodwood	498871	6627639	105	25	6						4	2		1	1	1	1	1							1	
465	Pink Bloodwood	498871	6627633	115	27	8						5	3		1	1	1	1	1							1	
466	Stag	498905	6627654	80	20	11		1	2	2	1	1	3	1	1	1	1	1	1	1	1	1			1	1	definite use by fauna
467	Stag	498913	6627739	75	13	2					1	1			1	1	1	1	1							1	
468	Stag	498969	6627751	65	15	7					1	1	2	3	1	1	1	1	1	1					1	1	
469	Stag	499013	6627780	65	20	11		1	2	1	1		3	3	1	1	1	1	1	1					1	1	
470	Swamp Mahogany	499561	6628389	140	18	7						4	3			1	1	1		1						1	
471	Pink Bloodwood	499038	6627772	105	24	4						3	1		1	1	1	1		1						1	
472	Stag	499070	6627776	70	19	10			1		1	5	3		1	1	1	1		1						1	
473	Turpentine	499084	6627817	90	19	2						1	1		1	1	1	1	1	1					1	1	
474	Stag	499118	6627888	65	14	2							1	1	1				1						1	1	
475	Coastal Blackbutt	499101	6627938	105	22	3						3				1	1									1	
476	Coastal Blackbutt	499101	6627939	90	21	2						2				1	1									1	
478	Coastal Blackbutt	499194	6627965	105	22	2			1			1				1	1									1	
480	Stag	499012	6627835	125	32	7						2	2	3	1	1	1	1	1	1	1	1			1	1	
481	Stag	498875	6627729	35	7	1					1								1						1		
491	White Mahogany	492522	6600188	130	15	1				1					1				1	1						1	Eastern Rosella using tree hollow
492	Broad-leaved Paperbark	493396	6601717	200	11	5			3	2						1				1						1	
493	Broad-leaved Paperbark	493392	6601720	40	11	3			2	1						1				1						1	
494	Broad-leaved Paperbark	493394	6601727	55	10	2			2							1										1	
495	Grey Mangrove	493782	6602801	75	7	4			2			2				1										1	
496	Broad-leaved Paperbark	494067	6602935	130	7	4		1	2	1						1				1						1	
497	Broad-leaved Paperbark	494048	6602890	65	7	5			3	1	1					1			1	1						1	
498	Broad-leaved Paperbark	494044	6602901	125	7	1					1								1							1	Common Ringtail Possum using
499	Broad-leaved Paperbark	494005	6602914	220	9	5			3	2						1				1						1	
500	Broad-leaved Paperbark	493993	6602976	40	8	2				1				1													Eastern Rosella using large limb hollow
501	White Mahogany	494353	6604053	90	16	6						3	2	1	1	1	1	1	1	1					1	1	
502	White Mahogany	494360	6604059	65	15	3						3			1	1										1	
503	White Mahogany	494370	6604038	70	16	3						3			1	1										1	
504	Small-fruited Grey Gum	494370	6604038	45	16	3						3			1	1										1	
505	White Mahogany	494347	6604049	90	16	6				1		2	3		1	1	1	1		1							Medium trunk hollow currently being used as extensive wear marks
506	White Mahogany	494348	6604045	35	9	3			2					1	1	1										1	
507	White Mahogany	494360	6604032	75	18	8						5	3		1	1	1	1	1	1						1	
508	White Mahogany	494375	6604033	65	19	1			1							1	1									1	
509	White Mahogany	494344	6604021	95	19	5						3	2		1	1	1	1		1						1	

HBT Ref No.	Species	Easting	Northing	DBH (cm)	~Tree Height (m)	No. Func. Holl.	Trunk Butt	Trunk Fissures	Trunk Small	Trunk Medium	Trunk Large	Limb Small	Limb Medium	Limb Large	SF	MB	SG	LG	Po	Pa	Co	SO	LFO	EB	LM	AH	Comments
		WGS84	WGS84						<5cm	5-15 cm	>15 cm	<5cm	5-15 cm	>15 cm													
510	White Mahogany	494344	6604022	95	18	9			1	1		3	3	1	1	1	1	1	1	1						1	
511	White Mahogany	494331	6604020	55	14	3						2	1			1	1			1						1	
512	White Mahogany	494326	6604003	55	15	2						2				1	1									1	
513	White Mahogany	494326	6603948	95	15	3						3				1	1									1	
514	Turpentine	494327	6603947	30	8	1			1						1											1	
515	White Mahogany	494327	6603937	95	19	4						2	1	1	1	1	1	1	1	1						1	
516	Turpentine	494327	6603913	40	9	2						1	1		1	1				1						1	
517	White Mahogany	494360	6604074	95	16	3				2		1			1					1						1	
518	Tallowwood	494358	6604104	65	18	3						2	1		1	1	1									1	
519	White Mahogany	494351	6604109	95	16	5				1		2	2			1	1	1	1	1						1	
520	White Mahogany	494351	6604133	45	13	1				1								1	1	1							Medium trunk hollow show signs of current use
521	Tallowwood	494356	6604153	105	23	6						4	2			1		1		1						1	
522	Tallowwood	494356	6604151	70	21	4						2	2			1		1		1						1	
523	White Mahogany	494328	6604137	105	20	9						4	3	2	1	1	1	1	1	1						1	
524	White Mahogany	494343	6604212	105	18	5						3	2		1	1	1	1	1	1						1	
525	Coastal Blackbutt	494336	6604291	130	23	3						3				1	1									1	Rainbow Lorikeet using medium trunk
526	Turpentine	494345	6604238	40	14	3			1	2					1		1			1				1		1	8.5 m above ground in trunk hollow nth facing
527	Turpentine	494336	6604234	75	15	4			2	2					1	1	1	1		1						1	
528	Coastal Blackbutt	494379	6604823	100	21	4						3	1			1	1	1		1						1	
529	Coastal Blackbutt	494376	6604808	100	21	3						3				1	1									1	
530	Coastal Blackbutt	494387	6604830	105	19	5						4	1			1	1	1	1	1						1	
531	Coastal Blackbutt	494424	6605254	95	16	6						3	3			1	1	1	1	1						1	
532	Stag	494468	6605254	45	12	9		1				5	3			1	1	1	1	1						1	
533	Coastal Blackbutt	494427	6605290	70	17	3						2	1			1	1	1	1	1						1	
534	Coastal Blackbutt	494448	6605406	55	15	2						2				1	1									1	
535	Coastal Blackbutt	494665	6605513	90	22	4						2	2			1	1	1		1						1	
536	Coastal Blackbutt	494661	6605516	105	22	10						4	5	1	1	1	1	1	1	1					1	1	
537	Coastal Blackbutt	494657	6605530	120	18	3						2	1		1	1	1	1	1	1						1	
538	Coastal Blackbutt	494653	6605567	100	20	5						3	2		1	1	1	1	1	1						1	
539	Coastal Blackbutt	494699	6605590	115	21	11			2			5	4		1	1	1	1	1	1						1	
540	Coastal Blackbutt	494740	6605764	115	21	4					1	3				1	1									1	
541	Coastal Blackbutt	494758	6605835	105	16	4						3	1			1	1	1		1						1	
542	Coastal Blackbutt	494757	6605788	135	21	4						2	2			1	1	1		1						1	
543	Coastal Blackbutt	494898	6606055	160	22	17	1	1	1			7	5	2	1	1	1	1	1	1		1			1	1	
544	Coastal Blackbutt	494859	6605960	80	17	4						3	1			1	1			1						1	
545	Coastal Blackbutt	494851	6605965	85	19	4						3	1			1	1			1						1	
546	Coastal Blackbutt	494776	6605802	85	17	5						4	1			1	1			1						1	
547	Coastal Blackbutt	494758	6605774	90	17	2						2				1	1									1	
548	Coastal Blackbutt	494810	6605714	125	24	16						8	6	2	1	1	1	1	1	1		1			1	1	
549	Coastal Blackbutt	494817	6605767	105	20	4						3	1		1	1	1	1	1	1						1	
550	Coastal Blackbutt	494831	6605835	105	26	8						5	3		1	1	1	1	1	1						1	
551	Coastal Blackbutt	494832	6605844	280	28	26						15	7	4	1	1	1	1	1	1	1	1			1	1	Near to the construction footprint. All efforts should be made to retain this tree as it contains the bulk of the immediate tree hollow resources

Appendix B
Threatened Flora Management Plan

Warrell Creek to Urunga Upgrade of the Pacific Highway

Threatened Flora Management Plan

Prepared for:

NSW Roads and Maritime Services
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Prepared by:

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Version 5: 1/7/2016

CONTENTS

Photo front page - Slender Marsdenia (*Marsdenia longiloba*)

EXECUTIVE SUMMARY

[Revision note: Version 5 of the TFMP (1/7/2016) is the same as Version 4 (24/12/2014) except for an update to Section 4.8.3, the translocation monitoring schedule. The following summary information from Version 4 remains unchanged and applies to Version 5.

Version 4 was prepared to assist with development, construction and operation of the southern half of the Warrell Creek to Urunga (WC2U) project known as the Warrell Creek to Nambucca Heads (WC2NH) upgrade. Additional threatened flora information relevant to WC2NH has been incorporated into the plan, including the results of additional flora surveys and analysis of impacts in terms of Roads and Maritime concept design.

This Plan update does not include additional records of threatened flora for the northern half of the WC2U project (i.e. NH2U) from pre-clearing surveys for NH2U. For example, the results of the targeted survey for Spider Orchid (*Dendrobium melaleucaphilum*) on NH2U were not included. NH2U is currently being constructed and management measures for protection of threatened flora, including translocation have already been implemented. Additional records from the NH2U construction phase were not considered relevant to implementation of this Plan for the WC2NH upgrade. (Seven-part tests of significance were revised after the NH2U pre-clearing flora survey to include additional records, but there was no change in the test conclusions.)

This version of the TFMP provides two definitions of directly impacted threatened flora. The two defintions differ in their spatial extent relative to the design footprint as seen below:

Northern Section NH2U - Directly impacted:- Directly impacted individuals are those located under the design footprint plus **10 metres**, which is the limit of clearing.

Southern Section WC2NH - Directly impacted:- Directly impacted individuals are those located:

- Under the concept design footprint plus **15 metres**.
- Under the operational water quality basins plus 10 metres.
- Under new or reconstructed access roads within Nambucca State Forest plus 10 metres.
- For utility adjustments within clearing requirements of utility authorities.
- Within three metre clearing width for boundary fencing - excluding within Nambucca State Forest and swamp forest where a flying fox camp is located.

The number of direct/indirect/in situ Rusty Plum, Slender Marsdenia and Floyds Grass differ slightly from ver. 1 (6/3/2013) of this plan. The number of Rusty Plum decreased following re-survey of the Cockburns Lane area at Warrell Creek in May 2014, as follows (previous in brackets): directly impacted 11 (12), indirectly impacted 1 (4) and in situ 0 (2). The number of Slender Marsdenia increased due to inclusion of additional records from the Slender Marsdenia genetic study currently underway and a utilities survey, as follows: directly impacted 176 (161), indirectly impacted 20 (22) and in situ 4 (20). Of the four Floyds Grass points, one is now directly impacted, two indirectly impacted and one in situ.]

ECOS Environmental Pty Ltd has been engaged by Roads and Maritime Services to prepare a Threatened Flora Management Plan for the Warrell Creek to Urunga upgrade of the Pacific Highway.

The Threatened Flora Management Plan includes:

- a targeted survey of threatened plant species within the approved Warrell Creek to Urunga project boundary;
- assessment of the feasibility of undertaking translocation of affected threatened plant species;
- specification of management measures to ensure the protection of in-situ threatened flora during highway construction and operation;
- design of a detailed translocation proposal for impacted threatened species where translocation is considered to be a feasible management option.
- assessment of the requirement for compensatory habitat as a mitigatory measure for impacted threatened flora

The targeted survey recorded six threatened species (four endangered and two vulnerable), two ROTAP species and one species recommended for threatened species listing within the project boundary.

Table 1A shows the number of species directly impacted, indirectly impacted and to remain in situ for the whole WC2U corridor.

Table 1A: Threatened and rare flora impacted by the whole WC2U project

WC2U (whole road corridor)	**Directly Impacted**		**Indirectly Impacted**		**Road Reserve - in-situ**	
Threatened Species	points	no.	points	no.	Points	no.
Slender Marsdenia (E) (*Marsdenia longiloba*)	68	176	7	20	2	4
Rusty Plum (V) (*Niemeyera whitei*)	12	12 +sdg	0	0	0	0
Maundia (V) (*Maundia triglochinoides*)	~500+ m^2		~50 m^2		~50 m^2	
Floyds Grass (E) (*Alexfloydia repens*)	1	~2m^2	2	~2m^2	1	~2m^2
Wooll's Tylophora (E) (*Tylophora woollsii*)	5	9	-	-	3	6
Spider Orchid (E) (*Dendrobium melaleucaphilum*)	13	~40	16	35	70	200
ROTAP*						
Ford's Goodenia (*Goodenia fordiana*)	9	9m^2	1	1m^2	-	-
Potential Threatened Species Listing						
Koala Bells (*Artanema fimbriatum*)	7	65	2	55	-	-

*Eucalyptus ancophila not included as it was relatively common in the study area.

Table 1B shows the number of species directly impacted, indirectly impacted and to remain in situ for the southern half of the project – WC2NH.

Table 1B - Threatened and rare flora impacted by the WC2NH project

Southern WC2NH section	**Directly Impacted**		**Indirectly Impacted**		**Road Reserve - in-situ**	
Threatened Species	points	no.	points	no.	Points	no.
Slender Marsdenia (E) (*Marsdenia longiloba*)	43	75	2	4	1	1
Rusty Plum (V) (*Niemeyera whitei*)	10	10 +sdg	0	0	0	0
Maundia (V) (*Maundia triglochinoides*)	~500+ m^2		~50 m^2		~50 m^2	
Floyds Grass (E) (*Alexfloydia repens*)	1	~2m^2	2	~2m^2	1	~2m^2
Wooll's Tylophora (E) (*Tylophora woollsii*)	2	2	0	0	0	0
Spider Orchid (E) (*Dendrobium melaleucaphilum*)	3	10	0	0	0	0
ROTAP						
Ford's Goodenia (*Goodenia fordiana*)	2	2m^2	1	1m^2	0	0
Potential Threatened Species Listing						
Koala Bells (*Artanema fimbriatum*)	2	13	0	0	0	0

The translocation feasibility assessment concluded that translocation of the subject species would be technically feasible and have significant conservation benefits for the impacted species.

The management plan also outlines a process for incorporating compensatory habitat for impacted threatened plant species in the Biodiversity Offset Strategy.

A Translocation Plan set out in Section 4 includes procedures for the translocation of four threatened plant species and two rare species impacted by WC2U upgrade. The proposed translocation involves three complementary activities:- salvage translocation, population enhancement and experimentation. Salvage translocation aims to save and re-establish those individuals of significant flora directly impacted by construction. Enhancement aims to improve the prospective viability of translocated populations by propagating and introducing additional individuals. The experimental component aims to increase understanding of species ecology and how translocation outcomes are affected by ecological factors. The Translocation Plan includes a monitoring program to be conducted during highway construction and operation. Evaluation criteria are defined for assessing translocation results.

The final two sections of the Management Plan deal with measures for the management of roadside (in-situ) threatened flora and management of unforseen impacts, including additional impacts due to possible design changes once the contract is awarded and the detailed design is prepared. Included in the former is a monitoring program for in-situ roadside threatened flora that would run for 5 years post-construction.

The following table lists the Minister for Planning's Conditions of Approval for the Warrell Creek to Urunga highway upgrade relating to threatened flora management and where these are addressed in the Threatened Flora Management Plan.

Conditions of Approval dealing with threatened flora management	Section in Management Plan where addressed
B7(a)	Sections 1 to 3.5
B7(b)	Section 4
B7(d)	Section 5
B10(a)	Section 4.6.7
B31(b)(vi)	Section 5
B31(b) (vii)	Section 6

1 INTRODUCTION

1.1 Purpose

ECOS Environmental has been engaged by Roads and Maritime Services (RMS) to prepare a Threatened Flora Management Plan for the Warrell Creek to Urunga Upgrade of the Pacific Highway.

The purpose of this Management Plan is to fulfill Condition of Approval No.B7 of the Minister of Planning and Infrastructure, for the Warrell Creek to Urunga project, which concerns the mitigation of impacts on threatened plant species. Specifically, the Minister's Condition of Approval (MCoA) requires an assessment of the potential for the translocation of plants impacted by the project, and the need for compensatory habitat.

MCoA B7 states:

"Mitigation Measures - Amorphospermum whitei and Marsdenia longiloba

B7. Prior to the commencement of any construction work that would result in the disturbance of Amorphospermum whitei and Marsdenia longiloba, the Proponent shall in consultation with the OEH develop a management plan for these species which:
(a) investigates the potential for the translocation of plants impacted by the project;
(b) if investigation under Condition B7(a) reveals translocation of impacted plants is feasible, includes details of a translocation plan for the plants consistent with the Australian Network for Plant Conservation 2nd Ed 2OO4: Guidelines for the Translocation of Threatened Species in Australia, including details of ongoing maintenance such as responsibilities, timing and duration;
(c) identifies a process for incorporating appropriate compensatory habitat for the impacted plants in the Biodiversity Offset Strategy referred to in Condition B8 should the information obtained during the investigation referred to in Condition B7(a) find that translocation is not feasible or where the monitoring undertaken as part of condition B10 finds that translocation measures have not been successful (as identified through performance criteria); and
(d) includes detail of mitigation measures to be implemented during construction to avoid and minimise impacts to areas identified to contain these species, including excluding construction plant, equipment, materials and unauthorised personnel.
Unless otherwise agreed to by the Director General, the Plan shall be submitted for the Director General's approval prior to the commencement of any construction work that would result in the disturbance of Amorphospermum whitei and Marsdenia longiloba." (MCoAs B7, B8 & B10 can be found in Appendix 5).

This management plan aims to satisfy the Minister’s requirements and formulate a comprehensive set of measures to mitigate impacts on threatened flora. As well as *Amorphospermum whitei* and *Marsdenia longiloba* specified in MCoA B7 above, RMS would apply the intent of this Condition of Approval to any other threatened plant species detected within the project boundary of the Warrell Creek to Urunga

Upgrade upgrade during the targeted threatened plant species survey carried out in conjunction with this management plan.
(Note - *Amorphospermum whitei* will be referred to below by its current name *Niemeyera whitei*.)

The threatened flora management tasks that ECOS Environmental Pty Ltd has been engaged by RMS to complete include:-

- targeted survey and marking of threatened plant species within the approved project boundary of the Warrell Creek to Urunga Upgrade prior to the commencement of construction;
- assessment of the feasibility of undertaking translocation of affected threatened plant species;
- specification of management measures to ensure the protection of in-situ threatened flora during highway construction and operation;
- design of a detailed translocation proposal for impacted threatened species where translocation is considered to be feasible management option.
- assessment of the requirement for compensatory habitat as a mitigatory measure for impacted threatened flora.

The contents of this report are set out as follows:-

- Section 2 provides an overview of the contents of the Threatened Flora Management Plan.

- Section 3 describes the methods and results of a survey targeting threatened flora which was conducted for this plan and then assesses the translocation potential of the species recorded. Section 3 also discusses the issue of compensatory habitat in the context of the feasibility of translocating species and overall conservation objectives.

- Section 4 sets out a Translocation Plan designed to salvage directly impacted threatened species and establish new, viable populations of these species.

- Section 5 provides details of measures to protect in-situ threatened flora within the project boundary during highway construction and operation.

- Section 6 addresses management of unforseen impacts on threatened and rare flora.

The remainder of this introduction provides a summary of Warrell Creek to Urunga Upgrade (WC2U) project and the natural environment of the project area, details of consultations with the Environmental Protection Authority (EPA) and the Department of Planning and Infrastructure (DPI) conducted during preparation of the report, and a glossary of terms.

Version 3 (26/11/2014) of the Threatened Flora Management Plan has been prepared to assist with implementation of the Plan for the southern half of the Warrell Creek to Urunga (WC2U) project, the Warrell Creek to Nambucca Heads (WC2NH), upgrade, soon to begin construction. Additional information relevant to WC2NH has been incorporated into the plan, including the results of additional threatened flora surveys and analysis of impacts in terms of the RMS concept design.

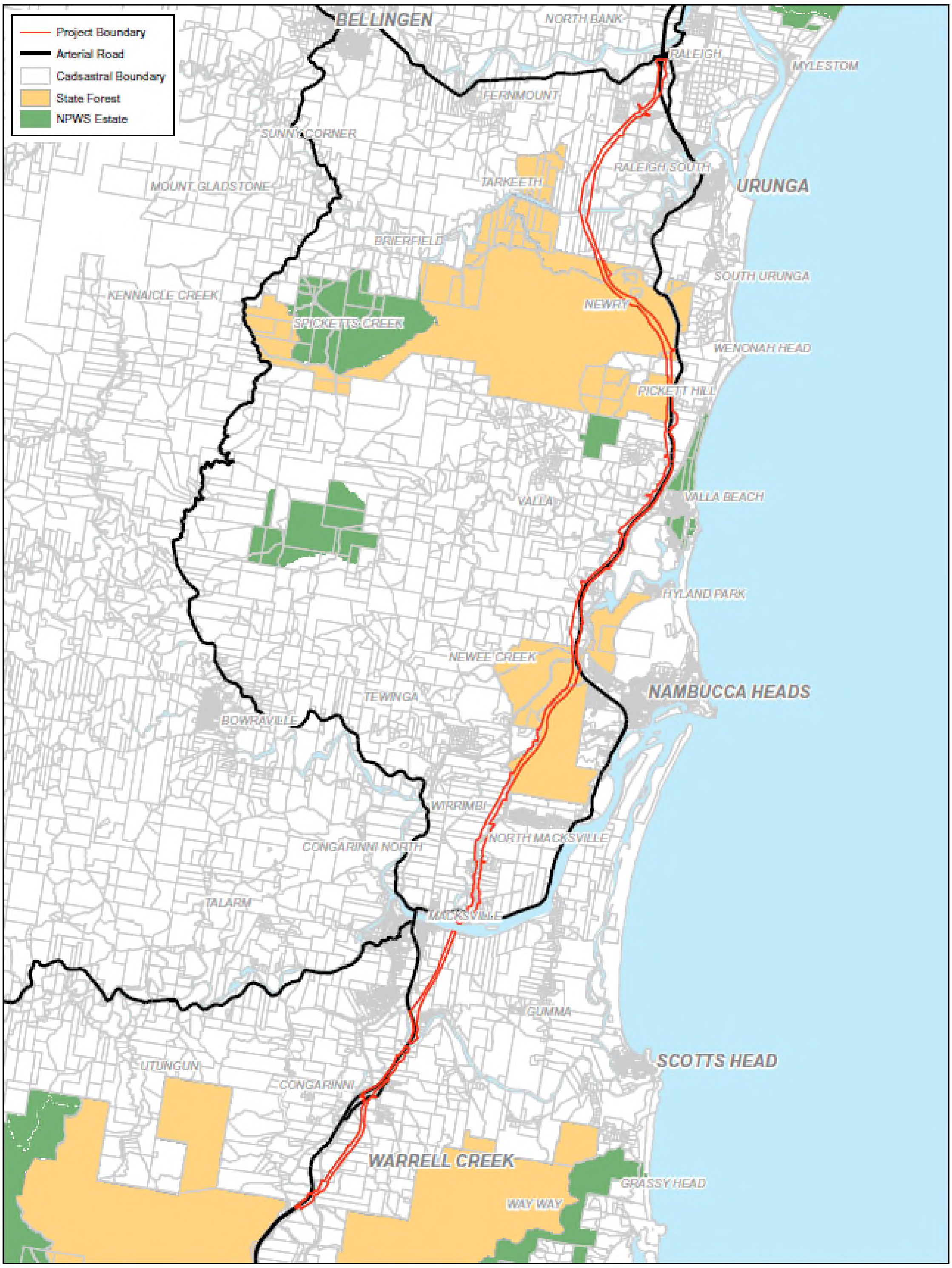

Figure 1: Location map of the Warrell Creek to Urunga Pacific Highway Upgrade corridor

Source:
Cadastre: Roads and Traffic Authority 2007
Roads: Geoscience Australia 2009
NPWS Estate: NPWS 2011
Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW Department of Primary Industries 2008

0 2 4 6 8
Kilometers
A4 Scale 1:150,000

map production by www.geoview.com.au

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1.2 Description of the Study Area

1.2.1 Location

The Warrell Creek to Urunga Upgrade of the Pacific Highway is located on the Mid North Coast of NSW and extends from Allgomera south of Warrell Creek, 42kms north to the Waterfall Way interchange at Raleigh, traversing the Nambucca and Bellingen local government areas (Figure 1). The study area for this report comprises land within the project boundary of WC2U upgrade, as approved by the Department of Planning.

1.2.2 Landscape Context

The study area lies within the coastal strip of the Manning-Macleay region and includes two landscape types: the Manning-Macleay Coastal Alluvial Plains and the Ingalba Coastal Hills (Mitchell 2003). The Manning-Macleay Coastal Alluvial Plains consists of wide valleys, channels, alluvial floodplains, swamps and terraces of rivers and creeks in the coastal part of the Manning and Macleay region. In the study area this landscape is present on the alluvial floodplains of the Nambucca and Kalang Rivers and smaller creeks including Deep Creek, Boggy Creek and Oyster Creek. Soils are formed on Quaternary alluvium and include dark organic loams and silty clays on the floodplain, gradational brown loams and yellow-brown texture-contrast soil on terraces, and organic silty mud in swamps. Forested areas are dominated by swamp sclerophyll forest, particularly Swamp Oak, and mixed floodplain forest.

The Ingalba Coastal Hills landscape comprises coastal hills and slopes underlain by metamorphic rocks of Permian age including slate, phyllite, schistose sandstone and schistose conglomerate, which collectively comprise the Nambucca Beds. Soil types formed on this geology include thin, stony gradational loam on upper slopes grading to yellow-brown texture-contrast soils on lower slopes and in valleys. The Ingalba Coastal Hills are represented by rolling hills with an elevation of a few hundred metres surrounding the coastal floodplain of Nambucca and Kalang Rivers and other small creeks. Natural vegetation consists of dry sclerophyll forest on upper slopes and ridges, and wet sclerophyll forest in gullies.

1.2.3 Native Vegetation

Approximately two-thirds of WC2U corridor intersects native vegetation. The most widespread vegetation types according to RTA (2010) are Dry and Moist Open Forest (i.e. dry and wet sclerophyll forest), which occur on hills and the coastal plain. Dry Open Forest dominated by Blackbutt (*E. pilularis*) is the commonest forest type (Table 1). This occurs on lower to upper hill slopes and has a grassy and/or shrubby understorey. Lower slopes and gullies support Moist Open Forest, which is characterised by a mesic understorey of small rainforest trees, shrubs and ferns. Two types of Moist Open Forest are present:- (i) Flooded Gum (*E. grandis*) and (ii) White Mahogany/Grey Gum/Ironbark (*E. acmendoides/E. propinqua/E. siderophloia*). Coastal floodplains support Moist Open Forest (Flooded Gum) and Swamp Sclerophyll Forest dominated by Swamp Oak (*Casuarina glauca*) and/or Paperbark (*Melaleuca stypheloides* and *Melaleuca quinquenervia*) and/or Swamp Mahogany (*Eucalyptus robusta*), together with small areas of Freshwater Wetland and Mangroves (Table 1).

The road corridor intersects native vegetation fragments of different sizes. On the cleared floodplains which are mostly used as agricultural land there is an abundance of small vegetation patches in the 1-10 ha range followed by larger patches in the 10-50 ha range (RTA 2010). The largest areas of continuous vegetation are located in Newry, Little Newry and Nambucca State Forests on hilly topography.

Table 1: Native vegetation types directly impacted by the WC2U road corridor, assuming a 10m construction buffer (source RTA 2010, Table 5-1)

Vegetation Association**	**Impact including 10m buffer (ha) (footprint)**
Dry Open Forest – Blackbutt	144.11
Moist Open Forest - White Mahogany/Grey Gum/Ironbark	28.76
Moist Open Forest - Flooded Gum	21.91
Mixed Floodplain Forest (EEC)	12.49
Swamp Forest - Swamp Mahogany/Paperbark (EEC)	12.47
Swamp Forest - Swamp Oak (EEC)	33.07
Freshwater Wetlands (EEC)	8.89*
Mangroves	0.19
Total	255.15

*updated in Dec. 2012 after follow-up vegetation mapping by Ecos Environmental for RMS
** Lowland Rainforest (EEC) was deleted in Ver. 3 after ground-truthing by ECOS Environmental (NH2U) and Geolink (WC2NH) found that vegetation mapped as Lowland Rainforest was either wet sclerophyll forest or camphor laurel.

1.3 Consultation

Consultation on the Threatened Flora Management Plan included the following steps:

The Draft Threatened Flora Management Plan was sent to the Environmental Protection Authority on 15/5/2012 for their review and comment. EPA provided comments on 20/7/2012.

A further draft of the Threatened Flora Management Plan was sent to the Environmental Protection Authority on 12/12/2012. EPA provided comments on 17/12/2012.

Full details of comments raised by EPA and RMS responses are attached in Appendix 9 of this report.

1.4 Glossary

Study area - for the purposes of this report, all land within the approved project boundary of WC2U Pacific Highway Upgrade.

Road corridor - all land within the approved project boundary of WC2U Pacific Highway Upgrade.

Road reserve - all land within the approved project boundary of WC2U Pacific Highway Upgrade, or land within the project boundary that is not part of the construction footprint (also referred to as residual land).

Footprint - the area within the project boundary that would will be cleared and disturbed during highway construction.

Wet sclerophyll forest - a broad vegetation type characterised by an upper stratum of *Eucalyptus* and sometimes *Lophostemon* and *Syncarpia*, with a mesophytic understorey of small trees, vines, shrubs or ferns.

Dry sclerophyll forest - a broad vegetation type characterised by an upper stratum of *Eucalyptus* and an understorey dominated by grasses and/or sclerophyllous shrubs.

Rainforest – can refer to a broad *vegetation type,* i.e. humid forest with a closed canopy; or it can refer to a class of *plant species,* i.e. broad-leaved/non-sclerophyllous species found in rainforest, but also in the understorey of open forest/wet sclerophyll forest. (Rusty Plum (*Niemeyera whitei*) is described as a ‘rainforest’ species below, as it has the leaf morphology of a rainforest plant, not because there is rainforest on WC2U; it occurs in wet sclerophyll forest.)

Genet - a plant individual originating by sexual reproduction (ie. chromosome recombination), which is genetically different from other plants of the same species. Genets grow from seed produced by the parent plant; ramets are produced vegetatively from the parent plant.

Ramet - a plant individual originating by vegetative reproduction and genetically the same as other individuals (ramets) from the same parent plant. There are various forms of vegetative reproduction. Ramets are usually produced from rhizomes and adventitious root suckers.

Sub-population - spatially discrete occurrences of a species more than 100 metres apart.

Threatened species point - GPS record or positional coordinates of a threatened species individual or closely spaced group of individuals.

Stem-individual - an individual plant in a group of ramets; used in this report to describe the structure and size of Slender Marsdenia occurrences.

Nationally rare or ROTAP species - a species listed in 'Rare or Threatened Australian Plants' (Briggs and Leigh 1995). Regionally significant - rare, disjunct or at the distributional limits of its range, after Sheringham and Westway (1995).

2 MANAGEMENT PLAN OVERVIEW

The following initiatives were incorporated in this management plan to mitigate impacts on threatened flora: -

- Targeted survey within the approved project boundary for threatened plant species, to provide comprehensive details of the distribution and number of threatened flora individuals;
- Consideration of road design adjustments to avoid or minimise where possible, impacts on any additional threatened flora individuals detected;
- Translocation of impacted threatened plant species where considered feasible and of conservation benefit;
- Protective measures for threatened flora retained in-situ within the project boundary/road reserve;
- Provision of threatened plant species compensatory habitat where considered essential to maintain or replace populations impacted by the project; and
- Management of unforseen additional impacts.

These measures are summarised briefly below and described in detail in the relevant sections of the management plan.

Targeted threatened flora survey

Botanical surveys of the preferred route for the WC2U upgrade were conducted in 2007 during the project Environmental Assessment (RTA 2010). A more intensive survey targeting threatened species within the approved boundary of the WC2U Upgrade was conducted by ECOS Environmental in Nov-Dec 2011, in conjunction with preparation of this management plan. Further flora survey work targeting threatened species was carried out in the Technical Review area in Oct 2012. The aim of surveys was to collect comprehensive and up-to-date data on the location and number of individuals of the threatened species within the approved project boundary, prior to the start of construction. Nationally rare (ROTAP) and regionally significant species were also recorded during the survey. The targeted surveys are described in detail in Section 3.

Avoiding impacts during highway design

The concept design for the WC2U project was developed during the route selection study and preliminary design stages, and includes refinements to avoid or minimise impacts on threatened flora within the study area. This included avoidance of potential habitat of the Eastern Underground Orchid (*Rhizanthella slateri*) in Newry State Forest (refer to page 104 of the Warrell Creek to Urunga- Submissions and preferred project report) and minimisation of impact on a population of the endangered Spider Orchid (*Dendrobium melaleucaphilum*) in Newry State Forest. The highway alignment in the concept design was assessed in the project Environmental Assessment, and approved by the Minister for Planning.

Since project approval was received, other initiatives have been implemented to avoid impacts to threatened species that occur within the project boundary. These include measures such as marking each threatened species within the project corridor with flagging tape and labels to identify each species in the field, and to provide reference points on sensitive area plans used during the project.

Power utility infrastructure has also been relocated away from areas that contain threatened species individuals where possible. Design of the service utilities upgrade was conducted after the targeted threatened flora survey was completed, allowing impacts to be minimised taking into consideration the results of the targeted survey.

Most of service utilities will be relocated to the outer part of the road reserve, which had been less intensively surveyed than the centre of the road corridor. To address possible gaps in flora survey coverage, a further survey was conducted of the routes proposed for service utilities upgrade to identify any additional impacted threatened species. Additional impacts were recorded at two locations involving ten additional individuals of three already recorded species. These are included on the species location maps in Appendix 1, indicated by the suffix - 'u'. The service utilites flora survey is described in the report: 'Targeted Flora Survey of Proposed Service Utility Alignments, Nambucca Exit to Urunga' (ECOS Environmental 2012)

Following the results of the targeted flora survey conducted for this report, the following threatened flora locations were identified as sites where particular attention would be given to minimising adverse impacts during construction:-

- Maundia population at Williamson's Creek
- Floyds Grass population at Warrell Creek
- Slender Marsdenia sites in the Little Newry and Nambucca State Forest areas
- Spider Orchid populations in Newry State Forest
- Rusty Plum population at Cockburn's Lane, Warrell Creek.

Notwithstanding the activities already undertaken to reduce the impacts of the upgrade on threatened species, RMS is committed to ensuring that the potential impact to threatened species within the road corridor is reduced where reasonable and feasible. This will occur during both the ongoing development of the detailed design, and the construction phase of the upgrade. Results of all survey efforts undertaken to date will be incorporated into all the relevant design drawings and plans throughout the design and construction stages. Additional details of mitigation measures to be implemented are discussed in Sections 5 of this report.

Translocation

The purpose of translocating impacted threatened species in a developmental context is to avoid a decline in population number and genetic diversity of threatened species as a result of development impacts. The objective of translocation is to establish new, compensatory populations that are self-sustaining over the long term, which is usually implemented by a combination salvage transplanting, propagation and introduction, and habitat restoration. As well as assisting the maintenance of population number and genetic diversity, translocation can improve understanding of threatened species life history and ecology, through attempts to manipulate and maintain natural populations. Following assessment of the technical feasibility and conservation benefits of species translocation, a Translocation Plan including pre-translocation assessment, translocation proposals for each species and post-translocation measures such as maintenance and monitoring is set out below in Section 4.

Compensatory Habitat

This section presents an assessment of whether compensatory habitat is required for threatened species impacted by the project, in the context of likely translocation outcomes for each impacted species and the overall objective of threatened flora mitigation for this project. The outcomes of threatened flora mitigation delivered by means of translocation and provision of compensatory habitat on previous North Coast highway projects is also discussed in Section 3.6.4.

Protection of in-situ roadside threatened flora

A substantial number of threatened species individuals will remain within the road reserve, outside the construction footprint. A series of measures designed to protect these plants from damage during construction and operation of the WC2U upgrade are set out in Section 5 of this report.

Management of unforseen additional impacts

Throughout the construction period there is a possibility of design changes that may impact on additional areas of native vegetation. This contingency would be managed with respect to the subject species as described in Section 6 below.

3 TARGETED FLORA SURVEYS

3.1 Environmental Assessment Vegetation Survey

A vegetation survey was conducted during the Environmental Assessment (EA) for the WC2U project in 2007, as described in the 'Working Paper 2, Flora and Fauna' (RTA 2010). The EA vegetation survey examined flora and plant communities on and adjoining the preferred route using quadrats, transects and traverses (see Figures 2-2 to 2-5, RTA 2010). The survey design employed a sampling approach rather than a continuous survey of the whole road corridor. *"Survey effort was determined through the stratification of the study area and the level of variability observed in each stratification unit."..."Stratification was based on a 150 m wide corridor (the study area) to account for the footprint and adjacent edge effects...The number of transects sampled was proportional to the size of the stratification units identified with up to two 100 m transects sampled per 2-50 ha of each stratification unit and three 100 m transects sampled per 51-250 ha of stratification unit (Department of Environment and Conservation 2004)"* (RTA 2010 p. 11-12).

The EA vegetation survey also involved targeted threatened species searches. *"Targeted threatened flora searches were focused on but not limited to slender marsdenia, rusty plum, Newry golden wattle, scented acronychia and milky silkpod, as specified in the Director-General's requirements. Also included in the targeted surveys were red bopple nut (Hicksbeachia pinnatifolia), Maundia triglochinoides and brown fairy-chain orchid (Peristeranthus hillii) "* (p. 12).

Two threatened species were recorded within the study area/road footprint during the EA survey: Marsdenia longiloba and Amorphospermum whitei (syn. Niemeyera whitei). Six additional threatened plant species were identified as potentially present within the road footprint - Acronychia littoralis, Acacia chrysotricha, Maundia triglochinoides, Parsonsia dorrigoensis, Hickesbeachia pinnatifolia and Peristeranthus hillii (RTA 2010, p. 155).

3.2 Targeted Orchid Surveys (EcoPro 2010 & Geolink 2012)

A flora survey targeting the endangered Eastern Underground Orchid and Spider Orchid was conducted by EcoPro in January and May 2010. The survey report concluded as follows:

"A detailed threatened orchid survey was undertaken within the proposed project road corridor located within Newry State Forest (on 18-22 January 2010). The main purpose of this survey was to identify individuals and habitat of the threatened Eastern Underground Orchid (*Rhizanthella slateri)*. Searches were also conducted for the threatened Spider Orchid (*Dendrobium melaleucaphilum*). A subsequent orchid survey was conducted in potential habitat for the Spider Orchid throughout the remainder of the proposed project road corridor and adjacent areas (on 17-19 May 2010). No Eastern Underground Orchids were found, although it was not the optimum time for this species detection.

Seven colonies of the threatened Spider Orchid were recorded. The two largest populations were found in Newry State Forest in two branches of the same drainage line. These sites were estimated to contain about 2,000 individuals.

The original route alignment in Newry State Forest would have significantly impacted on potential Eastern Underground Orchid habitat, the two largest populations of Spider Orchid and on the Slender Marsdenia colony in this area. To minimise the impact on all three threatened species the alignment was shifted to the west. It is also recommended that the construction boundary (consisting of the extent of earthworks plus an additional five metres) be locked into place in this area to prevent an additional encroachment into threatened species habitat during detailed design and construction.

Using this construction boundary to assess the significance of the Proposal, it was determined that the refined route alignment would not significantly impact on the three threatened species discussed in this report. The refined alignment removes only a very small portion of Eastern Underground Orchid potential habitat. It also entirely avoids any direct impact on the Slender Marsdenia colony, while only a small portion of the Spider Orchid populations (about 60) would be directly impacted. Spider Orchids are fairly easy to translocate, and it is recommended that any directly impacted individuals be translocated into adjacent habitat.

A number of other mitigation measures have been recommended to reduce indirect impacts associated with the Proposal. These include careful control of locational information and maps with regards to the threatened Spider Orchid; installation of protective fencing near threatened species populations, assessment of the need for additional drainage measures near Eastern Underground Orchid habitat and an assessment of the need for visual screening of the Spider Orchid populations near the alignment.

Two additional orchids considered to be of significance were recorded along the route alignment; the Great Climbing Orchid (*Psuedovanilla foliata*) and *Arthrochilus prolixus*." (EcoPro 2010, p. 36)

Spatial impact analysis of the EcoPro (2010) survey data using the latest highway design showed that ten of the Spider Orchid points recorded by EcoPro were directly impacted and15 indirectly impacted by the project (i.e. located within <10 m of the construction footprint. A further 69 points would remain in-situ within the road reserve and 363 points were outside the project boundary (see Appendix 2, Table 2). The figure of 60 directly impacted Spider Orchid plants reported by EcoPro (2010) does not apply to the current highway design and appears to be based on an earlier design version, which was modified to avoid impacting this species.

A further survey targeting the Eastern Underground Orchid, as well as two endangered species of *Diuris* was conducted by Geolink in September 2012. The purpose of this survey was to search for the Eastern Underground Orchid during its reported flowering period, as the previous targeted survey conducted by Ecos Environmental was in November 2011 at the end, or outside its known flowering period. The Geolink survey also targeted the Willawarrin Doubletail (*Diuris disposita*) and Byron Bay Diuris (*Diuris byronensis*), two endangered species of terrestrial ‘donkey’ orchid, which have both been recorded on the Mid North Coast in habitat similar to that found in the study area. The survey concluded that “No individuals of the subject orchid species were recorded at any of the targeted survey locations during the survey. No additional surveys for the target species along the NH2U section of the WC2U alignment are considered to be necessary. Safeguards and mitigation measures to protect potential occurrences of these species are considered to be adequate and any potential impacts of the Proposal on unidentified occurrences of these species are likely to be minor."

3.3 Targeted Survey for the Threatened Flora Management Plan

3.3.1 Survey Design

Due to the potential for additional threatened species and more individuals of already recorded species to be present in the road corridor, further targeted threatened flora survey work was commissioned by RMS to ensure that spatial threatened flora data forming the basis of the threatened flora management plan was as comprehensive as possible.

Desktop review indicated that threatened plant species could potentially occur in all habitats present in the road corridor, therefore all habitats would need to be surveyed during the follow-up survey. To ensure survey results were as comprehensive as possible it was considered necessary to conduct a continuous survey of the whole road corridor rather than adopt a sampling approach as used in the EA flora surveys.

The targeted survey was conducted by a team of three botanists with local flora survey experience. One botanist followed a traverse along the approximate centre line of the road corridor, using a Nautiz X7 handheld GPS/PDA for navigation. The other two botanists walked 20-50 metres to either side of the centre line, along roughly parallel meander traverses. The Nautiz was loaded with several GIS layers to assist in the survey including terrain contours, vegetation type, threatened flora locations (from the EA), the project boundary and the detailed road design. Field data were recorded with the PDA and entered using a touch screen keyboard.

The study area was stratified geographically into four sections approximately 10.5km long (equivalent to Figures 3-7 to 3-10 in Working Paper 2, Flora and Fauna):-
Section 1 - Nambucca River/Macksville to Allogomera
Section 2 - Nambucca Heads turn-off to the Nambucca River/Macksville
Section 3 - Little Newry State Forest to Nambucca Heads turnoff
Section 4 - Raleigh/Urunga to the southern boundary of Newry State Forest
Each section received approximately the same number of days. On average 4-5 km of road corridor were surveyed per day.

3.3.2 Indicative Species List

A list of threatened plant species potentially present in the study area was compiled prior to the start of the survey from OEH Wildlife Atlas records, the EPBC Act Protected Matters Search Tool and other flora survey reports (Table 2). Nationally rare species (ROTAP - Briggs and Leigh 1996) and regionally significant species (Sheringham and Westaway 1995; NPWS 1998) were included in the list of conservation significant species. State and Federal threatened species websites were checked for recent preliminary listings and final determinations of threatened plant species potentially in the study area.

Databases, reports and sources: -

- Wildlife Atlas - NSW Environmental Protection Authority (see Appendix 6);
- Protected Matters Search Tool - Federal Department of Sustainability, Environment, Water, Population and Communities (see Appendix 6);
- Australia's Virtual Herbarium;
- Tweedie, T.D., Bruskin, S., Chapman, W.S. and Heyward, R.W. (1995). Flora Survey, Urunga and Coffs Harbour Management Areas, Northern Region, New South Wales. Research Division, State Forests of New South Wales, Sydney;
- ROTAP (Briggs and Leigh 1995) for nationally rare species;
- Sheringham and Westaway (1995) and NPWS (1998) for regionally significant plants;
- ECOS Environmental (2006). Bonville Bypass Pre-clearing Threatened Flora Survey. Report to Abigroup Contractors P/L; and
- ECOS Environmental (2010). PART A: Targeted Survey of Threatened Flora on the Sapphire to Woolgoolga Upgrade of the Pacific Highway and Assessment of Translocation Feasibility. Report to Leighton Fulton Hogan Joint Venture.

Wildlife Atlas indicated that 15 threatened flora species were present within 10km of the road corridor (see Appendix 6). The dates of records showed that some were added to Wildlife Atlas after the EA surveys conducted in 2007. Other reports and information suggested that a further seven threatened plant species could occur in the study area, or a total of 22 potentially occurring threatened plant species (Table 2).

Table 2: Indicative list of threatened plant species known or potentially present in the study area based on the EA survey results, OEH Wildlife Atlas records and other sources. TSC Act and EPBC Act Conservation Status is shown as E – Endangered, CE - Critically Endangered, V- Vulnerable, nl - not listed.

Species	**TSC-EPBC Status**	**Habitat and Likelihood of Occurrence**
		Previously Recorded within Project Boundary
Marsdenia longiloba Slender Marsdenia	E - V	Wet sclerophyll forest in hilly terrain.
Niemeyera whitei Rusty Plum	V - nl	Wet sclerophyll forest.
		Possible Occurrence within Project Boundary
Acronychia littoralis Scented Acronychia	E - E	Coastal dune and back-barrier littoral rainforest and edges; Wildlife Atlas records in close vicinity to the project boundary.
Acacia chrysotricha - Newry Golden Wattle	E - nl	Wet sclerophyll forest edges; Wildlife Atlas records of this species are west of project boundary.
Maundia triglochinoides - Maundia	V - nl	Freshwater swamp; Wildlife Atlas records in close vicinity to the project boundary.

Tinospora tinosporoides - Arrow-head Vine	V - V	Subtropical and littoral rainforest; Wildlife Atlas records from Bundagen adjacent to the northern end of survey area.
Dendrobium melaleucaphilum	E - nl	Mainly in swamp sclerophyll forest on paperbarks, particularly Melaleuca stypelioides; Wildlife Atlas records in close vicinity to the project boundary.
Thesium australe Austral Toadflax	E - E	Grassy headlands, grassy open forest and woodland; generally in coastal areas only on headlands.
Alexfloydia repens - Floyds Grass	E - nl	Edges of coastal streams often within the tidal zone and in Swamp Oak forest; Wildlife Atlas records in close vicinity to the project boundary
Syzygium paniculatum - Magenta Lily Pilly	V - V	Rainforest, generally south of the survey area.
Phaius australis Swamp Orchid	E - E	Swamp sclerophyll forest margins with rainforest species, particularly palms and Alocasia; possible, but extremely rare between Coffs Harbour & Port Macquarie.
Senna acclinus	E - nl	Margin of open forest and rainforest; possible, recorded from the Coffs Habour and Port Macquarie areas.
Eleocharis tetraquetra Square-stemmed Spike Rush	E - nl	Coastal swamp and streamside seepage; possible but very rare, nearest records in the Coffs Harbour area.
Arthraxon hispidus A Grass	V - V	Swampy areas at the base of hillslopes; possible, recorded at Boambee and Kempsey.
Parsonsia dorrigoensis A vine	V - E	Wet sclerophyll forest and rainforest; recorded in State Forest immediately west of the survey area.
Hicksbeachia pinnatifolia - Red Bopple Nut	V - V	Wet sclerophyll forest and rainforest; recorded in State Forest not far west of survey area.
Diuris sp. aff chrysantha (Byron Bay Diuris)	E -	Grassy and heathy open forest; possible occurrence, recorded in the Coffs Harbour area (Conacher Consulting 2008).
Diuris disposita	E -	Grassy open forest in the Kempsey area, possible.
Diuris flavescens	CE -	Grassy open forest, known from one population near Wingham, outside chance.
Melaleuca biconvexa	V - V	Swamp sclerophyll forest, recorded Port Macquarie, outside chance.
		Unlikely
Chamaesyce psammogeton	E -	Recorded on the coast on sand, habitat not present in survey area.
Melaleuca groveana	V -	Recorded from rocky, heathy open forest, habitat not present in survey area.

3.3.3 Timing and Personnel

Approximately 80% of the road alignment was surveyed in November-December 2011 and the remaining 20% was surveyed in October 2012. The latter section was postponed until October 2012 due to a technical review of the Nambucca River crossing section, which extended from the southern boundary of Nambucca State Forest to the southern outskirts of Macksville. Targeted flora survey work was carried out by Dr Andrew Benwell, Justin O'Dowell and Shaan Watson.

3.3.4 Data Recording and Plant Marking

The location of all threatened plants found during survey was recorded with a Nautiz GPS/PDA. Each record was allocated a unique alphanumberic identifier comprising the first letters of the plant genus and species and a number (e.g. ML5 = Marsdenia longiloba, flora point number five). The GPS points referred to either a single plant, or group of closely spaced individuals (ie. <2 m apart). This was often the case with *Marsdenia longiloba*, which commonly occurred in clusters of two or more stems. Plants more than 10m apart were generally recorded as separate GPS points with different id codes. In the case of mat-forming such as *Maundia triglochinoides* and *Alexfloydia repens*, GPS points were recorded to show the extent of each patch. A proforma was set up in the Nautiz for recording species, identification number, plant height and other relevant details of each field point. The accuracy reported by the PDA was generally less than one meter.

3.3.5 Quadrats

Detailed vegetation quadrats were recorded to describe the habitat associated with each threatened species. Standard vegetation survey guidelines were used to record quadrat data (DEC 2004; NPWS 1995). The basic quadrat size was 400 m² (20x20m or 40x10m in linear habitats). Data were collected on species composition, vegetation structure, physical site variables and disturbance history. Species abundance was estimated visually according to the Braun Blanquet cover-abundance scale of 1 to 6, as follows:- 1 - sparse <5% crown-cover; 2 - any number <5%; 3 - 5-25%; 4 - 25-50%; 5 - 50-75% and 6 - 75-100% (Mueller-Dombois and Ellenberg 1974; NPWS 1995). The soil profile was examined to depth of approximately 80cm with a soil auger. Road cutting exposures indicated the soil profile at greater depth. The colour and soil texture of soil horizons was recorded. Soil pH was recorded with a MANUTEC soil pH test kit.

3.3.6 Targeted Survey for *Rhizanthella slateri*

An historical record of the Eastern Underground Orchid (*Rhizanthella slateri*) exists for Newry State Forest near the road alignmnent (EcoPro 2010). An area of potential habitat surrounding the historical record was identified by EcoPro (2010) with input from Mark Clements (CSIRO) and Bill Dowling who has studied the species on the Buladelah Bypass project. The Eastern Underground Orchid is a leafless, saprophytic orchid, which spends lives entirely underground apart from when it flowers, when flower heads push just above ground, usually amongst leaf litter. The flower heads have a diameter of about 20mm and are cream and purple in colour. Harden (1993) gives the flowering time as October and November. At Buladelah the species was reported to flower in September.

The area of potential habitat for the Eastern Underground Orchid mapped by EcoPro (2010) was surveyed for this report in November 2011. To identify other areas where the orchid may occur, habitat information was acquired from specimens of *Rhizanthella slateri* held at the Royal Botanic Gardens Herbarium in Sydney (10 collections) and the National Herbarium in Canberra (5 collections). This information indicated that *Rhizanthella slateri* occurs in wet and dry sclerophyll forest on siliceous soils formed on high quartz geology (e.g. sandstone and rhyolite). Chert, a siliceous metamorphic rock, appears to occur in the study area.

It was difficult to predict from geology and vegetation maps where areas of more siliceous soil might occur on the alignment, as the geology in the WC2U study area consists almost entirely of Permian metamorphics (Nambucca Beds) on hilly terrain, or floodplain alluvium in valleys. It was decided to search for *R. slateri* where vegetation indicators of more siliceous soil were observed, such as forest with a sclerophyllous or heathy understorey. At sites judged to be potential habitat for *R. slateri*, 10 m x 10 m plots were established and leaf litter and mulch partially removed so the ground surface could be examined for *R. slateri* flowers or seeding heads.

3.3.7 Additional Threatened Flora Records for WC2NH

For the southern WC2NH section, additional records of Slender Marsdenia within or adjoining the project boundry were incorporated into the TFMP from the following sources:

- ECOS Environmental (2014a). Targeted surveys (and sample collection) for a genetic study of *Marsdenia longiloba* currently being conducted by ECOS Environmental in collaboration with University of Sunshine Coast, titled "Analysis of genetic variability in the endangered species Slender Marsdenia (*Marsdenia longiloba*) at fine, medium and broad geographic scales"
- ECOS Environmental (2014b). Targeted re-survey of threatened species in the Cockburns Lane (Warrell Creek) area.
- ECOS Environmental (2014c).Targeted survey for a connector track with Old Coast Road, Nambucca Heads.
- GeoLink (2014). Targeted surveys along a utilities alignment.

3.3.8 Spatial Impact Analysis

The recorded flora points were overlaid on the highway design using a GIS to determine what points were directly impacted, indirectly impacted, remaining in-situ within the project boundary, or outside the project boundary, as follows:-
(Definitions of Directly impacted have been modified since version 1 dated 6/3/2013 submitted to the Dept of Planning)

Northern Section NH2U - Directly impacted:- Directly impacted individuals are those located under the design footprint plus 10 metres, which is the limit of clearing.

Southern Section WC2NH - **Directly impacted:**- Directly impacted individuals are those located:

- Under the concept design footprint plus **15 metres**.
- Under the operational water quality basins plus 10 metres.

- Under new or reconstructed access roads within Nambucca State Forest plus 10 metres.
- For utility adjustments within clearing requirements of utility authorities.
- Within three metre clearing width for boundary fencing - excluding within Nambucca State Forest and swamp forest where a flying fox camp is located.

Indirectly impacted:- Indirectly impacted individuals are those located within 10 m of the direct impact zone. The indirect impact zone is not subject to clearing, but threatened flora may be impacted by changes in microclimate, soil nutrient levels, weed invasion or other alteration of habitat conditions.

In-Situ within road reserve:- These individuals are located outside the direct and indirect impact zones between the indirect impact zone and the project boundary, also referred to as the road reserve boundary.

Outside project corridor:- These individuals are located outside the approved project corridor and are in most cases are considered to be directly or indirectly impact by the proposed construction works. Exceptions may include wetland species that could be affected outside the project.

3.4 SURVEY RESULTS

3.4.1 Summary

Six threatened species (four endangered and two vulnerable), three ROTAP species and one species recommended for threatened species listing were recorded during the targeted survey:-

Threatened
Slender Marsdenia (*Marsdenia longiloba*), a small vine.
Rusty Plum (*Niemeyera whitei*), a medium sized rainforest tree.
Maundia (*Maundia triglochinoides*), an aquatic, emergent herb.
Floyds Grass (*Alexfloydia repens*), a mat forming grass.
Wooll's Tylophora (*Tylophora woollsii*), a small vine.
Spider Orchid (*Dendrobium melaleucaphilum*), an epiphytic orchid.

ROTAP
Ford's Goodenia (*Goodenia fordiana*), a mat forming herb.
Bellingen Ironbark (*Eucalyptus ancophila*), a tall tree of wet sclerophyll forest.
Hammer Orchid (*Arthrochilis prolixus*), terrestrial orchid (recorded by EcoPro 2010).

Potential Threatened Species Listing
Koala Bells (*Artanema fimbriatum*), a perennial herb of coastal forests.

Results of spatial impact analysis are summarised in Table 3A & 3B. These show the number of species directly impacted, indirectly impacted and remaining in situ for the whole WC2U corridor and southern half (WC2NH), respectively. Threatened and rare flora records were classed as either: (i) directly impacted (i.e. Northern section NH2U design footprint plus 10m; Southen section WC2NH design footprint plus 15 meters and other parameters given in Section 3.3.8), (ii) indirectly impacted (within 10m of the direct impact zone), or (iii) in-situ within the road reserve (outside the indirect impact zone but within the project boundary). Data from the EcoPro (2010) targeted orchid survey were included in the spatial impact analysis.

Detailed maps of threatened and rare species location, showing the type of impact (direct, indirect and in-situ) can be found in Appendix 1. Maps showing the overall distribution of threatened species on the WC2U road corridor are presented in Appendix 2.

(An additional threatened species, the rainforest tree *Acronychia littoralis,* was tentatively identified at Deep Creek (Valla) from leaf material, but flowers and fruits collected several months later keyed out to the common species *Acronychia oblongifolia*. The small trees were atypical for *A. oblongifolia* as they occured as a thicket of stems, which is a feature of one of the two forms of *A. littoralis*. Also, leaf oil dots were less transparent than typical *A.oblongifolia*, another feature of *A. littoralis* (Benwell 1996). However, the flowers and fruits were too small for *A. littoralis* and closer to *A. oblongifolia*. The fruits collected at Deep Creek contained no seed and microscopic examination revealed shrivelled, infertile ovules, which indicated the stem thicket of *A. obl*ongifolia at this site was a sterile hybrid and the copse of stems had formed by vegetative reproduction from root suckers, visible at the site).

Table 3A: Threatened and rare flora impacted by the whole WC2U project

WC2U (whole road corridor)	**Directly Impacted**		**Indirectly Impacted**		**Road Reserve - in-situ**	
Threatened Species	points	no.	points	no.	Points	no.
Slender Marsdenia (E) (*Marsdenia longiloba*)	68	176	7	20	2	4
Rusty Plum (V) (*Niemeyera whitei*)	12	12 +sdg	0	0	0	0
Maundia (V) (*Maundia triglochinoides*)	~500+ m^2		~50 m^2		~50 m^2	
Floyds Grass (E) (*Alexfloydia repens*)	1	~2m^2	2	~2m^2	1	~2m^2
Wooll's Tylophora (E) (*Tylophora woollsii*)	5	9	-	-	3	6
Spider Orchid (E) (*Dendrobium melaleucaphilum*)	13	~40	16	35	70	200
ROTAP*						
Ford's Goodenia (*Goodenia fordiana*)	9	9m^2	1	1m^2	-	-
Potential Threatened Species Listing						
Koala Bells (*Artanema fimbriatum*)	7	65	2	55	-	-

*Eucalyptus ancophila not included as it was relatively common in the study area.

Table 3B - Threatened and rare flora impacted by the WC2NH project

Southern WC2NH section	**Directly Impacted**		**Indirectly Impacted**		**Road Reserve - in-situ**	
Threatened Species	points	no.	points	no.	Points	no.
Slender Marsdenia (E) (*Marsdenia longiloba*)	43	75	2	4	1	1
Rusty Plum (V) (*Niemeyera whitei*)	10	10 +sdg	0	0	0	0
Maundia (V) (*Maundia triglochinoides*)	~500+ m^2		~50 m^2		~50 m^2	
Floyds Grass (E) (*Alexfloydia repens*)	1	~2m^2	2	~2m^2	1	~2m^2
Wooll's Tylophora (E) (*Tylophora woollsii*)	2	2	0	0	0	0
Spider Orchid (E) (*Dendrobium melaleucaphilum*)	3	10	0	0	0	0
ROTAP						
Ford's Goodenia (*Goodenia fordiana*)	2	2m^2	1	1m^2	0	0
Potential Threatened Species Listing						
Koala Bells (*Artanema fimbriatum*)	2	13	0	0	0	0

3.4.2 Slender Marsdenia (*Marsdenia longiloba*)

Locations

Slender Marsdenia was recorded in small sub-populations scattered along the length of the WC2U road corridor. Approximately 200 individuals ('stem-individuals) were recorded in 23 different sub-populations in the Raleigh south area, Newry State Forest, Little Newry State Forest, Valla south, Nambucca State Forest and Warrell Creek sections of the WC2U corridor. (Sub-populations' were defined as geographically separate records at least 100m apart). The great majority of recorded points were within the zone of direct and indirect impact, as survey work was concentrated on the construction footprint and indirect impact zone.

Directly impacted

- A total of 68 gps points representing 176 individuals ('stem-individuals) are directly impacted. These represent at least 23 different sub-populations. 43 gps points and 75 individuals were directly impacted on the southern WC2NH section. Occurrences are mapped in Appendix 1.

Indirectly impacted

- A total of 7 gps points representing 20 individuals are indirectly impacted.

In-situ within road reserve

- Two points representing 4 individuals would remain in-situ within the road reserve. Additional individuals may be present in the outer part of the road reserve, as survey work was focused on the footprint.

Slender Marsdenia is a small vine growing to a maximum height of about 5m. Most plants recorded during the survey were much smaller than this, generally less than 0.5m tall and with few leaves (Table 4). Only one point had a flowering plant and no plants with seed pods were recorded. Seed pods of this species are extremely rare (Harden 1992), so reproduction appears to occur vegetatively by root spread and suckering and only very rarely by seedling recruitment.

Plate 1: Small Slender Marsdenia plant with smooth, hairless leaves.

Plate 2: Typical Slender Marsdenia habitat in wet sclerophyll forest with understorey of small rainforest trees, shrubs and ground ferns, and open litter or fern covered ground layer, the roughed barked tree is Turpentine.

Plate 3: Only one plant of Slender Marsdenia was found with flowers. ML-42

Table 4: Size class distribution of Slender Marsdenia points

Size Class - Height (largest stem-individual if more than one present)	**Number of points (not including the Nambucca review area)**
<0.5 m	40
0.5 - 1 m	8
1 - 1.5 m	7
1.5 - 2 m	2 (1 flowering)
Total	57

Habitat

Found in moist open forest and gradational subtropical and warm temperate rainforest, mostly below 200m altitude (Quinn *et al.* 1995). Characteristics of Slender Marsdenia habitat recorded on the WC2U road corridor included: -

- soil type a yellow to red clay podzol formed on Permian metasediments;
- soil A-horizon 15-30cm deep, dark brown, humus enriched topsoil;
- wet sclerophyll forest with an open to mid dense rainforest understorey usually on a lower slope;
- sloping (gentle to moderate) and well drained, often with a southern aspect;
- understorey moderately well lit and open, not dense or heavily shaded;
- topsoil only slightly acidic (pH >6).

The total area of modelled potential habitat of Slender Marsdenia on the southern half of the WC2U project (WC2NH) has been estimated as 17.8 Ha (Jacobs SKM 2014) and a similar area is expected on the northern half (NH2U).

5

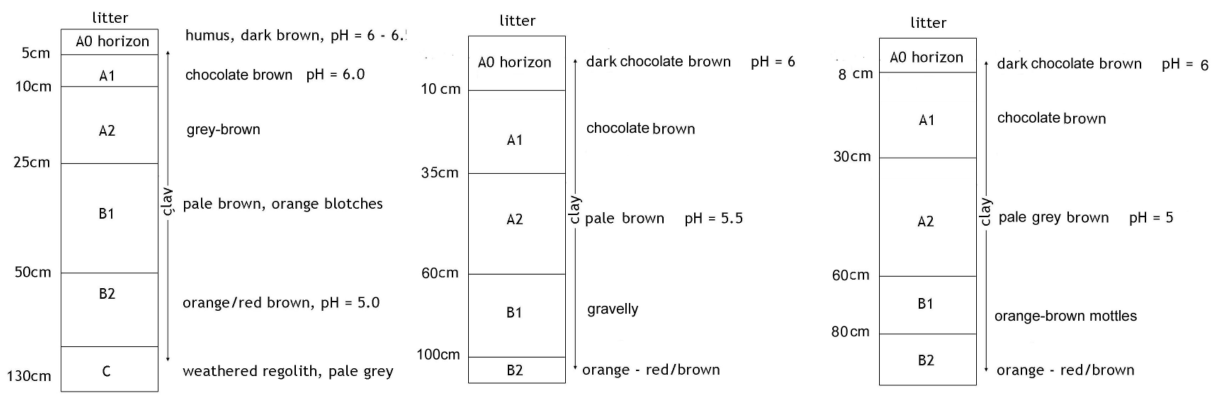

Figure a: Soil Profile at Mardenia longiloba site in Nambucca State Forest

Figure b: Soil Profile at *Niemeyera whitei* site at Cockburns Lane, Warrell Creek

Fiigure c: Soil Profile at *Acronychia littoralis* site at Deep Creek near Valla Beach

Figure 2: Representative soil profiles at threatened species sites on the WC2U corridor.

3.4.3 Rusty Plum (*Niemeyera whitei*)

Locations

Rusty Plum was recorded at three locations on the WC2U corridor:- Boggy Creek near Valla, north of the railway line at the Nambucca Heads turn-off, and Cockburn's Lane, Warrell Creek. Single small trees were recorded at Boggy Creek and the railway line. Eleven trees and saplings (plus seedlings) were recorded at Cockburn's Lane, Warrell Creek on the southern WC2NH section. Trees were up to 10 metres in height and 30 cm in diameter.

Directly impacted

- Ten trees at Cockburn's Lane (Warrell Creek) and the two trees north of the railway line Nambucca Heads and at Boggy Creek are directly impacted.

Note: nw-130 (green - outside project boundary) was included on Fig. 9 in Appx. 1. The position of this tree was estimated from a vantage point as it could not be accessed on the ground and may actually be within the road reserve; the precise location of the tree would be recorded during the pre-clearing survey.

Habitat

At Boggy Creek, a single Rusty Plum occurs on a creek bank in Flooded Gum wet sclerophyll forest with a well developed rainforest understorey. The tree north of the railway line is in wet sclerophyll forest on a south-facing hillslope. The population at Cockburn's Lane, Warrell Creek is in similar wet sclerophyll habitat on a south-facing hillslope and gully drainage line. The soil at the latter site is a red clay podzol formed on hornfels, a dark crystalline rock derived from the Nambucca Beds chert by secondary metamorphism during the Mt Yarrahappini intrusion (RTA 2010).

Plate 4: Rusty Plum sapling at Cockburn's Lane, Warrell Creek.

3.4.4 Woolls' Tylophora (*Tylophora woollsii*)

Locations

Woolls' Tylophora was recorded at Raleigh south, Newry State Forest and Nambucca State Forest at a total of four locations.

Directly impacted

- Nine individuals directly impacted at five locations in Newry and Nambucca State Forests and north of the Kalang River.

Indirectly impacted

- None recorded..

In-situ within road reserve

- Six individuals between the Kalang River and Raleigh south.

Note - Woolls' Tylophora is difficult distinguish from Slender Marsdenia on the basis of leaf morphology. The flowers of the two species are very different, but are rarely seen. Woolls' Tylophora was tentatively identified based on leaves that were more ovate, less elongated and darker green than Slender Marsdenia, sometimes with a purplish tinge to the petioles and underside of the leaves. *Tylophora woollsii* was postively identified on the Bonville upgrade project from a flowering plant (see Plate 6). Distinguishing the two species may not be crucial for management purposes, as both are listed as endangered.)

Habitat

Tylophora woollsii was recorded in wet sclerophyll habitat, as described for Slender Marsdenia, with which it co-occurs (see Slender Marsdenia habitat above).

Plate 5: *Tylophora woollsii* has very similar leaves to Slender Marsdenia, although the flowers are quite different (see Plate 3)

3.4.5 Maundia (*Maundia triglochinoides*)

Locations

Maundia was recorded only on the southern WC2NH half of the WC2U road corridor, at Williamson's Creek near Warrell Creek, and south of Macksville in freshwater wetland. The Williamson's Creek population occurs for ~150 metres along the creek either side of the existing Pacific Highway bridge, extending across the footprint of new bridge. There is a break in the population of about 40 meters under the existing highway bridge, which appears to be associated with a riffle section in the creek rather than shading by the bridge. RMS reported that a substantial quantity of Maundia was still present at the Williamson's Creek site in July 2014 (S. Walker pers.com.).

The second population occurs in a large freshwater wetland–swamp sclerophyll forest mosaic approx. 2 km southeast of Macksville. Not all of this habitat was surveyed due to access issues and it is likely other patches of Maundia occur between the Maundia records at the southern and northern limits of the swamp (see Appendix 1, Figure 11). On the southern edge of the swamp (mt-82), a large expanse of Maundia dominated freshwater wetland extended more than 100 meters outside the project boundary to the east, and only small section (~10-20m) extended inside the project boundary at representative point mt-82 (in November 2011).

<u>Directly impacted</u>

- Approximately 500 square meters of Maundia is directly impacted at Williamson's Creek and in freshwater wetland on the Nambucca floodplain. (Note – additional plants are likely to be directly impacted in the second area in the unsurveyed section between records Mt-82 and Mt-96 (Appendix 1, Figure 11) .

<u>Indirectly impacted</u>

- The Williamson's Creek population is indirectly impacted either side of the construction footprint/direct impact zone.
- An additional area of Maundia occurs in the indirect impact zone on the floodplain south of the Nambucca River.

<u>In-situ within road reserve</u>

- Part of the Williamson's Creek population is outside the indirect impact zone and within the in-situ zone on either side of the existing and new bridges.
- Some of the second population is also within the in-situ zone (to be confirmed during the pre-clearing survey).

Habitat

Maundia is an aquatic herb with emergent, sword-shaped leaves standing 0.5 m to 1 m high above water. The Maundia site on Williamson's Creek is located at the edge of the coastal floodplain, where the creek consists of a series of long pool and short riffle sections. Maundia grows in the pool sections in water 0.2 to 1 meter deep. Flood debris on the creek banks and fine sediment on Maundia leaves indicated that Maundia had been submerged during floods under fast flowing water. When inspected in October 2012, Maundia was just starting to produce new green shoots after dying back over winter. The Nambucca floodplain population occurs mostly in treeless freshwater wetland. Maundia will grow in full sun in treeless freshwater wetland or under medium shade in swamp forest.

Plate 6: Leaves and flower spike of *Maundia triglochinoides* at Williamson's Creek, November 2011.

Plate 7: Stand of Maundia in Williamson's Creek, a tributary of Warrell Creek, the water is 0.3-0.5 metres deep.

Plate 8: Williamson's Creek with band of Maundia in the creek at the base of slope and edge of tree line. Existing Pacific Highway bridge, looking south-west.

Plate 9: Williamson's Creek looking east under the existing Pacific Highway bridge; there was no Maundia in the section of the creek beneath the bridge and to either side for 20-30 metres.

3.4.6 Floyd's Grass (*Alexfloydia repens*)

Locations

Floyds Grass was recorded on the northern bank of Warrell Creek, on the eastern and western sides of the highway corridor, close to and within the project boundary. The population is confired to a narrow zone a few metres wide on the edge of Warrell Creek. On the western side of the corridor the population extends upstream of the project boundary for at least 20 metres. No plants were found downstream of the small patch on the eastern side of the corridor.

Directly impacted

- One gps point directly impacted, comprising approximately 2 m².

Indirectly impacted

- Two gps points indirectly impacted, comprising approximately 4 m².

In-situ within road reserve

- Nil (present outside the road reserve – one gps point).

Habitat

Floyds Grass occurs in a narrow zone 1-2 metres wide on the edge of Warrel Creek in Swamp Oak forest. The soil type is a humus-enriched, alluvial clay loam. The common native grass *Ottochloa gracillima* and Floyds Grass occur in different patches in essentially the same habitat indicating they are competitors.

Plate 10: Floyds Grass is a mat forming grass that looks somewhat like common Couch Grass.

3.4.7 Spider Orchid (*Dendrobium melaleucaphilum*)

Location

Dendrobium melaleucaphilum was recorded at three locations:-(i) ~4km north of the Kalang River, where only one mature plant was found, (ii) in Newry State Forest, where a substantial population was found in swamp forest next to the *Rhizanthella slateri* potential habitat area, and (iii) in Nambucca State Forest south of Nambucca Heads (EcoPro 2010). Population (ii) occurs on the eastern side of the road corridor and mostly outside the project boundary (see Appendix 1, Figure 4). The alignment was redesigned to minimise impact on the Spider Orchid population and potential *Rhizanthella slateri* habitat at this location. Impact analysis of the flora points recorded by EcoPro (2010) showed that the current design impacts directly on 13 Spider Orchid points, each point representing 1-5 Spider Orchids plants on one tree.

<u>Directly impacted</u>

- Thirteen Spider Orchid points are directly impacted. Each point represents from 1-5 individual plants (EcoPro 2010).

<u>Indirectly impacted</u>

- Sixteen Spider Orchid points are indirectly impacted. Each point represents from 1-5 individual plants (EcoPro 2010).

<u>In-situ within road reserve</u>

- Seventy (70) are located in situ within the road reserve.

Habitat

Dendrobium melaleucaphilum is an epiphytic orchid which grows in swamp sclerophyll forest and rainforest in coastal areas, often on *Melaleuca stypheliodes*.

Plate 11: *Dendrobium melaleucaphilum* (dm – 16a), a young plant growing on the bark of *Melaleuca stypheliodes* outside the project boundary.

3.4.8 Ford's Goodenia (*Goodenia fordiana*) (2RC-)

Locations

Ford's Goodenia was recorded at Raleigh south, Newry State Forest and Nambucca State Forest, and was most common in the Raleigh south area. Ten point localities were recorded, representing 8 locations. This prostrate ground-cover herb forms patches up to about a meter wide.

Directly impacted

- Nine of the ten gps points were directly impacted.

Indirectly impacted

- One gps point was indirectly impacted.

In-situ within road reserve

- Nil, however some plants are probably present in the road reserve outside the construction footprint, as the outer parts of the road corridor were not as closely searched.

Note - . Fords Goodenia is endemic to the NSW Lower North Coast between Coffs Harbour and Buladelah and is listed as nationally rare (Briggs and Leigh 1995).

Habitat

Found in wet sclerophyll forest under moderate to dense shade. The soil type is clay podzol formed on Permian metasediment.

Plate 12: Ford's Goodenia (*Goodenia fordiana*) a small herbaceous ground cover found in shaded wet sclerophyll forest on the WC2U road corridor.

3.4.9 Bellingen Ironbark (*Eucalyptus ancophila*) (2RC-)

Locations

Only a selection of locations of this nationally rare species was recorded, as the species was relatively common in the study area. This species occurs in wet sclerophyll forest in moist gullies and the hinterland margins of the coastal floodplain.

One very large old-growth specimen of *E. ancophila* was recorded north of the Kalang River on the clearing footprint. This tree on NH2U has since been protected by changes to the detailed design.

Note - *E. ancophila* is a medium-sized to tall forest tree known only from between Kempsey and Bellingen on the NSW Mid North Coast and is listed as nationally rare (ROTAP - Briggs and Leigh 1995). This species is one of a group of ironbarks distinguished by the combination of discolorous leaves, terminal inflorescences and flowers with staminodes. It has glossy green leaves which distinguish it from *E. fusiformis* , non-ribbed or non-angled fruit, which distinguishes it from *E. tetrapleura* and *E. fusiformis,* and longer leaves than *E. placita (www.anbg.gov.au/cpbr/cd-keys/Euclid/sample/html/ANCOPH.htm*).

Habitat

E. ancophila occurs in moist gully and valley bottom situations in wet sclerophyll forest on heavy clay podzols formed on Permian metasediments. Co-occuring tree species included Swamp Mahogany, Flooded Gum, Turpentine and White Mahogany.

3.4.10 Koala Bells (*Artanema fimbriatum*)

Locations

Artanema fimbriatum was recorded in the Raleigh, Raleigh south, Valla, Valla south and Nambucca State Forest areas. A total of ten gps points representing ten locations for recorded.

<u>Directly impacted</u>

- Seven locations are directly impacted.

<u>Indirectly impacted</u>

- Two locations are indirectly impacted; these are two and three metres from the edge of the construction footprint.

<u>In-situ within road reserve</u>

- None.

Note 1 - *Artanema fimbriatum* has been recommended for threatened species listing (NPWS 1998).

Habitat

Koala Bells was found mainly in damp sites on floodplains and occasionally in gullies in hilly terrain where crossed by tracks. Vegetation varied from open floodplain forest, swamp sclerophyll forest, clearings in dense wet sclerophyll forest and cleared or regenerating vegetation. At least half the occurrences were associated with track or clearing disturbance where patches of seedlings had established on bare soil.

Plate 13: Koala Bells (*Artanema fimbriatum*)

Plate 14: Wet sclerophyll forest habitat in Nambucca State Forest on the WC2U upgrade corridor

3.4.11 Other Rare of Regionally Significant Species

Several species were recorded near the southern limit of their range and were therefore of regional significance (Sheringham and Westaway 1995). Some appear to have spread from garden plantings to the adjoining road reserve, for example *Glochidion summatranum, Melicope elleryana* and *Macaranga tanarius*, and can be considered introduced native species. *Melicope elleryana* was seen at many locations in disturbed forest. Species occurring near the southern limit of their range without apparent human assistance included *Sannantha collina, Lepidozamia peroffskyana, Lophostemon suaveolens, Crinum pedunculatum, Cyperus filipes, Cymbidium maddidum* and *Lygodium scandens.* None of these species was considered rare enough to warrant specific conservation measures, but the records are of scientific interest as they more accurately define the present distributional range of each species. *Sannantha collina, Lepidozamia peroffskyana, Lophostemon suaveolens* and *Crinum pedunculatum* are suitable for use in highway landscaping, which could assist in preserving local populations of these species. Propagation should be from locally collected seed to preserve the local genotype best adapted to the local environment.

The Great Climbing Orchid (*Psuedovanilla foliata*) and the Hammer Orchid (*Arthrochilus prolixus*) were recorded by EcoPro (2010). Although not listed as threatened, they were considered to have conservation significance and it was recommended that " the two populations of *Arthrochilus prolixus* be translocated into nearby habitat by an orchid specialist. Translocation of the Great Climbing Orchid is not possible, however, it is recommended that seed be collected from the plants and replanted in newly created habitat on the edge of the alignment." (EcoPro (2010, p. 36)

The Hammer Orchid (*Arthrochilus prolixus*) is listed in ROTAP (Rare or Threatened Australian Plants - Briggs and Leigh 1995) under the category 'K', which indicates the species is poorly known, referring to its distribution and general abundance. In my own experience both the Hammer Orchid (*Arthrochilus prolixus*) and the Great Climbing Orchid (*Psuedovanilla foliata*) are widespread but uncommon. In Wildlife Atlas there are 22 records of the Great Climbing Orchid on the North Coast north of Pt Macquarie and 50 records of the Hammer Orchid on the North Coast.

The Great Climbing Orchid is a saprophytic orchid which flowers in summer and spends the rest of the year underground. Collection of seed, as recommended by EcoPro (2010) may not be practical, as seed may not be present when vegetation is cleared, or the plant may have died back to its underground saprophytic state. The Hammer Orchid is a small terrestrial ground orchid that flowers in late summer and autumn. The apparent rarity of these two species is at least partly due to their cryptic life cycle and limited capacity to be detected unless in flower. Most ground orchids are likely to be difficult to translocate successfully, due to their mycorrhizal requirements and sensitivity to small differences in soil microhabitat.

Translocation measures for the Hammer Orchid and Great Climbing Orchid as recommended by EcoPro (2010) are not considered warranted for the following reasons:

- Both species appear to be widely distributed, not particularly rare and may in fact be reasonably common, as they are often cryptic and hard to detect.

- Neither species is listed as threatened or recommended for threatened species listing and therefore not necessarily relevant to the Minister's CoA.
- Resources to conduct translocation and research on threatened and rare species are limited and need to be prioritised; it is probably not possible to include all species of conservation significance in the management plan.

3.4.12 *Rhizanthella slateri*

The area of potential habitat mapped by EcoPro (2010) was surveyed for the Eastern Underground Orchid in November 2011. In addition, habitat information provided by the Royal Botanic Gardens Herbarium in Sydney (10 collections) and the National Herbarium in Canberra (five collections) indicated that *Rhizanthella slateri* ocurrs in wet and dry sclerophyll forest on siliceous soils formed on high quartz geology (e.g. sandstone, rhyolite, chert).

Twelve locations supporting understorey vegetation with a higher cover-abundance of sclerophyllous species indicating more siliceous soil, such as *Allocasuarina littoralis* and *Leptospermum polygalifolium* were searched for *R. slateri*, but no plants (flowers or fruiting flower heads) were found. Survey work was conducted in late November at the end of the reported flowering period of *R. slateri*.

A further survey targeting the Eastern Underground Orchid was conducted by Geolink in September 2012. The purpose of this survey was to search for the Eastern Underground Orchid during its reported flowering period. The previous targeted survey conducted by Ecos Environmental was in November 2011, at the end, or outside its known flowering period. No plants were recorded by Geolink during the September (2012) survey and they concluded that the species were unlikely to occur in the survey area. Weather conditions were dry during the survey, but Geolink did not indicate this could have affected the survey results. *R. slateri* was recorded under varying weather conditions at Buladelah (RMS pers.comm.).

3.4.13 Limitations of the Survey

The timing of the survey was appropriate for identification of most potentially occurring threatened or rare species (see Table 3), the great majority of which are perennial, woody plants that can be identified from foliage throughout the year if flowers are not present.

Arthraxon hispidus (Hairy Joint Grass), an annual species, can be overlooked in spring and early summer when plants are still small. However, the plant can still be identified from small seedlings when the observer is familiar with them and it is unlikely the species was overlooked during survey work.

The targeted survey focused on the construction footprint. Vegetation in the outer part of the road reserve was not surveyed as rigorously, as any significant flora in this zone was unlikely to be impacted by construction. Nevertheless, much of the outer road reserve zone was also surveyed during the service utilities flora survey where the latter are mostly located (ECOS Environmental 2012). For any threatened flora individuals in the outer part of the road reserve that may have been missed during surveys, general prescriptions to minimise clearing and disturbance outside the construction footprint would provide adquate protection (see Section 5).

Most ground orchids tend to be missed by summer flora surveys as most species are autumn to early spring flowering herbs, and flowers are essential for species identificiation. Threatened ground orchid species potentially present in the WC2U road corridor that may have been overlooked by surveys conducted between late Spring and early Autumn include *Diuris sp. aff chrysantha* (Byron Bay Diuris), also known to occur in the Coffs Harbour area, and *Diuris disposita* from the Kempsey area. Diuris species generally flower in August and September, later than most other ground orchid genera. They occur in grassy open forest. The two *Diuris* species were included in the targeted survey conducted by Geolink (2012) in September, but no plants were found.

Plate 15: Flooded Gum wet sclerophyll forest with a well developed rainforest understorey in a gully at Cockburn's Lane, within the highway alignment.

3.5 DISCUSSION - Translocation Feasibility

3.5.1 Introduction

This section discusses the feasibility of undertaking salvage translocation of each of the threatened species directly impacted by the WC2U project, as required by Condition of Approval B7. (Translocation of some additional individuals, indirectly impacted under the current road design, may become necessary if the detailed road design changes after awarding the contract.) The feasibility of undertaking salvage translocation is assessed in terms of several factors including: -

- technical feasibility;
- potential for generation of new and useful scientific information; and
- availability of receival sites with suitable habitat and security of tenure.

These factors were drawn from the translocation principles set out in DECC (2007) "Translocation Policy and Guidelines" (Draft), specifically Policy Principles 1 to 4 ('General') and 22 ('Translocation in context of development consent and approval'). The overall thrust of these principles is that the potential conservation, scientific and educational benefits of translocation should outweigh the potential risks and costs.

3.5.2 Slender Marsdenia (*Marsdenia longiloba*)

Technical feasibility

Slender Marsdenia has been translocated on two previous highway upgrade projects: Bonville Deviation (Benwell and Watson 2011) and Sapphire to Woolgoolga (Benwell 2011). Results for the latter two projects demonstrated that this species has the potential to be translocated successfully.

Bonville Upgrade
Approximately 100 Slender Marsdenia were translocated from the road corridor of the Bonville Upgrade south of Coffs Harbour to two receival sites in 2006-7. Excavation of plants revealed that stems grew from a horizontal rhizome network at a depth of 5-10cm. Stems connected to a piece of rhizome ('stem-individuals') and stemless rhizome pieces were transplanted to pots in October 2006 and grown-on before planting out in the field. Ninety percent of plants and rhizomes survived transplanting to pots and grew rapidly in response to watering and fertiliser.

The potted plants were introduced to two translocation receival sites. The first site (TA1) was planted with 27 vines in February 2007 and the second site with 64 vines in February 2008.

In TA1, the vines grew well for the first six months, but had declined noticeably in vigour after 12 months. After 2 years the survival rate of stem individuals in TA1 was 33%.

In TA2, the 64 vines were planted ou to compare the species' performance on two soil types present at this site – grey clay loam with quartz gravel in the northern half of the site and brown clay loam in the southern half. A similar pattern of stem dieback and decline as recorded in TA1 was recorded in TA2, on both soil types. Plants showing stem dieback were excavated in winter 2009 and the rhizome system was found to be alive and healthy, but apparently in a dormant or suppressed state, at nearly all planting points. As the rhizome was still alive, the actual survival rate of transplants appeared was substantially higher (~ 80%) than that based on live stems (~25%). Live rhizomes were also found in a sample of plants that had died back in TA2. The decline was even more rapid, the survival rate falling to 22% after one year. After 4 years (2011) the survival rate of stem individuals was 26%, (minor re-shooting in TA2) about the same as TA1.

Monitoring of naturally growing local Slender Marsdenia populations in the road reserve showed no evidence of a seasonal growth pattern, rather new shoot growth could be found at any time of year, even in spring when the soil was relatively dry. There was no obvious relationship between shoot dieback and planting depth, or site variables such as aspect or soil type. However, stem dieback did appear to be induced by the planting treatment. Slow release fertilizer and hay mulch were used at both TA1 and TA2 to stimulate the growth of Slender Marsdenia. After the poor performance of Slender Marsdenia at TAI (planted a year earlier), larger planting holes were dug at TA2 and filled with humus enriched topsoil gathered from the adjacent forest. Slow release fertiliser was again added to the soil, as at TA1. This additional site preparation appeared to result in faster rate of decline after planting out.

The following hypothesis was proposed to explain the decline of Slender Marsdenia recorded in the Bonville translocation project. Slender Marsdenia is a small vine able to compete and co-exist with shrubs and trees by utilizing nutrients released in the topsoil by decomposition of organic matter. It can apparently do this efficiently when nutrients are produced steadily at very low concentration, as in humus enriched topsoil. When artificial fertiliser is added to the soil, it stimulates the roots of shrubs and trees to grown into the root zone of Slender Marsdenia causing increased interspecific root competition with Slender Marsdenia. This suppresses Slender Marsdenia growth and prevents stem growth and replenishment of rhizome food storage, causing the plant to eventually die. In summary, it is hypothesized that Slender Marsdenia is unable to absorb sufficient nutrient under conditions of high interspecific root density or competition.

To test this hypothesis, Slender Marsdenia translocated on WC2U will be directly transplanted to receival sites and planted with and without slow release fertiliser; no other soil improvement will be carried out. If the hypothesis is correct, then Slender Marsdenia plants translocated without addition of slow release fertiliser should show a higher survival rate.

Sapphire to Woolgooga Upgrade

A small number of Slender Marsdenia was transplanted on the Sapphire to Woolgoolga Upgrade. As on the Bonville project, the plants were transplanted first to pots and grown-on before planting out. Eight stem-individuals were introduced to the receipient site in March 2011. Five of these were transplanted stem-individuals and three were grown from rhizome pieces. The plants were introduced without fertiliser or any other nutrient enrichment except for a small amount of cane mulch. All were surviving in October 2011, but by October 2012 most had died back. Although the number of replicates was small, the results show a similar translocation response to the Bonville project (Ecos Environmental 2012). This could be related to the use of cane mulch, which if fairly rich in nutrient, or the cultivation in pots prior to planting out may be the operative factor leading to dieback.

Translocation Benefits

The following conservation, scientific and educational benefits would flow from the salvage translocation of this species on the WC2U project: -

- Preservation of a high conservation value species (Endangered). Relatively few populations are known to exist.
- Translocation of this species is technically feasible as successful transplanting, propagation and introduction have been carried out before (Benwell and Watson 2011), although further research and trials are required to improve translocation results.
- Translocation could build on insights into the species' ecology gained from the Bonville Translocation Project (Benwell and Watson 2006)
- Suitable translocation receival sites are available in the road reserve and/or adjacent State Forest at no additional cost to the taxpayer.
- Maintenance of (putative) genetic diversity in an endangered species by salvage and reestablishment of individuals that would otherwise be destroyed.
- Maintenance of population numbers of an endangered species by salvage and reestablishment of individuals that would otherwise be destroyed.

Translocation Risks

- The translocated individuals may fail to establish over the long-term.

Various choices are available for recipient sites to establish new or expanded populations of Slender Marsdenia, as detailed in Section 4.3.2 below. Details of performance criteria to assess the success or failure of translocation are presented in Section 4.6.8.

3.5.3 Woolls' Tylophora (*Tylophora woollsii*)

Technical feasibility

Woolls' Tylophora was translocated for the Bonville Deviation in 2006-7 (Benwell and Watson 2011). *Tylophora woollsii* is a small vine similar in appearance to Slender Marsdenia. On the Bonville project a few large *Tylophora woollsii* plants were recorded growing in moist open forest with Slender Marsdenia. Both vines have a rhizome, but in *T. woollsii* it does not appear to ramify and produce adventitious shoots as seen in Slender Marsdenia. *T. woollsii* was successfully transplanted to pots and when planted out grew well for 6-12 months then underwent stem decline, as in Slender Marsdenia. Excavation found that rhizomes were still alive so it appears to have the same problems of competition affecting Slender Marsdenia.

Translocation Benefits

The following conservation, scientific and educational benefits would flow from salvage translocation of this species on the WC2U project: -

- Preservation of a high conservation value species (Endangered). Relatively few populations are known to exist.

- Translocation of this species is technically feasible as successful transplanting, propagation and introduction have been carried out before (Benwell and Watson 2006), although further research and trials are required to improve techniques.

- Translocation of this species is technically feasible as transplanting, propagation and introduction have been successfully carried out before (Benwell and Watson 2011)

- Translocation could build on insights into the species' ecology gained from the Bonville Translocation Project (Benwell and Watson 2011).

- Suitable translocation receival sites are available in the road reserve and/or adjacent State Forest at no additional cost to the taxpayer.

- Maintenance of (putative) genetic diversity in an endangered species by salvage and reestablishment of individuals that would otherwise be destroyed.

- Maintenance of population numbers of an endangered species by salvage and reestablishment of individuals that would otherwise be destroyed.

Translocation Risks

- The translocated individuals may fail to establish over the long-term.

3.5.4 Rusty Plum (*Niemeyera whitei*)

Technical feasibility

Rusty Plum has been translocated on two previous highway upgrade projects: Bonville Deviation (Benwell and Watson 2011) and Sapphire to Woolgoolga (Benwell 2011). Results for these two projects demonstrated that Rusty Plum can be translocated successfully.

Bonville Upgrade
A total of 17 Rusty Plums were transplanted for the Bonville Deviation project in 2007 The survival rate after 4 years was 42% (Benwell and Watson 2011). This relatively low survival rate was due to a number of factors, which are avoidable or could be approached differently to improve survival rate. This includes the experimental pruning experiment applied to eight individuals. Factors contributing to the relatively low survival rate at Bonville were:-

- Eight individuals were subject to an experimental pruning/planting treatment to test if it was possible to successfully transplant trees with less pruning. The stem-branch system was reduced by about one half instead of two thirds or more, as usually carried out. The reduction in pruning resulted in greater transplant death, which appeared to be due to greater physiological stress of a larger shoot system making excessive demands on the impaired root system damaged during transplanting.

- Sub-optimal habitat; most of the receival site was on a grey clay podzol with impeded drainage, which is a sub-optimal habitat for Rusty Plum.
- Clearing mulch applied to the transplants caused yellowing of foliage and loss of vigour by increasing the soil C:N ratio (despite repeated addition of soluble and slow release fertiliser).
- Poor planting technique, the transplants should have been mounded up on the poorly drained clay soil.

Sapphire to Woolgoolga Upgrade
Survival was greatly improved on the S2W project where a site with more optimal habitat was selected. A total of 14 trees and saplings, and five seedlings were transplanted between October 2010 and September 2011. In addition, 68 seeds were planted in the translocation area in November 2010. The survival rate of transplants was 100% after one year and 75% of the introduced seed had germinated and survived after one year.

DECC (2007 p.23) states that "translocation of adult plants usually fails, whereas propagation followed by planting out may be more effective." Our experience with rainforest species translocation shows the opposite is true – the smaller the transplanted individual, the less its chance of survival and propagated seedlings can be difficult to establish in the field. Mature, long-lived resprouters (stress tolerators) transplant much better than obligate seeders. This has been tested on several translocation projects including Yelgun to Chinderah, Bonville and Brunswick Heads to Yelgun.

<u>Translocation Benefits</u>

The following conservation, scientific and educational benefits would accrue from the salvage translocation of this species on the WC2U project:-

- Translocation of this species is technically feasible as successful transplanting and propagation have been carried out before (Benwell and Watson 2011), although there is potential to improve the survival rate (see Sec. 4.4.3). It is noted that DECC (2007) cites Rusty Plum as an example of a species that has failed to translocate successfully (p.7). However, the results of the Sapphire to Woodlgoolga translocation project in particular show that this species can be translocated with a high survival rate.

- Suitable translocation receival sites are available in the road reserve and/or adjacent State Forest at no additional cost to the taxpayer.

- Maintenance of genetic diversity and population numbers by salvage and reestablishment of individuals that would otherwise be destroyed.

- Disturbed habitat will selected as a receival site which will then benefit from habitat restoration

Translocation Risks

- The translocated individuals may fail to establish over the long-term.

DECC (2007 p.23) states that "translocation of adult plants usually fails, whereas propagation followed by planting out may be more effective." Our experience with rainforest species translocation shows the opposite is true – the smaller the transplanted individual, the less its chances of survival and propagated seedlings are difficult to establish in the field. Mature long-lived resprouters (stress tolerators) transplant much better than obligate seeders. This has been tested on several translocation projects including Bonville, Sapphire to Woolgoolga

3.5.5 Maundia (*Maundia triglochinoides*)

Maundia occurs along Williamson's Creek for distance of ~150 m where it crosses the highway corridor. The creek will be re-routed during construction of a new bridge and most of the Maundia along the creek will have to be cleared, within the direct and indirect impact zones. A second population is located in freshwater swamp and adjoining swamp sclerophyll forest southeast of Macksville. Approximately 500 m² is currently estimated to be directly impacted. The total area may be greater, as ~1km section of swamp between mt-82 and mt-92 was not surveyed due to access issues.

Maundia also occurs extensively outside the project boundary. During the 2011 survey, a large area of Maundia dominated freshwater swamp was observed at mt-82 east of the road alignment (see Appendix 1, Figure 11) covering at least 1 hectare outside the project boundary. Other stands of Maundia were recorded in swamp sclerophyll forest west of the project boundary at mt-98 and mt-99 (see Appendix 1, Figure 11).

Recent surveys, particularly in the Lower Macleay district south of the Nambucca have found Maundia to be more common than previously thought. A flora survey targeting Maundia, conducted in 2012 for the Fredrickton to Eungai project (Benwell 2012), found that Maundia was relatively common on the Collombatti Creek floodplain and along creeks leading back into State Forest. During surveys of the same area for the Kempsey bypass EIS several years earlier, Maundia was very rare and present at only one or two locations. These were dry years when freshwater wetland contracted to drainage canals. So it appears that Maundia undergoes large fluctuations in population size and extent depending on rainfall in the current and preceding year. At present Maundia appears to be relatively secure on the NSW Mid North Coast which is at the centre of its distributional range.

The prospects for successfully translocating Maundia are uncertain. It is possible to introduce and establish many aquatic plant species and even whole wetland ecosystems in new areas, as evidenced by the number of plant nurseries dealing exclusively in native aquatic plants. An unsuccessful attempt was made to translocate Maundia by the Royal Botanical Gardens on the Central Coast by the introduction of propagated seedlings. One of the people involved indicated that Maundia seed were difficult to germinate and the seedlings failed to establish when planted out at the translocation site (Benwell 2012). Translocation of this species by transplanting established rhizomes may have a better chance of success, as the root system would already be grown and established. Pacifico has suggested transplanting Maundia from

Williamson's Creek to the re-routed creek, using a machine to move plants and substate together to the new drainage line. The new stream course would be engineered to recreate the still-water pools of the present stream. Transplanting could also be carried out manually for comparison, so that the shoot/leafy part of some plants was not overly damaged during transplanting, but mostly this would be done by machine and aim to regenerate Maundia from rhizome material transplanted with the muddy substrate.

Given the relatively secure status of *Maundia triglochinoides* on the NSW Mid North Coast it is proposed that management of the population on the Nambucca floodplain southeast of Macksville focus on amelioration of impacts to in-situ Maundia growing in wetland outside the direct and indirect impact zones, a significant task in itself. No translocation is proposed for Maundia on the Nambucca flooplain, unless opportunities arise to translocate the species to receival sites within the project boundary such as sed basins. Management will instead focus on protection/minimisation of impacts and monitoring of adjacent in-situ stands outside the direct and indirect impact zones.

During detailed design, emphasis would be placed on minimising impacts to Maundia remaining in-situ within and adjoining the project boundary. Management measures are detailed in Section 4.5.4 below. A well designed monitoring program to study the effect of the new highway on adjoining/in-situ Maundia stands would be of positive benefit both in understanding the effect of infrastructure construction on this wetland species and in clarifying its population dynamics, which appears to follow a boom and bust cycle in some areas (Benwell 2012).

3.5.6 Floyds Grass (*Alexfloydia repens*)

Technical feasibility

The revised concept design indicates that a small area of Floyds Grass is directly and indirectly impacted and would probably require translocation (~6 m²). Floyds Grass was successfully translocated for the Bonville Deviation project in 2006-8. The translocated population was still in good condition in 2013.

Translocation Benefits

The following conservation, scientific and educational benefits would flow from the salvage translocation of this species on the WC2U project: -

- Translocation would help to preserve populations of this high conservation value species (the only population known outside the Bonville-Coffs Harbour area).
- Suitable translocation receival sites are available in the road reserve and/or adjacent lands purchased by RMS.
- Maintenance of genetic diversity and population number by salvage and reestablishment of individuals that would otherwise be destroyed.

Translocation Risks

- The translocated individuals may fail to establish over the long-term due to unforeseen factors

3.5.7 Spider Orchid (*Dendrobium melaleucaphilum*)

Technical feasibility

There appear to be no previous attempts to translocate this species, although epiphytic orchids are commonly taken from the wild and established in cultivation (often illegally). Tranplanting of epiphytic orchid plants would be subject to similar pre-conditions as the other species, such as a suitable receival site with matching habitat, care and appropriate technique during transplanting and follow-up plant care, including watering. Propagation of orchid plants vegetatively or from seed, and introduction to appropriate habitat is considered to have a reasonable chance of success given the plants hardy, drought resistant growth-form, known habitat requirements and propagation capability.

Translocation Benefits

The following conservation, scientific and educational benefits would flow from the salvage translocation of this species on the WC2U project: -

- Translocation would help to preserve populations of this high conservation value species.
- Suitable translocation receival sites are available in the road reserve and/or adjacent lands purchased by RMS.
- Maintenance of genetic diversity and population number by salvage and reestablishment of individuals that would otherwise be destroyed.

Translocation Risks

- The translocated individuals may fail to establish over the long-term due to unforeseen factors

3.5.8 Other species

Of the other three conservation significant plant species recorded during the targeted survey - *Goodenia fordiana, Eucalyptus ancophila* and *Artanema fimbriatum* - translocation would be technically quite feasible for all three species. The ROTAP species *Goodenia fordiana* which is probably easy to transplant and propagate because of its mat forming growth form. Tranlocation of *Artanema fimbriatum* by transplanting or by propagation and introduction is also considered feasible as this was translocated successfully during the Oxley Highway upgrade near Port Macquaried. The ROTAP species *Eucalyptus ancophila* is relatively common in State Forest surrounding the WC2U corridor and for this reason is considered not to warrant translocation. It could be used in landscaping and revegetation, using seed collected during clearing.

Translocation of the rare species *Goodenia fordiana* and *Artanema fimbriatum* would aim to preserve impacted individuals and establish new stands or populations to compensate for those cleared.

3.5.9 Conclusion - Translocation Feasibility

This assessment concludes that salvage translocation of Slender Marsdenia, Woolls' Tylophora, Rusty Plum, Maundia, Floyds Grass and Spider Orchid (threatened species), and Goodenia fordiana and Koala Bells (rare or ROTAP species) is feasible and justified in terms of technical practicality, conservation benefit and advancements in conservation science and translocation techniques. Translocation of Maundia would be limited to the Williamson's Creek population and management of this species elsewhere would focus on minimisation of impacts and monitoring of in-situ stands outside the direct and indirect impact zones.

Four of these threatened species are listed under the TSC/EPBC Acts as Endangered, the highest category of conservation risk, so prevention of any loss to existing populations of these species is necessarily a high priority.

The risk of the translocated individuals failing to establish is lessened by RMS' commitment to follow-up maintenance and monitoring during highway construction and a minimum 5 year period after the completion of construction. Genetic risks to the subject species are not considered significant as all translocations will be limited to relocating individuals within their local population/source area.

Better understanding of threatened species habitat, plant morphology, disturbance response behaviour and population dynamics can be generated by systematic and well monitored salvage translocation, as proposed for the WC2U project.

3.6 DISCUSSION - Compensatory Habitat

3.6.1 Introduction

In relation to MCoA B7 & B8 (see Appendix 5), RMS has requested " A discussion of the process identified for incorporating compensatory habitat for the impacted plants in the Biodiversity Offset Strategy should translocation be identified as not feasible or where monitoring of translocated plants establishes that translocation has been unsuccessful."

3.6.2 Assessing Translocation Outcomes

In the Ministers Condition of Approval B7(c) the preparation of a Biodiversity Offset Strategy for threatened plants appears to be conditional upon the actual or likely outcome of undertaking translocation of the subject species. MCoA B7 (c) states: "*identifies a process for incorporating appropriate compensatory habitat for the impacted plants in the Biodiversity Offset Strategy referred to in Condition B8 should the information obtained during the investigation referred to in Condition B7(a) find that translocation is not feasible or where the monitoring undertaken as part of condition B10 finds that translocation measures have not been successful (as identified through performance criteria);*" In other words, inclusion of threatened plant species in a Biodiversity Offset Strategy would be required if translocation was not considered feasible, or if it was unsuccessful, as demonstrated by monitoring.

Section 3.5 above concluded that it is feasible to undertake translocation of the subject species, in terms of techical feasibility and potential conservation benefit. However it may not be practically possible to demonstrate through monitoring whether a translocation is successful or not over the long-term, because of the slow rate of processes involved in establishing a functional and viable population. There will be element of uncertainty as to the outcome, particulary for perennial, long-lived species that would not complete their life cycle during the time allocated for monitoring.

Monitoring of threatened species translocation for highway development projects managed by RMS is normally undertaken for 5-10 years. Is this long enough to demonstrate whether a translocation has been successful or not? If it is, is the lag time involved in demonstrating success or not, too long to expect a consistent management response several years after the start of highway operation?

Different sets of criteria have been developed for assessing the success of threatened species translocations. For example, Pavlik (1996) sets out a rigorous scheme of proximal (short-term) and distal (long-term) translocation objectives organised under four goals: abundance, extent, resilience and persistence. Typical proximal abundance objectives included "life cycle can be completed in-situ without habitat management; size distribution matches natural populations; and seed output matches natural populations" (see Table 6-1, p. 133). The proximal objectives for the other goals (i.e. extent, resilience and persistence) and the distal objectives for these goals are more complex and unlikely to be demonstrable during the life of a typical monitoring program. Long-lived trees, shrubs and vines may take several years to establish from seedlings, decades to reach reproductive maturity and centuries to demonstrate resilience to environmental perturbations and persistence. In a development context, goals and objectives need to be practically tailored to the species life history and the time period and resources available for monitoring. Even though Pavlick's criteria are perhaps too rigorous to be practically implemented, they are nevertheless comprehensive and valid for assessing whether a translocation has been successful or not in the long-term (i.e. 20-50+ years).

The outcome of threatened species translocation is therefore inevitably uncertain within the life of a typical monitoring program. The monitoring time-frame is too short to observe the complete life cycle of plants and ecosystem processes such as succession and habitat maturation that may determine if a population persists and reproduces or not. Given the complexity of factors affecting translocation outcomes and the long time period required to establish whether a translocation is successful or not, it would seem appropriate that mitigation measures for impacted threatened plant species include both translocation (where considered feasible) and provision of compensatory habitat containing populations of the same species that can be managed specifically for conservation purposes where feasible and reasonable.

This has been the general approach adopted on other Pacific Highway development projects on the NSW North Coast. For example, the Brunswick Heads to Yelgun, Yelgun to Chinderah, Bonville Deviation and Tugun Bypass projects, all provided compensatory habitat containing populations of impacted threatened species in addition to conducting translocation of the impacted species. On all of these projects, translocation was carried out at least in part to compensatory habitat containing populations of the impacted species, so the provision of compensatory habitat may provide a dual purpose in this regard. The primary benefit of translocation not provided by compensatory habitat is the maintenance of population number and genetic diversity. Without translocation, impacted threatened species would incur a net loss of population number and genetic diversity.

3.6.3 Compensatory Habitat for Threatened Plants

In relation to threatened plants, MCoA B8 provides the following guidelines for developing a Biodiversity Offset Strategy:

"Unless otherwise agreed to by OEH, offsets shall be provided on a like-for-like basis and at a minimum ratio of 4:1 'for areas of high conservation value (including EEC and threatened species or their habitat identified in the Environmental Assessment to be impacted by the project and poorly conserved vegetation communities identified as being more than 75% cleared in the catchment management area) and 2:1 for the remainder of native vegetation areas (including mangroves, seagrass, salt marsh and riparian vegetation). The Strategy shall include, but not necessarily be limited to:

(a) confirmation of the vegetation communities/ habitat (in hectares) to be offset and the size of offsets required (in hectares);

(b) details of the available offset measures that have been identified to compensate for the biodiversity impacts of the project, such as (but not necessarily limited to): suitable compensatory land options and/ or contributions towards biodiversity programs for high conservation value areas on nearby lands (including research programs). Where the use of State Forest land managed in accordance with an lntegrated Forestry Operations Approval is proposed to offset biodiversity impacts, the Proponent shall clearly demonstrate how this would provide the biodiversity outcomes required under this condition including any additional offset requirements to cover residual impacts;

(c) the decision-making framework that would be used to select the final suite of offset measures to achieve the aims and objectives of the Strategy, including the ranking of offset measures;
(d) a process for addressing and incorporating offset measures for changes to impact (where these changes are generally consistent with the biodiversity impacts identified for the project in the documents listed under condition A1, including:
i. changes to footprint due to design changes;
ii. changes to predicted impacts resulting from changes to mitigation measures;
iii. identification of additional species/habitat through pre-clearance surveys; and
iv. additional impacts associated with ancillaryfacilities; and
(e) options for the securing of biodiversity options in perpetuity." (MCoA B8)

3.6.4 Process for Incorporating Compensatory Habitat for Threatened Plants in the Biodiversity Offset Strategy

1) Identify the threatened species impacted.

2) Determine the type and extent of the habitat of the threatened species impacted

3) Determine the number of individuals (or other demographic measure as appropriate) of the threatened species impacted.

4) Determine the area of habitat of the threatened species impacted.

5) Determine the minimum quantity of mitigation at a ratio of 4:1 for number of individuals and habitat area of the threatened species impacted, according to MCoA B8.

6) Conduct desktop assessment of areas likely to contain suitable compensatory habitat for the subject species.

7) Conduct field survey to confirm that necessary attributes are present in nomimated areas - i.e. populations of the subject species, sufficient habitat area and suitable habitat condition.

8) Selection of appropriate compensatory habitat land for threatened plants, would be guided by the following criteria:

    - The compensatory habitat to be within 20km of the WC2U corridor.

    - The compensatory habitat to provide the same type of threatened species habitat to that removed (i.e. geology, soil type, topography, plant community).

    - The compensatory habitat to support populations or sub-populations of the subject threatened species similar in configuration to that removed.

    - The compensatory habitat to also contain suitable unoccupied recipient sites for conducting the translocation of impacted species, with the goal no net reduction in the local population of each species.

- Preferably the compensatory habitat would adjoin an existing Nature Reserve or National Park and be incorporated into NPWS estate.

- In accordance with MCoA B8, "Where the use of State Forest land managed in accordance with an lntegrated Forestry Operations Approval is proposed to offset biodiversity impacts, the Proponent shall clearly demonstrate how this would provide the biodiversity outcomes required under this condition including any additional offset requirements to cover residual impacts."

3.6.5 Determining the Type and Area of Threatened Plant Species Habitat

Several types of habitat would be required for compensatory habitat according to the different habitat preferences of the subject species:

- Wet sclerophyll forest in hilly terrain on Nambucca Beds geology.
- Well shaded rainforest understorey in wet sclerophyll forest, or swamp forest dominated by Melaleuca stypheloides.
- Riparian Swamp Oak forest.
- Freshwater wetland.

Table 5: Habitat types required to provide compensatory habitat for impacted threatened species on the WC2U upgrade.

Threatened Species	Habitat Type Required
Slender Marsdenia (*Marsdenia longiloba*)	Wet sclerophyll gully in hilly terrain on Nambucca Beds geology
Rusty Plum (*Niemeyera whitei*)	Wet sclerophyll gully on Nambucca Beds or hornfels geology
Wooll's Tylophora (*Tylophora woollsii*)	Wet sclerophyll gully on Nambucca Beds geology
Spider Orchid (*Dendrobium melaleucaphilum*)	Rainforest understorey in WSF; Swamp sclerophyll forest dominated by *Melaleuca styphelioides*
Floyds Grass (*Alexfloydia repens*)	Floodplain riparian Swamp Oak forest
Maundia (*Maundia triglochinoides*)	Freshwater wetland or swampy stream margin.

Determining the area of impacted threatened plant species habitat is not straight forward. For example, where does the habitat of a threatened species start and end? Are we referring to actual or potential threatened species habitat? Is the actual and potential habitat also dependent on adjoining habitats or plant communities to provide topographic shelter and protection?

The simplest approach may be to calculate the area of plant communities that provide habitat for the threatened species, according to the vegetation mapping in the EA, and multiple by four. A potential complication here is that there may be inaccuracies in the vegetation mapping and description, so that the mapped and field vegetation types do not correspond well, which was noted in a few cases during targeted survey. This would have to be considered in detemining the appropriate type and area of compensatory habitat.

4 TRANSLOCATION PLAN

4.1 Introduction

This section of the Threatened Flora Management Plan sets out a plan to translocate threatened plant species directly impacted by construction of the Warrell Creek to Urunga Upgrade of the Pacific Highway (Table 6), in accordance with Ministers Condition of Approval B7.

In addition to the two species specified in MCoA B7 (*Marsdenia longiloba* and *Niemeyera whitei*), RMS would also undertake the translocation of other threatened and rare (ROTAP) species recorded during the targeted flora survey, which are directly impacted by project works, as described in Section 3.

Table 6: Threatened and rare species directly impacted by the WC2U upgrade and included in this translocation plan.

Species	**Conservation Status**
Threatened Species	
Slender Marsdenia (*Marsdenia longiloba*)	TSC Act (V); EPBC Act (E)
Wooll's Tylophora(*Tylophora woollsii*)	TSC Act (E); EPBC Act (E)
Floyds Grass(*Alexfloydia repens*)	TSC Act (E)
Spider Orchid (*Dendrobium melaleucaphilum*)	TSC Act (E)
Rusty Plum (*Niemeyera whitei*)	TSC Act (V)
Maundia (*Maundia triglochinoides*)	TSC Act (V)
Other Species	
Ford's Goodenia (*Goodenia fordiana*)	ROTAP
Koala Bells (*Artanema fimbriatum*)	Potential Threatened Species Listing

The translocation plan has been structured according to the format recommended by the Australian Network for Plant Conservation (2004), as summarised below:

- Section 4.1 - Introduction.
- Section 4.2 - General Considerations - discusses the type of translocation action to be carried out, the objectives of the translocation project, designing translocated populations, genetic management and the advantages of incorporating experimental design.
- Section 4.3 - Pre-translocation Assessment - describes the selection of receival sites and the ecology of the subject species.
- Section 4.4 - The Translocation Proposal - outlines the overall translocation approach.
- Section 4.5 – The Species Proposals – outlines the proposals for each species to be to be translocated
- Section 4.6 - The Translocation Action - details how the translocations will be carried out.

- Section 4.7 - Post-translocation Actions - describes follow-up measures including maintenance, habitat restoration, monitoring and project evaluation.

Table 7: below provides definitions of various technical terms used in the translocation plan

Technical term	Definition
Translocation	The deliberate transfer of plants or regenerative plant material from one place to another, including existing or new sites or sites where the taxon previously occurred. (This term is synonymous with re-introduction.)
Transplanting	A translocation technique where plants are dug or excavated from the ground and moved to another site. Individuals translocated in this way are referred to as ‘transplants’.
Propagation	A translocation technique or approach where plants are propagated (e.g. seed, cuttings, tissue culture) under nursery conditions then introduced to a site.
Threatened species	Plant taxa in danger of extinction and protected by state or federal environmental legislation.
ROTAP Species	Rare Or Threatened Australian Plants listed in Briggs and Leigh (1995)
Population	In a general sense, a group of individuals sharing some common relationship (e.g. spatial, genetic, morphological). In one sense, a group of individuals in which there is free breeding and gene exchange.
Provenance	A genetically distinct area of a species distribution and usually thought to represent genetic adaptation to local environmental conditions.
In-situ	The original place; pertaining to the maintenance of plants in the wild.
Genetic variability	Variation in the genetic composition between individuals and populations.
Inbreeding	The mating of individuals related by descent, usually causing a reduction in gene heterozygosity and diversity.
Inbreeding depression	A reduction in vigour and fitness due to inbreeding.
Self-sustaining	A population of plants that maintains itself without external assistance.
Local population	An assemblage of individuals belonging to the same species occurring within 5 km of the project within similar habitat in terms of soil type and plant community.
Enhancement	An attempt to increase population size or genetic diversity by adding to individuals to an existing population. This may be part of the process of restoration or reconstruction of a site where the taxon occurs, but requires population manipulation to increase viability. Also referred to as re-enforcement, re-stocking, enrichment, supplementation or augmentation.
Reintroduction	An attempt to establish a population in a site where it formerly occurred, but where it is now extinct. This may be part of the process of restoration or reconstruction of a habitat where the taxon was previously known to occur. Also, referred to as re-

	establishment
Conservation	An attempt to establish a taxon, for the purposes of introduction conservation, at a site where it is not known to occur now or to have occurred in historical times, but which is considered to provide appropriate habitat for the taxon.”
Salvage dig	The transplantation of mature plants or soil to an area not affected by the development. Also referred to as transplantation or rescue dig. Salvage digs are likely to be the least effective method of translocation and should only occur when combined with other translocation methodologies.
Ameliorative enhancement	An attempt to increase population size by adding individuals to enhancement an existing population to ameliorate the loss of part of that population due to development.
Compensatory	The establishment of a population to compensate for the introduction impact of a development. In the majority of cases such translocations will meet the definition of introduction as described above.

4.2 General Considerations

4.2.1 What Kind of Translocation?

Translocation is defined as the "deliberate transfer of plants or regenerative plant material from one place to another, including existing or new sites or those where the taxon is now extinct." (ANPC 2004). Translocation is carried out in two main contexts: (i) as a research or conservation measure to assist in the recovery of threatened or rare species, and (ii) as a mitigation measure to ameliorate the adverse impact of a development activity (Falk *et al.* 1996, ANPC 2004). Translocation in both of these cases has the same general conservation purpose, which is to avoid loosing populations of threatened species and increasing the risk of population extinction (Pavlik 1996).

Under translocation for conservation purposes, three types of translocation are described by ANPC (2004):-

Enhancement: An attempt to increase population size or genetic diversity by adding to individuals to an existing population. This may be part of the process of restoration or reconstruction of a site where the taxon occurs, but requires population manipulation to increase viability. Also referred to as re-enforcement, re-stocking, enrichment, supplementation or augmentation.

Reintroduction: An attempt to establish a population in a site where it formerly occurred, but where it is now extinct. This may be part of the process of restoration or reconstruction of a habitat where the taxon was previously known to occur. Also, referred to as re-establishment.

Conservation introduction: An attempt to establish a taxon, for the purposes of conservation, at a site where it is not known to occur now or to have occurred in historical times, but which is considered to provide appropriate habitat for the taxon.

Under the heading of ameliorative or developmental translocation, three types of translocation are described: -
Salvage dig: The transplantation of mature plants or soil to an area not affected by the development. Also referred to as transplantation or rescue dig. Salvage digs are likely to be the least effective method of translocation and should only occur when combined with other translocation methodologies.

Ameliorative enhancement: An attempt to increase population size by adding individuals to an existing population to ameliorate the loss of part of that population due to development.

Compensatory introduction: The establishment of a population to compensate for the impact of a development. In the majority of cases such translocations will meet the definition of introduction as described above.

The translocation proposed for the WC2U project involves three complementary activities:- salvage translocation, population enhancement and experimentation. Salvage translocation aims to save and re-establish those individuals of significant flora directly impacted by construction. Enhancement aims to improve the prospective viability of the translocated population by propagating and introducing additional individuals. This is consistent with ANPC (2004) that recommends salvage translocations be combined with population enhancement to improve translocation outcomes. The experimental component aims to increase understanding of species ecology and how ecological factors affect translocation outcomes. Translocation presents a unique opportunity to conduct systematic research by conducting field manipulation of plants and growing conditions during the translocation process. It should be noted that while the proposed translocation involves an experimental component, the focus will be on ensuring successful salvage translocation and population enhancement.

4.2.2 WC2U Translocation Objectives

The overall objective of threatened plant translocation is to establish populations that are self-sustaining over the long term. To demonstrate successful translocation in the short-term the species concerned should be able to carry out basic life-history processes (i.e. healthy growth, reproduction, dispersal and recruitment) such that the probability of local extinction by random factors is low. Pavlik (1996) distinguished between short term goals (abundance, extent) and long-term goals (resilience and persistence). "Whereas abundance and extent can develop over short periods of time (1-10 years) and be directly influenced by design aspects of the (translocation) project, resilience and persistence are only tested over long periods of time (one to several decades) by natural variation in the environment and in the new population itself." (Pavlik 1996, p. 130).

It is also necessary to distinguish between biological success and project success in defining objectives. Biological success includes the performance of individuals or populations of the target taxon. Project success is broader. With an experimental design and careful monitoring, a translocation project can be successful even if its new population fails, by contributing to our knowledge of threatened or rare plants or by developing new management techniques, although mitigation efforts are usually required to achieve some level of biological success (Pavlik 1996).

Pavlik (1996) erected a scheme of proximal (early) and distal (late) objectives organised under the four translocation goals of abundance, extent, resilience and persistence. However, the scheme is suited to annual and short-lived perennial plants rather than long-lived rainforest trees and shrubs on the WC2U project. These may take several years to establish from seedlings, decades to reach reproductive maturity and centuries to demonstrate resilience to environmental perturbations and persistence. Objectives need to be practically tailored to species life history and the time period and resources available for monitoring.

Objectives and performance criteria that can be assessed in the short term whilst at the same time being consistent with and promoting longer term goals would be more appropriate.

In this context, the general objectives of this translocation project are defined as follows:

- To transplant and successfully re-establish impacted individuals of the subject species (and other significant species) at a nearby site with soil type and topography closely matching the original site of each species;
- To promote the long-term sustainability of the founder (translocated) population by enhancing population size and genetic diversity through propagation and introduction of additional individuals;
- To promote long-term sustainability by restoring good quality habitat and establishing functional habitat conditions;
- To undertake translocation using a monitored, experimental approach that improves knowledge of species ecology and translocation technology; and
- To preserve individuals of the subject species (and other significant species) in-situ wherever possible and limit transplanting to individuals directly impacted construction.

4.2.3 Designing Translocated Populations

According to Bottin *et al.* (2007) successful translocation depends on three criteria:-

- Consistency between the environmental characteristics of the translocation receival site and the ecological needs of the species;
- Sufficient population size; and
- Sufficient genetic variability.

Selecting suitable habitat for rare plant introductions can be far from self-evident. Consideration must be given to physical, biological, logistical and historical criteria (Fiedler and Laven 1996). These criteria were applied to the site selection process for this project, as described below (Section 4.3.2). Maintaining sufficient levels of genetic variability is discussed in Sec. 4.2.4 and 4.4.1.2. The remainder of this section is concerned with determining a sufficient size for initial or founder populations of the subject species.

"Models that predict extinction probabilities can be used to set a long-term abundance objective by determining the minimal viable population (MVP) size of a new population for its specific environment. One definition of MVP is the smallest number of individuals required for a 95% probability of survival over one hundred years. But applying such model predictions to a practical conservation effort is often specious and always difficult" (Pavlick 1996, p. 135).

There are no magic numbers for establishing populations with good long-term prospects for survival, but research has defined a range in which to begin. "Selection of an appropriate minimum viable population (MVP) size depends on the life history characteristics of the target species. Long-lived, woody, self-fertile plants with high fecundity would have an MVP in the range of 50 to 250 individuals" (Pavlick 1996, p. 137). The subject species to be translocated on the WC2U project fall within this general life history class, although fecundity appears not particularly high in some species. The minimum number of individuals in a self-sustaining population would therefore be 50. As a proportion of the individuals introduced as seedlings or propagated cuttings would be subject to selection and mortality or thinning of the initial population, the population introduced would need to be significantly larger than the MVP size. It is suggested that the translocation project aim at introducing two to three times the minimum MVP (100-150) to allow for mortality and thinning of the initial population.

4.2.4 Genetic Management

Genetic factors can play an important role in the short-term establishment and long term resilience and persistence of translocated populations. Ideally, a translocation project would include a genetic survey to determine the genetic structure of existing populations and appropriate level of genetic diversity in the translocated population. If information on genetic variation is not available, habitat type (e.g. geology, soil type, elevation, topographic position and associated plant community) and geographic distance can be used as surrogates for genetic variability and a basis for demarcating provenances. Studies have found that the genetic dissimilarity of populations usually increases as the distance between them increases so that geographic distance can be used as an indirect measure of the genetic difference between populations. This spatio-genetic relationship does not always apply though, as some species can be genetically homogeneous over large distances (Bussel et al. 2006) and marked genetic differentiation can occur over very short distances if there are abrupt changes in soil type or other aspects of habitat (Benwell 2011).

Conservation geneticists generally recommend that the best strategy for facilitating the persistence and evolutionary flexibility of species is by maintaining genetic diversity and heterozygosity in populations (Hopper and Coates 1990; Ellstrand and Ellam 1993; DECC 2007. Poorly selected genetic material can result in inbreeding or outbreeding depression, and loss of genetic flexibility to cope with changing environments. Consideration of genetic issues in a species translocation requires a balance between maximising genetic diversity, helping to purge deleterious alleles, avoiding breaking co-adapted gene complexes and avoiding importation of mal-adapted genes (Bottin et al. 2007).

The origin of introduced plants is the key issue here. Individuals are more likely to be adapted to site if they originate from the same site or locale, have been subject to a short ex situ period (e.g. during propagation or storage), or are from another population connected by gene flow (Bottin et al. 2007). In a salvage translocation context, the potential for introduction of inappropriate genetic material is probably low if individuals are relocated within the bounds of their local population, unless that population has already become inbred or genetically homogenised due to the effects of clearing. There may also be genetic risks if population enhancement is undertaken. For this project, the following procedures would be implemented to promote genetic diversity and avoid introduction of inappropriate genetic material during species translocation and habitat restoration:-

- Propagate from local (<10km) provenances.
- Where possible the source populations used for propagation should contain more than 10 mature individuals.
- Select propagation material from a broad sample of parent plants within local area.
- Limit the number of seedlings introduced from any one source individual to a maximum of 15% of the total number introduced.
- Avoid planting seedlings/cuttings propagated from the same parent plant close to each other.
- Label and monitor all plants throughout the translocation process.
- No more than 5% of reproductive material or available cuttings to be removed from a parent plant (unless it is going to be destroyed).

4.2.5 Experimental Component

Translocation projects incorporating experimental design can generate useful information on translocation techniques and species ecology (Guerrant 1996). For example, Ecker (1990) salvaged a number of plants of the rare cactus *Mammillaria thornberi* from a construction right of way in Arizona before their habitat was developed. Some of this material was used experimentally to test a number of hypotheses about how best to transplant it; planting cactus under nurse plants, especially creosotebush (*Larrea tridentata*) proved to be most successful. Experimental translocations of three endangered plants undertaken in South Australia confirmed the impact of specific site factors (weed competition, grazing and physical microsite factors) thought to affect the survival and establishment of seedlings of each species (Jusaitis 2005). Guerrant and Kaye (2007) recommended that translocation projects are best done as well designed scientific experiments that test explicit hypotheses.

An experimental approach would be incorporated in the WC2U translocation project where practical and not overly jeopardizing species survival 'targets' (i.e. experimentation may involve subjecting species to sub-optimal growth conditions). Experimental comparisons can produce valuable insights into species ecology and improve translocation techniques, both of which can assist species recovery. Salvage translocation can also test techniques for assisted migration or geographical transfer of species in response to climate change (DECC 2007). For example, the successful translocation of the endangered species Floyds Grass (*Alexfloydia repens*) at Bonville (Ecos Environmental 2009) demonstrated how this species could be relocated if its estuarine habitat is threatened with inundation by rising sea level, as predicted to occur this century due to global warming.

For the WC2U project it recommended that further research be conducted on Slender Marsdenia in particular, to clarify its life history attributes, population dynamics and site requirements. This is considered appropriate given the level of impact of the project on this species.

4.3 Pre-translocation Assessment

4.3.1 Species Ecology

4.3.1.1 Slender Marsdenia (*Marsdenia longiloba*)

Regional Distribution: Slender Marsdenia occurs between the Hastings River district (Port Macquarie) and southeast Qld and from the coast inland to the Great Escarpment ranges, at widely scattered locations.

Local Distribution: Slender Marsdenia was recorded in the Raleigh south, Newry State Forest, Little Newry State Forest, Valla south, Nambucca State Forest and Warrell Creek sections of the WC2U corridor. A total of 189 stem-individuals were recorded in at least 22 different sub-populations.

Habitat: Found in moist open forest and gradational subtropical and warm temperate rainforest, mostly below 200m altitude (Quinn *et al.* 1995). Characteristics of Slender Marsdenia habitat recorded on the WC2U road corridor included: -

- soil type a yellow to red clay podzol formed on Permian metasediments;
- soil A-horizon 15-30cm deep, dark brown, humus enriched topsoil;
- wet sclerophyll forest with an open to mid dense rainforest understorey usually on a lower slope;
- sloping (gentle to moderate) and well drained, often with a southern aspect;
- understorey moderately well lit and open, not dense or heavily shaded;
- topsoil only slightly acidic (pH >6).

Life History and Population Dynamics: Benwell and Watson (2011) have recorded the life history attributes of Slender Marsdenia during translocation and monitoring of this species for the Bonville upgrade near Coffs Harbour, as follows:-

- Slender Marsdenia is a small, perennial, rhizomatous vine.
- Sub-populations are composed of single-stemmed ramets growing from underground rhizomes; several stems may be attached to the same branching rhizome.
- Above ground stems are comparatively short-lived (1-10 years), while the rhizomes are probably more long-lived.
- The rhizomes are relatively thin, 10-30cm long and grow horizontally within the soil A1 horizon (occasional vertical rhizomes are also present); the rhizomes ramify through the soil, budding off and separating from the parent rhizome to form separate plants.
- Plants may die back to the rhizome and remain stem-less and dormant for up to two years (probably longer), then produce new stem shoots.
- Most stem-individuals never grow more than 30cm tall before dying back.
- Only large stem-individuals (ie >1m tall) produce flowers; production of pods and seed is extremely rare; only 1 pod has ever been recorded during several years of monitoring at several locations.
- *Marsdenia longiloba* appears to rely on vegetative reproduction for population persistence; flowering and seed dispersal play a minor role in this process.

- Discrete sub-populations and patches of *Marsdenia longiloba* may originate vegetatively from the same parent plant and spread over a considerable area (e.g. 0.04 ha).
- *Marsdenia longiloba* stems are conspicuously absent from recently (<1-6 yrs) logged or burnt forest, although monitoring of translocation areas has shown that quiescent rhizomes may be present in the soil. This suggests that conditions during early post-disturbance succession are not favourable for growth of *Marsdenia longiloba,* and stem growth may occur mainly during mid to late stages of succession. The response of *Marsdenia longiloba* to fire has never been monitored.

Transplanting potential: Slender Marsdenia has been transplanted successfully (Benwell and Watson 2011).

Propagation potential: Slender Marsdenia has been propagated successfully from rhizome pieces (Benwell and Watson 2011).

Recovery Plan: A Draft Recovery Plan has been prepared for the Slender Marsdenia.

4.3.1.2 Wooll's Tylophora (*Tylophora woollsii*)

Regional Distribution: *Tylophora woollsii* occurs from the Hawkesbury River north to Byron Bay and the Qld border, and from the coast inland to the Great Escarpment Ranges. There is a concentration of records in an arc extending from Coffs Harbour-Bellinger Valley northwest to Dorrigo district and Gibraltar Range (Wildlife Atlas).

Local Distribution: *Tylophora woollsii* was recorded at three locations on the WC2U corridor:- between Raleigh and the Kalang River, Newry State Forest and Nambucca State Forest. Single plants were found at two locations and two plants at the third location. This species may have been under-recorded as its leaves are very similar to *Marsdenia longiloba*. Generally, the species appeared to be very rare; all individuals were small plants.

Habitat: The species is found in rainforest and wet sclerophyll forest. Quinn *et al.* (1995) describe the habitat of this species as “brown clay over metasediments in wet sclerophyll forest at altitudes between 10 and 750 m.” In the Coffs Harbour area it occupies the same habitat as *Marsdenia longiloba*, which is moist open forest on mid to upper, SE/S-facing hillslopes with a weakly developed rainforest understorey.

Life History and Population Dynamics: Little is known about the life history and population dynamics of *Tylophora woollsii*.

Transplanting potential: *Tylophora woollsii* has been transplanted successfully.

Propagation potential: *Tylophora woollsii* has been propagated successfully from rhizome pieces.

Recovery Plan: A Draft Recovery Plan has been prepared for the Woolls’ Tylophora (Draft).

4.3.1.3 Rusty Plum (*Niemeyera whitei*)

Regional Distribution: Found from the Macleay River north to upper Tallebudgera Creek inland from the Gold Coast (Floyd 1989). The distribution of *Niemeyera whitei* is characterised by separate northern and southern meta-populations (NPWS 1998). The northern meta-population is restricted to the Mt Warning Shield on the NSW-Qld border. The southern meta-population occurs from the Coffs Harbour district south to Ingalba State Forest, and inland to the Dorrigo and Upper Bellinger districts (Wildlife Atlas). It is also reported from the Port Macquarie district (Harden 2000), which appears to represent a small, disjunct, southern population.

Habitat: Typical habitat consists of gully rainforest or wet sclerophyll forest with a well-developed rainforest understorey on medium fertility soil formed on metasediment or rhyolite. The altitudinal range of this species is from near sea level to 600 m (Floyd 1989).

Local Occurrence: *Niemeyera whitei* was recorded at two locations: Boggy Creek near Valla and Cockburn's Lane south of Warrell Creek. A single small tree was recorded at Boggy Creek and 17 trees and saplings plus seedlings were recorded in a 150 meter long section of the road corridor at Cockburn's Lane. The trees were up to 10 metres in height with a maximum diameter of about 30 cm.

Life History and Population Dynamics: Rusty Plum appears to be a long-lived tree. Field observations indicate that trees and saplings of this species recover from natural or man-made disturbance by epicormic and to lesser extent basal resprouting.

Transplantation potential: This species can be transplanted with a moderate to high success rate depending on choice of site (Benwell and Watson 2011).

Propagation potential: This species propagates readily from seed, which ripen in November in the Coffs Harbour area (Benwell and Watson 2011).

Recovery Plan: No Recovery Plan has been prepared for this species.

4.3.1.4 Floyd's Grass (*Alexfloydia repens*)

Regional Distribution: The species is only found between Coffs Harbour and Warrell Creek within 10km of the coast.

Local Distribution: Floyds Grass was recorded at one location on the northern bank of Warrell Creek on the eastern and western sides of the project boundary.

Habitat: The habitat of Floyd's Grass has been described as "coastal stands of Swamp Oak and Paperbark in peat-like soil edging the upper tidal areas of mangroves. It is known to grow on the banks of estuarine creeks." (DEC species profile). On Bonville Creek south of Coffs Harbour, Floyd's Grass occurs on estuarine levees and the edge of back-levees, in floodplain open forest and swamp sclerophyll forest, respectively. In Swamp Oak forest it occurs just above the king tide zone. Swamp Oak extends well into the king tide zone which appears to be unsuitable for Floyds Grass.

At Warrell Creek, Floyds Grass occurs in a narrow zone 1-2 metres wide on the edge of the creek in Swamp Oak forest. The soil type is a humus-enriched, clay loam formed on alluvium.

Life History and Population Dynamics: Translocation and monitoring of Floyds Grass for the Bonville Upgrade (Benwell and Watson 2011), yielded the following information on the species' life history and population dynamics:-

- *Alexfloydia repens* is a perennial, stoloniferous, matt-forming grass.
- The species spreads by stolons or runners. When introduced to Swamp Oak Forest after clearing the understorey and ground layer of exotics, stolons grew up to 2.4 metres long in 12 months.
- On bare ground formed either artificially, or as a result of flood erosion and dieback of ground layer vegetation, Floyds Grass can regenerate rapidly from runners to form a dense cover.
- Flowers are produced very sparsely in forested situations (ie. habitat with a tree canopy) and abundantly in more open habitat, where the vegetation structure has been simplified by disturbance (ie. tree clearing).
- To persist at a location *Alexfloydia repens* relies on vegetative regeneration after disturbance rather than seedling recruitment; new bare sites may be colonised by seed dispersal and seedling establishment, although there is little evidence to indicate this occurs frequently.
- Established ground cover vegetation forms a barrier to the spread of runners.
- The common native grass *Ottochloa gracillima* appears to compete strongly with Floyds Grass as they two species occur together in mutually exclusive patches in essentially the same habitat.

Transplanting potential: The stoloniferous growth habitat of Floyds Grass makes it relatively easy to transplant (Benwell and Watson 2011).

Propagation potential: Floyds Grass can be propagated vegetatively (Benwell and Watson 2011).

4.3.1.5 Spider Orchid (Dendrobium melaleucaphilum)

Regional Distribution: *Dendrobium melaleucaphilum* is an epiphytic orchid found in coastal districts and nearby ranges from lower Blue Mountains north to Qld. In NSW, it is currently known from seven recent collections.

Local Distribution: *Dendrobium melaleucaphilum* was recorded at two loocations within the project boundary - north of the Kalang River, where only one mature plant was found, and in Newry State Forest. Other occurrences have been recorded in Newry State Forest outside the road alignment

Habitat: *Dendrobium melaleucaphilum* is an epiphytic orchid, which grows in swamp sclerophyll forest, wet sclerophyll forest and rainforest in coastal areas, often on Prickly Paperbark (*Melaleuca stypheliodes*).

Life History and Population Dynamics: There is little information on the life history of this species. Orchids in general produce large quantities of very fine, wind dispersed seed. The seed germinates on a suitable substrate, in this case the rough papery bark of *Melaleuca stypheliodes,* where it must then be infected with a specific fungal symbiont in order for the plant to grow.

Transplanting potential: Dendrobium species transplant in cultivation with a high success rate as they have tough desiccation resistant leaves and a perennial pseudobulb from which new shoots will grow if the plant dies back. A high survival rate is also likely to be dependent on selection of an appropriate receival site and maintenance while plants become established.

Propagation potential: Dendrobium species can be propagated vegetatively or from seed.

Recovery Plan: A Recovery Plan has not been prepared for *Dendrobium melaleucaphilum.*

4.3.1.6 Ford's Goodenia (*Goodenia fordiana*)

Regional Distribution: Fords Goodenia is endemic to the NSW Lower North Coast between Coffs Harbour and Buladelah and is listed as nationally rare (Briggs and Leigh 1995).

Local Distribution: Ford's Goodenia was recorded at eight locations in the Raleigh south, Newry State Forest and Nambucca State Forest areas. It was most common in the Raleigh south area. This prostrate ground-cover herb forms patches up to about 0.5m wide.

Habitat: Found in gully wet sclerophyll forest under moderate to dense shade. The soil type is clay podzol formed on Permian metasediment.

Life History and Population Dynamics: Ford's Goodenia appears to regenerate vegetatively from stolons and by seed dispersal.

Transplanting potential: The stoloniferous growth form of Ford's Goodenia indicates that it can be transplanted with a high success rate, given appropriate receival site selection and maintenance during establishment.

Propagation potential: Probably vegetatively or from seed.

Recovery Plan: A Recovery Plan has not been prepared for *Goodenia fordiana*.

4.3.1.7 Koala Bells (*Artanema fimbriatum*)

Regional Distribution: The North Coast of NSW from Forster north to the Qld border (Wildlife Atlas) and also eastern Queensland.

Local Distribution: *Artanema fimbriatum* was recorded at a total of ten locations in the Raleigh, Raleigh south, Valla, Valla south and Nambucca State Forest areas.

Habitat: Koala Bells was found mainly in damp (not swampy) floodplain sites and occasionally in wet sclerophyll forest crossed by tracks. Vegetation varied from open floodplain forest, swamp sclerophyll forest, clearings in dense wet sclerophyll forest and cleared or regenerating vegetation. At least half the occurrences were associated with track or clearing disturbance where patches of seedlings had established on bare soil.

Life History and Population Dynamics: Regenerates from seed on tracks where the soil has been disturbed.

Transplanting potential: Best to transplant in spring.

Propagation potential: Can be propagated from seed or cuttings.

Recovery Plan: A Recovery Plan has not been prepared for *Artanema fimbriatum*.

4.3.1.8 Maundia (*Maundia triglochinoides*)

Regional Distribution: From Botany Bay north into south eastern Queensland.

Local Distribution: Only know locally from the wetland southeast of Macksville and Williamson's Creek

Habitat: Freshwater swamps, swamp sclerophyll forest, flowing creeks with pool and riffle sections, farm dams and channels.

Life History and Population Dynamics: Apparently grows as a long-lived perennial in permanent swamps, or if the swamp drys out it can persist as dormant seed in the soil. Capable of rapid population increase during periods of high rainfall and flooding conditions. The plant is rhizomatous and appears to spread by vegetative spread and seedling establishment (Benwell 2012).

Transplanting potential: Best to transplant in late spring.

Propagation potential: Can probably be propagated from rhizome cuttings.

Recovery Plan: A Recovery Plan has not been prepared for *Maundia glochinoides*..

4.3.2 Description of the Original/Donor Site

The Warrell Creek to Urunga Upgrade of the Pacific Highway is located on the Mid North Coast of NSW between Allgomera south of Warrell Creek and the Waterfall Way interchange at Raleigh, a distance of 42kms. The road corridor includes two landscape types: Alluvial Plains and Coastal Hills (see Section 1.2.2). Alluvial floodplains are present on the Nambucca and Kalang Rivers and smaller creeks such as Deep Creek, Boggy Creek and Oyster Creek. Soils are formed on Quaternary alluvium. Forested areas are dominated by swamp sclerophyll forest, particularly Swamp Oak, and mixed floodplain forest.

Coastal Hills surrounding the coastal floodplain are underlain by Permian metasediments. Characteristic soil types include thin, stony gradational loam on the slopes grading to yellow-brown texture-contrast soils on lower slopes and in valleys.

Forested areas are dominated by dry sclerophyll forests with moist sclerophyll forests in gullies.

The seven threatened and rare species proposed for translocation are associated with two habitat types: gully wet sclerophyll forest and alluvial floodplain forest (Table 8). Receival sites would be required that match the donor sites habitat characteristics.

Table 8: Habitat characteristics of donor sites where threatened species would be translocated from.

Broad habitat type	Threatened Species	Specific habitat type
Wet Sclerophyll Forest (wsf)	Slender Marsdenia (*Marsdenia longiloba*)	gully wsf on Permian metasediments, mostly lower slope and south aspect
	Rusty Plum (*Niemeyera whitei*)	gully wsf or perennial stream bank in hilly terrain on Permian metasediment
	Wooll's Tylophora (*Tylophora woollsii*)	gully wsf on Permian metasediments, lower slope, south aspect
	Ford's Goodenia (*Goodenia fordiana*)	gully wsf on Permian metasediments, lower slope, south aspect
	Koala Bells (*Artanema fimbriatum*)	wsf and open forest Permian metasediments, or alluvial floodplain
Alluvial Floodplain	Floyds Grass (*Alexfloydia repens*)	alluvial floodplain with Swamp Oak forest adjoining a creek
	Spider Orchid (*Dendrobium melaleucaphilum*)	alluvial floodplain supporting swamp sclerophyll forest or wsf

4.3.3 Selection of the Receival Site

Prospective recipient sites were required to meet the following criteria:-

- abiotic environment - soil type and topography closely matching the donor site;
- plant community – vegetation (extant or original) closely matching the donor site;
- site disturbed or partially cleared with regrowth, rather than undisturbed;
- close to a water source;
- the site of suitable size and area;
- accessible to vehicles and machinery, preferably with an existing access track;
- tenure suited to long-term conservation;
- close proximity to the original location of impacted individuals;
- no likelihood of impact during highway construction and operation;
- not affected by installation of new service utilities; and
- control of exotic plants in and around the translocation site is feasible.

Four types of land tenure were considered as possible receival sites for threatened species translocated from the WC2U project:

- State Forest adjoining the WC2U road corridor.
- Road reserve within the WC2U project boundary, but outside the construction footprint.

- Properties adjoining the WC2U corridor purchased by RMS, the residual land to be sold on by RMS after completion of highway construction.
- Land purchased by RMS to provide compensatory habitat for the WC2U project.

These tenures were assessed as follows: -

State Forest
State Forest was considered suitable for the location of translocation receival sites (particularly for threatened species were impacted where the road corridor crossed State Forest), as long the receival sites did not interfere with future logging operations. The visual amenity strip in State Forest which adjoins highways was seen as potentially suitable for translocation receival site. Logging exlusion areas such as drainage lines may also be suitable.

Road Reserve
Most areas of the WC2U road reserve were considered unsuitable as a translocation receival site due to:-

- limited lateral extent and area available to establishing a self-sustaining population;
- presence of in-situ threatened flora - disturbance by translocation activity;
- potential to be impacted by future highway widening;
- potential to be impacted by installation of service utilities for the current project; and
- potential for accidental damage during maintenance of roadside vegetation.

RMS purchased properties
Sites on RMS owned land outside the project boundary were considered better for establishing translocated populations because they were larger and unlikely to be affected by vegetation clearing for service installation and future highway upgrades. Several RMS owned properties with suitable habitat for receival sites are currently being considered. Legal covenants would be attached to these properties protecting translocation areas before they are sold on by RMS after completion of construction.

Compensatory habitat
No details of compensatory habitat for the WC2U are currently available.

Table 9: Attributes considered in selecting receival sites.

Site Attribute
Physical
slope aspect
slope angle
topographic position
Landform
Geology
soil
proximity to donor site
area of potential habitat available
Vegetation
original plant community
extant plant community

threatened species already present
invasive/difficult to control weeds present
Logistical
Accessibility
available water source
distance to water source
likelihood of disturbance during construction
Tenure/conservation
land ownership/ protection mechanism
potential disturbance by future road widening
other project conservation uses
Conservation benefits of the land
biogeographic context
configuration of the land
improves vegetation cover / habitat in a fragmented landscape, provides connectivity
close to extant population
better option than rehabilitating other degraded habitat.
land care involvement

4.3.4 Receival Sites

The following translocation receival sites were considered (see Appendix 7 for location maps): -

State Forest (visual amenity strip) adjoining the highway corridor

A significant number of individuals of threatened and rare flora are presently located in State Forest traversed by the highway corridor. To preserve these individuals in suitable habitat within the local area, relocation sites within State Forest adjacent to the highway corridor seem most appropriate. For threatened and rare species individuals currently located in State Forest, it is proposed to utilise adjoining State Forest within 50m of the road as the translocation receival site. This will become the new the visual amenity strip in State Forest adjoining the new highway so will not interfere with forestry logging operations. The species requiring translocation in State Forest are *Marsdenia longiloba* and *Tylophora woollsii*.

Area 1 (ch. 39160 - 38840)

Area 1 is located on a block of RMS owned land near the northern end of the WC2U corridor in the Urunga area, south of Bellingen Shortcut Road (see Appendix 7). The block includes a section of the road corridor and the residue includes a sizeable area of low lying and hill slope forest suitable as a receival site for Slender Marsdenia, Woolls' Tylophora, Spider Orchid, Goodenia fordiana and Koala Bells.

Area 2 (ch 37140 - 36700)

Area 2 is located on a block of RMS owned land north of the Kalang River (see Appendix 7). The block includes a section of the road corridor and the residue includes a sizeable area of hill slope and gully forest suitable as a receival site for Slender Marsdenia, Woolls' Tylophora, Goodenia fordiana and Koala Bells.

Area 3 (ch 28300 - 27640)

Area 3 comprises two blocks located on the southern boundary of Little Newry State Forest, adjoining the road corridor on the western side. This area is covered by forest and cleared land which would be suitable for translocation of Slender Marsdenia, Woolls' Tylophora, Rusty Plum, Goodenia fordiana and Koala Bells.

Note - Area 3 is not available as a receival site. Area 3 would not be considered further.

Area 4 (ch 1340 - 980)

Area 4 located at the southern end of the WC2U corridor south of Warrell Creek was selected as the receival site for populations of Rusty Plum and Slender Marsdenia impacted on this section of the road corridor. There are two potential receival sites: (i) within the project boundary either side of the construction footprint, or (ii) a triangle of residue land just to the north of (i). Land within the project boundary at (i), to be acquired by RMS, is quite wide and probably well in excess of what is required for construction works. The actual area disturbed by works may depend on the final detailed design. Land at (ii) is outside the project boundary and would not be disturbed during constrution. Final decision on the use of Area 4 (i) or (ii) could be made closer to the start of construction when translocations would be carried out.

4.3.5 Logistical Assessment

The translocations will be supervised by a plant ecologist, bush regenerator or horticulturist who has previous experience with the translocation of threatened species in northeast NSW. Table 10 below provides details of resources required for proposed translocation works.

Table 10: Personnel, equipment and materials required for translocation procedures

Procedures	Personnel	Plant and Equipment	Materials
Select and mark out translocation area, planting layout, access etc.	Plant ecologist, RMS.		pegs, flagging tape
Install stock fencing as required.	Plant ecologist, Fencing contractor.	tractor,	1.2m hinge-joint fencing, star pickets, fencing wire, strainers etc
Seed/cutting collection	Plant ecologist		secateurs, disinfectant, damp newspapers, zip lock bags, labelling
Propagation	Plant ecologist, plant nursery	nursery facilities.	soil mix, pots, labels etc.
Transplanting	Plant ecologist, assistants, machine operator	excavator, backhoe, truck, ute/trailer, spades, pruning saws,	tags, indelible pen
Install watering system	Plant ecologist, assistant	irrigation pump – e.g. 5hp firefighter petrol pump	polypipe, fittings, hoses
Habitat restoration	Plant ecologist, 2 assistants	bush regenerators kit	
Maintenance – watering, mulching, weed control	Plant ecologist, 2 assistants		herbicide, coarse straw mulch, slow release fertiliser, chemical record sheet
Monitoring	Plant ecologist	camera	data sheets, tags, indelible marker pen
Access control, fencing, signage	Plant ecologist/ Principal contractor		wire and paraweb fencing, signage

4.4 The Translocation Proposal

4.4.1 General Approach

The WC2U translocation project would involve salvage transplanting of five (six including Maundia at Williamson's Creek) threatened species and two rare species (Table 6) with the aim of establishing populations at new locations, which are self-sustaining over the long-term. As well as transplanting, this will require propagation and introduction of additional individuals to establish minimum viable population (MVP) sizes and adequate levels of genetic diversity. Further integral aspects of the translocation process include restoration of good quality habitat to the receival sites where required, adequate maintenance to ensure transplants and population enhancement individuals become established and monitoring and reporting of the translocation results.

4.4.2 Translocation Procedures

4.4.2.1 Salvage transplanting

Of the species to be translocated, one is a tree, two are small vines, one an epiphytic orchid, one a grass and two (three including Maundia) are herbaceous perennials. Salvage transplanting will be conducted for directly impacted individuals and any indirectly impacted individuals that the Project Ecologist considers are likely to go into decline due to their proximity to the edge of clearing (ie. changed microclimate etc). Tree species (Rusty Plum) will be transplanted with an excavator using the direct transplanting method. Manual transplanting would be used for the other species. Manual transplanting will involve digging up plants with a spade and mattock, or in the case of the epiphytic orchid removal from tree bark.

Salvage translocation of a wide range of rainforest tree and shrub species on the NSW North Coast has shown that most species have the capacity to recover from stem and root damage incurred during transplanting. The benefits of transplanting established individuals of threatened species were pointed out by Primack (1996):- "There are nonetheless ecological advantages to using transplanted plants rather than seeds in reintroduction (translocation) efforts. Plants, particularly adult plants have a higher likelihood of successful establishment than seeds (or seedlings) if they are planted into a suitable site and well tended. These plants have overcome the most vulnerable stages in their life cycle (seed germination and seedling establishment) so that their chances of surviving in the new habitat are greatly increased. These individuals also have proven genotypes that are free of lethal mutations and adapted to the general environmental conditions. When reintroduction efforts involve reproductively mature adult plants, the new population has the potential to flower, produce and disperse seeds and create a second generation of plants within a year (or so) of transplantation".

4.4.2.2 Population Enhancement

Additional individuals will be propagated and introduced to the translocation receival sites to (i) provide back-up individuals to replace mortalities incurred during transplanting, and (ii) to increase the probability of long-term population persistence by establishing a larger initital population. Population enhancement individuals will be propagated from seed or cuttings collected from local populations of each species.

The following procedures will be used to maintain the genetic integrity of local populations, whilest aiming to introduce a modest degree of genetic diversity:-

- Seed or cuttings to be collected from several parent plants in local area.
- The source populations should contain several mature individuals.
- Limit the number of seedlings introduced from any one source individual to a maximum of 20% of the total number introduced.
- Avoid planting seedlings / cuttings propagated from the same parent plant close together.
- Selection of propagation material should not be biased towards the tallest plant, the most attractive plant, the plant with the greatest amount of seed or flowers etc.
- Planted individuals to be clustered or arranged to increase the likelihood of cross-pollination.

The overall structure of the species translocations, including the number of transplant individuals and population enhancement individuals is provided in Table 11.

Table 11: The structure of the translocations in terms of number of transplant and MVP number to be established on the translocation site, how these would be propagated and seed collection time.
(Note – these numbers will be adjusted in proportion according to the final numbers salvaged, following detailed design and the contractor's pre-clearing targeted survey; no population enhancement is proposed for Maundia)

Species	Transplanted# Individuals	MVP Number	Type of propagation	Seeding time
Threatened Species				
Slender Marsdenia (Marsdenia longiloba)	176	300	rhizome cuttings	Winter
Rusty Plum (Niemeyera whitei)	13	150	seed	November
Floyds Grass (Alexfloydia repens)	~6m²	50m²		
Wooll's Tylophora (Tylophora woollsii)	5	50	rhizome cuttings	
Spider Orchid (Dendrobium melaleucaphilum)	~30	300	pseudobulbs & seed	spring
Other Species				
Ford's Goodenia (Goodenia fordiana)	~8	50	stolons	
Koala Bells (Artanema fimbriatum)	~20	100	seed	summer

Indirectly impacted individuals may also be translocated after completion of the detailed design, as determined by the Project Ecologist in consultation with the Principal Contractor.

4.4.2.3 Maintenance

Measures to be implemented to ensure adequate maintenance is carried out would include:-

- clear specification and scheduling of maintenance activities;
- supervision of maintenance activities;
- works to be carried out by bush regeneration specialists (not road construction staff); and
- commitment to monitoring and remedial action, where necessary.

A program of maintenance entailing weed control and bush regeneration would be undertaken for five years or until translocated populations are well established and surrounding habitat develops mature vegetation structure and exotics are reduced to low levels. The need for further maintenance will then be reviewed at the end of each year and a work program prepared for the following year.

4.4.2.4 Habitat restoration

Translocation receival sites with disturbed or degraded vegetation would be restored to good quality habitat using bush regeneration techniques and local species planting. The restoration work would be intensive for the 1-2 years, then gradually decrease.

4.4.2.5 Research and Experimentation

Slender Marsdenia (*Marsdenia longiloba*)
In the context of detailed data recorded on the distribution of Slender Marsdenia within the WC2U road corridor and the considerable number of individuals impacted by construction, a research project looking at the population genetics of Slender Marsdenia is being conducted by the Ecos Environmental Pty Ltd and the Genecology Research Centre of the University of the Sunshine Coast, as part of the offset package and in conjunction with the translocation plan for this species. The aim of genetic research is to identify patterns of genetic variation within and between populations of Slender Marsdenia at local and regional scales and to use this information to better understand the population genetic structure, life history, breeding system and population dynamics of this cryptic and poorly understood species. Such information can be used to improve management and science-based conservation of the species

The Bonville translocation project produced significant new information on the life history of Slender Marsdenia (see below), but the population processes by which Slender Marsdenia persists at a site remain poorly understoood. As well as providing information on spatial variation in genetic diversity, genetic analysis techniques can provide indirect evidence of rates and direction of pollen flow, levels of out-crossing and therefore method of reproduction – ie. vegetative or sexual/by seed. This type of research has been conducted by RMS previously for Scented Acronychia (*Acronychia littoralis*) on the Chinderah Bypass and the DoP consider research a valid 'offset' initiative.

Slender Marsdenia is an interesting plant as it appears to rarely if ever form seed. The Flora of NSW states the fruit has never been recorded, although the writer has observed the fruit on one occasion in a decade of surveying and monitoring vegetation where the species occurs. Patterns of genetic variation within and between sub-populations can be used to indicate levels of sexual and vegetative reproduction, which can provide insight into a species demographics and how it is able to persist in an area. The surveys conducted for whole WC2U project represent a 42km longitudinal sample of the species' distribution. Detailed mapping of sub-populations, the essential first stage of recording spatial data, has in effect been completed. Analysis of patterns of genetic variation within and between sub-populations along this geographic transect would greatly improve understanding of this species genetics and therefore the breeding system and processes by which populations are maintained. Research on these aspects of species ecology is consistent with Priority Recovery Actions recommended for Slender Marsdenia by the Commonwealth Department of Environment and Heritage (DEH) and the Environmental Protection Authority.

The genetic research project currently underway is titled Analysis of genetic variability in the endangered species Slender Marsdenia (*Marsdenia longiloba*) at fine, medium and broad geographic scales, and research is being directed at answering the following questions: -

- Given that Slender Marsdenia appears to rarely produce seed, how much genetic variation exists in this species within and between sub-populations within the Nambucca area and across the species distribution?

- What do patterns of genetic variation within and between sub-populations of Slender Marsdenia tell us about levels of sexual and vegetative reproduction, and levels out-crossing and inbreeding in Slender Marsdenia?

- Are sub-populations of Slender Marsdenia in adjacent gullies genetically different from each other? If they are genetically different, how did they become different when seed production (sexual reproduction/chromosomal recombination) is so rare? If they are genetically the same, how did they disperse to two adjacent gullies when seed production is so rare?

- What do patterns of genetic variation across the species distribution tell us about the frequency of pollination and direction of pollen flow in Slender Marsdenia across the landscape at different scales?

- What does the spatial distribution of genetic variability within and between populations indicate about present and past population dynamics of this species?

- Do patterns of genetic variation in Slender Marsdenia indicate any significant risk of causing inbreeding or outcrossing depression by undertaking translocation of the species?

- What other practical implications do the research findings have for conservation and management of Slender Marsdenia? Such as where are the areas of higher genetic diversity found within the species and how significant are the populations to be translocated for the genetic diversity of the species as a whole.

Approximately 360 samples have been collected across the species range from the Nambucca valley to northwest of Brisbane and patterns of genetic variation are being analysed using microsatellite and chloroplast DNA techniques. The latter is being used to elucidate the identification of Tylophora woollsii and Slender Marsdenia (Marsdenia longiloba), these species being very similar vegetatively and difficult to identify from vegetative features alone.

The translocation project for WC2U (NH2U/WC2NH has been planned to carrying on from the research conducted for the Bonville translocation project and has been designed to examine the survival response of Slender Marsdenia to different methods of translocation and micro-habitat type.

4.4.2.6 Monitoring

Monitoring is essential to document the establishment and survivorship of reintroduced plants and the basic life-history processes of growth and reproduction. "Monitoring is the foundation of success in a good reintroduction project; it is not a luxury. Monitoring is the stage that will eventually require the greatest amount of time in any reintroduction project." (Sutter 1996).

Monitoring techniques and processes must meet four criteria:-

- Monitoring data must have a known and acceptable level of precision.
- Data collection techniques are repeatable over years and across personnel.
- Data must be collected over a long enough period of time to capture important natural processes such as recruitment and responses to management.
- Monitoring must be efficient and practical within budget constraints (Sutter 1996).

A monitoring program designed to measure, assess and report the results of the translocation project will be conducted during construction and for a period of 5 years after the completion of translocation works, or for a total of approximately 8 years (see Section 4.6.7).

4.4.3 Implementation Schedule

The schedule for implementation of the translocation program is shown in Table 12 below.

Table 12: Implementation schedule for the WC2U Threatened Flora Translocation

No.	Tasks	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
1	Site Selection and Preparation						
1.1	Selection of translocation sites	+					
1.2	Plan Scope of Works for translocation, prepare list of material/equipment required	+					
1.3	Repair access tracks where required, mark out planting layout	+					
1.4	Erect necessary fencing and install watering system where required	+					
2	Transplant threatened and rare species						
2.1	Transplant directly impacted	+					

	individuals to the receival sites; tag and mark clearly						
2.2	Initial maintenance of transplants: water daily for two weeks then reduce; mulch; spray Maxicrop	+					
3	Population enhancement						
3.1	Seed and cutting collection	+	+				
3.2	Propagation	+					
3.3	Introduce propagated plants		+				
4	Habitat restoration						
4.2	Propagation of non-threatened species from locally collected seed, or source from local rainforest nurseries	+					
4.1	Plant out tubestock (disturbed or cleared sites only)	+	+				
5	Receival Site Maintenance						
5.1	Weed spraying	+	+	+	+	+	+
5.2	Slashing	+	+	+	+	+	+
6	Monitoring						
6.1	Monitor transplants:- Completion of transplanting; 3-monthly intervals for 1 yr; 6-monthly intervals for two years; and once a year thereafter	+	+	+	+	+	+
6.2	Monitor in-situ plants during road clearing and construction.	+	+	+	+		
6.3	Monitoring of in-situ roadside threatened plants during highway operation					+	+
7	Reporting						
7.1	Prepare annual report documenting the results of the translocation project	+	+	+	+	+	+
8	Project Review						
8.1	Five-year review of translocation project – Determine future project actions, including potential future maintenance and monitoring requirements.						+

4.5 Species Proposals

4.5.1 Slender Marsdenia (*Marsdenia longiloba*)

Slender Marsdenia occurs in small, sparse sub-populations scattered along the length of the WC2U road corridor. Approximately 200 individuals ('stem-individuals) were recorded in 23 different sub-populations from the Raleigh area, Newry State Forest, Little Newry State Forest, Valla south, Nambucca State Forest and Warrell Creek sections of the WC2U corridor. A total of 43 gps points and 75 individuals were recorded on the southern WC2NH section. Plans showing the location of recorded occurrences are provided Appendices 1 and 3.

Translocation of Slender Marsdenia for the northern (NH2U) project was undertaken in December 2013. In version one of the WC2U TFMP in was proposed that any further translocation of Slender Marsdenia on the southern half/WC2NH would be dependent on the results of Slender Marsdenia translocation on NH2U and that this would be assessed over a monitoring period of two years. This fitted in with initial information that the likely start of construction on the two sections would be two years apart. The project scheduling has since changed and construction of the southern section is likely to commence late 2014 or early 2015, only about 12 months since the NH2U translocation of Slender Marsdenia. This has necessitated an earlier decision whether or not to translocate Slender Marsdenia on the southern section based on monitoring results up to September 2014 – see Table 12b.

The previous attempt to translocate Slender Marsdenia (and Woolls Tylophora) on the Bonville project was unsuccessful after five years. Without going into detail, it was hypothesised that the poor result was due to the adverse of effect of slow release fertiliser and soil amelioration on Slender Marsdenia establishment at the receival site. A different approach has been applied on the NH2U project involving direct transplanting and no use of fertiliser. The results to September 2014 in Table 12b show no evidence of a marked decline in the health and vigour of Slender Marsdenia transplants during the first 9 months, despite a dry autumn and cold and dry winter in 2014. However, based on the survival pattern recorded on the Bonville translocation project, it is too early to say if results are definitely improved. Given the monitoring results recorded to Sept 2014 on NH2U and since construction of WC2NH is likely to start late 2014, translocation of Slender Marsdenia will also proceed on the WC2NH project so as not to delay the start of construction.

Table 12b: Results of the NH2U translocation of Slender Marsdenia after 3, 6 and 9 months after translocation.

NH2U – no fertiliser addition	**3 months** **March 2014**	**6 months** **July 2014**	**9 months** **Sept 2014**
condition - poor	16	14	20
condition – fair	35	45	40
condition – healthy	95	87	86
	146	146	146

Table 13: Directly impacted Slender Marsdenia recorded on the WC2U corridor. Each recorded point may encompass more than one plant, as indicated in column 'No.'

Southern Half (WC2NH) as of 10/6/2014

ID	Species	Easting	Northing	No.	Size
ml-125	Marsdenia longiloba	497488.408000	6610582.878000	1	0.1m
ml-126	Marsdenia longiloba	497493.501000	6610586.158000	1	0.1m
ml-127	Marsdenia longiloba	497496.352000	6610583.216000	3	1m
ml-128	Marsdenia longiloba	489653.000000	6594556.000000	1	0.1m
ml-22	Marsdenia longiloba	496188.410408	6608256.097960	2	0.1m
ml-23	Marsdenia longiloba	496180.251673	6608299.314590	1	1m
ml-24	Marsdenia longiloba	496177.372208	6608314.274170	1	0.5m
ml-25	Marsdenia longiloba	496182.954756	6608331.453140	2	0.8m
ml-26	Marsdenia longiloba	496256.890152	6608315.410310	6	0.5m
ml-27	Marsdenia longiloba	496471.828945	6608754.696510	1	0.4m
ml-35	Marsdenia longiloba	495663.835870	6607571.959330	1	4m
ml-36	Marsdenia longiloba	495660.804035	6607567.525330	1	0.2m
ml-37	Marsdenia longiloba	495671.485200	6607608.163410	3	0.8m
ml-38	Marsdenia longiloba	495684.423981	6607593.392690	1	0.1m
ml-39	Marsdenia longiloba	495702.778781	6607610.022940	1	0.1m
ml-40	Marsdenia longiloba	495744.282604	6607632.942110	1	small
ml-41	Marsdenia longiloba	495722.548309	6607682.802220	10	small
ml-42	Marsdenia longiloba	495722.699901	6607703.119170	1	1.5m
ml-43	Marsdenia longiloba	495716.783427	6607725.280690	1	0.1
ml-44	Marsdenia longiloba	495748.069111	6607748.011070	2	0.3m
ml-5	Marsdenia longiloba	496683.949976	6609585.722830	1	small
ml-63	Marsdenia longiloba	489635.678810	6594537.005010	1	0.1m
ml-68	Marsdenia longiloba	489663.695772	6594588.748820	1	1.5m
ml-7	Marsdenia longiloba	496637.195041	6609472.118760	6	0.6m
ml-71a	Marsdenia longiloba	489553.726825	6594591.727680	3	2m
ml-72	Marsdenia longiloba	489683.316469	6594582.857250	1	1m
ml-8	Marsdenia longiloba	496576.593202	6609216.292200	2	0.6m
ml-9	Marsdenia longiloba	496589.206798	6609222.021860	1	4m
ml-93	Marsdenia longiloba	494336.000000	6604191.000000	1	0.0
ml-136	Marsdenia longiloba	489584.000000	6594404.000000	1	0.0
ml-137	Marsdenia longiloba	495058.000000	6606623.000000	1	0.0
ml-133	Marsdenia longiloba	489559.000000	6594392.000000	2	0.0
ml-134	Marsdenia longiloba	489560.000000	6594392.000000	3	0.0
ml-135	Marsdenia longiloba	489567.000000	6594394.000000	1	0.0
ml-138	Marsdenia longiloba	489653.000000	6594556.000000	1	1.6
ml-147	Marsdenia longiloba	496207.000000	6608368.000000	1	3.0
ml-139	Marsdenia longiloba	489660.000000	6594591.000000	1	0.6
ml-141	Marsdenia longiloba	495672.000000	6607601.000000	1	0.2
ml-142	Marsdenia longiloba	496172.000000	6608264.000000	1	0.2
ml-143	Marsdenia longiloba	496185.000000	6608287.000000	1	2.2
ml-144	Marsdenia longiloba	496192.000000	6608323.000000	1	0.3
ml-145	Marsdenia longiloba	496184.000000	6608313.000000	1	0.3

ml-146	Marsdenia longiloba	496212.000000	6608369.000000	1	1.5

Northern Half (NH2U), as of 6/3/2013

ml-1	Marsdenia longiloba	497485.537248	6610602.704080	1	small
ml-2	Marsdenia longiloba	497468.445578	6610614.520770	1	small
ml-3	Marsdenia longiloba	497477.228559	6610618.955580	15	small
ml-49	Marsdenia longiloba	497496.039690	6612142.718430	1	0.15m
ml-46	Marsdenia longiloba	497598.702108	6613063.459720	40	to 5m
ml-48	Marsdenia longiloba	497602.055454	6613069.370790	10	to 1.5m
ml-16	Marsdenia longiloba	500442.890991	6618806.680550	1	0.4m
ml-15	Marsdenia longiloba	500426.432922	6618920.638680	1	3.5m
ml-14a	Marsdenia longiloba	500409.842004	6620668.210490	2	small
ml-14	Marsdenia longiloba	500386.537955	6620686.516890	2	small
ml-14b	Marsdenia longiloba	500435.641790	6620740.522920	1	small
ml-11	Marsdenia longiloba	499195.302516	6622426.508930	6	small
ml-12	Marsdenia longiloba	499214.008854	6622428.172560	1	small
ml-13	Marsdenia longiloba	499200.737108	6622446.456410	1	small
uml-6	Marsdenia longiloba	497772.427480	6625850.919071	1	1m
ml-17	Marsdenia longiloba	497791.779559	6625851.107730	1	small
uml-5	Marsdenia longiloba	497779.939952	6625872.714539	1	1.5m
ml-18	Marsdenia longiloba	497816.564585	6625875.307700	1	0.1m
ml-19	Marsdenia longiloba	497826.637279	6625891.378130	4	0.2m
ml-20	Marsdenia longiloba	497827.754605	6625902.460010	1	0.2m
ml-21	Marsdenia longiloba	497835.590897	6625905.231990	5	0.2m
ml-28	Marsdenia longiloba	498002.652999	6626288.504580	1	small
ml-33	Marsdenia longiloba	498121.454487	6626489.842450	1	0.3m
ml-34	Marsdenia longiloba	498198.977611	6626789.798790	1	4m

It is proposed to conduct the translocation of Slender Marsdenia as follows: -

- Directly impacted plants to be transplanted to adjoining State Forest, road reserve and RMS owned property, which ever is closest, provides suitable habitat and is in a location/tenure suitable for long-term conservation.

- Rhizome pieces dislodged during transplanting (soil breaks up easily) to be used to for propagation of population enhancement plants.

- All transplants to be tagged with its donor ID number throughout the translocation process; all propagated plants to be labelled with the parent donor ID number throughout the propagation and introduction process.

- Experimental work to be incorporated in the Slender Marsdenia translocation including:-

  - study of genetic variation within and between sub-populations using shoot material taken during transplanting (stems to be pruned).

  - study of flowering and seed production in transplants under pot cultivation

- study of plant response to translocation introduction treatments - i.e. direct transplanting vs. planting after initial pot stabilisation; fertiliser/mulch vs. no fertiliser treatment; disturbed vegetation vs undisturbed vegetation.

Monitoring of the translocation including the experiments would be conducted during construction and after construction for a minimum of 5 years, a total of approximately 8 years.

4.5.2 Wooll's Tylophora(*Tylophora woollsii*)

Five records of Woolls' Tylophora are directly impacted in Newry State Forest and Nambucca State Forest and would require translocation, as indicated in Table 14 below. Records are mapped in Appendices 1 and 3.

Table 14: Directly impacted *Tylophora woollsii* proposed for translocation. Each record is a gps point, which may encompass more than one plant.

tw-4	Tylophora woollsii	496704.871330	6609581.111790	1	small
tw-6	Tylophora woollsii	496614.669628	6609500.001180	1	0.4m
tw-9a	Tylophora woollsii	498593.927600	6622812.829640	1	0.5m
utw-1	Tylophora woollsii	497840.222513	6625937.923801	1	1.4
utw-2	Tylophora woollsii	497841.820182	6625946.420056	5	0.5

Translocation of Tylophora woollsii would be conducted as follows:

- As discussed in Section 3.3.4, identification of Tylophora woollsii is problematic, especially in the case of small plants. Most of the time we do not know for certain whether suspected *Tylophora woollsii* plants are in fact that species or Slender Marsdenia, unless flowering occurs, which is rare. A sample of *Tylophora woollsii* would be transplanted to pots and grown-on to encourage flowering and confirm the identification. Previous pot cultivation of *Tylophora woollsii* and Slender Marsdenia for the Bonville project showed that flowering can be induced in 12 months by providing additional fertiliser and water.

- Once positively identified from flowers, detailed examination of leaf morphology will be carried to determine features that can be used to identify the species and distinguish it from Slender Marsdenia using leaves.

- After identification, the potted plants would be introduced to field sites in State Forest.

- Population enhancement will be carried out if possible using salvaged rhizome pieces to propagate additional individuals from.

- All transplants to be tagged with its donor ID number throughout the translocation process; all propagated plants to be labelled with the parent donor ID number throughout the propagation and introduction process.

Monitoring of the translocation would be conducted during construction and after construction for a minimum of 5 years, a total of approximately 8 years.

4.5.3 Rusty Plum (*Niemeyera whitei*)

Rusty Plum was recorded at three locations on the WC2U corridor - Boggy Creek near Valla, north of the railway line at Nambucca Heads and Cockburn's Lane south of Warrell Creek. Single small trees at Boggy Creek and the railway line, and 11 trees and saplings at Cockburn's Lane (as well as seedlings) are directly impacted and would require translocation. The largest trees are 8-10 metres in height with a maximum diameter of about 30 cm. Occurrences of Rusty Plum are mapped in Appendix 1 and tabulated in Appendix 2.

Table 15: Directly impacted Rust Plum proposed for translocation. Each record is a gps point, which may encompass more than one plant (seedlings not listed).

ID	Species	Easting	Northing	No.	Size
nw-50	Niemeyera whitei	497460.267315	6612110.387950	1	2.5m
nw-50b	Niemeyera whitei	489598.600127	6594456.623420	1	8m
nw-54	Niemeyera whitei	489610.242842	6594455.157100	1	8m
nw-55	Niemeyera whitei	489599.063113	6594472.508300	1	sdlg
nw-56	Niemeyera whitei	489581.206261	6594468.612190	1	1.2m
nw-57	Niemeyera whitei	489570.696540	6594452.902240	1	7m
nw-58	Niemeyera whitei	489569.106161	6594448.467830	1	6m
nw-59	Niemeyera whitei	489571.204261	6594422.796200	1	10m
nw-64	Niemeyera whitei	489636.959937	6594531.465170	1	8m
nw-66	Niemeyera whitei	489647.610383	6594566.753670	1	4m
nw-73	Niemeyera whitei	489672.663574	6594549.969920	1	5m
unw-9	Niemeyera whitei	497406.818180	6611193.165320	1	7m
nw-129	Niemeyera whitei	489592.530000	6594469.550000	1	4m

Translocation of Rusty Plum would be conducted as follows: -

- Directly impacted individuals will be transplanted into adjoining habitat on RMS land.
- Population enhancement will be carried out by collecting seed from locally occurring trees and direct seeding into suitable habitat on RMS land.
- All transplants to be tagged with its donor ID number throughout the translocation process; all propagated plants to be labelled with the parent donor ID number throughout the propagation and introduction process.

Monitoring of the translocation would be conducted during construction and after construction for a minimum of 5 years, a total of approximately 8 years.

4.5.4 Maundia (*Maundia triglochinoides*)

Maundia occurs on the southern WC2NH section at two locations:- Williamson's Creek near Warrell Creek and the Nambucca River floodplain southeast of

Macksville. In Version 2 of the TFMP, no translocation of Maundia was proposed, rather management focused on amelioration of impacts and monitoring. However, Pacifico has indicated they would like to "give it a go" translocating Maundia during re-routing of Williamson's Creek. The only known previous attempt at translocating Maundia on the Central Coast by the Royal Botanic Gardens Sydney using propagated seedlings apparently failed. Translocation using established rhizomes may have better chance of success. Pacifico has suggested using a machine to move plants and substate together to the new drainage line. The new stream would be engineered to recreate the still-water pools of the present stream. Some plants could be transplanted by hand so that the shoot or leafy part of the plant was not overly damaged, but most of the transplanting would be by excavator and aim to regenerate Maundia plants from rhizome material moved with the muddy substrate.

The Nambucca floodplain population would be managed with the aim of minimising impacts to Maundia remaining within the project boundary after clearing and in wetland adjoining the road corridor, by applying the measures listed below.

Table 16a: Representative GPS points marking the extent of the Maundia stand at Williamson's Creek.

ID	Species	Easting	Northing	No.
mt-74	Maundia triglochinoides	491716	6598059	Mat
mt-75	Maundia triglochinoides	491659	6598066	Mat
mt-76	Maundia triglochinoides	491604	6598050	Mat
mt-77	Maundia triglochinoides	491524	6598033	Mat

Table 16b: Representative GPS points marking the approximate extent of the Maundia population on the Nambucca floodplain.

ID	Species	Easting	Northing	No.
mt-82	Maundia triglochinoides	492733	6600457	Mat
mt-94	Maundia triglochinoides	493295	6601470	Mat
mt-95	Maundia triglochinoides	493286	6601461	Mat
mt-96	Maundia triglochinoides	493285	6601445	Mat
mt-97	Maundia triglochinoides	493304	6601479	Mat

During detailed design and construction, emphasis would be placed on minimising impacts to in-situ individuals. Management measures include (but are not limited to) the following:-

(a) investigate engineering solutions, undertake design optimisation and adopt design and construction solutions which:

(i) minimise the footprint of the Project Works and Temporary Works adjacent to areas of Maundia triglochinoides;

(ii) precisely locate proposed construction and operational water quality treatment facilities to avoid direct and indirect impacts on Maundia triglochinoides; and

(iii) ensure that, during construction and operation of the Project Works, the drainage paths and the quantity and quality of water, both surface and subsurface, are maintained to Maundia triglochinoides populations;

(b) identify all Maundia triglochinoides populations on environmentally sensitive area mapping and in the Design Documentation as exclusion zones;

(c) locate ancillary facilities for the Contractor's Work to avoid direct and indirect impacts on Maundia triglochinoides;
(d) address any of the Contractor's Work that is undertaken within 100 m of Maundia triglochinoides in a site specific environmental work method statement;
(e) erect and maintain sediment fencing around all areas of Maundia triglochinoides that are affected by the Contractor's Work; and
(f) include in the urban and landscape design specific landscaping / revegetation measures to buffer the areas adjacent to Maundia triglochinoides populations with appropriate vegetation.

Maundia would be included in the Ecological Monitoring Program to assess the effectiveness of management measures (a) to (f) listed above. This would entail a series of 'control' and 'impact' (ie within and adjoining the project boundary) reference plots to be monitored during construction and for a minimum of five years during highway operation.

4.5.5 Floyds Grass (*Alexfloydia repens*)

Floyds Grass was recorded only on the southern WC2NH section at one location on the northern bank of Warrell Creek, within and outside project boundary (see Appendix 1). Impact analysis of the RMS concept design found that one gps point is directly impacted and two are indirectly impacted, comprising a total of approximately 6 m² of Floyds Grass. All points would probably require translocation as Floyds Grass is unlikely to survive long-term in the indirect impact zone, where it would be threatened by weed invasion and increased cover of native species such as ground ferns. Indirect impacts such as run-off from the construction zone and soil eutrophication could also be a problem, although sed and erosion control measures would minimise such impacts.

Table 17: GPS points marking directly and indirectly impacted Floyds Grass.

ID	Species	Easting	Northing	No.
ar-78	Alexfloydia repens	492334.706995	6599021.622260	mat
ar-79	Alexfloydia repens	492344.763916	6599013.133180	mat
ar-81	Alexfloydia repens	492261.429754	6599090.278560	mat

Translocation of Floyds Grass would be conducted as follows: -

- Directly impacted plants would be transplanted to suitable adjoining habitat on RMS land.

- Translocation methods would follow those used successfully on the Bonville Translocation Project.

4.5.6 Spider Orchid (*Dendrobium melaleucaphilum*)

Dendrobium melaleucaphilum was recorded at two locations on the northern half of the project - approximately 4km north of the Kalang River, where only one mature plant is in the indirect impact zone; and in Newry State Forest where 10 flora points containing approximately 10 to 20 plants are directly impacted. Additional indirectly impacted points with approximately 20 to 30 plants may require translocation. The individual north of the Kalang River is less than 4 metres from the edge of the construction zone and given its likely sensitivity to microclimatic change, translocation to appropriate habitat would be carried out. The mapped occurrences are shown in Appendix 1.

A third population occurs on the southern half of the project in Nambucca State Forest. Three flora points were recorded by EcoPro (2010) (see Appendix 1, Fig 9). These have not been confirmed and should be checked during at the pre-clearing stage of the project.

A large area of potential habitat for this species is present on the WC2U corridor, but a sizeable population occurs only at one location in Newry State Forest indicating how depleted this species has become. Population enhancement would be included as part of the translocation process to increase population size and compensate for loss of potential habitat due to highway construction.

Table 18: *Dendrobium melaleucaphilum* proposed for translocation, including points from EcoPro (2010).

ID	Species	Easting	Northing	No.
dm-34a	*Dendrobium melaleucaphilum*	498827.816416	6627524.966920	1
	Dendrobium melaleucaphilum	498943.121891	6622574.465214	1-5
	Dendrobium melaleucaphilum	496635.580000	6609457.970000	1-5
	Dendrobium melaleucaphilum	496639.630000	6609426.260000	1-5
	Dendrobium melaleucaphilum	498903.212004	6622587.312599	1-5
	Dendrobium melaleucaphilum	498898.412923	6622585.542959	1-5
	Dendrobium melaleucaphilum	498899.946650	6622585.542959	1-5
	Dendrobium melaleucaphilum	498896.780246	6622574.465214	1-5
	Dendrobium melaleucaphilum	498938.322809	6622561.497853	1-5
	Dendrobium melaleucaphilum	498944.746322	6622570.695981	1-5
	Dendrobium melaleucaphilum	498584.963644	6622899.449064	1-5
dm-1	*Dendrobium melaleucaphilum*	496635.580000	6609457.970000	1-5
dm-2	*Dendrobium melaleucaphilum*	496639.630000	6609426.260000	1-5
dm-3	*Dendrobium melaleucaphilum*	496064.044126	6608287.453294	1-5

It is proposed to conduct the translocation of *Dendrobium melaleucaphilum* as follows: -

- Follow-up pre-clearing survey to clarify the occurrence of Spider Orchid at sites recorded by EcoPro (2010).

- Translocate directly impacted individuals and indirectly impacted individuals if advised by the project plant ecologist.

- Translocated individuals will be re-located to swamp forest dominated by *Melaleuca styphelioides* (the favoured host) or well-developed rainforest understorey in wet scerlophyll forest. A section of bark supporting the Spider Orchid plant will be cut away from the tree and taken to the receival site for re-attachment to a suitable host tree (e.g. small *M. stypheloides* or rainforest tree with rough persistent bark). The transplants should be kept moist and out of the sun during transplanting. Cotton ribbon is used to fix the bark with orchid to the host tree, or wire if a whole branch or section of wood has been removed.

- Follow-up watering of plants is important to assist re-establishment; a dilute solution of seaweed fertiliser will be applied twice and then discontinued.

- Seed will be collected if present during transplanting, or collected from other plants in the local area, and propagated to produce individuals for population enhancement.

- Propagated plants will be grown-on to a mature size, hardened-off and then introduced to a receival site(s) selected to contain suitable habitat for this species.

- Six months before introduction, the propagated Spider Orchid plants will be inoculated with fungal mycorrhize using bark and soil organic matter collected from a local *Dendrobium melaleucaphilum* site.

Monitoring of the translocation would be conducted during construction and after construction for a minimum of 5 years, a total of approximately 8 years.

4.5.7 Ford's Goodenia (*Goodenia fordiana*)

Ford's Goodenia is directly impacted at nine locations at Raleigh south, Newry State Forest and Nambucca State Forest. Most are in the Raleigh south area. Locations are shown in Appendix 1.

Table 20: Directly impacted Ford's Goodenia proposed for translocation. Each record is a gps point, which may encompass more than one plant.

ID	Species	Easting	Northing	No.
gf	Goodenia fordiana	498645.057057	6623095.050150	mat
gf	Goodenia fordiana	498008.413738	6626272.991330	mat
gf	Goodenia fordiana	497989.696142	6626297.182810	mat
gf	Goodenia fordiana	498019.123273	6626308.639270	mat
gf	Goodenia fordiana	498017.824042	6626416.315720	mat
gf	Goodenia fordiana	498119.372903	6626503.140060	mat
gf	Goodenia fordiana	498740.165666	6627464.008120	mat
gf	Goodenia fordiana	495678.042363	6607581.015290	mat
gf	Goodenia fordiana	495708.849288	6607601.898610	mat
gf	Goodenia fordiana	498672.994767	6627368.143990	mat

It is proposed to conduct the translocation of Fords Goodenia as follows: -

- Directly impacted plants will be transplanted to a site adjoining the WC2U corridor containing suitable habitat, on RMS land.
- Since Fords Goodenia is a ROTAP species not listed as threatened; it is proposed to translocate a sample of directly impacted individuals comprising a minimum 30% of recorded flora points, as determined by the Project Ecologist.

Monitoring of the translocation would be conducted during construction and after construction for a minimum of 5 years, a total of approximately 8 years.

4.5.8 Koala Bells (*Artanema fimbriatum*)

Artanema fimbriatum is directly impacted at seven locations in the Raleigh, Raleigh south, Valla, Valla south and Nambucca State Forest areas.

Table 21: Directly impacted Koala Bells proposed for translocation. Each record is a gps point, which may encompass more than one plant.

ID	Species	Easting	Northing	No.
af	Artanema fimbriatum	497462.035272	6610707.607140	30
af	Artanema fimbriatum	497461.092414	6610642.223760	1
af	Artanema fimbriatum	495851.457703	6607944.201690	1
af	Artanema fimbriatum	496151.378340	6608221.361400	12
af	Artanema fimbriatum	498290.907731	6613899.162890	10
af	Artanema fimbriatum	498996.450225	6615072.078720	6
af	Artanema fimbriatum	500301.385190	6616814.366140	5

It is proposed to conduct the translocation of Koala Bells as follows: -

- Directly impacted plants will be transplanted to a site adjoining the WC2U corridor containing suitable habitat, on RMS land.
- Since Koala Bells is a ROTAP species not listed as threatened; it is proposed to translocate a sample of directly impacted individuals comprising a minimum 30% of recorded flora points, as determined by the Project Ecologist.

Monitoring of the translocation would be conducted during construction and after construction for a minimum of 5 years, a total of approximately 8 years.

4.6 The Translocation Action

4.6.1 Preparation for Transplanting

Prior to the start of transplanting the following actions would be carried out: -

- Mark out receival site;
- Repair access tracks;
- Install fencing to exclude stock and clearly demarcate the receival site; and
- Set up watering system.

4.6.2 Timing

Autumn on the NSW North Coast is the ideal time to conduct transplanting of trees, shrubs and vines, because of high soil moisture and cooler temperatures, which both reduce evapo-transpiration stress and promote transplant survival. At the same time, experience has shown provide a water source is readily available, transplanting of trees, shrubs and vines can be conducted at any time of year. In the case of Maundia, it would be best if transplanting was carried out in spring at the start of its growth season.

4.6.3 Transplanting

Transplanting would be carried out using an excavator or back-hoe to trench and lift the tree or shrub from the ground with a soil-root ball. Tree species would be pruned back and then transported to the receival site, planted and then watered. Pruning of the trunk and branch system is necessary to reduce transpiration demand on the damaged root syste, damaged during transplanting.

4.6.4 Pruning and Hygiene

Pruning of trees is essential to achieve satisfactory survival rates. Pruning is carried out after plants are excavated from the ground and before transportation to the receival site. Most of plant foliage is removed (~90%) and the length of the trunk and branch system reduced by about half. New tools (e.g. secateurs, pruning saw, bow-saw) would be used and disinfected by scrubbing with methylated spirits before use on each plant to guard against possible transfer of disease agents.

4.6.5 Watering

Prevention of tissue desiccation is the key to transplant survival in most species. Adequate water of transplants immediately after planting in the receival site is a crucial aspect of salvage transplanting. Watering needs to be every day for the first two weeks. The receival site should have access to a creek or dam from which water can be pumped rather than relying on a water carrier, which is also more expensive.

The soil around the transplant should be saturated as soon as it is planted. Watering would be carried out daily for the first two weeks then gradually reduced in frequency. Watering would be carried out using a small pump and applied by hand with a hose.

4.6.6 Anti-transpirant and Plant Stimulant

Maxicrop, a weak fertiliser and plant tonic made from seaweed, would be sprayed onto remaining foliage as well as the stem and bark of the transplants immediately after planting at the receival site. Maxicrop also functions as an anti-transpirant, temporarily blocking the leaf stomata. Trace elements and low concentrations of organic N, P and K help to optimise plant health and capacity for recovery.

4.6.7 Mulching

Mulching would be carried out directly after planting. Local slashed grass from the relocation site can be used, or if not available, then good quality straw hay can be purchased.

4.6.8 Shade-cloth Shelters

Shade cloth supported by stakes would be erected around transplanted trees to provide protection from wind and sun if initial conditions are exposed in the translocation area. The shelters would be required until fast growing species are established, probably for the first year.

4.6.9 Seed/cutting Collection and Propagation

Propagation of threatened and rare species would be required to establish minimum viable population sizes. Seed and cutting collection would be carried out from local populations of the subject species, i.e. within 10km of the project boundary.

The location of each parent plant from which seed / cuttings are collected would be recorded and the seed/cuttings kept in separate bags labeled with the parent plant number. Propagation trays containing the seed/cuttings would be labeled with this number throughout the propagation process.

Propagation would be carried out at a reputable local nursery using standard propagation procedures. Plants would be grown-on in super tubes or 140mm pots until at least 35cm tall and thoroughly hardened off before planting out.

Collection and propagation of seed and cuttings would be undertaken during and after transplanting until the required number of plants have been propagated.

4.7 Post-translocation Actions

4.7.1 Maintenance

On-going maintenance would be required for a minimum of five years or until the translocated populations are well established and habitat has been restored to good condition. Maintenance would involve the actions described below.

4.7.2 Watering

It is essential that the soil remains damp during the first months after transplanting. Watering would carried out daily for the first two weeks then gradually decreased. Care would be taken not to over-water and produce boggy soil conditions. Watering would be carried out by pumping from the local creek.

Later introductions of tubestock will be watered when first planted out. Further watering may be required during extended periods of dry weather.

4.7.3 Mulching

The transplants would be mulched twice a year for two years to suppress weed growth, increase soil organic matter, provide nutrient and improve plant condition. Mulch would be applied thickly so that it persists for six months. Tubestock plantings would also be mulched when first planted out.

4.7.4 Weed Control

Regular weed control would be carried out to ensure the transplants and later introductions are kept free of competition from introduced grasses and broad-leaved weeds. The herbicide Round-up Biactive (glyphosate 360 without surfactant) or similar would be used to minimise potential impacts on adjacent aquatic ecosystems.

All weed control work would be carried out by locally experienced and suitably licensed bush regenerators and supervised by a plant ecologist. This work would be carried out for a minimum of five years to fully rehabilitate the site.

4.7.5 Fire hazard Reduction

Where required a perimeter fire break would be maintained around the translocation receival site and slashed to control tall grass and weeds if they present a fire hazard.

4.7.6 Habitat Restoration

Bush regeneration and tubestock planting would be carried out to restore good quality habitat to the receival site, including a 20 meter buffer to the site.

4.8 Monitoring Program

4.8.1 Objectives

- To record data that will enable an assessment to be made of the success of the threatened flora translocations.

- To record data that assists advancement in translocation knowledge and practice from both positive and possible negative outcomes, to utilise in future translocation projects.

4.8.2 Monitoring Methods

All transplanted and population enhancement individuals are to be allocated a unique monitoring number. Flagging tape with the individual's monitoring number and source identification code (transplants only), are to be attached to each plant. Different individuals from the same donor point site are to be indicated by an additional suffix on the source identification code – e.g. Ml-46-7

In the case of Maundia translocated at Williamson's/Couche' Creek, clumps of translocated Maundia plants are to be marked with a numbered hardwood stake and details of each clump recorded as for the other species.

The main data fields to be recorded area are as follows:-

> Slender Marsdenia, Woolls' Tylophora, Rusty Plum, Maundia and Koala Bells: Monitoring Number, Date, Line, Source Label, Species - Translocation Plan Label, Species - Current ID, Condition, Height (cm), New Shoots (Y/N), Comment, sig. growth (+) or sig. dieback (-), Waypoint, Coordinates
>
> Spider Orchid: Monitoring Number, Date, Source Label, Species, Number of pseudobulbs with leaves, Length of the longest pseudobulb, New growth, Condition, Waypoint, Coordinates

Other observations such as possible disease, insect grazing and decline in habitat condition including weed invasion are to be recorded in the comments column.

The key attribute for evaluating species health and survival is Condition Class. This is to be scored on a scale of 0 to 6, as indicated in Tables 2-3 below.

Table 2: Condition Class scores applied to Slender Marsdenia and Woolls' Tylophora

Score	**Condition Class**
0	dead
1	stem died back, no leaves or green stem, may be a live stem stub
2	stem with leaves, no active growth; green leafless stem
3	stem with leaves, active growth – ie new shoot growth stem with leaves and plant >75cm tall
4	plant with lots of leaves, mature or nearing maturity
5	plant flowering or seeding

Table 3: Condition scores applied to Rusty Plum, Red Bopple Nut, Koala Bells and Maundia

Score	Condition Class
0	dead
1	leafless and no sign of re-shooting
2	pruned foliage retained, or small amount of re-shooting after defoliating, or foliage sparse/discoloured (<40 cm Koala Bells)
3	vigorous re-shooting (>40 cm Koala Bells)
4	crown recovering, foliage healthy
5	growing actively, flowering or seeding recorded

Table 4: Condition scores applied to Spider Orchid

Score	Condition Class
0	dead
1	pseudobulbs discoloured/being eaten/withering, no new growth
2	pseudobulbs healthy in colour, not withering, no new growth
3	plant small, not many healthy pseudobulbs, new growth occurring
4	several healthy pseudobulbs present, new growth occurring
5	several good sized, healthy pseudobulbs, flowering or seeding recorded

4.8.3 Timing/Frequency

NH2U Section
Monitoring frequency for the translocations is as follows: once every 3 months in the first year; every 6 months in the second year, then once a year to the end of the monitoring program. Monitoring is to be conducted during construction (~3 yrs) and after construction for 5 years, a total of 8 years.

WC2NH Section
Monitoring frequency for the translocations is as follows: three monitoring periods in the first year (6^{th}, 8^{th} and 12^{th} month), three monitoring periods in the second year (June 2016, November 2016 and January 2017), then once a year in November to the end of the monitoring program. Monitoring to be conducted during construction (~3 yrs) and after construction for 5 years, a total of 8 years.

November monitoring is designed to coincide with the flowering time of Marsdenia longiloba and Niemeyera whitei.

(Note – monitoring to be conducted before the 9^{th} of February 2017 which technically is the start of Year-3 of construction).

4.8.4 Data entry and analysis

Monitoring data are to be entersed into Excel spreadsheets.

Species Percent Survival (per Sector) to be calculated as:
((number of individuals in condition classes 2+3+4+5/total)*100)).

The species survival rates for WC2NH are to be compared with the results of the Bonville, Sapphire to Woolgoolga and Nambucca Heads to Urunga projects where the same species were translocated, using appropriate statistical methods – e.g. t-tests, analysis of variance or general linear modelling.

4.8.5 Annual monitoring report

An annual translocation monitoring report is to be prepared at the end of each year and include the following information: -

- Background and description of the translocation project;
- Implementation of the translocation project;
- A description of monitoring methods;
- An analysis of monitoring data on a species by species basis;
- An assessment of causes of plant mortality;
- A record of the plants transplanted and propagated;
- A description of the population enhancement program;
- An assessment of the success or failure of the translocation based on criteria set out in the WC2U TFMP (Section 4.7.8);
- An evaluation of the methods and cost-effectiveness of the translocation project; and
- Work plan for the next twelve months.

4.8.6 Performance Indicators

The following performance indicators are to be used to evaluate the success of the threatened species translocations (salvage translocation and population enhancement):

a) All directly impacted individuals of threatened species were salvaged and relocated to the receival site(s).
b) At least 60% of transplant and enhancement individuals are surviving after the first year, 50% after five years and 40% after eight years.
c) At the end of the monitoring program (8 years), at least 50% of surviving individuals have a Condition Class of 3 or higher.

4.8.7 Corrective Actions

Specific corrective actions will be triggered if monitoring identifies lower results than specified by the above performance indicators. If lower results are detected by the plant ecologist conducting the monitoring, the Environmental Manager will be informed within 5 working days, and corrective actions undertaken within 1 month. Examples of corrective actions to be considered include-

- Weed control in situations where exotic species increase and pose a potential threat to the vigour and persistence of the translocated species.
- Installation of surveillance cameras and signage to deter further theft of translocated species.
- Installation of hessian screening as a temporary measure to protect plants from over-exposure to sun and wind, until indivuduals become more established.

[See Table 4 Appendix 11 for summary of monitoring program]

5 MANAGEMENT OF ROADSIDE THREATENED FLORA

In-situ threatened flora located on the edge of the construction footprint would be protected during the construction and operation of the WC2U upgrade by a range measures directed at maintaining individuals and their habitat in good condition, as described below.

5.1 Safeguards During Clearing and Construction

Damage can potentially occur to significant flora close to the edge of the construction zone during vegetation clearing and construction activity. Any damage to legislatively protected threatened species (protected by law) that occurs during vegetation clearing and highway construction is likely to result in prosecution by the EPA. The following measures would be implemented to ensure that this does not occur:-

5.1.1 Pre-clearing Survey

To ensure that threatened plants on the edge of the construction zone are provided with protected during clearing, a pre-clearing survey would be undertaken once the clearing line is marked by surveyors prior to the start of clearing operations. Pre-clearing surveys are standard practice on most highway construction projects. Threatened species on the edge of clearing zone (Table 22) may have been under-recorded during the targeted survey.

Individuals of threatened and rare flora occurring within 10 metres of the clearing line will be recorded with a gps, tagged with a unique ID number and clearly marked with flagging tape.

Table 22: Threatened flora recorded within 10m of the direct impact zone that may require protective measures during clearing. 'Distance' is the distance of the plant to the edge of clearing. This table will require updating following completion of the detailed design and pre-clearing surveys.

ID	Species	Easting	Northing	No.	Ht	Distance
ar-81	Alexfloydia repens	492261.429754	6599090.278560	mat		2.82166
ar-79	Alexfloydia repens	492344.763916	6599013.133180	mat		9.18854
af	Artanema fimbriatum	498993.037493	6627709.492660	50		2.18388
af	Artanema fimbriatum	500347.886710	6616794.232820	5		3.60148
ml-30	Marsdenia longiloba	498005.986444	6626426.102340	2	0.3m	9.37399
ml-31	Marsdenia longiloba	498004.547702	6626422.038800	1	1.3m	9.95268
ml-32	Marsdenia longiloba	498104.834883	6626406.357810	1	0.4m	6.37603
ml-43	Marsdenia longiloba	495716.783427	6607725.280690	1	0.1m	4.21898
ml-47	Marsdenia longiloba	497588.956090	6613070.291360	10	to 1m	3.09248
ml-63	Marsdenia longiloba	489635.678810	6594537.005010	1	0.1m	2.37169

5.1.2 No-go Zones

No Go Zones would be designated at all in-situ threatened species locations within 10 metres of the construction footprint.

5.1.3 Fencing and Signage

Temporary fencing would be installed around the perimeter of each in-situ threatened species location before the start of vegetation clearing. The fencing would be kept in good repair during the construction period. A sign identifying the site as an Environmental Protection Area would also be attached to the fence.

5.1.4 Toolbox Sessions

All personnel would be informed at tool box sessions about the importance of observing protective measures for threatened plant species and the consequences if any damage occurs.

5.1.5 Tagging and Marking

Flagging tape would be attached to threatened plants so they are visible to surveyors and personnel walking through the area.

5.1.6 Mapping

All No-go Zones and Environmental Protection Areas (that include threatened flora locations) would be clearly marked on Sensitive Area Plans and all relevant design drawings used in day-to-day management of construction work.

5.2 Measures to Counteract Edge Effects

After clearing of the road corridor, threatened plant species at the edge of clearing become exposed to edge effect processes than can cause decline in plant condition. The main edge effect processes of concern to the management of threatened plant species are exposure/altered microclimatic, exotic species invasion, competitive displacement, soil eutrophication, sedimentation and changes in hydrology. In order to minimise any potential edge effect processes, the following measures would also be implemented where the construction corridor adjoins remnant and regenerating forest vegetation (as defined in the EA).

5.2.1 Sedimentation Control

Sedimentation controls are a highly effective means of minimising adverse effects on natural vegetation at the edge of clearing zones. Sedimentation controls prevent soil material and run-off, eutrophied and colonised by weed seed, from spilling into adjoining native vegetation and impacting on ground layer flora and initiating weed invasion. It also provides a visible physical barrier which deters movement of people and machines through a sensitive area.

Sedimentation controls would be installed along the upstream side of vegetation edges at: (i) in-situ threatened flora sites, set back from the stem/trunk at the edge of its crown (ii) the edge of EECs and rainforest revegetation locations. Sedimentation controls would be monitored regularly and repaired if damaged or filled with trapped sediment.

5.2.2 Landscaping and Revegetation

Results of landscaping adjoining roadside threatened species locations often have mixed results. Tall rank grass may end up being the dominant vegetation and landscape plantings may become suppressed or die. Threatened species sites are usually set back from the edge of the highway near the edge of the road reserve and are not readily visible from the roadside where landscaping and revegetation results may be much better.

Targeted landscaping and revegetation management is to be applied to roadside threatened species locations. Where threatened plant species are present on the edge of construction, the Landscaping/ Revegetation Plan is to revegetate batters and bare areas with ecologically compatible, native species to prevent weed growth, restore natural vegetation and provide edge protection for threatened species.

Weeds often invade roadside vegetation in salvaged topsoil used to top-dress batters and bare areas. The WC2NH footprint has extensive areas of weed free forest with topsoil free of weed seed and rhizomes that should be used for this purpose. Topsoil salvaged from weed free forest is to be used to top-dress batters and bare areas. (This topsoil can also be used to revegetate around sedimentation basins, which are usually finished early, ahead of other earthworks, as in the NH2U project.)

The Landscaping Plan and CEMP for the WC2NH project are to identify that specific revegetation measures are required as per points a) to d) below for roadside threatened flora to ensure these sites are adequately buffered with fast growing native species and weeds do not become dominant. The Landscaping Plan and CEMP are to contain an implementation schedule with actions for areas adjacent to in-situ threatened species.

Specific revegetation measures for areas adjacent to in-situ threatened species:-

a) Topsoil salvaged from weed free forest during clearing to be stored and used to top-dress batters and bare areas.

b) Alternatively, plant around threatened flora sites with tubestock of hardy, locally occurring native ground-covers, shrubs and small tree trees.

c) Carry out revegetation of bare/disturbed ground surrounding in-situ threatened species locations as soon as earthworks are completed. Use of forest topsoil with native species seedbank is recommended to ensure hardy, locally occurring species (gound-covers, shrubs and small trees) are established.

d) A plant ecologist/horticulturalist to identify/advise on areas of forest within the clearing footprint suitable for salvage of weed free topsoil for use in revegetation/landscaping and appropriate methods of storage and use.

5.3 Monitoring of In-situ Roadside Specimens

5.3.1 Monitoring Methods

Slender Marsdenia, Woolls' Tylophora, Rusty Plum and Koala Bells remaining in-situ within 10 meters of the edge of construction are to be monitored. The specific individuals to be monitored are to be determined after pre-clearing surveys have been completed and other details such as sedimentation basins have been added to the road construction design.

In the case of Maundia, indirect impacts may extend more than 10 meters from the edge of clearing/construction, because of the nature of its aquatic habitat. In the case of this species it is recommended that monitoring include all remaining in-situ plants within 30 metres of the construction footprint, particularly where Maundia grows up to the edge of the footprint.

In the case of Spider Orchid, impacts may also extend more than 10 meters from the edge of clearing/construction, because this species grows in a protected microclimate. It is therefore recommended that monitoring include all remaining in-situ plants within 20 metres of the construction footprint

In-situ roadside individuals will be tagged with the existing number in the TFMP, or if new individuals are identified these will be given a new unique number for monitoring. Since Maundia occurs as a mat of leafy shoots, the cover-abundance of this plant is to be recorded using a photographic record approach. Photographs are to be taken from an elevated position and a grid superimposed over the photograph to calculated crown cover/cover-abundance.

The same data will be recorded for in-situ threatened plants as the translocated plants.

5.3.2 Timing/Frequency

Monitoring frequency for in-situ roadside threatened plant is as follows: initially after installing protective barriers (prior to start of clearing), 6-monthly intervals for two years and once a year thereafter.

In addition to the above, monthly inspections of all in-situ flora are to be carried out during clearing and the construction phase (without recording monitoring data). Monitoring is to be conducted during construction (~3 yrs) and after construction for a minimum of 5 years, a total of 8 years.

5.3.3 Annual monitoring report

An annual report is to be prepared at the end of each year describing the results of monitoring in-situ roadside threatened plants. This report will be combined with the translocation monitoring in a single report (if only six months monitoring of in-situ plants has been completed that will be included in the annual monitoring report). The condition of each species is to be summarised and include an assessment of the effectiveness of mitigation measures and any corrective actions carried out.

5.3.4 Performance Indicators

The following performance indicators are to be used to evaluate the success of protective measures for in-situ threatened flora:

a) The survival rate of in-situ threatened flora at the finish of clearing is 100%. No accidental damage occurs during clearing.

b) The survival rate of in-situ threatened flora at the end of years 1-3 of the monitoring program is at least 80% and at least 70% at the end of years 4-8;

c) Of plants surviving at the end of each year, at least 75% are in good condition – i.e. they have healthy foliage, no sign of die-back or disease and exhibit new shoot growth (Condition Class 3 or >)

5.3.5 Corrective Actions

Specific corrective actions will be triggered if monitoring identifies lower results than specified by the above performance indicators. If lower results are detected by the plant ecologist conducting the monitoring, the Environmental Manager will be informed within 5 working days, and corrective actions undertaken within 1 month. Examples of corrective actions to be considered include-

- Weed control in situations where exotic species increase and pose a potential threat to the vigour and persistence of the translocated species.
- Installation of surveillance cameras and signage to deter further theft of in-situ species.
- Installation of hessian screening as a temporary measure to protect in situ threatened plants from over-exposure to sun and wind after vegetation clearing, until protective revegetation becomes established.

5.4 Slender Marsdenia and Woolls' Tylophora Habitat Condition

5.4.1 Monitoring Methods

Monitoring of potential changes in the habitat of Slender Marsdenia and Woolls'Tylophora is to be conducted within the indirect impact zone – ie within 10 metres of the edge of clearing/construction. A total of 17.8 Ha of Slender Marsdenia and Woolls' Tylophora habitat has been identified within the project boundary (Jacobs SKM 2014). Monitoring is to be conducted in areas of this habitat adjacent to the construction footprint and to be plot-based.

<u>Plot based assessment</u>
Permanent plots will be established in the indirect impact zone at 10 representative points in Slender Marsdenia and Woolls'Tylophora habitat. The plots are to be 10 metres wide and 20 metres long, with the long axis parallel to the edge of clearing. Monitoring will focus on recording vegetation structure, the level of weed incursion and microclimate descriptors. Structure consists of the height, crown cover and dominant species in each vegetation layer and will be recorded according to the current OEH vegetation standard (Native Vegetation Interim Type Standard –

http://www.environment.nsw.gov.au/research/VISplot.htm). This will provide a measure of the intactness of the habitat and potential changes in structure over time that could affect the growth of Slender Marsdenia and Woolls'Tylophora. All exotic species will be recorded and the species crown cover (cover-abundance) estimated visually according to the vegetation standard (ie. <1%, 1%, 5%, 10%, 15% etc). The abundances of all exotic species will be summed to provide an index of weed incursion. Total (overlapping) exotic species crown cover will also be recorded and used as an index.

To record microclimate the following categories (1-6) are to be applied:

Microclimate Class (less exposed to more exposed)	**Microclimate Type**
1	Sheltered aspect (e.g. south) and vegetation understorey slightly more open and exposed than before clearing.
2	Sheltered aspect (e.g. south) and vegetation understorey moderately more open and exposed than before clearing.
3	Sheltered aspect (e.g. south) and vegetation understorey much more open and exposed than before clearing.
4	Explosed aspect (e.g. east, north and west) and vegetation understorey slightly more open and exposed than before clearing.
5	Explosed aspect (e.g. east, north and west) and vegetation understorey moderately more open and exposed than before clearing.
6	Explosed aspect (e.g. east, north and west) and vegetation understorey much more open and exposed than before clearing.

Note – an increase in microclimate exposure class (e.g. 1 to 2) may be recorded between monitoring events if there is a noticeable decline in understorey or overstorey structure allowing greater sun and wind penetration, and consequent drying of Slender Marsdenia and Woolls' Tylophora habitat.

5.4.2 Timing/Frequency

The plots are to be established within one month of the finish of vegetation clearing (baseline monitoring) and then monitored at 12-monthly intervals during construction and the operation phase for a total of 8 years.

5.4.3 Annual monitoring report

The results of Slender Marsdenia and Woolls Tylophora habitat condition monitoring shall be included in the annual monitoring report. This is to be prepared at the end of each year. The quantitative habitat descriptors (i.e. vegetation structure, weed abundance and microclimate) are to be summarised and compared with the previous year(s) to assess any changes in habitat condition.

5.4.4 Performance Indicators

The following performance indicators are to be used to evaluate changes in habitat condition

a) Plot crown-cover of exotic species is no more than 15% (overlapping and/or summed) at the end of Year-1 and no more than 25% at the end of Years-2 to 8.

b) Baseline vegetation structure (height and crown cover) remains the same or increases in height and crown cover at the end of year compared to the previous year.

c) There is no increase in the microclimate exposure class (e.g. 1 to 2, or 4 to 5) compared to the previous year.

5.4.5 Corrective Actions

Specific corrective actions will be triggered if monitoring identifies changes as specified by the above performance indicators. If such changes are detected by the plant ecologist conducting the monitoring, the Environmental Manager will be informed within 5 working days, and corrective actions undertaken within 1 month. Examples of corrective actions to be considered include-

a) Weed control in and around Slender Marsdenia and Woolls' Tylophora habitat representative of such plots where exotic species exceed thresholds and pose a potential threat to habitat condition and the vigour and persistence of Slender Marsdenia and Woolls' Tylophora. Weed control to be applied by an experienced bush regenerator familiar with identification of Slender Marsdenia and Woolls' Tylophora.

b) Prioritise revegetation of batters and bare areas adjacent to Slender Marsdenia and Woolls' Tylophora habitat to minimise potential for deterioration in habitat microclimate and structure, and weed incursion. Use salvaged topsoil seed bank (Sec. 5.2.2) for this purpose to minimise weed spread from revegetated areas into adjacent habitat.

6 MANAGEMENT OF UNFORSEEN IMPACTS

Throughout the early works, detailed design and construction period there is a possibility of design refinements that may impact on additional areas of threatened species. This may include but not be limited to, clearing for: fencing, Property Works and Service Works.

A consistency assessment would be undertaken against the Minister for Planning's Conditions of Approval for the project. If the additional impacts are deemed inconsistent with the Minister for Planning's Conditions of Approval then a modification under Section 75 W of the *Environmental Planning and Assessment Act 1979* would be lodged for determination by the Minster for Planning. This process would also enable a detailed record of any additional impacts outside of what was anticipated in the Threatened Flora Management Plan.

If additional assessment identifies an increased impact to threatened species within the project corridor additional translocation measures would be considered. Any additional translocation measures would be determined using the same methodology as detailed in Section 4.4, 4.5 & 4.6 of this report. Any additional translocation efforts would be in accordance with the translocation objectives for the project which are defined as follows:-

- To transplant and re-establish impacted individuals of threatened species at a nearby site with soil type and topography closely matching the original site of each species;
- To promote the long-term sustainability of the founder (translocated) population by enhancing population size and genetic diversity through propagation and introduction of additional individuals;
- To promote long-term sustainability by restoring good quality habitat and establishing functional habitat conditions;
- To undertake translocation using a monitored, experimental approach that improves knowledge of species ecology and translocation technology; and
- To preserve individuals of threatened and rare species in-situ wherever possible and limit transplanting to individuals directly impacted by construction, or as otherwise directed by the Project Ecologist.

An addendum to the translocation plan would be prepared for any additional species or individuals to be translocated due to design changes associated with the detailed design period.

If any significant additional impacts, as identified by the Project Ecologist are identified, RMS would consult with Environmental Protection Authority and Department of Planning and Infrastructure to determine the appropriate approval and /or management measures necessary.

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APPENDIX 1: PLANS 2-13 SHOWING THE LOCATION OF THREATENED AND RARE SPECIES within the project boundary of the WC2U upgrade, as recorded during targeted flora surveys conducted for this report in November 2011 and October 2012, and EcoPro (2010). Additional threatened flora data for the southern half of WC2U (WC2NH) were included in Version 2 of the WC2U TFMP from the following sources:

- ECOS Environmental (2014a). Targeted surveys (and sample collection) for a genetic study of *Marsdenia longiloba* currently being conducted by ECOS Environmental in collaboration with University of Sunshine Coast, titled "Analysis of genetic variability in the endangered species Slender Marsdenia (*Marsdenia longiloba*) at fine, medium and broad geographic scales"
- ECOS Environmental (2014b). Targeted re-survey of threatened species in the Cockburns Lane (Warrell Creek) area.
- ECOS Environmental (2014c).Targeted survey for a connector track with Old Coast Road, Nambucca Heads.
- by GeoLink (2014). Targeted surveys along the utilities alignment.

Note - the road design shown on plans below for the northern half of WC2U (i.e. NH2U, presently under construction) is based on the (modified) Concept Design, as presented in the WC2U TFMP Ver. 1 (6/3/2013). The road design shown on the plans below for the southern half of WC2U (i.e. WC2NH) is the latest RMS Concept Design as of July 2014. Construction of WC2NH is expected to start later in 2014. Further small changes to the design of WC2NH may be required during the detailed design phase.

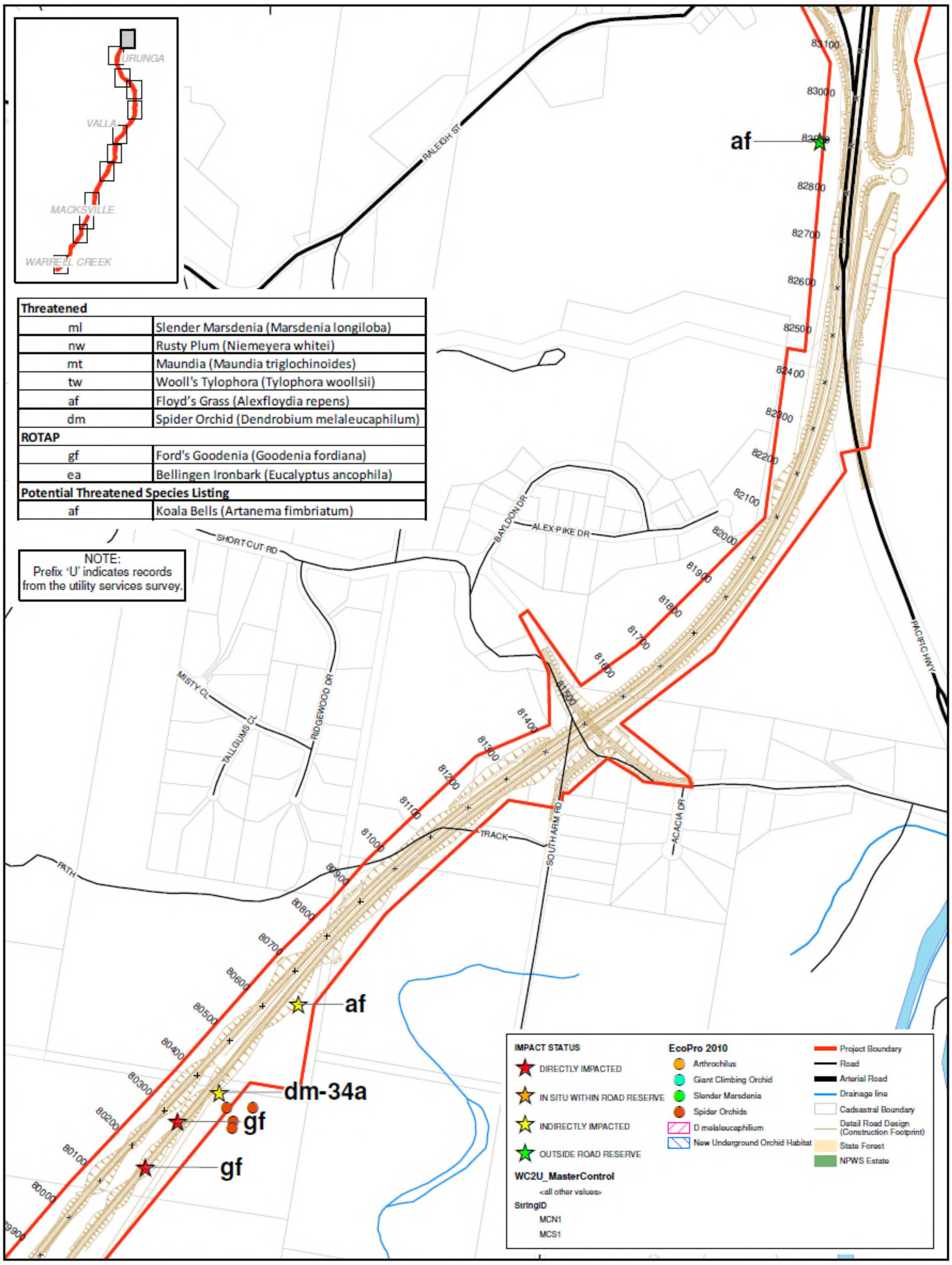

Figure 2 : Location of threatened and rare species recorded during the 2011 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

Cadastre: Roads and Traffic Authority 2007
Flora Survey: ECOS December 2011/ February 2012 / Oct-Nov 2012
Roads: GeoscienceAustralia 2009
Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW Department of Primary Indistries 2008

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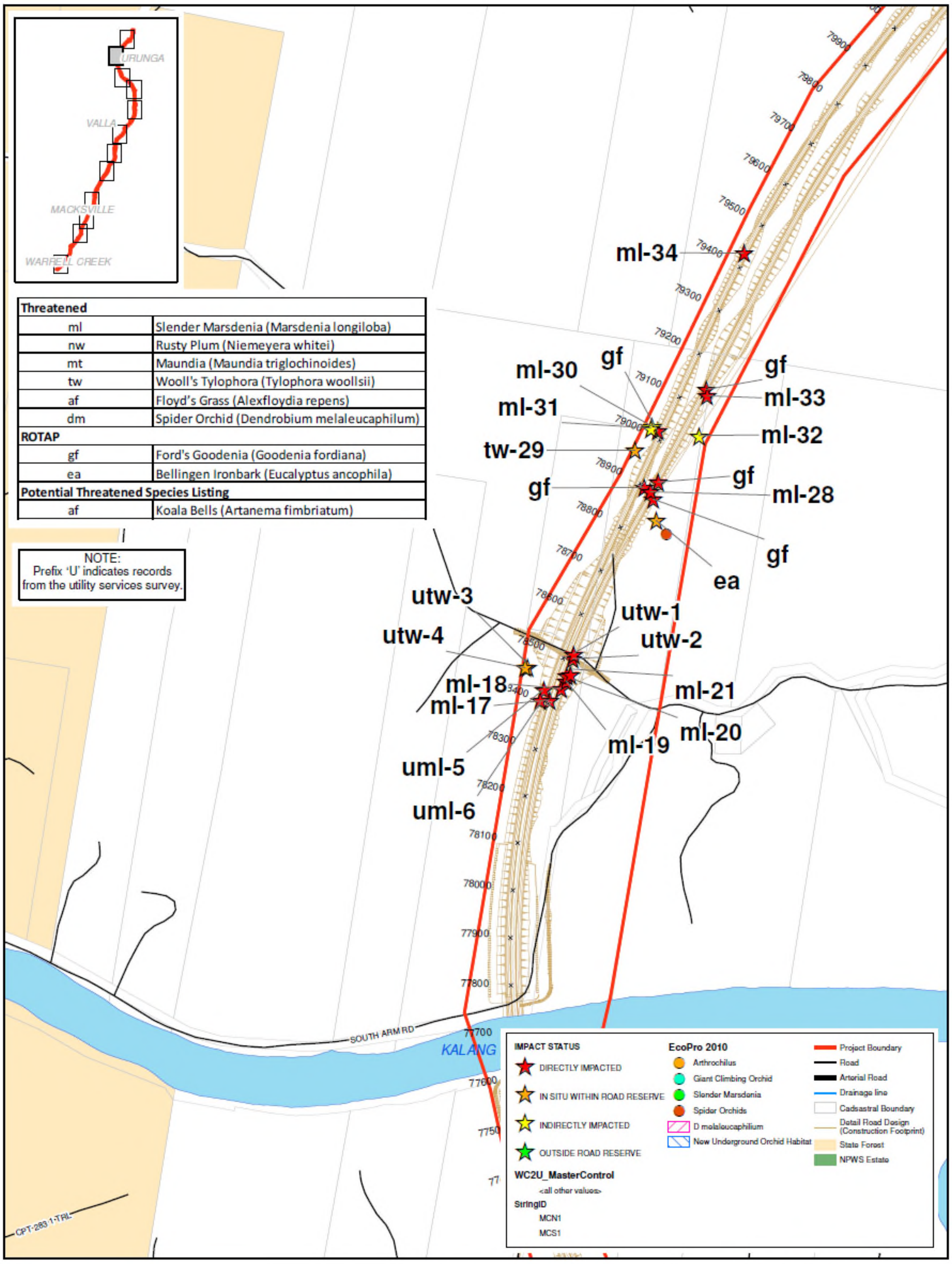

Figure 3 : Location of threatened and rare species recorded during the 2011 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

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Flora Survey: ECOS December 2011/ February 2012 / Oct-Nov 2012
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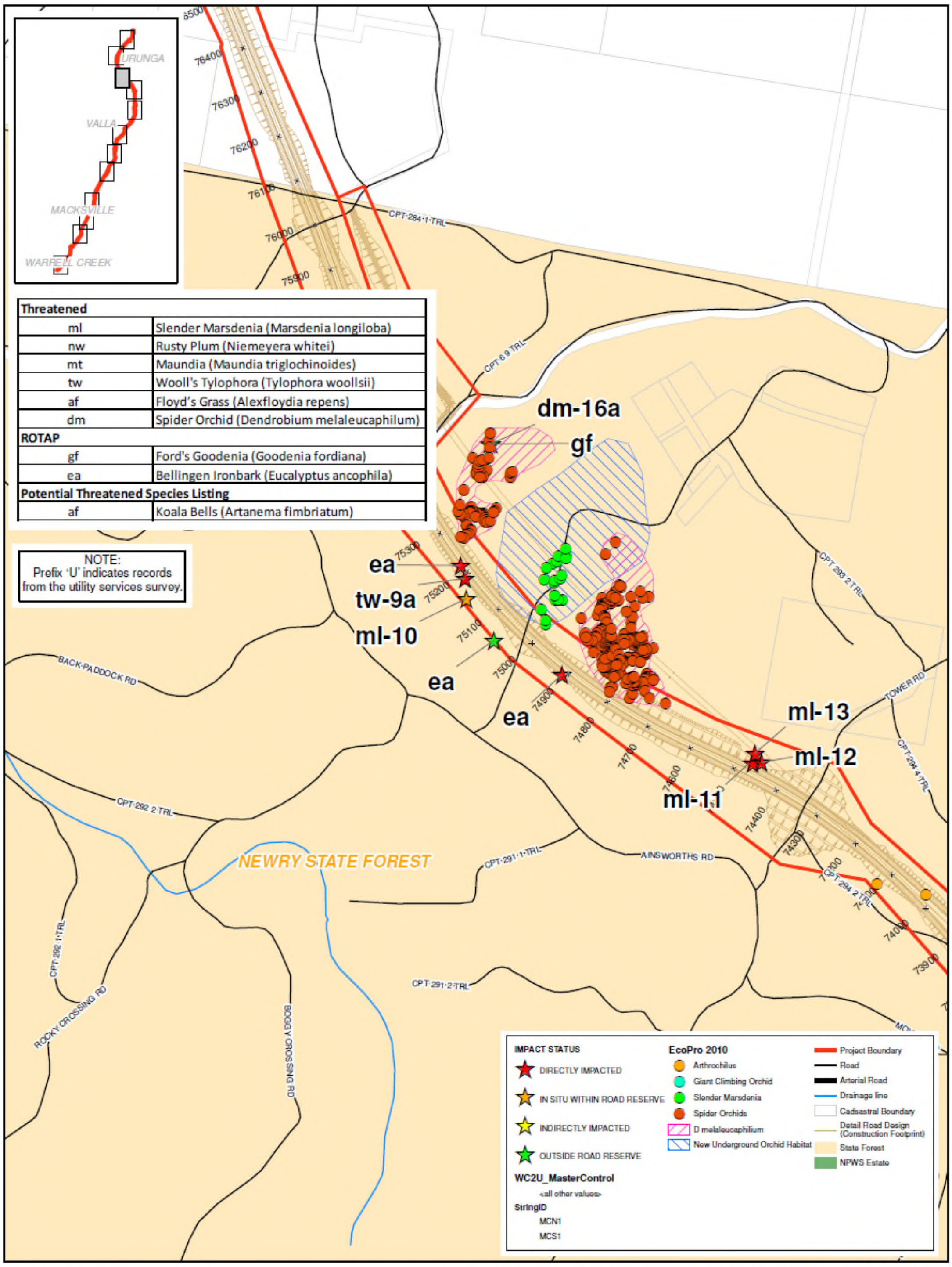

Figure 4 : Location of threatened and rare species recorded during the 2011 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

Cadastre: Roads and Traffic Authority 2007; Flora Survey: ECOS December 2011/ February 2012 / Oct-Nov 2012; Roads: GeoscienceAustralia 2009; Highway Design (footprint): RTA 2011; Project Boundary: RTA 2011; Drainage: GeoscienceAustralia 2009; State Forests: NSW Department of Primary Industries 2008

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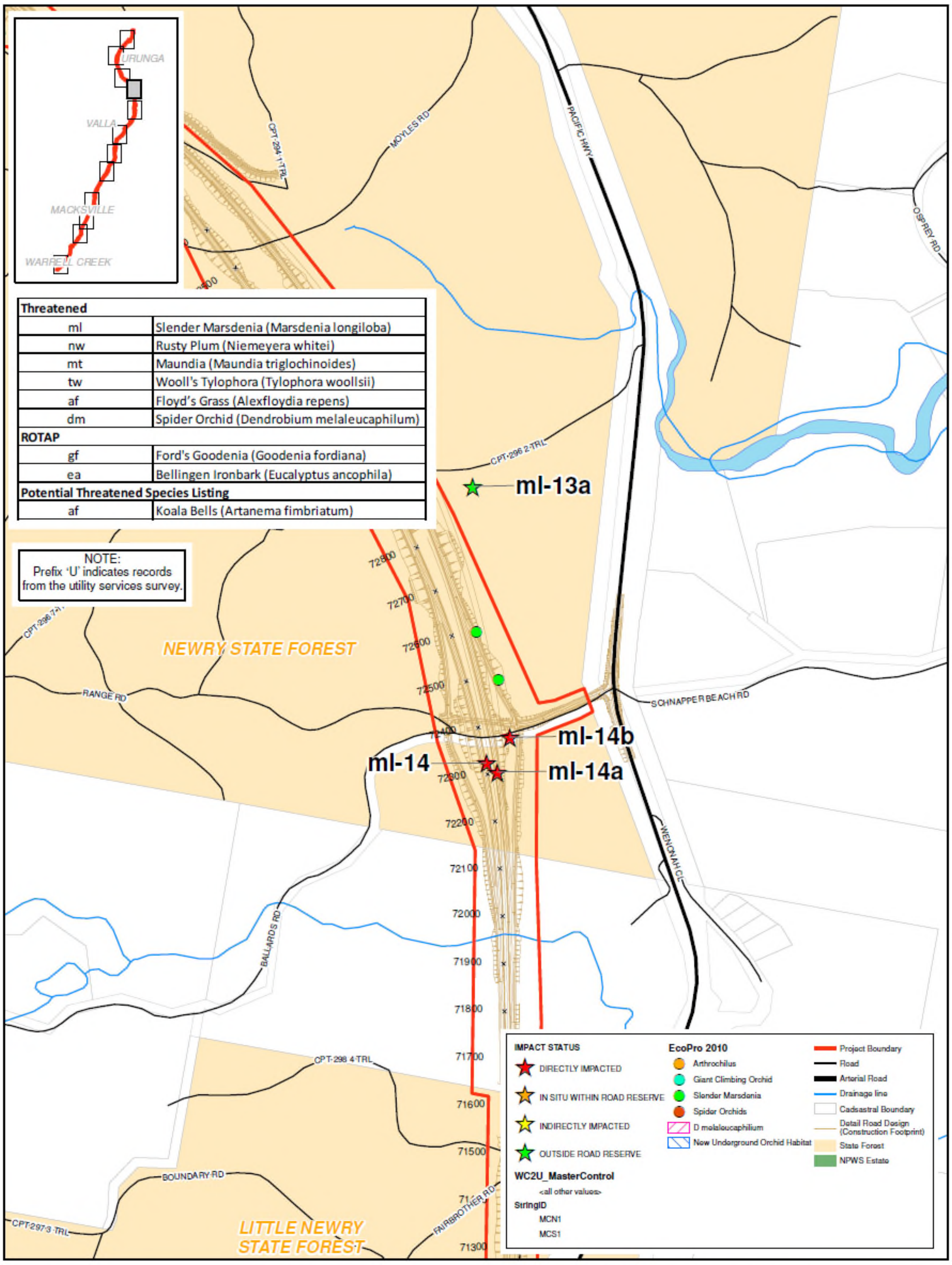

Figure 5 : Location of threatened and rare species recorded during the 2011 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

Cadastre: Roads and Traffic Authority 2007
Flora Survey: ECOS December 2011/ February 2012 / Oct-Nov 2012
Roads: GeoscienceAustralia 2009
Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW Department of Primary Indistries 2008

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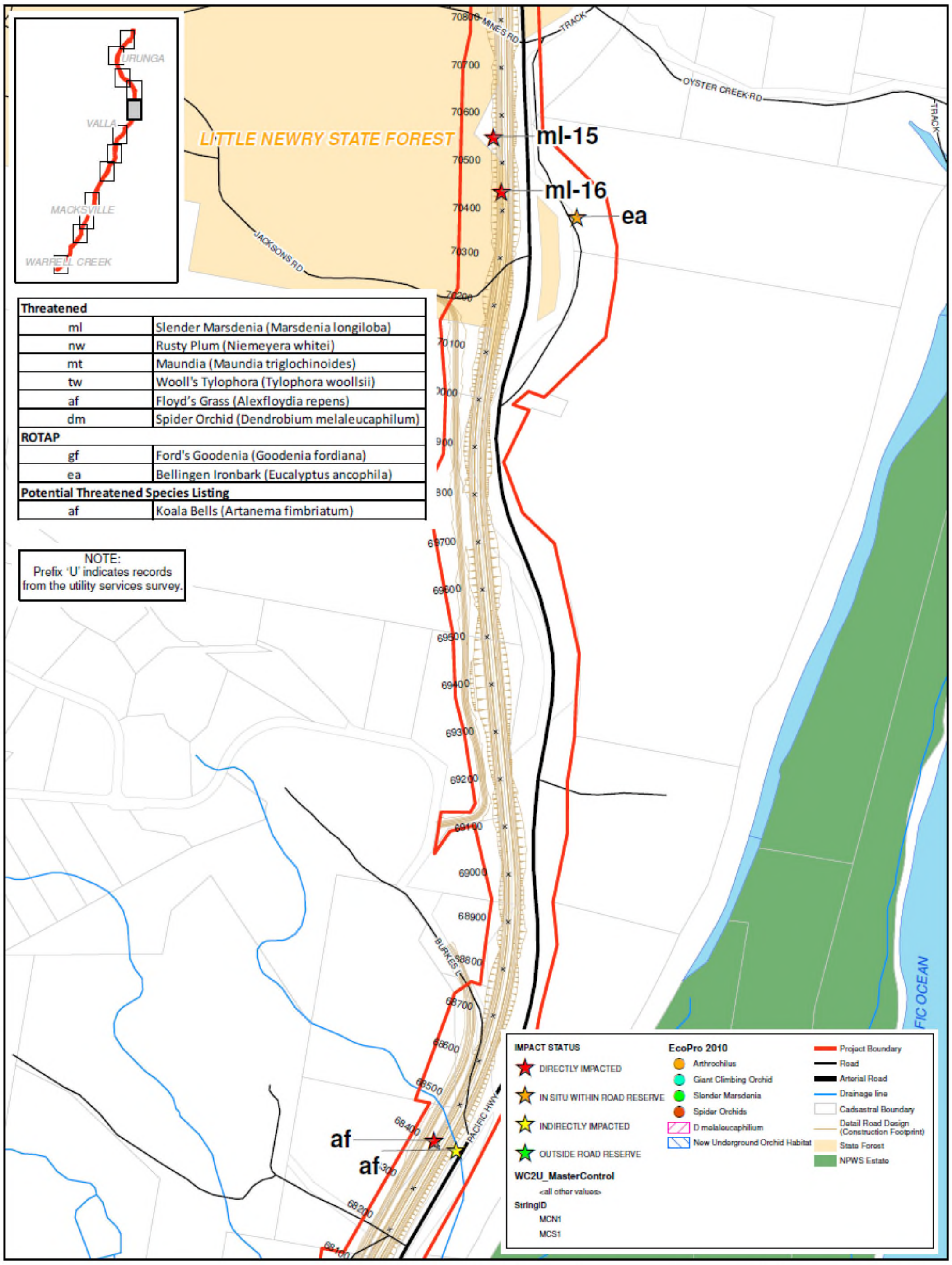

Figure 6 : Location of threatened and rare species recorded during the 2011 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

Cadastre: Roads and Traffic Authority 2007; Flora Survey: ECOS December 2011/ February 2012 / Oct-Nov 2012; Roads: GeoscienceAustralia 2009; Highway Design (footprint): RTA 2011; Project Boundary: RTA 2011; Drainage: Geoscience Australia 2009; State Forests: NSW Department of Primary Industries 2008

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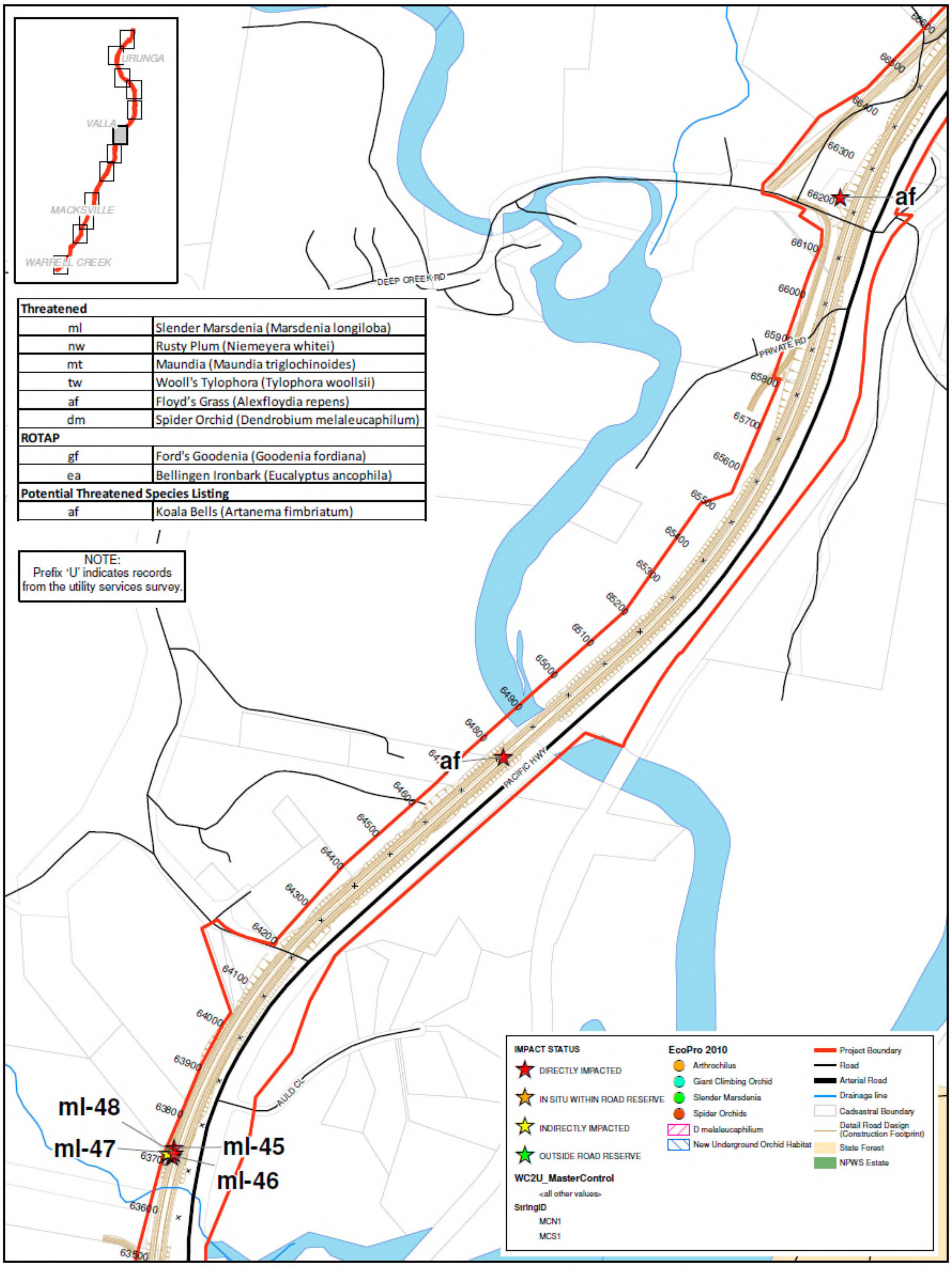

Figure 7 : Location of threatened and rare species recorded during the 2011 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

Cadastre: Roads and Traffic Authority 2007
Flora Survey: ECOS December 2011/ February 2012 / Oct-Nov 2012
Roads: GeoscienceAustralia 2009
Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW Department of Primary Industries 2008

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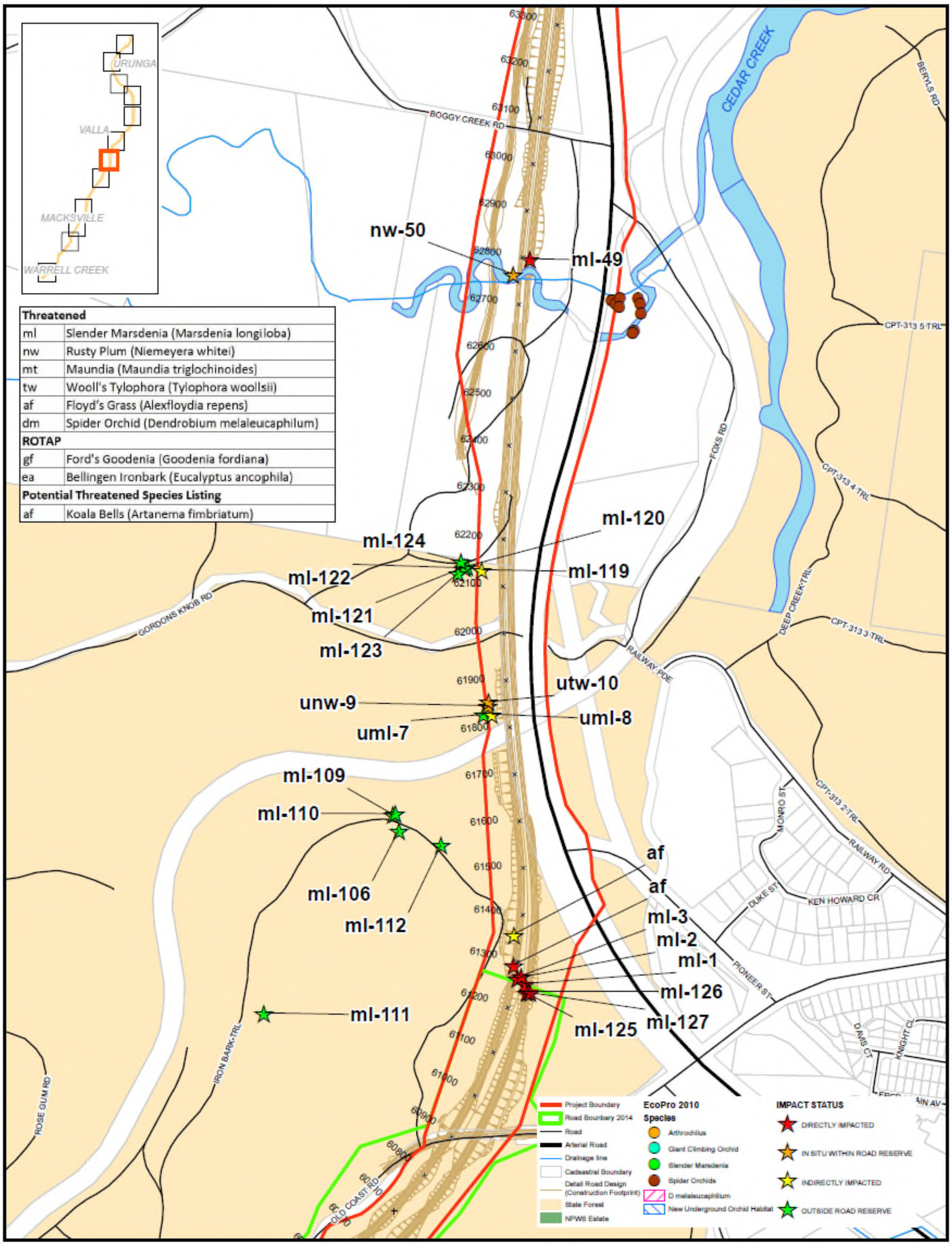
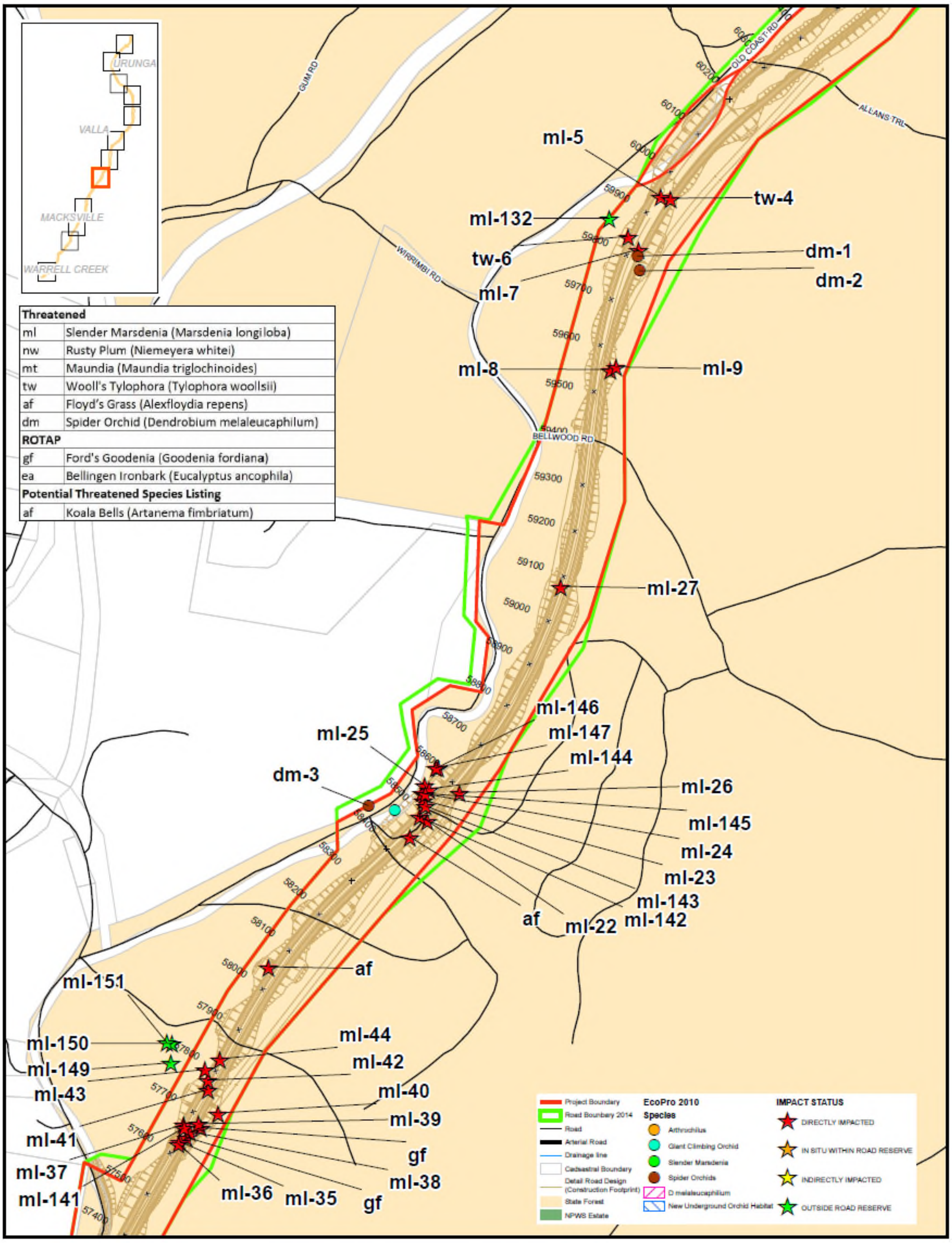


ECOS ENVIRONMENTAL PTY LTD

A4 Scale 1:10,000

Figure 8
Threatened and rare species recorded during the 2011-2014 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual



ECOS ENVIRONMENTAL PTY LTD

A4 Scale 1:10,000

Figure 9

Threatened and rare species recorded during the 2011-2014 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

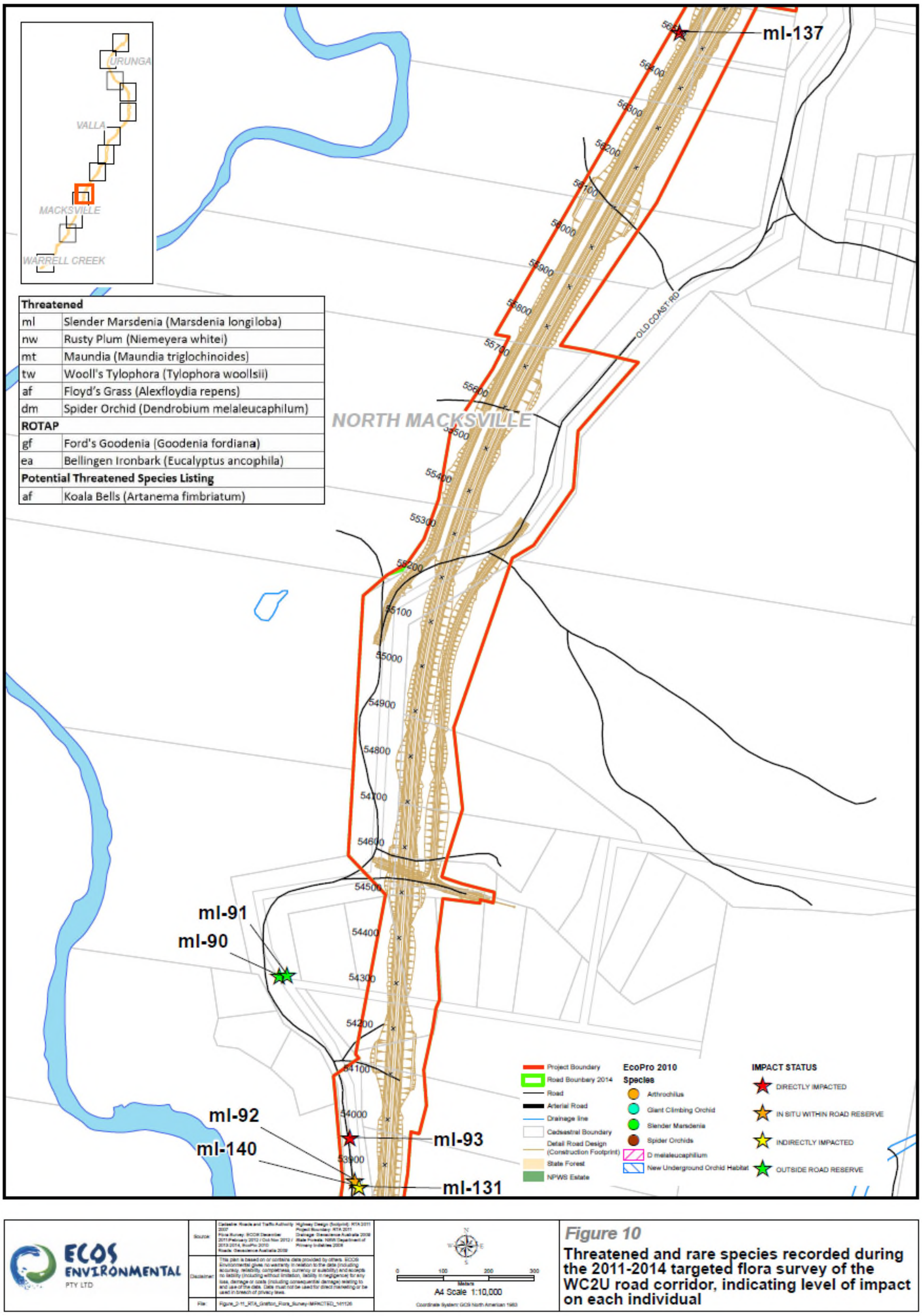


Figure 10
Threatened and rare species recorded during the 2011-2014 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

Note: ml-92 is shown as directly impacted (red) as it was indicated there would be an upgrade/works along Old Coast Road. The impact status of this point would be updated as the detailed design progresses and during the pre-clearing survey.

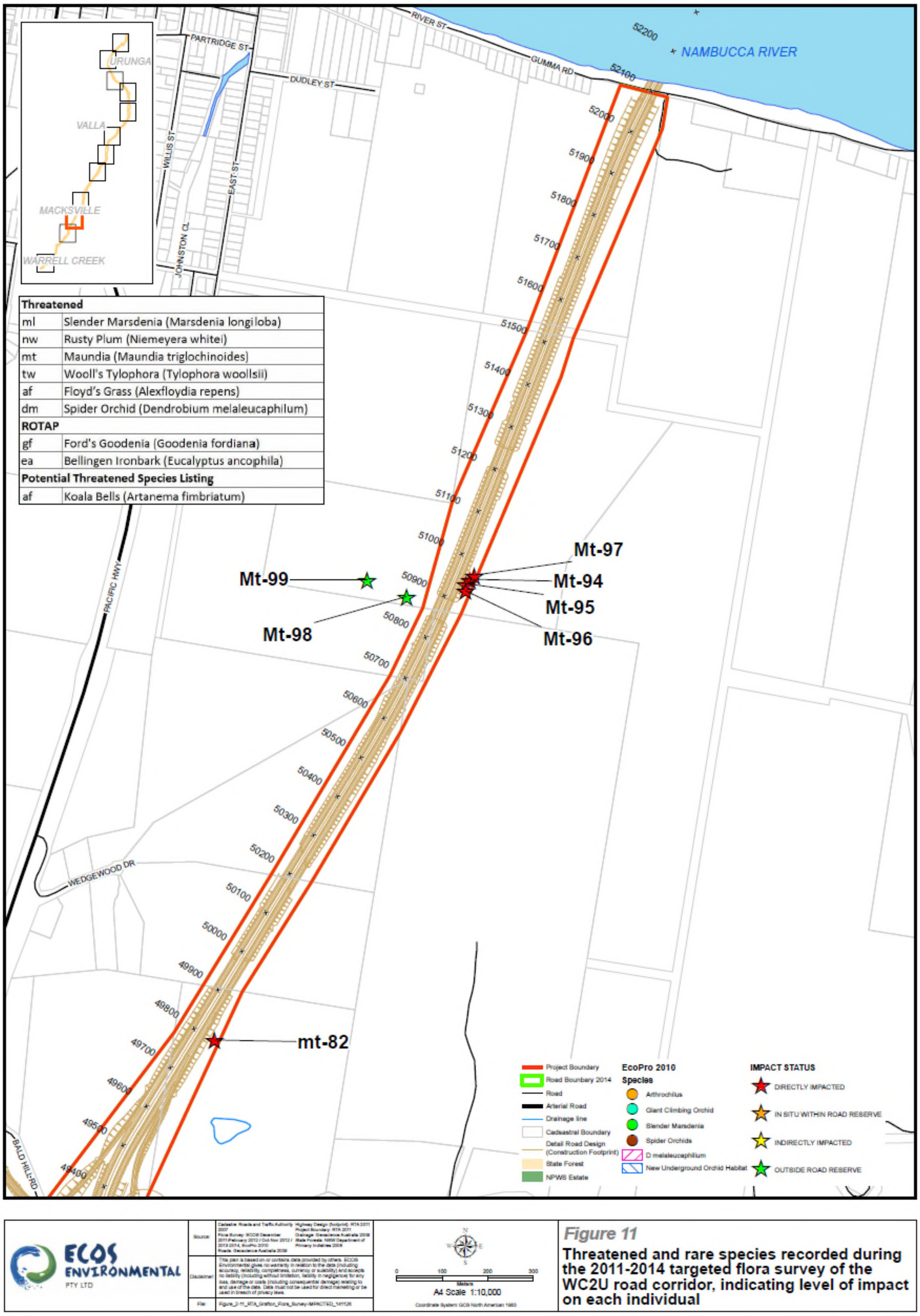


Figure 11
Threatened and rare species recorded during the 2011-2014 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

Note: mt-82 marks the western tip of a large population of Maundia that in 2011 extended for more than 100m east of the project boundary; between mt-82 and the project boundary was a short distance (few metres) of indirectly impacted. The section from mt-82 to mt-96 was not surveyed due to access limitations; Maundia distribution in this section will be clarified during the pre-clearing survey.

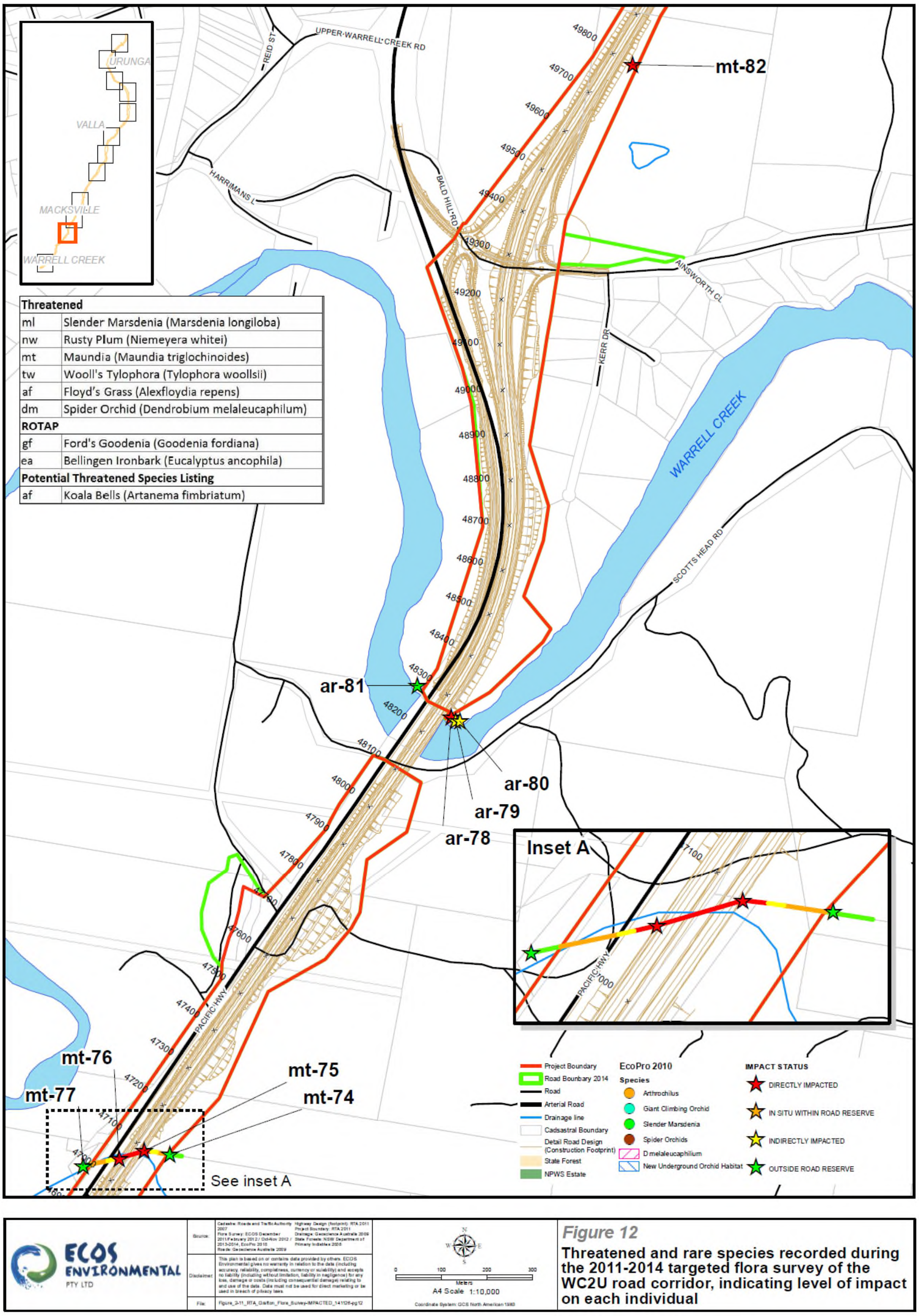


Figure 12
Threatened and rare species recorded during the 2011-2014 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

Note: the colour coding in the inset is to be interpreted as per impact status in the existing legend – ie. red = directly impacted; yellow = indirectly impacted; orange = in situ; green = outside road reserve/project boundary. See note on Fig 11 for point mt–82.

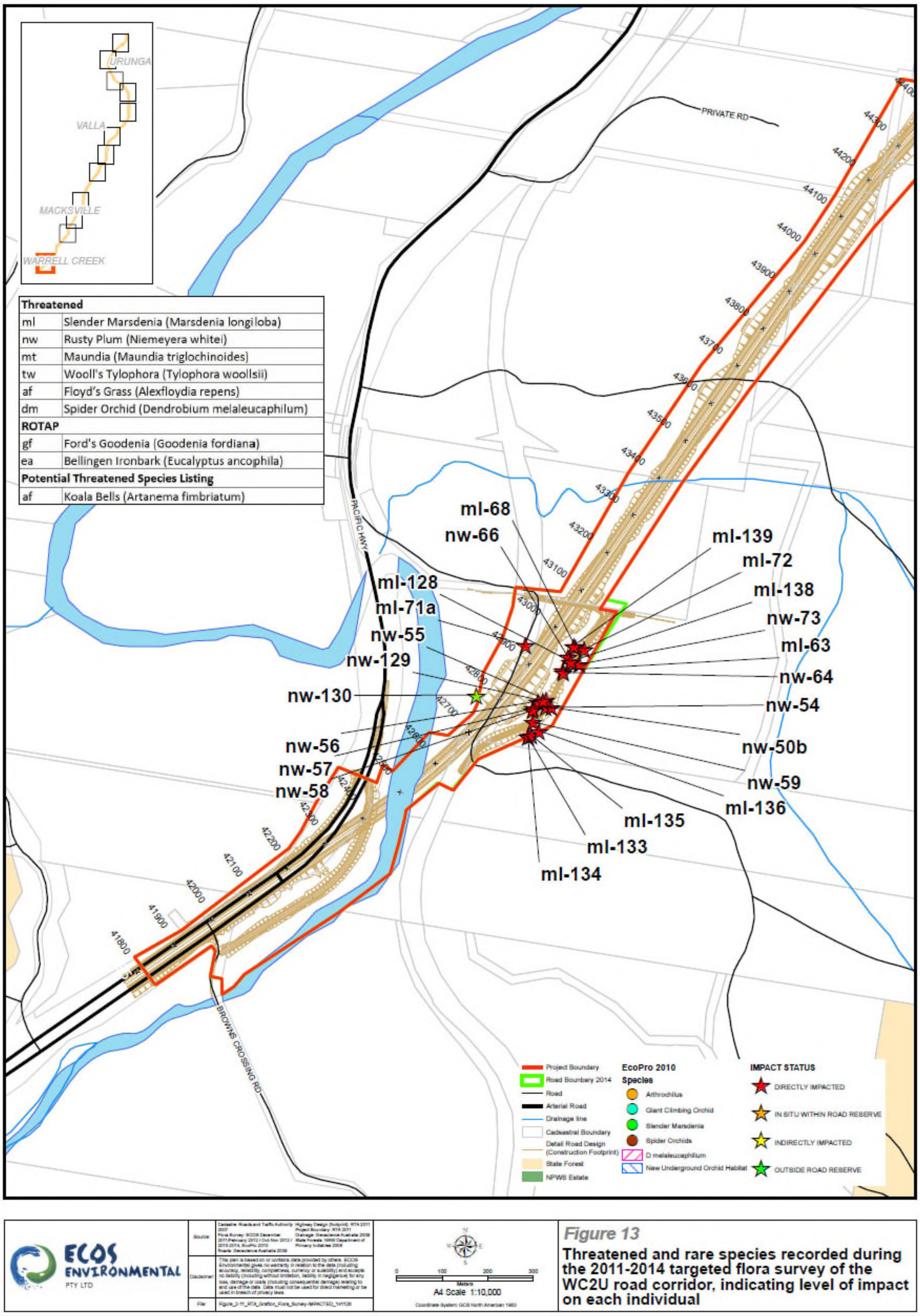


Figure 13
Threatened and rare species recorded during the 2011-2014 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

Note: the position of point nw-130 (green – outside project boundary) was estimated from a vantage point as it could not be accessed on the ground and it could actually be within the road reserve; the precise location of the tree would be recorded during the pre-clearing survey.

APPENDIX 2: LOCATION COORDINATES OF THREATENED FLORA AND RESULTS OF IMPACT ANALYSIS for (i) the southern half of WC2U – Warrell Creek to Nambucca Heads (WC2NH) and (ii) northern half of WC2U – Nambucca Heads to Urunga (NH2U), indicating if individuals are directly impacted, indirectly impacted, outside the indirect zone within the project boundary (in situ within the road reserve) or outside the project boundary/road reserve. The results for the EcoPro (2010) targeted orchid survey are given below

(i) Warrell Creek to Nambucca Heads (WC2NH)

ID	SPECIES	EASTING	NORTHING	NUMBERS	HEIGHT	IMPACT_RMS
ar-78	Alexfloydia repens	492334.706995	6599021.622260	mat		DIRECTLY IMPACTED
ar-79	Alexfloydia repens	492344.763916	6599013.133180	mat		INDIRECTLY IMPACTED
ar-80	Alexfloydia repens	492353.539390	6599011.846530	mat		INDIRECTLY IMPACTED
ar-81	Alexfloydia repens	492261.429754	6599090.278560	mat		OUTSIDE ROAD RESERVE
af	Artanema fimbriatum	495851.457703	6607944.201690	1		DIRECTLY IMPACTED
af	Artanema fimbriatum	496151.378340	6608221.361400	12		DIRECTLY IMPACTED
gf	Goodenia fordiana	495678.042363	6607581.015290	mat		DIRECTLY IMPACTED
gf	Goodenia fordiana	495708.849288	6607601.898610	mat		DIRECTLY IMPACTED
ml-22	Marsdenia longiloba	496188.410408	6608256.097960	2	0.1m	DIRECTLY IMPACTED
ml-23	Marsdenia longiloba	496180.251673	6608299.314590	1	1m	DIRECTLY IMPACTED
ml-24	Marsdenia longiloba	496177.372208	6608314.274170	1	0.5m	DIRECTLY IMPACTED
ml-25	Marsdenia longiloba	496182.954756	6608331.453140	2	0.8m	DIRECTLY IMPACTED
ml-26	Marsdenia longiloba	496256.890152	6608315.410310	6	0.5m	DIRECTLY IMPACTED
ml-27	Marsdenia longiloba	496471.828945	6608754.696510	1	0.4m	DIRECTLY IMPACTED
ml-35	Marsdenia longiloba	495663.835870	6607571.959330	1	4m	DIRECTLY IMPACTED
ml-36	Marsdenia longiloba	495660.804035	6607567.525330	1	0.2m	DIRECTLY IMPACTED
ml-37	Marsdenia longiloba	495671.485200	6607608.163410	3	0.8m	DIRECTLY IMPACTED
ml-38	Marsdenia longiloba	495684.423981	6607593.392690	1	0.1m	DIRECTLY IMPACTED
ml-39	Marsdenia longiloba	495702.778781	6607610.022940	1	0.1m	DIRECTLY IMPACTED

ml-40	Marsdenia longiloba	495744.282604	6607632.942110	1	small	DIRECTLY IMPACTED
ml-41	Marsdenia longiloba	495722.548309	6607682.802220	10	small	DIRECTLY IMPACTED
ml-42	Marsdenia longiloba	495722.699901	6607703.119170	1	1.5m	DIRECTLY IMPACTED
ml-43	Marsdenia longiloba	495716.783427	6607725.280690	1	0.1	DIRECTLY IMPACTED
ml-44	Marsdenia longiloba	495748.069111	6607748.011070	2	0.3m	DIRECTLY IMPACTED
ml-5	Marsdenia longiloba	496683.949976	6609585.722830	1	small	DIRECTLY IMPACTED
ml-63	Marsdenia longiloba	489635.678810	6594537.005010	1	0.1m	DIRECTLY IMPACTED
ml-68	Marsdenia longiloba	489663.695772	6594588.748820	1	1.5m	DIRECTLY IMPACTED
ml-7	Marsdenia longiloba	496637.195041	6609472.118760	6	0.6m	DIRECTLY IMPACTED
ml-71a	Marsdenia longiloba	489553.726825	6594591.727680	3	2m	DIRECTLY IMPACTED
ml-72	Marsdenia longiloba	489683.316469	6594582.857250	1	1m	DIRECTLY IMPACTED
ml-8	Marsdenia longiloba	496576.593202	6609216.292200	2	0.6m	DIRECTLY IMPACTED
ml-9	Marsdenia longiloba	496589.206798	6609222.021860	1	4m	DIRECTLY IMPACTED
mt-74	Maundia triglochinoides	491716.604039	6598059.237540	mat		INDIRECTLY IMPACTED
mt-75	Maundia triglochinoides	491659.329340	6598066.765920	mat		DIRECTLY IMPACTED
mt-76	Maundia triglochinoides	491604.147159	6598050.284420	mat		DIRECTLY IMPACTED
mt-77	Maundia triglochinoides	491524.399223	6598033.044450	mat		OUTSIDE ROAD RESERVE
mt-82	Maundia triglochinoides	492733.536182	6600457.027550	mat		DIRECTLY IMPACTED
nw-50b	Niemeyera whitei	489598.600127	6594456.623420	1	8m	DIRECTLY IMPACTED
nw-54	Niemeyera whitei	489610.242842	6594455.157100	1	8m	DIRECTLY IMPACTED
nw-55	Niemeyera whitei	489599.063113	6594472.508300	1	sdlg	DIRECTLY IMPACTED
nw-56	Niemeyera whitei	489581.206261	6594468.612190	1	1.2m	DIRECTLY IMPACTED
nw-57	Niemeyera whitei	489570.696540	6594452.902240	1	7m	DIRECTLY IMPACTED
nw-58	Niemeyera whitei	489569.106161	6594448.467830	1	6m	DIRECTLY IMPACTED
nw-59	Niemeyera whitei	489571.204261	6594422.796200	1	10m	DIRECTLY IMPACTED
nw-64	Niemeyera whitei	489636.959937	6594531.465170	1	8m	DIRECTLY IMPACTED
nw-66	Niemeyera whitei	489647.610383	6594566.753670	1	4m	DIRECTLY IMPACTED
nw-73	Niemeyera whitei	489672.663574	6594549.969920	1	5m	DIRECTLY IMPACTED

tw-4	Tylophora woollsii	496704.871330	6609581.111790	1		DIRECTLY IMPACTED
tw-6	Tylophora woollsii	496614.669628	6609500.001180	1		DIRECTLY IMPACTED
ml-90	Marsdenia longiloba	494181.000000	6604547.000000	2		OUTSIDE ROAD RESERVE
ml-91	Marsdenia longiloba	494198.000000	6604550.000000	1		OUTSIDE ROAD RESERVE
ml-92	Marsdenia longiloba	494347.000000	6604098.000000	1		IN SITU WITHIN ROAD RESERVE
ml-93	Marsdenia longiloba	494336.000000	6604191.000000	1		DIRECTLY IMPACTED
mt-94	Maundia triglochinoides	493295.000000	6601470.000000	mat		DIRECTLY IMPACTED
mt-95	Maundia triglochinoides	493286.000000	6601461.000000	mat		DIRECTLY IMPACTED
mt-96	Maundia triglochinoides	493285.000000	6601445.000000	mat		DIRECTLY IMPACTED
mt-97	Maundia triglochinoides	493304.000000	6601479.000000	mat		DIRECTLY IMPACTED
mt-98	Maundia triglochinoides	493156.000000	6601432.000000	mat		OUTSIDE ROAD RESERVE
mt-99	Maundia triglochinoides	493069.000000	6601470.000000	mat		OUTSIDE ROAD RESERVE
ml-111	Marsdenia longiloba	496931.363625	6610540.871290	1		OUTSIDE ROAD RESERVE
ml-125	Marsdenia longiloba	497488.408000	6610582.878000	1	0.1m	DIRECTLY IMPACTED
ml-126	Marsdenia longiloba	497493.501000	6610586.158000	1	0.1m	DIRECTLY IMPACTED
ml-127	Marsdenia longiloba	497496.352000	6610583.216000	2	1m	DIRECTLY IMPACTED
ml-128	Marsdenia longiloba	489653.000000	6594556.000000	1	0.1m	DIRECTLY IMPACTED
nw-129	Rusty Plum	489592.530000	6594469.550000	1	4m	DIRECTLY IMPACTED
nw-130	Rusty Plum	489445.710000	6594482.210000	1		OUTSIDE ROAD RESERVE
ml-131	Marsdenia longiloba	494356.000000	6604083.000000	3		INDIRECTLY IMPACTED
ml-132	Marsdenia longiloba	496575.000000	6609539.000000	1		OUTSIDE ROAD RESERVE
ml-133	Marsdenia longiloba	489559.000000	6594392.000000	2		DIRECTLY IMPACTED
ml-134	Marsdenia longiloba	489560.000000	6594392.000000	3		DIRECTLY IMPACTED
ml-135	Marsdenia longiloba	489567.000000	6594394.000000	1		DIRECTLY IMPACTED
ml-136	Marsdenia longiloba	489584.000000	6594404.000000	1		DIRECTLY IMPACTED
ml-137	Marsdenia longiloba	495058.000000	6606623.000000	1		DIRECTLY IMPACTED
ml-138	Marsdenia longiloba	489653.000000	6594556.000000	1	1.6m	DIRECTLY IMPACTED
ml-139	Marsdenia longiloba	489660.000000	6594591.000000	1	0.6m	DIRECTLY IMPACTED
ml-140	Marsdenia longiloba	494356.000000	6604084.000000	1		INDIRECTLY IMPACTED

ml-141	Marsdenia longiloba	495672.000000	6607601.000000	1	0.2m	DIRECTLY IMPACTED
ml-142	Marsdenia longiloba	496172.000000	6608264.000000	1	0.2m	DIRECTLY IMPACTED
ml-143	Marsdenia longiloba	496185.000000	6608287.000000	1	2.2m	DIRECTLY IMPACTED
ml-144	Marsdenia longiloba	496192.000000	6608323.000000	1	0.3m	DIRECTLY IMPACTED
ml-145	Marsdenia longiloba	496184.000000	6608313.000000	1	0.3m	DIRECTLY IMPACTED
ml-146	Marsdenia longiloba	496212.000000	6608369.000000	1	1.5m	DIRECTLY IMPACTED
ml-147	Marsdenia longiloba	496207.000000	6608368.000000	1	3m	DIRECTLY IMPACTED
ml-149	Marsdenia longiloba	495645.000000	6607740.000000	1		OUTSIDE ROAD RESERVE
ml-150	Marsdenia longiloba	495647.000000	6607781.000000	1		OUTSIDE ROAD RESERVE
ml-151	Marsdenia longiloba	495636.000000	6607784.000000	1		OUTSIDE ROAD RESERVE

(ii) Nambucca Heads to Urunga (NH2U)

ID	SPECIES	EASTING	NORTHING	NUMBERS	HEIGHT	IMPACT_RMS
af	Artanema fimbriatum	497461.092414	6610642.223760	1		DIRECTLY IMPACTED
af	Artanema fimbriatum	497462.035272	6610707.607140	30		DIRECTLY IMPACTED
af	Artanema fimbriatum	498290.907731	6613899.162890	10		DIRECTLY IMPACTED
af	Artanema fimbriatum	498996.450225	6615072.078720	6		DIRECTLY IMPACTED
af	Artanema fimbriatum	500347.886710	6616794.232820	5		INDIRECTLY IMPACTED
af	Artanema fimbriatum	500301.385190	6616814.366140	5		DIRECTLY IMPACTED
af	Artanema fimbriatum	498993.037493	6627709.492660	50		INDIRECTLY IMPACTED
af	Artanema fimbriatum	500084.954156	6629520.828840	5		OUTSIDE ROAD RESERVE
dm-16a	Dendrobium melaleucaphilum	498649.693941	6623095.420120	1		OUTSIDE ROAD RESERVE
dm-34a	Dendrobium melaleucaphilum	498827.816416	6627524.966920	1		INDIRECTLY IMPACTED
ea	Eucalyptus ancophila	500600.800758	6618752.556970	3	30m	IN SITU WITHIN ROAD RESERVE
ea	Eucalyptus ancophila	498796.690430	6622611.905850	10	30m	DIRECTLY IMPACTED

ea	Eucalyptus ancophila	498654.541974	6622683.550800	6	25m	OUTSIDE ROAD RESERVE
ea	Eucalyptus ancophila	498584.490443	6622840.717360	5	25m	DIRECTLY IMPACTED
ea	Eucalyptus ancophila	498014.979409	6626228.850630	1	45m	IN SITU WITHIN ROAD RESERVE
gf	Goodenia fordiana	498645.057057	6623095.050150	mat		OUTSIDE ROAD RESERVE
gf	Goodenia fordiana	498008.413738	6626272.991330	mat		DIRECTLY IMPACTED
gf	Goodenia fordiana	497989.696142	6626297.182810	mat		DIRECTLY IMPACTED
gf	Goodenia fordiana	498019.123273	6626308.639270	mat		DIRECTLY IMPACTED
gf	Goodenia fordiana	498017.824042	6626416.315720	mat		DIRECTLY IMPACTED
gf	Goodenia fordiana	498119.372903	6626503.140060	mat		DIRECTLY IMPACTED
gf	Goodenia fordiana	498672.994767	6627368.143990	mat		DIRECTLY IMPACTED
gf	Goodenia fordiana	498740.165666	6627464.008120	mat		DIRECTLY IMPACTED
ml-1	Marsdenia longiloba	497485.537248	6610602.704080	1	small	DIRECTLY IMPACTED
ml-2	Marsdenia longiloba	497468.445578	6610614.520770	1	small	DIRECTLY IMPACTED
ml-3	Marsdenia longiloba	497477.228559	6610618.955580	15	small	DIRECTLY IMPACTED
ml-112	Marsdenia longiloba	497307.547452	6610897.439340	1		OUTSIDE ROAD RESERVE
ml-106	Marsdenia longiloba	497217.461181	6610927.522240	1		OUTSIDE ROAD RESERVE
ml-109	Marsdenia longiloba	497205.154142	6610962.427000	1		OUTSIDE ROAD RESERVE
ml-110	Marsdenia longiloba	497210.424389	6610963.721250	1		OUTSIDE ROAD RESERVE
uml-7	Marsdenia longiloba	497397.718757	6611174.508620	2	0.5	OUTSIDE ROAD RESERVE
uml-8	Marsdenia longiloba	497415.287488	6611175.436340	2	5	INDIRECTLY IMPACTED
ml-123	Marsdenia longiloba	497343.340779	6611474.444920	1		OUTSIDE ROAD RESERVE
ml-119	Marsdenia longiloba	497393.491629	6611482.399180	3		INDIRECTLY IMPACTED
ml-122	Marsdenia longiloba	497357.393480	6611486.084350	3		OUTSIDE ROAD RESERVE
ml-121	Marsdenia longiloba	497357.233304	6611487.931290	4		OUTSIDE ROAD RESERVE
ml-120	Marsdenia longiloba	497362.503737	6611489.594860	2		OUTSIDE ROAD RESERVE
ml-124	Marsdenia longiloba	497349.723490	6611499.565420	3		OUTSIDE ROAD RESERVE
ml-49	Marsdenia longiloba	497496.039690	6612142.718430	1	0.15m	DIRECTLY IMPACTED

ml-46	Marsdenia longiloba	497598.702108	6613063.459720	40	to 5m	DIRECTLY IMPACTED
ml-48	Marsdenia longiloba	497602.055454	6613069.370790	10	to 1.5m	DIRECTLY IMPACTED
ml-47	Marsdenia longiloba	497588.956090	6613070.291360	10	to 1m	INDIRECTLY IMPACTED
ml-45	Marsdenia longiloba	497602.692015	6613080.268090	1	small	DIRECTLY IMPACTED
ml-16	Marsdenia longiloba	500442.890991	6618806.680550	1	0.4m	DIRECTLY IMPACTED
ml-15	Marsdenia longiloba	500426.432922	6618920.638680	1	3.5m	DIRECTLY IMPACTED
ml-14a	Marsdenia longiloba	500409.842004	6620668.210490	2	small	DIRECTLY IMPACTED
ml-14	Marsdenia longiloba	500386.537955	6620686.516890	2	small	DIRECTLY IMPACTED
ml-14b	Marsdenia longiloba	500435.641790	6620740.522920	1	small	DIRECTLY IMPACTED
ml-13a	Marsdenia longiloba	500357.942502	6621267.385270	1	small	OUTSIDE ROAD RESERVE
ml-11	Marsdenia longiloba	499195.302516	6622426.508930	6	small	DIRECTLY IMPACTED
ml-12	Marsdenia longiloba	499214.008854	6622428.172560	1	small	DIRECTLY IMPACTED
ml-13	Marsdenia longiloba	499200.737108	6622446.456410	1	small	DIRECTLY IMPACTED
ml-10	Marsdenia longiloba	498596.651119	6622771.273610	3	0.2m	IN SITU WITHIN ROAD RESERVE
uml-6	Marsdenia longiloba	497772.427480	6625850.919070	1	1	DIRECTLY IMPACTED
ml-17	Marsdenia longiloba	497791.779559	6625851.107730	1	small	DIRECTLY IMPACTED
uml-5	Marsdenia longiloba	497779.939952	6625872.714540	1	1.5	DIRECTLY IMPACTED
ml-18	Marsdenia longiloba	497816.564585	6625875.307700	1	0.1m	DIRECTLY IMPACTED
ml-19	Marsdenia longiloba	497826.637279	6625891.378130	4	0.2m	DIRECTLY IMPACTED
ml-20	Marsdenia longiloba	497827.754605	6625902.460010	1	0.2m	DIRECTLY IMPACTED
ml-21	Marsdenia longiloba	497835.590897	6625905.231990	5	0.2m	DIRECTLY IMPACTED
ml-28	Marsdenia longiloba	498002.652999	6626288.504580	1	small	DIRECTLY IMPACTED
ml-32	Marsdenia longiloba	498104.834883	6626406.357810	1	0.4m	INDIRECTLY IMPACTED
ml-31	Marsdenia longiloba	498004.547702	6626422.038800	1	1.3m	INDIRECTLY IMPACTED
ml-30	Marsdenia longiloba	498005.986444	6626426.102340	2	0.3m	INDIRECTLY IMPACTED
ml-33	Marsdenia longiloba	498121.454487	6626489.842450	1	0.3m	DIRECTLY IMPACTED
ml-34	Marsdenia longiloba	498198.977611	6626789.798790	1	4m	DIRECTLY IMPACTED

unw-9	Niemeyera whitei	497406.818180	6611193.165320	1	7	IN SITU WITHIN ROAD RESERVE
nw-50	Niemeyera whitei	497460.267315	6612110.387950	1	2.5m	IN SITU WITHIN ROAD RESERVE
utw-10	Tylophora woollsii	497407.934163	6611201.661690	4	1	IN SITU WITHIN ROAD RESERVE
tw-9a	Tylophora woollsii	498593.927600	6622812.829640	1	0.5m	DIRECTLY IMPACTED
utw-3	Tylophora woollsii	497745.864037	6625919.435150	2	1.3	IN SITU WITHIN ROAD RESERVE
utw-4	Tylophora woollsii	497740.905756	6625920.726980	3	0.4	IN SITU WITHIN ROAD RESERVE
utw-1	Tylophora woollsii	497840.222513	6625937.923800	1	1.4	DIRECTLY IMPACTED
utw-2	Tylophora woollsii	497841.820182	6625946.420060	5	0.5	DIRECTLY IMPACTED
tw-29	Tylophora woollsii	497970.168547	6626375.858880	1	0.3m	IN SITU WITHIN ROAD RESERVE

Table 2: Impact Analysis of threatened flora data recorded by EcoPro (2010) overlaid on the highway concept design

SPECIES	EASTING	NORTHING	IMPACTED
Slender Marsdenia	500412.655032	6620861.763829	DIRECTLY IMPACTED
Slender Marsdenia	500365.488803	6620960.403751	DIRECTLY IMPACTED
Spider Orchids	498943.121891	6622574.465214	DIRECTLY IMPACTED
Spider Orchids	496635.580000	6609457.970000	DIRECTLY IMPACTED
Spider Orchids	496639.630000	6609426.260000	DIRECTLY IMPACTED
Spider Orchids	498903.212004	6622587.312599	DIRECTLY IMPACTED
Spider Orchids	498898.412923	6622585.542959	DIRECTLY IMPACTED
Spider Orchids	498899.946650	6622585.542959	DIRECTLY IMPACTED
Spider Orchids	498896.780246	6622574.465214	DIRECTLY IMPACTED

Spider Orchids	498938.322809	6622561.497853	DIRECTLY IMPACTED
Spider Orchids	498944.746322	6622570.695981	DIRECTLY IMPACTED
Spider Orchids	498584.963644	6622899.449064	DIRECTLY IMPACTED
Arthrochilus	499558.731888	6622149.631687	DIRECTLY IMPACTED
Spider Orchids	498962.301725	6622589.202214	IN SITU WITHIN ROAD RESERVE
Slender Marsdenia	498762.875980	6622715.976409	IN SITU WITHIN ROAD RESERVE
Slender Marsdenia	498763.420206	6622724.784617	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498036.000000	6626200.000000	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498843.790000	6627493.210000	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498863.194922	6622659.337938	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498880.758570	6622646.490553	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498885.549406	6622642.721320	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498888.814760	6622640.951680	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498882.391247	6622635.412808	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498880.758570	6622633.523193	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498884.015679	6622629.863937	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498884.015679	6622627.984320	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498885.557652	6622624.325065	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498891.981164	6622624.325065	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498891.981164	6622627.984320	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498890.348487	6622629.863937	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498891.981164	6622618.786192	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498908.002840	6622613.247320	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498914.335648	6622611.367702	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498915.968325	6622616.906575	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498917.592757	6622618.786192	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498917.592757	6622618.786192	IN SITU WITHIN ROAD RESERVE

Spider Orchids	498919.134730	6622616.906575	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498951.178081	6622589.202214	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498951.178081	6622591.091829	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498955.968916	6622592.861469	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498955.968916	6622592.861469	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498954.344485	6622592.861469	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498952.711808	6622592.861469	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498951.178081	6622591.091829	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498947.912726	6622592.861469	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498946.378999	6622592.861469	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498946.378999	6622592.861469	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498952.711808	6622591.091829	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498952.711808	6622591.091829	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498954.344485	6622594.741087	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498967.100806	6622594.751084	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498952.711808	6622598.400342	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498949.545403	6622596.630702	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498947.912726	6622596.630702	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498946.378999	6622596.630702	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498946.378999	6622594.741087	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498944.746322	6622605.828830	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498939.947241	6622603.939214	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498938.322809	6622600.289957	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498936.780836	6622602.169574	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498933.523728	6622602.169574	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498944.746322	6622603.939214	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498911.169244	6622616.906575	IN SITU WITHIN ROAD RESERVE

Spider Orchids	498914.335648	6622613.247320	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498909.536567	6622616.906575	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498906.370163	6622618.786192	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498904.737486	6622618.786192	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498903.203758	6622622.445447	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498891.981164	6622626.104703	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498890.348487	6622626.104703	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498888.814760	6622626.104703	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498888.814760	6622627.984320	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498888.814760	6622627.984320	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498887.182083	6622629.863937	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498887.182083	6622629.863937	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498887.182083	6622627.984320	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498887.182083	6622629.863937	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498885.557652	6622627.984320	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498882.391247	6622627.984320	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498600.985319	6622906.877552	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498578.523639	6622954.857786	IN SITU WITHIN ROAD RESERVE
Spider Orchids	497671.126195	6612053.876649	IN SITU WITHIN ROAD RESERVE
Spider Orchids	497669.493518	6612053.876649	IN SITU WITHIN ROAD RESERVE
Spider Orchids	497677.549708	6612046.568137	IN SITU WITHIN ROAD RESERVE
Spider Orchids	496064.044126	6608287.453294	IN SITU WITHIN ROAD RESERVE
Spider Orchids	498888.814760	6622618.786192	INDIRECTLY IMPACTED
Spider Orchids	498896.780246	6622613.247320	INDIRECTLY IMPACTED
Spider Orchids	498898.412923	6622613.247320	INDIRECTLY IMPACTED
Spider Orchids	498901.579327	6622611.367702	INDIRECTLY IMPACTED
Spider Orchids	498946.378999	6622589.202214	INDIRECTLY IMPACTED

Spider Orchids	498947.912726	6622589.202214	INDIRECTLY IMPACTED
Spider Orchids	498944.746322	6622589.202214	INDIRECTLY IMPACTED
Spider Orchids	498930.357324	6622592.861469	INDIRECTLY IMPACTED
Spider Orchids	498904.745731	6622607.708447	INDIRECTLY IMPACTED
Spider Orchids	498906.370163	6622605.818832	INDIRECTLY IMPACTED
Spider Orchids	498970.366160	6622578.124469	INDIRECTLY IMPACTED
Spider Orchids	499013.533155	6622552.309723	INDIRECTLY IMPACTED
Spider Orchids	498979.956077	6622563.387468	INDIRECTLY IMPACTED
Spider Orchids	498596.186238	6622904.987937	INDIRECTLY IMPACTED
Spider Orchids	498591.387156	6622897.569447	INDIRECTLY IMPACTED
Arthrochilus	499456.376223	6622173.676793	INDIRECTLY IMPACTED
Giant Climbing Orchid	496119.901475	6608278.275162	INDIRECTLY IMPACTED
Spider Orchids	498899.930158	6622762.846869	OUTSIDE ROAD RESERVE
Spider Orchids	498888.790023	6622864.356207	OUTSIDE ROAD RESERVE
Spider Orchids	498941.571672	6622720.295530	OUTSIDE ROAD RESERVE
Spider Orchids	498909.511829	6622890.290928	OUTSIDE ROAD RESERVE
Spider Orchids	498928.716401	6622696.360402	OUTSIDE ROAD RESERVE
Spider Orchids	498928.716401	6622696.360402	OUTSIDE ROAD RESERVE
Spider Orchids	498941.563426	6622773.934612	OUTSIDE ROAD RESERVE
Spider Orchids	498978.306908	6622775.714250	OUTSIDE ROAD RESERVE
Spider Orchids	498965.550587	6622772.054995	OUTSIDE ROAD RESERVE
Spider Orchids	498949.528912	6622753.548762	OUTSIDE ROAD RESERVE
Spider Orchids	498944.738076	6622733.262891	OUTSIDE ROAD RESERVE
Spider Orchids	498960.767998	6622637.192446	OUTSIDE ROAD RESERVE
Spider Orchids	498975.156996	6622615.026957	OUTSIDE ROAD RESERVE
Spider Orchids	498989.545994	6622602.169574	OUTSIDE ROAD RESERVE

Spider Orchids	498931.973509	6622744.350634	OUTSIDE ROAD RESERVE
Spider Orchids	498960.751506	6622786.791995	OUTSIDE ROAD RESERVE
Spider Orchids	498927.182674	6622696.360402	OUTSIDE ROAD RESERVE
Spider Orchids	498907.986348	6622772.044997	OUTSIDE ROAD RESERVE
Spider Orchids	498949.537158	6622675.974552	OUTSIDE ROAD RESERVE
Spider Orchids	498688.844790	6623028.782739	OUTSIDE ROAD RESERVE
Spider Orchids	498688.844790	6623025.023504	OUTSIDE ROAD RESERVE
Spider Orchids	498688.844790	6623034.331609	OUTSIDE ROAD RESERVE
Spider Orchids	498693.643872	6623036.101249	OUTSIDE ROAD RESERVE
Spider Orchids	498637.712310	6623037.980866	OUTSIDE ROAD RESERVE
Spider Orchids	498640.870468	6623041.640122	OUTSIDE ROAD RESERVE
Spider Orchids	498631.280551	6623025.013506	OUTSIDE ROAD RESERVE
Spider Orchids	498631.280551	6623026.893123	OUTSIDE ROAD RESERVE
Spider Orchids	498909.520075	6622770.165379	OUTSIDE ROAD RESERVE
Spider Orchids	498901.562835	6622775.704252	OUTSIDE ROAD RESERVE
Spider Orchids	498621.690634	6623041.630124	OUTSIDE ROAD RESERVE
Spider Orchids	498911.152752	6622768.395740	OUTSIDE ROAD RESERVE
Spider Orchids	498912.785430	6622766.506124	OUTSIDE ROAD RESERVE
Spider Orchids	498915.951834	6622768.395740	OUTSIDE ROAD RESERVE
Spider Orchids	498909.520075	6622777.593867	OUTSIDE ROAD RESERVE
Spider Orchids	498907.986348	6622785.012357	OUTSIDE ROAD RESERVE
Spider Orchids	498620.148661	6623045.399356	OUTSIDE ROAD RESERVE
Spider Orchids	498907.986348	6622783.132740	OUTSIDE ROAD RESERVE
Spider Orchids	498917.576265	6622799.749358	OUTSIDE ROAD RESERVE
Spider Orchids	498920.742669	6622796.100100	OUTSIDE ROAD RESERVE
Spider Orchids	498919.109992	6622797.869740	OUTSIDE ROAD RESERVE
Spider Orchids	498987.913317	6622666.776424	OUTSIDE ROAD RESERVE

Spider Orchids	498975.148750	6622661.237551	OUTSIDE ROAD RESERVE
Spider Orchids	498973.524319	6622657.578296	OUTSIDE ROAD RESERVE
Spider Orchids	498970.357914	6622653.809063	OUTSIDE ROAD RESERVE
Spider Orchids	498971.891641	6622653.809063	OUTSIDE ROAD RESERVE
Spider Orchids	498970.357914	6622653.809063	OUTSIDE ROAD RESERVE
Spider Orchids	498621.682388	6623049.058611	OUTSIDE ROAD RESERVE
Spider Orchids	498967.092560	6622653.809063	OUTSIDE ROAD RESERVE
Spider Orchids	498967.092560	6622657.578296	OUTSIDE ROAD RESERVE
Spider Orchids	498967.092560	6622663.117169	OUTSIDE ROAD RESERVE
Spider Orchids	498968.725237	6622663.117169	OUTSIDE ROAD RESERVE
Spider Orchids	498973.524319	6622664.896807	OUTSIDE ROAD RESERVE
Spider Orchids	498970.357914	6622659.357934	OUTSIDE ROAD RESERVE
Spider Orchids	498970.357914	6622659.357934	OUTSIDE ROAD RESERVE
Spider Orchids	498970.357914	6622659.357934	OUTSIDE ROAD RESERVE
Spider Orchids	498970.357914	6622659.357934	OUTSIDE ROAD RESERVE
Spider Orchids	498626.481470	6623050.938229	OUTSIDE ROAD RESERVE
Spider Orchids	498970.357914	6622659.357934	OUTSIDE ROAD RESERVE
Spider Orchids	498963.926156	6622668.666039	OUTSIDE ROAD RESERVE
Spider Orchids	498962.293479	6622666.776424	OUTSIDE ROAD RESERVE
Spider Orchids	498963.926156	6622670.435679	OUTSIDE ROAD RESERVE
Spider Orchids	498963.926156	6622668.666039	OUTSIDE ROAD RESERVE
Spider Orchids	498962.293479	6622670.435679	OUTSIDE ROAD RESERVE
Spider Orchids	498962.293479	6622670.435679	OUTSIDE ROAD RESERVE
Spider Orchids	498963.926156	6622670.435679	OUTSIDE ROAD RESERVE
Spider Orchids	498963.926156	6622668.666039	OUTSIDE ROAD RESERVE
Spider Orchids	498962.293479	6622668.666039	OUTSIDE ROAD RESERVE
Spider Orchids	498616.891553	6623036.091251	OUTSIDE ROAD RESERVE

Spider Orchids	498962.293479	6622670.435679	OUTSIDE ROAD RESERVE
Spider Orchids	498962.293479	6622670.435679	OUTSIDE ROAD RESERVE
Spider Orchids	498965.558833	6622675.974552	OUTSIDE ROAD RESERVE
Spider Orchids	498965.558833	6622677.864167	OUTSIDE ROAD RESERVE
Spider Orchids	498967.092560	6622677.864167	OUTSIDE ROAD RESERVE
Spider Orchids	498965.558833	6622677.864167	OUTSIDE ROAD RESERVE
Spider Orchids	498963.926156	6622675.974552	OUTSIDE ROAD RESERVE
Spider Orchids	498962.293479	6622675.974552	OUTSIDE ROAD RESERVE
Spider Orchids	498960.759752	6622674.204912	OUTSIDE ROAD RESERVE
Spider Orchids	498960.759752	6622675.974552	OUTSIDE ROAD RESERVE
Spider Orchids	498644.127577	6623100.808078	OUTSIDE ROAD RESERVE
Spider Orchids	498960.759752	6622674.204912	OUTSIDE ROAD RESERVE
Spider Orchids	498955.960670	6622674.204912	OUTSIDE ROAD RESERVE
Spider Orchids	498955.960670	6622674.204912	OUTSIDE ROAD RESERVE
Spider Orchids	498955.960670	6622670.435679	OUTSIDE ROAD RESERVE
Spider Orchids	498951.169835	6622677.854169	OUTSIDE ROAD RESERVE
Spider Orchids	498952.703562	6622674.204912	OUTSIDE ROAD RESERVE
Spider Orchids	498955.960670	6622679.743784	OUTSIDE ROAD RESERVE
Spider Orchids	498963.926156	6622681.513424	OUTSIDE ROAD RESERVE
Spider Orchids	498967.092560	6622679.743784	OUTSIDE ROAD RESERVE
Spider Orchids	498957.494397	6622687.052297	OUTSIDE ROAD RESERVE
Spider Orchids	498645.669549	6623087.850715	OUTSIDE ROAD RESERVE
Spider Orchids	498959.127075	6622685.282657	OUTSIDE ROAD RESERVE
Spider Orchids	498959.127075	6622687.052297	OUTSIDE ROAD RESERVE
Spider Orchids	498952.703562	6622685.282657	OUTSIDE ROAD RESERVE
Spider Orchids	498954.327993	6622687.052297	OUTSIDE ROAD RESERVE
Spider Orchids	498954.327993	6622683.403040	OUTSIDE ROAD RESERVE

Spider Orchids	498952.703562	6622685.282657	OUTSIDE ROAD RESERVE
Spider Orchids	498952.703562	6622679.743784	OUTSIDE ROAD RESERVE
Spider Orchids	498952.703562	6622679.743784	OUTSIDE ROAD RESERVE
Spider Orchids	498955.960670	6622675.974552	OUTSIDE ROAD RESERVE
Spider Orchids	498952.703562	6622675.974552	OUTSIDE ROAD RESERVE
Spider Orchids	498947.904480	6622675.974552	OUTSIDE ROAD RESERVE
Spider Orchids	498947.904480	6622675.974552	OUTSIDE ROAD RESERVE
Spider Orchids	498647.293981	6623117.434694	OUTSIDE ROAD RESERVE
Spider Orchids	498946.370753	6622674.204912	OUTSIDE ROAD RESERVE
Spider Orchids	498951.169835	6622679.743784	OUTSIDE ROAD RESERVE
Spider Orchids	498951.169835	6622681.513424	OUTSIDE ROAD RESERVE
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Spider Orchids	498951.169835	6622685.282657	OUTSIDE ROAD RESERVE
Spider Orchids	498949.537158	6622685.282657	OUTSIDE ROAD RESERVE
Spider Orchids	498949.537158	6622688.941912	OUTSIDE ROAD RESERVE
Spider Orchids	498951.169835	6622687.052297	OUTSIDE ROAD RESERVE
Spider Orchids	498952.703562	6622688.941912	OUTSIDE ROAD RESERVE
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Spider Orchids	498647.293981	6623117.434694	OUTSIDE ROAD RESERVE
Spider Orchids	498960.759752	6622690.821530	OUTSIDE ROAD RESERVE
Spider Orchids	498967.092560	6622692.601167	OUTSIDE ROAD RESERVE
Spider Orchids	498954.327993	6622687.052297	OUTSIDE ROAD RESERVE
Spider Orchids	498947.904480	6622683.403040	OUTSIDE ROAD RESERVE
Spider Orchids	498944.738076	6622683.403040	OUTSIDE ROAD RESERVE
Spider Orchids	498943.105399	6622687.052297	OUTSIDE ROAD RESERVE
Spider Orchids	498941.571672	6622685.282657	OUTSIDE ROAD RESERVE
Spider Orchids	498610.558744	6623065.675229	OUTSIDE ROAD RESERVE

Spider Orchids	498939.938995	6622683.393042	OUTSIDE ROAD RESERVE
Spider Orchids	498938.314564	6622687.052297	OUTSIDE ROAD RESERVE
Spider Orchids	498938.314564	6622685.282657	OUTSIDE ROAD RESERVE
Spider Orchids	498936.772591	6622685.282657	OUTSIDE ROAD RESERVE
Spider Orchids	498941.571672	6622709.217785	OUTSIDE ROAD RESERVE
Spider Orchids	498931.981755	6622677.854169	OUTSIDE ROAD RESERVE
Spider Orchids	498973.524319	6622664.896807	OUTSIDE ROAD RESERVE
Spider Orchids	498871.152162	6622736.912148	OUTSIDE ROAD RESERVE
Spider Orchids	498880.742079	6622772.044997	OUTSIDE ROAD RESERVE
Spider Orchids	498880.742079	6622759.077636	OUTSIDE ROAD RESERVE
Spider Orchids	498880.742079	6622759.077636	OUTSIDE ROAD RESERVE
Spider Orchids	498885.541160	6622757.307996	OUTSIDE ROAD RESERVE
Spider Orchids	498887.173837	6622759.077636	OUTSIDE ROAD RESERVE
Spider Orchids	498885.541160	6622757.307996	OUTSIDE ROAD RESERVE
Spider Orchids	498885.541160	6622759.077636	OUTSIDE ROAD RESERVE
Spider Orchids	498890.340241	6622759.077636	OUTSIDE ROAD RESERVE
Spider Orchids	498890.340241	6622760.967252	OUTSIDE ROAD RESERVE
Spider Orchids	498891.964673	6622760.967252	OUTSIDE ROAD RESERVE
Spider Orchids	498890.340241	6622760.967252	OUTSIDE ROAD RESERVE
Spider Orchids	498893.597350	6622762.846869	OUTSIDE ROAD RESERVE
Spider Orchids	498879.208352	6622755.418381	OUTSIDE ROAD RESERVE
Spider Orchids	498879.208352	6622755.418381	OUTSIDE ROAD RESERVE
Spider Orchids	498879.208352	6622751.769124	OUTSIDE ROAD RESERVE
Spider Orchids	498875.951243	6622747.999891	OUTSIDE ROAD RESERVE
Spider Orchids	498885.541160	6622735.142508	OUTSIDE ROAD RESERVE
Spider Orchids	498887.173837	6622733.262891	OUTSIDE ROAD RESERVE
Spider Orchids	498887.173837	6622729.603636	OUTSIDE ROAD RESERVE

Spider Orchids	498891.972919	6622718.525890	OUTSIDE ROAD RESERVE
Spider Orchids	498890.340241	6622720.295530	OUTSIDE ROAD RESERVE
Spider Orchids	498879.216597	6622707.438147	OUTSIDE ROAD RESERVE
Spider Orchids	498879.216597	6622705.558530	OUTSIDE ROAD RESERVE
Spider Orchids	498874.417516	6622703.668915	OUTSIDE ROAD RESERVE
Spider Orchids	498869.618435	6622700.009659	OUTSIDE ROAD RESERVE
Spider Orchids	498860.028518	6622690.811532	OUTSIDE ROAD RESERVE
Spider Orchids	498864.827599	6622688.931914	OUTSIDE ROAD RESERVE
Spider Orchids	498866.361326	6622675.964554	OUTSIDE ROAD RESERVE
Spider Orchids	498869.626681	6622675.964554	OUTSIDE ROAD RESERVE
Spider Orchids	498871.160408	6622675.964554	OUTSIDE ROAD RESERVE
Spider Orchids	498877.583920	6622679.733786	OUTSIDE ROAD RESERVE
Spider Orchids	498880.750324	6622672.305299	OUTSIDE ROAD RESERVE
Spider Orchids	498880.750324	6622672.305299	OUTSIDE ROAD RESERVE
Spider Orchids	498884.015679	6622677.854169	OUTSIDE ROAD RESERVE
Spider Orchids	498885.549406	6622681.513424	OUTSIDE ROAD RESERVE
Spider Orchids	498888.806514	6622679.733786	OUTSIDE ROAD RESERVE
Spider Orchids	498888.806514	6622677.854169	OUTSIDE ROAD RESERVE
Spider Orchids	498890.348487	6622675.964554	OUTSIDE ROAD RESERVE
Spider Orchids	498891.972919	6622679.733786	OUTSIDE ROAD RESERVE
Spider Orchids	498891.972919	6622677.854169	OUTSIDE ROAD RESERVE
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APPENDIX 3: PLANS SHOWING THE DISTRIBUTION OF THREATENED AND RARE SPECIES on the whole WC2U road corridor

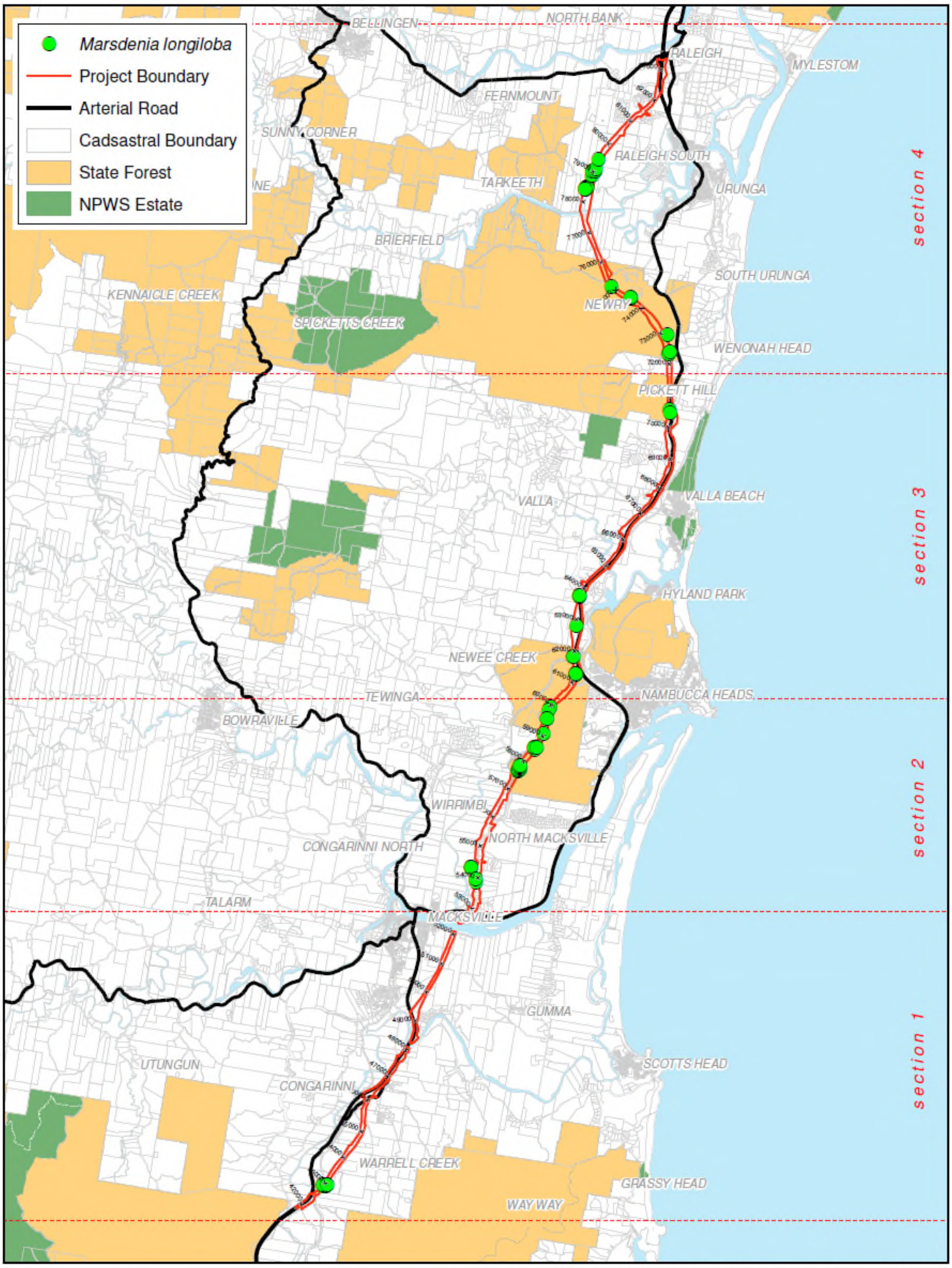

Figure 12: Distribution of Slender Marsdenia (Marsdenia longiloba) on the WC2U road corridor recorded during the 2011 targeted flora survey.

Cadastre: Roads and Traffic Authority 2007
Flora Survey: ECOS December 2011/ February 2012
Roads: Geoscience Australia 2009
Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW Department of Primary Industries 2008

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Kilometers
A4 Scale 1:150,000

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File: Figure_12_RTA_Grafton_Flora_Survey_Species_Distribution
Date: 10-03-2012

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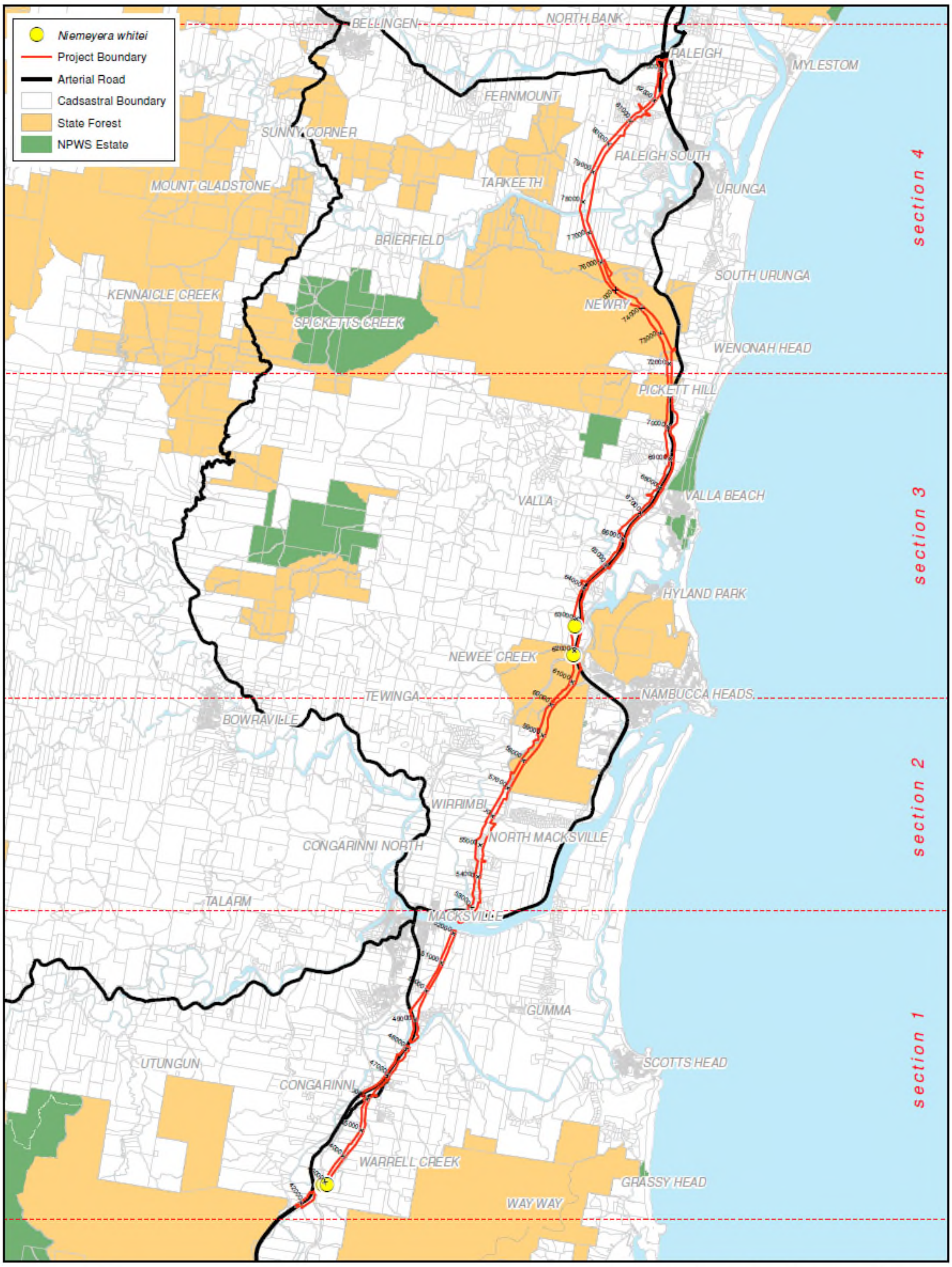

Figure 13: Distribution of Rusty Plum (Niemeyera whitei) on the WC2U road corridor recorded during the 2011 targeted flora survey.

Cadastre: Roads and Traffic Authority 2007
Flora Survey: ECOS December 2011/ February 2012
Roads: Geoscience Australia 2009
Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW Department of Primary Industries 2008

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File: Figure_13_RTA_Grafton_Flora_Survey_Species_Distribution
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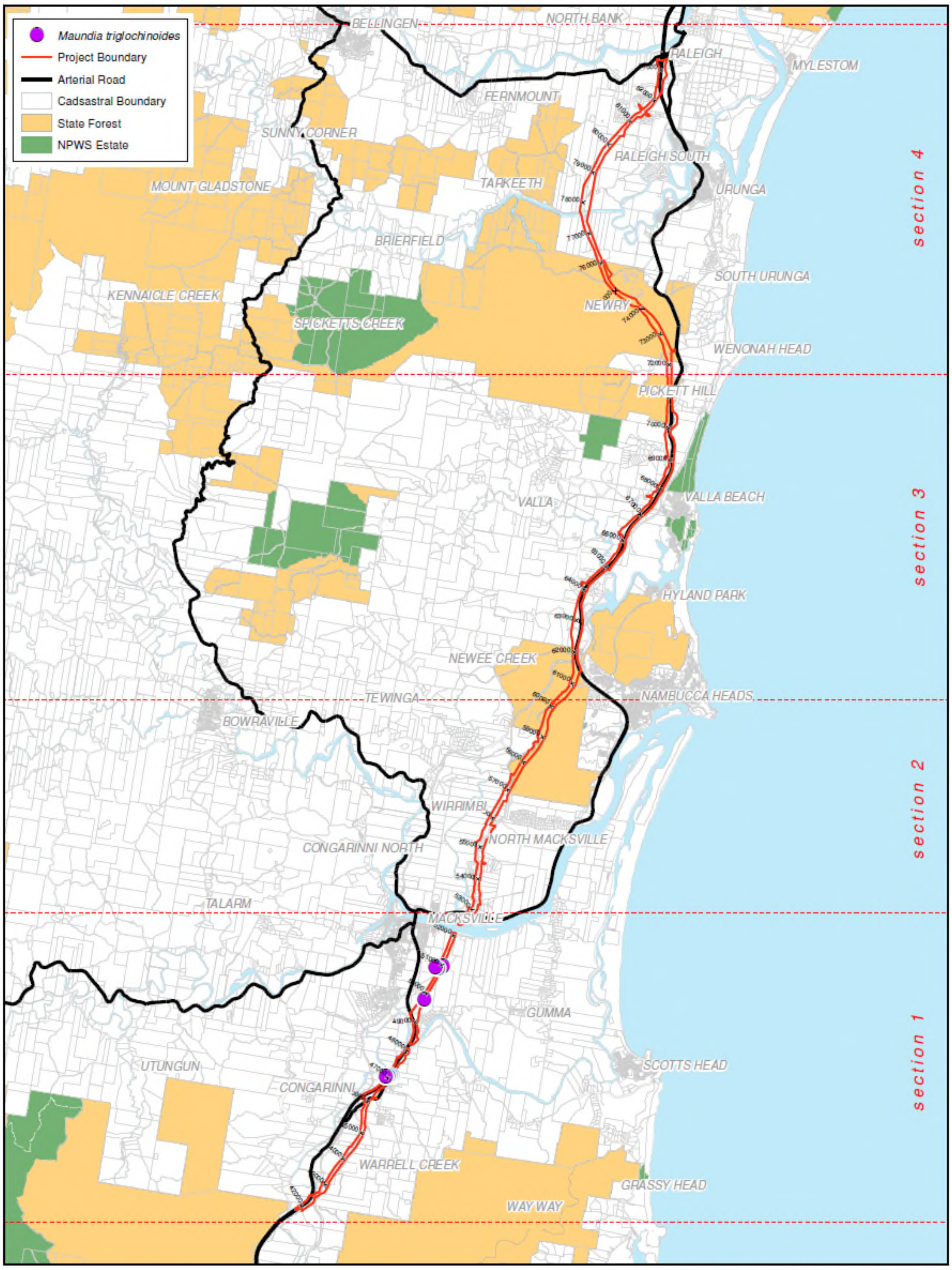

Figure 15: Distribution of Maundia (Maundia triglochinoides) on the WC2U road corridor recorded during the 2011 targeted flora survey.

Source:
Cadastre: Roads and Traffic Authority 2007
Flora Survey: ECOS December 2011
Roads: Geoscience Australia 2009
Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW Department of Primary Industries 2008

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0 2 4 6 8
Kilometers
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File: Figure_15_RTA_Grafton_Flora_Survey_Species_Distribution
Date: 25-01-2012

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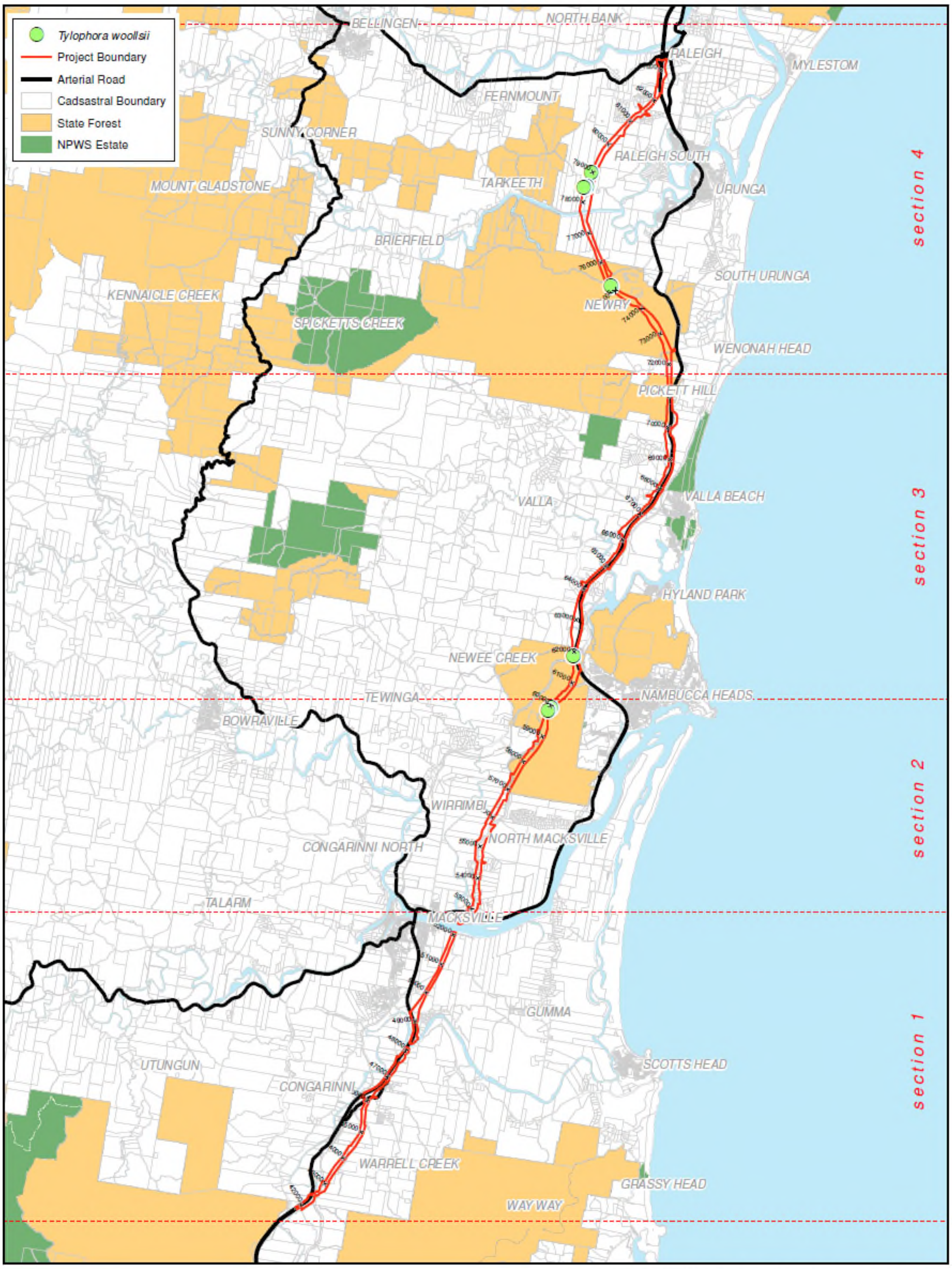

Figure 16: Distribution of Wooll's Tylophora (Tylophora woollsii) on the WC2U road corridor recorded during the 2011 targeted flora survey.

Cadastre: Roads and Traffic Authority 2007; Flora Survey: ECOS December 2011/February 2012; Roads: Geoscience Australia 2009; Highway Design (footprint): RTA 2011; Project Boundary: RTA 2011; Drainage: Geoscience Australia 2009; State Forests: NSW Department of Primary Industries 2008

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0 2 4 6 8 Kilometers

A4 Scale 1:150,000

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File: Figure_16_RTA_Grafton_Flora_Survey_Species_Distribution Date: 10-03-2012

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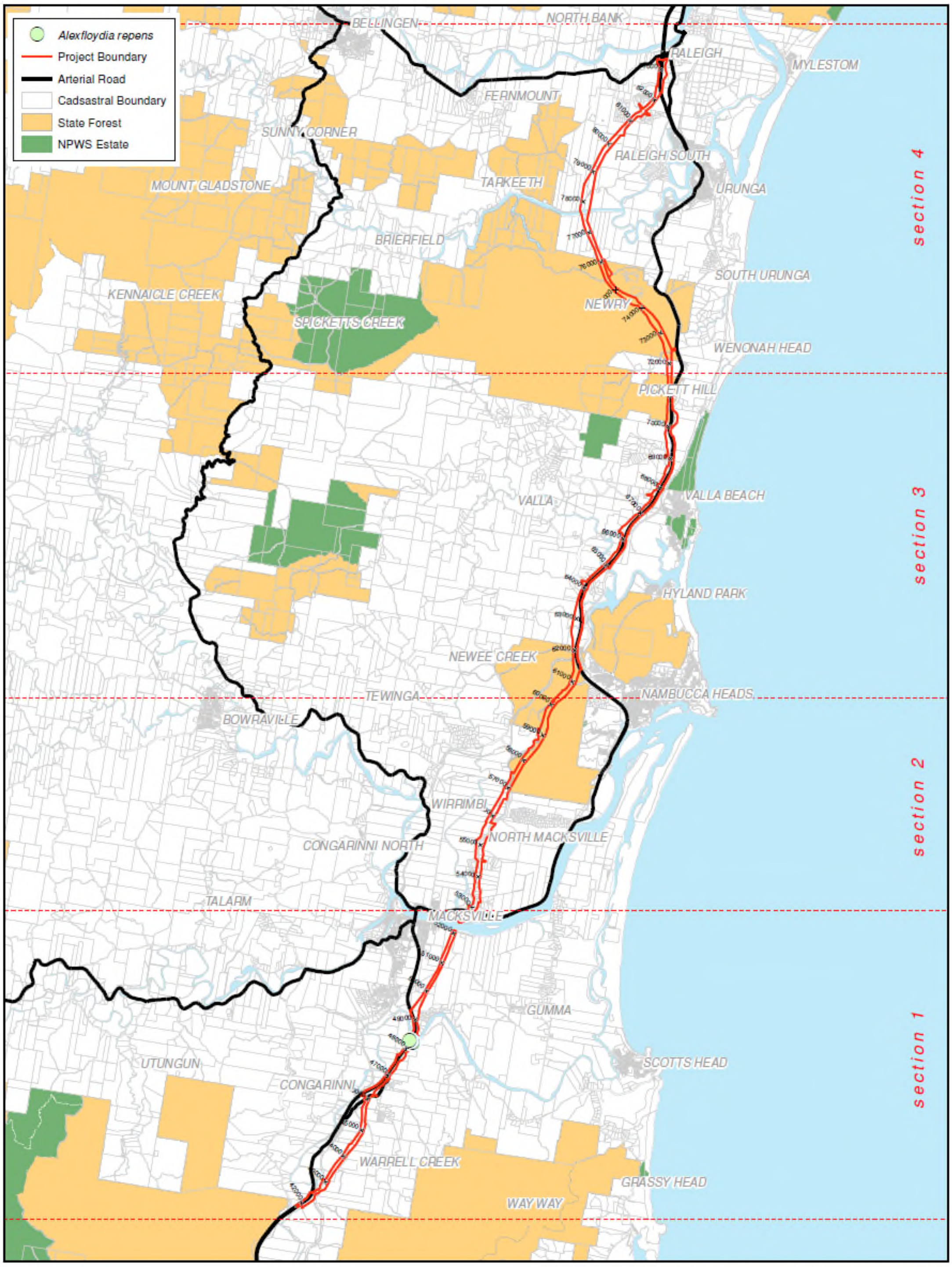

Figure 17: Distribution of Floyds Grass (Alexfloydia repens) on the WC2U road corridor recorded during the 2011 targeted flora survey.

Source:
Cadastre: Roads and Traffic Authority 2007
Flora Survey: ECOS December 2011
Roads: Geoscience Australia 2009
Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW Department of Primary Industries 2008

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0 2 4 6 8
Kilometers
A4 Scale 1:150,000

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File: Figure_17_RTA_Grafton_Flora_Survey_Species_Distribution
Date: 25-01-2012

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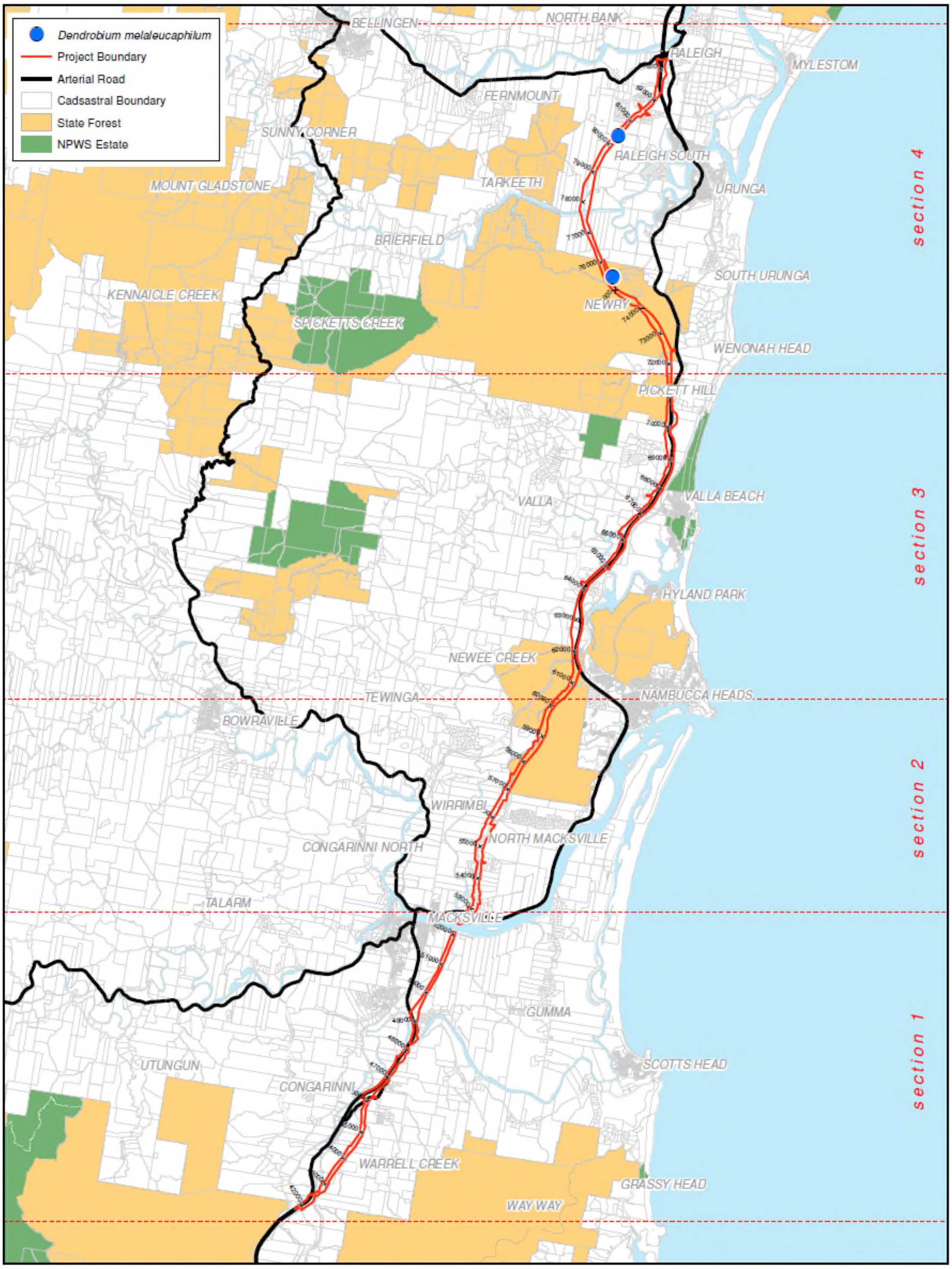

Figure 18: Distribution of Spider Orchid (Dendrobium melaleucaphilum) on the WC2U road corridor recorded during the 2011 targeted flora survey.

Source:
Cadastre: Roads and Traffic Authority 2007
Flora Survey: ECOS December 2011
Roads: Geoscience Australia 2009
Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW Department of Primary Industries 2008

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0 2 4 6 8
Kilometers
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File: Figure_18_RTA_Grafton_Flora_Survey_Species_Distribution Date: 25-01-2012

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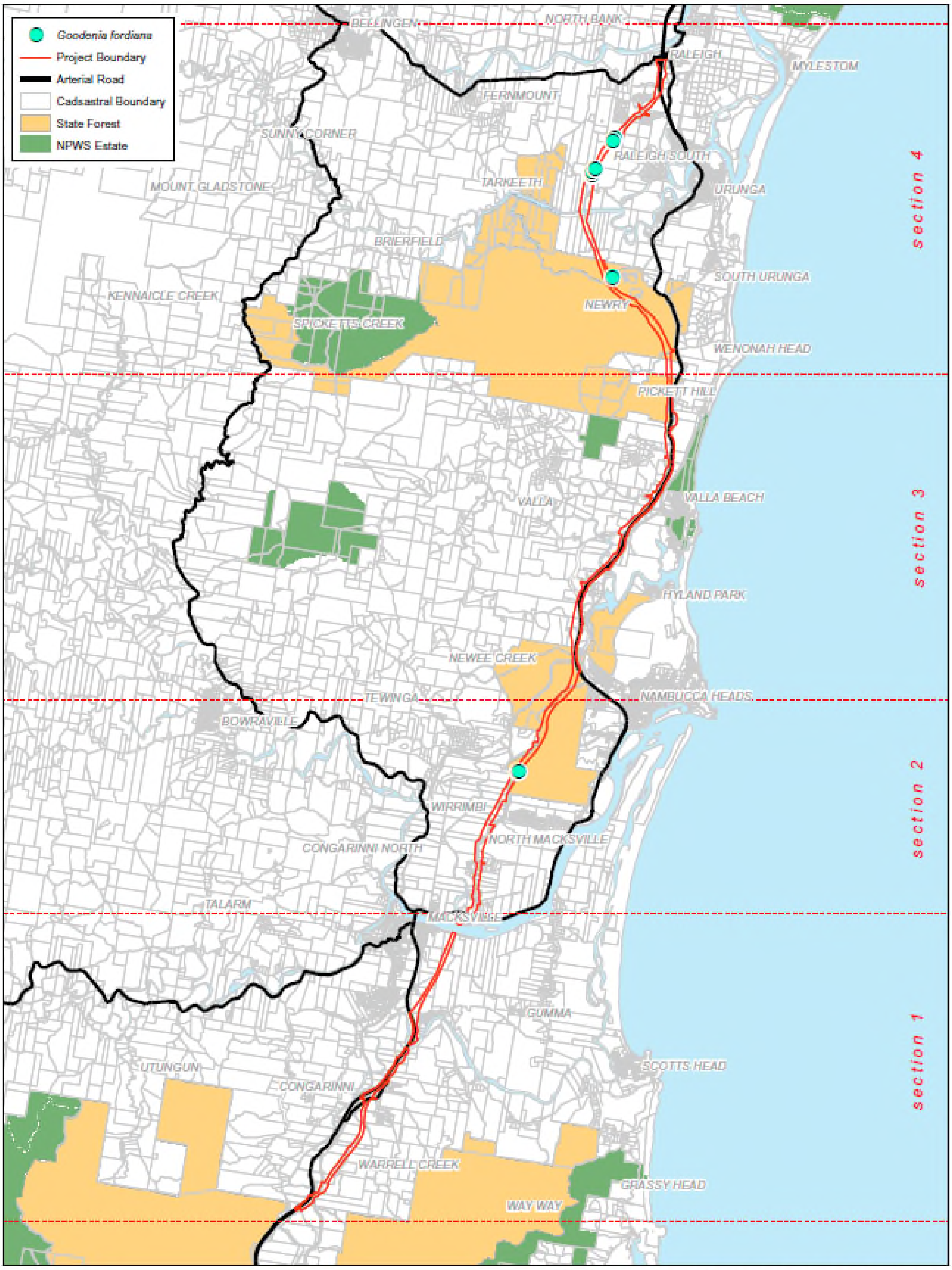

Figure 19: Distribution of Ford's Goodenia (Goodenia fordiana) on the WC2U road corridor recorded during the 2011 targeted flora survey.

Source:
Cadastre: Roads and Traffic Authority 2007
Flora Survey: ECOS December 2011
Roads: Geoscience Australia 2009
Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW Department of Primary Industries 2008

0 2 4 6 8
Kilometers
A4 Scale 1:150,000

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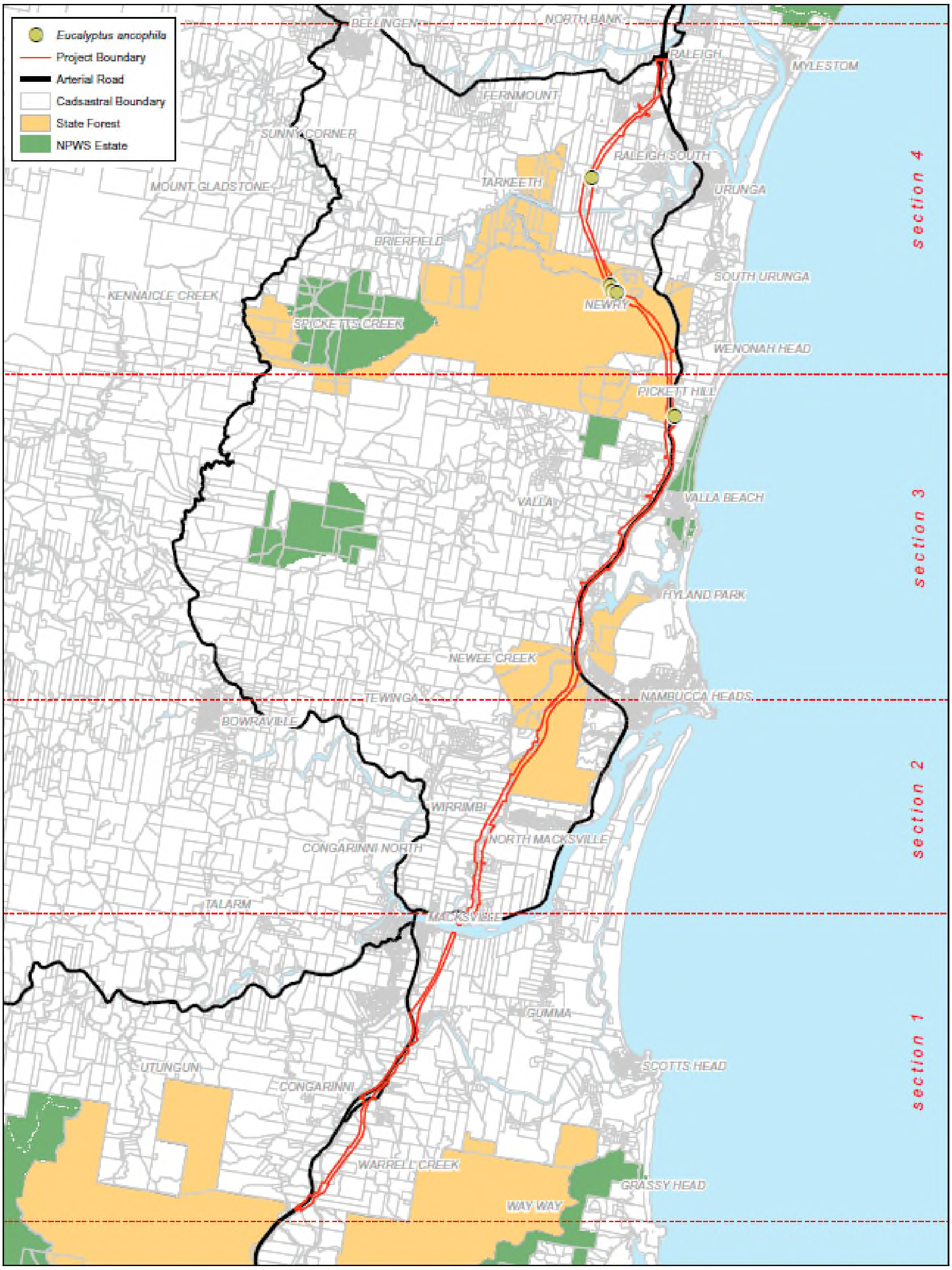

Figure 20: Distribution of Bellingen Ironbark (Eucalyptus ancophila) on the WC2U road corridor recorded during the 2011 targeted flora survey.

Source:
Cadastre: Roads and Traffic Authority 200?
Flora Survey: ECOS December 2011
Roads: Geoscience Australia 2009
Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW Department of Primary Industries 2008

0 2 4 6 8
Kilometres
A4 Scale 1:150,000

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GEOVIEW

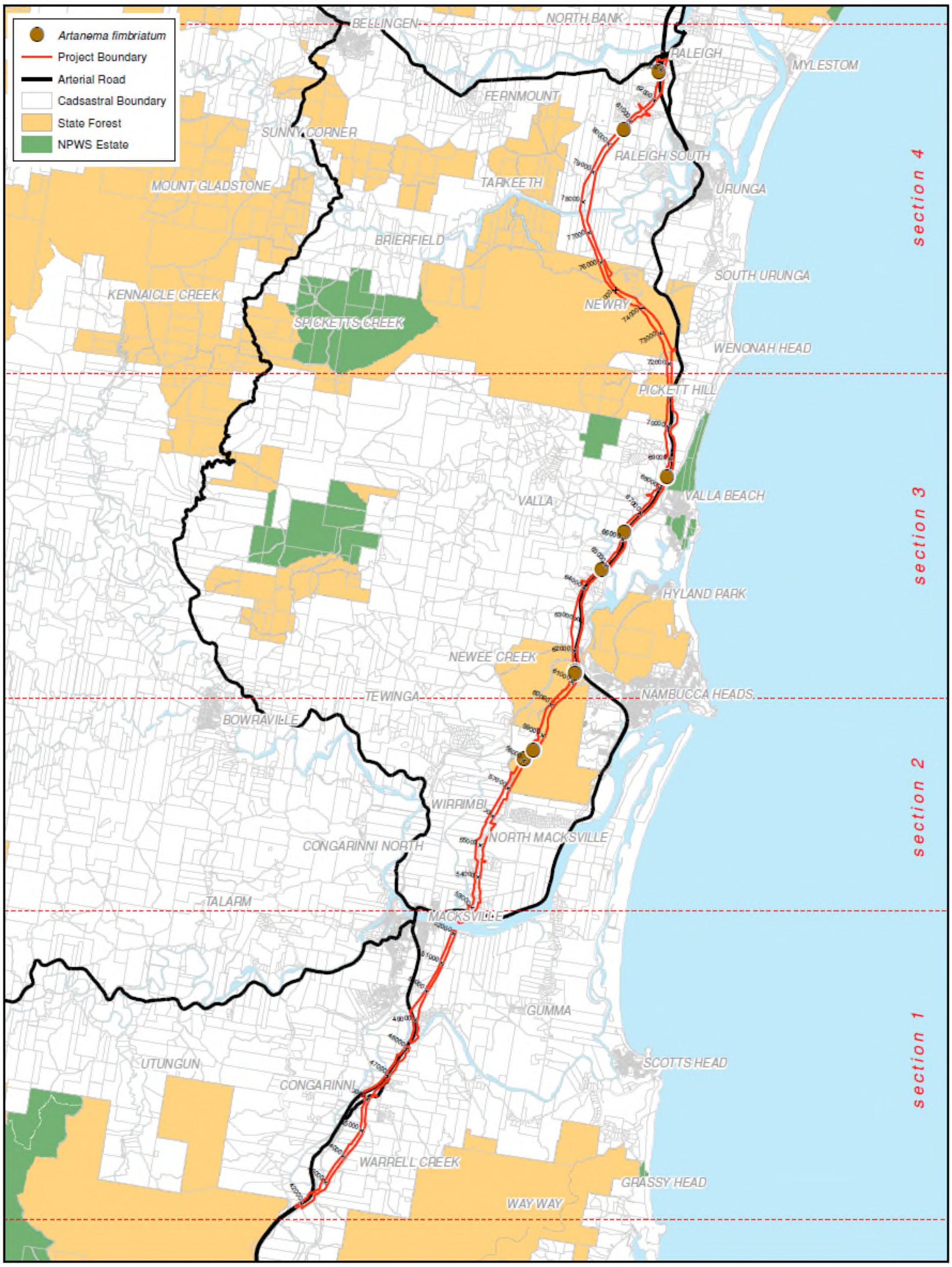

Figure 21: Distribution of Koala Bells (Artanema fimbriatum) on the WC2U road corridor recorded during the 2011 targeted flora survey.

Source:
Cadastre: Roads and Traffic Authority 2007
Flora Survey: ECOS December 2011
Roads: Geoscience Australia 2009
Highway Design (footprint): RTA 2011
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW Department of Primary Industries 2008

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0 2 4 6 8
Kilometers
A4 Scale 1:150,000

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File: Figure_21_RTA_Grafton_Flora_Survey_Species_Distribution
Date: 25-01-2012

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APPENDIX 4: THREATENED SPECIES QUADRATS

Quadrat 1
***Niemeyera whitei* (Rusty Plum) – TSC Act Vulnerable**

Location: Warrell Creek
NW-50
Vegetation Type: wet sclerophyll forest with well developed rainforest understorey.
Substrate: red clay loam on hornfels
Slope Aspect: south
Slope Angle: moderate
Disturbance history: logged 30-40 years ago; fire 50-100 years ago
Condition: good
Quadrat Size: 20m x 50m

Stratum	Height (m)	Crown Cover (%)	Species 1	Species 2	Species 3
Upper 2	20-40	50	*Eucalptus grandis*		
Upper 1	6-18	70	*Pouteria australis*	*Cissus hypoglauca*	*Alphitonia excelsa*
Mid	1-6	80	*Wilkea huegeliana*	*Lantana camara*	*Rubus moluccanus*
Lower	0-1	40	*Blechnum cartilagineum*	*Lomandra spicata*	*Lastreopsis decomposita*

Species (* exotic species)	Growth-form	Cover-abundance Class
Pouteria australis	T	3
Blechnum cartilagineum	F	3
Cryptocarya microneura	T	2
Wilkea huegeliana	S	2
Morinda jasminoides	V	3
Stenocarpus salignus	T	1
Cryptocarya rigida	T	2
Flagellaria indica	V	2
Pittosporum multiflorum	S	1
Endiandra muelleri ssp. muelleri	T	2
Lomandra spicata	H	3
Melicope micrococca	T	1
Notelaea longifolia	T	2
Niemerya whitei	T	2
Tabernaemontana pandaqui	S	2
Lastreopsis decomposita	F	2
Guioa semiglauca	T	2
Eucalyptus grandis	T	4
Cordyline stricta	S	2
Cyathea leichhardtiana	S	1
Alphitonia excelsa	T	3
Allocasuarina torulosa	T	2

Acacia floribunda	T	2
Acacia melanoxylon	T	1
**Lantana camara*	S	2
Embelia australasica	V	2
Ripogonum fawcettianum	V	2
Smilax glyciphylla	V	2
Litsea australis	T	1
Cissus hypoglauca	V	3
Rubus moluccanus	V	3
Synoum glandulosum	T	2
Neolitsea dealbata	T	1
Linospadix monostachys	S	2
Schizomeria ovata	T	1
Ficus coronata	T	2
Malasia scandens	V	2
Breynia oblongifolia	S	1
Ottochloa gracillima	G	2
Oplismenus imbecilis	G	2
Pseuderantherum variable	H	2
Hibbertia scandens	V	1
Archontophoenix cunninghamii	T	1
Pilidiostigma glabrum	S	1
Toona ciliata	T	1

Quadrat 3

Marsdenia longiloboa **(Slender Marsdenia) – TSC Act Endangered**

Location: Nambucca State Forest ~1 km southeast of gabbage tip.
Vegetation Type: wet sclerophyll forest with well developed rainforest understorey.
Substrate: clay loam on metasediment
Slope Aspect: south
Slope Angle: 3
Disturbance history: logged ~20 years ago
Condition: good
Quadrat Size: 20 m x 50 m

Stratum	Height (m)	Crown Cover (%)	Species 1	Species 2	Species 3
Upper	15-25	40	*Corymbia intermedia*	*Syncarpia glomulifera*	*Lophostemon confertus*
Mid 2	8-15	60	*Syncarpia glomulifera*	*Lophostemon confertus*	
Mid 1	1-8	80	*Endiandra muelleri*	*Endiandra discolor*	*Cissus hypoglauca*
Lower	0-1	70	*Blechnum cartilagineum*	*Lastreopsis decomposita*	*Ripogonum fawcettianum*

Species	Habit	Cover-abundance Class
Endiandra discolor	T	3
Blechnum cartilagineum	F	4
Calanthes spicata	H	1
Cryptocarya rigida	T	2
Ripogonum fawcettianum	V	3
Malasia scandens	V	2
Backhousia myrtifolia	S	1
Lastreopsis decomposita	F	2
Allocasuarina torulosa	T	2
Syzygium australe	T	1
Lophostemon confertus	T	3
Syncarpia glomulifera	T	5
Corymbia intermedia	T	4
Croton verrauxii	S	2
Dioscorea transversa	V	2
Pseuderantherum variable	H	2
Livistona australis	T	2
Litsea australis	T	2
Breynia oblongifolia	S	1
Cissus hypoglauca	V	3
Rubus moluccanus	V	2
Mischocarpus pyriformis	T	2
Wilkea huegeliana	S	2
Cordyline stricta	S	2
Melodinus australe	V	1
Notelaea longifolia	T	2
Alpinea small	H	2
Doodia aspera	F	2
Gymnostachys anceps	H	1
Flagellaria indica	V	1
Canthium coprosmoides	T	2
Citriobatus pauciflorus	S	1
Embelia australasica	V	1
Euphomatia bennettiana	S	1
Morinda jasminoides	V	2
Tabernaemontana pandaqui	S	2
Kreysigia multiflora	H	1
Cissus antarctica	V	1
Smilax australis	V	2

Quadrat 4

***Maundia triglochinoides* – TSC Act Vulnerable**

Location: Williamson's Creek ~1 km south of Warrell Creek, population extends up and downstream of existing Pacific Highway bridge
Vegetation Type: emergent aquatic vegetation
Substrate: running creek which floods
Slope Aspect: na
Slope Angle: na
Disturbance history: creek flows through cleared pastureland
Condition: good
Quadrat Size: 10 m x 50 m

Stratum	**Height (m)**	**Crown Cover (%)**	**Species 1**	**Species 2**	**Species 3**
Upper	1-2	80	*Persicaria strigosa*	*Maundia triglochinoides*	*Schoenoplectus mucronatus*

Species (* exotic species)	**Habit**	**Cover-abundance Class**
Philydrum lanuginosum	H	1
Schoenoplectus vallidus	R	1
Schoenoplectus mucronatus	R	3
*Paspalum urvillei	G	3
Perscaria strigosa	H	4
Alternanthera denticulatum	H	2
*Ligustrum sinense	T	3
Paspalum distichum	G	4
*Rumex sp.	H	2
Ranunculus plebeia	H	2
Cyclosorus interruptus	F	2
Juncus planifolius	R	2
*Cyperus eragrostis	H	2
Carex appressa	H	1
Enydra fluctuans	H	2
Typha orientalis	R	2
Ranunculus inundatus	H	2
Ludwigia peploides	H	2
Maundia triglochinoides	H	3

APPENDIX 5: MINISTER OF PLANNING'S CONDITIONS OF APPROVAL

Mitigation Measures - Amorphospermum whitei and Marsdenia longiloba

B7. Prior to the commencement of any construction work that would result in the disturbance of *Amorphospermum whitei* and *Marsdenia longiloba*, the Proponent shall in consultation with the OEH develop a management plan for these species which:
(a) investigates the potential for the translocation of plants impacted by the project;
(b) if investigation under Condition B7(a) reveals translocation of impacted plants is feasible, includes details of a translocation plan for the plants consistent with the Australian Network for Plant Conservation 2nd Ed 2OO4: Guidelines for the Translocation of Threatened Species in Australia, including details of ongoing maintenance such as responsibilities, timing and duration;
(c) identifies a process for incorporating appropriate compensatory habitat for the impacted plants in the Biodiversity Offset Strategy referred to in Condition B8 should the information obtained during the investigation referred to in Condition B7(a) find that translocation is not feasible or where the monitoring undertaken as part of condition B10 finds that translocation measures have not been successful (as identified through performance criteria); and
(d) includes detail of mitigation measures to be implemented during construction to avoid and minimise impacts to areas identified to contain these species, including excluding construction plant, equipment, materials and unauthorised personnel.
Unless otherwise agreed to by the Director General, the Plan shall be submitted for the Director General's approval prior to the commencement of any construction work that would result in the disturbance of Amorphospermum whitei and Marsdenia longiloba.

Biodiversity Offsets

B8. The Proponent shall, in consultation with the OEH and DPI (Fisheries), develop a Biodiversity Offset Strategy that identifies available options for offsetting the biodiversity impacts of the project in perpetuity, with consideration to OEH's Principles for the Use of Biodiversity Offsets. Unless otherwise agreed to by OEH, offsets shall be provided on a like-for-like basis and at a minimum ratio of 4:1 'for areas of high conservation value (including EEC and threatened species or their habitat identified in the Environmental Assessment to be impacted by the project and poorly conserved vegetation communities identified as being more than 75% cleared in the catchment management area) and 2:1 for the remainder of native vegetation areas (including mangroves, seagrass, salt marsh and riparian vegetation). The Strategy shall include, but not necessarily be limited to:
(a) confirmation of the vegetation communities/ habitat (in hectares) to be offset and the size of offsets required (in hectares);
(b) details of the available offset measures that have been identified to compensate for the biodiversity impacts of the project, such as (but not necessarily limited to): suitable compensatory land options and/ or contributions towards biodiversity programs for high conservation value areas on nearby lands (including research programs). Where the use of

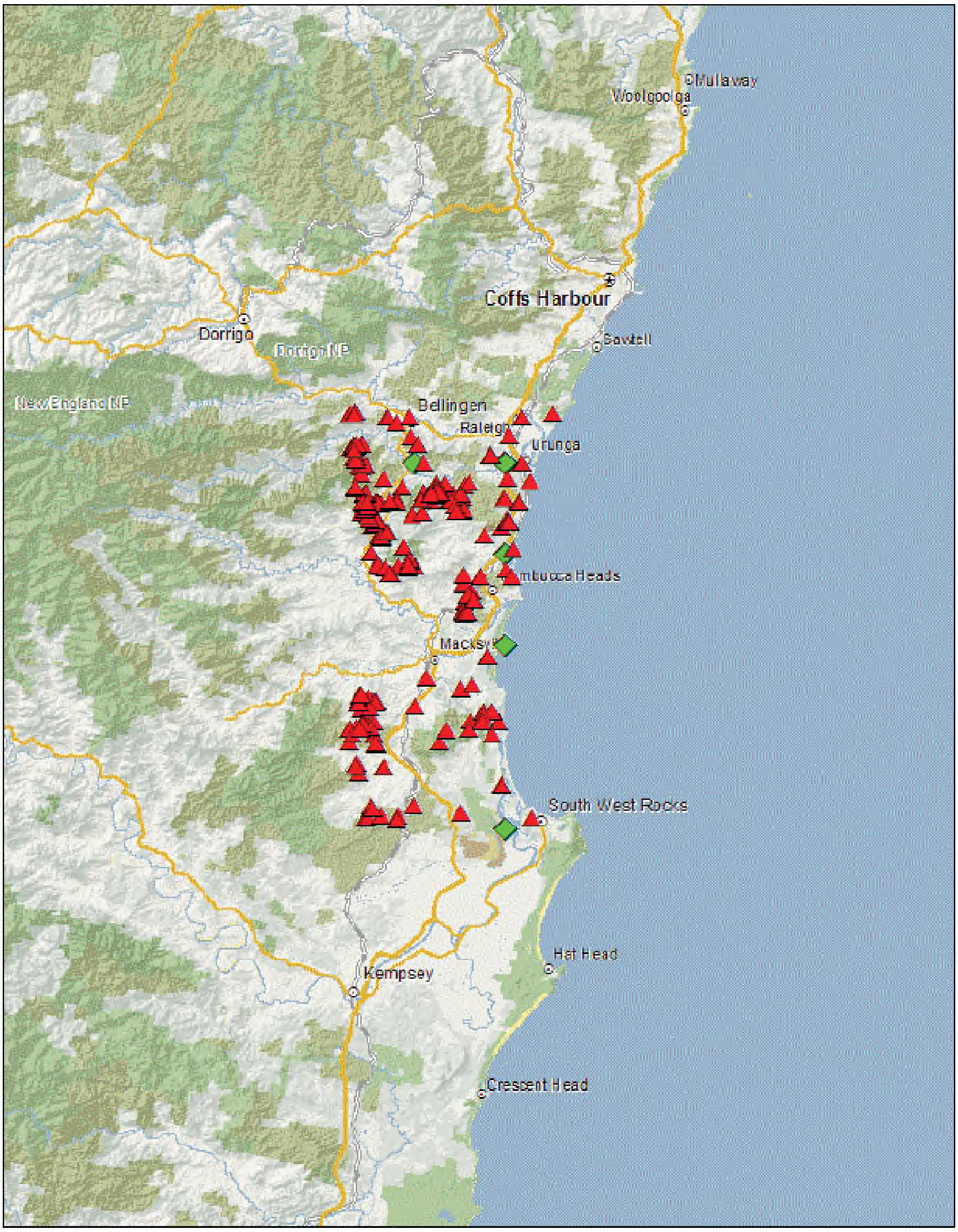
State Forest land managed in accordance with an lntegrated Forestry Operations Approval is proposed to offset biodiversity impacts, the Proponent shall clearly demonstrate how this would provide the biodiversity outcomes required under this condition including any additional offset requirements to cover residual impacts;
(c) the decision-making framework that would be used to select the final suite of offset measures to achieve the aims and objectives of the Strategy, including the ranking of offset measures;
(d) a process for addressing and incorporating offset measures for changes to impact (where these changes are generally consistent with the biodiversity impacts identified for the project in the documents listed under condition A1, including:
i. changes to footprint due to design changes;
ii. changes to predicted impacts resulting from changes to mitigation measures;
iii. identification of additional species/habitat through pre-clearance surveys; and
iv. additional impacts associated with ancillaryfacilities; and
(e) options for the securing of biodiversity options in perpetuity.
The Biodiversity Offset Strategy shall be submítted to, and approved by, the Director General prior to the commencement of any construction work that would result in the disturbance of any native vegetation, unless otherwise agreed by the Director General. Unless otherwise agreed, the Biodiversity Offset Strategy shall be submitted to the Director General for approval no later than 6 weeks prior to the commencement of any construction that would result in the disturbance of any native vegetation.
The Proponent may elect to satisfy the requirements of this condition by implementing a suitable offset package which addresses impacts from multiple Pacific Highway Upgrade projects (including the Warrell Creek to Urunga Project) within the North Coast Bio-region. Any NSW Government Department of Planning and lnfrastructure such agreement made with the OEH must be made in consultation with the Department and approved by the Director General within a timeframe agreed to by the Director General.

Within two years of the approval of the Biodiversity Offset Strategy, unless otherwise agreed by the Director General, the Proponent shall prepare and submit a Biodiversity Offset Package which identifies the final suite of offset measures to be implemented for the project for the approval of the Director General. The Package shall be developed in consultation with OEH, and shall provide details of:
(a) the final suite of the biodiversity offset measures selected for the project demonstrating how it achieves the requirements and aims of the Biodiversity Offset Strategy (including specified offset ratios);
(b) the final selected means of securing the biodiversity values of the offset package in perpetuity including ongoing management, monitoring and maintenance requirements; and
(c) timing and responsibilities for the implementation of the provisions of the package over time.
The requirements of the Package shall be implemented by the responsible parties according to the timeframes set out in the Package.

Ecological Monitoring

B10. Prior to the commencement of any construction work that would result in the disturbance of any native vegetation, the Proponent shall develop an Ecological Monitoring Program to monitor the effectiveness of the mitigation measures implemented as part of the project. The program shall be developed in consultation with OEH and prepared by a suitably qualified ecologist and shall include but not necessarily be limited to:
(a) an adaptive monitoring program to assess the effectiveness of the mitigation measures identified in condition 81 to 86, B7(b), B7(d), 821(c) and B3'1(b)and allow amendment to the measures if necessary. The monitoring program shall nominate appropriate and justified monitoring periods and performance targets against which effectiveness will be measured. The monitoring shall include operational road kill surveys to assess the effectiveness of fauna crossing and exclusion fencing implemented as part of the project;
(b) mechanism for developing additional monitoring protocols to assess the effectiveness of any additional mitigation measures implemented to address additional impacts in the case of design amendments or unexpected threatened species finds during construction (where these additional impacts are generally consistent with the biodiversity impacts identified for the project in the documents listed under condition A1;
(c) monitoring shall be undertaken during construction (for construction-related impacts) and from opening of the project to traffic (for operation/ongoing impacts) until such time as the effectiveness of mitigation measures can be demonstrated to have been achieved over a minimum of five successive monitoring periods (i.e. 5 years) after opening of the project to traffic, unless otherwise agreed to by the Director General. The monitoring period may be reduced with the agreement of the Director General in consultation with OEH, depending on the outcomes of the monitoring;
(d) provision for the assessment of the data to identify changes to habitat usage and if this can be attributed to the project;
(e) details of contingency measures that would be implemented in the event of changes to habitat usage patterns directly attributable to the construction or operation of the project; and
(f) provision for annual reporting of monitoring results to the Director General and OEH, or as otherwise agreed by those agencies.
The Program shall be submitted for the Director General's approval prior to the commencement
of any construction work that would result in the disturbance of any native vegetation. Unless otherwise agreed, the Program shall be submitted to the Director General for approval no later than 6 weeks prior to the commencement of any construction that would result in the disturbance of any native vegetation.

APPENDIX 6: NSW WILDLIFE ATLAS AND EPBC PROTECTED MATTERS SEARCH TOOL RESULTS



Legend

Species records mapped as held

Category 3 sensitive spp. 0.01°(~1km) rounded

Category 2 sensitive spp.0.1°(~10km) rounded

Atlas of NSW Wildlife records

N

Data from the BioNet Atlas of NSW Wildlife website, which holds records from a number of custodians. Location accuracy varies. Maps from the website are interactive: map displays can be modified from the original extent and a maximum of 5 species can be selected to display. Map may contain errors and omissions. Neither the Office of Environment and Heritage nor any other data custodian will accept liability for any loss, damage, cost or expenses incurred as a result of the use of, or reliance upon, the information in the map. Map copyright the State of NSW through the Office of Environment and Heritage.

Your Selection: Public Report of all Valid Records of Threatened (listed on TSC Act 1995) Plants in selected area [North: -30.44 West: 152.83 East: 153.11 South: -30.89] returned a total of 452 records of 15 species.

Report generated on 12/12/2011 2:23 PM

Data from the BioNet Atlas of NSW Wildlife website, which holds records from a number of custodians. The data are only indicative and cannot be considered a comprehensive inventory, and may contain errors and omissions.

Species listed under the Sensitive Species Data Policy may have their locations denatured (^ rounded to 0.1°; ^^ rounded to 0.01°).

Search criteria : Public Report of all Valid Records of Threatened (listed on TSC Act 1995) Plants in selected area [North: -30.44 West: 152.83 East: 153.11 South: -30.89] returned a total of 452 records of 15 species.

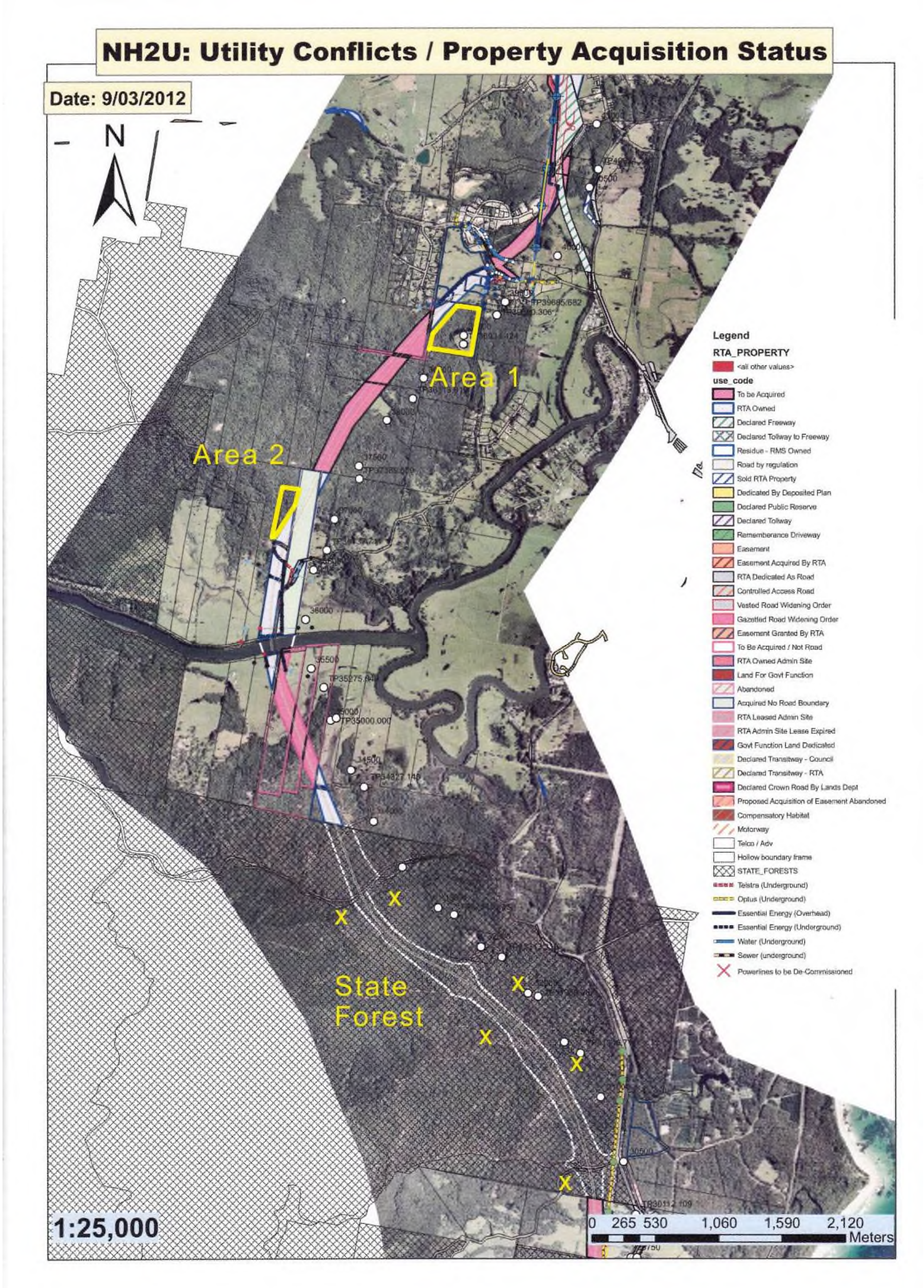
Report generated on 12/12/2011 2:17 PM

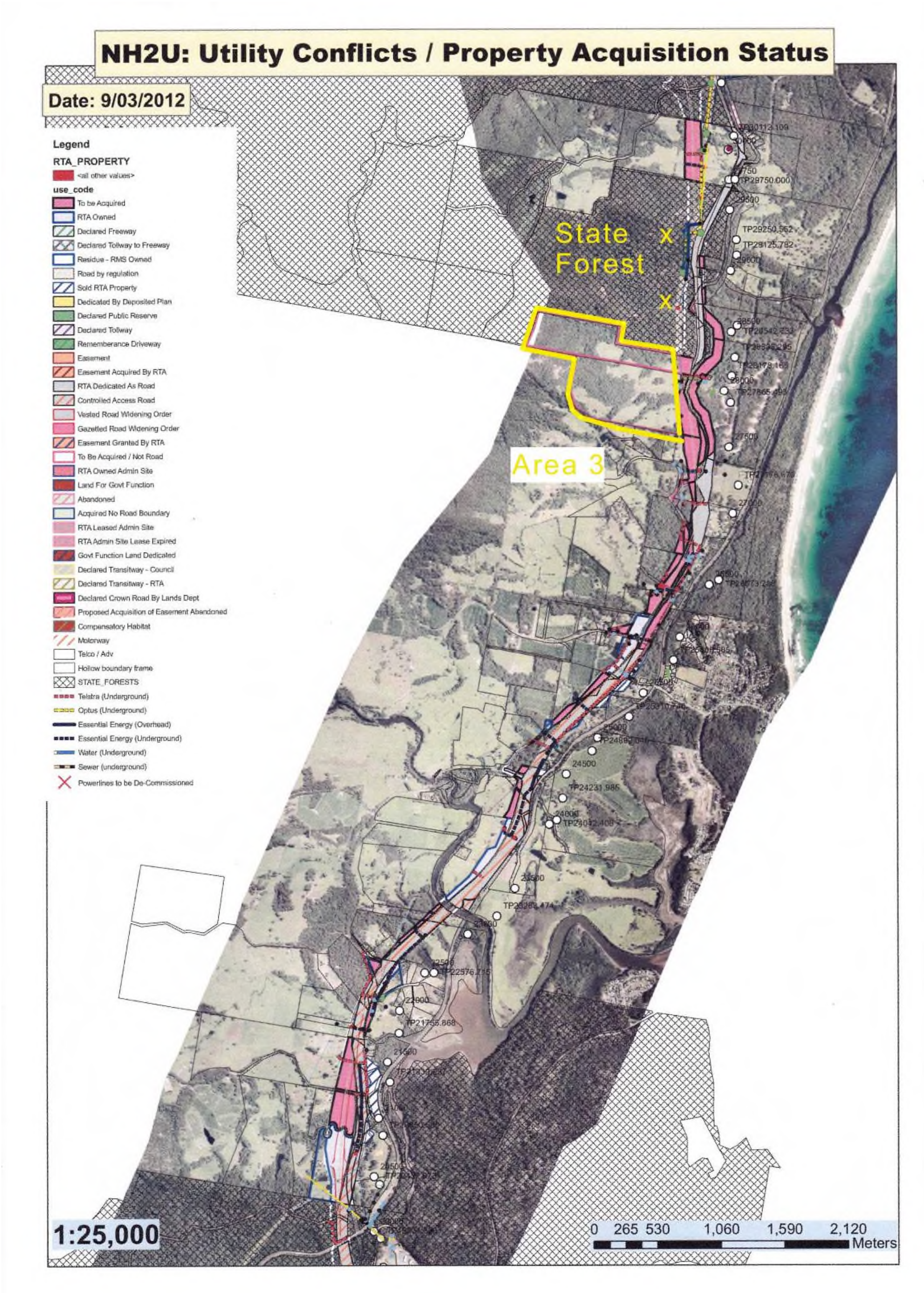
Kingdom	Class	Family	Species Code	Scientific Name	Exotic	Common Name	Legal Status	Records	Info
Flora	Flora	Apocynaceae	1233	*Marsdenia longiloba*		Slender Marsdenia	E1	58	
Flora	Flora	Apocynaceae	9505	*Parsonsia dorrigoensis*		Milky Silkpod	V	133	
Flora	Flora	Euphorbiaceae	9851	*Chamaesyce psammogeton*		Sand Spurge	E1	1	
Flora	Flora	Fabaceae (Mimosoideae)	3739	*Acacia chrysotricha*		Newry Golden Wattle	E1	102	
Flora	Flora	Juncaginaceae	3363	*Maundia triglochinoides*			V	1	
Flora	Flora	Menispermaceae	3691	*Tinospora tinosporoides*		Arrow-head Vine	V	2	
Flora	Flora	Myrtaceae	4252	*Melaleuca groveana*		Grove's Paperbark	V	5	
Flora	Flora	Myrtaceae	4293	*Syzygium paniculatum*		Magenta Lilly Pilly	E1	1	
Flora	Flora	Orchidaceae	6630	*^Dendrobium melaleucaphilum*		Spider orchid	E1	7	
Flora	Flora	Orchidaceae	4480	*^Phaius australis*		Southern Swamp Orchid	E1	1	
Flora	Flora	Poaceae	8979	*Alexfloydia repens*		Floyd's Grass	E1	1	
Flora	Flora	Proteaceae	5432	*Hicksbeachia pinnatifolia*		Red Boppel Nut	V	5	
Flora	Flora	Rutaceae	6457	*Acronychia littoralis*		Scented Acronychia	E1	13	
Flora	Flora	Santalaceae	5871	*Thesium australe*		Austral Toadflax	V	1	
Flora	Flora	Sapotaceae	11957	*Niemeyera whitei*		Rusty Plum, Plum Boxwood	V	121	

EPBC Act Protected Matters Report

PLANTS		
Acronychia littoralis		
Scented Acronychia [8582]	Endangered	Species or species habitat likely to occur within area
Allocasuarina defungens		
Dwarf Heath Casuarina [21924]	Endangered	Species or species habitat likely to occur within area
Arthraxon hispidus		
Hairy-joint Grass [9338]	Vulnerable	Species or species habitat may occur within area
Cryptostylis hunteriana		
Leafless Tongue-orchid [19533]	Vulnerable	Species or species habitat may occur within area
Cynanchum elegans		
White-flowered Wax Plant [12533]	Endangered	Species or species habitat likely to occur within area
Euphrasia arguta		
[4325]	Critically Endangered	Species or species habitat may occur within area
Hicksbeachia pinnatifolia		
Monkey Nut, Bopple Nut, Red Bopple, Red Bopple Nut, Red Nut, Beef Nut, Red Apple Nut, Red Boppel Nut, Ivory Silky Oak [21189]	Vulnerable	Species or species habitat likely to occur within area
Marsdenia longiloba		
Clear Milkvine [2794]	Vulnerable	Species or species habitat likely to occur within area
Parsonsia dorrigoensis		
Milky Silkpod [64684]	Endangered	Species or species habitat likely to occur within area
Quassia sp. Moonee Creek (J.King s.n. 1949) NSW Herbarium		
[82054]	Endangered	Species or species habitat likely to occur within area
Taeniophyllum muelleri		
Minute Orchid, Ribbon-root Orchid [10771]	Vulnerable	Species or species habitat likely to occur within area
Thesium australe		
Austral Toadflax, Toadflax [15202]	Vulnerable	Species or species habitat likely to occur within area
Tinospora tinosporoides		
Arrow-head Vine [5128]	Vulnerable	Species or species habitat likely to occur within area
Tylophora woollsii		
[20503]	Endangered	Species or species habitat likely to occur within area

APPENDIX 7: TRANSLOCATION RECEIVAL SITES

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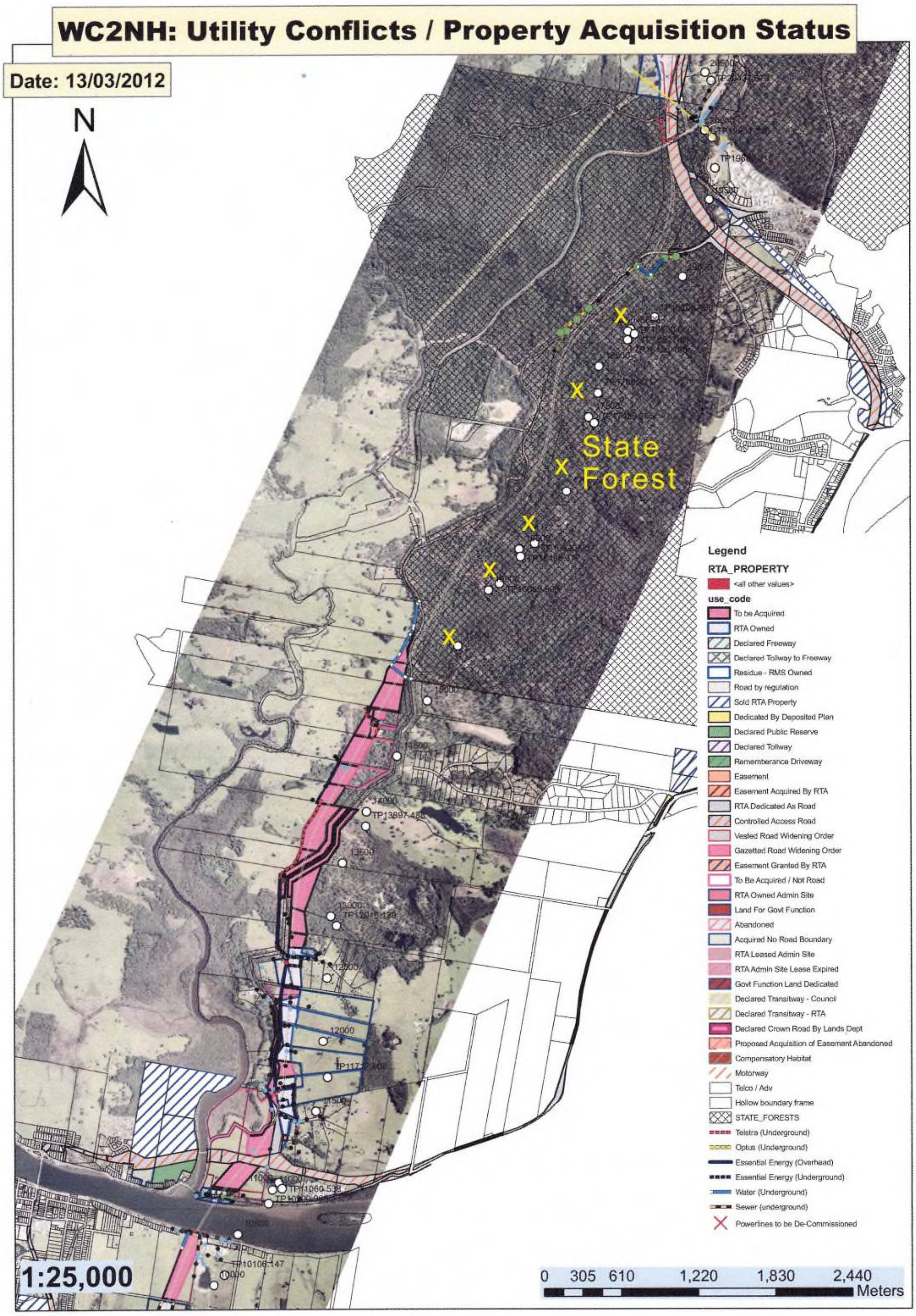
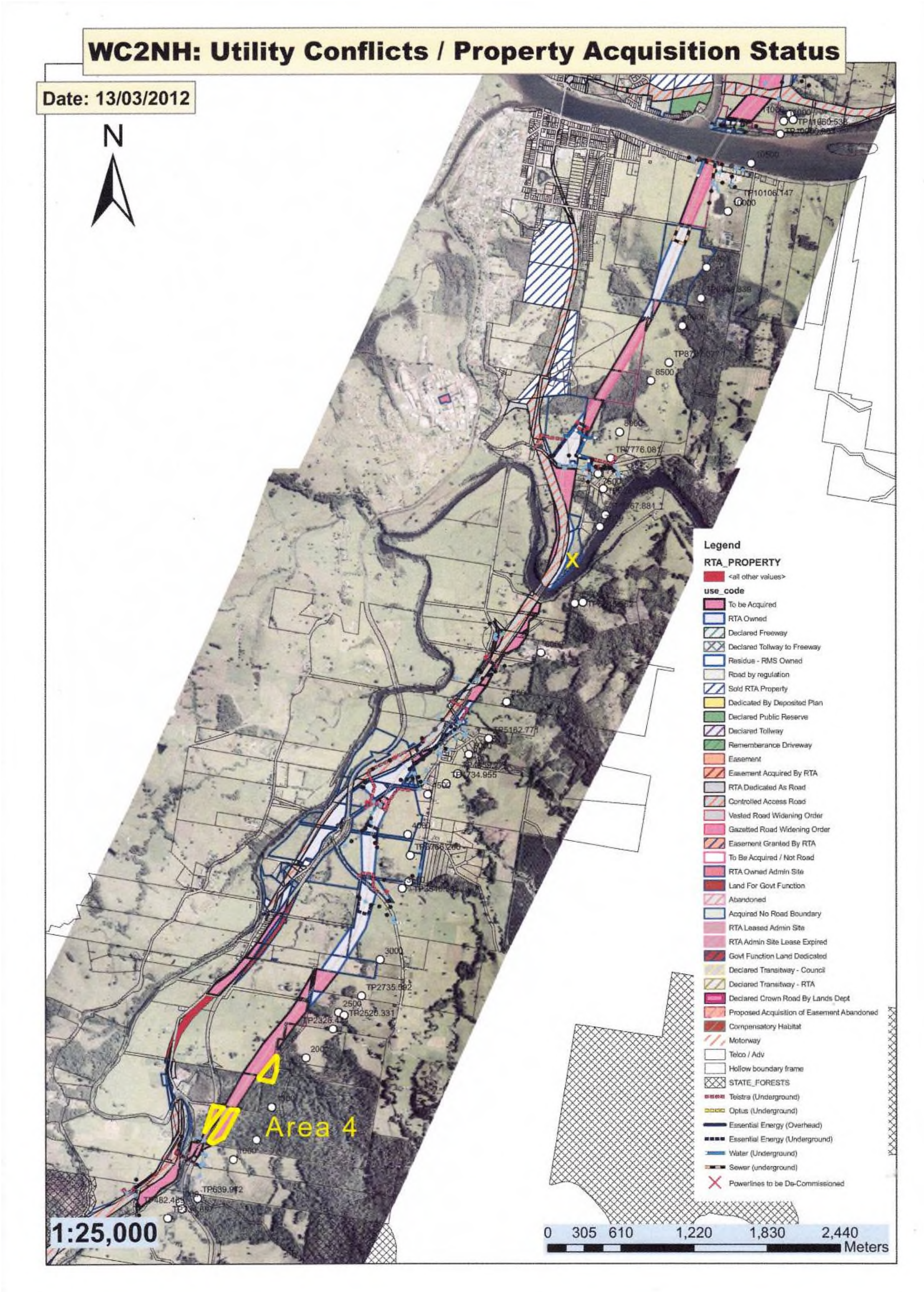
To be Acquired
RTA Owned
Declared Freeway
Declared Tollway to Freeway
Residue - RMS Owned
Road by regulation
Sold RTA Property
Dedicated By Deposited Plan
Declared Public Reserve
Declared Tollway
Rememberance Driveway
Easement
Easement Acquired By RTA
RTA Dedicated As Road
Controlled Access Road
Vested Road Widening Order
Gazetted Road Widening Order
Easement Granted By RTA
To Be Acquired / Not Road
RTA Owned Admin Site
Land For Govt Function
Abandoned
Acquired No Road Boundary
RTA Leased Admin Site
RTA Admin Site Lease Expired
Govt Function Land Dedicated
Declared Transitway - Council
Declared Transitway - RTA
Declared Crown Road By Lands Dept
Proposed Acquisition of Easement Abandoned
Compensatory Habitat
Motorway
Telco / Adv
Hollow boundary frame
STATE_FORESTS
Telstra (Underground)
Optus (Underground)
Essential Energy (Overhead)
Essential Energy (Underground)
Water (Underground)
Sewer (underground)
Powerlines to be De-Commissioned
State Forest
Area 3
1:25,000
0 265 530 1,060 1,590 2,120
Meters


WC2NH: Utility Conflicts / Property Acquisition Status
Date: 13/03/2012
N
State Forest
Legend
RTA_PROPERTY
<all other values>
use_code
To be Acquired
RTA Owned
Declared Freeway
Declared Tollway to Freeway
Residue - RMS Owned
Road by regulation
Sold RTA Property
Dedicated By Deposited Plan
Declared Public Reserve
Declared Tollway
Rememberance Driveway
Easement
Easement Acquired By RTA
RTA Dedicated As Road
Controlled Access Road
Vested Road Widening Order
Gazetted Road Widening Order
Easement Granted By RTA
To Be Acquired / Not Road
RTA Owned Admin Site
Land For Govt Function
Abandoned
Acquired No Road Boundary
RTA Leased Admin Site
RTA Admin Site Lease Expired
Govt Function Land Dedicated
Declared Transitway - Council
Declared Transitway - RTA
Declared Crown Road By Lands Dept
Proposed Acquisition of Easement Abandoned
Compensatory Habitat
Motorway
Telco / Adv
Hollow boundary frame
STATE_FORESTS
Telstra (Underground)
Optus (Underground)
Essential Energy (Overhead)
Essential Energy (Underground)
Water (Underground)
Sewer (underground)
Powerlines to be De-Commissioned
1:25,000
0 305 610 1,220 1,830 2,440
Meters


WC2NH: Utility Conflicts / Property Acquisition Status
Date: 13/03/2012
N
Area 4
Legend
RTA_PROPERTY
<all other values>
use_code
To be Acquired
RTA Owned
Declared Freeway
Declared Tollway to Freeway
Residue - RMS Owned
Road by regulation
Sold RTA Property
Dedicated By Deposited Plan
Declared Public Reserve
Declared Tollway
Rememberance Driveway
Easement
Easement Acquired By RTA
RTA Dedicated As Road
Controlled Access Road
Vested Road Widening Order
Gazetted Road Widening Order
Easement Granted By RTA
To Be Acquired / Not Road
RTA Owned Admin Site
Land For Govt Function
Abandoned
Acquired No Road Boundary
RTA Leased Admin Site
RTA Admin Site Lease Expired
Govt Function Land Dedicated
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Declared Transitway - RTA
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Proposed Acquisition of Easement Abandoned
Compensatory Habitat
Motorway
Telco / Adv
Hollow boundary frame
STATE_FORESTS
Telstra (Underground)
Optus (Underground)
Essential Energy (Overhead)
Essential Energy (Underground)
Water (Underground)
Sewer (underground)
Powerlines to be De-Commissioned
1:25,000
0 305 610 1,220 1,830 2,440
Meters

APPENDIX 8: THREATENED PLANT SPECIES ASSESSMENT OF SIGNIFICANCE

Addendum to the Environmental Assessment for the Warrell Creek to Urunga Upgrade (RTA 2010):

(yellow highlight indicates new text)

Threatened Species Assessments of Significance

A total of six species listed under the State Threatened Species Conservation Act (TSC Act) were recorded on the approved Warrell Creek to Urunga highway corridor during a targeted threatened species survey conducted in November 2011:-
Marsdenia longiloba
Niemeyera whitei
Maundia triglochinoides
Alexfloydia repens
Tylophora woollsii
Dendrobium melaleucaphilum

A significant number of additional individuals of the two species already recorded (the first two listed above) were also recorded during the targeted survey. The TSC Act and EPBC Act assessments presented in the EA (RTA 2010) are revised below to take into account this new information

Revision of RTA (2010) - Appendix B Assessment of significance (EP&A Act)

Note - As the project is assessed according to Part 3A of the EP&A Act, 7-part Test assessments of significance are not required. The format and section numbering in the informal assessments presented in RTA (2010) is followed below.

B.1 Threatened flora recorded

B.1.1 *Marsdenia longiloba* - Endangered Species: TSC Act
Marsdenia longiloba (Slender Marsdenia) is a small species of vine found in rainforest and wet sclerophyll forest at scattered locations from Barrington Tops north to southeast Queensland (NPWS 2002b). This species has mostly been recorded as occurring in low abundance in small population clusters. The population, or sub-populations recorded in the study area consist of scattered individuals in the understorey of moist eucalypt forest growing with various ferns, herbs and other twiners under an open to dense rainforest sub-canopy.

Translocation and monitoring of *Marsdenia longiloba* for the Bonville Upgrade in the Coffs Harbour LGA provided insight into various aspects of the life history of this species. Life history attributes reported by Benwell and Watson (2011) included:

- *Marsdenia longiloba* is a perennial, rhizomatous vine.

- Sub-populations are composed almost entirely of single-stemmed ramets produced from underground rhizomes, with several stems commonly attached to same rhizome network.

- Above stems are comparatively short-lived (1-3 years), while the rhizomes are probably more long-lived.

- The rhizomes are relatively thin, 10-30cm long and grow horizontally within the soil A1 horizon (occasional vertical rhizomes are also present); the rhizomes ramify through the soil, budding off existing rhizomes and severing connection to form separate plants.

- Plants may die back to the rhizome and remain stem-less and apparently dormant for up to two years (probably longer), then produce new stem shoots.

- Most stem-individuals never grow more than 30cm tall before dying back.

- Only large stem-individuals (ie >1m tall) produce flowers; production of pods and seed is extremely rare; only 1 pod has ever been recorded during several years of monitoring at several locations.

- *Marsdenia longiloba* appears to rely on vegetative reproduction for population persistence; flowering and seed dispersal play a minor role in this process.

- Discrete sub-populations and patches of *Marsdenia longiloba* may originate vegetatively from the same parent plant and spread over a considerable area (e.g. 0.04 ha)

- *Marsdenia longiloba* stems are conspicuously absent from recently (<1-6 yrs) logged or burnt forest, although monitoring of translocation areas has shown that quiescent rhizomes may be present in the soil. This suggests that conditions during early post-disturbance succession are not favourable for growth of *Marsdenia longiloba,* and stem growth may occur mainly during mid to late stages of succession.

The hypothesis implicit in the last dot point requires further study. In particular, the response of *Marsdenia longiloba* to fire has never been monitored.

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

The 2011 targeted threatened flora survey of the WC2U road corridor recorded *Marsdenia longiloba* at a total of 69 GPS points, which represented 203 plants and at least 22 different sub-populations ('sub-populations' were defined as geographically discrete records at least 100m apart). This species was comparatively widespread, being recorded at Raleigh south, Newry State Forest, Little Newry State Forest, Valla south, Nambucca State Forest and Warrell Creek. Of the total 203 plants recorded, 161 were directly impacted and 22 were indirectly impacted. The number of plants in the road reserve outside the construction zone was under-recorded, as the survey focused on the construction footprint. It is estimated that another 50 plants would probably occur in the outer part of the road reserve where they would not be impacted by roadworks.

The EA survey showed that sub-populations of *Marsdenia longiloba* extend outside the road corridor. Throughout Newry, Little Newry and Nambucca State Forest, as well as in larger vegetation remnants on private property, scattered individuals of *Marsdenia longiloba* are likely to occur where suitable habitat is present. Suitable habitat consists of gullies and lower slopes in wet sclerophyll forest, particularly on a southerly aspect. Wildlife Atlas reports other several locations for *Marsdenia longiloba* surrounding the WC2U highway corridor, including areas west of the project in Nambucca State Forest and surrounding the Nambucca waste management facility; south of the Project area in Ngamba Nature Reserve; and north of the project in the Bellingen district. Much habitat for *Marsdenia longiloba* is found in State Forest in logging exclusion zones along creeks and gullies, where it receives a measure of protection.

Significant numbers of *Marsdenia longiloba* would remain in the local area and thereby maintain large-scale population processes that may be important to the life cycle and persistence of the species. Individuals in close vicinity to the road corridor may be indirectly impacted through changes in micro-climatic, potential increases in weed invasion and sedimentation, and potential changes in hydrology. This may adversely affect the ability of individuals within 10 metres of the roadside (i.e. indirectly disturbed habitat) to remain healthy and complete their life cycle. Mitigation measures including confining vegetation clearing strictly to the construction footprint, sediment and erosion control measures and ecologically designed landscaping would minimise these indirect impacts. Potential decline in population number due to clearing would be also be mitigated by undertaking translocation of the species .

Marsdenia longiloba belongs to the plant family Asclepiadaceae. Pollinators of this family are typically butterflies and moths. The specific pollinators of *Marsdenia longiloba* and whether they are diurnal or nocturnal has not been determined. Several sub-populations would be intersected by the Project and therefore impact on pollinator movements between individuals on either side of the Project. Therefore the movement of genetic material may be impacted in these subpopulations, and could potentially lead to some inbreeding depression. However, the observed life history attributes of *Marsdenia longiloba* indicate this species relies on vegetative reproduction for population persistence, and that pollination and seed dispersal play a minor role in its persistence at a locality. Project interference with the very limited pollination activity in this species is unlikely to significantly affect the life cycle of *Marsdenia longiloba* by altering the genetic structure of populations through processes such as inbreeding.

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

The Project would remove habitat for this species in several areas and potentially lead to biophysical changes to other areas of habitat. There is potential for the Project to alter habitat attributes of surrounding areas through indirect impacts of changes in hydrological and nutrient regimes within habitats downstream of the proposed development and through edge effects. This could result in habitat changes, including increases in weed abundance, altered soil conditions and sedimentation. These changes may potentially lead to the area of occupancy of the population to be significantly reduced. However mitigation measures during construction and the implementation of specific design features into the proposed development are likely to minimise these indirect impacts. These would include: (i) measure to ensure that vegetation clearing is confined strictly to the construction footprint, (ii) measures to control sediment run-off (particularly sedimentation fencing) and (iii) ecologically designed landscaping.

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

The distribution of *Marsdenia longiloba* extends from Barrington Tops to southeast Queensland (NPWS 2002b). Therefore *Marsdenia longiloba* is in the central portions of its distribution in the Nambucca-Urunga area.

How is the Project likely to affect current disturbance regimes?

Current disturbance regimes potentially affecting *Marsdenia longiloba* include:-
(i) weed invasion by *Lantana camara*, (ii) bushfire, (iii) logging and clearing, as follows:-

(i) The Project is likely to contribute to further invasion of *Lantana camara* particularly along the edges of the Project where there would be increased sunlight availability. Other indirect impacts such as increased water and nutrients may also aid the growth of *Lantana camara*. Weed control during construction and operation of the highway would greatly reduce this threat to *Marsdenia longiloba* habitat.

(ii) Bushfires in *Marsdenia longiloba* habitat can start from arson, accidental ignition, control burning and lightning strikes. The Project may result in an increase in fire frequency due to fires started by arson or accidental ignition. At the same time, the new highway corridor may result in a barrier to the spread of fire, resulting in a decrease in fire frequency. Increase in fire intensity may result from changes in fuel characteristics in roadside vegetation, causing increased flammability. However, the number of fires resulting from roadside ignition has decreased significantly in recent decades due to greater environmental awareness, harsh penalties and roadside maintenance.

(iii) Vegetation clearing is likely to change microclimatic conditions in forest to a depth of 10-20 metres from the edge of the road corridor (Benwell 2010). This may in turn lead to an increase in weeds and sclerophyllous plants, producing a general increase in forest understorey density, which appears to create unsuitable habitat conditions for *Marsdenia longiloba*. Such changes in habitat structure are reduced if no soil disturbance occurs beyond the limits of clearing. This can be ensured by mitigation measures such as strict controls on clearing, No Go zones and use of sedimentation fencing.

How is the Project likely to affect habitat connectivity?

Marsdenia longiloba generally occurs in gully areas running perpendicular to the Project. Therefore suitable areas of habitat would be fragmented from the Project, with some subpopulations being dissected. Pollinator movements may extend across the proposed highway allowing exchange of genetic material between fragmented areas of habitat, assuming flying insects are the main pollinators, however as already discussed, populations of *Marsdenia longiloba* persist by vegetative reproduction rather than pollination and seed production, as evidenced by the extreme rarity of seed production. Individuals would generally remain on either side of the road corridor following direct impact to individuals through clearing of the construction footprint. Substantial numbers of plants are likely to occur in surrounding habitat not affected by the highway construction.

How is the Project likely to affect critical habitat?

No critical habitat has been identified for this species.

B.1.2 *Amorphospermum whitei* (syn. *Niemeyera whitei*) Vulnerable: TSC Act

Amorphospermum whitei is a medium size rainforest tree found on the coast and adjacent ranges of northern NSW from the Macleay River into southern Queensland, and its distributional stronghold is on the mid north coast in the Coffs Harbour district (NPWS 2002b). Rusty Plum is found in rainforest and the rainforest understorey of wet sclerophyll forest, generally below 600 m altitude and on low to moderate fertility soils derived from metasediments and rhyolite (Floyd 1989).

Limited information on the life history of *Amorphospermum whitei* was reported by Novello and Klohs (1998). They reported that the large seed of this species is supposedly dispersed by mammal species and is viable for a period of 1-3 months, and that once seedlings are established it can take up to six years for the tree to reproduce. More rigorous information on the life history of *Amorphospermum whitei* was recorded during translocation and monitoring of this species for the Bonville and Sapphire to Woolgoolga Pacific Highway upgrade projects. As part of the Sapphire to Woolgoolga project, 68 seeds of *Amorphospermum whitei* were direct seeded into suitable, regrowth wet sclerophyll forest habitat. After 6 months, 75% of the seed had germinated, 12% had rotted, 6% was either eaten or removed (dispersed?) and 7% were ungerminated, but still intact and presumably viable. Of the germinated seedlings, a third were grazed by possums or wallabies in the first 3 months then all reshot again, as the large seed still contained stored food. The seedlings were subsequently protected under wire cages (Benwell 2011).

Ninety, one year old *Amorphospermum whitei* seedlings were introduced to potential habitat during the Bonville Upgrade. The mean height of three year old seedlings in three different planting treatments ranged from 33 to 40cm. This is a slow growth rate indicating that seedlings would be unlikely to reach reproductive maturity in six years as reported by Novello and Klohs (1998). It is estimated that the fastest growing seedlings would require 10-20 years to reach reproductive maturity (i.e. start seed production).

A single isolated tree of *Amorphospermum whitei* in the Coffs Harbour Botanical Gardens has been observed to produce normal sized fruits with seeds inside, indicating the species can set seed by self-pollination. Whether this still requires an insect pollinator and the role and importance of cross-pollination in maintaining genetic diversity is unknown.

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

Amorphospermum whitei was recorded at three locations: Boggy Creek near Valla, north of the railway line at the Nambucca turn-off and Cockburns Lane south of Warrell Creek. A single small tree was recorded at Boggy Creek and a population of 17 trees and saplings, plus seedlings were recorded at Cockburns Lane in a 150 meter long section of the road corridor. The trees were up to 10 metres in height with a maximum diameter of about 30 cm. Of the 17 individuals at Cockburns Lane, Warrell Creek, 14 are directly impacted, three are indirectly impacted and two would remain in situ. The single tree at Boggy Creek is reported to require removal in the EA, although spatial impact analysis indicated it was outside the impact zone.

At Cockburns Lane, a few *Amorphospermum whitei* would remain in situ in the road reserve and others probably occur in forest east of the road alignment. Also, *Amorphospermum whitei* probably occurs at other locations in the Boggy Creek catchment on private land to the west of the road alignment. There are two records of *Amorpospermum whitei* higher in the Boggy Creek catchment in Nambucca State Forest approximately two km to the southwest of the individual recorded in the Project area (NSW DPI 2007). In addition, Wildlife Atlas indicates that *Amorphospermum whitei* is found in the Bellingen district, in Newry State Forest <5km west of the Project, other locations at Valla, Nambucca State Forest and Ingalba State Forest <5km west of the Project. Habitat for *Amorphospermum whitei* is largely protected in State Forest areas in logging exclusion zones along creeks and gullies.

The impact of the WC2U highway upgrade on *Amorphospermum whitei* at two locations is therefore comparatively minor in terms of the local distribution of this species. Significant numbers of *Amorphospermum whitei* would remain in the local area within 10km of the project, thereby maintaining large-scale population processes such as gene flow via pollination between sub-populations. In the immediate vicinity of the WC2U highway upgrade a small number of individuals would be indirectly impacted through changes in micro-climatic, potential increases in weed invasion and sedimentation, and potential changes in hydrology. This may adversely affect the ability of a small number of individuals to complete their life cycle and maintain population number through seedling recruitment. A decrease in population number can be avoided by undertaking translocation of the species, which has been shown to be successful on other projects (Benwell 2011).

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

The Project would remove habitat for this species in several areas and potentially lead to biophysical changes to areas of habitat. There is potential for the Project to alter habitat attributes of surrounding areas through indirect impacts which potentially include altering of hydrological and nutrient regimes in habitats downstream of the proposed development and edge effects. This could result in habitat changes, including increases in weed abundance, altered soil conditions and sedimentation. Considering that *Amorphospermum whitei* was recorded in only two locations in the study area and the substantial wider distribution of the species in the local area, it is unlikely that the Project would lead to the area of occupancy of the population to be significantly reduced from potential changes to areas of suitable habitat. Mitigation measures during construction, and the implementation of specific design features into the proposed development are likely to minimise these indirect impacts.

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

The distribution of *Amorpospermum whitei* is characterised by separate northern and southern meta-populations (NPWS 1998). The northern meta-population is restricted to the Mt Warning Shield on the NSW-Qld border. The southern meta-population occurs from the Coffs Harbour district south to Ingalba State Forest, inland to the Dorrigo and Upper Bellinger districts (Wildlife Atlas). It is also reported from the Port Macquarie district (Harden 2000), which appears to represent a small, disjunct, southern population.

The *Amorpospermum whitei* occurrence at Cockburns Lane, Warrell Creek South is therefore at the southern limit of the southern meta-population, along with occurrences in Ingalba State Forest.

How is the Project likely to affect current disturbance regimes?

Current disturbance regimes potentially affecting *Amorpospermum whitei* habitat include:-
(i) invasion by woody weeds, including *Lantana camara*, *Ligustrum sinense* and *Cinnamomum camphora*. The Project is likely to contribute to further invasion of woody weeds along the edges of the Project where there would be increased sunlight availability, water and nutrients. Weed control specifically targeted to threatened species habitat during construction and operation of the highway would greatly reduce this threat to *Amorpospermum whitei* habitat.

(ii) bushfire - the thick rough bark of *Amorpospermum whitei* indicates it can survive fire and recover by resprouting. This is also consistent with its response to transplanting, where it regenerates by epicormic and basal shoot resprouting. Therefore, fire is unlikely to have a significant adverse impact on this species, as long as they are not too frequent or intense.

(iii) logging and adjacent clearing - vegetation clearing is likely to change microclimatic conditions in forest to a depth of 10-20 metres from the edge of the road corridor (Benwell 2010). This may adversely affect habitat conditions for *Amorpospermum whitei* located near the road edge. Degradation of forest habitat adjoining roadside habitat can be reduced by measures to minimise clearing and soil disturbance, and ecologically compatible landscaping after the finish of construction.

How is the Project likely to affect habitat connectivity?

Amorpospermum whitei generally occurs in gully areas running perpendicular to the Project. Therefore suitable areas of habitat would be fragmented from the Project. Although no individuals were recorded in the study area in most areas of suitable habitat, individuals are potentially present in areas beyond the study area, and there are records to the west of the Project in several areas. Pollinator movements may extend across the proposed highway allowing exchange of genetic material between fragmented areas of habitat, assuming flying insects are the main pollinators, however this is largely unknown. Seed dispersal across the proposed development is likely to be impacted to some degree, as terrestrial fauna movement is likely to be impacted, however seed dispersal by flying mammals and birds is unlikely to be significantly impacted.

As the species already has a naturally patchy or fragmented distribution in the local area according to the landscape pattern of hill slopes and drainage lines, the WC2U highway corridor, would not significantly increase the current level of habitat dis-connectivity.

How is the Project likely to affect critical habitat?

No critical habitat has been identified for this species.

B.1.4 *Maundia triglochinoides* - Vulnerable Species: TSC Act

Maundia triglochinoides is a emergent aquatic plant of coastal floodplains, found from Sydney (Botany Bay) north to southern Queensland (Wildlife Atlas; DECC 2002). Maundia grows in swamps, creeks and shallow freshwater, 30-60 centimetres deep, on heavy clay alluvium of low to medium nutrient levels. Flowering occurs during summer. *Maundia triglochinoides* is similar in appearance to *Triglochin procerum* (now split into several species). *Maundia triglochinoides* can be distinguished by its leaves which are convex and hollow (not flat as in *Triglochin procerum*)*;* it has white rhizomatous roots to 10 cm+ long; and the flower spike is shorter and comprised of capsules rather than schizocarps as in *Triglochin* species.

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

Maundia triglochinoides was recorded at two locations south of Macksville. One location is on Williamson's Creek where it crosses the highway corridor. The second location is a freshwater swamp just south of Macksville. The Williamson's Creek population follows the creek for approximately 150 metres across the road corridor and extends further upstream and downstream outside the road corridor. *Maundia triglochinoides* appears to spread vegetatively from its rhizome system and hundreds of plants were present at both locations.

Under the current concept plan design, Maundia is unlikely to be directly impacted by construction of the WC2U upgrade. The population on Williamson's Creek is located under footprint of the new highway bridge, within the stream and along its edge and it should be possible to manage this species in situ without the need for translocation. Sedimentation fencing installed on either side of the creek and attention to water quality entering the creek from the construction site through the use of retention basins should maintain current habitat conditions during construcion.

It was initially thought that overhead bridge works would adversely affect the population by shading, however, further study of this species in the Frederickton to Eungai area indicates this may not be the case. Direct sunlight would still reach the stream from the eastern and western sides of the highway bridge in early morning and late afternoon. In the Frederickton to Eungai area, Maundia occurrences have been found in shaded open-forest situations, demonstrating the species does not require full sun exposure (Benwell 2012). The populations on WC2U could still be adversely impacted by possible changes in hydrology, water quality and weed invasion,

The second population occurs in a freshwater wetland on the Nambucca River floodplain south of Macksville. This population just overlaps with the project's eastern boundary and is only marginally affected. Large numbers of plants outside the road corridor, particularly on the eastern side, would remain undisturbed, enabling normal population processes such as pollination, seed set, dispersal and seedling establishment to continue.

Road construction has the potential to impact indirectly on *Maundia triglochinoides* populations at both locations through sedimentation and changes to water quality (e.g. nutrient levels and pH) in its freshwater aquatic habitat. These factors can be controlled by mitigation measures including minimising vegetation clearing and strict adherence to marked clearing boundaries, drainage plans incorporating sediment capture structures, artificial wetlands to absorb nutrients, weed management planning, and ecologically compatible landscaping.

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

The Project would result in the removal of only a small area of unoccupied potential habitat for this species comprising up to two hectares of dams, creeks and wetland areas.

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

Maundia triglochinoides is restricted to coastal NSW north from Sydney (Botany Bay) extending into southern Queensland. Therefore this species would not be at the limit of its distribution in the WC2U locality.

How is the Project likely to affect current disturbance regimes?

Natural and anthropogenic disturbance regimes are currently operating in *Maundia triglochinoides* habitat. The main natural disturbance is flood events that submerge plants and expose them to risk of erosion and sedimentation. Anthropogenic disturbances comprise impacts from grazing and agricultural weeds. Creek lines in cleared land and wetland areas have been highly impacted from grazing. Aquatic weed species such as *Salvinia molesta* infest some wetland areas south of the Nambucca River.

These impacts would be minimised within and adjoining the road corridor by grazing exclusion fencing, drainage, erosion and sedimentation controls and weed control.

How is the Project likely to affect habitat connectivity?

Potential breaks in the *Maundia triglochinoides* population on Williamson's Creek due to the new bridge would be comparatively minor (i.e. 50-100 metres wide) and substantial numbers of plants and area of habitat in this population would remain unaffected. This level of impact would not greatly affect habitat connectivity or disrupt processes such as pollination, seed dispersal and seedling establishment that rely on habitat connectivity.

How is the Project likely to affect critical habitat?

No critical habitat has been identified for this species.

B.1.5 *Alexfloydia repens* - Endangered Species: TSC Act

Alexfloydia repens is a grass with a restricted distribution between Coff Harbour and Macksville, on or near the banks of creeks within 10 km of the sea where it occurs in Swamp Oak forest and Floodplain Open Forest. It is generally found adjacent to the upper limit of the king tide zone of coastal estuaries and its habitat floods after heavy rain at least once a year on average, sometimes several times (Benwell 2009). The following information on the life history and population dynamics of *Alexfloydia repens* was recorded during translocation and monitoring of the species for the Bonville Upgrade (Benwell 2006-2011):

Alexfloydia repens is a perennial, matt-forming grass.

- The species spreads by stolons or runners. Small plants of Floyds Grass planted into Swamp Oak Forest after clearing the ground of exotics, produced runners up to 2.4 metres long in 12 months.
- On bare ground created either artificially, or by flood-induced dieback of ground layer vegetation, Floyds Grass regenerates rapidly from runners to form a dense cover.
- Established ground cover vegetation of grass and fern species forms a barrier which stops the spread of runners.
- Flowers are produced very sparsely in forested situations (ie. habitat with a tree canopy) and abundantly in more open habitat, where the vegetation structure has been simplified by disturbance (ie. tree clearing).
- To persist at a location *Alexfloydia repens* relies on vegetative regeneration after disturbance rather than seedling recruitment; it is possible new bare sites are by seed dispersal and seedling establishment, although there is little evidence that this occurs frequently.

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

Alexfloydia repens was recorded at one location where the project boundary meets the northern bank of Warrell Creek. Plants were found on either side of the road corridor. No plants were found within the road corridor at the edge of Warrell Creek, although suitable habitat is present. *Alexfloydia repens* occurs upstream of the road corridor for at least 20 metres. No plants were found downstream of the patch on the eastern boundary, for 50 metres, although a large population was recently located approximately 1 km downstream of the road corridor. It is likely that other patches of *Alexfloydia repens* are present along Warrell Creek upstream and downstream of the highway corridor.

Impact analysis of the RMS concept design found that one gps point is directly impacted and two are indirectly impacted, comprising a total of approximately 6 m² of Floyds Grass. All points would probably require translocation as Floyds Grass is unlikely to survive long-term in the indirect impact zone, where it would be threatened by weed invasion and increased cover of native species such as grasses and ground ferns. As noted above, this species can be translocated with a high likelihood of success. Indirect impacts such as run-off from the construction zone and soil eutrophication could also be a problem, although sed and erosion control measures would minimise such impacts.

Construction related factors with potential to adversely effect the life cycle of *Alexfloydia repens* growing adjacent to the road corridor at Warrell Creek include clearing encroachment, sediment run-off, micro-climate change, soil eutrophication and weed invasion. These factors can be controlled using mitigation measures such minimising vegetation clearing and strict adherence to marked clearing boundaries, drainage plans incorporating sediment capture structures, artificial wetlands to absorb nutrients, weed management planning, and ecologically compatible landscaping.

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

Alexfloydia repens inhabits a narrow zone 1-3 metres wide on the edge of Warrell Creek, in Swamp Oak forest. The soil type is a humus-enriched, alluvial clay loam. The road corridor directly and indirectly impacts on approximately 6 m² of actual habitat within the project boundary. This is a very small area in comparison to the known extent of *Alexfloydia repens* at Warrell Creek, where the species occurs directly upstream of the road corridor and a large population has recently been found approximately 1km downstream of the road corridor. Further occurrences are likely in between these two locations. The road corridor directly and indirectly impacts on <1% of the known distribution of *Alexfloydia repens* at Warrell Creek.

Potential adverse effects of the WC2U project on adjoining habitat include clearing encroachment, sediment run-off, soil eutrophication and weed invasion. Any potential adverse impact arising from these factors can be controlled using measures such minimising clearing and strict adherence to marked clearing boundaries, drainage plans incorporating sediment capture structures, soil nutrient management to minimise increases in nutrient levels, weed management planning and ecologically compatible landscape design. Weed control and habitat restoration can be used to improve the condition of *Alexfloydia repens* habitat adjacent to the bridge site at Warrell Creek and within the road corridor if considered appropriate.

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

The *Alexfloydia repens* population at Warrell Creek is at the extreme southern limit of its distribution. Highway construction would impact directly and indirectly on a very small portion of this population, which likely extends upstream and downstream of the project for some distance.

How is the Project likely to affect current disturbance regimes?

The main disturbance process currently affecting *Alexfloydia repens* at Warrell Creek is weed invasion, particularly by *Lantana camara* and *Paspalum wettsteinii.* The Project has the potential to contribute further to the invasion exotic species, particularly along the edges of the Project where there would be increased sunlight availability and localised changes in soil water and nutrients may also aid the growth of weed species.

Minimisation of clearing, sed and erosion control, weed control and ecologically compatible landscaping would greatly reduce the impact of the WC2U project on the Warrell Creek population.

How is the Project likely to affect habitat connectivity?

The road corridor bisects a narrow stip of *Alexfloydia repens* habitat, the width of the road corridor, at Warrell Creek. This is unlikely to have a significant impact on habitat connectly for this species, as being a species of floodplains, seed and runners are probably dispersed by water movement, particularly during floods. *Alexfloydia repens* occurs both upstream and downstream of the highway impact site.

Removal of *Paspalum wettsteinii* and other ground species would probably allow *Alexfloydia repens* to re-colonise the creek bank within the road corridor and re-connect occurrences on the eastern and western sides of the project.

How is the Project likely to affect critical habitat?

No critical habitat has been identified for this species.

B.1.6 *Dendrobium melaleucaphilum* - Endangered Species: TSC Act

Dendrobium melaleucaphilum, an epiphytic orchid, occurs in coastal districts and nearby ranges, extending from Queensland to its southern distributional limit in the lower Blue Mountains. In NSW, it is currently known from seven recent collections. There has been no subsequent confirmation from the locations of three earlier (pre-1922) collections and it is possible that these are now extinct (OEH website).

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

Dendrobium melaleucaphilum was recorded at two locations within the project boundary, in Newry State Forest and a site approximately 4km north of the Kalang River. Only plant was found at the latter site, whereas a substantial population occurs at the Newry State Forest location. Ten Spider Orchid flora points comprising 15-30 Spider Orchid plants are directly impacted by construction and possibly another 20 Spider Orchid plants would be indirectly impacted by increased exposure to the extent that eventual mortality would be likely. A significant area of potential habitat for *Dendrobium melaleucaphilum,* including swamp sclerophyll and moist open forest is present on the road corridor.

As part of the management of this species, additional individuals would be propagated from locally collected seed and introduced to suitable habitat adjoining the road corridor, or to a suitable translocation receival site. This would allow life cycle processes such as pollination, seed dispersal and recruitment to be re-established.

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

The habitat of *Dendrobium melaleucaphilum* comprises swamp sclerophyll forest and rainforest understorey in wet sclerophyll/moist open forest. The Project will impact directly on this habitat by clearing and indirectly by creating new forest edges, which would alter the microclimate of adjoining *Dendrobium melaleucophilum* habitat by allowing greater sunlight and wind penetration. Indirect impacts can be reduced to some extent by minimising vegetation clearing and landscape planting to restore protective buffer vegetation on the roadside after construction has finished. *Melaleuca stypheloides* would be widely used in landscaping to provide the favoured host plant for *Dendrobium melaleucaphilum.*

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

The distribution of *Dendrobium melaleucaphilum* extends from the Hawksbury River to Southeast Qld. The WC2U highway upgrade is approximately in the centre of its distribution.

How is the Project likely to affect current disturbance regimes?

The Project will cause an increase in disturbances including vegetation clearing, Lantana invasion and change in micro-climate of adjoining vegetation. Increased vegetation clearing has the potential to result in an increase in fire frequency and intensity by changing the characteristics of fire fuels (e.g. increase in dry grass on the roadside). *Dendrobium melaleucaphilum* is likely to be adversely impacted by an increase in bushfires. Minimisation of clearing, weed control and roadside slashing maintenance (fuel reduction) can be all be used to reduce direct and indirect impacts on the habitat and surviving population of this species.

Perhaps the most severe disturbance affecting *Dendrobium melaleucaphilum* is illegal orchid collecting. The WC2U project has the potential to increase this activity by enabling easier access to forest areas, however, fauna fencing should largely prevent access from the edge of the new highway.

How is the Project likely to affect habitat connectivity?

Potential habitat for *Dendrobium melaleucaphilum* includes swamp sclerophyll forest and the rainforest understorey in wet sclerophyll forest. Fragmentation of this habitat would result from construction of the WC2U upgrade, but the level of fragmentation would be relatively low considering that areas of continuous potential habitat would remain in Newry State Forest, Nambucca State Forest and other areas. These would allow population processes such as pollination, seed dispersal and seedling establishment to operate and thereby maintain and increase population numbers. The functionality of habitat connections is severely comprised by the extreme rarity of the species, due to orchid collecting, fire, past logging and habitat clearance.

How is the Project likely to affect critical habitat?

No critical habitat has been identified for this species.

B.1.7 *Tylophora woollsii* - Endangered Species: TSC Act

Tylophora woollsii is a small species of vine found in rainforest and wet sclerophyll forest from the Hawkesbury River north to the Qld border, and from the coast inland to the Great Escarpment Ranges. There is a concentration of records in an arc extending from the Coffs Harbour-Bellinger Valley area northwest to the Dorrigo district and the Gibraltar Range. Wildlife Atlas reports 60 records of the species in NSW.

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

Tylophora woollsii was recorded at three locations on the WC2U corridor:- between Raleigh and the Kalang River, Newry State Forest and Nambucca State Forest. Nine individuals would be directly impacted and six would remain in-situ within the Road Reserve. Generally, the species appears to be rare in the local area; all individuals were small plants unlikely to flower in the near future. Note – there is an element of uncertainty regarding the identification of this species as its leaves are very similar to *Marsdenia longiloba*. Flowers are required for postive identification but have not been observed.

Information on the life history of *Tylophora woollsii* recorded during translocation of this species for the Bonville project showed it has similar life history attributes to *Marsdenia longiloba*. One contrasting feature was that *Tylophora woollsii* did not appear to spread vegetatively like *Marsdenia longiloba,* although rhizomes were present. It appeared to regenerate by resprouting from these, but without multiplying into ramets.

Construction related factors with potential to adversely affect the life cycle of *Tylophora woollsii* at Warrell Creek include clearing encroachment, sediment run-off, micro-climate change, soil eutrophication and weed invasion. These factors can be controlled using mitigation measures such minimising vegetation clearing and strict adherence to marked clearing boundaries, drainage plans incorporating sediment capture structures, artificial wetlands to absorb nutrients, weed management planning, and ecologically compatible landscaping.

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

The habitat of *Tylophora woollsii* on the WC2U corridor comprises wet sclerophyll forest. The Project would remove habitat for this species in several areas and potentially lead to biophysical changes to areas of habitat. There is potential for the Project to alter habitat attributes of surrounding areas through indirect impacts which potentially include altering of hydrological and nutrient regimes within habitats downstream of the proposed development and edge effects. This could result in habitat changes, including increases in weed abundance, altered soil conditions and sedimentation. These changes may potentially lead to the area of occupancy of the population to be significantly reduced. However mitigation measures during construction and the implementation of specific design features into the proposed development are likely to minimise these indirect impacts. These would include: (i) measure to ensure that vegetation clearing is confined strictly to the construction footprint, (ii) measures to control sediment run-off (particularly sedimentation fencing) and (iii) ecologically designed landscaping.

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

The distribution of *Tylophora woollsii* extends from the outskirts of Sydney north the Qld border and into southeast Queensland, from the coast west to the Great Escarpment Ranges (Wildlife Atlas). *Tylophora woollsii* is in the central part of its coastal distribution in the Nambucca-Urunga area.

How is the Project likely to affect current disturbance regimes?

Current disturbance regimes potentially affecting *Tylophora woollsii* include:- (i) weed invasion by *Lantana camara*, (ii) bushfire, (iii) logging and adjacent clearing, as follows:-

(i) The Project is likely to contribute to further invasion of *Lantana camara* particularly along the edges of the Project where there would be increased sunlight availability. Other indirect impacts such as increased water and nutrients may also aid the growth of *Lantana camara*. Weed control during construction and operation of the highway would greatly reduce this threat to *Tylophora woollsii* habitat.

(ii) Bushfires in *Tylophora woollsii* habitat can start from arson, accidental ignition, control burning and lightning strikes. The Project may result in an increase in fire frequency due to fires started by arson or accidental ignition. Increase in fire intensity may result from changes in fuel characteristics in roadside vegetation, resulting in increased flammability. However, the number of fires resulting from roadside ignition has decreased significantly in recent decades due to increased environmental awareness, harsh penalties for causing fires and maintenance of roadside vegetation

(iii) Vegetation clearing is likely to change microclimate conditions in forest to a depth of 10-20 metres from the edge of the road corridor (Benwell 2010). This may in turn lead to an increase in weeds and sclerophyllous plants, producing a general increase in forest understorey density, which appears to create unsuitable habitat conditions for *Tylophora woollsii*. Such changes in habitat structure are reduced if no soil disturbance occurs beyond the limits of clearing. This can be ensured by mitigation measures such as strict controls on clearing, No Go zones and use of sedimentation fencing.

How is the Project likely to affect habitat connectivity?

Tylophora woollsii generally occurs in gully areas running perpendicular to the Project. Therefore suitable areas of habitat would be fragmented from the Project, with some subpopulations being dissected. Pollinator movements may extend across the proposed highway allowing exchange of genetic material between fragmented areas of habitat, assuming flying insects are the main pollinators, however as already discussed, populations of *Tylophora woollsii* persist by vegetative regeneraration rather than pollination and seed production. Individuals would generally remain on either side of the road corridor following direct impact to individuals through clearing of the construction footprint. Substantial numbers of plants are likely to occur in surrounding habitat not affected by the highway construction.

How is the Project likely to affect critical habitat?

No critical habitat has been identified for this species.

Revision of RTA (2010) - Appendix C Assessment of significance (EPBC Act)

C.1 Endangered species

C.1.2 *Tylophora woollsii*

Is the action likely to lead to a long-term decrease in the size of an important population

Tylophora woollsii was recorded at three locations on the WC2U corridor:- between Raleigh and the Kalang River, Newry State Forest and Nambucca State Forest. Nine individuals would be directly impacted and six would remain in-situ within the Road Reserve. Generally, the species appears to be rare in the local area; all individuals were small plants unlikely to flower in the near future. Note – there is an element of uncertainty regarding the identification of this species as its leaves are very similar to *Marsdenia longiloba*. Flowers are required for postive identification but have not been observed.

A population is defined as an occurrence of a species in a particular geographical area. There are no guidelines as to the size of this area, but usually it would cover relatively uniform habitat (i.e. vegetation and geology) and have distinctive geographical boundaries. On this basis, two populations of *Tylophora woollsii* can be recognised from the results of flora survey work:-

- Urunga to the Kalang River;
- Kalang River to the Nambucca River.

Substantial areas of potential habitat exist between the road corridor and the coast, which are likely to support further individuals.

An 'important population' is defined by DEH (2009) as a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in Recovery Plans, and/or that are:

- key source populations either for breeding or dispersal;
- populations that are necessary for maintaining genetic diversity; and/or
- populations that are near the limit of the species range.

The populations recorded in the study area are regarded as being "important populations", as relatively few populations have been recorded close to the coast. Several of the coastal occurrences are protected in reserves.

Road construction would impact directly on nine individual plants. In an attempt to avoid a decrease in the size of populations, translocation would undertaken to salvage and re-establish directly impacted individuals at suitable receival sites.

Reduce the area of occupancy of an important population

The area of occupancy would be reduced in these two impacted populations, although the linear nature of the Project limits the direct impacts to these populations. There is potential for the Project to contribute to indirect impacts through altering hydrological and nutrient regimes in habitats downstream of the proposed development which could potentially result in habitat changes, leading to the area of occupancy of the population to be significantly reduced. However mitigation measures during construction and the implementation of specific design features into the proposed development would potentially minimise these indirect impacts.

Fragment an existing important population into two or more populations

The project would intersect and cause some degree of fragmentation to two populations. Generally *Tylophora woollsii* has a sporadic distribution and occurs in low abundance. The species therefore has a naturally patchy or fragmented distribution, which is probably governed by soil type, topography and disturbance. A measure of connectivity would still remain between occurrences similar to that currently existing and probably enabling processes such as cross-pollination to occur.

Adversely affect habitat critical to the survival of the species

Habitat critical to the survival of a species refers to areas that are necessary:

- For activities such as foraging, breeding, roosting, or dispersal.
- For the long-term maintenance of the species including the maintenance of other species essential to the survival of the species, such as pollinators.
- To maintain genetic diversity and long-term evolutionary development.
- For the reintroduction of populations or recovery of the species.

Habitat supporting populations is directly impacted by the project, but loss of this habitat is not considered critical to the survival of the species, as the area of habitat is not great relative to the extent of potential habitat available and there does not appear to be anything particularly special or different about the habitat to be removed. Direct impacts would be limited to the proposed development area comprising a relatively small area of the available habitat for this species in the local area. There is potential for the Project to contribute to indirect impacts through altering hydrological and nutrient regimes. Mitigation measures would limit the degree of indirect impacts to the surrounding areas of *Tylophora woollsii* habitat.

Disrupt the breeding cycle of an important population

Breeding cycle processes such as pollination and seed production have not been studied in this species. The road corridor by reducing the area of occupancy and the extent of potential habitat may reduce the potential for cross-pollination between sub-populations. The vigour of *Tylophora woollsii* may be indirectly impacted by changes in hydrology and soil nutrient status, thereby affecting the breeding cycle of individuals. Mitigation measures including sediment and erosion control and weed control would limit the degree of indirect impacts on this species.

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

The Project would decrease the area of habitat available for *Tylophora woollsii*, including moderately disturbed or degraded areas impacted by logging and weed invasion. Indirect impacts from the Project would potentially contribute to these existing threatening processes through altering hydrology and nutrient regimes; however these impacts can be limited through the implementation of mitigation measures. Although *Tylophora woollsii* seems to be resilient to some habitat disturbance, further disturbances may lead to declines in the population. Considering the linear nature of the proposed development which runs perpendicular to most of the gully habitats where *Tylophora woollsii* occurs, habitat removal would be limited to the direct impact area and relatively extensive areas of habitat would remain surrounding the Project.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species habitat

The Project could potentially result in the spread and aid the growth of invasive species currently present such as *Lantana camara*. Changes to hydrological and nutrient regimes in these areas as a result of the Project may further encourage weed growth.

Mitigation measures would be implemented to minimise impacts from nutrient loads, sedimentation and altered hydrology regimes. Weed management should be implemented during the construction phase of the Project to limit the spread of exotic weed species, including appropriate disposal of exotic vegetative material and propagules.

Introduce disease that may cause the species to decline

Diseases potentially affecting native vegetation in the study area include Root Rot Fungus (*Phytophora cinnamomi*) and Myrtle Rust. *Phytophora* is not a threat to plant communities on the NSW North Coast where this pathogen appears to be indigenous and the flora adapted to it. Myrtle Rust would not affect *Marsdenia longiloba* as it only affects plants in the plant family Myrtaceae (not the Apocynaceae). To minimise the chance of introducing new plant pathogens, machinery would be washed down before moving from area to area and personnel excluded from walking through habitat areas unless necessary.

Interferes substantially with the recovery of the species

The Project would not conflict with the recovery actions proposed for *Tylophora woollsii*. Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protecting fencing, ongoing monitoring of populations and weed control within habitat areas.

Conclusion

Based on the above assessment, *Tylophora woollsii* is unlikely to be significantly impacted by the WC2U project. As such a referral under the provisions of the EPBC Act is not recommended for this species.

C.3 Vulnerable species

C.3.1 *Marsdenia longiloba*

Marsdenia longiloba (Slender Marsdenia) is a small species of vine found in rainforest and wet sclerophyll forest at scattered locations from Barrington Tops north to southeast Queensland (NPWS 2002b). This species has mostly been recorded as occurring in low abundance in small population clusters. The populations recorded in the study area consist of scattered individuals occurring in the understorey with various ferns, herbs and other twiners in moist eucalypt forest with an open to dense rainforest subcanopy.

Translocation and monitoring of *Marsdenia longiloba* for the Bonville Upgrade in the Coffs Harbour LGA provided insight into various aspects of the life history of this species. Life history attributes reported by Benwell and Watson (2011) included:

- *Marsdenia longiloba* is a perennial, rhizomatous vine.
- Sub-populations are composed almost entirely of ramets or single stemmed plants produced from an underground rhizome; several plants or ramets may be attached to the same rhizome system.
- Above ground stems are comparatively short-lived (1-3 years), while the rhizomes are probably more long-lived.
- The rhizomes are relatively thin, 10-30cm long and grow horizontally within the soil A1 horizon (occasional vertical rhizomes may also be present); the rhizomes branch off each other, often at right angles, and may separate to form discrete plants.
- Stems may die back to the rhizome and the plant remain stem-less and apparently dormant for up to two years (probably longer), then produce new stem shoots.
- Most stems never grow more than 30cm tall before dying back.
- Only large stems (ie >1m tall) produce flowers; production of pods and seed is extremely rare; only 1 pod has ever been recorded during several years of monitoring at several locations.
- *Marsdenia longiloba* appears to rely on vegetative reproduction for population persistence; flowering and seed dispersal play a minor role in this process.
- Discrete sub-populations and patches of *Marsdenia longiloba* probably originate vegetatively from the same parent plant and spread over a considerable area (e.g. 0.04 ha)
- *Marsdenia longiloba* stems are conspicuously absent from recently (<1-6 yrs) logged and contolled burned forest. Monitoring of translocated plants showed that dormant, stem-less rhizomes may persist in recently disturbed forest. This suggests that conditions during early post-disturbance succession may not be favourable for growth of *Marsdenia longiloba,* and stem growth and flowering may occur mainly during mid to late stages of succession.

The last hypothesis requires further study. In particular, the response of *Marsdenia longiloba* to fire has never been systematically monitored.

Is the action likely to lead to a long-term decrease in the size of an important population

A population is defined as an occurrence of a species in a particular geographical area. There are no guidelines as to the size of a population or the area the population is contained in, but usually it would cover a relatively uniform area of habitat or terrain (i.e. vegetation and geology) and have distinctive geographical boundaries. On this basis, four populations of *Marsdenia longiloba* can be recognised from the results of the targeted survey of the WC2U corridor conducted in 2011:

- between Urunga and the Kalang River;
- Newry SF, Little Newry SF and adjoining private property;
- Nambucca SF and adjoining private property; and
- Warrell Creek South (which likely extends to the Mt Yarrahappini area).

The road corridor intersects a considerable number of sub-populations within each of these populations. However, substantial areas of potential habitat extend beyond the road corridor, which are likely to support additional individuals. The EA showed that sub-populations extended for at least 250 metres from the highway centreline. Generally this species has been recorded as occurring in low abundance in small population clusters throughout its range.

An ‘important population’ is defined by DEH (2009) as a population that is necessary for a species’ long-term survival and recovery. This may include populations identified as such in Recovery Plans, and/or that are:

- key source populations either for breeding or dispersal;
- populations that are necessary for maintaining genetic diversity; and/or
- populations that are near the limit of the species range.

The populations recorded in the study area are regarded as being “important populations” as they are relatively large populations. The populations are likely to extend further upstream and downstream of the road corridor where it intersects drainage lines in hill and gully topography, and therefore consist of larger populations than recorded.

Individuals in close vicinity to the road corridor may be indirectly impacted through changes in micro-climatic, potential increases in weed invasion and sedimentation, and potential changes in hydrology. This may adversely affect individuals within 10-20 metres of the roadside. These indirect (edge) impacts can be minimised by confining vegetation clearing strictly to the construction footprint, sediment and erosion control measures and ecologically designed landscaping. Translocation of directly impacted *Marsdenia longiloba* to adjacent habitat will be undertaken to maintain population size and genetic diversity. This would also be undertaken in conjuction with research on aspects of the species ecology and population dynamics.

Reduce the area of occupancy of an important population

In the four impacted populations, individuals would be retained on one or both sides of the road, with direct impacts limited to the road footprint. The area of occupancy would be reduced in these four impacted populations, although the linear nature of the Project limits the direct impacts to these populations. There is potential for the Project to contribute to indirect impacts through altering hydrological and nutrient regimes in habitats downstream of the proposed development which could potentially result in habitat changes, leading to the area of occupancy of the population to be significantly reduced. However mitigation measures during construction and the implementation of specific design features into the proposed development would potentially minimise these indirect impacts.

Fragment an existing important population into two or more populations

The project would intersect four populations causing breaks in habitat up to 80-150 metres wide. Generally this species has been recorded as occurring in low abundance in small population clusters, therefore it tends to have a naturally patchy or fragmented distribution. This patchiness is governed by topography and disturbance (logging, clearing and fire). A measure of connectivity would still remain between plants on either side of the road corridor, enabling processes such as cross-pollination to occur, although as discussed, *Marsdenia longiloba* appears to rely on vegetative reproduction for population persistence at a given locality. Also, substantial areas of potential habitat would remain on either side of the road corridor allowing large-scale population processes to continue such as changes in population dynamics at different stages of secondary succession.

Adversely affect habitat critical to the survival of the species

Habitat critical to the survival of a species refers to areas that are necessary:

- For activities such as foraging, breeding, roosting, or dispersal.
- For the long-term maintenance of the species including the maintenance of other species essential to the survival of the species, such as pollinators.
- To maintain genetic diversity and long-term evolutionary development.
- For the reintroduction of populations or recovery of the species.

Habitat supporting important populations is directly impacted by the project, but loss of this habitat is not considered critical to the survival of the species, as the area of habitat is not great relative to the extent of habitat available and there does not appear to be anything particularly special or different about the habitat to be removed compared with the area remaining.

The habitats where *Marsdenia longiloba* was recorded included moderately disturbed and degraded areas impacted by weed invasion, logging activities, fire and cattle grazing. There were better quality pockets of native vegetation cover where the majority of *Marsdenia longiloba* individuals were recorded. Direct impacts would be limited to the proposed development area comprising a relatively small area of the available habitat for this species in the local area. There is potential for the Project to contribute to indirect impacts through altering hydrological and nutrient regimes in habitats downstream of the proposed development, which could potentially result in habitat changes, leading to further weed invasion in areas of habitat downstream. Although mitigation measures would potentially limit the degree of indirect impacts to the surrounding areas of habitat for *Marsdenia longiloba*, the Project is likely to contribute to existing threatening processes in close vicinity to the road corridor (i.e. <20-50m). *Marsdenia longiloba* is reserved in several National Parks in northern NSW and southeast Queensland. Better quality examples of habitat are likely to be present within these conservation reserves where threatening processes are limited.

Disrupt the breeding cycle of an important population

Marsdenia longiloba appears to rely on vegetative regeneration and reproduction for persistence at a location. Growth appears to be suppressed during the early stage of post-disturbance secondary succession, for example after fire or logging. Flowering is uncommon and seed production is extremely rare at any time. Clearing would tend to induce secondary succession close to the cleared road corridor and therefore suppress it growth and reproduction. This effect can be reduced to a narrow band only a few metres wide if clearing is confined strictly to marked clearing boundary and soil disturbance beyond the boundary does not occur. Sedimentation fencing is very effective in this regard, by preventing soil spillage. The project is unlikely to disrupt the breeding cycle of *Marsdenia longiloba* as vegetative reproduction can continue and in the event of any flowering there would be opportunities for cross-pollination amongst individuals remaining on one or both sides of the road corridor.

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

The Project would decrease the area of habitat available for *Marsdenia longiloba*, including moderately disturbed and degraded areas impacted by weed invasion, logging activities and fire. Indirect impacts from the Project would potentially contribute to these existing threatening processes through altering hydrology and nutrient regimes. These impacts can be limited through the implementation of suitable mitigation measures. Although *Marsdenia longiloba* seems to be resilient to some habitat disturbance, further disturbances may lead to declines in the population. Considering the linear nature of the proposed development, which runs perpendicular to most of the gully habitats where *Marsdenia longiloba* occurs, habitat removal would be limited to the direct impact area and relatively extensive areas of habitat would remain surrounding the Project.

Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species habitat

The Project could potentially result in the spread and aid the growth of invasive species currently present in the population of *Marsdenia longiloba* such as *Lantana camara*. Changes to hydrological and nutrient regimes in these areas as a result of the Project may further encourage weed growth.

Mitigation measures would be implemented to minimise impacts from nutrient loads, sedimentation and altered hydrology regimes. Weed management should be implemented during the construction phase of the Project to limit the spread of exotic weed species, including appropriate disposal of exotic vegetative material and propagules.

Introduce disease that may cause the species to decline

Diseases potentially affecting native vegetation in the study area include Root Rot Fungus (*Phytophora cinnamomi*) and Myrtle Rust. *Phytophora* is not a threat to plant communities on the NSW North Coast as cases of Phytophora dieback are rarely reported from this region. *Phytophora cinnamomi* has been isolated from rainforest in eastern Australian soils where appears to be indigenous and the local flora adapted to its presence in the soil.

Myrtle Rust would not affect *Marsdenia longiloba* (family Apocynaceae) as it only affects plants in the plant family Myrtaceae. To minimise the chance of introducing new plant pathogens, machinery would be washed down before moving from area to area and personnel excluded from walking through habitat areas unless necessary.

Interferes substantially with the recovery of the species

The Project would not conflict with the recovery actions proposed for *Marsdenia longiloba*. Some recovery actions could potentially be implemented for the individuals that are proposed to be retained surrounding the proposed development including protecting fencing, ongoing monitoring of populations and weed control within habitat areas.

Conclusion

Given the linear footprint of the WC2U project and the widespread distribution of *Marsdenia longiloba* in the Nambucca district and the Mid North Coast, it is considered unlikely this species would be significantly impacted by the project. As such a referral under the provisions of the EPBC Act is not recommended for this species.

APPENDIX 9: DETAILS OF CONSULTATION- RESPONSE TO EPA COMMENTS

ENVIRONMENT PROTECTION AUTHORITY - COMMENT SHEET

RMS response dated 12/12/2012 to EPA comments dated 20/7/2012

Project:	Pacific Highway Upgrade Warrell Creek to Urunga		
Document title:	Threatened Plant Species Management Plan		
Revision No.:	22 April 2012		
Reviewer name:	Craig Harré	Review date:	20/07/12

Report Reference	EPA Comments	Response
3.5.5 Maundia	Clarify if the in-situ population is included in the monitoring proposal.	The in-situ population is included in the monitoring proposal - see Section 3.5.5 (p.84), specifically, "(iii) Inclusion of *Maundia triglochinodes* into the Ecological Monitoring Program required for the WC2U project to determine the impact on adjoining *Maundia triglochinoides* during construction and operation, which is to include a component investigating and clarifying the life history attributes and population dynamics of the species" (p. 46)
3.5.6 Floyds Grass	Advise how the translocated Floyds Grass is performing now. Is long term management needed?	The translocated Floyds Grass at Bonville is still performing well. It covers about 80% of the low lying area within the fenced enclosure up to the creek bank. There has been increase of the native fern species Hypolepis muelleri (Harsh Ground Fern) which can smother Floyds Grass, but it is only likely to displace part of the translocated population. Monitoring of the population is due again in October 2012.
3.5.9 Other species	Refer to Herons Creek apparently successful translocation efforts or any lessons with *Artanema fimbriatum.*	Rachael Bannister of BMD was contacted regarding the outcome of the Artanema fimbriatum translocation at Herons

Report Reference	EPA Comments	Response
		Creek. She said there had been no systematic monitoring or reporting on the translocation, but that translocated plants had reshot after dying back in winter. The translocation was carried out using the direct transplanting method – ie transplanting directly into the receival site.
3.6.2 Assessing Translocation Outcomes	The document recognises the inconsistency between biodiversity offsetting requirements which are to be informed in some future time by translocation feasibility and success. EPA agrees with the rationale presented in this discussion and notes that translocation is a mitigation measure, not an offset. Therefore by following the suggested approach by establishing viable translocated populations, plus acquiring offset land containing targeted threatened species at a ratio of 4:1 there should be a net gain for the species.	Yes I would agree with this assessment – ie. the conservation status of the species would be improved.
3.6.4 Process for….8) 4th dot point	The timing is unlikely to be favourable to facilitate this process.	4) Determine the area of habitat of the threatened species impacted. Habitat of the threatened species could be determined from vegetation and terrain mapping – e.g Slender Marsdenia occurs in moist to wet sclerophyll forest on mid to lower hill slopes. This could be done manually then digitised to calculate the area.
4.2.3 Designing Translocated Populations	What is the size of the original population that these threatened species will be removed from? Also, will this remnant population maintain an effective MVP?	The boundary of the original population area would have to be defined, for example: “Plants found within a radius of 2 to 5km on the same habitat (ie geology and vegetation type)” has been used as a definition of a local population in previous translocation plans for the purposes of local impact assessment and for provenance seed collection. In the case of MVP’s the population unit may be smaller depending on how it is defined, such as the area in which cross-pollination between individuals, or seed dispersal can occur, probably <1km. MVP’s differ according to plant growth form and breeding system – ie trees have different MVPs to herbs. It’s a complicated subject, as discussed in Sec. 4.2.3. Pavlick

Report Reference	EPA Comments	Response
		1996 provides some general guidelines.
4.3.3 Selection of the Receival Site	State Forest – this seems to offer the greatest number of benefits in terms of protection as long as the site is in FMZ 3 or better. However, the feasibility and likelihood of this occurring should be explored now by RMS to gain an understanding on whether this is likely to be permitted in SF. Road Reserve – not preferred given the problems cited in the document unless there are plans for larger areas of road reserve in the appropriate locatin to facilitate this action. RMS purchased properties	Preliminary discussions will be conducted with Forests NSW to determine the feasibility of using receival sites in management zones FMZ3 or similar, specifically the visual amenity strip adjoining the new highway corridor. Agreed that the Road Reserve is generally not suitable as a receival site.

ENVIRONMENT PROTECTION AUTHORITY - COMMENT SHEET

RMS response dated 25/2/2013 to second round of EPA comments dated 17/12/2012

Project:	Pacific Highway Upgrade Warrell Creek to Urunga		
Document title:	Threatened Plant Species Management Plan		
Revision No.:	12/12/2012		
Reviewer name:	Craig Harré	**Review date:**	17/12/2012

EPA Comments	Response
1. The EPA does not support attempts to	Translocation is defined by ANPC (2004) as 'The deliberate transfer of plants or

translocate *Maundi triglochinoides*. Please refer to EPA comments for the Frederickton to Eungai section of the Pacific Highway Upgrade regarding translocation feasibility and the RMS justification for not attempting translocation. In summary the EPA believes *Maundia* presents as a ‘boom and bust’ species that is highly responsive to favourable rainfall conditions. Rather than undertaking a risky and uncertain translocation exercise under conditions and within habitat that may not be favourable for *Maundia* proliferation, the EPA suggests the following points for consideration as an alternative: identify or facilitate creation of suitable habitat adjacent to the upgrade, ensure there is hydrological connectivity to remnant or other known *Maundia* populations, salvage directly impacted *Maundia* seed (purportedly viable for long periods) and sow within the adjacent habitat under ideal conditions. Also focus on protecting in situ individuals and encouraging ‘*Maundia* friendly’ design features in drainage areas and under bridges.	regenerative plant material from one place to another, including existing or new sites or sites where the taxon previously occurred.” Translocation can be implemented using a range of different methods including transplanting and seeding into habitat. The seed introduction method would be just as risky and uncertain as transplanting, as it has never been tried for this species and there are other difficulties such as identifying suitable long-term habitat or creating such habitat. Maundia produces a hard seed, which is relatively large for a wetland herb (2-3mm long), and the seed is reported by the Royal Botanical Gardens to be difficult to germinate. Maundia appears to have undergone large population expansion in the F2E area on the Collombatti floodplain, which is probably because swamp habitat on this floodplain is subject to large fluctuations in extent (it has a network of drains so isn’t as stable as it originally was). However, Maundia is also found in relatively deep and permanent water bodies including lagoons, sluggish drainage lines and farm dams where it does not exhibit boom and bust. On WC2U, the population on Williamson’s Creek grows in a permanent drainage line in deep water (>0.5m); plants have been observed there for two seasons. Rather than boom and bust, it is more true to say that Maundia has a capacity for rapid population increase under favourable habitat conditions. This is due to its rhizomatous growth habit as well as seed dispersal – see photos 21&22 in Benwell report for F2E. The latter report attributed the apparent increase in Maundia at F2E to several years of above average rainfall and consequent increase in swamp habitat (Benwell 2012 sec.3.3 ver. 1). Given the poor results from previous translocation attempts for this species it is recommended that only those plants within the footprint be removed and that the threats for the remaining individuals be managed. (Pasons Brinkerhoff 2007, Technical Report 2, Appendix A, p. A-9). Management would focus on Maundia remaining in the road reserve and on directly adjoining land.

	During detailed design, emphasis would be placed on minimising impacts to threatened species such as Maundia and Floyds Grass to protect in situ individuals. Management measures on WC2U would be similar to those adopted for Maundia on F2E, as follows: (a) investigate engineering solutions, undertake design optimisation and adopt design and construction solutions which: (i) minimise the footprint of the Project Works and Temporary Works adjacent to areas of Maundia triglochinoides; (ii) precisely locate proposed construction and operational water quality treatment facilities to avoid direct and indirect impacts on Maundia triglochinoides; and (iii) ensure that, during construction and operation of the Project Works, the drainage paths and the quantity and quality of water, both surface and subsurface, are maintained to Maundia triglochinoides populations; (b) identify all Maundia triglochinoides populations on environmentally sensitive area mapping and in the Design Documentation as exclusion zones; (c) locate ancillary facilities for the Contractor's Work to avoid direct and indirect impacts on Maundia triglochinoides; (d) address any of the Contractor's Work that is undertaken within 100 m of Maundia triglochinoides in a site specific environmental work method statement; (e) Erect and maintain sediment fencing around all areas of Maundia triglochinoides that are affected by the Contractor's Work; and (f) include in the urban and landscape design specific landscaping / revegetation measures to buffer the areas adjacent to Maundia triglochinoides populations with appropriate vegetation. Also, in line with the F2E report ver.1 section 3.3, point (iii): The Ecological Monitoring Program for WC2U would include monitoring of in-situ Maundia within and adjoining the project boundary to assess the effectiveness of management measures (a) to (f) listed above. This will entail a series of 'control' and 'potential impact' (ie adjoining construction) reference plots to be monitored for a minimum of five years.

2. The EPA draws attention to the Floyds Grass population on this project. Given the presence of Floyds Grass, has the project considered the possible impact on the Black grass-dart? Has this endangered species been recorded on this local population of Floyds Grass? If this species is recorded on Floyds Grass, the case for translocation would be strengthened.	2a. The design of the Warrell Creek bridge crossing currently does not directly impact on Floyds Grass and the Threatened Flora MP (sec. 4.4.5) does not propose to translocate the species, rather manage it in-situ unless this proves to be impractical in light of the detailed design. 2b. If it became necessary to translocate Floyds Grass, a targeted survey for the Black grass dart would be conducted by an appropriately qualified and experienced expert who would also advise on how best to manage the Black grass dart in this context. 2c. Floyd's Grass habitat was examined for presence of the Black grass-dart during survey work for the WC2U MP, but none were observed. The Warrell Creek site was surveyed in November-December 2011. The Black grass-dart was observed at Bonville between Feb and April on sunny days (Ecos Environmental 2009), so the survey at Warrell Creek may have been too early to detect the species. Any survey would be conducted at a time and during weather when the butterfly is known to be active – ie sunny days in Feb-March.
3. The EPA notes the high number of proposed *Marsdenia* individuals proposed for translocation. Given the low to moderate translocation success rate for this species is it prudent to translocate 151 individuals? Rather than attempting to translocate all impacted individuals why not take a representative sample of each sub-population?	3a. Yes, the translocation success rate for this species in the past was low. Previously on the Bonville project the species was transplanted to pots then stabilised and grown-on under nursery conditions before planting-out in the wild. The plants thrived under pot cultivation and after introduction for the first year, but then tended to go into decline (not all individuals). A likely reason for this decline is considered to be root competition from surrounding species which grew into the root space of Slender Marsdenia because of the soil amelioration/enrichment applied at planting-out, including slow release fertiliser. The latter attempt to stimulate growth in Slender Marsdenia appeared to have the opposite effect by promoting root competition from other species. The translocation proposal for WC2U is designed to test this hypothesis by directly transplanting the species (rather than growing it pots first) and not adding fertiliser. A subset (~25%) would receive fertiliser to provide a comparison which could be tested statistically. 3b. Most Slender Marsdenia individuals are small plants and can be transplanted with a spade and mattock, so a substantial number can be moved in a relatively short time

	compared to trees that require machinery. 3c. A good sized sample would provide a better test of different translocation methods/introduction conditions. 3d. The WC2U upgrade will be built in two stages. According to the MP a total of 105 Slender Marsdenia were directly impacted on the northern half and ~60 on the southern half. RMS proposes to under-take translocation of Slender Marsdenia on the northern section (NH2U) as described in the Threatened Flora Management Plan. Translocation of Slender Marsdenia on the southern half (probably to commence 2-3 years after NH2U) would not be carried out unless testing of the revised translocation method resulted in a marked improvement in survival rate and establishment. Note - the numbers of Slender Marsdenia requiring translocation is likely to be subject to slight variation between 2011(the targeted survey for the MP) and when the translocation is carried out, as some ‘shoot-individuals’ will die back and other new ones appear. (A pre-clearing/pre-translocation survey conducted by the contractor will update this data.)

APPENDIX 10: SPECIFIC BACKGROUND INFORMATION AND MANAGEMENT MEASURES FOR SLENDER MARSDENIA (*MARSDENIA LONGILOBA*) FOR THE WARRELL CK TO NAMBUCCA HEADS PROJECT (STAGE 2 OF THE WC2U PROJECT)

(Note – the information below is taken from the main body of the WC2U TFM Plan above. Additional generic measures to be applied to management of threatened flora, including *Marsdenia longiloba,* are set out in the complete WC2U TFM Plan)

3.4 SURVEY RESULTS

3.4.1 Summary

Five threatened species, one ROTAP species and one species recommended for threatened species listing were recorded during the targeted survey:-

Threatened
Slender Marsdenia (*Marsdenia longiloba*), a small vine.
Rusty Plum (*Niemeyera whitei*), a medium sized rainforest tree.
Maundia (*Maundia triglochinoides*), an aquatic, emergent herb.
Floyds Grass (*Alexfloydia repens*), a mat forming grass.
Wooll's Tylophora (*Tylophora woollsii*), a small vine.

ROTAP
Ford's Goodenia (*Goodenia fordiana*), a mat forming herb.

Potential Threatened Species Listing
Koala Bells (*Artanema fimbriatum*), a perennial herb of coastal forests.

Results of spatial impact analysis for WC2NH are summarised in Table 3B. These show the number of individuals of species directly impacted, indirectly impacted and to remain in situ for the WC2NH Project. Threatened and rare flora records were classed as either:
(i) directly impacted:-

- Under the concept design footprint plus **15 metres**.
- Under the operational water quality basins plus 10 metres.
- Under new or reconstructed access roads within Nambucca State Forest plus 10 metres.
- For utility adjustments within clearing requirements of utility authorities.
- Within three metre clearing width for boundary fencing - excluding within Nambucca State Forest and swamp forest where a flying fox camp is located.

(ii) indirectly impacted (within 10m of the direct impact zone) or
(iii) in-situ within the road reserve (outside the indirect impact zone but within the project boundary).

Detailed maps of threatened and rare species locations on WC2NH showing the type of impact (direct, indirect and in-situ) can be found in Appendix 1, Sheets 8 to 13.

Table 3B - Threatened and rare flora impacted by the WC2NH project

Southern WC2NH section	**Directly Impacted**		**Indirectly Impacted**		**Road Reserve - in-situ**	
Threatened Species	points	no.	points	no.	Points	no.
Slender Marsdenia (E) (*Marsdenia longiloba*)	43	75	2	4	1	1
Rusty Plum (V) (*Niemeyera whitei*)	10	10 +sdg	0	0	0	0
Maundia (V) (*Maundia triglochinoides*)	~500+ m^2		~50 m^2		~50 m^2	
Floyds Grass (E) (*Alexfloydia repens*)	1	~2m^2	2	~2m^2	1	~2m^2
Wooll's Tylophora (E) (*Tylophora woollsii*)	2	2	0	0	0	0
Spider Orchid (E) (*Dendrobium melaleucaphilum*)	3	10	0	0	0	0
ROTAP						
Ford's Goodenia (*Goodenia fordiana*)	2	2m^2	1	1m^2	0	0
Potential Threatened Species Listing						
Koala Bells (*Artanema fimbriatum*)	2	13	0	0	0	0

3.4.2 Slender Marsdenia (*Marsdenia longiloba*)

Locations

Slender Marsdenia was recorded in small sub-populations scattered along the length of the WC2NU road corridor. Eighty individuals ('stem-individuals) were recorded and 15 different sub-populations identified between Warrell Creek and Nambucca Heads. (Sub-populations' were defined as geographically separate records at least 100m apart). The great majority of recorded points were within the zone of direct and indirect impact, as survey work was concentrated on the construction footprint and indirect impact zone.

Directly impacted

- o A total of 43 gps points representing 75 individuals ('stem-individuals) are directly impacted. These represent 11 different sub-populations (4 identified sub-populations were outside but close to the project boundary).

Indirectly impacted

- o A total of 2 gps points representing 4 individuals are indirectly impacted.

In-situ within road reserve

- o One point representing 1 individual would remain in-situ within the road reserve. Additional individuals may be present in the outer part of the road reserve, as survey work was focused on the footprint.

Slender Marsdenia is a small vine growing to a maximum height of about 5m. Most plants recorded during the survey were much smaller than this, generally less than 0.5m tall and with few leaves (Table 4). Two plants with flowers were recorded and one plant with seed pods was recorded. Seed pods of this species are extremely rare (Harden 1992), so reproduction appears to occur vegetatively by root spread and suckering and only very rarely by seedling recruitment, although this requires further studies to confirm.

Plate 1: Small individual Slender Marsdenia plant with smooth, hairless, opposite leaves.

Plate 2: Typical Slender Marsdenia habitat in wet sclerophyll forest with understorey of small rainforest trees, shrubs and ground ferns, and open litter or fern covered ground layer, the roughed barked tree is Turpentine.

Plate 3: Only one plant of Slender Marsdenia was found with flowers. ML-42

Table 4: Size class distribution of Slender Marsdenia points

Size Class - Height (largest stem-individual if more than one present)	**Number of Individuals (Percent)**
<0.5 m	70%
0.5 - 1 m	14%
1 - 1.5 m	12%
1.5 - 2 m	4%

Habitat

Found in moist open forest and gradational subtropical and warm temperate rainforest, mostly below 200m altitude (Quinn *et al.* 1995). Characteristics of Slender Marsdenia habitat recorded on the WC2U road corridor included: -

- soil type a yellow to red clay podzol formed on Permian metasediments;
- soil A-horizon 15-30cm deep, dark brown, humus enriched topsoil;
- wet sclerophyll forest with an open to mid dense rainforest understorey usually on a lower slope;
- sloping (gentle to moderate) and well drained, often with a southern aspect;
- understorey moderately well lit and open, not dense or heavily shaded;
- topsoil only slightly acidic (pH >6).

The total area of modelled potential habitat of Slender Marsdenia on the southern half of the WC2U project (WC2NH) has been estimated as 17.8 Ha (Jacobs SKM 2014).

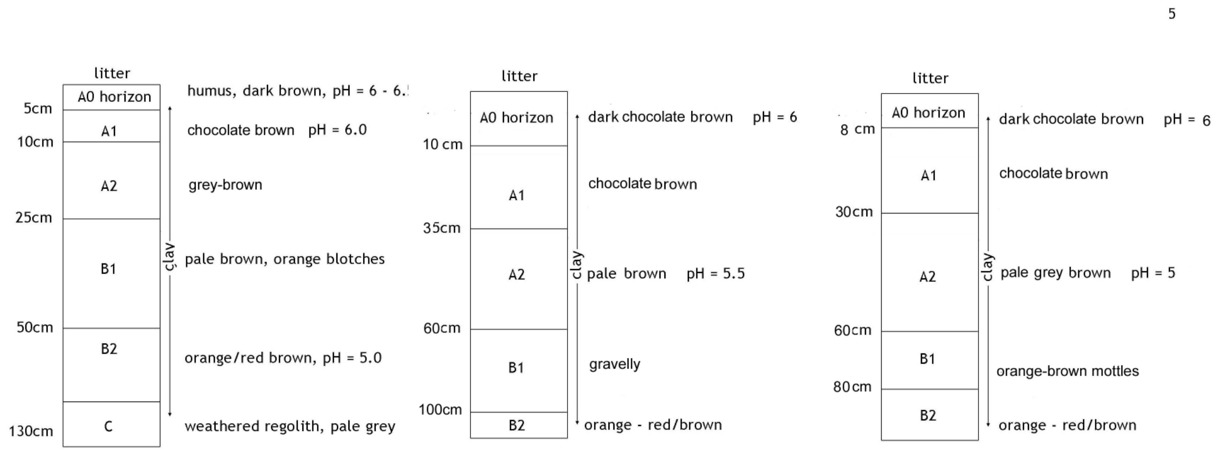

Figure a: Soil Profile at Mardenia longiloba site in Nambucca State Forest

Figure b: Soil Profile at *Niemeyera whitei* site at Cockburns Lane, Warrell Creek

Fiigure c: Soil Profile at *Acronychia littoralis* site at Deep Creek near Valla Beach

Figure 2: Representative soil profiles at threatened species sites on the WC2U/ WC2NH corridor.

3.5 DISCUSSION - Translocation Feasibility

3.5.1 Introduction

This section discusses the feasibility of undertaking salvage translocation of each of the threatened species directly impacted by the WC2NH project, as required by Condition of Approval B7. (Translocation of some additional individuals, indirectly impacted under the current road design, may become necessary if the detailed road design changes after awarding the contract.) The feasibility of undertaking salvage translocation is assessed in terms of several factors including: -

- technical feasibility;
- potential for generation of new and useful scientific information; and
- availability of receival sites with suitable habitat and security of tenure.

These factors were drawn from the translocation principles set out in DECC (2007) “Translocation Policy and Guidelines” (Draft), specifically Policy Principles 1 to 4 (‘General’) and 22 (‘Translocation in context of development consent and approval’). The overall thrust of these principles is that the potential conservation, scientific and educational benefits of translocation should outweigh the potential risks and costs.

3.5.2 Slender Marsdenia (*Marsdenia longiloba*)

Technical feasibility

Slender Marsdenia has been translocated on two previous highway upgrade projects: Bonville Deviation (Benwell and Watson 2011) and Sapphire to Woolgoolga (Benwell 2011). Results for the latter two projects demonstrated that this species has the potential to be translocated successfully.

Bonville Upgrade

Approximately 100 Slender Marsdenia were translocated from the road corridor of the Bonville Upgrade south of Coffs Harbour to two receival sites in 2006-7. Excavation of plants revealed that stems grew from a horizontal rhizome network at a depth of 5-10cm. Stems connected to a piece of rhizome (‘stem-individuals’) and stemless rhizome pieces were transplanted to pots in October 2006 and grown-on before planting out in the field. Ninety percent of plants and rhizomes survived transplanting to pots and grew rapidly in response to watering and fertiliser.

The potted plants were introduced to two translocation receival sites. The first site (TA1) was planted with 27 vines in February 2007 and the second site with 64 vines in February 2008.

In TA1, the vines grew well for the first six months, but had declined noticeably in vigour after 12 months. After 2 years the survival rate of stem individuals in TA1 was 33%.

In TA2, the 64 vines were planted ou to compare the species’ performance on two soil types present at this site – grey clay loam with quartz gravel in the northern half of the site and brown clay loam in the southern half. A similar pattern of stem dieback and decline as recorded in TA1 was recorded in TA2, on both soil types. Plants showing stem dieback were excavated in winter 2009 and the rhizome system was found to be alive and healthy, but apparently in a dormant or suppressed state, at nearly all planting points. As the rhizome was still alive, the actual survival rate of transplants appeared was substantially higher (~ 80%) than that based on live stems (~25%). Live rhizomes were also found in a sample of plants that had died back in TA2. The decline was even more rapid, the survival rate falling to 22% after one year. After 4 years (2011) the survival rate of stem individuals was 26%, (minor re-shooting in TA2) about the same as TA1.

Monitoring of naturally growing local Slender Marsdenia populations in the road reserve showed no evidence of a seasonal growth pattern, rather new shoot growth could be found at any time of year, even in spring when the soil was relatively dry. There was no obvious relationship between shoot dieback and planting depth, or site variables such as aspect or soil type. However, stem dieback did appear to be induced by the planting treatment. Slow release fertilizer and hay mulch were used at both TA1 and TA2 to stimulate the growth of Slender Marsdenia. After the poor performance of Slender Marsdenia at TAI (planted a year earlier), larger planting holes were dug at TA2 and filled with humus enriched topsoil gathered from the adjacent forest. Slow release fertiliser was again added to the soil, as at TA1. This additional site preparation appeared to result in faster rate of decline after planting out.

The following hypothesis was proposed to explain the decline of Slender Marsdenia recorded in the Bonville translocation project. Slender Marsdenia is a small vine able to compete and co-exist with shrubs and trees by utilizing nutrients released in the topsoil by decomposition of organic matter. It can apparently do this efficiently when nutrients are produced steadily at very low concentration, as in humus enriched topsoil. When artificial fertiliser is added to the soil, it stimulates the roots of shrubs and trees to grown into the root zone of Slender Marsdenia causing increased interspecific root competition with Slender Marsdenia. This suppresses Slender Marsdenia growth and prevents stem growth and replenishment of rhizome food storage, causing the plant to eventually die. In summary, it is hypothesized that Slender Marsdenia is unable to absorb sufficient nutrient under conditions of high interspecific root density or competition.

To test this hypothesis, Slender Marsdenia translocated on WC2U will be directly transplanted to receival sites and planted with and without slow release fertiliser; no other soil improvement will be carried out. If the hypothesis is correct, then Slender Marsdenia plants translocated without addition of slow release fertiliser should show a higher survival rate.

Sapphire to Woolgooga Upgrade

A small number of Slender Marsdenia was transplanted on the Sapphire to Woolgoolga Upgrade. As on the Bonville project, the plants were transplanted first to pots and grown-on before planting out. Eight stem-individuals were introduced to the receipient site in March 2011. Five of these were transplanted stem-individuals and three were grown from rhizome pieces. The plants were introduced without fertiliser or any other nutrient enrichment except for a small amount of cane mulch. All were surviving in October 2011, but by October 2012 most had died back. Although the number of replicates was small, the results show a similar translocation response to the Bonville project (Ecos Environmental 2012). This could be related to the use of cane mulch, which if fairly rich in nutrient, or the cultivation in pots prior to planting out may be the operative factor leading to dieback.

Translocation Benefits

The following conservation, scientific and educational benefits would flow from the salvage translocation of this species on the WC2NH project: -

- Preservation of a high conservation value species (Endangered). Relatively few populations are known to exist.

- Translocation of this species is technically feasible as successful transplanting, propagation and introduction have been carried out before (Benwell and Watson 2011), although further research and trials are required to improve translocation results.

- Translocation could build on insights into the species' ecology gained from the Bonville Translocation Project (Benwell and Watson 2006)

- Suitable translocation receival sites are available in the road reserve and/or adjacent State Forest at no additional cost to the taxpayer.

- Maintenance of (putative) genetic diversity in an endangered species by salvage and reestablishment of individuals that would otherwise be destroyed.

- Maintenance of population numbers of an endangered species by salvage and reestablishment of individuals that would otherwise be destroyed.

Translocation Risks

- The translocated individuals may fail to establish over the long-term.

Various choices are available for recipient sites to establish new or expanded populations of Slender Marsdenia, as detailed in Section 4.3.2 below. Details of performance criteria to assess the success or failure of translocation are presented in Section 4.6.8.

4 TRANSLOCATION PLAN

4.1 Introduction

This section of the Threatened Flora Management Plan sets out a plan to translocate threatened plant species directly impacted by construction of the Warrell Creek to Urunga Upgrade of the Pacific Highway (Table 6), in accordance with Ministers Condition of Approval B7.

In addition to the two species specified in MCoA B7 (*Marsdenia longiloba* and *Niemeyera whitei*), RMS would also undertake the translocation of other threatened and rare (ROTAP) species recorded during the targeted flora survey, which are directly impacted by project works, as described in Section 3.

Table 6: Threatened and rare species directly impacted by the WC2NH upgrade and included in this translocation plan.

Species	**Conservation Status**
Threatened Species	
Slender Marsdenia (*Marsdenia longiloba*)	TSC Act (V); EPBC Act (E)
Rusty Plum (*Niemeyera whitei*)	TSC Act (V)
Floyds Grass(*Alexfloydia repens*)	TSC Act (E)
Wooll's Tylophora(*Tylophora woollsii*)	TSC Act (E); EPBC Act (E)
Spider Orchid (*Dendrobium melaleucaphilum*)	TSC Act (E)
Other Species	
Ford's Goodenia (*Goodenia fordiana*)	ROTAP
Koala Bells (*Artanema fimbriatum*)	Potential Threatened Species Listing

The translocation plan has been structured according to the format recommended by the Australian Network for Plant Conservation (2004), as summarised below:

- Section 4.1 - Introduction.
- Section 4.2 - General Considerations - discusses the type of translocation action to be carried out, the objectives of the translocation project, designing translocated populations, genetic management and the advantages of incorporating experimental design.
- Section 4.3 - Pre-translocation Assessment - describes the selection of receival sites and the ecology of the subject species.
- Section 4.4 - The Translocation Proposal - outlines the overall translocation approach.
- Section 4.5 – The Species Proposals – outlines the proposals for each species to be to be translocated
- Section 4.6 - The Translocation Action - details how the translocations will be carried out.
- Section 4.7 - Post-translocation Actions - describes follow-up measures including maintenance, habitat restoration, monitoring and project evaluation.

4.3 PRE-TRANSLOCATION ASSESSMENT

4.3.1 Species Ecology

4.3.1.1 Slender Marsdenia (*Marsdenia longiloba*)

Regional Distribution: Slender Marsdenia occurs between the Hastings River district (Port Macquarie) and southeast Qld and from the coast inland to the Great Escarpment ranges, at widely scattered locations.

Local Distribution: Slender Marsdenia was recorded a several locations between Warrell Creek and Nambucca Heads the WC2NH corridor. A total of 80 stem-individuals were recorded in 11 different sub-populations. Additional sub-populations were identified outside but close to the project boundary.

Habitat: Found in moist open forest and gradational subtropical and warm temperate rainforest, mostly below 200m altitude (Quinn *et al.* 1995). Characteristics of Slender Marsdenia habitat recorded on the WC2NH road corridor included: -

- soil type a yellow to red clay podzol formed on Permian metasediments;
- soil A-horizon 15-30cm deep, dark brown, humus enriched topsoil;
- wet sclerophyll forest with an open to mid dense rainforest understorey usually on a lower slope;
- sloping (gentle to moderate) and well drained, often with a southern aspect;
- understorey moderately well lit and open, not dense or heavily shaded;
- topsoil only slightly acidic (pH >6).

Life History and Population Dynamics: Benwell and Watson (2011) have recorded the life history attributes of Slender Marsdenia during translocation and monitoring of this species for the Bonville upgrade near Coffs Harbour, as follows:-

- Slender Marsdenia is a small, perennial, rhizomatous vine.
- Sub-populations are composed of single-stemmed ramets growing from underground rhizomes; several stems may be attached to the same branching rhizome.
- Above ground stems are comparatively short-lived (1-10 years), while the rhizomes are probably more long-lived.
- The rhizomes are relatively thin, 10-30cm long and grow horizontally within the soil A1 horizon (occasional vertical rhizomes are also present); the rhizomes ramify through the soil, budding off and separating from the parent rhizome to form separate plants.
- Plants may die back to the rhizome and remain stem-less and dormant for up to two years (probably longer), then produce new stem shoots.
- Most stem-individuals never grow more than 30cm tall before dying back.
- Only large stem-individuals (ie >1m tall) produce flowers; production of pods and seed is extremely rare; only 1 pod has ever been recorded during several years of monitoring at several locations.
- *Marsdenia longiloba* appears to rely on vegetative reproduction for population persistence; flowering and seed dispersal play a minor role in this process.

- Discrete sub-populations and patches of *Marsdenia longiloba* may originate vegetatively from the same parent plant and spread over a considerable area (e.g. 0.04 ha).
- *Marsdenia longiloba* stems are conspicuously absent from recently (<1-6 yrs) logged or burnt forest, although monitoring of translocation areas has shown that quiescent rhizomes may be present in the soil. This suggests that conditions during early post-disturbance succession are not favourable for growth of *Marsdenia longiloba,* and stem growth may occur mainly during mid to late stages of succession. The response of *Marsdenia longiloba* to fire has never been monitored.

Transplanting potential: Slender Marsdenia has been transplanted successfully (Benwell and Watson 2011).

Propagation potential: Slender Marsdenia has been propagated successfully from rhizome pieces (Benwell and Watson 2011).

Recovery Plan: A Draft Recovery Plan has been prepared for the Slender Marsdenia.

4.4 THE TRANSLOCATION PROPOSAL

4.4.1 General Approach

The WC2NH translocation project would involve salvage transplanting of five threatened species and two rare species (Table 6) with the aim of establishing populations at new locations, which are self-sustaining over the long-term. As well as transplanting, this will require propagation and introduction of additional individuals to establish minimum viable population (MVP) sizes and adequate levels of genetic diversity. Further integral aspects of the translocation process include restoration of good quality habitat to the receival sites where required, adequate maintenance to ensure transplants and population enhancement individuals become established and monitoring and reporting of the translocation results.

4.4.2.5 Research and Experimentation

Slender Marsdenia (*Marsdenia longiloba*)
In the context of the detailed data recorded on the local distribution of Slender Marsdenia within the WC2U road corridor and the considerable number of individuals impacted by construction, a research project looking at the population genetics of Slender Marsdenia is being conducted by the Ecos Environmental Pty Ltd and the Genecology Research Centre of the University of the Sunshine Coast, as part of the offset package and in conjunction with the translocation plan for this species. The aim of genetic research is to identify patterns of genetic variation within and between populations of Slender Marsdenia at local and regional scales and to use this information to better understand the population genetic structure, life history, breeding system and population dynamics of this cryptic and poorly understood species. Such information can be used to improve management and science-based conservation of the species

The Bonville translocation project produced significant new information on the life history of Slender Marsdenia (see below), but the population processes by which Slender Marsdenia persists at a site remain poorly understoood. As well as providing information on spatial variation in genetic diversity, genetic analysis techniques can provide indirect evidence of rates and direction of pollen flow, levels of out-crossing and therefore method of reproduction – ie. vegetative or sexual/by seed. This type of research has been conducted by RMS previously for Scented Acronychia (*Acronychia littoralis*) on the Chinderah Bypass and the DoP consider research a valid 'offset' initiative.

Slender Marsdenia is an interesting plant as it appears to rarely if ever form seed. The Flora of NSW states the fruit has never been recorded, although the writer has observed the fruit on one occasion in a decade of surveying and monitoring vegetation where the species occurs. Patterns of genetic variation within and between sub-populations can be used to indicate levels of sexual and vegetative reproduction, which can provide insight into a species demographics and how it is able to persist in an area. The surveys conducted for whole WC2U project represent a 42km longitudinal sample of the species' distribution. Detailed mapping of sub-populations, the essential first stage of recording spatial data, has in effect been completed. Analysis of patterns of genetic variation within and between sub-populations along this geographic transect would greatly improve understanding of this species genetics and therefore the breeding system and processes by which populations are maintained. Research on these aspects of species ecology is consistent with Priority Recovery Actions recommended for Slender Marsdenia by the Commonwealth Department of Environment and Heritage (DEH) and the Environmental Protection Authority.

The genetic research project currently underway is titled Analysis of genetic variability in the endangered species Slender Marsdenia (*Marsdenia longiloba*) at fine, medium and broad geographic scales, and research is being directed at answering the following questions: -

- Given that Slender Marsdenia rarely if ever produces seed, how much genetic variation exists in this species within and between sub-populations within the Nambucca area and across the species distribution?

- What do patterns of genetic variation within and between sub-populations of Slender Marsdenia tell us about levels of sexual and vegetative reproduction, and levels out-crossing and inbreeding in Slender Marsdenia?

- Are sub-populations of Slender Marsdenia in adjacent gullies genetically different from each other? If they are genetically different, how did they become different when seed production (sexual reproduction/chromosomal recombination) is so rare? If they are genetically the same, how did they disperse to two adjacent gullies when seed production is so rare?

- What do patterns of genetic variation across the species distribution tell us about the frequency of pollination and direction of pollen flow in Slender Marsdenia across the landscape at different scales?

- What does the spatial distribution of genetic variability within and between populations indicate about present and past population dynamics of this species?

- Do patterns of genetic variation in Slender Marsdenia indicate any significant risk of causing inbreeding or outcrossing depression by undertaking translocation of the species?

- What other practical implications do the research findings have for conservation and management of Slender Marsdenia? Such as where are the areas of higher genetic diversity found within the species and how significant are the populations to be translocated for the genetic diversity of the species as a whole.

Approximately 360 samples have been collected across the species range from the Nambucca valley to northwest of Brisbane and patterns of genetic variation are being analysed using microsatellite and chloroplast DNA techniques. The latter is being used to elucidate the identification of Tylophora woollsii and Slender Marsdenia (Marsdenia longiloba), these species being very similar vegetatively and difficult to identify from vegetative features alone.

The translocation project for WC2U (NH2U/WC2NH has been planned to carrying on from the research conducted for the Bonville translocation project and has been designed to examine the survival response of Slender Marsdenia to different methods of translocation and micro-habitat type.

4.5 SPECIES PROPOSALS

4.5.1 Slender Marsdenia (*Marsdenia longiloba*)

Slender Marsdenia occurs in small, sparse sub-populations scattered along the length of the WC2U road corridor. Approximately 200 individuals ('stem-individuals) were recorded in 23 different sub-populations along the whole WC2U road corridor.

A total of 80 individuals were recorded and 15 sub-populations identified within or close to southern WC2NH project. Plans showing the location of recorded occurrences are provided Appendix 1.

Translocation of Slender Marsdenia for the northern (NH2U) project was undertaken in December 2013. In version one of the WC2U TFMP in was proposed that any further translocation of Slender Marsdenia on the southern half/WC2NH would be dependent on the results of Slender Marsdenia translocation on NH2U and that this would be assessed over a monitoring period of two years. This fitted in with initial information that the likely start of construction on the two sections would be two years apart. The project scheduling has since changed and construction of the southern section is likely to commence late 2014 or early 2015, only about 12 months since the NH2U translocation of Slender Marsdenia. This has necessitated an earlier decision whether or not to translocate Slender Marsdenia on the southern section based on monitoring results up to September 2014 – see Table 12b.

The previous attempt to translocate Slender Marsdenia (and Woolls Tylophora) on the Bonville project was unsuccessful after five years. Without going into detail, it was hypothesised that the poor result was due to the adverse of effect of slow release fertiliser and soil amelioration on Slender Marsdenia establishment at the receival site. A different approach has been applied on the NH2U project involving direct transplanting and no use of fertiliser. The results to September 2014 in Table 12b show no evidence of a marked decline in the health and vigour of Slender Marsdenia transplants during the first 9 months, despite a dry autumn and cold and dry winter in 2014. However, based on the survival pattern recorded on the Bonville translocation project, it is too early to say if results are definitely improved. Given the monitoring results recorded to Sept 2014 on NH2U and since construction of WC2NH is likely to start late 2014, translocation of Slender Marsdenia will also proceed on the WC2NH project so as not to delay the start of construction.

Table 12b: Results of the NH2U translocation of Slender Marsdenia after 3, 6 and 9 months after translocation.

NH2U – no fertiliser addition	**3 months** **March 2014**	**6 months** **July 2014**	**9 months** **Sept 2014**
condition - poor	16	14	20
condition – fair	35	45	40
condition – healthy	95	87	86
	146	146	146

Table 13: Directly impacted Slender Marsdenia recorded on the WC2U corridor. Each recorded point may encompass more than one plant, as indicated in column 'No.'
Southern Half (WC2NH) as of 10/6/2014

ID	Species	Easting	Northing	No.	Size
AB_2014_1	Marsdenia longiloba	497488.408000	6610582.878000	1	0.1m
AB_2014_2	Marsdenia longiloba	497493.501000	6610586.158000	1	0.1m
AB_2014_3	Marsdenia longiloba	497496.352000	6610583.216000	3	1m
AB2014__ML1	Marsdenia longiloba	489653.000000	6594556.000000	1	0.1m
ml-22	Marsdenia longiloba	496188.410408	6608256.097960	2	0.1m
ml-23	Marsdenia longiloba	496180.251673	6608299.314590	1	1m
ml-24	Marsdenia longiloba	496177.372208	6608314.274170	1	0.5m
ml-25	Marsdenia longiloba	496182.954756	6608331.453140	2	0.8m
ml-26	Marsdenia longiloba	496256.890152	6608315.410310	6	0.5m
ml-27	Marsdenia longiloba	496471.828945	6608754.696510	1	0.4m
ml-35	Marsdenia longiloba	495663.835870	6607571.959330	1	4m
ml-36	Marsdenia longiloba	495660.804035	6607567.525330	1	0.2m
ml-37	Marsdenia longiloba	495671.485200	6607608.163410	3	0.8m
ml-38	Marsdenia longiloba	495684.423981	6607593.392690	1	0.1m
ml-39	Marsdenia longiloba	495702.778781	6607610.022940	1	0.1m
ml-40	Marsdenia longiloba	495744.282604	6607632.942110	1	small
ml-41	Marsdenia longiloba	495722.548309	6607682.802220	10	small
ml-42	Marsdenia longiloba	495722.699901	6607703.119170	1	1.5m
ml-43	Marsdenia longiloba	495716.783427	6607725.280690	1	0.1
ml-44	Marsdenia longiloba	495748.069111	6607748.011070	2	0.3m
ml-5	Marsdenia longiloba	496683.949976	6609585.722830	1	small
ml-63	Marsdenia longiloba	489635.678810	6594537.005010	1	0.1m
ml-68	Marsdenia longiloba	489663.695772	6594588.748820	1	1.5m
ml-7	Marsdenia longiloba	496637.195041	6609472.118760	6	0.6m
ml-71a	Marsdenia longiloba	489553.726825	6594591.727680	3	2m
ml-72	Marsdenia longiloba	489683.316469	6594582.857250	1	1m
ml-8	Marsdenia longiloba	496576.593202	6609216.292200	2	0.6m
ml-9	Marsdenia longiloba	496589.206798	6609222.021860	1	4m
ml-93	Marsdenia longiloba	494336.000000	6604191.000000	1	0.0
V10	Marsdenia longiloba	489584.000000	6594404.000000	1	0.0
V11	Marsdenia longiloba	495058.000000	6606623.000000	1	0.0
V7	Marsdenia longiloba	489559.000000	6594392.000000	2	0.0
V8	Marsdenia longiloba	489560.000000	6594392.000000	3	0.0
V9	Marsdenia longiloba	489567.000000	6594394.000000	1	0.0
GS1	Marsdenia longiloba	489653.000000	6594556.000000	1	1.6
GS10	Marsdenia longiloba	496207.000000	6608368.000000	1	3.0
GS2	Marsdenia longiloba	489660.000000	6594591.000000	1	0.6
GS4	Marsdenia longiloba	495672.000000	6607601.000000	1	0.2
GS5	Marsdenia longiloba	496172.000000	6608264.000000	1	0.2
GS6	Marsdenia longiloba	496185.000000	6608287.000000	1	2.2
GS7	Marsdenia longiloba	496192.000000	6608323.000000	1	0.3
GS8	Marsdenia longiloba	496184.000000	6608313.000000	1	0.3
GS9	Marsdenia longiloba	496212.000000	6608369.000000	1	1.5

It is proposed to conduct the translocation of Slender Marsdenia as follows: -

- Directly impacted plants to be transplanted to adjoining State Forest, road reserve and RMS owned property, which ever is closest, provides suitable habitat and is in a location/tenure suitable for long-term conservation.

- Rhizome pieces dislodged during transplanting (soil breaks up easily) to be used to be used for propagation of population enhancement plants.

- All transplants to be tagged with its donor ID number throughout the translocation process; all propagated plants to be labelled with the parent donor ID number throughout the propagation and introduction process.

- Experimental work to be incorporated in the Slender Marsdenia translocation including:-

  - study of genetic variation within and between sub-populations using shoot material taken during transplanting (stems to be pruned).

  - study of flowering and seed production in transplants under pot cultivation

  - study of plant response to translocation introduction treatments - i.e. direct transplanting vs. planting after initial pot stabilisation; fertiliser/mulch vs. no fertiliser treatment; disturbed vegetation vs undisturbed vegetation.

Monitoring of the translocation would be conducted during construction, as described above, and after construction for a minimum of 5 years, a total of approximately 8 years (also refer to Appendix 11 - Table 4).

APPENDIX 11: SUMMARY OF MANAGEMENT GOALS, CONTROL MEASURES, MONITORING, PERFORMANCE THRESHOLDS AND CORRECTIVE ACTIONS FOR IMPLEMENTATION OF THE WARRELL CREEK TO URUNGA THREATENED FLORA MANAGEMENT PLAN (TABLES 1-4)

Table 1: Summary of pre-construction management goals, mitigation measures, performance thresholds and corrective actions for management of threatened flora.

Main goal	Mitigation / control measure- CEMP to incorporate these measures	Monitoring / timing frequency	Responsibility	Performance threshold	Corrective actions if deviation from performance criteria
• There is no loss or damage to threatened plants within project boundary during the early works period leading up to the start of construction. • Directly impacted threatened plant species are translocated from the clearing zone/ construction footprint according to TFMP prior to the start of clearing/construction near the flora requiring translocation.	• Pre-clearing survey of threatened flora to confirm current location/ numbers of threatened flora requiring translocation and that individual ID tags are in place and correctly numbered. • Exclusion zones identified in CEMP/ temporary fencing put in place to protect any threatened plants to be translocated that are in close vicinity/ potentially impacted by early work activities. • Exclusion zones put in place to protect in situ individuals within 10m of the construction zone/clearing limit prior to the start of construction.	• Pre-clearing threatened flora survey completed. • Exclusion zones checked and signed off. • Receival site agreed to by all parties. • Hold point: Exclusion zones identified and in place before commencement of works.	• Design and construct (D&C) contractor.	• Salvage translocation (transplanting) of all directly impacted threatened flora completed according to the WC2U TFMP, Sections 4.5, 4.6 & 4.7. • No loss or damage to threatened flora occurs prior to translocation being implemented.	• Construction activities not to commence at locations of flora requiring translocation until salvage translocation works are completed. • Review undertaken and correct control measures.

	• Translocation receival site finalised and necessary site preparation carried out at least one month in advance of the start of translocation, and due consideration given to the site selection factors listed in WC2U TFMP Section 4.3.3. • Salvage translocation of directly impacted threatened flora individuals carried out according to procedures described in the WC2U TFMP Sections 4.5, 4.6 & 4.7.				

Table 2: Summary of construction management goals, mitigation measures, performance thresholds and corrective actions for management of threatened flora.

Main goal	Mitigation / control measure	Monitoring / timing frequency	Responsibility	Performance threshold	Corrective actions if deviation from performance criteria
• No damage occurs to indirectly impacted and in situ threatened flora remaining within the project boundary after salvage translocation of directly impacted individuals. • Other works associated with the translocation of threatened flora (ie. in addition to salvage translocation/transplanting) such as propagation, population enhancement, habitat rehabilitation at the receival site, are implemented according to the WC2U TFMP	• Exclusion zones identified on sensitive area plans and fencing barriers maintained during construction. • Signage added to fencing to indicate environmental protection/no-go zones. • Targets and time line for implementation of other translocation works after the (pre-construction) salvage translocation	• 3- monthly monitoring of translocated/ transplanted threatened flora during year 1 of construction, then 6-monthly monitoring thereafter (in accordance with procedure outlined in the TFMP (section 4.7.7) • 3- monthly monitoring of in situ threatened flora during year 1 of construction, then 6-monthly monitoring thereafter, as described in WC2U TFMP Section 5.3. • Annual monitoring report detailing the monitoring results for translocated threatened flora and in situ threatened flora, prepared according to the requirements of the WC2U TFMP Section 4.7.7	• Design and construct (D&C) contractor.	• All translocation actions required during the construction phase are implemented including monitoring and preparation of the annual monitoring report. • Annual monitoring report provides full description of management plan implementation and results, as per the required contents in Section 4.7.7, and an evaluation of outcomes according to criteria listed in Section 4.7.8 of the WC2U TFMP.	• Review any failure to implement or complete translocation actions required during the construction phase and devise appropriate corrective actions.

Table 3: Summary of operation management goals, mitigation measures, performance thresholds and corrective actions for management of threatened flora.

Main goal	Mitigation / control measure	Monitoring / timing frequency	Responsibility	Performance threshold	Corrective actions if deviation from performance criteria
• No damage occurs to in situ threatened flora remaining within the project boundary. • Any remaining works associated with the translocation of threatened flora such as propagation, population enhancement, habitat rehabilitation at the receival site, are implemented according to the WC2U TFMP	• Signage, exclusion fencing installed around in situ threatened flora within project boundary. • Targets and time line for implementation/ completion of other translocation works during the operation phase	• 6- monthly monitoring of translocated/ transplanted threatened flora during years 2 & 3, then monitoring once a year thereafter • 6- monthly monitoring of in situ threatened flora within project boundary during years 2 & 3, then monitoring once a year thereafter	Roads and Maritime Services	• All translocation actions required during the operation phase are implemented, including monitoring and preparation of the annual monitoring report. • Annual monitoring report provides full description of management plan implementation and results, as per the required contents in Section 4.7.7, and an evaluation of outcomes according to criteria listed in Section 4.7.8 of the WC2U TFMP.	• Review any failure to implement or complete translocation actions required during the operation phase and devise appropriate corrective actions.

Table 4: Summary of monitoring program for threatened flora, including performance thresholds and corrective actions. There are Three main monitoring components: - threatened flora translocations, in-situ roadside threatened flora & threatened flora habitat.

Monitoring Component	Main goal	Monitoring / timing frequency	Responsibility	Performance threshold	Corrective actions if deviation from performance criteria
Translocation:– salvage translocation and population enhancement	To record monitoring data that enables an assessment to be made of the success of the threatened flora translocations, implemented as per the TFMP.	Salvage transplants Monitoring frequency:- 1. 3-monthly intervals in first year after introduction 2. 6-monthly intervals in year 2 and year 3. 3. once a year thereafter to the end of monitoring program 4. 8 years in total - ~ 3 yrs during construction and 5 years during operation. Population enhancements Monitoring frequency:- 1. at introduction 2. 6-monthly intervals in first year. 3. once a year thereafter to the end of monitoring program 4. 8 years in total - ~ 3 yrs during construction and 5 years during operation.	Pacifico/Roads and Maritime Services	1. All recorded directly impacted individuals are translocated. 2. At least 60% of transplant and enhancement individuals are surviving after the first year, 50% after five years and 40% after eight years. 3. At the end of the monitoring program at least 50% of surviving individuals have a Condition Class of 3.	1. Identify reasons for failure to translocate individuals and implement corrective measures – eg. translocate if still in situ; inform management of the reasons for failure to avoid occurence on future projects. 2. Assess reasons for failure to reach first year target and implement corrective measures as required - e.g. hessian screening to mitigate over-exposure while revegetation is established; surveillance cameras and signage to deter theft; weed control to counter weed invasion. 3. In the final monitoring report, analyse and discuss the reasons for failure to reach the performance target and evaluate the success of the translocation project in terms of the survival rates, the benefits/risks of conducting the translocation (see Sect.

					3.5) and the economic costs and benefits.
In-situ Roadside Threatened Flora	To record monitoring data that enables an assessment to be made of the effectiveness of mitigation measures for protection of in-situ threatened flora.	Monitoring frequency:- 1. initially after installation of protective fencing 2. 6-monthly intervals in years 1 and year 2. 3. once a year thereafter to the end of monitoring program 4. 8 years in total - ~ 3 yrs during construction and 5 years during operation. Monitoring above to be augmented by monthly site inspections/ checking of fenced in-situ threatened flora to make sure no encroachment/ damage has occurred.	Pacifico/Roads and Maritime Services	1. The survival rate of in-situ threatened flora at the finish of clearing is 100%. No accidental damage occurs during clearing. 2. The survival rate of in-situ threatened flora at the end of years 1-3 of the monitoring program is at least 80% and at least 70% at the end of years 4-8; 3. Of plants surviving at the end of each year, at least 75% are in good condition – i.e. they have healthy foliage, no sign of die-back or disease and exhibit new shoot growth (Condition Class 3 or >)	1. Identify reasons for damage/failure to protect in situ threatened flora and implement corrective actions as necessary. 2. Assess reasons for failure to reach performance threshold and implement corrective actions as required. For example,; hessian screening to protect plants from over-exposure; addition of hay mulch where plants are in poor condition, weed control to counter weed invasion 3. Assess reasons for <75% of in situ plants not being in good condition and apply appropriate mitigation if possible, such as the measures for 2.
Threatened Flora Habitat (Slender Marsdenia and Woolls'	To record monitoring data that enables an assessment to be made of the effectiveness of mitigation measures for protection of Slender	Monitoring frequency:- 1. within one month of finish of clearing (baseline). 2. end of each year/12-monthly intervals for 8 years (ie. 3 years construction, 5 years operation)	Pacifico/Roads and Maritime Services	1. Plot crown-cover of exotic species is no more than 15% (overlapping and/or summed) at the end of Year-1 and no more than 25% at the end of Years- 2	1. Weed control in and around Slender Marsdenia and Woolls' Tylophora habitat representative of such plots where exotic species exceed thresholds; to be applied by

Tylophora)	Marsdenia and Woolls' Tylophora habitat adjacent to construction.			to 8 2. Baseline vegetation structure (height and crown cover) remains the same or increases in height and crown cover at the end of year compared to the previous year. 3. There is no increase in the microclimate exposure class (e.g. 1 to 2, or 4 to 5) compared to the previous year.	an experienced bush regenerator familiar with identification of Slender Marsdenia and Woolls' Tylophora. 2. Prioritise revegetation of batters and bare areas adjacent to Slender Marsdenia and Woolls' Tylophora habitat. Use salvaged topsoil seed bank to minimise weed spread from revegetated areas into adjacent habitat.

Appendix C
Ecological Monitoring Program

Warrell Creek to Nambucca Heads

Stage 2 Ecological Monitoring Program

Roads and Maritime Services | June 2018

NSW GOVERNMENT

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Revision History

Revision	Date	Description	Approval
A	6/12/2017	Amendment to original Benchmark Environmental Management plan to : • Tables 2.1 and 3.3 to align culvert monitoring with the approved Koala and Spotted tailed quoll management plans • Table 3.1 to align the monitoring frequencies with the approved Flying Fox Management Plan • Update references and other editorial corrections • Update Road Kill Monitoring program. • Include DPE as recipient of annual road kill monitoring reports	Chris Clark
B	5/03/2018	• Update Table 3.1 to align with approved management plans • Update Tables 2.1 and 3.3 to include the combined culvert at chainage 58510 in the underpass monitoring to align with the approved species specific management plans • Minor editorial and formatting corrections • Updating section 3.12 - Landscape Rehabilitation • Inclusion of section 3.15 detailing requirement to undertake Slender Marsdenia and Wools' Tylophora Habitat Condition Monitoring • Addition of giant barred frog monitoring in Butchers Creek in excess to that required by the approved Giant Barred Frog Management Plan.	Chris Clark
C	1/06/2018	• Minor editorial and formatting corrections • Removal of requirement to undertake monthly photo points during operational landscape rehabilitation monitoring	Chris Clark

Contents

1. Introduction

In June 2003, planning commenced on the upgrade of the Pacific Highway between Warrell Creek to Urunga, south of Coffs Harbour (WC2U). The project involves an upgrade of the existing highway to four lane divided highway from the existing Allgomera deviation, south of Warrell Creek, to the Waterfall Way at Raleigh.

Project approval was granted on 19 July 2011, under Part 3A of the Environmental Planning and Assessment Act 1979. The project was identified as a critical infrastructure project by the NSW State Government, designed to improve safety, traffic efficiency and increase capacity along the Pacific Highway. It forms part of the overall program for upgrading the Pacific Highway. The proposed upgrade extends over approximately 42 kilometres, which has been divided into two stages:

Stage 1 - Nambucca Heads to Urunga section (chainage 61265-83682); and
Stage 2 - Warrell Creek to Nambucca Heads section (chainage 41765-61265).

The construction of the WC2U upgrade project will involve the disturbance of existing structures, native vegetation, and native fauna habitat(s) in the vicinity of the works. It will also involve the removal of up to 255 Ha of native vegetation.

As part of the Proposal's approval, the development of an Ecological Monitoring Program (EcMP) is required for each stage to address the Minister for Planning and Infrastructure's Condition of Approval (MCoA) B10. To satisfy MCoA B10 the ecological monitoring programs involve preconstruction, construction and post construction phases.

Benchmark Environmental Management (BEM)[1] was contracted by the NSW Roads and Maritime Services (Roads and Maritime) to prepare the EcMP for Stage 2 of the WC2U upgrade project in accordance with MCoA B10, which states that:

> *Prior to the commencement of any construction work that will result in the disturbance of any native vegetation, the Proponent shall develop an Ecological Monitoring Program to monitor the effectiveness of the mitigation measures implemented as part of the project. The program shall be developed in consultation with EPA and prepared by a suitably qualified ecologist and shall include but not necessarily be limited to:*
>
> *(a) an adaptive monitoring program to assess the effectiveness of the mitigation measures identified in condition B1 to B6, B7(b), B7(d), B21(c) and B31(b) and allow amendment to the measures if necessary. The monitoring program shall nominate appropriate and justified monitoring periods and performance targets against which effectiveness will be measured. The monitoring shall include operational road kill surveys to assess the effectiveness of fauna crossing and exclusion fencing implemented as part of the project;*
>
> *(b) mechanism for developing additional monitoring protocols to assess the effectiveness of any additional mitigation measures implemented to address additional impacts in the case of design amendments or unexpected threatened species finds during construction (where these additional impacts are generally consistent with the biodiversity impacts identified for the project in the documents listed under condition A1);*
>
> *(c) monitoring shall be undertaken during construction (for construction-related impacts) and from opening of the project to traffic (for operation/ongoing impacts) until such time as the effectiveness of mitigation measures can be demonstrated to have been achieved over a minimum of five successive monitoring periods (i.e. 5 years) after opening of the project to traffic, unless otherwise agreed to by the Director General. The monitoring period may be reduced with the agreement of the Director General in consultation with OEH, depending on the outcomes of the monitoring;*
>
> *(d) provision for the assessment of the data to identify changes to habitat usage and if this can be attributed to the project;*

[1] Benchmark Environmental Management prepared the original version of the Ecological Monitoring program approved on 16/12/14. As Benchmark Environmental Management is no longer in business, Roads and Maritime Services has prepared this Revision A to the report

(e) *details of contingency measures that will be implemented in the event of changes to habitat usage patterns directly attributable to the construction or operation of the project; and*

(f) *provision for annual reporting of monitoring results to the Director General and OEH, or as otherwise agreed by those agencies. The Program shall be submitted for the Director General's approval prior to the commencement of any construction work that will result in the disturbance of any native vegetation. Unless otherwise agreed, the Program shall be submitted to the Director General for approval no later than 6 weeks prior to the commencement of any construction that will result in the disturbance of any native vegetation.*

In addition, the EcMP incorporates monitoring components associated with several management strategies and plans prepared for the project, including:

- Nest Box Plan of Management (LES 2013b);
- Green-thighed Frog Management Strategy (LES 2013a);
- Giant Barred Frog Management Strategy (LES 2014a);
- Microchiropteran Bat Strategy (LES 2014b);
- Spotted-tailed Quoll Management Plan (GeoLINK 2014b);
- Koala Management Plan (GeoLINK 2014a);
- Yellow-bellied Glider Ecological Monitoring Program (Goldingay 2014);
- Road-kill Monitoring Program (NSW Roads and Maritime 2014);
- Grey Headed Flying-fox Management Plan (Gorecki *et al*. 2014); and
- Threatened Flora Management Plan (Benwell 2014).

There are 64 mitigation measures relevant to the EcMP preparation for Stage 2 of the WC2U upgrade project, which are listed in Table 1.1. The mitigation measures have been grouped into seven categories:

1. Pre-clearing and clearing procedures;
2. Fauna underpass structures and exclusion fencing;
3. Widened vegetated medians;
4. Nestbox installation;
5. Landscape rehabilitation
6. Protection of in-situ threatened flora populations; and
7. Establishment of translocation areas.

1.1. Order of precedence

In the event of any inconsistency, ambiguity or discrepancy between this Ecological Monitoring program and the target species management plans within the Flora and Fauna Management Plan for the Warrell Creek to Nambucca Heads Pacific Highway upgrade project, the following order of precedence must apply:

(a) Target Species Management Plan[2].

(b) The Flora and Fauna Management Plan for the Warrell Creek to Nambucca Heads Pacific Highway upgrade project

The aim of the EcMP, as stated in Revised Statement of Commitment F13, is to assess the effectiveness of fauna and flora impact mitigation measures. The Contractor must address the requirements of this EcMP in design, construction and maintenance of the Project Works, Temporary Works and Maintenance Works where relevant.

The EcMP addresses the requirements of MCoA B10 in five chapters:

1. Chapter one states the aim of the EcMP and identifies those responsible for its implementation;
2. Chapter two identifies which proposed mitigation measures are to be subject to monitoring.
3. Chapter three provides a detailed description of the monitoring methods recommended for each proposed mitigation measure.
4. Chapter four identifies potential contingencies that may be applied if any of the mitigation measures prove to be insufficient; and

[2] Notwithstanding the order of precedence, Roads and Maritime is also committed to undertaking giant barred frog monitoring in Butchers Creek in excess to that required by the approved Giant Barred Frog Management Plan.

5. Chapter five specifies the reporting requirements.

1.2. Agency Consultation

As a note of clarity, where species specific management plans require consultation with the OEH and/or the EPA, consultation will be with the EPA as per the current Memorandum of Understanding between Roads and Maritime Service and the EPA, as the EPA has taken on the roles of the OEH for the management of Pacific Highway upgrade projects.

2. Mitigation measures requiring monitoring

The EcMP for Stage 2 will focus on all seven groups of mitigation measures proposed as part of the Warrell Creek to Urunga Pacific Highway Upgrade project:

1. Pre-clearing and clearing procedures;
2. Fauna underpass structures and exclusion fencing;
3. Widened vegetated medians and glider crossing structures;
4. Nestbox installation;
5. Landscape rehabilitation
6. Protection of in-situ threatened flora populations; and
7. Establishment of translocation areas.

A description of each proposed mitigation measure nominated for monitoring is provided below.

Table 1.1: Mitigation measures relevant to EcMP preparation for Stage 2 of the WC2U upgrade project. MCoA = Minister's Condition of Approval; SOC = Revised Statement of Commitment; EA = Project Environmental Assessment; FMP = Flying-fox Management Plan; KMP = Koala Management Plan; GBFMS = Giant Barred Frog Management Strategy; GTFMS = Green-thighed Frog Management Strategy; MBMS = Microbat Management Strategy; STQMP = Spotted-tailed Quoll Management Plan.

Source	Mitigation Measure	Relevant Section of EcMP
MCoA B1	The Proponent shall implement the fauna and waterway crossings identified in the documents listed under condition A1(d) at the locations and in accordance with the minimum design dimensions identified in the documents listed under condition A1(d), unless otherwise agreed to by the Director General.	Section 2.2 and 3.8
MCoA B2	As part of detailed design, the Proponent shall further investigate design refinements to improve fauna connectivity between Chainages 19150 and 19820.	Section 2.2 and 3.8
MCoA B4	The Proponent shall in consultation with OEH, ensure that the design of the project as far as feasible and reasonable, incorporates provision for glider crossings (such as widened medians and maintenance or enhancement of habitat within the medians and corresponding carriageway boundaries) where the alignment crosses areas of recognised glider habitat.	Section 2.3 and 3.10
MCoA B6	Prior to the commencement of any construction work that will result in the disturbance of any native vegetation (or as otherwise agreed to by the Director General), the Proponent shall in consultation with OEH prepare and submit for the approval of the Director General a Nest Box Plan to provide replacement hollows for displaced fauna consistent with the requirements of SoC F7. The plan shall detail the number and type of nest boxes to be installed which must be justified based on the number and type of hollows removed (based on detailed pre-construction surveys), the density of hollows in the area to be cleared and adjacent forest, and the availability of adjacent food resources. The plan shall also provide details of maintenance protocols for the nest boxes installed including responsibilities, timing and duration.	Section 2.4 and 3.11
MCoA B7(b)	If investigation under Condition B7(a) reveals translocation of impacted plants is feasible, includes details of a translocation plan for the plants consistent with the Australian Network for Plant Conservation 2OO4: Guidelines for the Translocation of Threatened Plants in Australia 2"d Ed, including details of ongoing maintenance such as responsibilities, timing and duration;	Section 2.7 and 3.14
MCoA B7(d)	Includes detail of mitigation measures to be implemented during construction to avoid and minimise impacts to areas identified to contain these species, including excluding construction plant, equipment,	Section 2.6 and 3.13

Source	Mitigation Measure	Relevant Section of EcMP
	materials and unauthorised personnel.	
MCoA B31(b)	A Construction Flora and Fauna Management Plan to detail how construction impacts on ecology will be minimised and managed.	Section 2.1 and 3.2
MCoA B31(b)(i)	Undertake pre-construction surveys to verify the construction boundaries/footprint of the project based on detailed design and to confirm the vegetation to be cleared as part of the project.	Section 2.1.1 and Section 3.2
MCoA B31(b)(iii)	Prepare a Giant Barred Frog management plan, in the case that this species or its habitat is identified to occur in the project corridor or its vicinity.	Section 2.1.1; Section 3.3.2
MCoA B31(b)(iv)	Prepare a micro-bat management strategy, in the case that micro bats or evidence of roosting are identified during pre-construction surveys. The strategy shall detail measures to avoid, minimise and mitigate impacts to these species and identified roost sites, including short and long term management measures.	Section 2.1.1; Section 3.4
MCoA B31(b)(v)	Develop general work practices to minimise the potential for damage to native vegetation (particularly EECs) not proposed to be cleared as part of the project and native fauna during construction.	Section 2.1
MCoA B31(b)(vi)	Develop specific procedures to deal with EEC/threatened species anticipated to be encountered within the project corridor including re-location, translocation and/or management and protection measures.	EcMP
SOC F1	Clearing of native vegetation (including endangered ecological communities) will be restricted to the minimum area necessary for construction.	Section 2.1.1 and 3.2
SOC F2	A qualified ecologist will identify any vegetation (including Marsdenia longiloba) to be retained and to be clearly delineated on work plans within the construction corridor. Erection of flagging/fencing on-site prior to any construction works, which is to remain in place for the full construction period, will clearly delineate this vegetation.	Section 2.1.1 and 3.2
SOC F3	Threatened species directly impacted by the Proposal will be translocated to a suitable location outside the impact zone. A further visual inspection will be conducted post clearance to identify threatened species which may be indirectly impacted outside the cleared zone. Landscape planting to commence	Section 2.7 and 3.14

Source	Mitigation Measure	Relevant Section of EcMP
	along the road boundary as soon as possible during construction.	
SOC F4	Plantings of rusty plum (Amorphospermum whitei) in areas of suitable habitat adjacent to the Proposal will follow from seed collection and propagation.	Section 2.7 and 3.14
SOC F6	A suitably qualified ecologist will undertake pre-clearance surveys for threatened species including frogs. Searches will include nests and hollow bearing trees. Re-location of fauna species at risk of injury found in pre-clearance surveys or during construction will be in suitable habitat as close as possible to the area in which they were found. Immediately prior to clearing an inspection will confirm that the sites subject to pre-clearance surveys remain free of fauna.	Section 2.1 and 3.2
SOC F7	Where feasible and reasonable the identification and distribution of natural and artificial habitat features and resources (such as hollow-bearing trees, hollow logs, nest boxes and bush rocks) will occur along the Proposal. This relocation will limit injury to fauna and damage to existing vegetation. A nest box plan will be developed for the Proposal.	Section 2.1 and 3.2
SOC F8	Retention of mature trees in the median at locations identified in the environmental assessment will provide a stepping stone for gliders. Protection of these trees will occur (F2), and lopping and pruning is not to occur without expert advice.	Section 2.3 and 3.10
SOC F9	Provision of fauna crossings will be as identified in the environmental assessment. All fauna crossings will be confirmed with the EPA and DPI during the detailed design phase.	Section 2.2 and 3.8
SOC F11	Erection of fauna exclusion fencing (e.g. floppy-top fencing) along the Proposal at appropriate locations will direct fauna movement towards fauna-crossing structures.	Section 2.2 and 3.8
EA Ch10 – Section 10.5.1.1	Revegetation/rehabilitation of the site should be conducted progressively during the construction phase to ensure the use of collected topsoil and seed and to develop different successional stages of rehabilitation.	Section 2.5 and 3.12
EA Ch10 – Section 10.5.1.1	A weed management plan is to be prepared as part of the flora and fauna management sub plan, outlining weed management actions to be carried out during construction to prevent the spread of weeds and plant pathogens.	Section 2.5 and 3.12

Source	Mitigation Measure	Relevant Section of EcMP
EA Ch10 – Section 10.5.1.2	A suitably qualified ecologist will undertake searches in the construction footprint for native fauna immediately prior to clearing activities. Searches will include nests and large hollow-bearing trees and target habitats of hollow dwelling species, koalas, spotted-tailed quolls and frogs. During the proposed clearing works, an experienced wildlife handler should be present to retrieve any displaced fauna and release the fauna into adjacent habitats safe from construction work.	Section 2.1 and 3.2
EA Ch10 – Section 10.5.1.2	Re-survey immediately prior to construction to identify nest locations for Osprey, Black-necked Stork and brolga. The location of the identified Osprey nest will be checked to confirm if it is present before clearing commences.	Section 2.1 and 3.2
EA Ch10 – Section 10.5.1.2	Provide dedicated and incidental fauna crossing structures at key locations for forest fauna species identified to target the range of large, medium and smaller species present such as Yellow-bellied Glider, Koala and Giant Barred Frog.	Section 2.2, 2.3, 3.8 and 3.10
EA Ch10 – Section 10.5.1.2	A fauna rescue framework for clearing has been developed by the RMS in consultation with the EPA and will be used as a basis for developing a protocol for the handling and translocation of fauna during construction.	Section 2.1 and 3.2
EA Ch10 – Section 10.5.1.2	Nest boxes are to be installed, where required, in accordance with specialist advice and in consultation with the EPA, prior to construction, to replace hollow resources that are proposed to be removed.	Section 2.4 and 3.11
EA Ch10 – Section 10.5.1.2	Bridges at Warrell Creek, Nambucca River, Deep Creek and the Kalang River and culverts identified in this environmental assessment as having a potential role in fauna crossing, will be designed to facilitate fauna movements	Section 2.2 and 3.8
EA Ch10 – Section 10.5.1.2	A strategy would be developed in consultation with Forests NSW, for monitoring the Yellow-bellied Glider population in the affected area of Nambucca State Forest as part of the flora and fauna management plan. This would need to include the identification of home range territories in proximity to the highway, den locations, monitoring movements (marking and radio-tagging), particularly across the future road, and long term fecundity.	Section 3.6
EA Ch10 – Section 10.5.1.2	Strategies will be developed to deal with incidents involving individual animals during construction activities in consultation with the EPA officers, WIRES and/or other relevant local wildlife carer groups.	Section 2.1 and 3.2

Source	Mitigation Measure	Relevant Section of EcMP
EA Ch10 – Section 10.5.2	Native and locally indigenous plants will be used in the landscaping and disturbed areas will be progressively revegetated.	Section 2.5 and 3.12
EA Ch10 – Section 10.5.2	Weeds in areas disturbed by construction activities will be managed for a minimum of two years after construction completion.	Section 2.5 and 3.12
EA Ch10 – Section 10.5.3	Widening of the median at important locations.	Section 2.3 and 3.10
EA Ch10 – Section 10.5.3	Provision of dedicated, combined and incidental fauna underpass structures.	Section 2.2 and 3.8
EA Ch10 – Section 10.5.3	Exclusion fencing will be installed around the crossing structures to prevent access to the carriageway for up to 500 metres either side.	Section 2.2 and 3.8
EA Ch10 – Section 10.5.4	Development of a rehabilitation and weed control strategy as part of the construction environmental management plan, with specific mitigation measures for control of the spread of weeds and habitat rehabilitation, particularly along roadside verges, adjacent to culvert entrances and bridge pylons.	Section 2.5 and 3.12
EA Ch10 – Section 10.5.4	A protocol will be developed for weed infested areas to ensure that all potential weed propagules from soil and vegetative material are appropriately disposed of.	Section 2.5 and 3.12
EA Ch10 – Section 10.5.5	Roadside verges will be rehabilitated adjacent to culvert entrances and bridge pylons.	Section 2.5 and 3.12
FMP – Section 5.3.5	Prior to the commencement of clearing operations, the project ecologist would identify all areas that contain vegetation and habitat to be retained within the flying-fox camp, including exclusion zones	Section 2.1 and 3.2
FMP – Section 5.3.5	Prior to the commencement of clearing operations targeted surveys for flying-foxes would be undertaken.	Section 2.1 and 3.2
FMP – Section 4.4.2	Habitat exclusion zones and construction buffer zones around the flying-fox colony would be designated and fenced/marked prior to construction.	Section 2.1 and 3.2

Source	Mitigation Measure	Relevant Section of EcMP
FMP – Section 5.3.1 & 7.3.3	Construction activities along the approved alignment within the vicinity of the flying fox camp would be restricted to the period between 1 May and 15 September each year. If during this period, GHFF are present in the clearing corridor the contingency strategy would be implemented. Construction would halt if there are heavily pregnant GHFF or female GHFF with dependent young present within 100m of these individuals/groups.	Section 2.1.1 and 3.2
FMP – Section 5.3.8	Impacts to the flying-fox camp from construction noise, vibration and light would be managed through maintaining a works buffer of 300 metres between the perimeter of the camp and major construction activities undertaken between mid-September and the end of April the following year.	Section 2.1.1 and 3.2
FMP – Section 5.3.8	Activities within the 300 metre buffer zone between mid-September and the end of April the following year would be restricted to low noise / low disturbance construction activities required for monitoring, maintenance and incident response purposes. Observational monitoring of the camp for a-typical behavioural responses would be undertaken during the execution of these activities to assess any impacts on the flying-foxes.	Section 2.1.1 and 3.2
FMP – Section 5.3.8	A buffer of 500 metres would be imposed between the flying-fox camp and any ancillary sites throughout the period of construction of the Project.	Section 2.1.1 and 3.2
FMP – Section 7.3.3	An ecologist would be present during clearing activities in the vicinity of the flying-fox roost.	Section 2.1.2 and 3.2
KMP – Section 4.5.7	For all koalas detected on/near the site, the Koala Management Protocol and Koala Relocation Strategy is to be implemented (refer KMP)	Section 2.1
KMP – Section 5.4.4	Pre-clearing surveys will include spotlight surveys within suitable habitat the night before clearing operations commencing in a given area.	Section 2.1
KMP – Section 5.4.5	Where continuous lines of jersey (concrete) barriers are to be installed, gaps are to be provided to allow escape of animals off the highway. Where gaps cannot be provided, a suitable material will be placed over the barrier to enable koalas to climb over.	Section 3.5
KMP – Section 5.4.6 & 6.3.2	Undertake and maintain habitat rehabilitation works within identified areas associated with the Project Site to create additional koala habitat.	Section 2.5 & 3.12

Source	Mitigation Measure	Relevant Section of EcMP
GBFMS – Section 3.5.2	Giant Barred Frog habitat at Upper Warrell Creek (ch. 42565) should be protected from non-essential construction related works.	Section 2.1 and 3.2
GBFMS – Section 4.4.2 & 4.5.3	Within 6 weeks of scheduled clearing/ground disturbance operations in Giant Barred Frog habitat, , the Project Ecologist will perform pre-clearing surveys over a minimum of two non-consecutive nights (i.e. before clearing commences)	Section 2.1 and 3.2
GBFMS – Section 4.5.4	Within Giant Barred Frog habitat the clearing and grubbing activities will be supervised by the Project Ecologist until such a time they are confident no Giant Barred Frogs remain within the work site.	Section 2.1 and 3.2
GBFMS – Section 4.5.6	Permanent frog fencing will be installed in Upper Warrell Creek.	Section 3.3.2
GTFMS – Section 2.2	Areas of suitable habitat for the green-thighed frog should be protected from non-essential construction related works. The locating of access tracks, utilities redistribution, car parking facilities and other ancillary works including topsoil stock piles, lay down areas, wash down bays, site shedding and compound sites should not be located in this area.	Section 2.1 and 3.2
GTFMS – Section 2.3	Searches to detect green-thighed frogs will be undertaken in areas of suitable habitat immediately prior to clearing.	Section 2.1 and 3.2
GTFMS – Section 2.5	Temporary frog fencing will be installed within 3 days of scheduled clearing at all known green-thighed frog locations (i.e. ch.60065 and ch.60865)	Section 3.3.1
GTFMS – Section 2.3	Frog breeding ponds will be constructed at three locations – chainages 58015, 581645 and 60065	Section 2.1 and 3.3.1
GTFMS – Section 2.5.2	Permanent frog fencing will be installed where green-thighed frog ponds have been constructed.	Section 2.1 and 3.3.1
MBMS – Section 3	Installation of microbat roost boxes. Bat boxes should be installed by an ecologist 6 - 12 months prior to planned roost exclusion.	Section 2.4 and 3.4

Source	Mitigation Measure	Relevant Section of EcMP
MBMS – Section 3	The contractor would manage the integrity of drainage lines and associated riparian vegetation so as to not constrict microbat flyways.	Section 2.1.1 and 3.4
STQMP – Section 5.45	A suitably qualified ecologist will undertake searches in the construction footprint for s-t quoll immediately prior to clearing activities focusing on potential dens, large hollow-bearing trees and fallen logs and rock platforms.	Section 2.1
STQMP – Section 5.45	During pre-clearing surveys, the Project Ecologist will identify and mark large fallen logs (>300mm, non-decayed) for relocation within adjacent areas inside the project boundary, particularly near fauna crossings, rehabilitation areas and areas of retained forest.	Section 2.1

2.1. Pre-clearing and clearing procedures

The Revised Statement of Commitments (SoC), WC2U upgrade project Environmental Assessment (EA) and relevant management strategies include a range of procedures to be undertaken during the construction phase of the project aimed at reducing the incidence of wildlife mortality during the clearing process. The procedures include:

- SoC F1 - Clearing of native vegetation, including Endangered Ecological Communities (EECs) will be restricted to the minimum area necessary for construction;
- SoC F2 - A qualified ecologist will identify any vegetation (including Marsdenia longiloba) to be retained and to be clearly delineated on work plans within the construction corridor. Erection of flagging/fencing on-site prior to any construction works, which is to remain in place for the full construction period, will clearly delineate this vegetation;
- SoC F6 - A suitably qualified ecologist will undertake pre-clearance surveys for threatened species including frogs. Searches will include nests and hollow bearing trees. Re-location of fauna species at risk of injury found in pre-clearance surveys or during construction will be in suitable habitat as close as possible to the area in which they were found. Immediately prior to clearing an inspection will confirm that the sites subject to pre-clearance surveys remain free of fauna;
- SoC F7 - Where feasible and reasonable the identification and distribution of natural and artificial habitat features and resources (such as hollow-bearing trees, hollow logs, nest boxes and bush rocks) will occur along the Proposal. This relocation will limit injury to fauna and damage to existing vegetation. A nest box plan will be developed for the Proposal;
- EA Chapter 10 Section 10.5.1.2 - A suitably qualified ecologist will undertake searches in the construction footprint for native fauna immediately prior to clearing activities. Searches will include nests and large hollow-bearing trees and target habitats of hollow dwelling species, koalas and frogs. During the proposed clearing works, an experienced wildlife handler should be present to retrieve any displaced fauna and release the fauna into adjacent habitats safe from construction work;
- EA Chapter 10 Section 10.5.1.2 - Re-survey immediately prior to construction to identify nest locations for Osprey, Black-necked Stork and brolga. The location of the identified Osprey nest will be checked to confirm if it is present before clearing commences;
- EA Chapter 10 Section 10.5.1.2 - A fauna rescue framework for clearing has been developed by Roads and Maritime Services in consultation with EPA and will be used as a basis for developing a protocol for the handling and translocation of fauna during construction;
- EA Chapter 10 Section 10.5.1.2 - Strategies will be developed to deal with incidents involving individual animals during construction activities in consultation with the EPA officers, WIRES and/or other relevant local wildlife carer groups;
- Flying-fox Management Plan Section 5.3.5 – (with regard to the flying-fox camp) prior to the commencement of clearing operations, the project ecologist would identify all areas that contain vegetation and habitat to be retained, including exclusion zones;
- Flying-fox Management Plan Section 5.3.5 – (with regard to the flying-fox camp) prior to the commencement of clearing operations targeted surveys for flying-foxes would be undertaken;
- Giant Barred Frog Management Strategy Section 2.4.1 – temporary fencing shall be installed at known giant barred frog sites prior to commencement of clearing operations;
- Giant Barred Frog Management Strategy Section 4.5.3 - within 6 weeks of scheduled clearing/ground disturbance operations in Giant Barred Frog habitat, the Project Ecologist will perform pre-clearing surveys over a minimum of two non-consecutive nights;
- Giant Barred Frog Management Strategy Section 4.5.4 - within giant barred frog habitat the clearing and grubbing activities will be supervised by the Project Ecologist until such a time they are confident no giant barred frogs remain within the work site.
- Green-thighed Frog Management Strategy Section 2.5 – temporary fencing shall be installed at known green-thighed frog sites prior to commencement of clearing operations;

- Koala Management Plan Section 4.5.7 and 5.4.4 - Pre-clearing surveys will also include spotlight surveys within suitable habitat the night before clearing operations commencing in a given area. For all koalas detected on/near the site during construction the Koala Management Protocol and Koala Relocation Strategy will be implemented.
- Spotted-tailed Quoll Plan of Management Section 5.4.5 - During pre-clearing surveys, the Project Ecologist will identify and mark large fallen logs (>300mm, non-decayed) for relocation within areas adjacent clearing footprint and within project boundary, particularly near fauna crossings, rehabilitation areas and areas of retained forest.

Although not specified in the EA or SoCs, vegetation containing hollow-bearing trees will be cleared using a staged clearing process developed in consultation with EPA. Furthermore, information on tree hollow characteristics will be collected during the staged clearing process to enable the quantification of actual tree hollows removed during construction. The resulting information will be used to assess the adequacy of the proposed nest box quantities specified in the project Nest Box Management Plan and as required to comply with MCoA No. B6.

2.1.1. Pre-clearing surveys

Prior to commencement of clearing operations the project ecologist will identify all areas within the project corridor that contain vegetation to be retained (including EECs) and suitable habitat for hollow-dependent fauna, koalas, roosting flying-foxes and threatened frog species.

Delineation of clearing boundaries and exclusion zones

Targeted surveys will be undertaken to delineate the boundaries of vegetation (including EECs) to be retained within the project corridor. The clearing limits will then be subject to geodetic survey to enable accurate installation of protective fencing and inclusion on constraints mapping.

Furthermore, all exclusion zones for the protection of threatened frog habitat, microbat riparian habitat and the flying-fox camp are to be clearly delineated and fenced/marked prior to commencement of clearing or construction works.

Habitat resource surveys

A large proportion of potential hollow-bearing trees within the WC2U upgrade corridor were mapped and marked by Lewis Ecological Surveys (LES) between December 2011 and March 2012. However, further surveys will be conducted up to seven days prior to commencement of clearing to re-mark potential habitat trees, detect additional habitat trees (e.g. trees containing nests, hollows, fissures, termitaria and dreys), hollow logs, ground nests, dens and large rocks within the clearing limits. Suitable release sites for fauna that may be encountered during clearing will be identified during the pre-clearing surveys. Activity levels at known and potential raptor nests identified by LES (2012) will also be assessed during the pre-clearing surveys.

Habitat resources identified during the pre-clearing surveys will be marked with bright coloured flagging tape and numbered with bright coloured spray paint. The location of each habitat resource will be recorded using a handheld GPS (UTM WGS 84). Details of additional habitat resources will then be forwarded to the relevant project Environmental Officer for inclusion on sensitive area mapping.

Hollow-dependent fauna surveys

Spotlighting surveys to detect hollow-dependent fauna will be conducted within areas of forest habitat containing potential hollow-bearing trees. These surveys will be completed up to seven days prior to clearing operations.

Koala surveys

Surveys for koalas will involve spotlighting within areas of suitable habitat on the night prior to clearing operations. Diurnal visual searches will also be conducted in areas of suitable habitat immediately prior to commencement of clearing operations to detect any koalas that enter the area overnight. For all koalas detected on/near the site during construction the Koala Management Protocol and Koala Relocation Strategy will be implemented (refer Koala Management Plan (GeoLINK 2017).

Spotted-tailed quoll surveys

Pre-clearing surveys conducted immediately prior to commencement of clearing shall include searches of potential denning habitat, including large hollow logs and rock piles. In the event that a quoll is identified, no works would be undertaken within 200m of the animal until such time as the animal has self-relocated. A Fauna Management Protocol for Spotted-tailed Quoll is described in Table 4.1 of the Spotted-tailed Quoll Management Plan (GeoLINK 2017).

Frog surveys

Targeted surveys for threatened frogs were undertaken by LES in late 2011. The surveys detected two threatened frog species within the project corridor, green-thighed frog (*Litoria brevipalmata)* and giant barred frog (*Mixophyes iteratus*) (LES 2013a, 2014a). Management strategies for both of these species have been prepared by LES.

Frog surveys within suitable microhabitats will also be conducted either the night prior to or immediately prior (ie. less than two hours) to commencing clearing operations depending on the seasonal timing of proposed clearing operations. Nocturnal surveys, consisting of spotlighting searches and call playback census, will be conducted during warmer months (October to May) when frogs are generally more active. Frog surveys conducted during the colder months will be limited to active daytime searches (15 minutes per hectare) immediately prior to commencing clearing operations. Pre-clearing surveys in giant barred frog habitat areas should not take place during winter periods or other periods of likely dormancy including extended dry weather periods (i.e. more than7 nights without a rainfall event of greater than 10 mm in 24 hrs).

Active searches will involve turning of rocks and logs, raking of debris and peeling of decorticating bark. Captured individuals will be held temporarily in a plastic bag with a small amount of water (1 frog per bag) and relocated in areas of suitable habitat adjacent to the clearing footprint.

All field survey, capture and release tasks will be conducted in accordance with the NPWS (2001) Hygiene Protocol for the Control of Disease in Frogs.

Microbat surveys and management

Bridge and culvert structures along the WC2U upgrade corridor were surveyed by LES in December 2011 and October 2012 to identify sites used for roosting by microbats. Nine of the 69 structures surveyed contained evidence of microbat use, while 22 of the structures were considered to contain suitable roosting habitat for microbats (LES 2014b). Consequently, a microbat management strategy has been prepared by LES.

Flying-fox surveys

During vegetation clearing activities in the remnant patch of swamp forest that contains the Macksville flying-fox camp (note: clearing restricted to between 1 May and 15 September), observation of a dusk exit flight and a dawn entry flight would be used to monitor presence/absence of flying-foxes. Clearing of vegetation within the buffer zone would halt if a heavily pregnant grey-headed flying fox (GHFF) or female GHFF with dependent young were present. An ecologist, experienced with flying foxes would be on site during removal of vegetation in vicinity of the camp. Other construction activities would halt if heavily pregnant GHFF or female GHFF with dependent young were present after 31 August.

Diurnal visual searches will be conducted within the remnant patch of swamp forest that contains the Macksville flying-fox camp immediately prior to commencement of clearing operations to detect any roosting flying-foxes. If a flying-fox is identified within the construction clearing zone, all clearing works will cease within 100 metres of the observed individual, or the edge of the group if a number of individuals are identified. Clearing will not commence in the area where the flying-foxes were identified until clearance is given by the project ecologist.

Final pre-clearing visual searches

A final pre-clearing visual search will be undertaken by the project ecologist immediately prior (ie. less than two hours) to commencement of clearing operations to ensure that the areas to be cleared are as free of fauna as possible.

Captured fauna will be released into adjacent or proximate areas of suitable habitat beyond the project clearing limit. Captured giant barred frogs will be relocated to the nearest side of the clearing limit within 100m of capture site. Captured koalas would be relocated within suitable habitat as identified by the Project Ecologist (refer to Koala Capture Relocation Strategy within Koala Management Plan).

2.1.2. Clearing process

Staged clearing

Following the completion of the pre-clearing surveys described in Section 2.1.1, tree removal will be staged, with non-habitat trees being removed first, then the potential habitat trees being removed with a swivel head harvester at least 48 hours later to enable resident hollow-dependent fauna time to evacuate the tree prior to felling. A suitably qualified, licensed and experienced ecologist and a suitable licensed and experienced wildlife carer will be present to observe the removal of each potential habitat tree. The wildlife carer will manage any injured or displaced fauna residing in felled trees. The ecologist will inspect each felled tree to record tree hollow characteristics and any evidence of habitation.

The project ecologist will be responsible for the relocation and release of any displaced fauna once the health of captured individuals has been confirmed by the wildlife carer. The reporting requirements for the tree clearing phase of the project are provided in Section 3.2.2.

Clearing supervision by ecologist

An ecologist would be present during clearing activities in giant barred frog habitat and in the vicinity of the flying-fox camp. The ecologist would manage any injured or displaced giant barred frogs or flying-foxes with assistance from a wildlife carer or vet for rehabilitating injured wildlife. The ecologist or wildlife carer would relocate and release displaced individuals upon confirmation of the animal's health.

Incidental fauna management

A suitably licensed and experienced wildlife handler will be made available to attend the project site during clearing operations to ensure rapid treatment and management of any displaced fauna detected incidentally by clearing operators or project personnel. The specific procedure for managing incidental fauna is detailed in the project CEMP.

Post-clearing inspections

Weekly post-clearing inspections shall be undertaken by the contractor throughout the construction phase of the project to ensure that all works are compliant with approved clearing limits and exclusion zones, and to check the integrity of exclusion fencing/barricades.

2.2. Fauna underpasses and exclusion fencing

Requirements for fauna underpasses as part of the WC2U upgade project are stipulated in MCoAs B1, B2 and B3. Relevant SoCs and EA mitigation measures include:

- SoC F9 - Provision of fauna crossings will be as identified in the environmental assessment. All fauna crossings will be confirmed with the EPA and DPI during the detailed design phase;
- SoC F11 - Erection of fauna exclusion fencing (e.g. floppy-top fencing) along the Proposal at appropriate locations will direct fauna movement towards fauna-crossing structures;
- Chapter 10 Section 10.5.1.2 - Provide dedicated and incidental fauna crossing structures at key locations for forest fauna species identified to target the range of large, medium and smaller species present such as Yellow-bellied Glider, Koala, Giant Barred Frog and Green-thighed Frog;
- Chapter 10 Section 10.5.1.2 – all bridges on the project and culverts identified as having a potential role in fauna crossing will be designed to facilitate fauna movements;
- Chapter 10 Section 10.5.3 - Provision of dedicated, combined and incidental fauna underpass structures; and
- Chapter 10 Section 10.5.3 - Exclusion fencing will be installed around the crossing structures to prevent access to the carriageway for up to 500 metres either side.

A total of 23 fauna underpass structures are proposed for Stage 2 of the WC2U upgrade project. These will consist of 13 sites with box culverts, three sites with a pipe culvert and seven bridge sites. Eleven fauna underpass structures are proposed for monitoring (*Table 2.1*).

Table 2.1: *Underpass structures within Stage 2 of the WC2U upgrade project proposed for monitoring following EPA and Roads and Maritime meeting 25/9/14.*

Chainage Referral	Fauna crossing structure type	Structure form	Dimension	Target Species for Monitoring
42500	Combined	Bridge over Upper Warrell Ck		GBF
55120	Dedicated	Box Culvert	3000x3000	Koala & Quoll
56410	Combined	Box Culvert	2400x2400	Koala & Quoll
57770	Dedicated	Box Culvert	3000x3000	Koala & Quoll
58510	Combined	Box Culvert	3000x3000	Koala & Quoll
58560	Dedicated	Box Culvert	3000x3000	Koala & Quoll
59090	Dedicated	Box Culvert	3000x3000	Koala & Quoll
59550	Dedicated	Box Culvert	3000x3000	Koala & Quoll
59750 NB lanes	Dedicated	Box Culvert	2400x2400	Koala & Quoll
59760 SB Lanes	Dedicated	Box Culvert	2400x2400	Koala & Quoll
60600 NB Lanes	Dedicated	Box Culvert	2400x2400	Koala & Quoll
60610 SB Lanes	Dedicated	Box Culvert	2400x2400	Koala & Quoll

The purpose of the fauna underpasses and associated fauna exclusion fencing will be to maintain the viability of local populations of terrestrial fauna by facilitating wildlife movement between proximate areas of habitat either side of the Upgrade corridor, thus maintaining genetic variation and providing opportunities for species dispersal and recolonisation. Fauna underpass will be designed to accommodate use by several threatened fauna species including the spotted-tailed quoll (*Dasyurus maculatus*), koala (*Phascolarctos cinereus*) and giant barred frog (*Mixophyes iteratus*).

Flying-fox camp exclusion fence

Approximately 530m of three meter high exclusion fencing will be installed along the northbound and southbound carriageways in the vicinity of the Macksville flying fox camp. The fence is designed to minimise the risk of flying fox's striking trucks and vehicles when exiting or entering the camp.

2.3. Widened vegetated median and glider crossing structures

MCoA B4 states "*The Proponent shall in consultation with EPA, ensure that the design of the project as far as feasible and reasonable, incorporates provision for glider crossings (such as widened medians and maintenance or enhancement of habitat within the medians and corresponding carriageway boundaries) where the alignment crosses areas of recognised glider habitat*". Furthermore, SoCs and EA mitigation measures relevant to the provision of widened medians include:

- SoC F8 - Retention of mature trees in the median at locations identified in the environmental assessment will provide a stepping stone for gliders. Protection of these trees will occur (F2), and lopping and pruning is not to occur without expert advice; and
- Chapter 10 Section 10.5.3 - Widening of the median at important locations.

The purpose of the widened vegetated median will be to maintain habitat connectivity for glider species known or likely to occur in the locality in order to maintain genetic variation and to provide opportunities for dispersal and recolonisation. Threatened glider species targeted by the mitigation measure include the squirrel glider (*Petaurus norfolcensis*) and yellow-bellied glider (*Petaurus australis*).

The only vegetated median within Stage 2 of the project will be located through Nambucca State Forest. The vegetated median will consist of a strip of retained tall sclerophyll forest vegetation (minimum 50 metres wide), which will extend up to 300 metres in length. Continuous lengths of wildlife exclusion fencing will be installed either side of the Upgrade corridor in this locality to limit potential use of the vegetated median by ground-based fauna, thus minimising the incidence of road-strike mortalities.

In addition, MCoA B2 requires the RMS to further investigate design refinements to improve fauna connectivity between chainages 19150 and 19820. Design refinements include the addition of one rope bridge and one glider pole crossing point consisting of three poles. Detailed design requirements are listed in Section 14.3 of Appendix 14 Scope of Works and Technical Criteria.

2.4. Nest box installation

Requirements for the installation of nest boxes are stipulated in:

- EA Chapter 10 Section 10.5.1.2 - Nest boxes are to be installed, where required, in accordance with specialist advice and in consultation with the EPA, prior to construction, to replace hollow resources that are proposed to be removed; and
- Microbat Management Strategy Section 3 - Bat boxes should be installed by an ecologist six to 12 months prior to planned roost exclusion.

2.4.1. Nest boxes for hollow resource replacement

The purpose of nest box installation is to implement nest boxes as a compensatory mechanism for the loss of den, roost and nest resources (LES 2013b). A Nest Box Management Plan (NBMP) has been prepared by LES and approved by DPE in accordance with MCoA B6, which states *"prior to the commencement of any construction work that will result in the disturbance of any native vegetation (or as otherwise agreed to by the Director General), the Proponent shall in consultation with OEH prepare and submit for the approval of the Director General a Nest Box Plan to provide replacement hollows for displaced fauna consistent with the requirements of SoC F7. The plan shall detail the number and type of nest boxes to be installed, which must be justified based on the number and type of hollows removed (based on detailed pre-construction surveys), the density of hollows in the area to be cleared and adjacent forest, and the availability of adjacent food resources. The plan shall also provide details of maintenance protocols for the nest boxes installed including responsibilities, timing and duration"*.

Nest boxes are to be installed at ten locations within Stage 2 of the WC2U project. Detailed descriptions of nest box locations, nest box types and target species for each area are provided in the NBMP (LES 2013b). At least 60 percent of the nest boxes are to be installed prior to or during clearing works to provide alternative shelter for hollow-dependent fauna displaced during the clearing phase. The remaining nest boxes will be installed once the abundance of actual tree hollows removed has been confirmed by the clearing phase monitoring.

2.4.2. Nest boxes targeting microbats

Nest boxes to accommodate microchiropteran bats impacted by project works on existing bridges and culverts would be installed by an ecologist six to 12 months prior to planned roost exclusion in accordance with the Microchiropteran Bat Management Strategy prepared by LES (2014b).

2.5. Landscape rehabilitation

Relevant EA and management plan mitigation measures include:

- Chapter 10 Section 10.5.1.1 - Revegetation/rehabilitation of the site should be conducted progressively during the construction phase to ensure the use of collected topsoil and seed and to develop different successional stages of rehabilitation;
- Chapter 10 Section 10.5.1.1 - A weed management plan is to be prepared as part of the flora and fauna management sub plan, outlining weed management actions to be carried out during construction to prevent the spread of weeds and plant pathogens;

- Chapter 10 Section 10.5.2 - Native and locally indigenous plants will be used in the landscaping and disturbed areas will be progressively revegetated;
- Chapter 10 Section 10.5.2 - Weeds in areas disturbed by construction activities will be managed for a minimum of two years after construction completion;
- Chapter 10 Section 10.5.4 - Development of a rehabilitation and weed control strategy as part of the construction environmental management plan, with specific mitigation measures for control of the spread of weeds and habitat rehabilitation, particularly along roadside verges, adjacent to culvert entrances and bridge pylons;
- Chapter 10 Section 10.5.4 - A protocol be developed for weed infested areas to ensure that all potential weed propagules from soil and vegetative material are appropriately disposed of; and
- Chapter 10 Section 10.5.5 - Roadside verges will be rehabilitated adjacent to culvert entrances and bridge pylons.
- Koala Management Plan Section 6.3.2 - Habitat rehabilitation works will be conducted within areas identified for additional koala habitat/connectivity.

In order to comply with MCoA B21(c) the contractor will prepare and implement an Urban Design and Landscape Plan (UDLP) for the project. The UDLP will include locations along the project corridor directly or indirectly impacted by the construction of the project (e.g. temporary ancillary facilities, access tracks, watercourse crossings, etc.) that are proposed to be actively rehabilitated, regenerated and/ or revegetated to promote biodiversity outcomes and visual integration. The UDLP will provide details of species to be replanted, including their appropriateness to the area and considering existing vegetation and habitat for threatened species.

2.6. Protection of in-situ threatened flora populations

The relevant mitigation measure for the protection of in-situ threatened flora species is stipulated in MCoA B7(d), which states *"the Proponent shall in consultation with the EPA develop a management plan for these species which includes detail of mitigation measures to be implemented during construction to avoid and minimise impacts to areas identified to contain these species, including excluding construction plant, equipment, materials and unauthorised personnel".*

In situ threatened flora located within the road reserve outside the construction footprint will be protected during highway construction and operation by a range measures directed at maintaining species and their habitat in good condition. Detailed descriptions of the proposed mitigation and management measures are provided in the threatened flora management plan prepared by Benwell (2017), and include:

- implementation of safeguards during clearing and construction - no-go zones, fencing and signage, toolbox sessions, tagging and marking and population mapping; and
- protection from edge effects - sedimentation fencing, shade/dust screening, landscaping, revegetation and weed control.

2.7. Establishment of translocation areas

The relevant mitigation measure for the establishment of translocation areas for threatened flora species is stipulated in MCoA B7(b), which states *"the Proponent shall in consultation with the EPA develop a management plan for these species which, if investigation under Condition B7(a) reveals translocation of impacted plants is feasible, includes details of a translocation plan for the plants consistent with the Australian Network for Plant Conservation 2"d Ed 2OO4: Guidelines for the Translocation of Threatened Plants in Australia 2nd Ed., including details of ongoing maintenance such as responsibilities, timing and duration".*

An additional mitigation measure relevant to the establishment of translocation areas is provided in SoC F4 - *Plantings of rusty plum (Amorphospermum whitei) in areas of suitable habitat adjacent to the Proposal will follow from seed collection and propagation*.

This mitigation measure is also described in SoC F3 - *Threatened species directly impacted by the Proposal will be translocated to a suitable location outside the impact zone. A further visual inspection will be conducted post clearance to identify threatened species which may be indirectly impacted outside the cleared zone. Landscape planting is to commence along the road boundary as soon as possible during construction*.

Within Stage 2 of the WC2U upgrade project translocations are proposed for five threatened flora species directly impacted by the Upgrade, *Niemeyeri whitei, Marsdenia longiloba, Tylophora woollsii*, *Alexfloydia repens* and *Dendrobium melaleucaphilum* (Benwell 2014). In addition, translocations are proposed for two rare flora species directly impacted by the Upgrade, *Goodenia fordiana* and *Artanema fimbriatum*.

The primary aims of the proposed translocations are to:

- save and re-establish those individuals of significant flora directly impacted by construction; and
- improve the prospective viability of the translocated population by propagating and introducing additional individuals (Benwell 2014).

Details of the proposed translocation areas and procedures are provided in the Warrell Creek to Urunga Upgrade Threatened Flora Management Plan (Benwell 2016).

3. Monitoring methods[3]

3.1. Timing and duration of monitoring

Details of the timing and duration of monitoring for each mitigation measure are provided in the following sections and summarised in *Table 3.1*.

[3] Note: monitoring methodologies may be modified through appropriate consultation (and stakeholder approval when required) where outcomes are still able to be achieved but more efficient methods and/or technology is able to be implemented.

Table 3.1: *Summary of the timing and duration of monitoring events for each proposed mitigation measure.* P & C = pre-clearing and clearing procedures; GTF = green-thighed frog monitoring; GBF = giant barred frog monitoring; MRB = microbat roost box monitoring; MH = microbat habitat monitoring; MBP&B = Microbat Persistence & Behaviour Monitoring (Crouches Ck Bridge); YG = yellow-bellied glider monitoring; KP = Koala population monitoring; FFH = Flying-fox habitat monitoring; FFP = Flying-fox population monitoring; FFRK = Flying-fox road kill monitoring; FU = fauna underpass and exclusion fence monitoring; RK = Road Kill Monitoring; VM = vegetated median; GCS = glider crossing structures; NM = nest box monitoring; LR = landscape rehabilitation monitoring; ITF = in-situ threatened flora population monitoring; TA = translocation area monitoring; MTH = Marsdenia Tylophora Habitat Monitoring.

Mitigation Measure	Pre-construction	Construction Phase (up to 4 years)				Operational Phase (to commence following project completion)									
		Year 1	Year 2	Year 3	Year 4	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
P & C		A; W; Sp; Su													
GTF						Once per year [4]	Once per year	Once per year	Once per year	Once per year					
GBF	Sp; Su; A	Sp; Su; A		Sp; Su; A		Sp; Su; A		Sp; Su; A		Sp; Su; A					
MRB			A; W; Sp; Su	A; W; Sp; Su	A; W; Sp; Su	A; W; Sp; Su	A; W; Sp; Su								
MH	Once prior to construction	Monthly		Monthly	Monthly										
MBP&B		A; W; Sp; Su	A; W; Sp; Su												
YG	W/Sp		W/Sp			W/Sp	W/Sp		W/Sp			W/Sp			W/Sp
KP	W/Sp	Sp		Sp		Sp		Sp		Sp					
FFH						Quarterly [3]									
FFP	Monthly	Monthly; Fortnightly (1 Aug - 30 April)	Monthly; Fortnightly (1 Aug - 30 April)	Monthly;	Monthly;	Monthly [3]									
FFRK		Incidental observations	Incidental observations	Incidental observations	Incidental observations	Weekly for 12 weeks then weekly in Oct, Jan, Apr, July	Weekly in Oct, Jan, Apr, July	Weekly in Oct, Jan, Apr, July	Weekly in Oct, Jan, Apr, July	Weekly in Oct, Jan, Apr, July					
FU	W (quoll) as part of baseline					W; Sp/Su	W; Sp/Su	/W; Sp/Su	W; Sp/Su	W; Sp/Su					
RK		Daily (Clearing); Weekly (Construction)	Weekly	Weekly	Weekly	Weekly for 12 weeks then weekly in Oct, Jan, Apr, July	Weekly in Oct, Jan, Apr, July	Weekly in Oct, Jan, Apr, July	Weekly in Oct, Jan, Apr, July	Weekly in Oct, Jan, Apr, July					
VM/GCS							Su/A; W/Sp	Su/A; W/Sp		Su/A; W/Sp					
NM				W; Su	W; Su		W; Su		W; Su						
LR			Sp; Su	A; W; Sp; Su	A; W	A; W; Sp;Su	A; W; Sp; Su	A; W; Sp; Su							
ITF		A; Sp	A; Sp	Sp	Sp	Sp	Sp	Sp	Sp	Sp					
TA	A; W; Sp; Su	A;W Sp	Nov	Nov	Nov	Nov	Nov	Nov	Nov	Nov					
MTH		A; Sp	A; Sp	Sp	Sp	Sp	Sp	Sp	Sp	Sp					

Note 1: A; W; Sp; Su - Autumn; Winter; Spring; Summer. Note 2: Monitoring periods may be reduced with the agreement of the Director General in consultation with EPA and DoEE, depending on the outcomes of the monitoring. Note 3: Green thighed frog – once per year at least 10-12 months apart when rainfall >75mm over 24hr or >150mm over 72 hr Note 4: Flying Fox – operational phase when upgrade to Macksville Camp opens to traffic

3.2. Pre-clearing and clearing procedures

3.2.1. Timing of monitoring

Surveys for delineating clearing limit boundaries and exclusion zones, identifying habitat resources and detecting hollow-dependent fauna, koalas and frogs will be completed shortly prior to the commencement of clearing operations. Wildlife rescue and tree hollow inspection procedures will be undertaken in conjunction with the second clearing stage, which involves the felling of potential habitat trees.

3.2.2. Monitoring procedure

The results of the targeted vegetation boundary and exclusion zone delineation surveys (refer to Section 2.1.1) will be incorporated into the project constraints mapping, which will be submitted as part of annual reporting to the Roads and Maritime and EPA.

Monitoring of pre-clearing and clearing procedures will include data collection and reporting tasks that will be submitted to Roads and Maritime, DPE and EPA. Information contained within the annual reporting shall include:

- a habitat tree register – to present the tree hollow data collected from habitat trees removed during clearing operations. The information will be analysed and compared with the potential tree hollow data contained in the NBMP prepared by LES (2012a) to ensure that an adequate supply of nest boxes has been installed to mitigate the impacts of tree hollow removal;
- detailed descriptions of methods used during the pre-clearing and clearing procedures;
- results of pre-clearing and clearing procedures including lists of fauna species displaced by clearing, species captured, species released and any wildlife mortalities resulting either directly or indirectly from the clearing operations;
- discussion of the pre-clearing and clearing procedures in terms of their effectiveness and any problems encountered that relate to the methods employed; and
- any recommended refinements to the pre-clearing and/or clearing procedures that may be adopted during future clearing operations.

The types of information to be collected during each pre-clearing and clearing procedure are provided in Table 3.2.

Table 3.2: *Information to be collected during each pre-clearing and clearing procedure.*

Mitigation Management Procedure	Required Information
Habitat Resource Surveys	Sampling date; observers; start/finish chainages; sampling start/finish times; threatened flora observations; additional habitat resources; GPS locations for observations.
Hollow-dependent Fauna Surveys Stag Watching (optional technique)	Sampling date; observers; habitat tree number; tree location; tree species; sampling start/finish times, prevailing weather conditions; hollow-dependent fauna species and abundances observed; location and characteristics of occupied hollow(s) on the subject tree.
Spotlighting	Sampling date; observers; start/finish chainages; sampling start/finish times, prevailing weather conditions; fauna species and abundances observed; fauna behaviour (ie. foraging, emerging from hollow, moving through site); habitat type occupied by observed fauna; GPS locations of fauna observations.
Koala Surveys	Sampling date; observers; start/finish chainages; sampling start/finish times, GPS locations of observed koalas; koala sex and age; species and DBH of occupied trees; method of site marking used; management procedure applied.

Mitigation Management Procedure	Required Information
Koala Surveys	Sampling date; observers; start/finish chainages; sampling start/finish times, GPS locations of observed koalas; koala sex and age; species and DBH of occupied trees; method of site marking used; management procedure applied.
Frog Surveys (including clearing supervision)	Sampling date; observers; location; sampling start/finish times, prevailing weather conditions; frog species and abundances observed/captured; condition of captured individuals; release date, release time; GPS location of release point; habitat type at release point.
Flying-fox Surveys (including clearing supervision)	Sampling date; observers; location; sampling start/finish times, prevailing weather conditions; flying-fox species and abundances observed/captured; condition of captured individuals; GPS locations of observed, captured and released individuals.
Habitat Tree Removal	Habitat tree number; removal date; observers; removal method (e.g. sawn, pushed, hard or soft impact); tree hollow characteristics (e.g. hollow type, entrance diameter, hollow depth, evidence of fauna usage); species breeding status and condition of fauna captured/observed; release date; GPS location of release point; habitat type at release point; release method.
Final Pre-clear Searches	Sampling date; observers; start/finish chainages; sampling start/finish times; fauna observations and captures; GPS locations for observation and release points.
Post-clearing Inspections	Sampling date; observers; start/finish chainages; compliance with clearing limits, compliance with exclusion zones, integrity of exclusion zone fencing/barricades, GPS locations for any non-compliances and photos of non-compliances.

3.2.3. Potential indicators of success

Potential indicators of success for the pre-clearing and clearing procedures will include:

- low rates of fauna injury and mortality resulting from clearing operations, particularly of threatened fauna species;
- successful capture and release of fauna displaced by clearing operations;
- accurate quantification of tree hollow resources being removed; and
- adherence to clearing limits and exclusion zones.

3.3. Threatened frog population monitoring

3.3.1. Green-thighed frog

Timing of monitoring

Monitoring will be undertaken on five occasions, commencing in the first year of the operational phase and finishing five years post-construction. The monitoring events will be at least 10 to 12 months apart but ultimately dependant on rainfall events. Monitoring will commence once the vegetation on the edges of the constructed ponds is considered sufficient (>20% groundcover). Inspections of permanent frog fences for breaches by frogs will be undertaken during population monitoring.

Monitoring methods

Monitoring of the green-thighed frog population will consist of two main components:

- Monitoring of constructed breeding ponds; and
- Monitoring the integrity of frog fences.

Monitoring will be undertaken on a rainfall event basis when 24 hour rainfall totals exceed 75mm or a cumulative total of 150mm over a 72 hour period. Such rainfall events will be monitored via 'on site' weather stations which are to be programmed to generate a sms message to the field survey team phone, and alternatively, the Bureau of Meteorology (BOM) website and specifically the Nambucca Heads Bowling Club (Station No. 059024). Further details of monitoring methods are provided in the green-thighed frog management strategy prepared by LES (2013a).

Potential indicators of success

Performance indicators of success will be based on either the:

- Continued presence of Green-thighed Frogs at breeding ponds;
- Green-thighed Frogs calling from the edge of the constructed ponds; or
- The presence of tadpoles, juveniles or metamorphs during follow up surveys.

3.3.2. Giant barred frog

Timing of monitoring

Baseline population monitoring was undertaken prior to construction, and consisted of one survey in spring, summer and autumn (i.e. three surveys). Subsequent population monitoring events will also consist of three surveys (spring, summer and autumn) to be undertaken for years 1, 3 and 5 of the operational phase (Table 3.1). The timing of monitoring can be varied where approved by DoEE in consultation with EPA. Inspections of permanent frog fences for breaches by frogs will be undertaken during population monitoring.

Monitoring methods

Population monitoring of the giant barred frog (Mixophyes iteratus) will be undertaken at Upper Warrell Creek where the species is known to occur and Butchers Creek.. The monitoring program will consist of:

- **Upper Warrell Creek**: Establishment of a one kilometre transect, which would consist of 450m upstream and downstream of the project corridor and 100m within the project corridor;
- **Butchers Creek**: Establishment of a 400m transect, which would consist of 200m upstream and downstream of the project corridor.
- A minimum sampling duration along the transect of two person hours per sampling event;
- Baseline data was collected in three sampling events, spring, summer and autumn, prior to commencement of construction works;
- Captured individuals to be PIT tagged to record re-captures during subsequent surveys. Data to be recorded per individual will include location, sex and breeding condition, snout-vent length, weight and general condition. Individuals captured during the summer survey should be swabbed for presence of Chytrid fungus;
- Tadpole surveys during the spring survey using bait traps (20 traps per transect in Upper Warrell Creek and 8 traps per transect in Butchers Creek) and opportunistic dip netting during spring and autumn surveys; and
- Collection of abiotic data and habitat attributes.

No reference site has been proposed for the monitoring program as a means of managing the potential spread of chytrid fungus. Further details of monitoring methods are provided in the giant barred frog management strategy prepared by LES (2014a).

Potential indicators of success

Performance indicators of success will be based on either the:

- Continued presence of giant barred frog along any part of the 1 km transect. This approach compensates for the mobile habits of this species and the shifting patterns of seasonal habitat use;

- The recapture of one or more giant barred frog following their relocation from the clearing footprint (if this occurs); or
- The presence of tadpoles, metamorphs or juveniles frogs during follow up surveys post construction (LES 2014a).
- <30% decline in measured habitat parameters;
- <15% increase in bare ground cover;
- No statistically significant changes in measured water quality parameters;
- No road kill of Giant Barred Frog resulting from operation of highway.

3.4. Microbat monitoring

3.4.1. Timing of monitoring

Microbat roost boxes will be monitored quarterly, commencing six months after installation, for a period of five years. Microbat habitat monitoring will be conducted once prior to construction and monthly during construction. Inspection of riparian zones to assess impacts on flyway function will also be conducted once post-construction. A program to monitor bat persistence and behaviour will be developed by the contractor and the Project Ecologist and/or microbat specialist. Monitoring will continue for two years during adjacent construction works.

3.4.2. Monitoring procedures

Microbat roost boxes

The microbat boxes will be inspected quarterly to determine species presence/absence, an estimate or count of numbers and breeding activity. Information will also be collected as to the roost identification number, date and time of the inspection. Bat box inspections will commence six months after installation and finish after two years of operation (Table 3.1).

Habitat monitoring

Habitat monitoring will focus on inspections of the riparian zone to assess whether flyways have been constricted as part of construction works. Therefore, on either side of the construction corridor a photo point will be installed and a visual assessment undertaken to gauge whether the flyway has been maintained or is in need of corrective actions (i.e. vegetation management).

Monitoring of water quality will also be undertaken on both the upstream and downstream sides of the construction works. This monitoring will be undertaken on a monthly cycle in accordance with the Construction Environmental Management Plan (CEMP) and collect the following parameters: turbidity; total suspended solids; conductivity and pH at both upstream and downstream points.

Microbat persistence and behaviour monitoring

A program to monitor bat persistence and behaviour at the Crouches Creek Bridge will be developed by the contractor and the Project Ecologist and/or microbat specialist. This site has been selected because it contained the largest microbat roost during the summer field survey and provides the greatest opportunity to examine the disturbance thresholds of microbats. The monitoring must consider the differences in roost use between summer and winter along with the species that are likely to use it as a roost. Monitoring would be initiated once construction works are adjacent to Crouches Creek and would be conducted seasonally for two years.

3.4.3. Potential indicators of success

Performance indicators of success may include:

- Occupation of roost boxes by a range of target species;
- No constriction of riparian zone flyways caused by construction activities;

3.5. Koala monitoring

Koala population surveys were conducted by GeoLink (2014c) to identify the location and extent of resident koala activity within the WC2NH project corridor. The results of the surveys confirmed that koala activity was limited to low level usage in the Nambucca State Forest/Old Coast Road area. The survey reports concluded that there were insufficient data to provide an accurate population estimate of koalas in the area and that the provision of GPS/VHF fitted collaring and pit tagging koalas or establishing transect survey control sites was not required.

3.5.1. Population monitoring

Transect surveys will be conducted in spring during construction phase (years 1 and 3) and operational phase (years 4, 6 & 8). Transects are to be established on each side of the Project footprint within the Nambucca State Forest/Old Coast Road area between chainage 15600 and 19500 as per the Koala Management Plan (GeoLINK 2017). Both diurnal and nocturnal transect surveys will be conducted during each survey period with the addition of spotlighting on tracks and easements across the survey area.

3.5.2. Injury/mortality from construction activities or road strike

Road mortality monitoring will be conducted during the construction and operational phase. Details on methodology and timing are provided in Section 3.9 and Appendix A. Furthermore, post-clearing inspections of areas cleared should be undertaken to identify any koalas injured or killed.

Where continuous lines of jersey barriers are to be installed, gaps are to be provided to allow animal escape. Where this is not possible, a suitable material will be installed to enable koalas to climb over the barrier. Barriers should be periodically inspected to ensure compliance.

3.5.3. Potential indicators of success

Koala abundance and distribution pre-construction are similar to post-construction and maintained in the vicinity of Nambucca State Forest / Old Coast Road.

No koala injuries or mortalities as a consequence of construction activities or operation of the Upgrade.

3.6. Yellow-bellied glider population monitoring

3.6.1. Population monitoring

It is stated in Section 10.5.1.2 of the EA that a strategy would be developed for monitoring the yellow-bellied glider population in the affected area of Nambucca State Forest as part of the flora and fauna management plan. This requires the development and implementation of a monitoring program to provide baseline data on the yellow-bellied glider population prior to commencement of construction.

The monitoring program proposed aims to assess both individual level and population level responses to the highway upgrade. An individual level response will be measured by comparing forest use adjacent to the highway upgrade before and after construction. A population level response will be measured by comparing proportion of survey sites occupied by yellow-bellied gliders in Nambucca SF with that measured at reference locations before and after construction.

Assessment of individual response (i.e. habitat use) to highway upgrade will be conducted using spotlighting and song meters to detect and record yellow-bellied glider calls in the vicinity of the highway upgrade. Population assessments will be conducted using spotlighting in Nambucca SF and at reference sites located in nearby Yarriabini NP and Ngambaa NR. The sampling methodology and timing will be undertaken in accordance with the yellow-bellied glider ecological monitoring program prepared by Goldingay (2014).

Pre-construction baseline surveys will be conducted on all survey transects (i.e. 6 habitat use transects and 90 population monitoring transects) on three occasions within the one season. Eight song meters installed near the location of the highway upgrade within Nambucca SF will sample for three months pre-construction. Surveys will also be conducted at completion of clearing (i.e all transects spotlighted on three occasions and song meters active for six months) and ideally at a similar time of the year to the baseline surveys (Aug-Oct). Post-construction monitoring will then occur in years 1, 2, 4, 7 and 10. Post-construction monitoring should endeavour to include six song meters in each of the three forest blocks where population monitoring with spotlighting is conducted. This will provide an opportunity to compare the results of song meters versus spotlighting and if they prove to be a more effective technique then it could be used as the only technique in subsequent years to assess population stability.

3.6.2. Fire / logging events

In the event that either logging or wildfire occur in any of the three Nambucca SF blocks used for population monitoring, an additional round of three surveys should be conducted within six months of the event. Surveys would occur on all baseline transects and six song meters would also be installed and sampled within each of the three forest blocks. Reference sites will only be included if two or more of the three Nambucca SF blocks are affected simultaneously.

3.6.3. Potential indicators of success

- No reduction in proportion of sites occupied by yellow-bellied gliders in Nambucca SF post-construction.
- No reduction in forest use adjacent to the highway in Nambucca SF post-construction.

3.7. Flying fox camp monitoring

3.7.1. Population monitoring

Population monitoring at the flying-fox camp would be undertaken to confirm flying-fox presence and determine patterns of occupation, species composition, demographic composition, key behaviours, and habitat characteristics. These data will inform mitigation measures and monitoring activities during construction and operation. The sampling methodology and timing will be undertaken in accordance with the flying-fox management plan (Gorecki et al. 2017).

Population monitoring commenced in the winter of 2013 to provide a baseline of population condition prior to road construction, which will provide a point of comparison to assess the impacts of the road on the population of flying-foxes and monitor the effectiveness of mitigation measures (Gorecki et al. 2017). Population monitoring will continue to be undertaken monthly throughout the pre-construction phase, construction phase and first year of the operational phase of the project. The fortnightly field monitoring program would continue through construction of the Project during the period when the flying-foxes are expected to be in the camp (i.e. from 1 August until monitoring confirms camp vacated). The monitoring program would be reviewed regularly and refined if considered appropriate.

3.7.2. Habitat monitoring

Monitoring of flying-fox habitat quality adjacent to the Project would be undertaken for the first year after the opening of the Project to traffic unless otherwise agreed with DPE, EPA and DoEE.

3.7.3. Exclusion fence and road mortality / vehicle strike monitoring

Approximately 530m of three meter high exclusion fencing will be installed along the northbound and southbound carriageways in the vicinity of the Macksville flying fox camp. The fence is designed to minimise the risk of flying fox's striking trucks and vehicles when exiting or entering the camp. To monitor its effectiveness, road mortality monitoring would be conducted commencing within one month of opening of the Project to traffic. Surveys would target 500m either side of the Macksville flying-fox camp. Surveys would occur weekly during October (spring), January (summer), April (autumn) and July (winter) for up to five consecutive years post opening to traffic, or until mitigation measures have been demonstrated to be effective.

3.7.4. Potential indicators of success

- No deterioration in the quality of adjacent habitat vegetation as a result of the Project;
- No significant reduction in reproductive output (measured as mean percentage of females with young in target trees) relative to the control site; and
- No incidence of road mortality in vicinity of Macksville camp.

3.8. Fauna underpasses and exclusion fencing

Monitoring of the fauna underpasses and exclusion fencing will be conducted after installation and once the Upgrade has become operational.

Of the 23 fauna underpass structures proposed for Stage 2 of the WC2U upgrade project, 12 structures have been selected for monitoring (Table 3.3). An underpass structure was deemed suitable for monitoring if it was located in an area of suitable habitat for one or more of the target threatened species (ie. koala, spotted-tailed quoll and giant barred frog).

Table 3.3: *Proposed fauna underpass structures suitable for monitoring. SQ=spotted-tailed quoll; K = koala; GBF = Giant Barred Frog.*

Chainage	Structure	Dimensions	SQ	K	GBF
42500	Bridge				✓
55120	Box Culvert	1 x 3000 x 3000	✓	✓	
56410	Box Culvert	1 x 2400 x 2400	✓	✓	
57770	Box Culvert	1 x 3000 x 3000	✓	✓	
58510	Box Culvert	1 x 3000 x 3000	✓	✓	
58560	Box Culvert	1 x 3000 x 3000	✓	✓	
59090	Box Culvert	1 x 3000 x 3000	✓	✓	
59550	Box Culvert	1 x 3000 x 3000	✓	✓	
59750 North Bound Lanes	Box Culvert	1 x 2400 x 2400	✓	✓	
59760 South Bound Lanes	Box Culvert	1 x 2400 x 2400	✓	✓	
60600 North Bound Lanes	Box Culvert	1 x 2400 x 2400	✓	✓	
60610 South Bound Lanes	Box Culvert	1 x 2400 x 2400	✓	✓	

It was agreed with EPA that bridge underpasses would generally not require monitoring given that such structures have been demonstrated to provide effective fauna movement on other similar road projects. However, it was also agreed with the EPA that, the bridge at chainage 42500 (Upper Warrell Ck) would be monitored for use by giant barred frog.

3.8.1. Timing of monitoring

The timing of fauna underpass/exclusion fence monitoring has been selected to coincide with the breeding seasons and likely dispersal periods of the threatened fauna species targeted by the underpass structures, koala and spotted-tailed quoll (ie. late spring/summer and late autumn/winter). Fauna movements are expected to be more frequent and extensive during the breeding seasons and dispersal periods due to expansion of home ranges and movement of juveniles away from natal areas. Therefore, these periods are likely to represent peaks in fauna movement and increased likelihood of fauna underpass use.

With the exception of pre-construction baseline monitoring for spotted-tailed quoll, monitoring of the underpasses will commence after the Upgrade has become operational. Monitoring events will be undertaken in all structures identified in Table 3.3 in late spring/summer and late autumn/winter. This shall be undertaken each year for up to 5 consecutive years during the operational phase of the project (Table 3.1). The autumn/winter monitoring events will be conducted over 60 days each year, preferably commencing July/August. The spring/early summer monitoring events will also be conducted over 60 days each year, preferably commencing in late November.

3.8.2. Fauna census techniques

Monitoring of the selected fauna underpasses will involve sampling within each underpass structure and its entrances, in retained habitats adjacent to the fauna underpass and in the areas isolated by exclusion fencing leading into the underpass structures. Monitoring should involve the use of several fauna census techniques including:

- motion-sensing cameras;
- hairtube sampling;
- scat and track searches; and
- use of artificial groundcover (e.g. corrugated iron or plywood sheeting).
- Sand pads

Fauna underpass structures

Hairtubes will be attached to fauna furniture within each underpass structure at various heights where possible to sample both ground-based and arboreal fauna. Hairtubes will be baited with a combination of vegetarian and meat baits.

Motion-sensing cameras will be installed at both entrances to each fauna underpass structure to detect mainly medium to large fauna species and their direction of movement. Camera monitoring will continue for the duration of the sampling period.

A single sand pad (~1m wide) will be placed within the centre of each underpass structure. During sand pad inspections, each fauna underpass structure will also be carefully searched for fauna scats, hair and tracks. Sand pad monitoring will be conducted for a minimum of eight nights during each sampling period and scat/track searches at least twice per sampling period.

If the underpass “fauna furniture” does not include logs or rocks to provide suitable shelter for small ground mammals, reptiles and frogs, then artificial groundcover will be placed in the underpass to sample these faunal groups. The artificial groundcover will be installed at the beginning of each monitoring event and checked when conducting sand pad inspections.

Adjacent forest habitat

Forest habitat adjacent to the fauna underpass entrances will be surveyed to assess the range of fauna species occurring in the proximity of each underpass structure. The results will then be compared with the underpass monitoring results to identify which species present in the immediate area are not utilising the underpass structure.

The sampling area in forest adjacent to each underpass entrance shall cover at least one hectare where possible. The census techniques will include spotlighting, arboreal and ground-based trapping (using cage and box traps), pitfall trapping, hairtube sampling, timed diurnal and nocturnal active searches (e.g. under fallen logs, litter, decorticating and fallen bark and rocks) and scat and track searches.

Fauna underpass exclusion fencing

Monitoring of areas isolated by the wildlife exclusion fencing leading into the fauna underpasses will be undertaken. The purpose of the monitoring is to assess the effectiveness of the exclusion fencing design (including drop-down structures) in protecting smaller less mobile fauna species such as frogs, reptiles and small mammals from road strike mortality whilst funnelling them into the underpass structures. Limiting the sampling to within 200 metres either side of the underpass structure should be sufficient to accommodate the predominantly small home ranges of the target species (ie. smaller less mobile fauna).

Monitoring techniques will include the use of remote-sensing cameras or sand pads (possibly in conjunction with drift fencing), hairtubes, timed diurnal active searches (e.g. under fallen logs, litter, decorticating and fallen bark and rocks) and scat, track, foot-based road mortality searches from the inside of the fauna fence and car-based road mortality searches from the roadway side of the fence. Monitoring will also include an inspection of the exclusion fencing to assess fence condition, structural integrity, overhanging vegetation and vine growth.

3.8.3. Potential indicators of success

Potential indicators of success for the fauna underpass and exclusion fence monitoring will include:

- low rates of use of fauna underpasses and adjacent habitats by feral predators;
- high levels of fauna underpass use by a wide variety of native fauna species;
- No change to densities, distribution, habitat use and movement patterns compared to baseline population data of target species
- evidence of use by dispersing individuals and different age cohorts;
- use by cover-dependent species and species with low mobility;
- no breaches in fauna exclusion fencing; and
- low incidences of fauna road strike mortality.

3.9. Road mortality monitoring

3.9.1. Methodology

During and up to one month following clearing operations, daily road mortality surveys of the existing highway will be conducted. The frequency of surveys will then shift to weekly for the duration of construction. Upon opening of the project to traffic (i.e. operational phase), the opened sections of the WC2NH Upgrade will be monitored on a weekly basis for 12 weeks and thereafter each section will be monitored weekly for four weeks in October (Spring), January (Summer), April (Autumn) and July (Winter) by a two-person team in a vehicle. Monitoring will continue for up to five consecutive years post construction, or until mitigation measures have been demonstrated to be effective. Refer to Appendix A for detailed methodology.

3.9.2. Performance measures

Lower rates of road kill in proximity to fauna fencing (i.e. areas of the main carriageways within areas adjacent to installed fauna fencing) than in sections of the upgrade not near fauna fencing during monitoring events up to 5 years post construction phase, or until such time as mitigation measures have been demonstrated to be effective.

3.10. Widened vegetated median and glider crossing structures

3.10.1. Timing of monitoring

The timing of monitoring for the widened vegetated median has been selected to coincide with the breeding season and probable dispersal periods of the yellow-bellied glider (*Petaurus australis*), which are likely to represent peaks in glider movement, resulting in greater likelihood of use of the vegetated median.

Monitoring of the vegetated medians will be conducted in years 2, 3 and 5 of the operational phase of the Upgrade project (Table 3.1). Monitoring activities would be conducted during two eight-week periods: Summer/Autumn (e.g. Feb/Mar) and Winter/Spring (e.g. Aug/Sep). Additional years of monitoring may be required if the vegetated median is found to be ineffective and requires modification or supplementation with alternative glider crossing structures.

3.10.2. Fauna census techniques

Monitoring of the vegetated median will involve sampling within the vegetated median and within retained habitat either side of the Upgrade corridor. Monitoring will involve the use of several fauna census techniques including hairtube sampling, spotlighting surveys, call playback. Specific details of each monitoring technique include:

Spotlighting surveys (including call playback):

- Two occasions during each monitoring period
- Each roadside and median
- 500m-long transects

Hairtube sampling:

- One 2-week period during each monitoring period
- Each roadside and median
- Use spotlight transects with 10 tubes/transect (i.e. 50m spacing)

A work method statement will be developed to address traffic safety impacts of spotlighting.

3.10.3. Potential indicators of success

Potential indicators of success for the vegetated median monitoring will include:

- evidence of regular use of median vegetation and crossing structures by yellow-bellied gliders;
- evidence of use by dispersing individuals and different age cohorts; and
- use of vegetated median and crossing structures by other glider species e.g. sugar glider and greater glider.

3.11. Nest box monitoring

3.11.1. Timing of monitoring

LES (2013b) has proposed that nest box monitoring will take place in winter 12 months after the installation period, followed by a summer census to account for seasonal variation in the use of the nest boxes. Winter and summer monitoring events will be conducted in years three and four of the construction phase as well as years two and four of the operational phase (Table 3.1).

During each monitoring event, the following information shall be collected for each nest box using a field proforma:

- inspection dates, weather conditions (i.e. rain, wind, cloud cover, ambient temperature) and time each box was inspected;
- nest box number;
- is the nest box currently occupied by native fauna, if yes, what species;
- if no, are there signs of use and can the species be identified or assigned to a group (i.e. bats, birds);
- has the nest box been used by a pest species (i.e. european bees, common myna, termites);
- is there any deterioration of the nest box;
- is there any maintenance required; and
- has the surrounding landscape changed (i.e. clearing, partial clearing).

Factors to be considered as part of the maintenance schedule include:

- the need to remove exotic pests species such as common mynas, common starling and european bees;
- replacement of fallen, damaged or degraded nest boxes;
- repositioning or relocation of dysfunctional nest boxes;
- checking each box is not holding water or leaking; and
- removing excess nesting material as this may impede access over time.

3.11.2. Potential indicators of success

Potential indicators of success for the nest box mitigation measure will include:

- low rates of nest box occupancy by feral species;
- use of nest boxes by a wide variety of hollow-using native fauna species;

- species use of nest boxes is consistent with the species targeted by the nest box design; and
- high level of nest box durability, with minimal maintenance requirements.

3.12. Landscape rehabilitation

3.12.1. Timing of monitoring

Monitoring frequency for Landscape Rehabilitation shall be undertaken quarterly in the first 4 years of operation as per Table 3.1 of the Ecological Monitoring Program.

Review of the Roads and Maritime Vegetation and Landscaping Specifications (R178, R179 and R174) and Section 5.7.2 of the adopted Pacific Highway Upgrade Warrell Creek to Nambucca Heads Detailed Design Report (Spackman Mossop Michaels 2016) the following matters are required for the Landscape Rehabilitation Monitoring as part of the Ecological Monitoring Program:

- A colour coded and annotated map detailing the treatments applied including
- Treatment type and date of application / treatment for each monitoring site
- Noting if cover crop has been applied to each monitoring site
- Seed or planting mix type (native) applied for each monitoring site
- Topsoil media component mix % for each monitoring site (topsoil, integrated shredded mulch, other ameliorants)
- Fertiliser application rates and types for each monitoring site
- Details of any herbicide application for each monitoring site, in accordance with R178
    - details of any weed removal (by hand) for each monitoring site. To be plotted on map.
    - Photo Points – ensure photos are taken monthly at the established monitoring locations (plotted on map with GPS coordinates and marked onsite with a colour coded stake). Data obtained is to be used to:
    - Monitor progress of rehabilitation works and record using photo points
    - Modify treatments and identify areas requiring further attention
    - Erect signage in accordance with R178 and R179
    - Details of any seed suppliers (name, address, etc.) used (native and cover crop)
    - Details of seed certification or seed treatment by supplier.

3.12.2. Monitoring Locations

To enable effective monitoring of the Landscape Sites, the twelve (12) monitoring locations described in Table 3.4 have been selected to provide a representative sample of landscape treatments as part of the Warrell Creek to Nambucca Heads Project:

Table 3.4: *Landscape treatment monitoring locations.*

Number	Location	Treatment
1	Fill 4 Embankment East – Southern Zone	Seed Mix 1 (hydroseeding)
2	Fill 4 Embankment West – Southern Zone	Seed Mix 2 (hydroseeding)
3	Cut 2 Embankment East – Southern Zone	Seed Mix 3 (hydroseeding)
4	Ancillary Area Fill 19 West – Northern Zone	Seed Mix 4 (direct seeding)
5	Fill 5 Vegetated Drainage Swale – Southern Zone	Seed Mix 5 (hydroseeding)

Number	Location	Treatment
6	Cut 22 Embankment East – Northern Zone	Bushland Reconstruction (see note 1 below)
7	Cut 22 Embankment West – Northern Zone	Bushland Reconstruction
8	Fill 20 Embankment East – Northern Zone	Bushland Reconstruction
9	Cut 18 Embankment East – Northern Zone	Bushland Reconstruction
10	Williamson Creek	Landscape Planting (see note 2 below)
11	Stoney Creek	Landscape Planting
12	Butchers Creek	Landscape Planting

Note 1: Bushland Reconstruction: require a mix of bushland topsoil media, integrated shredded mulch, seed and ameliorants. The ratio required for this mix require a maximum of 40% shredded mulch. The species included in the Bushland Reconstruction mix comprise:

- *Acacia longifolia* (Wattle) @ 0.25kg/ha
- *Acacia floribunda* (Wattle) @ 0.25kg/ha
- *Acacia fimbricata* (Wattle) @ 0.25kg/ha
- *Cymbopogon refractus* (Barbed Wire Grass) @ 1.00kg/ha
- *Hardenbergia violacea* (Purple Twining-pea) @ 1.00kg/ha
- *Themeda australis* (Kangaroo Grass) @ 1.00kg/ha

Note 2: Landscape Plantings: Indigenous species suited to the bioregion as per the UD02 Urban Design and Landscaping Package.

3.12.3. Methodology

A standardised monitoring methodology shall be utilised for the Landscape Rehabilitation, which shall include the following approach:

- Installation of permanent 50 metre monitoring transects at each of the twelve (12) monitoring sites using a 50 metre tape measure and installation of a white wooden stake at each end of the transect. The transect location shall be chosen on the basis of sampling a representative section of the core area of the site and shall be aligned along the face of each batter (usually in a north-south alignment). Monitoring site details shall be written on each peg for ease of identification. Flagging tape shall also be installed on each peg.
- GPS survey of each marker peg
- A photograph shall be taken along the transect from each of the marker pegs at each monitoring event and incorporated into each monitoring report.
- Collection of data based on a field proforma shall be as follows:
    - Treatment percentage cover
    - Braun Blanquet cover class score
    - Weed species present

- o Details on plant species present (included in mix)
- o Details on plant species present (not included in mix)
- o Signs of stress, predation or disease

3.13. In-situ threatened flora populations

3.13.1. Timing of monitoring

The recommended timing for monitoring of in-situ threatened flora populations is as follows: collection of baseline data upon installation of protective barriers, 6-monthly intervals for two years and once a year thereafter for five years post-construction (Table 3.1). The monitoring program will then be reviewed and a strategy developed for further monitoring if required.

3.13.2. Monitoring procedure

Monitoring of in-situ threatened flora populations will aim to assess the effectiveness of protective measures and provide feedback to management on any need for corrective measures if required (Benwell 2014). Each specimen within the in-situ populations will be tagged with an ID code, which will be written on flagging tape and attached to the plant. A map of each in-situ population will be prepared showing the position of all plants (with identification number). The maps can be used to relocate individuals if tags are dislodged or interfered with. The following data are to be recorded for each in-situ specimen:

Identification

- genus;
- species and subspecies;
- plant identification number; and
- location.

Plant condition

- general condition – score on a scale of 0 to 5, where 0 is dead and 5 is excellent;
- leaf condition –healthy/unhealthy, colour, vigour;
- flower/fruit – flower/fruit presence;
- length of new shoots – average length of new shoots (eyeball estimate) and abundance of shoots (many/few etc);
- disease symptoms – evidence of disease;
- recruitment; and
- evidence of any other damage or disturbance.

Site conditions

- plant community canopy height and cover;
- weed abundance and composition;
- climatic events (e.g. drought, unusually cold winter temperatures etc);
- maintenance carried out – when and what kind of maintenance carried out at the site since the last monitoring; and
- any other ecological impacts.

3.13.3. Potential indicators of success

Potential indicators of success for the protection of in-situ threatened flora populations will include:

- no net loss of plant abundance within each in-situ population;

- no reduction in population extent;
- no reduction in reproductive vigour;
- good quality habitat successfully restored around each in-situ population site;
- maintenance carried out each year as described in the threatened flora management plan prepared by Benwell (2014); and
- threatening processes including weed invasion controlled or eradicated.

3.14. Translocation areas

3.14.1. Timing of monitoring

Monitoring frequency for the translocations is as follows: three monitoring periods in the first year (6th , 8th and 12th month), three monitoring periods in the second year (June 2016, November 2016 and January 2017),then once a year in November to the end of the monitoring program. Monitoring to be conducted during construction (~3 yrs) and after construction for 5 years, a total of 8 years.)

3.14.2. Monitoring procedure

Monitoring of translocation areas will aim to record information that can be used to evaluate the success of the translocations and identify causes of survival or mortality. Transplanted individuals will be tagged with the ID code allocated during the targeted survey. This will be written on flagging tape and attached to the plant. A map of each translocation area will be prepared showing the position of all translocated plants (with identification number). The maps can be used to relocate individuals if tags are dislodged or interfered with. Enhancement individuals will also be tagged with flagging tape and numbered and recorded when planted out. The following data are to be recorded for each translocated individual.

Identification

- genus;
- species and subspecies;
- identifier – unique plant number;
- translocation – transplant/cutting/seedling;
- place of origin – original site or source location; easting, northing & description; and
- date – date of monitoring.

Plant condition

- condition when planted – good root-ball, minimal root-ball, bare rooted;
- height – initial height (also later dates as required);
- number of stems – number of stems at transplanting;
- diameter – initial diameter (also later dates as required);
- general condition – score on a scale of 0 to 5, where 0 is dead and 5 is excellent;
- leaf condition – healthy/unhealthy, colour, vigour;
- bark condition – bark damage, healing;
- flower/fruit – flower/fruit presence;
- recent shoot growth – average length of new shoots or recent foliage growth (eyeball estimate) and abundance of new shoot growth (many/few etc);
- insect grazing – evidence of insect grazing;
- mammal grazing - evidence of mammal grazing;
- disease symptoms – evidence of disease;

- recruitment – evidence of recruitment; and
- evidence of any other damage or disturbance.

Site conditions

- plant community canopy height and cover;
- weed abundance and composition;
- climatic events (e.g. drought, unusually cold winter temperatures etc);
- maintenance carried out – when and what kind of maintenance carried out at the site since the last monitoring; and
- any other ecological impacts.

3.14.3. Potential indicators of success

Potential indicators of success for the translocation plan will include:

- for each translocated species, at least 60% of the transplants and enhancement introductions are surviving after the first year and 50% after five years;
- flowering/seeding occurs in transplanted individuals (unless saplings);
- representatives from a range of individuals from the local population are established;
- the new or enhanced populations have similar growth characteristics to the natural populations;
- good quality habitat successfully restored in and surrounding the recipient site;
- maintenance carried out each year as described in the threatened flora management plan prepared by Benwell (2014); and
- threatening processes including weed invasion controlled or eradicated.

3.15. Slender Marsdenia and Wools' Tylophora Habitat Condition Monitoring

3.15.1. Timing of monitoring

The plots are to be established within one month of the finish of vegetation clearing (baseline monitoring) and then monitored at 12-monthly intervals during construction and the operation phase for a total of 8 years.

3.15.1. Monitoring Method

Monitoring of potential changes in the habitat of Slender Marsdenia and Woolls' Tylophora is to be conducted within the indirect impact zone – ie within 10 metres of the edge of clearing/construction. Monitoring is to be conducted in areas of this habitat adjacent to the construction footprint and to be plot-based. Permanent plots were established in the indirect impact zones at 10 representative points in Slender Marsdenia and Woolls' Tylophora habitat as mapped by Dr Andrew Benwell in spring 2010. Each plot is 10 m wide and 20 m long, with the long axis parallel to the edge of clearing. The corners of each plot were marked with pink flagging tape and the GPS co-ordinates of the corners of plots also recorded. Plots were established on 26 November 2015 around the time that clearing operations in the northern zone of the project were being completed. The following parameters were measured at each plot (refer to Section 5.4 of the TFMP for more information):

- Native vegetation structure
- Level of weed incursion
- Microclimate class.

3.15.2. Performance Indicators

The following performance indicators are to be used to evaluate changes in habitat condition

- Plot crown-cover of exotic species is no more than 15% (overlapping and/or summed) at the end of Year-1 and no more than 25% at the end of Years-2 to 8.

- Baseline vegetation structure (height and crown cover) remains the same or increases in height and crown cover at the end of year compared to the previous year.
- There is no increase in the microclimate exposure class (e.g. 1 to 2, or 4 to 5) compared to the previous year.

4. Potential contingency measures

The MCoA B10(d) requires the formulation of potential contingency measures that will be implemented in the event of changes to habitat usage patterns directly attributable to the construction or operation of the project.

The type(s) of potential contingency measures available in the event that a mitigation measure is ineffective in preventing impacts on habitat usage patterns by native fauna will vary depending on the nature, location and/or magnitude of the impact. Consequently, this monitoring program provides only a basic list of potential contingency measures that may be applicable to the broader range of potential problems associated with each mitigation measure. The contingency measures are provided in Table 4.1.

Table 4.1: *Potential problems and contingencies associated with each proposed mitigation measure.*

Mitigation Measure	Potential Problems	Potential Contingency Measures
Clearing Procedures	• high rates of fauna injury and mortality resulting from clearing operations; • poor success at capturing and releasing affected fauna.	• review clearing procedures; • increase habitat tree retention times; • increase staff numbers.
Fauna Underpasses / Exclusion Fencing	• high rates of feral predator activity; • low levels of native fauna movement and species diversity in underpasses; • no use of underpasses by cover-dependent species or species with low mobility or target threatened species ; • high rates of fauna road mortality.	• modify habitat structure near underpass entrances; • modify underpass “fauna furniture”; • modify or add potential groundcover resources; • modify exclusion fencing design, location or extent depending on the species and location of mortalities.
Vegetated Median	• no evidence of use of the vegetated median or glider crossing structures by the target glider species	• modify or install alternative crossing structures (e.g. glider poles and/or rope bridges)
Nest Box Installation	• high rates of nest box occupancy by feral species; • nest boxes used by a limited number of native fauna species; • species use is incompatible with nest box type; • poor nest box durability.	• modify nest box designs to exclude undesirable species or relocate affected nest boxes to more appropriate habitat; • review the selection and abundance of nest box designs; • identify causes of nest box failure and modify nest box design or construction accordingly.
Microbat Roost Boxes	• low use of nest boxes by target species.	• modify nest box design and/or location; • assess the occurrence of alternative roost sites in the vicinity to determine need for supplementary nest boxes.

Mitigation Measure	Potential Problems	Potential Contingency Measures
Koala Monitoring	• Koala killed as a consequence of construction activities • Koala killed on adjacent existing highway	• Notify DoEE and EPA. • Adaptive management response. • Assess future road kill risk • Assess adequacy of fauna fencing
Yellow-bellied Glider Monitoring	• reduction in occupancy within Nambucca SF	• review adequacy of crossing structures • consult with SF about forest management practises

5. Reporting and review

Monitoring results for all mitigation measures will be compiled, analysed and discussed in annual reports, which will be submitted to Roads and Maritime Services, the Secretary of Planning & Environment and EPA. The annual reporting will include review and updating of the EcMP to account for any changes in detailed design, inclusion of additional management plans, identification of control sites and any insights relevant to current management practices.

In addition, brief data reports will be provided to Roads and Maritime Services outlining the results of monitoring for the following components:

- Road mortality monitoring – quarterly;
- Grey-headed Flying Fox population monitoring – monthly.

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Appendix A: WC2NH Road Kill Monitoring

Timing of Monitoring

Timing of road kill surveys for the WC2NH Project is described in Table 1.

Table 1 – Timings and locations of road kill surveys

Project Phase	Timing of Survey	Location
During clearing operations	Daily	Portion of existing Pacific Hwy adjacent to clearing operations
One month following clearing operations	Daily	Portion of existing Pacific Hwy adjacent to clearing operations
Duration of construction	Weekly	Entire length of existing Hwy in Project area
Upon opening of each stage of the project to traffic (operational phase)	Weekly for 12 weeks commencing the week of opening each stage to traffic.	Entire length of opened stage.
Upon completion of the Project (operation phase)	Excluding the season/s covered by the initial 12 week monitoring period (refer above), weekly during October (spring), January (summer), April (autumn) and July (Winter) for up to 5 consecutive years post construction, or until mitigation measures have been demonstrated to be effective.	Entire length of completed Project

Monitoring Program Objectives

The aim of the monitoring program is to;

- report on any animal road kill on the project following the opening to traffic; and
- assess the effectiveness of the presence of fauna fencing to prevent fauna being killed by vehicles while attempting to cross the WC2NH Upgrade.

Monitoring Procedure

A two-person team vehicle being driven along the entire length of the highway in the Project area and identifying dead wildlife (road kill) seen on the road and within three metres of the road edge. The passenger will search the road and its verge for road kill. When a road kill is observed from the vehicle, a closer visual inspection of the carcass will be undertaken where safe access is available. If safe access is not possible, due to local traffic conditions, binoculars will be used to try to identify and provide as detailed information as is possible on the carcass.

Road kill fauna will be identified to species level where possible, with reference to field guides. Where there is any doubt to the identification of the carcass, photographs will be taken and forwarded to a qualified ecologist for identification /confirmation of species. Those too seriously damaged to be accurately identified will be recorded as “unknown”.

To assist with the correct identification of road kills, the following will be undertaken –

a. The provision of a qualified ecologist (shall be a recognised expert in mammal identification in coastal northern NSW) to undertake the initial phase of operational monitoring (first season) with relevant Roads and Maritime team members providing appropriate detailed training and a baseline of expert monitoring of road kills;

b. The provision of specialist training (to be provided by an expert as above in point a) in fauna identification for Contractors and Roads & Maritime staff involved in the construction phase monitoring of road kill; and

c. Where there is any doubt to the identification of the carcass, the provision of photographs of road kill to be sent to a qualified ecologist (an expert as above in point a) to confirm the identity of road kill and to maintain a permanent record of road kill for further comparisons, if needed.

Monitoring Methodology

- The highway will be monitored using the method previously indicated (section 1.3) consisting of a two-person team traversing the Upgrade in a vehicle to locate and identify road kills;
- The speed of travel will be the same in all cases to avoid confounding the data collection, and should be as slow as is safely possible;
- The highway will be surveyed weekly for four weeks in Spring, Summer, Autumn and Winter (see Table 1);
- Where possible, each survey shall be completed within two hours of sunrise in order to maximise the potential to record road kills before either carrion eating animals or traffic render any road kill unidentifiable;
- if possible, each survey will be carried out on the same day of the week to remove the influence of varying environmental conditions and to ensure consistent temporal spacing;
- For each road kill observed, the following attributes will be recorded

    a. Geographic Coordinates of any road kill.

    b. Whether fauna fencing was installed at/near the location.

    c. Species of road kill where possible, however, where there is any doubt as to the identification of the carcass, photographs shall be forwarded to a qualified ecologist for identification /confirmation of the species.

If the animal is identified as an EPBC Act threatened species, the carcass will be photographed and the following information will also be recorded where possible and safety considerations permit

a. Sex and age class (juvenile or adult).

b. Presence f pouch young (for marsupials).

c. Presence of flightless young (for flying-foxes or other bats).

d. Distance to a fauna connectivity structure.

e. Distance to drop down structure.

f. If fauna fencing was installed, is there any damage to the fence in the vicinity.

g. Weather conditions at the time of the monitoring (from the Bureau of Meteorology) – including temperature, rainfall in the last 24 hours, moon phase

h. If the animal is identified as a flying-fox:

    a. Distance to nearest camp,
    b. Distance to nearest canopy vegetation,

c. Presence of flowering food trees in neighbouring median or roadside vegetation; plants identified to species and referenced with diet list.

Analysis of data

The data to be collected will be analysed using a suitable nonparametric test such as a Kruskal-Wallis test. The aim will be to test both whether the fenced and unfenced locations have different mean numbers of road kills and if the amount of road kill varies through time in either or both of the two types of areas. Associations with other measured variables will be described as data allow, including sex, age class, presence of dependent young and, in the case of flying-foxes, proximity to roost sites or flowering food trees. Such information will indicate if the mitigation measures in the area are working as expected to keep road kills to acceptable levels and that none of the target species are killed.

Reporting

Quarterly reports

A report will be prepared by the ecologist following the initial 12 week monitoring period (after opening for each stage) to identify any roadkill hotspots and review the mitigation measures. The initial report and ongoing seasonal reports of the data collected will be provided to Roads and Maritime. This will include graphs of the data and any previously collected data to provide simple visual comparisons of road kill. This will also include overall road kill counts as well as separate graphs for each of the target species (if deaths have occurred).

Anecdotal road kill information collected on days that are not monitored as part of this program may be added as a note for discussion.

Annual Reports

The annual report will be prepared in consultation with a qualified ecologist and provided to DPE, DoEE and EPA within one month of completion of the fourth monitoring season. From then on it will be provided within one month of the same monitoring season in subsequent years until monitoring is completed (Table 1).

Analysis of the data itself shall be included in an annual monitoring report. This report will include a statistical analysis of all of the data collected to that time including graphical representations of the road kill that is recorded.

Annual reports will record any potential or obvious failures in road kill mitigation identified in the monitoring program and provide a date by which meetings will take place to discuss any such adverse findings. This will include at least:

- where statistically larger number numbers of road killed animals are detected on fenced sections compared to unfenced sections;
- where any of the target threatened fauna are recorded as killed;
- where there is a clear pattern of unexpected road kill at any point on the Upgrade.

Performance Measures

Lower rates of road kill in proximity to fauna fencing (ie areas of the main carriageways within areas adjacent to installed fauna fencing) than in sections of the upgrade not near fauna fencing during monitoring events up to 5 years post construction phase, or until such time as mitigation measures have been demonstrated to be effective.

Adaptive Management

Where any annual report identifies a significant difference between the road kill numbers of the fenced and unfenced areas, DoEE and EPA shall be notified, and a meeting will be set to discuss such differences with the relevant agencies & Roads and Maritime.

Such a meeting would occur within one month of completion of the annual report, which should ensure sufficient time to consider/review the response to any recorded significant differences.

Appendix D

Giant Barred Frog Management Strategy

WARRELL CREEK TO URUNGA:

GIANT BARRED FROG MANAGEMENT STRATEGY

DECEMBER 2014

Disclaimer

The client (Roads and Maritime Services) may only use this document for the purposes for which it was commissioned. This report relies upon data, surveys, measurements and results based on a short-term objective study in response to a brief provided and largely defined by the client (RMS and their representatives: Tammie Tribe; Shayne Walker). Although conclusions have been based on the available data at the time, some professional judgement has been applied in reaching these conclusions due to the temporal limitations arising from the dynamic nature of available information, legislation, schedules, individual species and associated habitats. Every attempt has been made to ensure the accuracy and objectivity of the report's findings, conclusions and recommendations. Lewis Ecological Surveys does not accept responsibility for its use beyond the scope of works.

…………………………
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…3rd December 2014………
Date

ACKNOWLEDGEMENTS

Ben Lewis (Lewis Ecological Surveys) – Field surveys, report author and project management.

George Madani (Lewis Ecological Surveys) – Field survey.

Tammie Tribe (Roads and Maritime Services) – Logistics and project management.

Andrew Mula (Roads and Maritime Services) - Logistics and project management.

Shayne Walker (Roads and Maritime Services) - Logistics and project management.

Dr Frank Lemckert (Niche Pty Ltd) – Management strategy review.

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Report to be cited as: Lewis, B.D. (2014). Warrell Creek to Urunga: Giant Barred Frog Management Strategy. Report prepared for the Roads and Maritime Services by Lewis Ecological Surveys. ©

Revision History:

Rev.	Project Number	Date	Description	Prepared By	Reviewed By
A	2071112b	19.6.2012	Draft for comment	Ben Lewis (Lewis Ecological Surveys)	Kristy Harvey (RMS) John O'Donnell
B	2071112b	29.6.2012	Draft for comment	Ben Lewis (Lewis Ecological Surveys)	Kristy Harvey (RMS) John O'Donnell
C	2071112b	20.7.2012	Final for comment	Ben Lewis (Lewis Ecological Surveys)	Simone Garwood (verbal) - EPA Craig Harre (EPA)
E	2071112b	27.2.2013	Final for comment	Ben Lewis (Lewis Ecological Surveys)	Belinda Bock (RMS)
F	2071112b	26.2.2014	Final for comment	Ben Lewis (Lewis Ecological Surveys)	Niche Environmental Frank Lemckert + Andrew Mula (RMS)
G	2071112b	15.8.2014	Final for comment	Ben Lewis (Lewis Ecological Surveys)	Andrew Mula (RMS)
H	2071112b	8.10.2014 28.10.2014	Final for comment	Ben Lewis (Lewis Ecological Surveys)	Niche Environmental Frank Lemckert
I	2071112b	4.11.2014	Final for comment	Ben Lewis (Lewis Ecological Surveys)	Andrew Mula (RMS) Shayne Walker (RMS)
J	2071112b	4.11.2014	Final for comment	Ben Lewis (Lewis Ecological Surveys)	Shayne Walker (RMS) Chris Clark (RMS)
K	2071112b	2.12.2014	Final for comment	Ben Lewis (Lewis Ecological Surveys)	Brian Tolhurst (EPA)

Distribution History:

A	15.6.2012			Environmental Officer	Kristy Harvey
B	20.6.2012			Environmental	Kristy Harvey
C	29.6.2012			Officer	Kristy Harvey
D	26.7.2012			Environmental Officer	Kristy Harvey
E*	31.10.2012	Final		Environmental Officer	Belinda Bock
F	27.2.2013	Final		Environmental Officer	Belinda Bock
G	14.4.2014	Final	Roads and Maritime Services	Environmental Officer	Andrew Mula
H	11.9.2014	Draft	Roads and Maritime Services	Environmental Officer	Andrew Mula
I	28.10.2014	Draft	Roads and Maritime Services	Environmental Officer	Andrew Mula
J	6.11.2014	Final	Roads and Maritime Services	Environmental Officer	Andrew Mula / Shayne Walker
K	11.11.2014	Final	Roads and Maritime Services	Environmental Officer	Andrew Mula / Shayne Walker / Chris Clark
L	03.12.2014	Final	Roads and Maritime Services	Environmental Officer	Andrew Mula / Shayne Walker / Chris Clark

* in response to additional investigations within the Nambucca Investigation Area between ch. 49265 and ch.56865

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1.0 Introduction

1.1 Background to the Project

The Pacific Highway Upgrade Program is a joint commitment by the Australian and New South Wales (NSW) governments to improve the standard and safety of the Pacific Highway between Hexham and the Queensland border. The Pacific Highway Upgrade Program includes the upgrade of the Pacific Highway between Warrell Creek and Urunga (WC2U) comprised of approximately 42 kilometres of dual carriageway road that would bypass the towns of Warrell Creek, Macksville, Nambucca Heads and Urunga on the Mid North Coast of NSW. The WC2U Project has been divided into two construction stages and includes the following:

- Stage 1 consisting of the northern 22.5 kilometres of the Project between Nambucca Heads and Urunga (NH2U).
- Stage 2 consisting of the southern 19.5 kilometres of the Project between Warrell Creek and Nambucca Heads (WC2NH).

The Environmental Assessment (EA) prepared for the Warrell Creek to Urunga Pacific Highway Upgrade project identified potential habitat for the Giant Barred Frog at several creeks and drainage lines in the northern half of the study area, through Nambucca, Little Newry and Newry State Forests (SKM 2010). The EA identified the proposal as having the potential to impact on this species as it would directly traverse streams and rivers across the study area. This was investigated in further detail with the Roads and Maritime Services (RMS) engaging Lewis Ecological Surveys to perform field surveys of the project route and based on these results and any updated information from desktop surveys formulate a Giant Barred Frog management strategy for the Upgrade.

1.2 Order of Precedence

In the event of any inconsistency, ambiguity or discrepancy between this Management Plan and the Flora and Fauna Management Plan for the Warrell Creek to Nambucca Heads Pacific Highway upgrade project, the following order of precedence must apply:

1. This Giant Barred Frog Management Strategy; followed by
2. The Flora and Fauna Management Plan for the Warrell Creek to Nambucca Heads Pacific Highway upgrade project (AFJV 2014).

1.3 Objectives of the Management Strategy

There are two key objectives of this management strategy, firstly, to demonstrate through the life of the Project that mitigation has maintained or improved the population size and habitat of the Giant Barred Frog at all sites where a population is present, and secondly, in the event significant negative changes are detected in the habitat of the Giant Barred Frog the Department of Environment (DoE) and Environmental Protection Agency (EPA) will be advised and agreed adaptive actions taken will be undertaken within three months to reverse the negative trend.

1.4 Subject Species – Giant Barred Frog (*Mixophyes iteratus*)

1.4.1 Description

The Giant Barred Frog (*Mixophyes iteratus*) is a large, dark-olive green to black coloured frog that grows to 115 mm. It has a pointed snout and a broad lateral band of dark spots dividing the dark dorsal surface from the white or pale yellow, ventral surface (underside). The limbs have dark crossbars. The hind side of the thighs are black with large yellow spots. Two joints of the fourth toe are free of web (Cogger 2000). The skin is finely granular above but smooth below. The call of the male Giant Barred Frog is a deep guttural grunt (OEH 2014).

Giant Barred Frog tadpoles are large and grow to over 100 mm in length. They are deep-bodied and ovoid, with a tail length twice that of the body. The tadpole's eyes are dorsolateral. The tadpoles are coloured yellow-brown above with dark spots and a dark patch at the base of tail. The underside is silver-white. The intestinal mass is obscured but the heart and lungs are visible from below (except near metamorphosis). The tail is thick and muscular (Anstis 2002). Fins are low and opaque with dark flecking (except the anterior half of the ventral fin; Meyer *et al.* 2001).

1.4.2 Distribution

The Giant Barred Frog is currently known from mid to low altitudes below 610 m above sea level (Hines *et al.* 2004), along the 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 (Figure 1-1). Considered to have disappeared south of the Hawkesbury and there are no recent records from the Blue Mountains (Hines and SEQTFRT 2002). Between Port Macquarie and Urunga the species appears to be patchily distributed with some confirmed recent locations from upper Warrell Creek and in smaller fast flowing streams in Way Way State Forest (Lewis 2014; Figure 1-1).

Plate 1-1. Giant Barred Frog (*Mixophyes iteratus*).

1.4.3 Habitat and Ecology

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). . They feed primarily on large insects and spiders.

1.4.4 Conservation Status

In NSW, the Giant Barred Frog is currently listed as <u>Endangered</u> pursuant to the NSW *Threatened Species Conservation* Act (1995) and Commonwealth *Environmental Protection and Biodiversity Conservation* Act (1999).

1.5 Initial Targeted Field Survey Program

1.5.1 Warrell Creek to Nambucca Heads

Initial targeted field surveys were performed between November 2011 and January /February 2013. During this time, all of the freshwater creeks considered as either semi-permanent or permanent in nature were surveyed regardless of the extent of riparian vegetation. Some neighbouring dams close to streams were also surveyed in light of recent findings on the Sapphire to Woolgoolga Project. The Nambucca River and Newee Creek were not considered suitable frog habitat due to their saline nature and were omitted from the field sampling program. Despite Butchers Creek initially being identified as containing potential habitat during the Environmental Assessment and during the first round of field surveys in 2011/12, further field surveys later in 2013 rendered there was little likelihood of Butchers Creek supporting populations of Giant Barred Frog. A reference site in Way Way State Forest (E:494538 N:6596076) was used to demonstrate conditions were suitable for the detection of Giant Barred Frogs throughout the sampling period (i.e. 2011-2013).

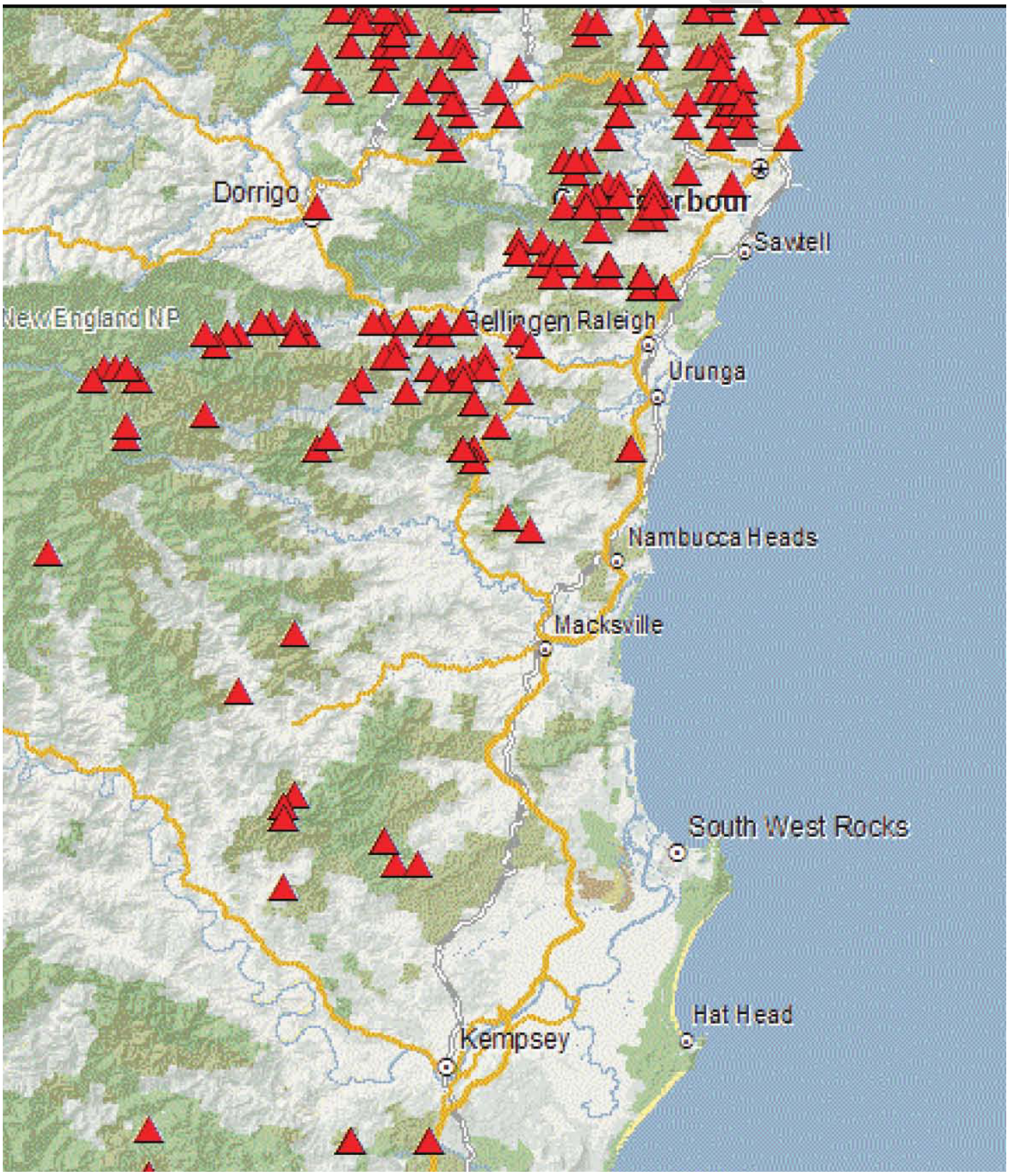

Figure 1-1. Localised distribution of Giant Barred Frog between Kempsey and Urunga.
Note - Triangles represent approximate location as sensitive 2 species.

Surveys were undertaken when the survey site received >10 mm of rainfall in 24 hours with field surveys performed within 7 days of this event. Surveys during heavy rainfall events/flooding were abandoned or repeated again at a later date when flooding had subsided. All sites were surveyed on at least two occasions during suitable conditions with additional surveys performed at sites which had an increased likelihood of supporting Giant Barred Frog. For example, Butchers Creek (ch. 43300) was surveyed during the summer of 2011 and 2012 and on three separate occasions during spring 2013.

1.5.2 Nambucca Heads to Urunga

Initial targeted Field surveys were performed in the same manner as described in Section 1.3.1 for the Nambucca Heads to Urunga section of the Upgrade between November 2011 and 2013. Despite some areas initially being identified as containing potential habitat during the Environmental Assessment and during the first round of field surveys in 2011/12 some subsequent field surveys later in 2013 rendered there was little likelihood of these areas supporting populations of Giant Barred Frog. They included Boggy Creek and McGraths Creek which had been subject to an additional three repeated surveys performed in December-February of 2012/13. The Kalang River and Bellingen River and Deep Creek were not considered suitable frog habitat due to their saline nature and were omitted from the field sampling program.

2.0 Results of the Initial Targeted Surveys

2.1 Warrell Creek to Nambucca Heads

Initial targeted field surveys resulted in the detection of only one Giant Barred Frog at Upper Warrell Creek (ch. 42565). At this location, one adult female (approximate snout-vent 120 mm) was recorded on the edge of the RMS project boundary (Figure 1-2). The individual was approximately 10 m from the water's edge and completely exposed above the leaf litter close to overhanging vegetation (i.e. *Lomandra longifolia*). Giant Barred Frogs were always recorded at the Way Way State Forest reference site and thus demonstrating that conditions were suitable to enable the detection of this species.

Following detection of the Giant Barred Frog at Upper Warrell Creek pre-construction baseline monitoring was undertaken to describe the population and existing habitat condition in more detail. The pre-construction baseline monitoring report is available in Appendix B.

2.2 Nambucca Heads to Urunga

No Giant Barred Frog populations were recorded in this section of the Upgrade. Despite some areas initially being identified as containing potential habitat during the Environmental Assessment and during the first round of field surveys in 2011/12, subsequent field surveys later in 2012/2013 (December-February) rendered there was little likelihood of these areas supporting populations of Giant Barred Frog.

2.3 Discussion of Initial Targeted Surveys

Field surveys confirmed the presence of Giant Barred Frogs in the Warrell Creek to Urunga study area with a population being identified at the southern limit of the Upgrade (Upper Warrell Creek ch. 42565). Despite some areas being initially identified as containing potential habitat in the Environmental Assessment, the surveys performed by Lewis Ecological Surveys found either no evidence to support this earlier assertion or employed a field survey program that was considered rigorous enough to confirm the presence or absence of Giant Barred Frog. For example, Butchers Creek (ch. 43330), Boggy Creek (ch. 62765) and McGraths Creek (ch. 71965) were surveyed on two occasions in 2011/12 and repeated again with three additional surveys between September and November 2013 for Butchers Creek and between December and February of 2012/13 for Boggy Creek and McGraths Creek. Normally three surveys would be sufficient to obtain a confidence interval at or above 95%. For example, surveys performed in the Bungawalbin Catchment consistently yielded Giant Barred Frog on the first and second occasion whilst the third visit to a site rarely yielded additional new locations for frogs (Lewis and Rohweder 2005). The absence of frogs following five surveys at those sites believed to provide some potential habitat for Giant Barred Frogs would indicate with a high degree of probability that they do not exist at these locations, a fact also supported with the apparent absence of historic records for the immediate area (*see* Figure 1-1).

A reference site was used throughout the field sampling as a means to demonstrate that conditions were suitable for the detection of Giant Barred Frogs. Whilst locating such a site proved initially problematic, largely due to the fact that no sites could be located close to the project the Way Way site was a useful indicator to demonstrate the prevailing abiotic conditions were always suitable when field sampling was undertaken. This site was, however, different from many of the sites being sampled along the project route because it was a rocky fast flowing stream within a continuous tract of forest unaffected by agriculture.

2.4 Areas Subject to Giant Barred Frog Management

A Giant Barred Frog population was only recorded at Upper Warrell Creek (ch. 42565) with this area identified for management. No other areas within the Upgrade Project have been proposed for Giant Barred Frog management; however, provisions are available within this management strategy to allow for unexpected finds procedures and the actions therein.

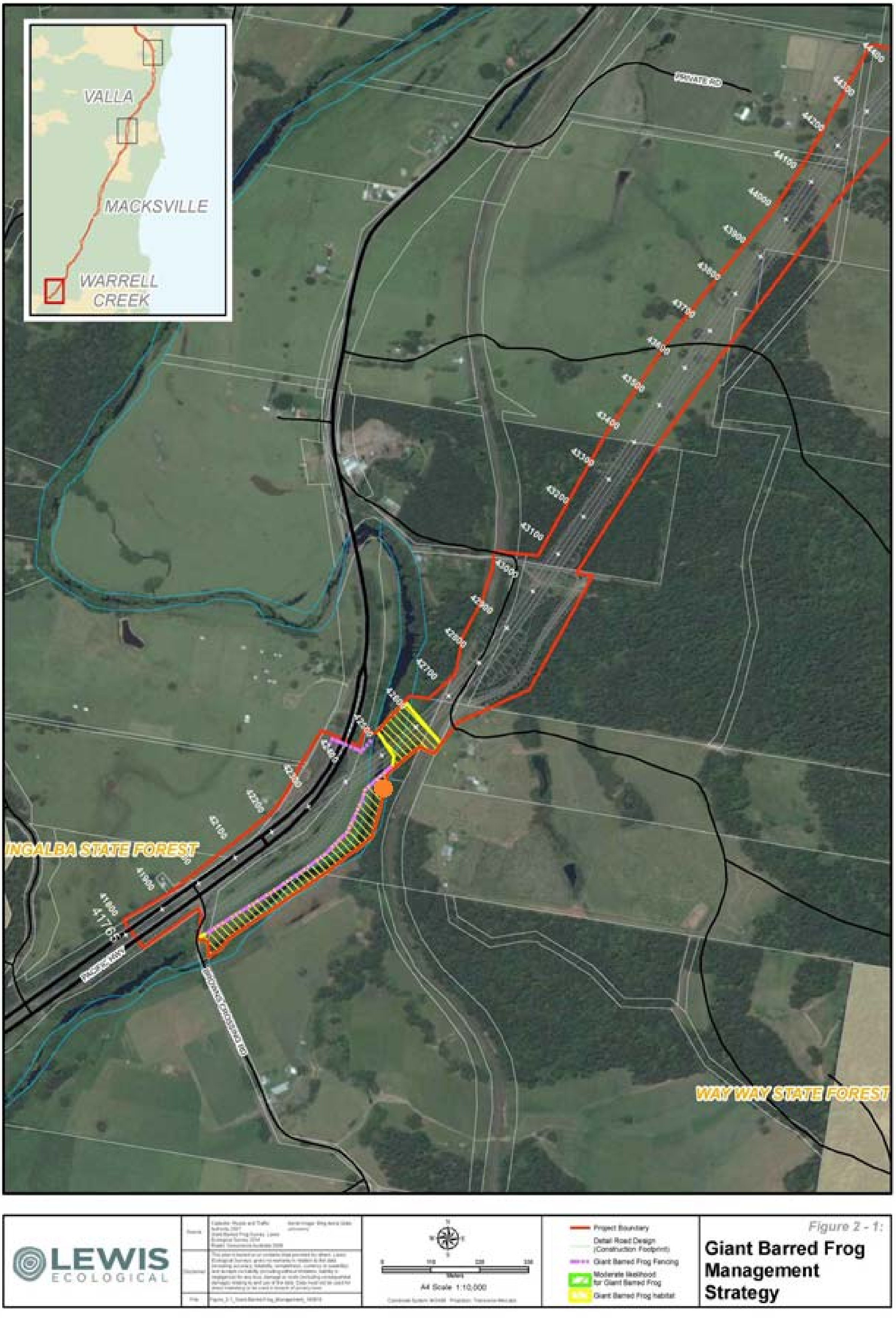

Figure 1-2. Location of the Giant Barred Frog records (orange circle) during initial field surveys of the Upper Warrell Creek site.

3.0 Pre-construction Management Measures

3.1 Overview of Activities

Pre-construction activities would involve the following works:

- Field survey;
- Water quality monitoring;
- Translocation of threatened plants;
- Geotechnical investigations;
- Completion of utility relocations; and
- Construction of sites accesses.

3.2 Timing

Pre-construction works are to be undertaken up until the commencement of construction stage works which are scheduled to commence in January 2015.

3.3 Summary of Potential Impacts

Pre-construction activities may have the following potential impacts to the Giant Barred Frog:

- Mortality to Giant Barred Frog from pre-construction activities; and
- Spread of Chytrid fungus.

3.4 Main Goals for Management

There are four main goals for the management of Giant Barred Frogs including:

- No loss of known Giant Barred Frog habitat from pre-construction activities;
- No injury/mortality to Giant Barred Frog from pre-construction activities;
- Minimise the spread of Chytrid fungus during pre-construction activities; and
- Ensure that appropriate habitat offsets have been identified for Giant Barred Frog conservation.

3.5 Mitigation Measures

3.5.1 Detailed Design Considerations

As detailed design progresses, a number of factors will be addressed to minimise potential impacts on the Giant Barred Frog. These include:

- Avoiding and minimising vegetation removal where feasible and reasonable;
- Protection of existing known habitat (*see* Section 3.5.2);
- Review and enhance where relevant the proposed temporary frog fencing to reduce the likelihood of road kills;
- Review and enhance the landscape and rehabilitation plan as well other temporary seeding schedules to maintain or enhance habitat connectivity.

3.5.2 Protection of Existing Habitat

Upper Warrell Creek at ch. 42565 should be protected from pre construction and construction related works other than what is considered essential. The locating of access tracks, utilities redistribution, car parking facilities and other ancillary works including topsoil stock piles, lay down areas, wash down bays, site shedding and compound sites should not be located in this area. This approach will be in accordance with MCoA:

C1. The Proponent shall employ all feasible and reasonable measures to minimise the clearing of native vegetation to *the greatest extent practicable during the construction of the project*

C27 Unless otherwise approved by the Director General in accordance with this condition, the sites for ancillary facilities associated with the construction of the project shall (c) be located in areas of low ecological significance and require minimal clearing of native vegetation (not beyond that already required by the project).

The protection of the identified areas should include the demarcation of clearing limits and signage identifying these areas as 'no go' zones.

3.5.3 Controls on Habitat Clearing (Pre-construction)

During the pre-construction stage of the Project (prior to approval of the CEMP) only clearing defined as 'minor' (see Approval Instrument Definitions for "construction") can be undertaken, unless approval is sought from the Director-General. Prior to any clearing taking place, a suitably qualified Project Ecologist will undertake an inspection of vegetation to be cleared to determine that only 'minor clearing' is to be undertaken. Minor clearing will be defined as the following:

- Vegetation that does not include mature trees >150 mm diameter at breast height (DBH);
- Vegetation that does not comprise known threatened fauna habitat. In the case of the Giant Barred Frog, this is defined as Upper Warrell Creek at ch. 42565 and neighbouring riparian vegetation for distances of up to 75 m (Figure 2-1).
- Areas of vegetation that have ecological constraints (e.g. threatened flora habitat/ areas of endangered ecological communities).

3.5.4 Pre-construction Baseline Monitoring (Upper Warrell Ck)

Pre-construction baseline monitoring has been undertaken to obtain data on the local Giant Barred Frog population at Upper Warrell Ck (ch. 42565). These surveys were undertaken in Spring 2013, Summer 2014 and Autumn 2014 with each survey occurring within 7 days of a suitable rainfall event defined here as >10 mm in 24 hours and the ambient air temperature was >18°C at the commencement of the survey and not lower than 14.4 °C during the survey. The Bureau of Meteorology (BOM) weather stations at Macksville Country Club (059018) and Fisherman's Reach (059143) were used as reference points to identify a rainfall event and provide a guide for prevailing ambient air temperatures. No surveys were performed during heavy rainfall events/flooding. This sampling rationale has considered other studies which have examined the environmental conditions on the activity of Giant Barred Frogs (e.g. Koch and Hero 2007). Further details are provided in Appendix B of this management strategy.

3.6 Performance Measures and Corrective Actions

The performance measures and corrective actions for the pre construction management of Giant Barred Frogs is summarised in Table 3-1. This table also describes how the identified mitigation measures are to be monitored, the timing and frequency of monitoring, who is responsible for implementing the measures, the performance thresholds that each goal is measured against and the corrective actions if the performance thresholds are triggered.

Table 3-1. Pre-construction management goals, mitigation measures and their timing, performance thresholds and corrective actions during the pre-construction works.

Management Goal	Mitigation/ Control Measure	Monitoring / Timing Frequency	Responsibility	Performance Threshold	Corrective Actions if Deviation from performance Criteria
No loss of known Giant Barred Frog habitat from pre-construction activities	No areas of Giant Barred Frog habitat to be cleared during preconstruction	Constraints maps to include Giant Barred Frog habitat mapping	AFJV (Design team)/ suitably qualified Project Ecologist	No Giant Barred Frog habitat to be cleared during preconstruction	Consideration of additional offsets for habitat loss
	All ancillary sites to be located outside of mapped Giant Barred Frog habitat.	Ecological assessments to be prepared for ancillary sites to verify minimal impacts to Giant Barred Frog habitat	AFJV (Environmental team)/ suitably qualified Project Ecologist	No areas of mapped Giant Barred Frog habitat to be impacted by the ancillary facilities	Consideration of additional offsets for habitat loss
No injury/mortality to Giant Barred Frog from pre-construction activities	No areas of Giant Barred Frog habitat to be cleared during preconstruction	Constraints maps to include Giant Barred Frog habitat mapping	AFJV (Design team)/ suitably qualified Project Ecologist	No Giant Barred Frog habitat to be cleared during preconstruction	Consideration of additional offsets for habitat loss
	All ancillary sites to be located outside of mapped Giant Barred Frog habitat.	Ecological assessments to be prepared for ancillary sites to verify minimal impacts to Giant Barred Frog habitat	AFJV (Environmental team)/ suitably qualified Project Ecologist	No areas of mapped Giant Barred Frog habitat to be impacted by the ancillary facilities	Consideration of additional offsets for habitat loss
Minimise the spread of Chytrid fungus during pre-construction activities	No areas of Giant Barred Frog habitat to be accessed during preconstruction	Constraints maps to include Giant Barred Frog habitat mapping	AFJV (Design team)/ suitably qualified Project Ecologist	No Giant Barred Frog habitat to be cleared during preconstruction	Consideration of additional offsets for habitat loss
	All ancillary sites to be located outside of mapped Giant Barred Frog habitat.	Ecological assessments to be prepared for ancillary sites to verify minimal impacts to Giant Barred Frog habitat	AFJV (Environmental team)/ suitably qualified Project Ecologist	No areas of mapped Giant Barred Frog habitat to be impacted by the ancillary facilities	Consideration of additional offsets for habitat loss
Ensure that appropriate habitat offsets have been identified for Giant Barred Frog conservation	Perform field surveys at nominated biodiversity offset sites	Spring and Summer 2014	Roads and Maritime	Giant Barred Frog potential habitat identified in the nominated biodiversity offset sites	Located additional areas and survey for Giant Barred Frog

4.0 Construction Management Measures

4.1 Timing

Construction works are scheduled to commence in January 2015 and are expected to be completed in late 2017.

4.2 Summary of Potential Impacts

The construction stage works have the following potential impacts on Giant Barred Frog:

- Loss of known Giant Barred Frog habitat to accommodate the Project over Upper Warrell Creek;
- Injury/ mortality to individuals during the clearing and subsequent construction works; and
- Fragmentation of habitat.

4.3 Main Goals for Management

The main goals for Giant Barred Frog management during construction include:

- Minimise the loss of known Giant Barred Frog habitat during clearing and grubbing operations;
- Minimise road kill during construction activities;
- No injury/ mortality to Giant Barred Frog from construction activities;
- Undertake habitat rehabilitation works within identified areas of the Project Site to create or improve existing Giant Barred Frog habitat.

4.4 Mitigation Measures

4.4.1 Pre-clearing Surveys at Sites with Known Giant Barred Frog Habitat

Pre-clearing surveys will provide an additional safeguard to reduce direct mortality to individual frogs during the clearing and grubbing phase of the project. At known Giant Barred Frog sites (Upper Warrell Creek) the following pre-clearing survey procedure shall be undertaken.

4.4.2 Early Works – Establishing Site Controls (Temporary Frog Fencing)

a) The works area for the temporary fencing is inspected/searched by the Project Ecologist immediately prior to installing the temporary fencing. The search should use active techniques such as raking the leaf litter, call broadcast (this species will readily call during the day) and inspections around tussocks (i.e. *Lomandra* clumps in particular) and logs.

b) Temporary frog fencing installed for up to 200 m either side of the stream (minimum 900 mm high above ground and buried to a depth of 50-100 mm)[1]. Where the terrestrial habitat bordering the stream is cleared land (i.e. Upper Warrell Creek ch. 700) this may be reduced to 100 m. In each instance a return wing (5 m in length) will be installed to reduce frogs breaching the fence.

c) Fencing to be installed and inspected/signed off by the ecologist with Giant Barred Frog experience or a suitably qualified person who has successfully detected this species on at least 10 occasions at different sites. This procedure should form part of the pre clearing/ground disturbance checklist/permit.

[1] It is acknowledged that installation of the fence itself will represent ground/vegetation disturbance and as such it should be subject to a pre clearing active search survey and the works supervised by the Project Ecologist.

d) Fencing will be installed at least 5 days prior to the scheduled clearing date so that active searches can be performed within the clearing footprint (see below).

e) All this is to be in place at least 5 days prior to nominated clearing start date.

f) Daily inspections of temporary frog exclusion fencing shall be undertaken following completion of pre- clearing survey (as below) up until the installation of the permanent Giant Barred Frog fencing

4.5.3 Pre-clearing Survey for Giant Barred Frogs

a) Within 6 weeks of scheduled clearing/ground disturbance operations, the Project Ecologist will perform pre-clearing surveys over a minimum of two non-consecutive nights (i.e. before clearing commences). Surveys during heavy rainfall events/flooding are not supported and should be abandoned or repeated again at a later date when flooding has subsided. Pre-clearing surveys in known Giant Barred Frog habitat areas are not to take place during winter periods or other periods of likely dormancy including extended dry weather periods (i.e. more than 7 nights without a rainfall event of greater than 10 mm in 24 hrs).

b) Surveys to last 1 person hour per hectare of habitat to be disturbed/removed and involve the use of call broadcast, spotlighting and active searches of litter, debris and logs. For any individuals that have their home range within the construction site they will be temporarily relocated during construction. Relocation points will be minimised as much as practical from collection point (see below).

c) All Giant Barred Frogs captured will be relocated to the nearest side of the clearing limit with information collected on sex, breeding condition and snout-vent length. Alternative relocation sites may be considered provided they occur within the same drainage. As a general rule frogs should not be relocated further than 100 m from the capture site which should theoretically remain within an individual’s home range.

d) Frogs with a snout-vent length >40 mm will be PIT[2] tagged to document the performance measure of this as a suitable relocation strategy. Juvenile/sub adult frogs may be marked in accordance with the animal care and ethics licence of the Project Ecologist or frog expert. Toe-clipping is one possible method, however, not all animal care and ethics committees support this approach.

e) A frog hygiene protocol will be adopted at sites with Giant Barred Frog (*see* Appendix D). This protocol will be in accordance with Department of Environment and Climate Change DECC (now OEH) Hygiene protocol for the control of disease in frogs Information Circular Number 6 (*see* DECC 2008).

f) In the instance of flooding in the area and flood water breaches the exclusion fencing, the Project Ecologist with Giant Barred Frog experience or frog expert to be consulted regarding replacement of fencing.

4.5.4 Clearing Supervision in Giant Barred Frog areas

a) At the Upper Warrell Creek site (ch. 42565) the clearing and grubbing activities will be supervised by the Project Ecologist until such a time they are confident no Giant Barred Frogs remain within the work site.

b) Captured frogs will be treated as per 4.5.3 c) and 4.5.3 d).

c) The need to perform additional night time surveys will be at the discretion of the Project Ecologist or frog expert. For example, only part of the site may have been cleared or more suitable weather conditions present an increased opportunity to detect frogs.

2 Passive Integrated Transponder (i.e. microchip as used to mark and identify domestic animals).

4.5.5 Dewatering Procedures in Giant Barred Frog areas

a) The dewatering process will be supervised by the Project Ecologist with the aforementioned Giant Barred Frog experience (see Section 4.4.2 c), in accordance with an Environmental Work Method Statement (EWMS) and the DECC (2008) hygiene protocol for the control of disease in frogs. All waterways and dams within those areas identified as Giant Barred Frog habitat will be subject to this dewatering process if dewatering is required. .

b) Where the water body is to be pumped dry the intake pipe must be positioned in the deepest section.

c) Screening of the pump intake (5mm mesh size) will be installed to prevent tadpole entrainment.

d) Once the remaining water body is shallow enough to be effectively waded through by field personnel intensive dip netting will be undertaken to remove as many aquatic fauna as practical.

e) All tadpoles that can be clearly identified to a genus other than *Mixophyes* do not need sorting. Tadpoles to be placed into holding containers. The size of these containers will be left to the discretion of the Project Ecologist.

f) All tadpoles will be released into permanent/semi-permanent pools in adjacent habitats. Tadpoles will be first acclimatised to the recipient sites water temperature by immersing bags or aquaria in the release pools to allow a gradual equilibrium of water temperature prior to release.

g) In stances where there are numerous tadpoles from a wide range of species, preferential treatment will be given to Giant Barred Frog tadpoles due to their legislative status as an endangered species. The release of predatory species (i.e. eels) will not occur in areas where Giant Barred Frog tadpoles are being released. This will reduce the risk of predation and/or competition.

4.5.6 Permanent Frog Fencing

a) Frog fencing must be installed in areas where the presence of Giant Barred Frogs has been confirmed and there is a 'high' risk of frogs accessing the carriageway. A high risk has been defined as earth embankments/batters within 200 m of the stream.
b) The fence must provide the required protection for between 100-200 m either side of the stream. Based on the concept design frog fencing may be required at Ch. 41965-42515 (either side of Upper Warrell Creek as shown in Figure 1-2).

Design wise, the frog fencing can be a standalone fence positioned between the floppy top fauna fence or boundary fence and the carriageway (i.e. toe of the batter). From a design perspective, the fence is a larger version of the design used at a number of Green-thighed Frog locations. It will stand at least 900 mm in height and comprise neoprene rubber sheeting including a small rubber return of not less 100 mm on the ground. The fence hot dip galvanized pressed sheet metal or powder coated aluminum pressed sheet mounted on a galvanized star picket (Figure 4-1). This design has been installed on the Kempsey Bypass Project and was supported by the EPA (Lewis 2011). An alternative option may be to retrofit a similar design described above to any proposed floppy top fauna fencing.

The success of this design will be based on the absence of Giant Barred Frog fence breaches[3]. As part of the monitoring procedures for measuring the effectiveness of the frog fencing, some monitoring of fence breaches must be undertaken by a suitable qualified zoologist at certain times of the year (i.e. when population monitoring occurs). This monitoring program will involve surveys for Giant Barred Frog on both sides of the frog fence as this data will clearly show whether the frog fence is effective at excluding frogs.

[3] This will also be detailed in the EMS required for the project.

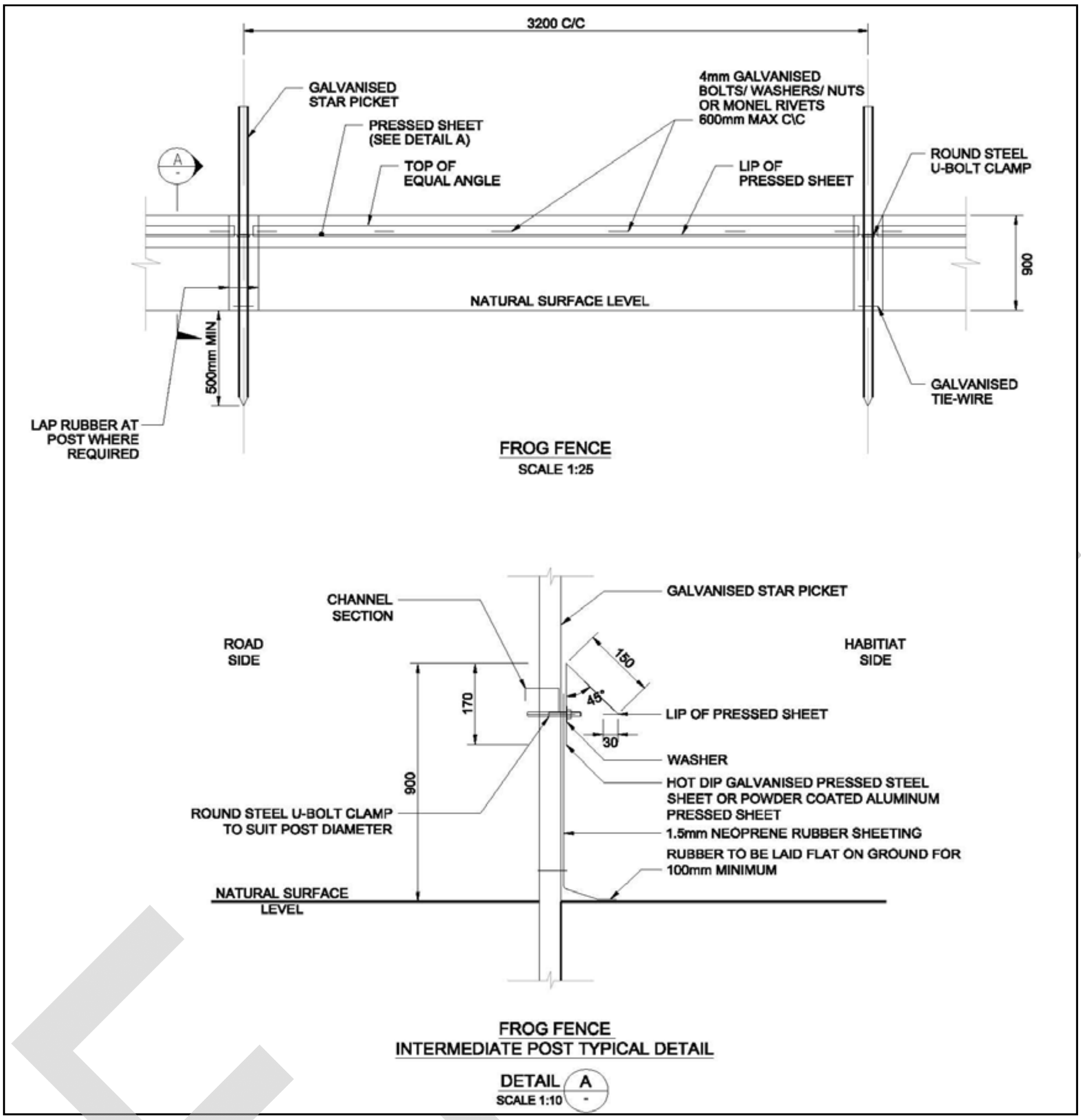

Figure 4-1. Example of a frog fence design for Warrell Creek to Urunga.

4.5.7 Unexpected Finds Process

An unexpected finds process has been developed to manage instances where Giant Barred Frog may be detected during pre-clearing surveys, clearing operations or dewatering works for the upgrade. This is in response to field surveys not being exhaustive (<3 surveys at any given site) and the ability of Giant Barred Frogs to move relatively large distances in short time periods. For example, many tens of metres when the clearing footprint will rarely extend beyond 100 m.

In an unexpected finds instance the management strategies outlined in this plan will be adopted and include:

1. Protection of Giant Barred Frog habitat including provisions for its protection from ancillary areas and their associated impacts consistent with MCoA C1 and C27;
2. Temporary and if required permanent frog fencing;
3. Additional pre-clearing surveys as deemed appropriate by the Project Ecologist or frog expert;
4. An examination and review of the adequacy of the proposed mitigation measures proposed at that site in consultation with the EPA, and
5. Implementation of the monitoring program in accordance with Section 7.0 and the performance measures outlined in this management strategy.

5.0 Construction Stage Monitoring

Monitoring during the construction phase of the Project will focus on the following:

- Ecological Assessments to be prepared for any additional areas to be cleared to verify minimal impacts to Giant Barred Frog habitat;
- Monitoring of temporary frog exclusion fencing and at a later stage in the project the permanent frog exclusion fencing once installed;
- Monitoring the stability of the Giant Barred Frog population and habitat condition in areas adjacent to the Project in the same manner as prescribed in the preconstruction baseline survey (see Appendix B);
- Road kill surveys performed daily during the clearing operations and weekly thereafter; and
- Monitoring and maintenance of plantings used in rehabilitated areas and monitoring on the extent of weeds (Table 5-1).

5.1 Performance Measures and Corrective Actions

The performance measures and corrective actions for the pre construction management of Giant Barred Frogs is summarised in Table 5-1. This table also describes how the identified mitigation measures are to be monitored, the timing and frequency of monitoring, who is responsible for implementing the measures, the performance thresholds that each goal is measured against and the corrective actions if the performance thresholds are triggered.

Table 5-1. Management goals, mitigation measures and their timing, performance thresholds and corrective actions during construction.

Management Goal	Mitigation/ Control Measure	Monitoring / Timing Frequency	Responsibility	Performance Threshold	Corrective Actions if Deviation from performance Criteria
Minimise habitat loss for the Giant Barred Frog from clearing.	Any design changes required during the construction stage would minimise clearing of Giant Barred Frog habitat where feasible and reasonable	Ecological Assessments to be prepared for additional areas to be cleared to verify minimal impacts to Giant Barred Frog habitat	AFJV (Environmental team, Design team)	Giant Barred Frog habitat to be cleared to not exceed approvals	Notification to DoE and EPA if the performance thresholds cannot be met Additional habitat rehabilitation works to be undertaken on the Project to offset losses Consideration of additional offsets for habitat loss
	The limits of clearing are to be clearly marked on all relevant work plans and protective fencing erected to mark these limits (i.e. 'no-go' areas)	Clearing limits to be checked prior to the commencement of clearing by survey and environmental team	AFJV (Environmental team, Survey team)	Final Sensitive Area Plans identify sensitive areas and 100% of clearing drawings identify clearing extents Clearing limit does not exceed approved limits (State and Commonwealth)	
No injury/ mortality to Giant Barred Frog from construction activities	Preparation of an EWMS would be undertaken for all construction activities to clearly communicate relevant measures within this plan to work crews Ongoing induction of all personnel involved with construction activities would be undertaken to advise of Giant Barred Frog management requirements Early Works – Establishing Site Controls (Temporary Frog Fencing) (4.4.2) Pre-clearing Survey for Giant Barred Frogs (4.4.3) Clearing Supervision in Giant Barred Frog areas (4.5.4) Dewatering Procedures in Giant Barred Frog areas (4.5.5) Permanent Frog Fencing (4.5.6) Unexpected Finds Procedure (4.5.7)	Pre-clearing permits/checklists to be completed by the Project Ecologist with Giant Barred Frog experience prior to the clearing of any vegetation Post-clearing inspections of recently cleared areas (<1 day) in known Giant Barred Frog habitat to identify any individuals injured or killed during clearing The detection of chytrid fungus 'sick and dying' frogs Dewatering permit/checklist to be completed by the Project Ecologist with Giant Barred Frog experience prior to any water bodies being dewatered in Giant Barred Frog habitat Daily inspections of temporary frog exclusion fencing following completion of pre-clearing survey until the installation of the permanent Giant Barred Frog fencing	AFJV (Environmental/ Construction team)/ suitably qualified Project Ecologist	No Giant Barred Frog injuries/ mortalities of adults or tadpoles as a consequence of construction activities.	Notification to DoE and EPA if Giant barred Frog mortality is recorded on the Project. Seek advice from DoE and EPA for current best practise for Chytrid fungus Reinstate site controls as relevant to this management strategy.

Management Goal	Mitigation/ Control Measure	Monitoring / Timing Frequency	Responsibility	Performance Threshold	Corrective Actions if Deviation from performance Criteria
To collect data to demonstrate that mitigation has maintained the population size and habitat of the Giant Barred Frog similar to results of the preconstruction baseline surveys	Temporary frog exclusion fencing Maintenance of revegetation/ rehabilitation areas of Upper Warrell Creek All mitigation measures applied during construction as per Table 5-1	Continuation of the pre construction field survey program on an annual basis and at appropriate times for sampling (i.e. >10 mm in past 7 days) in spring, summer and autumn in Years 1 & 3 (Construction stage of the Project)	Roads and Maritime / AFJV	Giant Barred Frog recorded along the monitoring transect The detection of Chytrid fungus No breaches in fauna exclusion fencing.	Extend the monitoring transect by 500 m to determine presence of Giant Barred Frogs in adjacent areas Review/audit the performance of Weed and Pathogen Plan as (*see* Appendix D) Modify, if appropriate, design of existing measures where feasible and reasonable Advise DoE and EPA and discuss adaptive management actions including assisted plantings. Within two weeks of the change being identified with corrective action agreed by DoE, EPA and Roads and Maritime implemented within 3 months
Minimise road kill of Giant Barred Frog during construction activities.	Giant Barred Frog road kill to be reported to the Project Ecologist during daily/weekly monitoring An assessment of future road kill risks including adaptive management actions is to be provided by the Project Ecologist where: • A Giant Barred Frog is detected within/ near the site; or	Daily inspection of roads within likely Giant Barred Frog range (as assessed by Project Ecologist) during clearing operations Weekly inspection of roads within likely Giant Barred Frog range (as assessed by Project Ecologist) for duration of	AFJV (Environmental team/ suitably qualified Project Ecologist	No road kill of Giant Barred Frog resulting from the Project.	An assessment of future road kill risk will be undertaken by the Project Ecologist for areas where Giant Barred Frog road kill have been detected. This assessment will aim to provide actions to mitigate

Management Goal	Mitigation/ Control Measure	Monitoring / Timing Frequency	Responsibility	Performance Threshold	Corrective Actions if Deviation from performance Criteria
	• Giant Barred Frog road kill is detected	construction			the risk of future Giant Barred Frog road kill in such areas Review the integrity of the fence, its design, its extent for either the temporary or permanent fencing.
Undertake habitat rehabilitation works within identified areas of the Project Site to create or improve existing Giant Barred Frog habitat	Progressive rehabilitation of identified areas (refer to Appendix C) Key rehabilitation measures will include planting of the northern bank of Upper Warrell Creek on either side of the bridge Progressive revegetation/ rehabilitation during construction Use of locally endemic native species representative of those currently growing along Upper Warrell Creek Monitoring and maintenance of plantings Managing and controlling weeds	Monitoring and maintenance of rehabilitation areas to be undertaken regularly as part of the Project landscaping contract. Weed monitoring would be undertaken on the site.	AFJV (Landscape Design/ Construction team)	Successful establishment of Giant Barred Frog habitat in the nominated areas	Consideration of additional landscaping/ habitat rehabilitation works.

6.0 Operational Management Measures

6.1 Summary of Potential Impacts

The operational stage of the Project has the potential to have the following impacts on Giant Barred Frog:

- Fragmentation and loss of habitat; and
- Risk of vehicle strike associated with the upgrade.

6.2 Main Goals for Management

The main goals for management include:

- Maintain habitat connectivity for Giant Barred Frog as the population extends to both sides of the carriageway;
- Minimise vehicle strike of Giant Barred Frog during operational activities; and
- Maintain habitat rehabilitation areas.

6.3 Mitigation Measures

6.3.1 Habitat Offset Strategy

This Strategy would be prepared and implemented to offset the biodiversity impacts of the Project to address the *Environmental Protection and Biodiversity Conservation* Act (1999) offset requirements.

Table 6-1. Management goals, mitigation measures and their timing, performance thresholds and corrective actions during operational phase of the Project.

Main Goal	Mitigation/ Control Measure	Monitoring / Timing Frequency	Responsibility	Performance Threshold	Corrective Actions if Deviation from performance Criteria
Maintain habitat connectivity for Giant Barred Frog as the population extends to both sides of the carriageway	Permanent frog exclusion fencing Maintenance of revegetation/ rehabilitation areas of Upper Warrell Creek	Monitoring existing 1km transect at Upper Warrell Creek in spring, summer and autumn as per methods outlined in Appendix B for year 4, 6 and 8 Regular monitoring of the rehabilitation areas would be undertaken as part of the landscape maintenance works.	Roads and Maritime/ AFJV	Continued presence of Giant Barred Frog from any part of the 1km transect once Operational Monitoring commenced Presence of tadpoles, metamorphs or juvenile frogs during follow up surveys No greater than 30% change in foliage projection cover (fpc) for overstorey trees, shrubs and groundcover No greater than 30% reduction in litter cover No greater than 15% increase in soil cover No statistically significant differences ($p<0.05$ level) in declining water quality parameters	If no frogs are found, the search is repeated over an area extended by a further 500 m upstream and downstream and based on these results, the management actions and ongoing monitoring program for the Giant Barred Frog at Upper Warrell creek be redefined in consultation with the EPA and DoE Advise DoE and EPA and discuss adaptive management actions including assisted plantings. Within two weeks of the change being identified with corrective action agreed by DoE, EPA and Roads and Maritime implemented within 3 months
Minimise vehicle strike of Giant Barred Frog during operational activities	Permanent frog exclusion fencing	Initially during the monitoring existing 1km transect at Upper Warrell Creek in spring, summer and autumn as per methods outlined in Appendix B for year 4, 6 and 8 Post 5 years, the Roads and Maritime Roads Asset Division will undertake monitoring of fauna fencing on a regular basis	Roads and Maritime /AFJV	No road kill of Giant Barred Frog resulting from operation of highway	Review the integrity of the fence, its design, its extent of permanent fencing.

7.0 Monitoring Program

The monitoring methodology for the Giant Barred Frog on the WC2NH Project is included in Appendix B. This methodology has been peer reviewed by a Giant Barred Frog expert, Dr Frank Lemckert and is summarised in this section of the report. The objectives of the monitoring program are:

- To demonstrate through the life of the Project that mitigation has maintained or improved population sizes and habitat of the Giant Barred Frog. The use of preconstruction, during construction and post construction monitoring to measure both frog distribution, abundance and habitat quality with defined thresholds will be used to measure the overall performance of the mitigation; and
- To ensure that mitigation measures are effective in maintaining Giant Barred Frog connectivity near the Project.

7.1 Giant Barred Frog Population Monitoring

7.1.1 Objectives

To demonstrate through the life of the Project that mitigation has maintained or improved population sizes and habitat of the Giant Barred Frog. The use of preconstruction, during construction and post construction monitoring to measure frog distribution, abundance and habitat quality with defined thresholds will be used to measure the overall performance of the mitigation.

7.1.2 Methodology

See Appendix B for Giant Barred Frog monitoring procedure.

7.2 Sites Requiring Monitoring

The monitoring program will be limited to Upper Warrell Creek (ch. 42565) in the southern part of the project corridor. A reference or control site was not proposed because Giant Barred Frogs were found at only one site along the project and pairing this with a control site proved problematic for the following reasons:

- A nearby control site exhibiting the same habitat attributes, 'large slow moving stream in partly cleared farmland" unaffected by the Pacific Highway could not be located. The only site able to be located was Way Way State Forest which differed in its habitat, being a faster flowing stream, unfragmented forest and no agriculture in this part of the catchment (Figure 1-1).

- In consultation with EPA representatives, ongoing concern in Chytrid management during construction was considered a critical issue. The risk of managing Chytrid is considerable when workers, machinery and materials are transported from numerous locations. Therefore, increasing risk of chytrid transfer to a control site with very different habitat attributes, does not appear to be a good outcome for the Giant Barred Frog.

7.3 Construction and Post Construction Population and Habitat Monitoring Regime

During construction, the maintenance of existing Giant Barred Frog management actions and site controls will be performed on a regular basis as shown in Table 5-1. In addition, frog population and habitat monitoring surveys will be performed in accordance with the details described in Appendix B. This will include population monitoring along the existing 1 km transect in spring, summer and autumn of Year 1 and 3 of the construction phase of the project along with annual habitat monitoring. This program will include the monitoring of frog fence breaches during each monitoring event and involve surveys on both sides of the fence to clearly show whether the fence is effective at excluding frogs and thus mitigated a potential threat of road strike. Further details for construction and post construction monitoring are shown in Table 7-1.

Table 7-1. Summary of the monitoring schedule, goals, timing, responsibility, performance threshold and corrective actions during the construction and operation (i.e. post construction) phase of the Project.

Monitoring Component	Main Goal	Timing/ Frequency	Responsibility	Performance Threshold	Corrective Actions if Deviation from performance Criteria
Giant Barred Frog population and habitat monitoring	To collect data to demonstrate that mitigation has maintained or improve population sizes and habitat of the Giant Barred Frog	Pre-construction baseline surveys completed between spring 2013 and autumn 2014 (see Appendix B) Continuation of the pre construction field survey program on an annual basis in spring, summer and autumn in Years 1 & 3 (Construction stage of the Project) Continuation of the pre construction field survey program on an annual basis in spring, summer and autumn in Years 4, 6 and 8 (operational stage of the Project)	Roads and Maritime AFJV	Giant Barred Frog recorded along the monitoring transect The detection of Chytrid fungus No breaches in fauna exclusion fencing.	Extend the monitoring transect by 500 m to determine presence in adjacent areas Modify, if appropriate, design of existing measures where feasible and reasonable Advise DoE and EPA and discuss adaptive management actions including assisted plantings. Within two weeks of the change being identified with corrective action agreed by DoE, EPA and Roads and Maritime implemented within 3 months Consider additional offset measures to provide additional compensation for animals and habitat lost due to the development

8.0 REPORTING AND DOCUMENT REVIEW REQUIREMENTS

8.1 Pre-construction Baseline Monitoring

See Appendix B for the Preconstruction Baseline Monitoring report.

8.2. Monitoring During Construction

The contractor will submit twice yearly monitoring compliance tracking reports to Roads and Maritime for review. Roads and Maritime will then provide a final copy of the report for information purposes to the Environmental Protection Agency and Department of the Environment. This report will be subject to a review in relation to information provided on the mitigation of impacts for the Giant Barred Frog including the results of the pre-clearing surveys, any road kill related monitoring to date, the population and habitat monitoring surveys performed in Year 1 and 3, , integrity of the temporary frog exclusion fencing and any dewatering processes which have been performed within Giant Barred Frog habitat.

8.3 Post Construction (Operational) Monitoring

The contractor will submit an annual monitoring report to Roads and Maritimes Services for review. Roads and Maritime Services will then provide a final copy of the report for information purposes to the Environmental Protection Agency and Department of Environment. This report will be subject to a review in relation to information on the mitigation of impacts and include comparisons of frog numbers and habitat condition parameters between the preconstruction surveys and the subsequent surveys performed during construction (Year 1 and 3) and the post construction surveys performed in years 4, 6 and 8. This will be reported on bi annually (i.e. every second year).

9.0 CONCLUSION

Surveys for the Giant Barred Frog revealed the presence of a population at Upper Warrell Creek (ch. 42565). Although a reference site was located in nearby Way Way State Forest, the differing habitat at this site precluded it from being used as a control site in the pre and post construction monitoring program.

The strategy has two key objectives, firstly, to demonstrate through the life of the Project that mitigation has maintained or improved population sizes and habitat of the Giant Barred Frog. This is being delivered via a set of upfront management actions, centered on the identification and protection of Giant Barred Frog habitat, suitably experience persons conducting pre-clearing surveys during early works when site controls are being established, clearing supervision with surveys being performed during suitable weather conditions and dewatering processes to capture tadpoles along with the installation of temporary and permanent frog fencing throughout the construction and operating phases of the Project. The use of pre and post construction monitoring to measure frog distribution, abundance and habitat quality with defined thresholds will be used to measure the overall performance of the mitigation.

In the event that significant negative changes are recorded, the second objective of this management strategy focuses on advising the Department of Environment (DoE) and Environmental Protection Agency (EPA) and agreeing on adaptive actions to be undertaken within three months to reverse the negative trend. Where the implementation of this management strategy identifies the mitigation as being unsuccessful, offsetting will be undertaken by the Roads and Maritime.

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11.0 APPENDIX A – LOCATION OF HABITAT SAMPLING POINTS

Table A-1. Location of habitat sampling sites and zones at the Upper Warrell Creek monitoring site and zones relevant to Figure 2-1.

Label/Zone	Easting GDA 94	Northing GDA 94
(Upstream) Zone 21	488905	6593837
Zone 21	488938	6593878
Zone 20	488978	6593903
Zone 19	489014	6593946
Zone 18	489046	6593992
Zone 17	489089	6594013
Zone 16	489133	6594030
Zone 15	489171	6594047
Zone 14	489206	6594072
Zone 13	489232	6594106
Zone 12	489243	6594152
Zone 11	489253	6594206
Zone 10	489274	6594256
Zone 9	489254	6594295
Zone 8	489261	6594342
Zone 7	489278	6594381
Zone 6	489293	6594422
Zone 5	489306	6594464
Zone 4	489319	6594520
Zone 3	489322	6594568
Zone 2	489313	6594618
(Downstream) Zone 1	489305	6594671

12.0 Appendix B – Pre-construction Baseline Monitoring

See next page.

WARRELL CREEK TO NAMBUCCA HEADS:

GIANT BARRED FROG PRE-CONSTRUCTION BASELINE MONITORING

LEWIS ECOLOGICAL

AUGUST 2014

Disclaimer

The client (Roads and Maritime Services) may only use this document for the purposes for which it was commissioned. This report relies upon data, surveys, measurements and results based on a short-term objective study in response to a brief provided and largely defined by the client (RMS and their representatives: Tammie Tribe; Shayne Walker). Although conclusions have been based on the available data at the time, some professional judgement has been applied in reaching these conclusions due to the temporal limitations arising from the dynamic nature of available information, legislation, schedules, individual species and associated habitats. Every attempt has been made to ensure the accuracy and objectivity of the report's findings, conclusions and recommendations. Lewis Ecological Surveys does not accept responsibility for its use beyond the scope of works.

…………………………
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…19th August 2014………
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ACKNOWLEDGEMENTS

Ben Lewis (Lewis Ecological Surveys) – Field surveys, report author and project management.

George Madani (Lewis Ecological Surveys) – Field survey.

Andrew Smith (Lewis Ecological Surveys) – Report review.

Tammie Tribe (Roads and Maritime Services) – Logistics and project management.

Andrew Mula (Roads and Maritime Services) - Logistics and project management.

Shayne Walker (Roads and Maritime Services) - Logistics and project management.

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Report to be cited as: Lewis, B.D. (2014). Warrell Creek to Nambucca Heads: Giant Barred Frog Pre-construction Baseline Monitoring. Report prepared for the Roads and Maritime Services by Lewis Ecological Surveys. ©

Distribution History:

Date	Status	No. Copies	Format	Dispatched	Client	Client Contact
25.7.2014	Draft	1	PDF	Email	Roads and Maritime Services	Shayne Walker
19.8.2014	Version B	1	PDF	Email	Roads and Maritime Services	Shayne Walker

Revision History:

Date	Status	Reviewer	Organisation
25.7.2014	Draft version 1	Dr Andrew Smith	Lewis Ecological Surveys
4.8.2014	Draft for Comment	Shayne Walker	Roads and Maritime Services
4.8.2014	Draft for Comment	Andrew Mula	Roads and Maritime Services
4.8.2014	Draft for Comment	Chris Clarke	Roads and Maritime Services

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1.0 INTRODUCTION

1.1 Project Overview and Background to this Monitoring

The Pacific Highway Upgrade Program is a joint commitment by the Australian and New South Wales (NSW) governments to improve the standard and safety of the Pacific Highway between Hexham and the Queensland border. The Pacific Highway Upgrade Program includes the upgrade of the Pacific Highway between Warrell Creek and Urunga (WC2U) comprised of approximately 42 kilometres of dual carriageway road that would bypass the towns of Warrell Creek, Macksville, Nambucca Heads and Urunga on the Mid North Coast of NSW. The WC2U Project has been divided into two stages and includes the following:

- Stage 1 consisting of the northern 22.5 kilometres of the Project between Nambucca Heads and Urunga (NH2U).
- Stage 2 consisting of the southern 19.5 kilometres of the Project between Warrell Creek and Nambucca Heads (WC2NH).

The Environmental Assessment (EA) prepared for the Warrell Creek to Urunga Pacific Highway Upgrade project identified potential habitat for the Giant Barred Frog at several creeks and drainage lines in the northern half of the study area, through Nambucca, Little Newry and Newry State Forests (SKM 2010). The EA identified the proposal as having the potential to impact on this species as it would directly traverse streams and rivers across the study area. Subsequent surveys of the project route and all freshwater streams between December 2011 and November 2013 (i.e. summer/spring) resulted in the discovery of a Giant Barred Frog population at Upper Warrell Creek at ch. 42565 (Lewis 2014). Consequently, a Giant Barred Frog Management Strategy was developed to ensure the management of this species during the construction and operation of the Upgrade which included a requirement to perform pre-construction monitoring prior to construction (Lewis 2014).

In the context of the above, Lewis Ecological Surveys (LES) was engaged by the NSW Roads and Maritime Services (RMS) to implement the pre-construction baseline monitoring for the Giant Barred Frog (*Mixophyes iteratus*) between spring 2013 and autumn 2014.

1.2 Purpose and Objectives

This pre-construction baseline monitoring fulfils the pre-construction monitoring commitments of the Giant Barred Frog management strategy (Lewis 2014). This includes the implementation of field survey techniques as specified in the management strategy and outlines key biological components of the frog population and the prevailing habitat and water quality attributes prior to construction commencing.

1.3 Subject Species – Giant Barred Frog

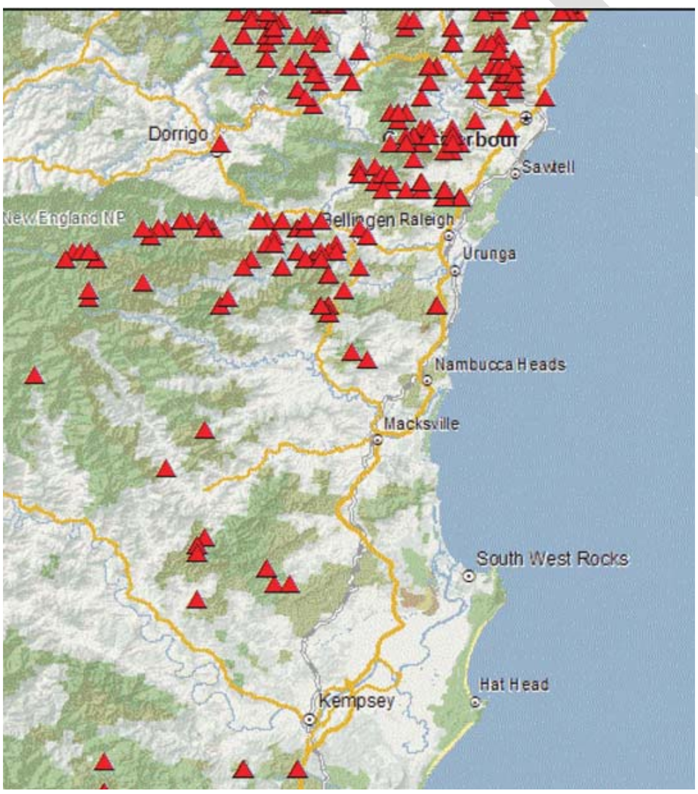
1.3.1 Description

The Giant Barred Frog (*Mixophyes iteratus*) is a large, dark-olive green to black coloured frog that grows to 115 mm. It has a pointed snout and a broad lateral band of dark spots dividing the dark dorsal surface from the white or pale yellow, ventral surface (underside). The limbs have dark crossbars. The hind side of the thighs are black with large yellow spots. Two joints of the fourth toe are free of web (Cogger 2000). The skin is finely granular above but smooth below. The call of the male Giant Barred Frog is a deep guttural grunt (OEH 2014).

Giant Barred Frog tadpoles are large and grow to over 100 mm in length. They are deep-bodied and ovoid, with a tail length twice that of the body. The tadpole's eyes are dorsolateral. The tadpoles are coloured yellow-brown above with dark spots and a dark patch at the base of tail. The underside is silver-white. The intestinal mass is obscured but the heart and lungs are visible from below (except near metamorphosis). The tail is thick and muscular (Anstis 2002). Fins are low and opaque with dark flecking (except the anterior half of the ventral fin; Meyer *et al.* 2001).

Plate 1-1. Giant Barred Frog (*Mixophyes iteratus*).

1.3.2 Distribution



The Giant Barred Frog is currently known from mid to low altitudes below 610 m above sea level (Hines *et al.* 2004), along the 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 (Figure 1-1). Considered to have disappeared south of the Hawkesbury and there are no recent records from the Blue Mountains (Hines and SEQTFRT 2002). Between about Kempsey and Urunga the species appears to be patchily distributed with some confirmed recent locations from upper Warrell Creek and in smaller fast flowing streams in Way Way State Forest (Lewis 2014; Figure 1-1).

Figure 1-1. Localised distribution of Giant Barred Frog between Kempsey and Urunga.
Note - Triangles represent approximate location as sensitive 2 species.

1.3.3 Habitat and Ecology

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 n.d., 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 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 disperse hundreds of metres away from streams. They feed primarily on large insects and spiders.

1.3.4 Conservation Status

In NSW, the Giant Barred Frog is currently listed as <u>Endangered</u> pursuant to the NSW *Threatened Species Conservation* Act (1995) and Commonwealth *Environmental Protection and Biodiversity Conservation* Act (1999) (OEH 2014; SPRAT profile).

2.0 SURVEY METHODS

Field surveys were performed in accordance with the approved Giant Barred Frog management strategy for the Warrell Creek to Urunga Pacific Highway Upgrade (Lewis 2013). At this time of implementing the pre construction monitoring the strategy and survey requirements had been approved by the Department of Planning and Environment (DP&E) and the Environmental Protection Authority (EPA).

2.1 Timing of Surveys

Field surveys were undertaken at the following times:

- Spring sampling was undertaken on the 20th September 2013 in response to a rainfall trigger event of 10.8 mm being recorded on the 17th September (Macksville Country Club Station No. 059018).
- Summer sampling was undertaken on the 29th January 2014 in response to a rainfall trigger event of 22.6 mm recorded on the 23rd January with an additional 13.2 mm being recorded in the 7 days leading up to the field survey.
- Autumn sampling was undertaken on the 2nd April 2014 in response to a rainfall trigger event of 20.6 mm recorded on the 28th March with an additional 10.4 mm being recorded in the 7 days leading up to the field survey.

2.2 Frog Surveys

Frog surveys were performed in the manner outlined in the Giant Barred Frog management strategy (Lewis 2013). This involved:

- Surveys being performed within 7 days of a rainfall event exceeding 10 mm in 24 hours using the Bureau of Meteorology (BOM) weather stations at Macksville Country Club (059018) and Fisherman's Reach (059143) when there was some missing data or some other discrepancy. For example, isolated thunderstorm activity that resulted in sporadic rainfall;
- 1 km transect with 450 m either side of the construction footprint (~100 m represents construction footprint) and divided into 20 x 50 m zones (Figure 2-1);
- Each field survey involved a meandering transect on both sides of the stream bank with all captured Giant Barred Frogs permanently marked using a PIT tag (i.e. micro-chipped) and specifically a Trovan Nanotransponder (000735#### series). Survey effort ranged from 3.25 – 6.25 hours per transect with variability in time length attributed to variations in habitat, accessibility and the number of frogs being processed;
- For each frog, the following information was collected:
  - Location according to demarcated survey zone (20 x 50 m zones);
  - 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);
  - Age class (adult = >60 mm; sub adult = 40-60 mm; juvenile = <40 mm)
  - Snout-vent length (mm);
  - Weight (grams); and
  - Breeding condition with:
    - 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 are gravid (i.e. typically adult weighing > 100 grams) or not gravid (egg bearing);
    - frogs with a snout vent length of <60 mm were classified as immature.

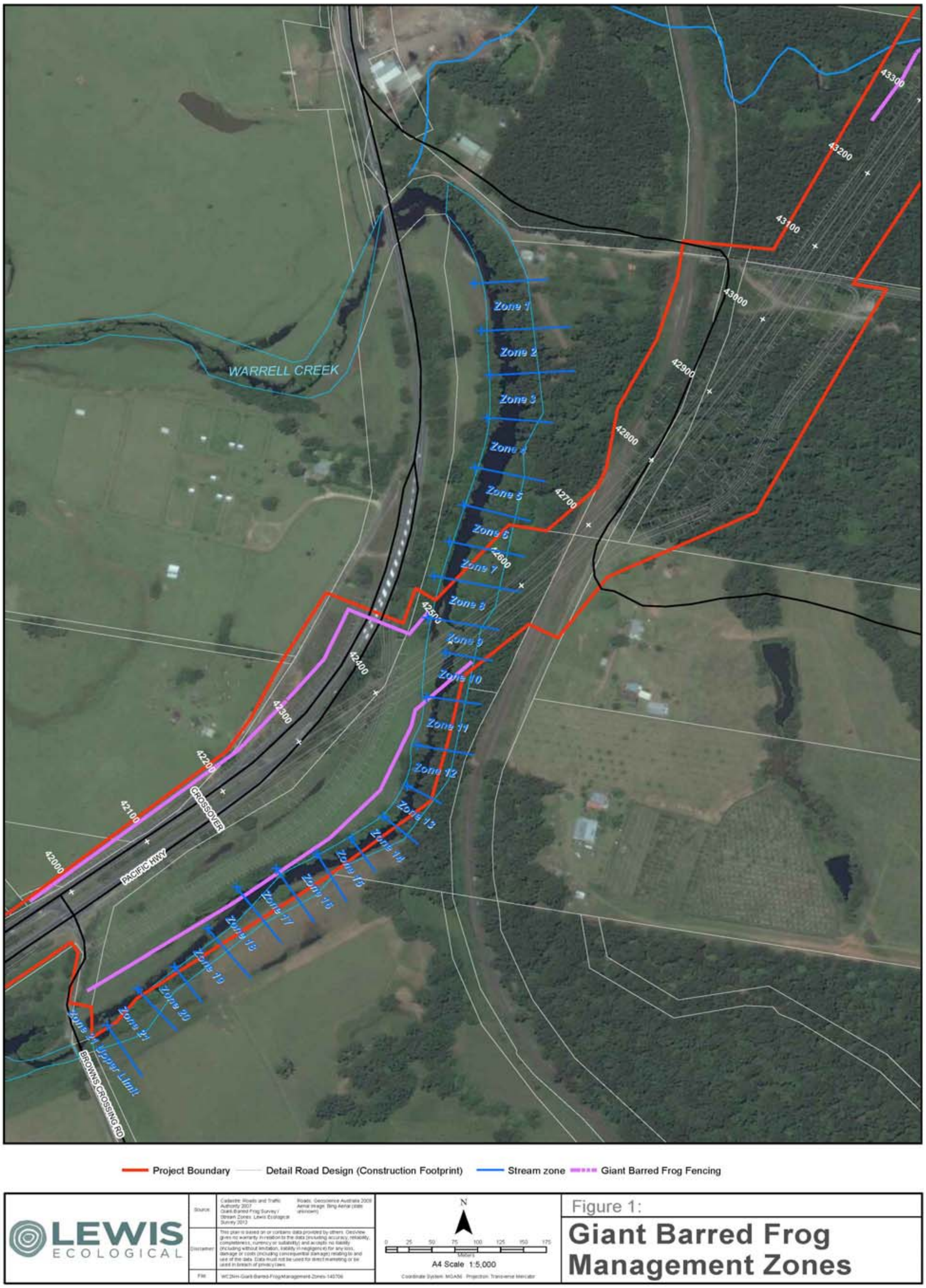


Figure 2-1. Location of the monitoring transect and recording zones 1-20.

2.3 Swabbing for Chytrid Fungus

Swabbing for Chytridiomycosis or Chytrid fungus was undertaken during the summer monitoring event on the 29th January 2014. The objective of this was to establish a pre-construction baseline indices as to the exposure of Chytrid fungus given the overall lack of information on the extent of this disease within Giant Barred Frog populations on the mid north coast given the disease is a highly contagious, highly virulent disease of frogs. Chytrid Fungus is currently listed as a key threatening process for frogs pursuant to the NSW *Threatened Species Conservation* Act (1995).

Half of all frogs captured during the summer monitoring event were swabbed for Chytrid testing. This involved the use of a sterile swab and wiping the outer skin with a sterile cotton-tipped swab. The swab is wiped over the body creases, such as under the arms and inside of the thighs and groin, to collect loose skin samples. Swabs were then placed into a sterile container and held in a refrigerator until they could be delivered to Newcastle University for testing.

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

2.4 Tadpole Surveys

Tadpole surveys were undertaken during the spring survey using the following procedure:

- The 1 km transect was divided up into 20 x 50 m zones with seven zones in the downstream corridor, five zones partially or totally within the construction corridor and eight zones upstream of the road corridor.
- Within each zone, one bait trap (~300 mm x 200 mm) were installed and left operating for 3 hours. This equated to 20 bait traps and 60 hours of survey effort.

Some dip-netting was undertaken to confirm the presence of Giant Barred Frog tadpoles during both the spring and autumn monitoring. During these surveys the presence of exotic fish was also recorded.

Table 2-1. A key developed for determining reproductive condition in male barred frogs (*Mixophyes*).

Nuptial Pad Colour	Comments
No Colour	• Males may be active or dormant but don't present as being sexually active to mate with females. • No colour can occur at any time throughout the year but pronounced periods include dry springs and late autumn with the onset of winter.
Light	• Some colouration indicating frogs are likely to become active (late winter) or have been active but generally not breeding. For example, prevailing weather conditions are unsuitable. • Frogs with light nuptials are generally on the shoulder periods of breeding events and a small percentage of the male population is likely to classify into this category at almost any time of the year apart from June and July.
Moderate	• Males are normally active, will often readily respond to calls. Ready to mate with gravid females if weather conditions are suitable. • These frogs may occasionally be involved in intraspecific aggression indicating their readiness to mate with females. • Colouring may be evident between August-May and is considered cyclic and surrounding breeding events.
Very Dark	• Males are normally active, ready to mate with gravid females if conditions are suitable. • Some observations of intraspecific aggression can occur between males at this stage. • Colouring may be evident between August-May and is considered cyclic with early season suspected of being driven through warming air temperature whilst prevailing rainfall conditions are considered the primary queue during summer and autumn.

2.5 Abiotic Data

The following abiotic variables were collected during the survey.

- Rainfall measured in four scales:
  - During the survey;
  - Within past 24 hours;
  - Within past 7 days; and
  - Within past 30 days.
- Relative humidity measured with wet/dry bulb thermometer at the start and finish of the frog survey and averaged;
- Air temperature measured with a thermometer at the start and finish of the frog survey and averaged;
- Wind speed measured in subjective scale (0= no wind, 1 = light rustles of leaves on trees, 2 = leaves and branches moving and 3 = whole canopy moving);
- Water level measured with a permanently installed water staff or an electronic device if available from the Bureau of Meteorology (BOM).

2.6 Habitat Data

The following habitat data were recorded at each of the 20 demarcated zones and for both the southern and northern riparian zones given they differed markedly:

- Landuse: Description of existing land uses of dairy cattle farming, beef cattle farming, private natural reserve;
- Broad vegetation type within the immediate riparian zone (primary stream bank): Riparian Rainforest, Dry Sclerophyll Forest, Woodland, Mallee; Heath/Shrub; Sedgeland, Grassland or Cleared Land;
- In stream physical characteristics including:
  - Stream width and depth (metres);
  - Presence of pools and/or riffles
  - bed composition (sand, clay, rock, organic or other to be specified);
  - type of emergent vegetation if present
- Stream bank characteristics including:
  - Bank profile expressed as steep, benched or a gradual incline from the water's edge
- Vegetation associated with the stream bank in terms of its foliage projection cover (fpc) for overstorey trees, shrubs and groundcover;
- Groundcover composition including a measure of vegetative ground cover, litter cover, soil cover and exposed rock expressed as a composition percentage of 100%.
- The depth of litter was also measured and assigned to one of the following categories:
  - Deep (>10 mm); Moderate (20-100 mm); Shallow (>0-20 mm); or Absent (0 mm).
- Water quality monitoring with water samples being taken on the day of the summer survey (29th January) and at the next pronounced wet weather period triggering runoff (18th February) following by another dry weather sampling event on the 25th February. The samples were measured for the following:
  - Heavy Metal including arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc.
- Hydrocarbons from the following groups:
  - Naphthalene group including TRH>C10-C16, TRH>C10-C16 less Naphthalene (F2), TRH>C16-C34, TRH>34-C40, TRH C6-C10 and TRH C6-C10 LESS BTEX (F1);
  - BTEX group including Benzene, Ethylbenzene, m&p-Xylenes, o-Xylene, Toluene and Xylenes – total
- Nutrients including Nitrogen (as N), Suspended Solids and Total Phosphorus
- Field Physicochemical data including Dissolved Oxygen, Conductivity, pH, Temperature and Turbidity

Water quality data was analysed by Coffey Geotechnics using a National Association of Testing Authorities (NATA) accredited laboratory.

2.7 Determining Population Size

The Lincoln–Petersen method (also known as the Petersen–Lincoln index) was used to calculate the population size. This method was used in preference to the triple catch calculation given the low numbers of frogs recorded during the spring survey would only inflate the population estimate. The Lincoln–Petersen method is used to estimate population size when only two visits are made to the study area and assumes the study population is "closed". In other words, the two visits to the study area are close enough in time so that no individuals die, are born, move into the study area or move out of the study area between visits. The model also assumes that no marks fall off animals between visits to the field site by the researcher, and that the researcher correctly records all marks.

The Lincoln–Peterson estimator is asymptotically unbiased as sample size approaches infinity, but is biased at small sample sizes. An alternative less biased estimator of population size is given by the Chapman estimator.

- $$N = \frac{(M+1)(C+1)}{R+1} - 1,$$

Where, as before:

N = Estimate of total population size
M = Total number of animals captured and marked on the first visit
C = Total number of animals captured on the second visit
R = Number of animals captured on the first visit that were then recaptured on the second visit

An approximately unbiased variance of *N*, or var (*N*), can be estimated as:

- $$\operatorname{var}(N) = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)(R+1)(R+2)}.$$

As in all estimates, it is also useful to have some information about the uncertainty of the estimate (as measured by the standard error (SE), and/or by 95% confidence intervals). The standard error of the estimate of *N* is given by the following formula:

SE = sqrt { [(M+1)(C+1)(M-R)(C-R)] / $(R+1)^2$(R+2) }

The standard error gives an idea of where the sample mean is likely to be found if the experiment were conducted repeatedly. From the standard error, we can also calculate the 95% confidence limits of the estimate (which defines the range of values within which the true population size is likely to lie with 95% certainty), using the following formula:

- 95% confidence interval = *N* $\pm$ (1.96)(SE)

3.0 RESULTS

3.1 Abiotic Data

The spring sampling was undertaken on the 20th September 2013 in response to a rainfall trigger event of 10.8 mm on the 17th September (Table 3-1). This was the most notable rainfall event since the 14th June when 14.8 mm was recorded and remained the most notable rainfall up until the 19th October when 22.4 mm was recorded (Appendix). Although the survey was performed during relatively mild temperatures of 15.1°C the dissipating cloud cover reduce the relative humidity further from 59% at 1850 hours to 40% at 2135 hours.

The summer sampling was undertaken on the 29th January 2014 in response to a rainfall trigger event of 22.6 mm on the 23rd January. This was the first suitable rainfall event for the summer period with the previous suitable event occurring on the 30th November (outside summer sampling period) when 32.6 mm was recorded (Appendix). The field survey was performed during mild summer temperatures of 20.9°C at 2100 hours which dropped to 14.5°C at the completion of the survey at 0245 hours. The humidity remained high throughout the sampling period ranging from 74-91% despite there being no cloud cover or rain being recorded in the past 5 days.

The autumn sampling was undertaken on the 2nd April 2014 in response to a rainfall trigger event of 20.6 mm on the 28th March. Around this time there were a number of sporadic rainfall events with 24 hours total approaching and often exceeding 10 mm (Appendix). The air temperature was warmer than expected with 21.1°C at 1948 hours and this declined to 18.4°C by 0030 hours making it warmer overall than the summer survey. The humidity remained high throughout the sampling period ranging from 77–91% and although there was very little cloud cover there had been some recent rainfall of 3.2 mm in the past 24 hours.

Table 3-1. Abiotic conditions during the pre-construction baseline monitoring at Upper Warrell Creek.

Date	Time	Time (24 hours)	Air Temp °C	Water Temp °C	Cloud Cover %	Humidity %	Wind[1]	Rain[2]	Steam Depth (mm)
20.9.2013	Start Time	1850	15.5	13	15	59	0	0	nd
	Finish time	2135	14.6	13	0	40	1	0	nd
	Spring Summary	2 hours 45 minutes	15.05	13	7.5	49.5	0.5	0	nd
29.1.2014	Start Time	2100	20.9	24	0	74	0	0	nd
	Finish time	0245	14.5	24	0	91	0	0	nd
	Summer Summary	5 hours 45 minutes	17.7	24	0	82.5	0	0	nd
2.4.2014	Start Time	1948	21.1	19	15	77	0	1	nd
	Finish time	0030	18.4	19	0	91	0	0	nd
	Summer Summary	4 hours 48 minutes	19.75	19	7.5	84	0	0.5	nd
Rain	During (mm)		Past 24 Hours (mm)			Past 7 Days (mm)		Past 30 Days (mm)	
20.9.2013	0		0			18.3		18.3	
29.1.2014	0		0			31.2		56.8	
2.4.2014	0		3.2			40.4		77.4	

3.2 Giant Barred Frog - Demography

3.2.1 Captures and Age Classes

There was a total of 47 Giant Barred Frogs recorded during the pre-construction baseline survey (Table A3 in Appendix). This comprised:

- 38 individuals classified into the follow age classes:
    - 22 adults with 11 females and 11 males
    - 8 sub adults; and
    - 8 juveniles.

The remaining nine frogs included five recaptures and four adults identified as one female and three males that could not be captured to verify whether they had been previously PIT tagged. Consequently they could not be used in determining the population structure nor population estimate (see below).

The seasonal trend of frog captures is shown in Figure 3-1. Spring surveys recorded only one sub adult frog with this individual being captured from zone 10 on the northern bank which lies partially within the proposed construction footprint. The summer survey recorded 24 frogs comprising eight juveniles, three sub adults and 13 adults with this later group being comprised of five females and eight males. Three of the recorded male frogs could not be captured for micro-chipping. The autumn survey recorded 22 frogs comprising six sub adults and 16 adults with this later group being comprised of eight females and eight males (i.e. ratio of 1:1). One female frogs avoided capture during this monitoring period.

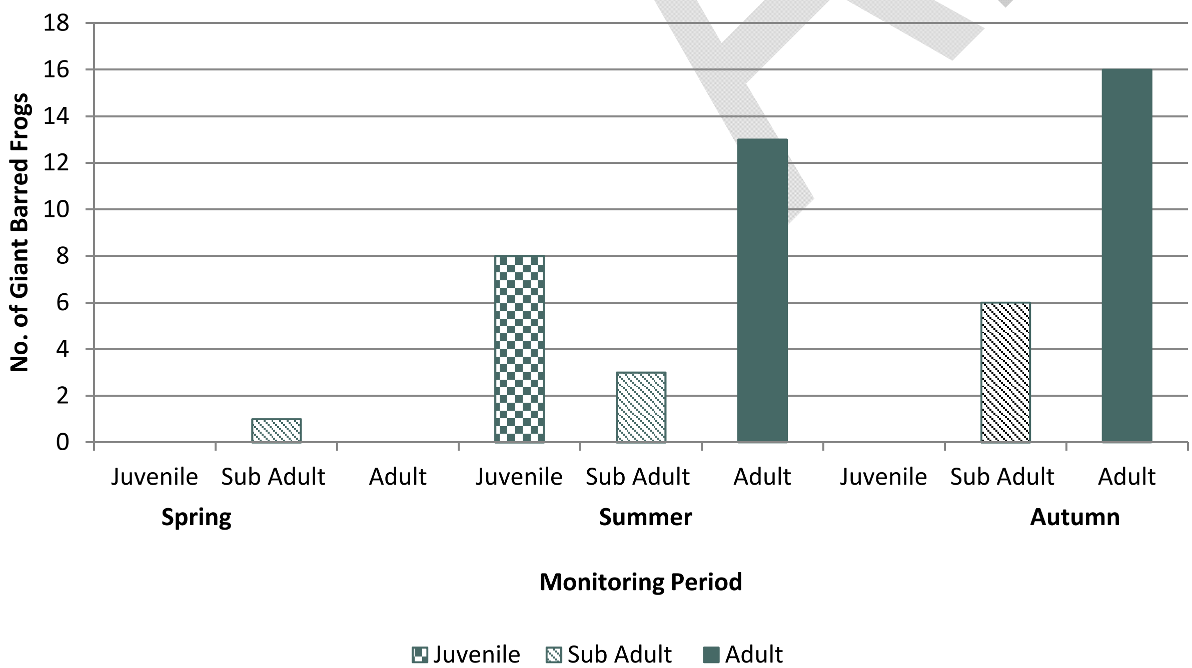


Figure 3-1. Age class structure of Giant Barred Frog across the three monitoring periods.

3.2.2 Calculating Population Size

The two samples collected during the summer and autumn monitoring have been used to calculate population size. The summer monitoring recorded 24 frogs, however, three of the male frogs could not be captured and were consequently removed from the population estimate (i.e. they weren't PIT tagged to confidently identify them as new or recaptured individuals). The autumn monitoring recorded 22 frogs with one frog avoiding capture and thus leaving 21 frogs. Five of the 21 captured frogs were recaptures from the summer sampling. Using the Lincoln–Peterson estimator for all frogs captured and PIT tagged the population has been calculated as follows:

- Population Estimate = 79.7 Giant Barred Frogs
- Standard Error = 22.17
- 95% confidence interval = 46.2

If this were to be divided proportionally between the recorded age classes then the population would be estimated to comprise:

- 16 Juveniles;
- 19 sub adults; and
- 45 adults with a male to female sex ratio of approximately 1:1.

The use of the adult population estimate may be more applicable given the subject animal is an *R* selected species which produces large numbers of offspring with a low probability of surviving to adulthood. Using the Lincoln–Peterson estimator for all adult frogs captured and PIT tagged the population has been calculated as follows:

- Population Estimate = 43 adult Giant Barred Frogs
- Standard Error = 13.59
- 95% confidence interval = 43 ± 26.6

3.3 Presence of Chytrid Fungus

One of the 17 frogs returned a positive test for the presence of chytrid fungus (*Batrachochytrium dendrobatidis*). The test was not conclusive across all three replicates but rather just one of the three (Table A4 in Appendix). This frog (ID:07359051) was recorded from the northern bank in Zone 8 which forms part of the proposed construction zone (Figure 2-1).

3.4. Habitat Use

3.4.1 Frog Distribution Along the Transect

Giant Barred Frogs were recorded between survey zones 2 through to 20 and occupied 14 (70%) of the 20 zones (Figures 2-1 and 3-2). Ten frogs were recorded below the construction footprint whilst 11 were recorded above it (Figure 3-3). Twenty-one frogs were recorded within the construction footprint with another six recorded from zones that may occur partially within the footprint depending on the final clearing footprint (Figure 3-3).

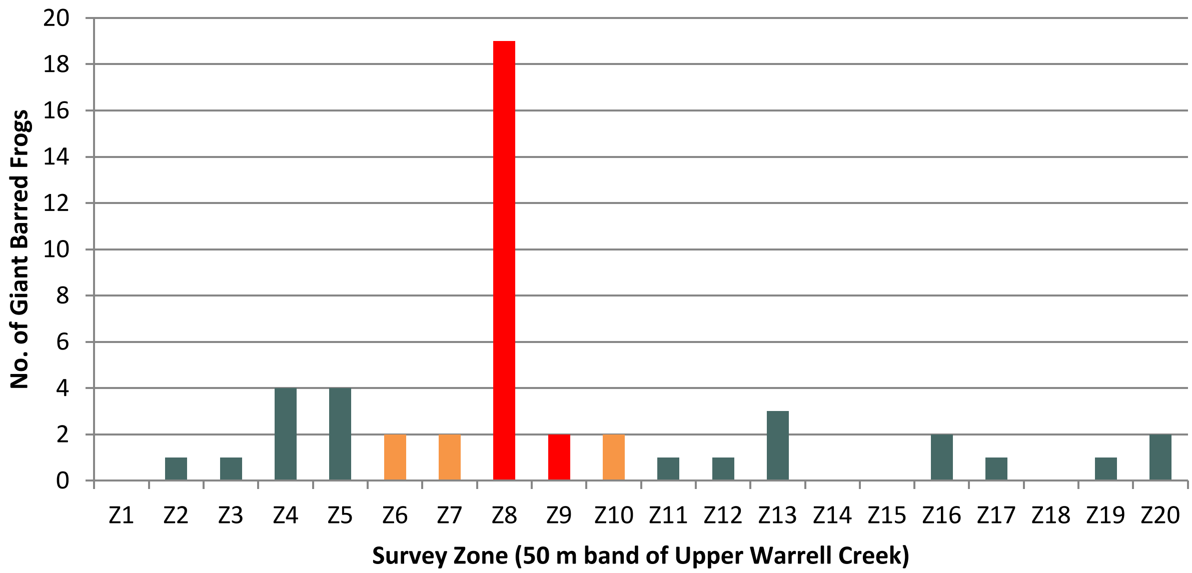


Figure 3-2. Cumulative number of frogs recorded in each of the monitoring zones.

Figure 3-3. Cumulative number of frogs recorded in each of the monitoring zones.

3.4.2 How the Frogs are using the Existing Habitat

The mean distance frogs were recorded from the stream edge ranged from 1.1 m in spring (n=1) to 5.9 m in autumn (n=22, SE = 3.51; Figure 3-4). Eight frogs were recorded at distances of 10-22 m from the stream edge with 75% of these being adults comprising two males and four females. The two remaining frogs were sub adults observed at 10 and 11.5 m from the stream edge.

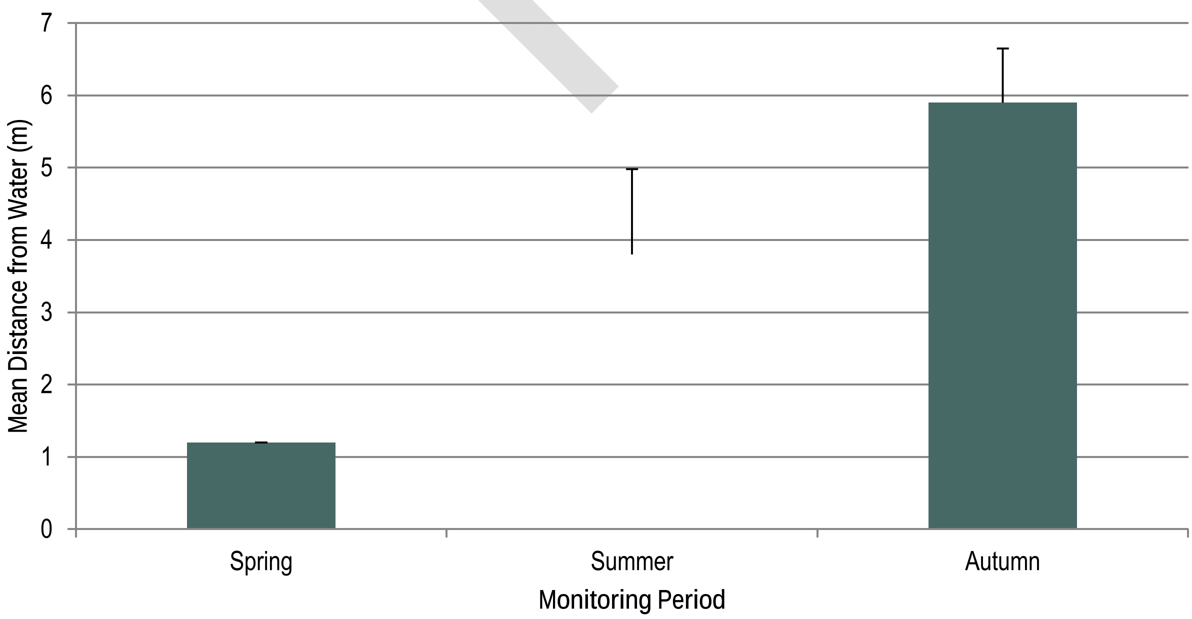


Figure 3-4. Mean distance (+SE) from water during each of the three monitoring periods.

3.4.3 Recaptured Frogs

Three of the five recaptured frogs remained in the same zone between the summer and autumn sampling (Table A3 in Appendix). The two remaining frogs, an adult male with moderate and dark nuptials moved between Zone 5 and 8 or about 120 m whilst a sub adult frog had moved from Zone 10 down to Zone 8 or about 75 m (Figure 2-1). During the two monitoring periods this particular individual (ID:7356782) had grown around 7 mm (14% increase in length) and attained an extra 5.75 grams (38% increase).

3.4.4 Breeding Cues

None of the captured female frogs were noted as being in a gravid condition (egg bearing condition) during each of the surveys. In contrast, all of the captured male frogs displayed some reproductive scoring with two assigned as having 'light' coloured nuptials, seven with 'moderate' coloured nuptials and four with 'dark' coloured nuptials. Individuals from each of the reproductive categories were present during both the summer and autumn monitoring events. No adults were captured during the spring monitoring.

No tadpoles were captured during the survey. All three monitoring events recorded data that suggests the Giant barred Frog population is breeding within the monitoring transect. This includes:

- One sub adult during the spring survey and represents the first time the population is producing offspring;
- Eight juveniles and two sub adults during the summer survey; and
- Six sub adults during the autumn survey.

This data would suggest that metamorphosis for most of the juvenile frogs occurred sometime between November and December with some extending through into early January. There was some clustering of juvenile captures and these were associated with the back channels bordering the southern bank of Zone 9 and Zone 18.

3.5 Habitat Condition

3.5.1 General Land Use and Broad Classification Type

The habitat data collected has characterised the site as being located predominantly within degraded agricultural land with the southern bank being entirely used as a beef cattle farming enterprise using set stocking principals (i.e. no rest period and constant herbivory pressure). The northern bank contains a mosaic of land uses with dairy cattle farming extending between Zone 14 upstream to Zone 21. This type of farming differs from that on the southern bank whereby the existing pastures are periodically intensely grazed and then left to recover leading to a dense sword of introduced grasses with native herbs and annuals growing in those periodically inundated areas. Below this point and up until Zone 11 the area is undisturbed closed forest classified here as riparian rainforest but also consistent with other vegetation classifications that may describe it as wet sclerophyll forest. Zones 8-10 are also riparian rainforest but with some minor disturbances associated with an access track to an irrigation pump. Below this point in Zones 5-7 there is a disturbed area which may have historically been grazed by cattle and be left to passively regenerate. Some periodic maintenance of taller trees tends to occur in this area with a powerline easement running east-west. Below this point, Zones 1-4 tend to be remnant vegetation again describe here as riparian rainforest or wet sclerophyll forest.

Compositionally, the southern bank is comprised of 37% as cleared land and 63% as disturbed riparian rainforest whilst the northern bank is comprised of 25% cleared land, 25% as disturbed riparian rainforest and 50% as undisturbed riparian rainforest.

3.5.2 Characteristics of the Riparian Terrestrial Zone

The vegetation on top of the primary or main stream bank is patchy distributed along the transect with some notable gaps between Zones 14-18 on the northern bank and Zones 0, 10-11 and 18-21 on the southern bank. An estimate of overstorey cover across the entire site was calculated at 50.4% but with marked variation calculated here with a standard deviation of 33.8%. With regard to the four management zones, overstorey vegetation cover was highest below the construction footprint (mean=62%; SD=25.4%) and at its lowest above the construction footprint (mean=43%; SD=37.8%). This was the same for shrub cover with the range varying from 13.2% (SD=8.1%) below the construction footprint to 6% (SD=6.38) cover above the construction footprint. The mean groundcover across the entire transect was calculated at 54.3% (SD=33.7%) with this large variation attributed to variable tree cover with exposed tree less areas supporting higher levels of groundcover comprised often as improved pasture grasses.

The extent of litter cover was calculated at 33% (SD=29.6%) across the site but this varied between 24% (SD=24.1%) above the construction footprint to 47.8% (SD=30.8%) or almost twice that below the construction footprint. Apart from the management zone partially within the construction footprint, bare dirt was similar across the transect with a range of 8.5-14% recorded. Typically higher levels were recorded where cattle had accessed areas beneath trees on the primary bank as cattle camps displacing the expected leaf litter. Litter depth itself was calculated as 30% of the site containing no litter at all, 30% containing on shallow areas (0-20mm) of litter, 22.5% as having moderate (20-100 mm) litter and 17.5% as having deep litter (>100 mm) present with a particular zone. Most of the management zones had a range of litter depths (Table 3-3).

The stream bank profile is characterised with 16% of the transect containing steep sided banks, approximately 55% having benched or stepped banks and the remaining 29% being gradual (Table 3-1). Areas upstream and downstream of the construction site exhibit steep sided banks but not within the construction limit nor the partial zones. Some gradual banks were recorded in each of the management zones. All of the stream banks are comprised of a sandy loam soil type typically on lower catchments in the Warrell Creek area.

3.5.3 Physical Stream Characteristics

Upper Warrell Creek was estimated at 8 m width in Zone 20-21 and it becomes gradually wider reaching 18 m before reducing to around 10 m within Zone 9. At this point there is a riffle where the stream reduces to approximately 4 m in width. There are no other riffle zones within the monitoring transect. Beyond this point it quickly reaches and maintains a 20-25 m width for more than 500 m.

Water depth ranges from 1.5 m at Zone 9 to around 3 m through most of the main pools. The upper reaches of the transect were estimated to be around 2 m in depth. The stream bed itself is made up almost exclusively of sandy silts often with a deep detritus layer. The exception is the rifle zone location in Zone 9 which contains some gravel.

Emergent or floating aquatic vegetation is present in virtually all of the zones with the main species being Water Lilly (*Nymphaea spp*), Knotweeds (*Persicaria spp*) and Common Spikerush (*Eleocharis sphacelata*). This later species is limited to the upper reaches of the transect and was recorded in Zones 18-21.

The exotic Mosquito Fish (*Gambusia holbrooki*) was recorded throughout the site. Greater numbers were generally dip-netted around dense aquatic vegetation.

3.5.4 Water Quality Monitoring

The water quality monitoring collected on the 29th January, 18th and 25th February is summarised in Table 3-2. None of the concentrations for the eight heavy metals and 13 Hydrocarbons were recorded at levels exceeding the ANZECC Freshwater Trigger Value. Nitrogen exceeded the trigger value for a lowland rivers in south eastern Australia with mean value of 0.53 mg/L (SD=0.13) although this figure was below 0.5 mg/L during the wet monitoring period. Dissolved oxygen consistently exceed the trigger value for a lowland rivers in south eastern Australia with 2.26-2.55 mg/L recorded across the four management zones and an overall site value of 2.42 mg/L (SD=1.12). The remaining physio chemical data were within the recommended values.

Table 3-2. Summary of the measured habitat attributes across the entire site and at four different management zones.

Attributes/Site	Entire Site	Below	Partially	Construction	Above
Landuse					
Type of existing landuse present	• Natural – North Bank: 41% South Bank: 0% • Natural regeneration from past disturbance – North Bank: 18% South Bank: 0% • Farming (Dairy) – North Bank: 41% South Bank: 0% • Farming (Beef) – North Bank: 0% South Bank: 100%	• Natural regeneration from past disturbance - Northern Bank: Zones 0-5 Southern Bank: Nil • Farming (beef) – Northern Bank: Nil Southern Bank: Zones 0-5	• Natural Forest- Northern Bank: Zone 10 Southern Bank: Nil • Natural but regeneration from past disturbance Northern Bank: Zones 6-7 Southern Bank: Nil • Farming (beef) – Northern Bank: Nil Southern bank: Zones 6,7&10	• Natural but regeneration from past disturbance Northern Bank: Zones 8-9 Southern Bank: Nil • Farming (beef) – Northern Bank: Nil Southern Bank: Zones 8-9	• Natural – Northern Bank: Zones 11-13 Southern Bank: Nil • Farming (beef) – Northern Bank: Nil Southern Bank: Zones 11-21 • Farming (Dairy) – Northern Bank: Zones 14-21) Southern Bank: Nil
Broad Vegetation Type	• Riparian Rainforest (undisturbed) – Northern Bank: 50% Southern Bank: 0% • Riparian Rainforest (disturbed) – Northern Bank: 25% Southern Bank: 63% • Cleared Land – Northern Bank: 25% Southern Bank: 37%	• Riparian Rainforest (undisturbed) – Northern Bank: Zones 1-5 Southern Bank: Nil • Riparian Rainforest (disturbed) – Northern Bank: Nil Southern Bank: Zones 1-5 • Cleared Land – Northern Bank: Nil Southern Bank: Zone 0	• Riparian Rainforest (undisturbed) – Northern Bank: Zone 10 Southern Bank: Nil • Riparian Rainforest (disturbed) – Northern Bank: Zones 6-7 Southern Bank: Zones 6-7 • Cleared Land – Northern Bank: Nil Southern Bank: Zone 10	• Riparian Rainforest (disturbed) – Northern Bank: Zone 8 Southern Bank: Zones 8-9 • Cleared Land – Northern Bank: Zone 9 Southern Bank: Nil	• Riparian Rainforest (undisturbed) – Northern Bank: Zones 11-13 Southern Bank: Nil • Riparian Rainforest (disturbed) – Northern Bank: Zones 19-21 Southern Bank: Zones 12-18 • Cleared Land – Northern Bank: Zones 14-18 Southern Bank: Zones 11&19-21

Attributes/Site	Entire Site	Below	Partially	Construction	Above
Riparian Terrestrial Zone					
Vegetation					
Overstorey	50.4 (33.8)	62.1 (25.4)	55.2 (36.0)	48.8 (28.7)	43 (37.8)
Shrub Cover	8.7 (7.5)	13.2 (8.1)	11.2 (7.7)	7.5 (5.6)	6 (6.38)
Groundcover	54.3 (33.7)	39.3 (33.0)	48 (38.6)	64 (34.9)	62 (31.6)
Litter Cover	33 (29.6)	47.8 (30.8)	43.5 (38.4)	24.5 (26.7)	24 (24.1)
Soil Cover	12.8 (10.4)	12.8 (9.9)	8.5 (6.1)	11.5 (8.4)	14 (12.0)
Rock	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Litter Depth	Absent = 30% Shallow =30% Moderate =22.5% Deep = 17.5% Sample Size = 40	Absent = 16.7% Shallow =25% Moderate =16.7% Deep = 41.6% Sample Size =12	Absent = 33.3% Shallow =0% Moderate =33.3% Deep =33.3% Sample Size =6	Absent = 25% Shallow =50% Moderate =25% Deep = % Sample Size = 4	Absent = 36.4% Shallow =31.8% Moderate =18.2% Deep = 13.6% Sample Size = 22
Stream Bank Profile	• Steep: North: 32% South: 0% • Benched: North: 27% South: 82% • Gradual: North: 41% South: 18%	• Steep: North: Zones 0-3 South: Nil • Benched: North: Zone 5 South: Zones 1-5 • Gradual: North: Zones 4 South: Zone 0	• Steep: North: Nil South: Nil • Benched: North: Zone 7 South: Zones 6-7 • Gradual: North: Zones 6,10 South: Zone 10	• Steep: North: Nil South: Nil • Benched: North: Zone 9 South: Zone 8 • Gradual: North: Zone 8 South: Zone 9	• Steep: North: Zones 12,19&20 South: nil • Benched: North: Zones 11,13&21 South: Zones 12-21 • Gradual: North: Zones 14-18 South: Zone 11
Stream Bank Composition	Sandy soil - loam	Sandy soil - loam	Sandy soil - loam	Sandy soil - loam	Sandy soil - loam
Stream Characteristics					
Structure	Two long pools with one small rifle zone at Zone 9	One long pool	One long pool	Convergence of two pools with a small riffle	One long pool
Width (m)	8-25 (m=16.6; SD=5.8)	20-25 (m=24.1; SD=1.9)	16-20 (m=18.1; SD=1.8)	10-12 (m=11; SD=1.2)	8-18 (m=13.2; SD=3)
Depth (m)	1.5-3 (m=3; SD=0)	3 (m=3; SD=0)	3 (m=3; SD=0)	1.5-1.8 (m=1.7; SD=0.2)	1.5-3 (m=2.2; SD=0.5)
Substrate	Sandy soil loam with deep detritus layer. Gravel limited to rifle zone within construction footprint	Sandy soil loam with deep detritus layer.	Sandy soil loam with deep detritus layer.	Sandy soil loam with deep detritus layer. Riffle has some gravel.	Sandy soil loam with deep detritus layer.

Attributes/Site	Entire Site	Below	Partially	Construction	Above
Types of Emergent Aquatic Vegetation	Water Lilly (*Nymphaea spp*), Knotweed (*Persicaria spp*) and Common Spikerush (*Eleocharis sphacelata*)	water Lilly (*Nymphaea spp*)	Knotweed (*Persicaria spp*) and Water Lilly (*Nymphaea spp*) + *Cyperus spp*	Knotweed (*Persicaria spp*) and Water Lilly (*Nymphaea spp*) + *Cyperus spp*	Water Lilly (*Nymphaea spp*), Knotweed (*Persicaria spp*) and Common Spikerush (*Eleocharis sphacelata*)
Non-native Fish					
Mosquito Fish (*Gambusia holbrooki*)	Present	Present	Present	Present	Present
Water Quality					
Heavy Metals					
Arsenic	0.104 (0.0005)	0.002 (0)	0.0017 (0)	0.0017 (0)	0.0015 (0.0005)
Cadmium	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	<0.001	<0.001	<0.001	<0.001	<0.001
Lead	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	<0.005	<0.005	<0.005	<0.005	<0.005
Hydrocarbons					
Naphthalene	<0.02	<0.02	<0.02	<0.02	<0.02
TRH>C10-C16	<0.05	<0.05	<0.05	<0.05	<0.05
TRH>C10-C16 less Naphthalene (F2)	<0.05	<0.05	<0.05	<0.05	<0.05
TRH>C16-C34	0.82 (0.3)	0.15 (0.1)	0.15 (0.1)	0.15 (0.1)	0.15 (0.1)
TRH>34-C40	<0.1	<0.1	<0.1	<0.1	<0.1
TRH C6-C10	<0.02	<0.02	<0.02	<0.02	<0.02
TRH C6-C10 LESS BTEX (F1)	<0.02	<0.02	<0.02	<0.02	<0.02
BTEX group					
Benzene	<0.001	<0.001	<0.001	<0.001	<0.001
Ethylbenzene	<0.001	<0.001	<0.001	<0.001	<0.001
m&p-Xylenes	<0.002	<0.002	<0.002	<0.002	<0.002
o-Xylene	<0.001	<0.001	<0.001	<0.001	<0.001
Toluene	<0.001	<0.001	<0.001	<0.001	<0.001
Xylenes – total	<0.003	<0.003	<0.003	<0.003	<0.003
Nutrients					

Attributes/Site	Entire Site	Below	Partially	Construction	Above
Nitrogen (as N)	0.53 (0.13)	0.51 (0.14)	0.51 (0.14)	0.51 (0.15)	0.539 (0.11)
Suspended Solids	7.52 (5.57)	7.18 (0.78)	7.25 (0.75)	7.25 (0.87)	11.61 (8.45)
Total Phosphorus	0.029 (0.016)	0.03 (0.01)	0.03 (0.01)	0.03 (0.01)	0.041 (0.013)
Field Physio-chemical Data					
Dissolved Oxygen	2.42 (1.12)	2.26 (0.29)	2.28 (0.29)	2.28 (0.32)	2.55 (1.56)
Conductivity	228.23 (13.83)	227.38 (15.24)	226.57 (14.75)	226.57 (16.16)	229.90 (12.58)
pH	6.50 (0.29)	6.58 (0.14)	6.57 (0.14)	6.57 (0.15)	6.42 (0.37)
Temperature	24.38 (0.34)	24.32 (0.30)	24.30 (0.29)	24.30 (0.32)	24.46 (0.37)
Turbidity	8.80 (4.38)	9.20 (3.91)	9.13 (3.70)	9.13 (4.05)	8.46 (4.97)

4.0 DISCUSSION

Pre-construction baseline monitoring has shown that Giant Barred Frogs continue to inhabit Upper Warrell Creek within and adjacent to the proposed construction footprint. Monitoring surveys performed during spring 2013 confirmed the population breeds at this location and subsequent surveys confirm at least two cohorts of offspring were present during the summer survey with both juvenile and sub adult frogs present. The autumn sampling found only sub adult frogs present in the population and based on recorded growth rates of juvenile frogs it is likely that tadpoles began metamorphosis between late spring through to about late December.

The influence of environmental variables on the recording rate of frogs is thought to be more influenced by a combination of both rainfall leading up to the survey and the prevailing temperature at the time of the survey. Both the summer and autumn surveys were performed at a time when the site had received more than 30 mm of rainfall in the past 7 days and combined with mild temperatures this contributed to the capture of relatively high numbers of frogs. It is thought that temperature tends to have less of an influence provided an adequate amount of rainfall has fallen at the site within 7 days of performing the survey (B. Lewis unpub data). This is exemplified by the cold summer night in January when temperatures were just 14.5°C at 0245 hours but frogs were still active and above the leaf litter. In contrast, the spring survey was performed during a period of reduced rainfall which resulted in far fewer frogs being detected during similar mild temperatures. Surveys performed around the same time between Port Macquarie and Kempsey tended not to show this marked affect with the number of captured frogs being similar between spring and summer and individuals, particularly female adults being active at temperatures down to around 10°C (Lewis 2014).

The study performed by Koch and Hero (2007) on the Giant Barred Frog suggested greater survey efficiencies when temperatures were above 18°C, but individuals in different age-sex classes can have different responses and other factors also influence the activity of individual frogs on any given night. Similar studies have also found that environmental variables alone did not explain the majority of the variation in amphibian density (Salvador and Carrascal 1990; Ovaska 1991; Fukuyama *et al*. 1998; Brown and Shine 2002). These additional factors, which influence how easily they are detected, may include differences in the actual density and behaviour between the difference age-sex classes. To address this, the Warrell Creek to Urunga Giant Barred Frog management strategy proposed monitoring to occur at three seasonal time scales within the recognised period of activity (September-May) and that monitoring must take into account other environmental variables of which we have identified rainfall (>10 mm in past 7 days).

The population estimate has shown there is likely to be around 43 (±26.6) adults present along the 1 km transect. Given the recorded sex ratio, the population is likely to comprise an equal number of male and females. If we use this as the baseline data set for determining a decline in the population then we must remember that the results from these surveys are only a snap shot in time and reflects a sample from the population during a period of below average rainfall and where no breeding is likely to have taken place in the 2013/14 season given no flood events occurred. In contrast, the previous 2012/13 season produced several flood events which enabled frogs to breed at this site and as a result the population size estimated here (43 ±26.6 adults) may be slightly higher than normal.

The capture data showed a relatively continuous distribution of frogs across the 20 zones with this peaking within the construction footprint of Zone 8. Although most of the frogs from this zone were recorded from a back channel area which lies adjacent to the bridge and associated earthworks for the service road, it highlights the importance of temporary frog fencing during the construction of the project. The fact that frogs are seldom more than 10 m from the edge of the stream indicates they are less likely to access the service road. This may increase in response to increased planting of vegetation to improve habitat quality in the area as frogs were up to 22 m from the water's edge in areas where the forest was undisturbed. The distance frogs tend to be from the water edge is often linked to the amount of prevailing rainfall with frogs moving further from the stream edge during flood events but this does not normally exceed 50 m (Streatfeild 1999; Lemckert and Brassil 2000). The recorded frog movements during this baseline survey show that frogs move within and out of the proposed construction zone with individuals moving up to three zones within a relatively short amount of time (i.e. ~70 days). These movements imply that any prescribed relocation of individuals over relatively small distances (i.e. <60 m) is likely to result in individuals still remaining within their maternal home range. This is consistent with the findings of Lemckert and Brassil (2000) who reported nightly movements from 0 m to over 100 m, but all were within a 20 m wide band either side of the stream.

No tadpoles were recorded during the field sampling of the survey zones (1-20) with sampling being conducted in spring and again in autumn. This has been attributed to the difficulties of sampling the site where the open areas are often deep (>1.5 m) and inaccessible or contain dense aquatic vegetation in the shallower reaches (i.e. <1 m). Therefore, tadpole sampling may be of limited value. Based on the presence of multiple juvenile frogs around the back channels which support dense aquatic vegetation these areas are likely to be important for tadpoles to avoid predation. Given the proximity of one of these areas on the southern bank of Zone 8 it will be important for site controls such as temporary frog fencing to be installed and rigorously maintained.

The detection of Chytrid fungus from one frog in only one of the replicates indicates that Chytrid may be present in the population. This finding is consistent with sampling from some other populations between Port Macquarie and Kempsey performed at the same time (Lewis 2014).The management of Chytrid at this location will help to prevent the inadvertent spread of it to other locations along the construction corridor.

The habitat data showed no consistent pattern with the capture of frogs with both adults, sub adults and juveniles being captured across the broad land use and forest types. What is clear from the habitat data is that the southern bank is comprised of either cleared land or disturbed riparian rainforest as a result of ongoing cattle grazing and any impacts associated with the new bridge could easily be offset with the exclusion of cattle to reduce disturbance of leaf litter fall and some assisted rehabilitation of the creek banks riparian vegetation. The effects of agriculture are also evident in the water quality data with total nitrogen being recorded at elevated levels during the sampling period.

5.0 RECOMMENDATIONS

Based on the results obtained during the survey the following recommendations have been proposed:

1) RMS explore opportunities to improve habitat condition during the early stages of the project. This could include:
    a. The removal of livestock from those areas now owned by the RMS;
    b. Following the removal of livestock some assisted planting of locally occurring native riparian trees (i.e. Overstorey and mi stratum type species including Water Gum *Tristaniopsis laurina,* Watrehousia *Waterhousea floribunda,* Lillypilly *Acmena smithii* and some sparse groundcover plants including Matrush *Lomandra longifolia*) be undertaken. Performing this task early on will allow some measurable gain of habitat condition during the Giant Barred Frog monitoring period.
2) Water quality data continue to be collected at SW1 (Browns Crossing Road Bridge) and SW2 (Zone 8) ensuring sampling is undertaken during both dry and wet weather events.
3) Temporary frog fencing is installed at least 5 days before construction works take place within 50 m of the creek and a series of pre-clearance survey performed in accordance with the approved Giant Barred Frog management strategy to ensure no frogs remain within the construction footprint.

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7.0 APPENDIX – FIELD SURVEY DATA

Table A1. Rainfall data between June 2013 and April 2014 from weather station 059018 (Macksville Country Club. Source: www.bom.nsw.gov.au. Green shading = rainfall trigger event; Red shading = field survey date; Blue shading is water quality monitoring data. Days refer to cumulative data collected over longer periods.

Date/Month	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1st	0	6.6	0	0	0	0	0	0	0	17.6	3.2
2nd	↓	8	0	0	0	0	4.4	0	0	17.2	0
3rd	3.02 days	1.2	0	0	0	0	0	0	0	6.2	0
4th	0	0	0	0	0	0	0	0	0	0	0
5th	0	0	0	0	0	0	2.2	0	15.2	0	0
6th	0	0	0	0	0	0	0	0	1.4	0	0
7th	0	0	0	0	0	0	0	0	0	0	33
8th	0	0	0	0	0	0	0	9.8	0	0.6	0
9th	0	0	0	0	0	0	0	0.6	0	0	0
10th	0	0	0	0	0	↓	2	7.6	0	0	0
11th	3.6	1	0	0	0	31.72 days	0	0.8	0	14.2	0
12th	1	1.6	0	0	0	34.2	0	0	0	0	0
13th	14.8	0	0	0	0	18.2	0	0	1.8	0	0
14th	0	0	0	4.4	0	5	↓	5	9.8	0	0
15th	0	0	0	0	0	0	↓	1.8	0	0	0
16th	0	0	0	1.1	0	↓	5.03 days	0	0	0	0
17th	0	0	0	10.8	0	↓	0.8	0	48	8.2	0
18th	0	0	0	2	1.8	10.03 days	0	0	0.4	0	0
19th	0	0	0	0	22.4	3.2	0	0	0	0	0
20th	0	↓	0	0	0	0	0	0	0.4	0	0
21st	0	↓	0	0	0	0	0	0	42.8	7.8	0
22nd	0	15.03 days	0	0	0	0	0	22.6	0	0	0
23rd	0	0	0	0	0	8.6	0	8.6	0	0	0
24th	0	0	0	0	0	13.6	0	0	0	0	0
25th	0	0	0	0	0	0	↓	0	6.6	9.4	0
26th	0	0	0	0	0	31.2	↓	0	0	0	↓
27th	↓	0	0	0	0	0	15.43 days	0	0	0	↓
28th	33.42 days	↓	0	0	0	0	0	0	0	20.6	22.03 days
29th	↓	1.22 days	0	0	0	0	0	0		0	0
30th	11.12 days	0	0	0	3.4	32.6	0	0		7.2	0
31st		0	0		0		0	0		0	
Highest Daily	14.8	8	0	10.8	22.4	34.2	4.4	22.6	48	20.6	33
Monthly Total	66.9	34.6	0	18.3	27.6	188.3	29.8	56.8	126.4	109	58.2

Table A2. Minimum air temperature data between June 2013 and April 2014 from weather station 059017 (Wide Street Kempsey 35 km to the south). Days refer to cumulative data collected over longer periods.
Source: www.bom.nsw.gov.au. Red shading = field survey date

Day/Month	June	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1st	10.8	13	13	9.9	12.5	10.5	13.6	17.4	14.7	19.8	18.5
2nd	14	14	6.4	9.6	15.6	12.4	13.3	20.8	16.4	19.1	18.4
3rd	13.4	8.8	6.2	10.5	11.3	14.3	12.6	21.7	15.9	18.4	17.6
4th	7.7	7.5	4.5	8.9	11	14.2	12.8	22.1	16	17.8	16.8
5th	8.9	7	4.2	7.4	8	11.8	19	20.7		16.7	16.9
6th	11.1	5	3.4	6.9	7.6	10.5	12.3	18.4	16.4	16.3	19.3
7th	13.1	2.5	8		11	10.6	10.4	18.5	16.7	15.6	17.8
8th	12.5	4	6.2	9.62 days	13.2	13.3	11.2	16.9	14.2	16.5	15.7
9th	11.3	4.8	11.8	17.9	8.9	14.9	14.7	17.7	16	16.2	16.4
10th	10.8	8.7	7.4	12.5	9.4	19.4	21	17.6	15.6	17.9	17
11th	9.5	9.4	6.8	12.3	13	16.5	16.9	18	16.1	16.6	16.5
12th	12.7	7	8.9	9.6	17.4	17.4	19.2	16.5	17.4	16.1	17.4
13th	12.2	7.3	5.1	11	15.9	15.1	17.7	17.4	21.9	16.9	14.5
14th	11.2	7.8	5.9	11.5	17.8	16.2	18	17.6	20.2	17	16.3
15th	5.5	8	5	11.7	8.2	16.3	18.2	16.9	20.2	16	14.6
16th	6.6	10	3.5	15.2	8.6	15.3	19	17.5	21.5	17.6	13.8
17th	6.5	9.3	6.7	13.4	10.6	13.2	16	18.3	19.7	15.3	12.7
18th	5	9	4.6	9.6	14.1	13.2	14.9	17	20	15.2	12
19th	4.4	10.3	3	8.9	11.4	14.5	15.6	16.6	20.6	15.7	11.5
20th	8.9	13.9	8.2	8.5	13.2	14.8	14.2	17.7	23	19.3	13.5
21st	8.4	4.5	0.6	6.7	14	14.6	15.8	20.9	22.1	19.4	13.2
22nd	6.6	8.3	1.4	8	14.5	18	16.7	22.5	20.5	16.4	14.8
23rd	5.9	2.8	1.8	9.5	14.7	18.5	18	20.6	19.7	17.3	15.2
24th	7.5	4	6.7	12	19.9	15.9	20.2	18.9	16.2	16.9	13.6
25th	3	12	7.9	11.8	13	14.7	19.2	20.6	17.9	17.2	12.5
26th	5.3	7.6	6.4	11	11.4	14	20.6	18.6	16.2	17	12.9
27th	10.7	6.7	10	7.6	11.6	13.8	17.2	16.8	18.5	19.7	17.2
28th	12.5	8.2	7.9	10.7	13.5	11.9	19.9	17.9	20.2	18.5	16.3
29th	11.2	9.7	9	7.7	14.5	16.6	17.8	15.9		17	13
30th	11	11.5	11	9.2	16.1	16.4	15.2	15.4		18.5	12.8
31st		9.1	12		9.2		15.8	15.6		18.9	
Highest daily	14	14	13	17.9	19.9	19.4	21	22.5	23	19.8	19.3
Lowest daily	3	2.5	0.6	6.7	7.6	10.5	10.4	15.4	14.2	15.2	11.5

Table A3. Raw data for the frog surveys during each survey period.
Bold type denote recaptured frog.

Survey Period	Date	Sex	Age Class	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Amended Zone	Relevance to Construction Footprint	Side of Creek	Distance to water	Activity	Microhabitat	Chytrid Swab	Notes
Spring	20.9.2013	Unknown	Sub Adult		50.7	19.0	735ADA8	C3	10	Partially Within	North	1.2	Observed	Above Litter	No	Captured around 10 m from the original capture site in Lewis 2012.
Summer	29.1.2014	Unknown	Sub adult	-	41.4	9.5	7356782	C1	8	Construction Footprint	SOUTH	2.5	Observed	Above Litter	Yes	
Summer	29.1.2014	Female	Adult	Not Gravid	70.3	46	7352C35	C1	8	Construction Footprint	NORTH	10	Observed	Above Litter	Yes	
Summer	29.1.2014	Female	Adult	Not Gravid	67.9	45.5	7359051	C1	8	Construction Footprint	NORTH	0.1	Observed	Partially buried UL	Yes	
Summer	29.1.2014	Unknown	Sub adult	-	41.3	11	735D187	C2	12	Construction Footprint	NORTH	3.5	Observed	Above Litter	No	
Summer	29.1.2014	Unknown	Juvenile	-	31.8	5	7354569	D2	2	Downstream	SOUTH	0.1	Observed	On dirt	No	
Summer	29.1.2014	Male	Adult	no data	no data	no data	no data	D3	3	Downstream	SOUTH	1	Heard	Under Litter	No	Frog could not be captured
Summer	29.1.2014	Male	Adult	no data	no data	no data	no data	D4	4	Downstream	NORTH	2	Heard	Under Litter	No	Frog could not be captured
Summer	29.1.2014	Male	Adult	no data	no data	no data	no data	D4	4	Downstream	NORTH	4	Heard	Under Litter	No	Frog could not be captured
Summer	29.1.2014	Unknown	Juvenile	-	35.1	6.75	735ABA3	D8	8	Construction Footprint	SOUTH	3	Observed	Above Litter	Yes	
Summer	29.1.2014	Unknown	Juvenile	-	34.7	6.75	735C8FA	D8	8	Construction Footprint	SOUTH	0.3	Observed	Above Litter	Yes	
Summer	29.1.2014	Unknown	Juvenile	-	37.3	9.75	7358816	D8	8	Construction Footprint	SOUTH	0.1	Observed	Above Litter	Yes	
Summer	29.1.2014	Unknown	Juvenile	-	36.3	8	735B63D	D8	8	Construction Footprint	SOUTH	0.1	Observed	On dirt	Yes	
Summer	29.1.2014	Unknown	Juvenile	-	39.7	10	7358320	D8	8	Construction Footprint	NORTH	1.5	Observed	Above Litter	No	
Summer	29.1.2014	Male	Adult	Dark	69	44.5	7357C02	D8	8	Construction Footprint	SOUTH	1.2	Observed	Above Litter	yes	Associated with back channel where several juvenile frogs
Summer	29.1.2014	Male	Adult	Dark	71.8	51.75	7357E40	D8	8	Construction Footprint	SOUTH	1.2	Observed	On Grass	Yes	
Summer	29.1.2014	Female	Adult	Not Gravid	90.5	132	7358A4D	D8	8	Construction	SOUTH	1.4	Observed	On Grass	Yes	

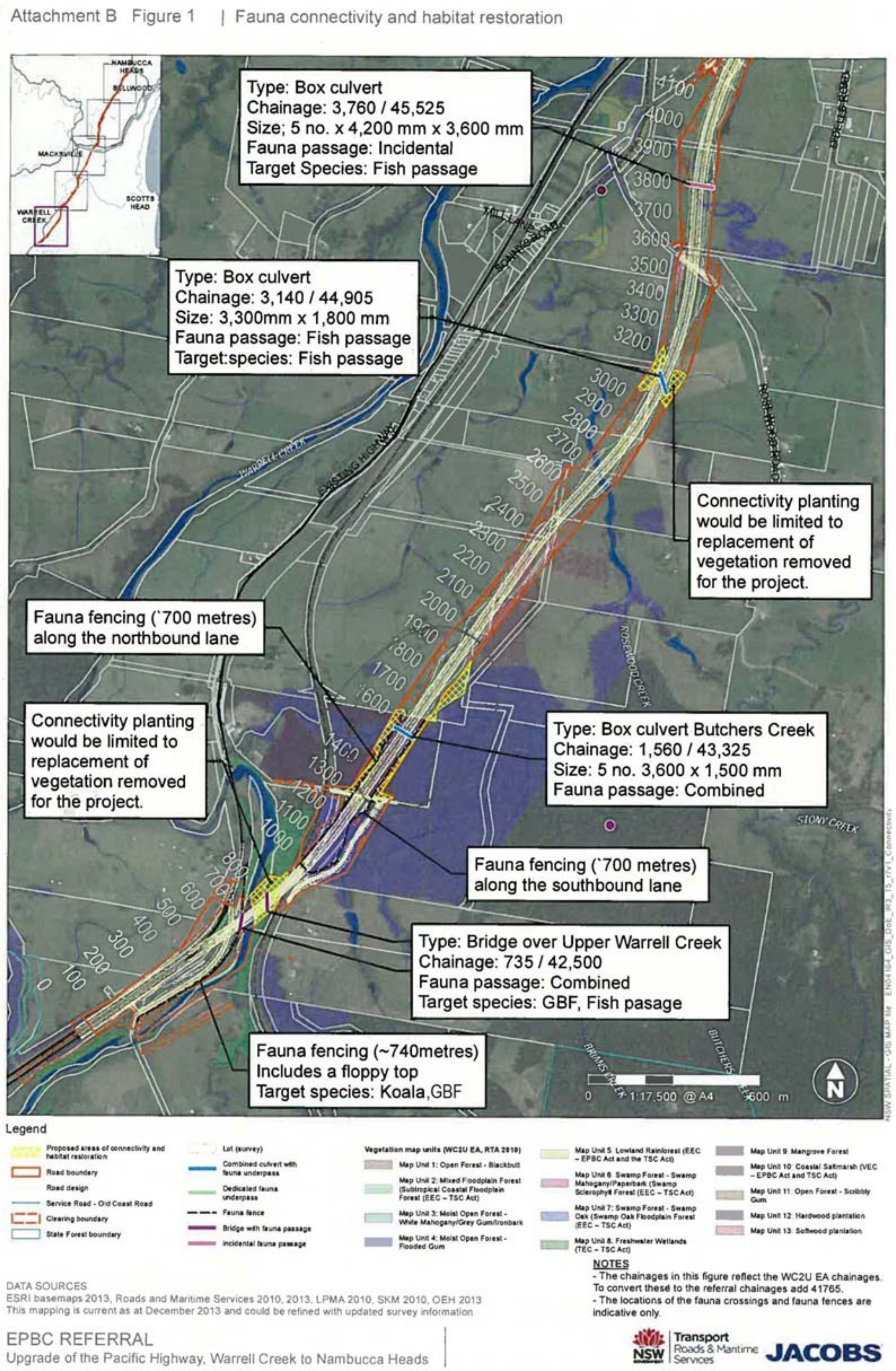
Survey Period	Date	Sex	Age Class	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Amended Zone	Relevance to Construction Footprint	Side of Creek	Distance to water	Activity	Microhabitat	Chytrid Swab	Notes
										Footprint						
Summer	29.1.2014	Female	Adult	Not Gravid	85.6	97.5	735AFF6	D8	8	Construction Footprint	SOUTH	1	Observed	Above Litter	Yes	
Summer	29.1.2014	Unknown	Juvenile	-	29.9	5.5	TOO SMALL	U1	13	Upstream	NORTH	2	Observed	On dirt	No	22 m from main channel but using side creek where 2 m from water
Summer	29.1.2014	Female	Adult	Not Gravid	79.3	64	73542F8	U1	13	Upstream	NORTH	22	Observed	Above Litter	Yes	
Summer	29.1.2014	Unknown	Juvenile	-	37	7.25	735339E	U5	16	Upstream	SOUTH	0.5	Observed	On Flood Debris	Yes	On bank associated with back channel
Summer	29.1.2014	Male	Adult	Dark	66.9	36.5	735B207	U5	16	Upstream	SOUTH	0.1	Observed	On dirt	Yes	On bare bank area at waters edge
Summer	29.1.2014	Male	Adult	Light	71.2	48.25	735BEA5	U6	17	Upstream	SOUTH	17	Observed	Above Litter	Yes	On Bank of back channel which is dry except for one small pond surrounded with Persicaria
Summer	29.1.2014	Male	Adult	Moderate	71.5	50.5	7352E8E	U7	19	Upstream	SOUTH	13	Observed	On Pasture Grass	Yes	On Bank of back channel which is dry except for one small pond surrounded with Persicaria
Summer	29.1.2014	Unknown	Sub adult	-	41	10.5	73542E6	U9	20	Upstream	NORTH	4	Observed	on dirt	No	
Autumn	2.4.2014	Male	Adult	Moderate	71	52	7352A6F	C1	8	Construction Footprint	NORTH	3	Observed	Above Litter	No	
Autumn	2.4.2014	Unknown	Sub Adult		49.8	17.5	735C8FA	C1	8	Construction Footprint	SOUTH	10	Observed	Above litter at base of tree	No	Recapture
Autumn	2.4.2014	Unknown	Sub Adult		47.7	16.25	7359E81	C2	9	Construction Footprint	NORTH	4	Observed	On Dirt	No	
Autumn	2.4.2014	Unknown	Sub Adult		48.5	15.25	7356782	C3	10	Partially Within	SOUTH	7.5	Observed	On dirt	No	Recapture
Autumn	2.4.2014	Female	Adult		67.5	78.8	7352C35	C3	13	Partially Within	NORTH	9	Observed	Above litter at base of tree	No	
Autumn	2.4.2014	Unknown	Sub Adult		44.7	13.25	735746C	D4	4	Downstream	SOUTH	3.5	Observed	Above litter	No	

Survey Period	Date	Sex	Age Class	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Amended Zone	Relevance to Construction Footprint	Side of Creek	Distance to water	Activity	Microhabitat	Chytrid Swab	Notes
Autumn	2.4.2014	Unknown	Sub Adult		49.6	17	7354CF6	D4	4	Downstream	NORTH	5	Observed	Above litter	No	
Autumn	2.4.2014	Male	Adult	Light	70.4	44	7353126	D5	5	Downstream	SOUTH	4	Observed	Above litter	No	Male wrestling with Frog 735746C
Autumn	2.4.2014	Male	Adult	Moderate	74.1	52.25	7357C02	D5	5	Downstream	SOUTH	4	Observed	Above litter	No	Recapture. Frog wrestling with Frog 7353126
Autumn	2.4.2014	Female	Adult		91.3	109	73535FD	D5	5	Downstream	SOUTH	8	Observed	Above litter	No	
Autumn	2.4.2014	Female	Adult		83.2	81	73586B8	D5	5	Downstream	SOUTH	5	Observed	Above litter at base of tree	No	
Autumn	2.4.2014	Male	Adult	Moderate	70.7	47.5	7355BE6	D6	6	Partially Within	NORTH	2.2	Observed	On Dirt	No	
Autumn	2.4.2014	Unknown	Sub Adult		50.2	17.5	735B10D	D6	6	Partially Within	SOUTH	11.5	Observed	Above litter	No	Possibly shed PIT tag
Autumn	2.4.2014	Male	Adult	Moderate	68.5	45	735A444	D7	7	Partially Within	SOUTH	1.5	Observed	Above litter	No	
Autumn	2.4.2014	Female	Adult		86.6	91	7359D06	D7	7	Partially Within	SOUTH	8	Observed	Above litter	No	
Autumn	2.4.2014	Male	Adult	Dark	73.5	54	7357E40	D8	8	Construction Footprint	SOUTH	3	Observed	Above litter	No	Recapture
Autumn	2.4.2014	Male	Adult	Moderate	73.4	57	735BE2B	D8	8	Construction Footprint	SOUTH	3	Observed	Above litter	No	
Autumn	2.4.2014	Female	Adult		84.8	90.5	735AFF6	D8	8	Construction Footprint	SOUTH	7.5	Observed	Above litter	No	Recapture
Autumn	2.4.2014	Female	Adult		85.5	87	735C651	D8	8	Construction Footprint	SOUTH	12	Observed	Above litter	No	
Autumn	2.4.2014	Female	Adult		81.7	69	73530F1	D8	8	Construction Footprint	NORTH	13	Observed	On Grass	No	
Autumn	2.4.2014	Male	Adult	Moderate	68.9	42.75	7353B68	U1	11	Upstream	NORTH	3	Observed	Above Litter	No	
Autumn	2.4.2014	Female	Adult		nd	na	ND	U9	20	Upstream	NORTH	2	Observed	On Grass	No	Escaped-avoided capture George!

Table A4. Results of Chytrid testing performed on a subset of individuals captured during the summer monitoring survey.

Frog Number	Date	Species	Animal number	Sex	Rep 1	Rep 2	Rep 3	Mean calculated concentration
1	29/01/2014	*Mixophyes iteratus*	07358A4D	Female	0	0	0	0
2	29/01/2014	*Mixophyes iteratus*	07359051	Female	0	0.058	0	0
3	29/01/2014	*Mixophyes iteratus*	0735AFF6	Female	0	0	0	0
4	29/01/2014	*Mixophyes iteratus*	073542F8	Female	0	0	0	0
5	29/01/2014	*Mixophyes iteratus*	0735ABA3	Juvenile	0	0	0	0
6	29/01/2014	*Mixophyes iteratus*	07358816	Juvenile	0	0	0	0
7	29/01/2014	*Mixophyes iteratus*	0735C8FA	Juvenile	0	0	0	0
8	29/01/2014	*Mixophyes iteratus*	0735339E	Juvenile	0	0	0	0
9	29/01/2014	*Mixophyes iteratus*	0735BEA5	Male	0	0	0	0
10	29/01/2014	*Mixophyes iteratus*	07352E8E	Male	0	0	0	0
11	29/01/2014	*Mixophyes iteratus*	07357E40	Male	0	0	0	0
12	29/01/2014	*Mixophyes iteratus*	07352C35	Male	0	0	0	0
13	29/01/2014	*Mixophyes iteratus*	07357C02	Male	0	0	0	0
14	29/01/2014	*Mixophyes iteratus*	07356782	Sub Adult	0	0	0	0
15	29/01/2014	*Mixophyes iteratus*	0735B63D	Juvenile	0	0	0	0
16	29/01/2014	*Mixophyes iteratus*	07354569	Juvenile	0	0	0	0
17	29/01/2014	*Mixophyes iteratus*	0735B207	Male	0	0	0	0

13.0 Appendix C – Fauna Connectivity and Habitat Restoration



14.0 Appendix D – Weed and Pathogen Plan (AFJV)

See next page.

1.1 Frog Hygiene Protocols

Frog hygiene protocols aim to prevent the spread of amphibian chytrid fungus during the Warrell Creek to Nambucca Heads Pacific Highway Upgrade Project. Indications of this pathogen have to date not been detected within the local frog population. As the pathogen typically exists within water bodies, topsoil and the upper soil profile, this protocol focuses on controlling the potential spread of this pathogen during the "high risk stage" which is defined as being when in contact with the existing natural ground surface within the Giant Barred Frog and Green Thighed Frog hygiene management areas (as defined in Map 1 to Map 3 of this protocol).

1.1.1 Wash Down

- Wash down procedures for vehicles, plant and footwear are to be implemented when entering / exiting the frog hygiene management area (refer to Map 1 to Map 3) at any time when these items have been in contact with the existing natural ground surface. Once topsoil and vegetative material has been removed from the designated frog hygiene management zone, new plant and equipment entering the zone would not require wash-down whereas plant and equipment leaving the zone and having had contact with the natural ground surface will still require wash-down.
- Wash down bays will be implemented at appropriate entry / exit points.
- Wash down bays will incorporate an area for site personnel to disinfect boots when entering / leaving sterile zones during clearing / grubbing and stripping of topsoil.
- Wash down bays will be situated at least 100 m from waterways.
- Wash down areas will be contained with wash-down material (liquid and sediment) to be removed off site to a licensed waste facility.
- All construction personnel must be made aware of the requirements for wash down with this procedure to be a hold point for works commencing.
- Disinfection will be via the use of proprietary available Chloramine and Chlorhexidine based fungicides, cleaning products containing benzalkonium chloride or bleach and alcohol (ethanol or methanol).
- 70% isopropyl wipes may be suitable for the disinfection of small equipment.

1.1.2 Excavated Topsoil

- Excavated topsoil from the frog hygiene management zone must be either reused within the same creek catchment or buried on site.
- If the material is to be stockpiled and reused at a later date, the origin of this material must be tracked and wash-down procedures implemented when reuse occurs.

1.1.3 Entry into GBF / GTF Habitat (outside the Project Site)

- A "permit to enter" system will be established to regulate entry of personnel into areas of GBF / GFF habitat occurring outside of the Project Site.
- Any entry into areas of GBF / GTF habitat (outside the Project Site) will require personnel to disinfect boots before / after entering such areas. Portable spray packs with appropriate disinfectant (refer to Appendix A) will be made available at wash down bays.
- All personnel will be made aware of their responsibilities relating to Chytrid management on the site.

1.1.4 Vehicle Movements

- Vehicle movements will be restricted to designated tracks, trails and parking areas by a specific Vehicle Movement Plan (VMP) which will apply at all times throughout the works.
- Vehicle movements within the frog hygiene management areas will be kept to a minimum during excessively wet or muddy conditions.
- Designated parking and turn-around points must be provided on hard well-drained surfaces within the frog hygiene management zone.

1.1.5 Frog Handling

The Project Ecologist and personnel licensed / authorised to handle GBF / GTF are to adhere to the following hygiene protocols in accordance with the *Hygiene Protocols for the Control of Disease in Frogs* (NPWS, 2008) (refer to Appendix A): -

- New gloves / bags will be used for each frog captured;
- Individual bags / containers will be used for each frog held and containers (if reusable will be washed) prior to reuse. Containers will be labelled with the date and location);
- When moving between separate sites during frog surveys, footwear / waders will be thoroughly cleaned and disinfected;
- When moving between separate sites during frog surveys, equipment used (such as callipers, scales etc) will be thoroughly cleaned and disinfected; and
- Vehicle tyres will be washed / disinfected before and after visiting frog sites.
- Vehicle tyres can be disinfected with the aforementioned disinfectants or cleaning product s with active ingredient benzalkonium chloride (See Appendix A).
- Should a sick frog be identified the project environmental staff are to be notified to ensure that controls remain effective and that staff are reminded of their responsibilities. Manage the sick frog in accordance with the protocol.

1.2 Frog Hygiene Management Areas

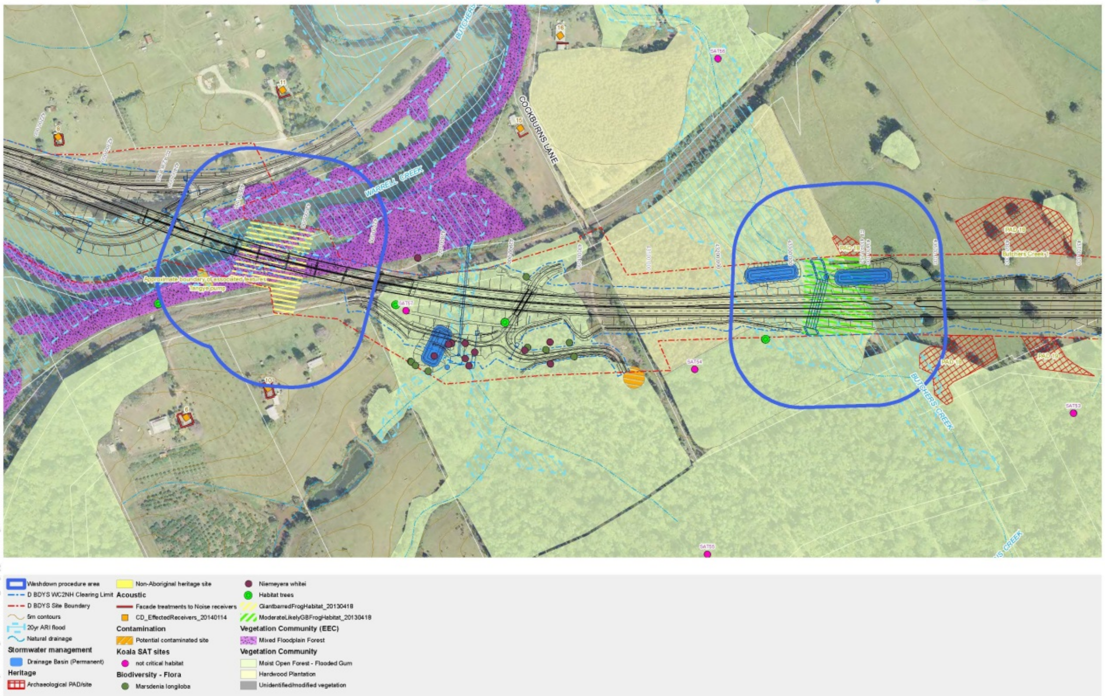
Frog hygiene management areas have been created based on previous ecological assessment and in locations that have been identified as one of the following:

- Green Thighed Frog habitat;
- Likely Green Thighed Frog habitat;
- Giant Barred Frog habitat; and
- Moderately likely Giant Barred Frog habitat.

The locations of the frog hygiene Management Areas are shown in the Frog Hygiene Management Area Maps (Figure 1 to Figure 3). The five locations are all between chainage 42400 and 61000, as identified below:

- Near Swampy Creek and CPT 318/3 Trail. Between chainage 59900 and 60300;
- Adjacent to Bellwood Creek. Between chainage 60700 and 61000;
- Between Teague Ridge Road and Belwood Road. Between chainage 57300 and 59500;
- On the eastern side of Warrell Creek. Between chainage 42400 and 42750; and
- Butchers Creek travels through the site. Between chainage 43200 and 43550.

AFJV ARUP aurecon Design Joint Venture



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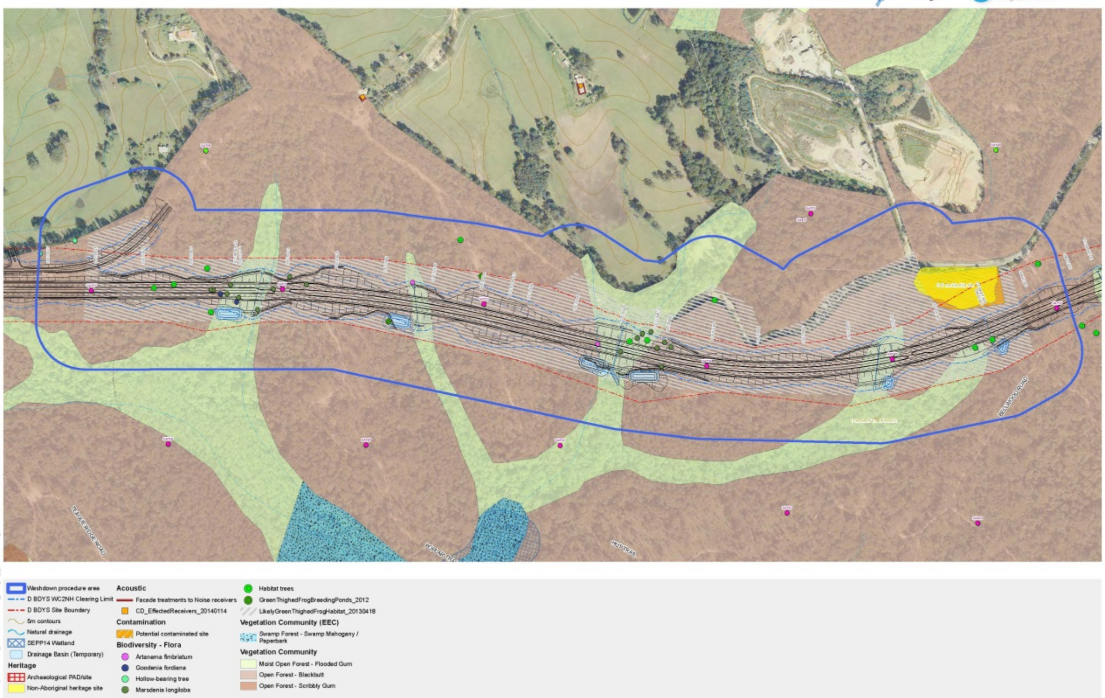
PACIFIC HIGHWAY UPGRADE **WARRELL CREEK TO NAMBUCCA HEADS**

Projection: GDA 1994 MGA Zone 56
Source: RMS, AADJV

FIGURE: Frog Hygiene Management Areas (Map 1 of 3)

AFJV ARUP aurecon Design Joint Venture



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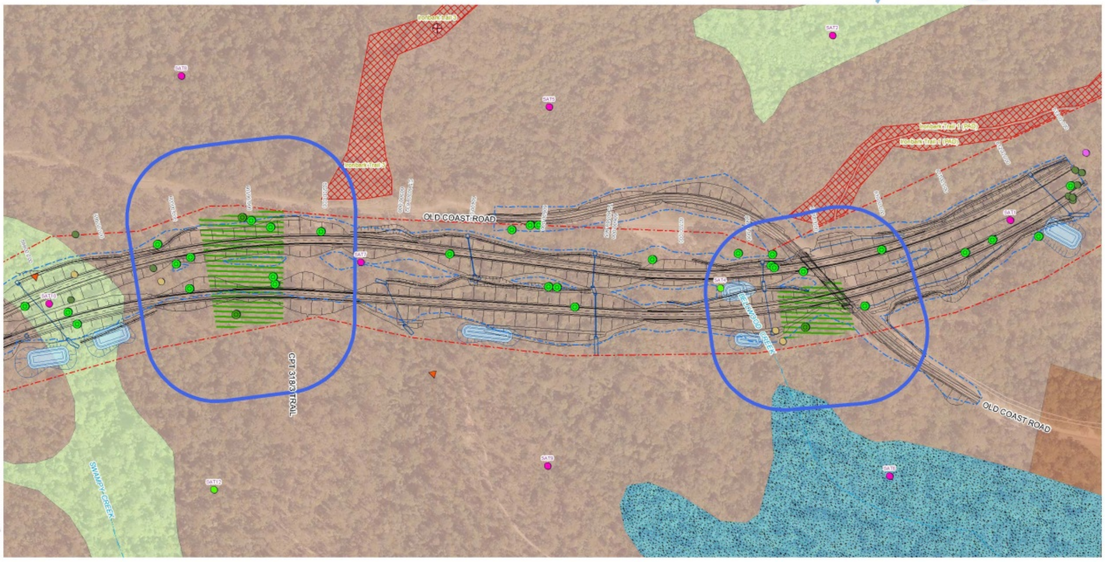
PACIFIC HIGHWAY UPGRADE **WARRELL CREEK TO NAMBUCCA HEADS**

Projection: GDA 1994 MGA Zone 56
Source: RMS, AADJV

FIGURE: Frog Hygiene Management Areas (Map 2 of 3)



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- Washdown procedure area
- D BDYS WC2NH Clearing Limit
- D BDYS Site Boundary
- 5m contours
- Natural drainage
- Drainage Basin (Temporary)

Heritage

- Archaeological PAD/site
- Aboriginal Artefact

Biodiversity - Fauna

- Yellow-bellied Glider

Biodiversity - Flora

- Artanema fimbriatum
- Marsdenia longiloba
- Tylophora woollsii
- Habitat trees
- GreenThighedFrogBreedingPonds_2012
- CD_GreenThighedFrogHabitat_20120723

Vegetation Community (EEC)

- Swamp Forest - Swamp Mahogany / Paperbark

Vegetation Community

- Moist Open Forest - Flooded Gum
- Open Forest - Blackbutt
- Open Forest - Scribbly Gum

1:4,000

0 100 200 m

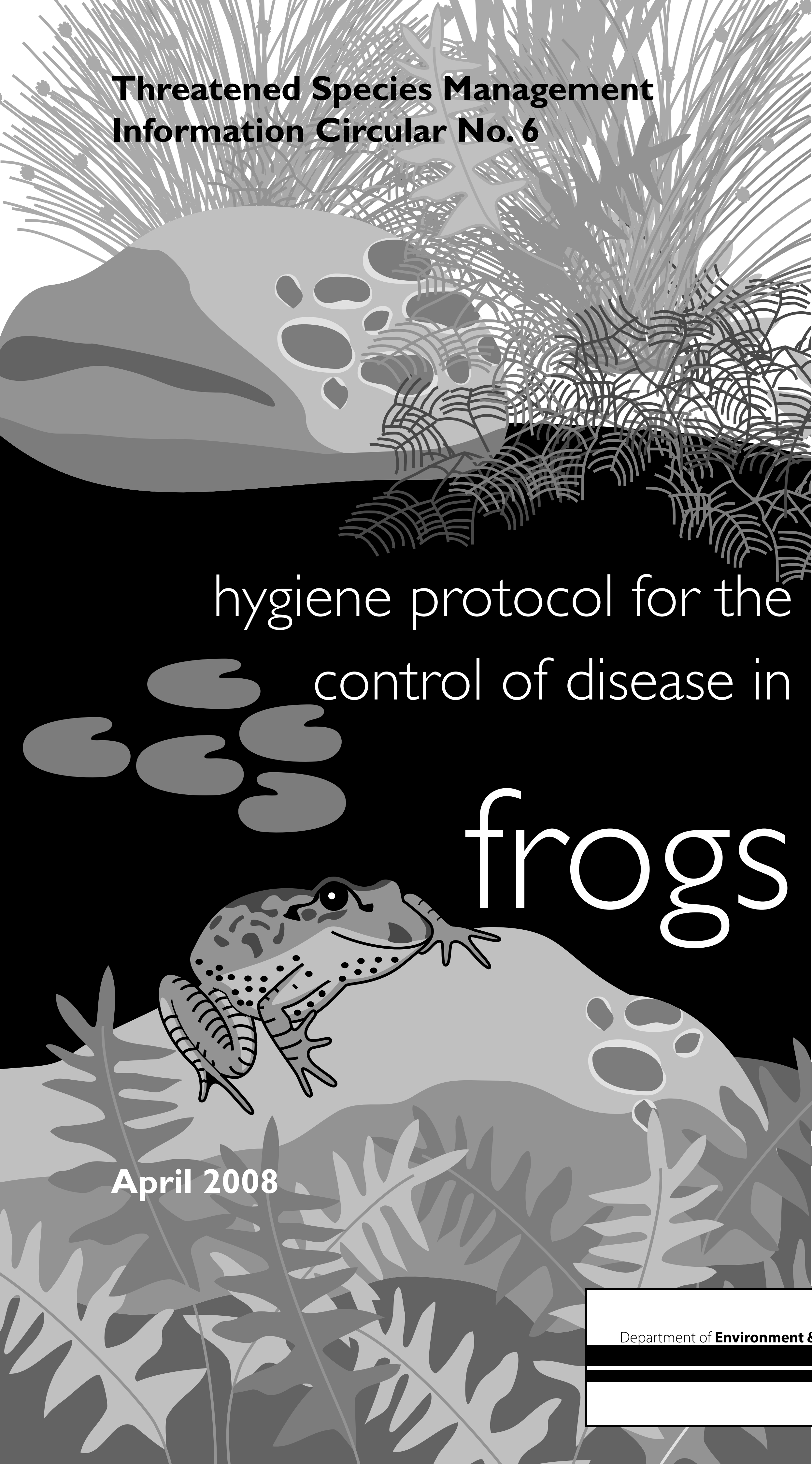
PACIFIC HIGHWAY UPGRADE **WARRELL CREEK TO NAMBUCCA HEADS**

Projection: GDA 1994 MGA Zone 56
Source: RMS, AADJV

FIGURE: Frog Hygiene Management Areas (Map 3 of 3)

APPENDIX A - HYGIENE PROTOCOLS FOR THE CONTROL OF DISEASE IN FROGS (NPWS, 2008)

Threatened Species Management
Information Circular No. 6



hygiene protocol for the control of disease in frogs

April 2008

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This document can be sourced from the DECC website:
www.environment.nsw.gov.au/resources/nature/hypfrog.pdf Ê

This document should be cited as: Ê
Department of Environment and Climate Change (NSW) 2008.
Hygiene protocol for the control of disease in frogs.
Information Circular Number 6. DECC (NSW), Sydney South.

ISBN 0 7313 6372 8 Ê
DECC 2008/199 Ê

Acknowledgments

NSW National Parks and Wildlife Service Declining Frog Working Group who recommended the preparation and provided input into the development of this strategy.

Ross Wellington and Ron Haering (both DECC) the authors of this document.

Thanks to Jack Baker, Lee Berger, Mark Endersby, Jeff Hardy, Frances Hulst, Alex Hyatt, Keith McDougall, Diana Mendez, Deborah Pergolotti, Graham Pyke, Marjo Rauhala, Julie Ravallion, Karrie Rose, Lothar Voigt and Arthur White for their advice and/or technical review.

This hygiene protocol is an adaptation of the Declining Amphibian Population Task Force (DAPTF) Fieldwork Code of Practice and the recommendations of Speare et al. (1999) and has drawn on recommendations from earlier guidelines prepared by Environment ACT.

Foundation for National Parks and Wildlife funded the printing of this protocol.

hygiene protocol for the control of disease in frogs

1 introduction

This information circular outlines measures to:

- Prevent or reduce disease causing pathogens being transferred within and between wild populations of frogs.
- Ensure captive frogs are not infected prior to release.
- Deal safely with unintentionally transported frogs.
- Assist with the proper identification and management of sick and dead frogs in the wild.

1.1 Who should read this document?

This protocol is intended for use by all researchers, wildlife consultants, fauna surveyors and students undertaking frog field-work. In addition, the protocol should be read by Department of Environment and Climate Change (DECC) personnel, frog keepers, wildlife rescue and carer organisations, herpetological/frog interest groups/ societies, fauna park/zoo operators/workers and other individuals who regularly deal with or are likely to encounter frogs.

This protocol outlines the expectations of the DECC regarding precautionary procedures to be employed when working with frog populations. The intention is to promote implementation of hygiene procedures by all individuals working with frogs. New licences and licence renewals will be conditional upon incorporation of the protocol. The DECC recognises that some variation from the protocol may be appropriate for particular research and frog handling activities. Such variation proposals should accompany any licence application or renewal to the DECC.

1.2 Background

1.2.1 Amphibian Chytrid Fungus

The apparent decline of frogs, including extinctions of species and local populations, has attracted increased international and national concern. Many potential causes for frog declines have been proposed (eg see Pechmann et al., 1991; Ferrero and Bergin, 1993; Pechmann and Wilbur, 1994; Pounds and Crump, 1994; Pounds et al., 1997). However, the patterns of decline at many locations suggest that epidemic disease maybe the cause (Richards et al., 1993; Laurance et al., 1996; Alford and Richards, 1997). Recent research has implicated a water-borne fungal pathogen *Batrachochytrium dendrobatidis* as the likely specific causative agent in many of these declines both in Australia and elsewhere (Berger et al., 1998; 1999). This agent is commonly known as the amphibian or frog chytrid fungus and is responsible for the disease Chytridiomycosis (Berger et al., 1999).

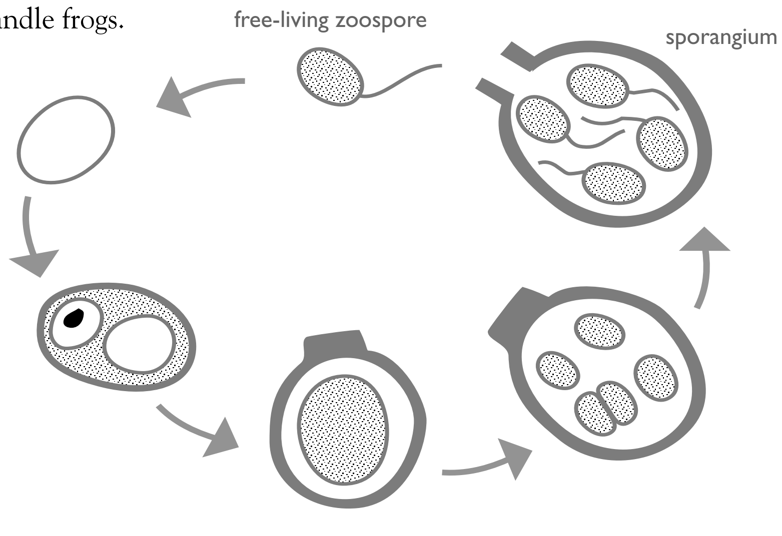
B. dendrobatidis is a form of fungus belonging to the phylum Chytridiomycota. Most species within this phylum occur as free-living saprophytic fungi in water and soil and have been found in almost every type of environment including deserts, artic tundra and rainforest and are considered important primary biodegraders (Powell 1993). *B. dendrobatidis* is a unique parasitic form of Chytridiomycete fungi, in that it invades the skin of amphibians, including tadpoles, often causing sporadic deaths with up to 100% mortality in some populations. Chytridiomycosis has been detected in over 40 species of native amphibian in Australia (Mahony and Workman 2000). However, it is not currently known whether the fungus is endemic or exotic to Australia.

The infective stage of *B. dendrobatidis* is the zoospore and transmission requires water (Berger et al.,1999). Zoospores released from an infected amphibian can potentially infect other amphibians in the same water. More research is needed on the dynamics of infection in the wild. *B. dendrobatidis* is known to be susceptible to seasonal temperature changes, dehydration, salinity, water pH, light, nutrition and dissolved oxygen (Berger et al., 1999).

1.3 Objectives

The objectives of the hygiene protocol are to:

- Recommend best-practice procedures for DECC personnel, researchers, consultants and other frog enthusiasts or individuals who handle frogs.
- Suggest workable strategies for those regularly working in the field with frogs or conducting fieldwork activities in wetlands and other aquatic environments where there is the potential for spreading pathogens such as the frog chytrid fungus.
- Provide background information and guidance to people who provide advice or supervise frog related activities.
- Provide standard licence conditions for workers engaged in frog related activities.
- Inform Animal Care and Ethics Committees (ACEC) for their consideration when granting research approvals.



Life cycle of frog chytrid fungus from infective free-living zoospore stage to sporangium (adapted from L. Berger).

2 site hygiene management

A checklist of risk management procedures and recommended standard hygiene kit is provided in Appendix 1. Please note Footnote 1 on page 4.

Individuals studying frogs often travel and collect samples of frogs from multiple sites. Some frog populations can be particularly sensitive to the introduction of infectious pathogens such as the frog chytrid fungus. Also, the arrangement of populations in the landscape may make frogs particularly vulnerable to transmission of infectious pathogens. Therefore, it is important that frog workers recognise the boundaries between sites and undertake measures which reduce the likelihood of spreading infection.

Where critically endangered species or populations of particular risk are known to occur, this protocol should be applied over very short distances ie a single site may need to be subdivided and treated as separate sites.

When planning to survey multiple sites, always start at a site where frog chytrid fungus is not known to be present before entering other infected areas.

2.1 Defining a site

Defining the boundary of a site maybe problematic. In some places, the boundary between sites will be obvious but in others, less so. Undertaking work at a number of sites or conducting routine monitoring at a series of sites within walking distance creates obvious difficulties with boundary definitions. It is likely that defining the boundary between sites will differ among localities. It may be that a natural or constructed feature forms a logical indicator of a site boundary eg a road/ track, a large body of water such as a river or the sea, a marked habitat change or a catchment boundary.

As a guiding principle, each individual waterbody should be considered a separate site.

When working along a river or stream or around a wetland or a series of interconnecting ponds it is reasonable, in most instances, to treat such examples as a single site for the purposes of this protocol. Such a case would occur in areas where frogs are known to have free interchange between ponds.

Where a stream consists of a series of distinctive tributaries or sub-catchments or where there is an obvious break or division then they should be treated as separate sites, particularly if there is no known interchange of frogs between sites.

2.2 On-site hygiene

When travelling from site to site it is recommended that the following hygiene precautions be undertaken to minimise the transfer of disease from footwear, equipment and/or vehicles.

Footwear

Footwear must be thoroughly cleaned and disinfected at the commencement of fieldwork and between each sampling site.

This can be achieved by initially scraping boots clear of mud and standing the soles in a disinfecting solution. The remainder of the boot should be rinsed or sprayed with a disinfecting solution that contains *benzalkonium chloride* as the active ingredient. Disinfecting solutions should be prevented from entering any water bodies.

Rubber boots such as 'gum boots' or 'Wellingtons' are recommended because of the ease with which they can be cleaned and disinfected.

Several changes of footwear bagged between sites might be a practical alternative to cleaning.

Equipment

Equipment such as nets, balances, callipers, bags, scalpels, headlamps, torches, wetsuits and waders etc that are used at one site must be cleaned and disinfected before re-use at another site.

Disposable items should be used where possible. Non-disposable equipment should be used only once during a particular field exercise and disinfected later or disinfected at the site between uses using procedures outlined in 2.4 below.

Vehicles

Where necessary, vehicle tyres should be sprayed/flushed with a disinfecting solution in high-risk areas.

Transmission of disease from vehicles is unlikely to be a problem. However, if a vehicle is used to traverse a known frog site, which could result in mud and water being transferred to other bodies of water or frog sites, then wheels and tyres should undergo cleaning and disinfection. This should be carried out at a safe distance from water bodies, so that the disinfecting solution can infiltrate soil rather than run-off into a nearby water body.

Spraying with 'toilet duck' (active ingredient *benzalkonium chloride*) is recommended to disinfect car wheels and tyres.

Cleaning of footwear before getting back into the car will prevent the transfer of pathogens from/to vehicle floor and control pedals.

2.3 Handling of frogs in the field

The spread of pathogenic organisms, such as the frog chytrid fungus, may occur as a result of handling frogs.

Frogs should only be handled when necessary.

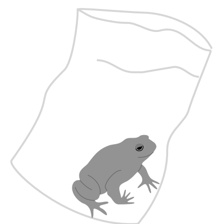
Where handling of frogs is necessary the risk of pathogen transfer should be minimised as follows:

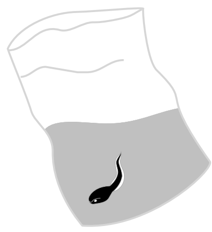
- Hands should be either cleaned and disinfected between samples or a new pair of disposable gloves used for each sample[1]. This may be achieved by commencing with a work area that has a dish containing a disinfecting solution and paper towels.
- A 'one bag – one frog' approach to frog handling should be used especially where several people are working together with one person processing frogs and others doing the collecting. Bags should not be reused.
- A 'one bag – one sample' approach to tadpole sampling should be used. Bags should not be reused.

Researchers who use toe clipping or Passive Integrated Transponder (PIT) tagging are likely to increase the risk of transmitting disease between frogs due to the possibility of directly introducing pathogens into the frogs' system. This can be minimised by using:

- Disposable sterile instruments
- Instruments disinfected previously and used once
- Instruments disinfected in between each frog

Disinfecting solutions containing *benzalkonium chloride* are readily available from local supermarkets. Some brands include Toilet Duck, Sanpic, New Clenz and Pine Clean.





[1] As a principle, this protocol assumes that not all frogs in an infected pond will be contaminated by the frog chytrid fungus. The infective load of a body of water may not be high enough to cause cross contamination of individual frogs in the same pond. Therefore care should be taken to use separate gloves and bags and clean hands for each sample, to avoid transmission of high infective loads between individuals.

Open wounds from toe clipping and PIT tagging should be sealed with a cyanoacrylate compound such as *Vetbond©* to reduce the likelihood of entry of pathogens. The DECC ACEC further recommends the application of topical anaesthetic *Xylocaine©* cream and *Betadine©* disinfectant (1% solution) before and after any surgical procedure. This should then be followed by the wound sealant.

All used disinfecting solutions, gloves and other disposable items should be stored in a sharps or other waste container and disposed or sterilised appropriately at the completion of fieldwork. Disinfecting solutions must not come into contact with frogs or be permitted to contaminate any water bodies

2.4 Disinfection Methods

Disinfecting agents for hands and equipment must be effective against bacteria and both the vegetative and spore stages of fungi. The following agents are recommended:

- Chloramine and Chlorhexidine based products such as *Halamid©*, *Halasept©* or *Hexifoam©* are effective against both bacteria and fungi. These products are suitable for use on hands, footwear, instruments and other equipment. The manufacturers instructions should be followed when preparing these solutions.
- Bleach and alcohol (ethanol or methanol), diluted to appropriate concentrations can be effective against bacteria and fungi. However, these substances may be less practical because of their corrosive and hazardous nature.

  When using methanol either:

  - immerse in 70% methanol for 30 minutes or
  - dip in 100% methanol then flame for 10 seconds or boil in water for 10 minutes

Fresh bleach (5% concentration) may be also effective against other frog pathogens such as Rana Virus.

Some equipment not easily disinfected in these ways can be effectively cleaned using medical standard 70% isopropyl alcohol wipes – *Isowipes©*.

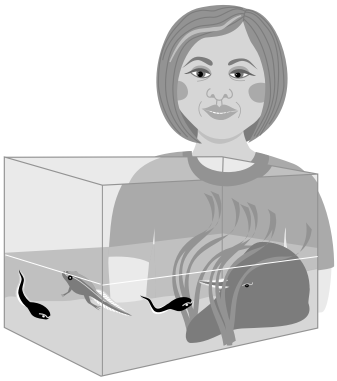
3 captive frog hygiene management

3.1 Housing frogs and tadpoles

Frogs and tadpoles should only be removed from a site when absolutely necessary.

When it is necessary for frogs or tadpoles to be collected and held for a period of time, the following measures should be undertaken:

- Animals obtained at different sites should be kept isolated from each other and from other captive animals.
- Aquaria set up to hold frogs should not share water, equipment or any filtration system. Splashes of water from adjacent enclosures or drops of water on nets may transfer pathogens between enclosures.
- Prior to housing frogs or tadpoles, ensure that tanks, aquaria and any associated equipment are disinfected.
- Tanks and equipment should be cleaned, disinfected and dried immediately after frogs/tadpoles are removed.



Careful maintenance of your enclosures will ensure a safe and hygienic environment for captive frogs and tadpoles.

When contemplating a release of captive bred tadpoles for conservation purposes a Translocation Proposal should be submitted to the DECC and pathological screening for disease should be undertaken (see also DECC Translocation Policy). Tadpoles can be tested by randomly removing 10 individuals at 6 weeks and again at 2 weeks before anticipated release. Testing could be undertaken by the pathology section at Taronga Zoo, Newcastle University, CSIRO Australian Animal Health Laboratories at Geelong and James Cook University at Townsville. Such an arrangement would need to be negotiated by contacting one of these institutions well before the anticipated release date. (see Appendix 2 for contact details)

DECC have licenced NSW Schools to allow students and/or teachers to remove tadpoles for classroom life cycle studies. They are authorised to remove individuals from only one location, each school also requires endorsement from Department of Education and Training Animal Care and Ethics Committee and comply with this protocol.

Tadpoles collected for these purposes are to be obtained from the local area of the school and are not to be obtained from DECC Reserves. As soon as tadpoles have transformed, froglets must be returned to the exact point of capture. Tadpoles from different locations are not to be mixed.

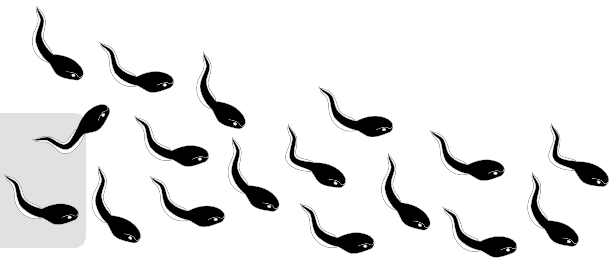
Antifungal cleansing treatments to clear tadpoles of the frog chytrid fungus are currently being trialed. In the future, such a treatment may be an added procedure required prior to froglet releases.

Detailed information on safely maintaining frogs in captivity is provided in Voigt (2001).

3.2 Tadpole treatment

In most instances:

Release to the wild of tadpoles held or bred in captivity should be avoided.



3.3 Frog treatment

The rigour with which frogs must be treated to ensure pathogens are not introduced to native populations means that any proposal for the removal of adult frogs (particularly threatened species) from wild populations should be given careful consideration.

When it is essential for frogs to be removed from the wild, the following should apply.

Individuals to be released should be quarantined for a period of 2 months and monitored for any signs of illness or disease.

Frogs must not be released if any evidence of illness or infection is detected. If illness is suspected, further advice must be sought from a designated frog recipient (Appendix 2) as soon as possible to determine the nature of the problem. Chytridiomycosis can be diagnosed in live frogs by microscopical examination of preserved toe clips or from shedding skin samples. Research is still in progress on the development of a simple technique for the detection of Chytridiomycosis and a treatment for infected frogs.

Current methods which may be used include:

- A technique for the treatment of potentially infected frogs is to place the frogs individually in a 1mg/L benzalkonium chloride solution for 1 hour on days 1, 3, 5, 9, 11 and 13 of the treatment period. Frogs are then isolated/quarantined for two months. This and other possible treatments are documented in Berger and Speare (1998)
- *Betadine*© and *Bactone*© treatments have also been used on adult frogs with some success (M. Mahony, Newcastle University pers. comm.)
- *Itraconazole*© is an expensive drug which has been used successfully (Lee Berger CSIRO Australian Animal Health Laboratory pers. comm.). Information on this method is available on the Website http://www.jcu.edu.au/school/PHTM/frogs/adms/attach6.pdf.

Frogs undergoing treatment should be housed individually and kept separate from non-infected individuals.

3.4 Displaced frogs

Displaced frogs are those native frog species and introduced Cane Toads (Bufo marinus) which have been unintentionally transported around the country with fresh produce, transported produce and landscaping supplies. Procedures to be undertaken when encountering introduced/displaced native frog species (as well as Cane Toads) are as follows.

3.4.1 Banana box frogs

'Banana Box' frog is the term used to describe several native frog species (usually Litoria gracilenta, L. infrafrenata, L. bicolor and L. caerulea) commonly transported in fruit and vegetable shipments and landscaping supplies. In the past, well meaning individuals have attempted to return these frogs to their place of origin but this is usually impossible to do accurately. There is risk of spread of disease if these frogs are transferred from place to place.

It is strongly recommended that:

Displaced Banana Box frogs should be treated as if they are infected and should not to be freighted anywhere for release to the wild unless specifically approved by DECC.

When encountering a displaced frog:

- Contact a licensed wildlife carer organisation to collect the animal. The frog should then undergo a quarantine period of 2 months along with an approved disinfection treatment.
- Post-quarantine, the frog (if one of the species identified above) may be transferred to a licensed frog keeper. All other species require the permission from DECC Wildlife Licensing and Management Unit (WLMU) prior to transfer. Licensed carer groups are to record and receipt frogs obtained and disposed of in this way.
- Licensed Frog Keepers are to list these frogs in their annual licence returns to DECC.

Frogs held by licensed frog keepers are not to be released to the wild except with specific DECC approval.

Displaced frogs may be made available to recognised institutions for research projects, display purposes or perhaps offered to the Australian Museum as scientific specimens once approval has been provided by the DECC WLMU.

Frogs are often unintentionally transported with fresh produce and landscaping supplies. They are collectively known as 'banana box' or displaced frogs.

3.4.2 Cane toads

Cane toads are known carriers of the Frog chytrid fungus and should not be knowingly transported or released to the wild.

If a cane toad is discovered outside of its normal range, it should be humanely euthanased in accordance with the recommended NSW Animal Welfare Advisory Council procedure (see Appendix 3). Care should be taken to avoid euthanasia of native species due to mistaken identity.

An NPWS information brochure titled 'Cane Toads in NSW' provides further information on cane toads and assistance with identification of some of the commonly misidentified native species. This information is also available on the DECC website.

3.4.3 Local frog species

Frogs encountered on roads, around dwellings and gardens or in swimming pools should not be considered as displaced frogs.

Frogs encountered in these situations should be assisted off roads, away from dwellings, or out of swimming pools preferably to the nearest area of vegetation or suitable habitat.

Incidences of frogs spawning or tadpoles appearing in swimming pools should be referred to a wildlife carer/rescue organisation for assistance (see Appendix 4).

Contact the Frogwatch Helpline if you are unsure whether a frog is a local species or displaced.

4 sick or dead frogs

Unless an obvious cause of illness or death is evident (eg predation or road mortality): Sick or dead frogs encountered in the wild should be collected and disposed of in accordance with the procedures described in section 4.2 below.

4.1 Symptoms of sick and dying frogs

Sick and dying frogs exhibit a range of symptoms characteristic of chytrid infection. Symptoms may be expressed in the external appearance or behaviour of the animal. A summary of these symptoms are described below. More detailed information can be found in Berger et al., (1999) or at the James Cook University Amphibian Disease website at: http://www/jcu.edu.au/school/phtm/PHTM/frogs/ampdis.htm.

Appearance (one or more symptoms)

- darker or blotchy upper (dorsal) surface
- reddish/pink-tinged lower (ventral) surface and/or legs and/or webbing or toes
- swollen hind limbs
- very thin or emaciated
- skin lesions (sores, lumps)
- infected eyes
- obvious asymmetric appearance

Behaviour (one or more symptoms)

- lethargic limb movements, especially hind limbs
- abnormal behaviour (eg a nocturnal, burrowing or arboreal frog sitting in the open during the day and making no vigorous attempt to escape when approached)
- little or no movement when touched

Great barred frog (*Mixophyes fasciolatus*) with severe Chytrid infection — note lethargic attitude and sloughing skin. Photo: L. Berger

Diagnostic behaviour tests

Sick frogs will fail one or more of the following tests:

test	healthy	sick
Gently touch with finger	Frog will blink	Frog will not blink above the eye
Turn frog on its back	Frog will flip back over	Frog will remain on its back
Hold frog gently by its mouth	Frog will use its forelimbs to try to remove grip	No response from frog

4.2 What to do with sick or dead frogs

A procedure for the preparation and transport of a sick or dead frog is given below[2]. Adherence to this procedure will ensure the animal is maintained in a suitable condition for pathological examination and assist the DECC and researchers to determine the extent of the disease and the number of species affected.

- Disposable gloves should be worn when handling sick or dead frogs. Avoid handling food and touching your mouth or eyes as this could transfer pathogens and toxic skin secretions from some frog species.
- New gloves and a clean plastic bag should be used for each frog specimen to prevent cross-contamination. When gloves are unavailable, use an implement to transfer the frog to a container rather than using bare hands.
- If the frog is dead, keep the specimen cool and preserve as soon as possible (as frogs decompose quickly after death making examination difficult). Specimens can be fixed/preserved in 70% ethanol or 10% buffered formalin.

Cut open the belly and place the frog in about 10 times its own volume of preservative. Alternatively, specimens can be frozen (although this makes tissues unsuitable for some tests). If numerous frogs are collected, some should be preserved and some should be frozen. Portions of a dead frog can be sent for analysis eg a preserved foot, leg or a portion of abdominal skin.

- The container should be labelled showing at least the species, date and location. A standardised collection form is provided in Appendix 5.
- If the frog is alive but unlikely to survive transportation (death appears imminent), euthanase the frog (see Appendix 3) and place the specimen in a freezer. Once frozen, the specimen is ready for shipment to the address provided below.
- If the frog is alive and likely to survive transportation, place the frog into either a moistened cloth bag with some damp leaf litter or into a plastic bag with damp leaf litter and partially inflated before sealing. Remember to keep all frogs separated during transportation.
- Preserved samples can be sent in jars or wrapped in wet cloth, sealed in bags and placed inside a padded box.
- Send frozen samples in an esky with dry ice (available from BOC/CIG Gas outlets).
- Place live or frozen specimens into a small styrafoam esky (available from K-Mart/Big W for approximately $2.50).
- Seal esky with packaging tape and address to one of the laboratories listed in Appendix 4.
- Send the package by courier.

Further information on sick and dying frogs is available on the Amphibian Disease Home Page at http://www.jcu.edu.au/dept/PHTM/frogs/ampidis.htm — in particular refer to *'What to do with dead or ill frogs'*.

[2] The measures described below are standard procedures and may vary slightly depending on the distance and time required to reach the intended recipient. Contact the intended recipient of the sick or dead frog prior to sending to confirm the appropriate procedure.

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appendix 1

hygiene protocol checklist and field kit

The following checklist and field kit are designed to assist with minimising the risk of transferring pathogens between frogs.

Have you considered the following questions before handling frogs in the field:

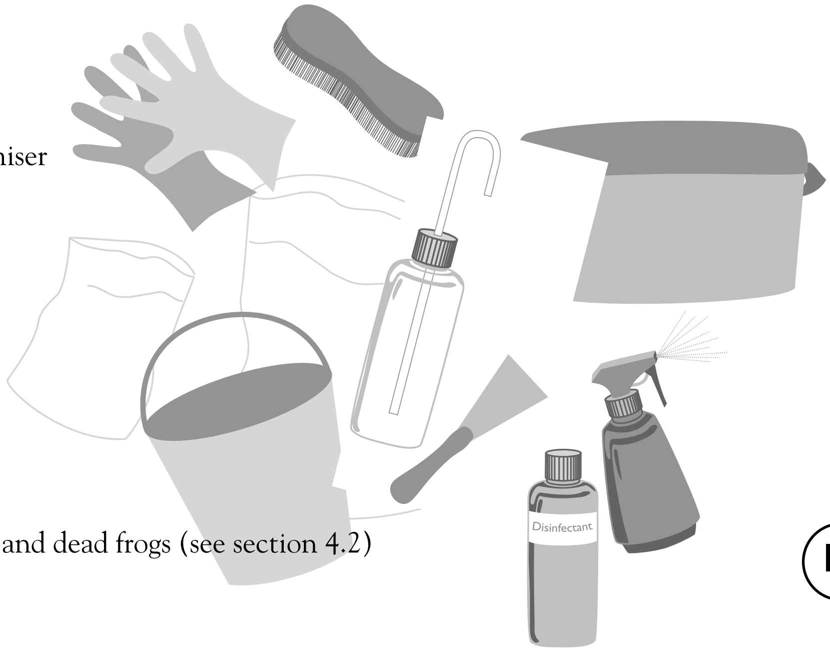
- Has your proposed field trip been sufficiently well planned to consider hygiene issues?
- Have you taken into account boundaries between sites (particularly where endangered species or populations at risk are known to occur)?
- Have footwear disinfection procedures been considered and a strategy adopted?
- Have you planned the equipment you will be using and developed a disinfection strategy?
- Are you are planning to visit sites where vehicle disinfection will be needed (consider both vehicle wheels/tyres and control pedals) and if so, do you have a plan to deal with vehicle disinfection?
- Have handling procedures been planned to minimise the risk of frog to frog pathogen transmission?
- Do you have a planned disinfection procedure to deal with equipment, apparel and direct contact with frogs?

If you answered NO to any of these questions please re-read the relevant section of the DECC Hygiene Protocol for the Control of Disease in Frogs and apply a suitable strategy.

Field hygiene kit

When planning to survey frogs in the field a portable field hygiene kit should be assembled to assist with implementing this protocol. Recommended contents of a field hygiene kit would include:

- Small styrofoam eski
- Disposable gloves
- Disinfectant spray bottle (atomiser spray) and/or wash bottle
- Disinfecting solutions
- Wash bottle
- Scraper or scrubbing brush
- Small bucket
- Plastic bags large and small
- Container for waste disposal
- Materials for dealing with sick and dead frogs (see section 4.2)



appendix 2

Always contact the relevant specialist prior to sending a sick or dead frog. In some cases, only wild frogs will be assessed for disease. Analysis may also attract a small fee per sample.

designated sick and dead frog recipients

Contact one of the following specialists to arrange receipt and analyse sick and dead frogs. Make contact prior to dispatching package:

Karrie Rose
Australian Registry if Wildlife Health
Taronga Conservation Society, Australia
PO Box 20
MOSMAN NSW 2088

Phone: 02 9978 4749
Fax: 02 9978 4516
Krose@zoo.nsw.gov.au

Diana Mendez or
Rick Speare
School of Public Health,
Tropical Medicine and
Rehabilitation Sciences
James Cook University
Douglas Campus
TOWNSVILLE QLD 4811

Phone: 07 4796 1735
Fax: 07 4796 1767
Diana.Mendez@jcu.edu.au
Richard.Speare@jcu.edu.au

Michael Mahony
School of Biological Sciences
University of Newcastle
CALLAGHAN NSW 2308

Phone: 02 4921 6014
Fax: 02 4921 6923
bimjm@cc.newcastle.edu.au

For information on frog keeping licences and approvals to move some species of displaced frog contact:

Co-ordinator, Wildlife Licensing
Wildlife Licensing and Management Unit
DECC
PO Box 1967
Hurstville NSW 1481
Ph 02 9585 6481
Fax 02 9585 6401
wildlife.licensing@environment.nsw.gov.au

For information on the possible identity of displaced frogs contact:

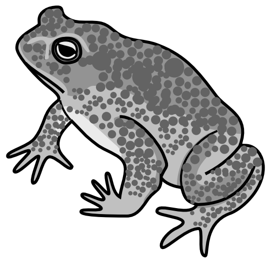
Frog and Tadpole Society (FATS)
Frogwatch Helpline

Ph: 0419 249 728

appendix 3

NSW Animal Welfare Advisory Council methodology

The NSW Animal Welfare Advisory Council procedure for humanely euthanasing cane toads or terminally ill frogs is stated as follows:



- Using gloves, or some other implement, place cane toad or terminally ill frog into a plastic bag.
- Cool in the refrigerator to 4°C.
- Crush cranium with a swift blow using a blunt instrument.

Note: Before killing any frog presumed to be a cane toad, ensure that it has been correctly identified and if outside the normal range for cane toads in NSW (north coast) that local DECC regional office is informed.

appendix 4

licensed wildlife carer and rescue organisations

Following is a list of wildlife rehabilitation groups licensed by Department of Environment and Climate Change (NSW):

Northern NSW

Australian Seabird Rescue
For Australian Wildlife Needing Aid (FAWNA)
Friends of the Koala
Friends of Waterways (Gunnedah)
Great Lakes Wildlife Rescue
Koala Preservation Society of NSW
Northern Rivers Wildlife Carers
Northern Tablelands Wildlife Carers
Tweed Valley Wildlife Carers
Seaworld Australia
WIRES branches in Northern NSW

Southern NSW

Looking After Our Kosciuszko Orphans (LAOKO)
Native Animal Network Association
Native Animal Rescue Group
Wildcare Queanbeyan
WIRES branches in Southern NSW

Sydney, Hunter and Illawarra

Hunter Koala Preservation Society
Ku-ring-gai Bat Colony Committee
Kangaroo Protection Co-operative
Native Animal Trust Fund
Organisation for the Rescue and Research of Cetaceans (ORRCA)
Sydney Metropolitan Wildlife Services
Wildlife Aid
Wildlife Animal Rescue and Care (Wildlife ARC)
Waterfall Springs Wildlife Park
Oceanworld
Wildlife Care Centre, John Moroney Correctional Centre
Koalas in Care
WIRES branches around Sydney, Hunter and Illawarra

Western NSW

Rescue and Rehabilitation of Australian Native Animals (RRANA) Ê
RSPCA Australian Capital Territory Inc.
Wildlife Carers Network (Central West) Ê
WIRES branches in Western NSW Ê
Cudgegong Wildlife Carers Ê

[4] Note: some of these organisations may not care for frogs.

appendix 5 — sick or dead frog collection form

Sender details:

name: address: postcode:

phone: (w) (h) fax: email:

Collector details: (where different to sender)

name: address: postcode:

phone: (w) (h) fax: email:

Specimen details:

record no: no. of specimens: species name: date collected:
day/month/year

time collected: sex: status at time of collection: date sent:
male/female healthy(H)/ sick(S)/ dead(D) day/month/year

location: map grid reference:
(easting) (northing)

reason for collection:

Batch details for multiple species collection:

species	no.	locality	(AMG)	date	sex	status (H/S/D)

habitat type: vegetation type: micro habitat:
eg creek, swamp, forest eg rainforest, sedgeland eg creek bank, under log, amongst emergent vegetation, on ground in the open

unusual behaviour of sick frogs:
eg lethargic, convulsions, sitting in the open during the day, showing little or no movement when touched.

dead frogs appearance:
eg thin, reddening of skin on belly and/or toes, red spots, sore, lumps or discolouration on skin

deformed frogs: dead/sick tadpoles:
eg limb(s) missing, abnormal shape or length eg numbers/behaviour

unusual appearance of egg masses: recent use of agricultural chemicals in area:
eg grey or white eggs eg pesticides, herbicides, fertilisers

other potential causes of sickness/mortality/comments/additional information:

NSW
NATIONAL
PARKS AND
WILDLIFE
SERVICE

General inquiries: PO Box A290 South Sydney 1232 Ê
Phone: 9995 5000 or 1300 361967 Ê
Fax: 02 9995 5999 **Web site:** www.environment.nsw.gov.au Ê

Department of **Env**

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Appendix E

Green-thighed Frog Management Strategy

Transport
Roads & Maritime
Services

GREEN THIGHED FROG MANAGEMENT PLAN

Warrell Creek to Urunga upgrade

MARCH 2013

PACIFIC HIGHWAY UPGRADE:

WARRELL CREEK TO URUNGA

GREEN-THIGHED FROG MANAGEMENT STRATEGY

MARCH 2013

PREPARED FOR THE ROADS AND MARITIME SERVICES BY:

LEWIS ECOLOGICAL SURVEYS

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ACKNOWLEDGEMENTS

Ben Lewis (Lewis Ecological Surveys) – Field surveys, report author.

Adrian Vannisse (GeoView) – GIS map production.

Kristy Harvey (Roads and Maritime Services) – Project management, background data and review.

Belinda Bock (Roads and Maritime Services) – Project management, background data and review.

Brett Hoffman (Roads and Maritime Services) – Project manager and logistics.

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Top – The vulnerable Green-thighed Frog (*Litoria brevipalmata*) from ch. 60065 Nambucca State Forest
Left to Right – Staged construction of Green-thighed Frog ponds on the Kempsey Bypass Project (Fill 6).

Report to be cited as: Lewis, B.D (2013). Warrell Creek to Urunga: Green-thighed Frog Management Strategy. Report prepared for Roads and Maritime Services by Lewis Ecological Surveys. ©

Document Control

Distribution

Version	Date	Status	Report Author	Format	Dispatched	Client	Client Contact
A	28.5.2012	Draft for comment	Ben Lewis	PDF & Word	Email	Roads and Maritime Services	Kristy Harvey
B	18.6.2012	Final	Ben Lewis	PDF & Word	Email	Roads and Maritime Services	Kristy Harvey
C	29.6.2012	Final	Ben Lewis	PDF & Word	Email	Roads and Maritime Services	Kristy Harvey
D	24.7.2012	Final	Ben Lewis	PDF & Word	Email	Roads and Maritime Services	Kristy Harvey
E	19.9.2012	Final	Ben Lewis	PDF & Word	Email	Roads and Maritime Services	Belinda Bock
F*	31.10.2012	Final	Ben Lewis	PDF & Word	Email	Roads and Maritime Services	Belinda Bock
G	22.3.2013	Final	Ben Lewis	PDF & Word	Email	Roads and Maritime Services	Belinda Bock

* In response to additional surveys within the Nambucca Floodplain Investigation area.

Revision / Review

Date	Version	Status	Reviewer	Delivered Format	Dispatched	Represent
15.6.2012	A	Draft for comment	Brett Hoffman	PDF	Email	Roads and Maritime Services
15.6.2012	A	Draft for comment	John O'Donnell	Email dot points	Email	Roads and Maritime Services
29.6.2012	B	Draft for comment	Kristy Harvey	Comments in word document	Email	Roads and Maritime Services
20.7.2012	C	Final to EPA	Craig Harré	PDF	Email	Environment Protection Authority
7.9.2012	D	Final	Belinda Bock	Comments in word document	Email	Roads and Maritime Services
1.3.2013	F	Final	Michael Young	Comments in word document	Email	NSW Department of Planning and Infrastructure

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ABBREVIATIONS

Abbreviation	Description
WC2U	Warrell Creek to Urunga Pacific Highway Upgrade
WC2N	Warrell Creek to Nambucca Heads Staged Construction of the WC2U Approval
N2U	Nambucca Heads to Urunga (northern section of WC2U Pacific Highway Upgrade)
MCoA	Ministers Condition of Approval
EPA	Environmental Protection Authority
RMS	Roads and Maritime Services
LES	Lewis Ecological Surveys
Vulnerable	Species listed as vulnerable under schedule two of the NSW *Threatened Species Conservation* Act (1995)

1.0 INTRODUCTION

1.1 Background

Lewis Ecological Surveys (LES) has been contracted by Roads and Maritime Services (RMS) to prepare a management strategy for a population of Green-thighed Frog (*Litoria brevipalmata*) recorded during targeted frog surveys for the Warrell Creek to Urunga Pacific Highway Upgrade project (Lewis in prep). This species is currently listed as 'vulnerable' pursuant to the NSW *Threatened Species Conservation* Act (1995). Factors implicated in the decline of *L. brevipalmata* include habitat destruction and modification particularly the coastal lowlands which apparently form important breeding habitats (Ehmann 1997; Lemckert *et al.* 1997; Lemckert 1999).

The Environmental Assessment (EA) prepared for the Warrell Creek to Urunga Pacific Highway Upgrade project did not record Green-thighed Frog despite there being four records around Nambucca Heads and suitable habitat within neighbouring state forests and private lands (SKM 2010; Figure 1-1 and 1-2). The historic records span a time period over the past 15 years and occur on either side of the carriageway between ch.59265 and ch.61765. To address this, a test of significance has been prepared and provided in Appendix A.

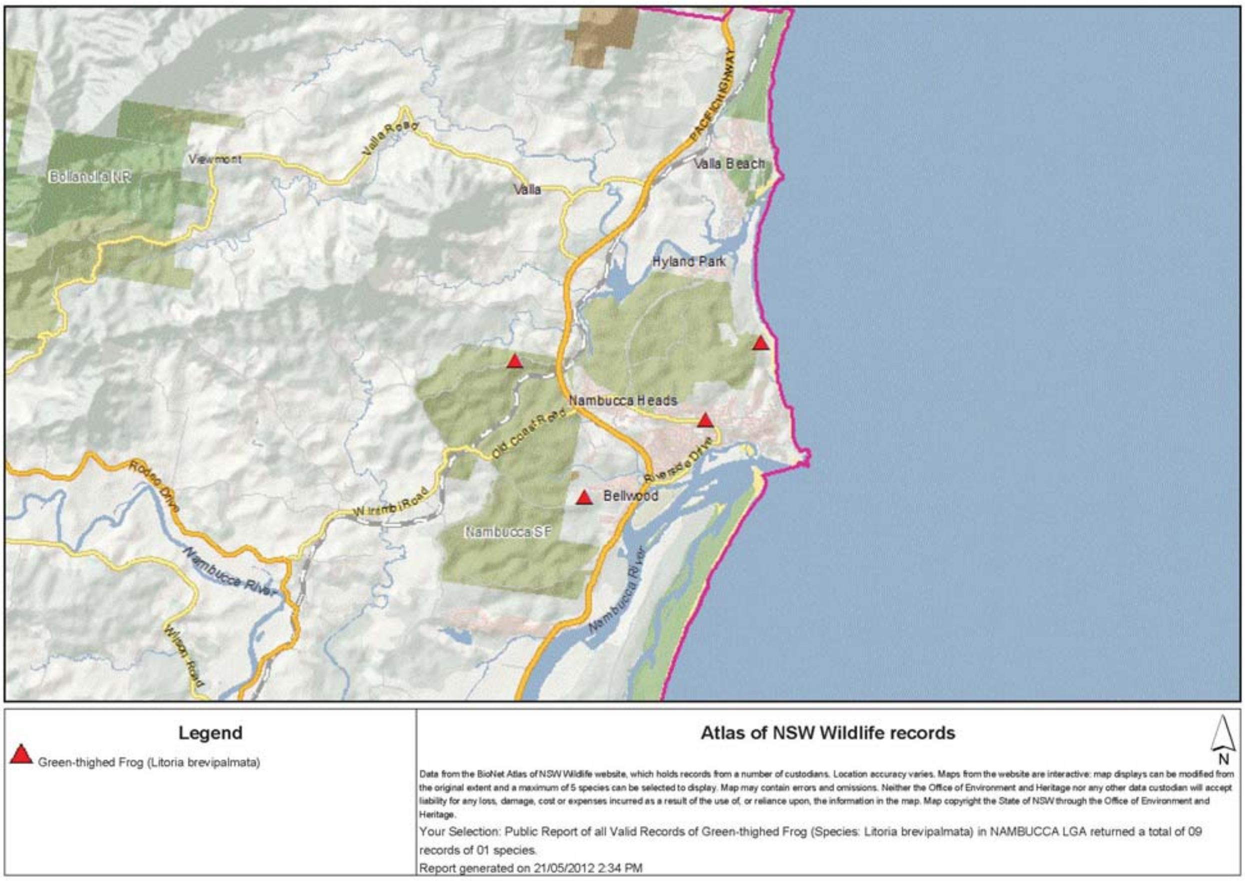

Figure 1-1. Location of documented Green-thighed Frog records.

1.2 The Subject Species –Green-thighed Frog (*Litoria brevipalmata*)

The Green-thighed Frog is a small to medium sized (max. 47 mm) hylid frog found in coastal and sub coastal areas from near Bundaberg (Cordalba) in the north to Ourimbah (i.e. central coast NSW) in the south (Mahony 1993; Barker *et al.* 1995; Cogger 1995; Lemckert *et al.* 1997; Lemckert 1999; Murphy and Turnbill 1999; Lewis 2000). It is a relatively distinct species with a prominent white upper lip, armpits and groin marked in lime green with black markings (Barker *et al.* 1995; Cogger 1995; Lemckert 1999). Despite these distinct markings and relatively wide distribution, it is known from few areas (Mahony 1993; *see* Ehmann 1997; Lemckert *et al.* 1997; Murphy & Turnbill 1999). Its cryptic habits ensured it remained

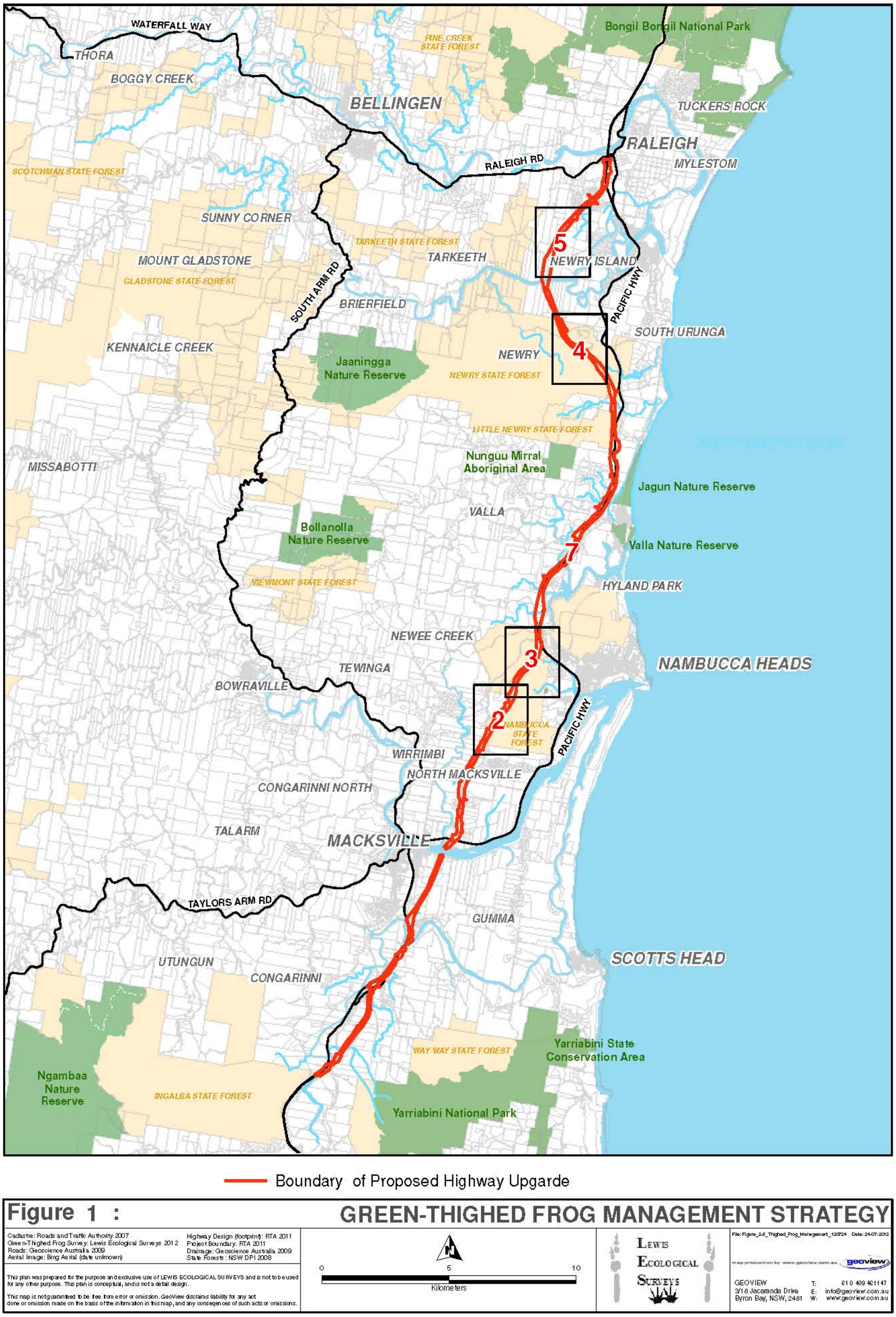

Figure 1-2. Overall of the Warrell Creek to Urunga Project.

unknown to science until 1972 (Tyler *et al.* 1972). The main habitat requirement of *L. brevipalmata* is warm temperate lowland forest (Tyler 1992). More recent records have indicated other habitat types used e.g. dry sclerophyll forest in the northern part of its range (Nattrass and Ingram 1993; Lemckert 1999; Murphy and Turnbill 1999) and coastal swamp forests and wet heath associations (Lewis 2005).

Litoria brevipalmata is uncommon in north-eastern NSW with <20 records in north-east NSW. It is often only seen during breeding events between October to April after local flooding (Mahony 1993; Barker *et al.* 1995; Ehmann 1997; Lemckert *et al.* 1997; Lemckert 1999). Males are frequently found perched on fallen tree branches above or close to still water (Barker *et al.* 1995; White 1995; Ehmann 1997; Lemckert *et al.* 1997).

1.3 Objectives

The objective of this report is to provide a systematic and justifiable process for the development of management strategies, associated designs and where applicable which can be monitored to assess their effectiveness.

2.0 MANAGEMENT & MONITORING STRATEGIES

Seven management strategies have been proposed as a means to avoid, minimise, mitigate and monitor impacts to Green-thighed Frog. They include:

1. **Identification of Green-thighed Frog habitat**
2. **Protection of existing habitat**
3. **Pre-clearing surveys**
4. **Creation of breeding ponds**
5. **Design and installation of permanent frog fencing**
6. **Unexpected finds procedure linking to strategies 2-5 and 7**
7. **Monitoring of the breeding pond areas**

A summary of these actions and the associated technique is shown in Table 2-1.

2.1 Identification of Green-thighed Frog Habitat

A targeted Green-thighed Frog survey was undertaken by Lewis Ecological Surveys between January-March 2012 and within the Nambucca Floodplain Investigation area during October 2012. This survey confirmed the presence of Green-thighed Frog in Nambucca State Forest at:

- Ch.60065 within the road corridor where 2 male frogs were recorded; and
- Ch.60865 eastern side of RMS corridor where 1 male frog was recorded (Figure 2-1).

The northern part of the study area did not receive the required rainfall during the field survey period. It was still subject to field surveys between January and March 2012 to look for frogs and to identify suitable areas of breeding habitat. Based on the existing habitat the following areas are suspected as providing habitat for Green-thighed Frog:

Warrell Creek to Nambucca Heads

1. Associated low lying and flooded areas between ch.57365 and ch.59365 (Figure 2-2);

Nambucca Heads to Urunga

2. The low flat area that supports wet forest with swamp forest associations between ch.74665 and ch.74965 – Newry State Forest between Cut 20 and Martells Road (Cryptic Orchid habitat) shown in Figure 2-3.
3. The low lying area between ch.78765 and ch.78965 – north of the Kalang River and local access road 6 (Figure 2-4).
4. The two low lying drainages between ch.79765 and ch.80765 – Riddel property (Figure 2-4).

The above areas should be identified as sensitive environmental areas of 'moderate' and 'high' ecological value and delineated accordingly within the Construction Environmental Management Plan (CEMP). In this context, clearing of vegetation should be kept to a minimum in accordance with MCoA C1 and C27 (see below).

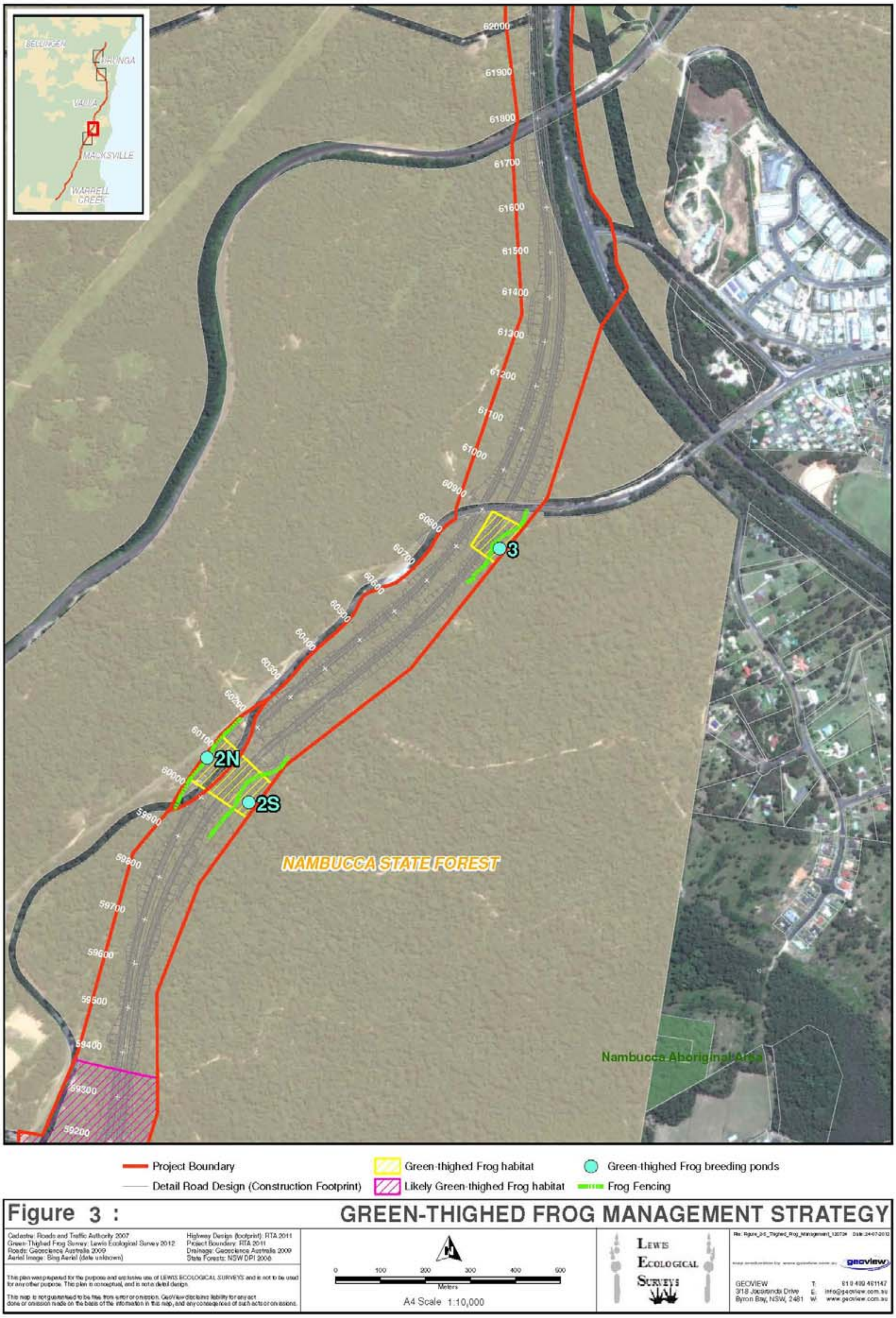

Figure 2-1. Known Green-thighed Frog locations within the RMS corridor and proposed mitigation strategies.

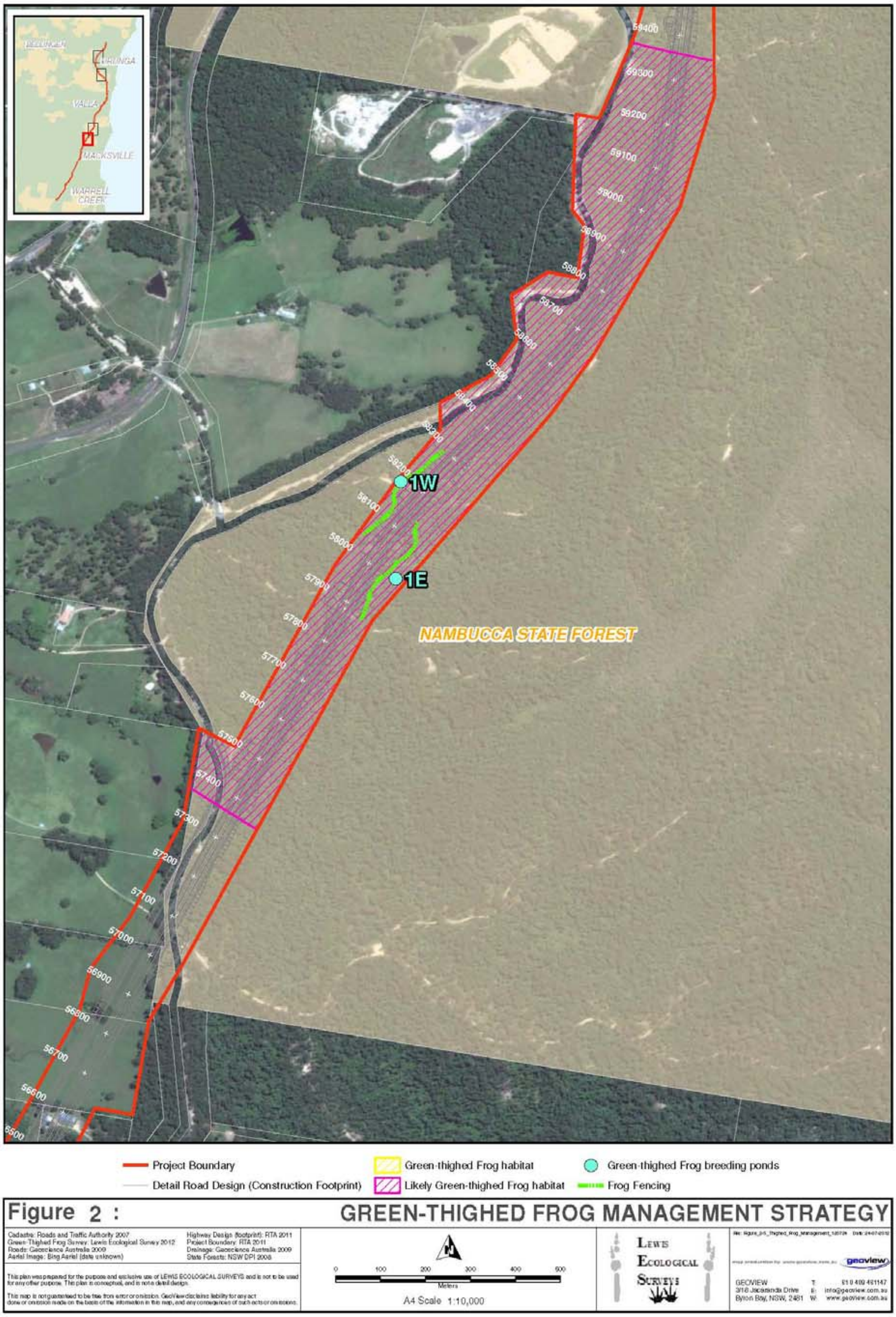

Figure 2-2. Likely Green-thighed Frog habitat within the RMS corridor and proposed mitigation strategies for the southern construction stage Warrell Creek to Nambucca Heads.

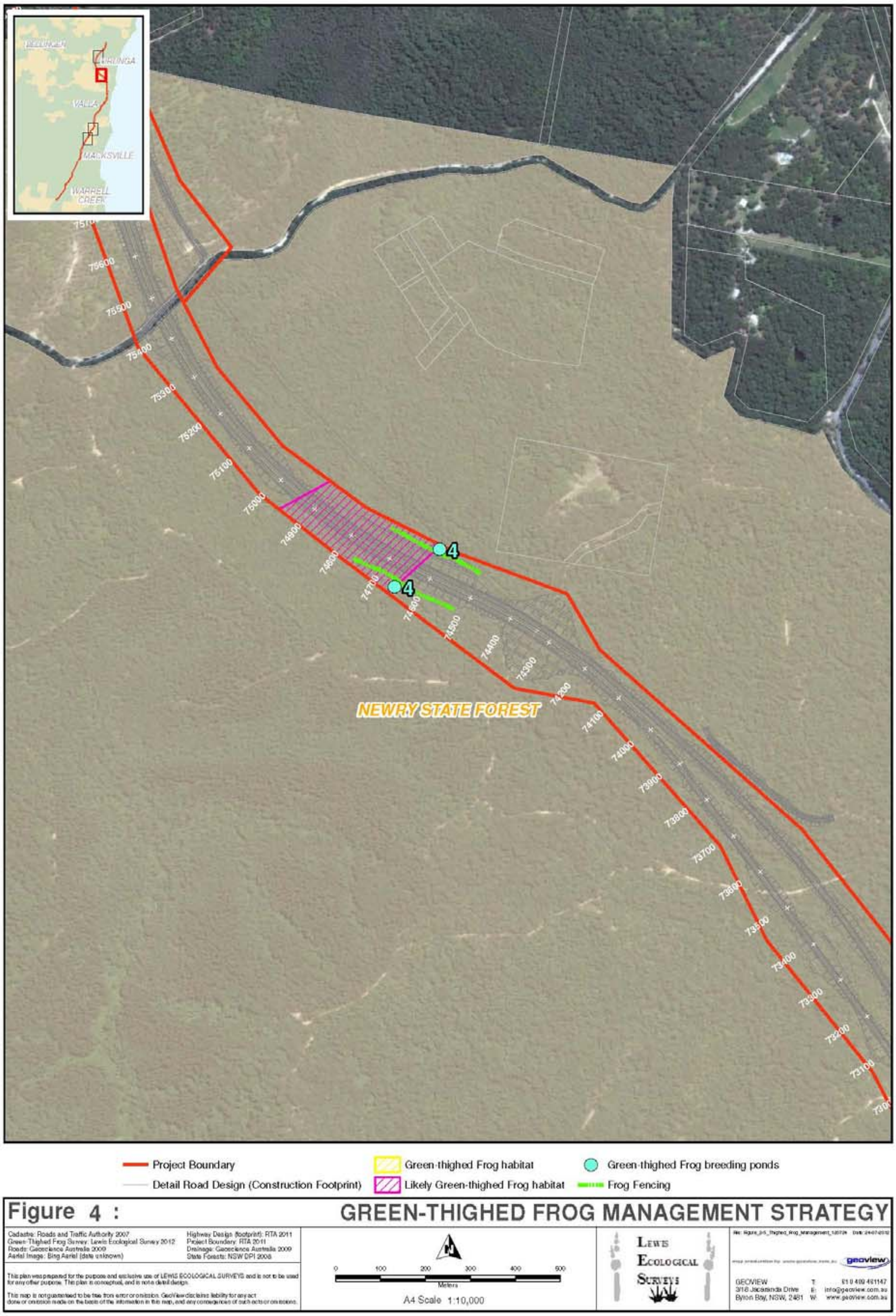

Figure 2-3. Likely Green-thighed Frog habitat within the RMS corridor and proposed mitigation strategies for the northern construction stage Nambucca Heads to Urunga.

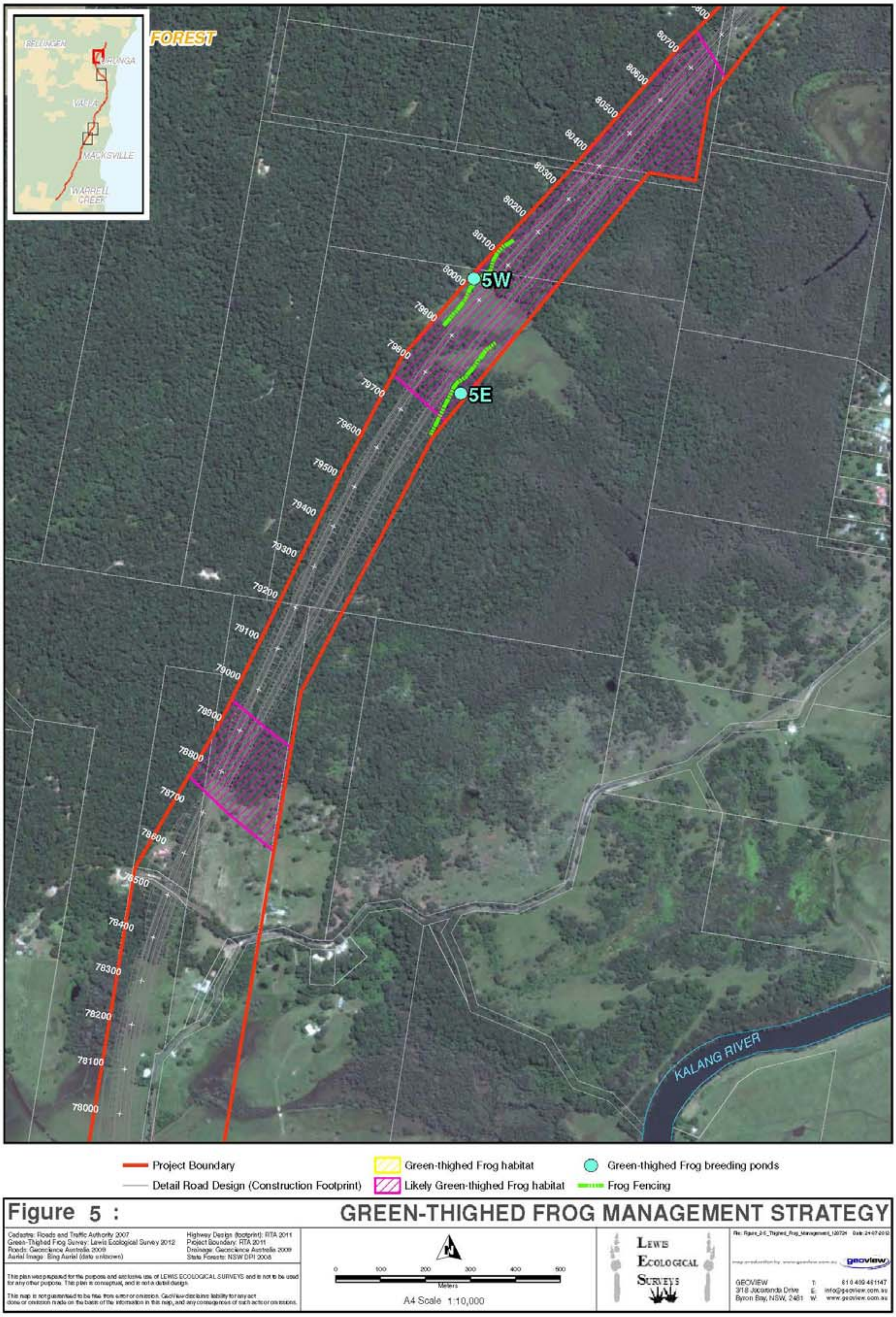

Figure 2-4. Likely Green-thighed Frog habitat within the RMS corridor and proposed mitigation strategies for the northern construction stage Nambucca Heads to Urunga.

2.2 Protection of Existing Habitat

Following the identification of Green-thighed Frog habitat these areas must be protected from construction related works other than what is considered essential. The locating of access tracks, utilities redistribution, car parking facilities and other ancillary works including topsoil stock piles, lay down areas, wash down bays, site shedding and compound sites must not be located in these areas. This approach will be in accordance with MCoA:

C1. The Proponent shall employ all feasible and reasonable measures to minimise the clearing of native vegetation to the greatest extent practicable during the construction of the project

C27 Unless otherwise approved by the Director General in accordance with this condition, the sites for ancillary facilities associated with the construction of the project shall (c) be located in areas of low ecological significance and require minimal clearing of native vegetation (not beyond that already required by the project).

The protection of the identified areas should include the demarcation of clearing limits and signage identifying these areas as 'no go' zones.

Due consideration is required for drainage works and the design given that road projects of this nature normally improve drainage rather than impede it for Green-thighed Frog. Where this cannot be achieved the provision of frog breeding ponds should provide an adequate mitigation tool provided they are constructed correctly (*see* Section 2.4).

2.3 Pre-clearing Surveys

Frog surveys will be limited to active searches set at 15 minutes per hectare of suitable microhabitats immediately prior (<2 hrs) to commencing clearing operations. Active searches will involve the use of a small wrecking bar to actively turn rocks, logs, rake debris and search within low dense vegetation around depressions and drainage lines. The requirement for nocturnal surveys will be made at the discretion of the Project Ecologist performing the pre clearing surveys.

Captured frogs will be held temporarily in a plastic bag with a small amount of water (1 frog per bag) and relocated in areas of suitable habitat adjacent to the clearing footprint and not more than 200 m from the capture site. This is consistent with Department of Environment and Climate Change (DECC) Hygiene protocol for the control of disease in frogs.

2.4 Creation of Breeding Ponds

Five locations have been identified as suitable recipient sites for frog breeding ponds with three located in the Warrell Creek to Nambucca Heads Upgrade section and two in the Nambucca Heads to Urunga section (Table 2-1; Figure 2-1 to 2-5).

The key element with designing a breeding site for Green-thighed Frog 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, a temporary water body should hold surface water for between 40-50 days at sunny exposed sites and for between 60-80 days at shaded locations following a suitable summer rainfall event of 100-150 mm in 24-36 hours.

Another key message in the design of the breeding ponds is to not over design the pond and replicate features from other known breeding locations on the mid north coast and thus provide the best opportunity for a successful breeding event. Essentially, a simple shallow excavation that will hold water for the required period is all that is needed as this species has been regularly encountered breeding in inundated motor vehicle wheel ruts, disused logging dumps, roadside culverts and eroded gully lines (B. Lewis unpublished data). Where possible a number of options should be proposed and can include *in situ* habitat if it is deemed suitable. The design and construction of breeding ponds will be supervised by the Project Ecologist.

Table 2-1. Summary of proposed Green-thighed Frog breeding pond locations. Ponds constructed as per Figure 2-5.

Site No.	Side of Carriageway	Chainage (north from Kempsey)	Design (*see* Figure 2-5)	Landscaping	Substrate	Action
Warrell Creek to Nambucca Heads						
1E	Eastern side of carriageway	58015	• Five 4x3 m ($12m^2$). • Maximum depth 400 mm. • No steeper than a 1:4 battered slope. • Install a water staff.	• Vegetated after construction • Open swale vegetated with grass or sedges (i.e. *Carax sp.*, *Fimbristylis*).	• In situ soil/clay obtained at or near to the site.	• Locate adjacent to drainage line (southern side) within RMS corridor (i.e. Flooded Gum/Blackbutt overstorey). • Ponds to support water for up to 60-80 days. • Ponds staggered upslope to allow for variability in rainfall/flooding and hence drying out.
1W	Western side of carriageway	58165	• Five 4x3 m ($12m^2$). • Maximum depth 400 mm. • No steeper than a 1:4 battered slope. • Install a water staff.	• Vegetated after construction • Open swale vegetated with grass or sedges (i.e. *Carax sp.*, *Fimbristylis*).	• In situ soil/clay obtained at or near to the site.	• Locate in open area within RMS corridor on upper slopes/ridge line (i.e. Blackbutt Forest). • Ponds to support water for up to 60-70 days.
2S	Southern side of carriageway	60065	• Five 4x3 m ($12m^2$). • Maximum depth 400 mm. • No steeper than a 1:4 battered slope. • Install a water staff.	• Vegetated after construction • Open swale vegetated with grass or sedges (i.e. *Carax sp.*, *Fimbristylis*).	• In situ soil/clay obtained at or near to the site.	• Locate in open area within RMS corridor. • Ponds to support water for up to 60-70 days.

Site No.	Side of Carriageway	Chainage (north from Kempsey)	Design (*see* Figure 2-5)	Landscaping	Substrate	Action
2N	Northern side of carriageway	60065	• Five 4x3 m ($12m^2$). • Maximum depth 400 mm. • No steeper than a 1:4 battered slope. • Install a water staff.	• Vegetated after construction • Open swale vegetated with grass or sedges (i.e. *Carax sp.*, *Fimbristylis*).	• In situ soil/clay obtained at or near to the site.	• Investigate the suitability of ponds between new carriageway and Old Coast Road once final design is completed. **Note** – need to avoid locating ponds in areas where it may increase road strike. May need to position on northern side of Old Coast Road or alternatively reposition ponds at ch. 59715.
3	Eastern side of carriageway	60865	• Five 4x3 m ($12m^2$). • Maximum depth 400 mm. • No steeper than a 1:4 battered slope. • Install a water staff.	• Vegetated after construction • Pond and verges to include native grasses or sedges (i.e. *Fimbristylis* or *Carax sp.*).	• In situ soil/clay obtained at the site.	• Locate on high point (i.e. ridge) in dry sclerophyll forest where Scribbly Gum is present. • Ponds to support water for up to 60-70 days. • Position southern side of Old Coast Road.
	Nambucca Heads to Urunga					
4	Both sides of carriageway	74665	On each side construct: • Five 4x3 m ($12m^2$). • Maximum depth 400 mm. • No steeper than a 1:4 battered slope. • Install a water staff.	• Vegetated after construction • Pond and verges to include native grasses or sedges (i.e. *Fimbristylis* or *Carax sp.*).	• In situ soil/clay obtained at the site.	• Locate ponds adjacent to drainage line to adjust for various hydrological regimes associated with flooding (i.e. stepping ponds away from creek line). • Ponds to support water for up to 60-80 days.
5E	Eastern side of carriageway	79845	On each side construct: • Five 4x3 m ($12m^2$). • Maximum depth 400 mm. • No steeper than a 1:4 battered slope. • Install a water staff.	• Vegetated after construction • Pond and verges to include native grasses or sedges (i.e. *Fimbristylis* or *Carax sp.*).	• In situ soil/clay obtained at the site.	• Locate ponds on edge of forest in open pasture. • Ponds to support water for ~60 days.
5W	Western side of carriageway	80015	On each side construct: • Five 4x3 m ($12m^2$). • Maximum depth 400 mm. • No steeper than a 1:4 battered slope. • Install a water staff.	• Vegetated after construction • Pond and verges to include native grasses or sedges (i.e. *Fimbristylis* or *Carax sp.*).	• In situ soil/clay obtained at the site.	• Locate ponds on edge of forest in open pasture at toe of slope. • Ponds to support water for 60-80 days.

a. September 2011 b. September 2011 c. March 2012

Figure 2-5. Construction of Green-thighed Frog ponds at Fill 6 Kempsey Bypass project (September 2011-March 2012).

2.5 Design and Installation of Permanent Frog Fencing

2.5.1 Temporary Frog Fencing

Temporary frog fencing will be installed at all known Green-thighed Frog locations currently limited to Ch.60065 and Ch.60865. At both of these locations, temporary frog fencing is to extend for 100-150 m with the upper and lower limits to be finalised following consultation with the Project Ecologist. The temporary frog fence should have the following design considerations:

a) Fence height of at least 500 mm[1] and buried to a depth of at least 50-100 mm;
b) Return wing of 3-5 metres to reduce the opportunity for frogs to breach the fence;
c) The installed fence will be inspected/signed off by an ecologist with sufficient frog expertise. This procedure should form part of the pre clearing/ground disturbance checklist/permit.
d) Fencing will be installed within 72 hrs of the clearing of the construction footprint[2].

2.5.2 Permanent Frog Fencing

Frog fencing will be installed in areas where Green-thighed Frog ponds have been constructed. The fence will span a minimum of 125 m on either side of the frog ponds to reduce the incidence of road strike. Further frog fencing may be required by the Project Ecologist after further surveys have been undertaken (i.e. following the results of pre-clearing surveys). As a minimum the following chainages require frog fencing:

- Eastern side of ch. 57890-58140;
- Western side of ch. 58040-58290;
- Both sides of ch. 59940-60190;
- Eastern side of ch. 60740-60990 (noting abutment works associated with Old Coast Road may alleviate need for frog fencing);
- Both sides of ch. 74540-74790;
- Eastern side of ch. 79720-79970; and
- Western side of ch. 79890-80140.

Design wise, the frog fencing must be a standalone fence positioned between the floppy top fauna fence and the carriageway (i.e. toe of the batter). From a design perspective, the fence will stand 500 mm in height and comprise neoprene rubber sheeting including a small rubber return of not less 100 mm on the ground. The fence hot dip galvanized pressed sheet metal or powder coated aluminum pressed sheet mounted on a galvanized star picket (Figure 2-6).

[1] This height is considered sufficient to avoid the need to have a return lip at the top of the fence given its temporary nature and the objective of discouraging frog movement into the construction zone.
[2] It is not considered practical to install a frog fence prior to clearing as it will be damaged during the clearing operation. The pre-clearing survey performed by the Project Ecologist has the objective of capturing frogs within the clearing zone immediately prior to clearing.

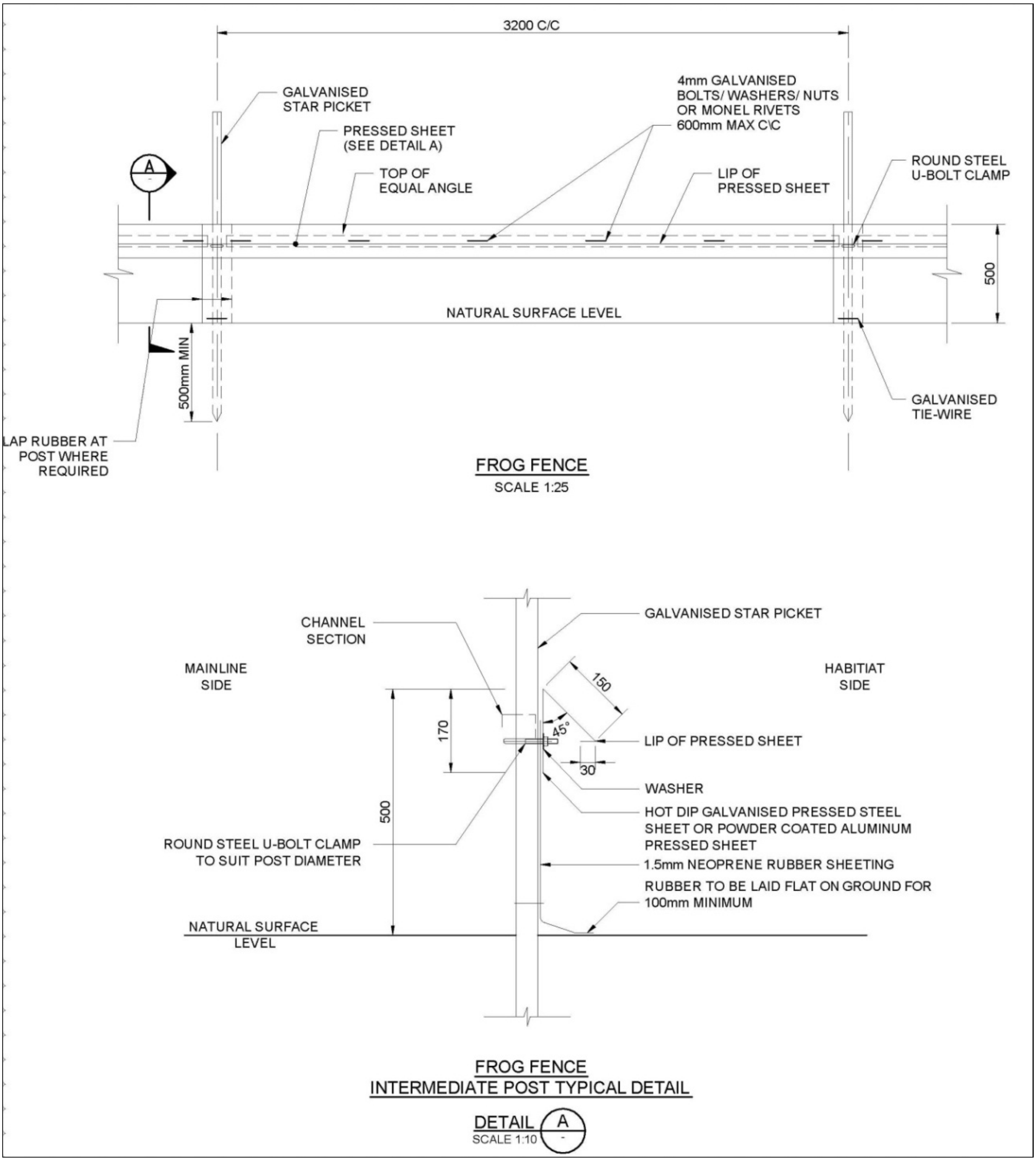

Figure 2-6. An example of frog fence design that could be used for Warrell Creek to Urunga.

As part of the monitoring procedures for measuring the effectiveness of the frog fencing some specific monitoring for frog fencing breaches must be undertaken by a suitable qualified zoologist at certain times of the year (i.e. when breeding pond monitoring occurs). Moreover, surveys for frogs will be undertaken on either side of the frog fence. The success of this design will be based on the absence of Green-thighed Frog fence breaches.

2.6 Unexpected Finds Process

An unexpected finds process has been developed to manage instances where Green-thighed Frog may be detected during pre-clearing surveys or during clearing operations for the upgrade. This is in response to field surveys not being undertaken at a suitable time in the northern part of the study area (ch. 66765-82765) and the cryptic nature of this species. For example the area between ch.78765 and ch.78965 is considered suitable for Green-thighed Frogs but there appears to be an adequate amount of breeding areas adjacent to the RMS corridor. Given this, it was not considered necessary to nominate this area in preference for other suitable habitat ~ 1 km to the north where ponds have been proposed (i.e. ch. 79845).

Where the above occurs, unexpected finds process requires the adoption and implementation of strategies outlined in this plan; specifically the provision for protection of existing habitat, creation of breeding ponds, installation of permanent fencing and the associated monitoring outlined in Section 2.8 of this strategy.

2.7 Updating the Management Strategy

This management strategy would be updated following the discovery of additional Green-thighed Frog locations/population and the need for additional measures including but not limited to frog fencing and breeding ponds. This is applicable for either the Warrell Creek to Nambucca Heads or Nambucca Heads to Urunga sections of the Warrell Creek to Urunga project.

2.8 Monitoring of Green-thighed Frogs

Two components have been identified for the monitoring of Green-thighed Frogs:

1) Monitoring of breeding ponds; and
2) Monitoring the integrity of the frog fences

2.8.1 Green-thighed Frog Breeding Ponds

All five breeding pond locations would be monitored; however, the monitoring would be staggered over two construction periods. The timing identified below aligns with the Nambucca to Urunga section of the Upgrade.

i. Timing

Monitoring will be undertaken on five occasions in Years 4-8 with each event at least 10-12 months apart but ultimately dependant on rainfall events (Table 2-2). On each occasion the site would be surveyed for 30 minutes during stage 1 and for 20 minutes during stage 2 (see below). Most of these monitoring events would occur during the operational phase of the project (Years 5-8). Monitoring would commence once the vegetation on the edges of the constructed ponds is considered sufficient (>20% groundcover). The timing would be staggered accordingly for the Warrell Creek to Nambucca Heads section of the upgrade.

ii. Monitoring Procedure

Monitoring of the constructed breeding ponds would be undertaken on a rainfall event basis when 24 hr rainfall totals exceed 75 mm or a cumulative total of 150 mm over a 72 hour period[3]. Such rainfall events would be monitored via 'on site' weather stations which are to be programmed to generate a sms message to the field survey team phone, and alternatively, the Bureau of Meteorology (BOM) website and specifically the Nambucca Heads Bowling Club (Station No. 059024). Surveys would be performed using a two stage process outlined below.

Stage 1 – Determining Presence and Breeding Activity

Upon the study area receiving the required rainfall, a reference site would be visited to determine the extent of Green-thighed Frog activity. At present, a site near ch. 60065 has been nominated given it is

[3] 50 mm is often proposed, however, it is rarely considered suitable; B Lewis unpub data.

readily accessible, however, efforts should be made to locate another site which is not going to be removed/disturbed by the upgrade. Sites to the north in Nambucca State Forest represent other suitable locations as reference sites. Regardless of the outcomes of this survey, the constructed ponds and their surrounds would also be surveyed.

The survey would comprise a 30 minute nocturnal active search at each of the three breeding pond areas using a hand held spotlight. Peripheral habitats (i.e. <100 m) would also be surveyed at this time. Upon the completion of Stage 1 surveys the next stage would be implemented.

Stage 2 – Determining the Success of the Breeding Event

All sites would be subject to follow-up surveys between 30-50 days after the initial census to assess the outcome of the breeding event. This follow up survey will comprise:

- A 20 minute active search for metamorphs and juvenile frogs around the pond edge and vegetation immediately adjacent to the pond (i.e. <10 m);
- Dip-netting of the constructed pond and subsequent tadpole identification. Specific attention will be given toward identifying the presence of fish (both native and exotic) along with predatory invertebrates such as dytiscid larvae;
- The depth of the ponds would be measured from the permanently installed water staff; and
- Photo taken from a designated photo point.

iii. Performance Indicators

Performance indicators of success will be based on either the:

- Continued presence of Green-thighed Frog at Sites 2S, 2N and 3;
- Green-thighed Frogs calling from the edge of the constructed ponds; or
- The presence of tadpoles, juveniles or metamorphs during follow up surveys.

Signs of the mitigation being unsuccessful will be based on the:

- Absence of Green-thighed Frogs from sites 2S, 2N and 3. The corrective action for this would be to firstly, implement additional surveys of adjacent areas to confirm Green-thighed Frogs remain in that general area, and secondly, undertake a review and if deemed necessary modify the ponds to improve an site suitability problems.
- Ponds not holding water for a sufficient time to enable tadpoles to reach metamorphosis. The corrective action for this would involve a review and if deemed necessary, modify the ponds by placing a semi permeable layer or further excavation.
- Ponds holding water for too long and representing unsuitable habitat (i.e. permanent versus ephemeral).The corrective action for this would be to improve drainage to ensure the ponds dries out.
- Exotic fish fauna recorded in breeding ponds. The corrective action for this would be to improve drainage to ensure the pond dries out.

A summary of the timing, responsibilities and documentation requirements is outlined below in Table 2-2.

Table 2-2. Timing of key actions, responsibilities and documentation requirements.

Management Action / Year Number	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Responsibility	Documentation Requirements
Pre Construction										
Prepare Green-thighed Frog Management Strategy	√								RMS	Construction Environmental Management Plan
Construction										
Habitat Protection		√	√	√					Contractor	Ecological Monitoring Program
Pre-clearing Surveys		√	√						Contractor	Ecological Monitoring Program Post Clearing report Green-thighed Frog Management Strategy (updated)
Temporary Frog Fencing		√	√						Contractor	Construction Environmental Management Plan
Permanent Frog Fencing			√	√					Contractor	Ecological Monitoring Program
Breeding Ponds			√	√					Contractor	Ecological Monitoring Program
Unexpected Finds Procedure		√	√	√					Contractor	Green-thighed Frog Management Strategy (updated) Ecological Monitoring Program
Post Construction / Operation										
Monitoring effectiveness of mitigation				√	√	√	√	√	Contractor	Ecological Monitoring Program - Annual reporting

3.0 REFERENCES

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4.0 APPENDIX A – TEST OF SIGNIFICANCE

Introduction

The following assessment of significance was conducted for the Green-thighed Frog in accordance with the *Draft Guidelines for Threatened Species Assessment* (Department of Environment and Climate Change and Department of Primary Industries 2005). This was in response to Green-thighed Frog not being previously considered in the Environmental Assessment (SKM 2010) and its subsequent discovery at two locations and identification of others areas of suitable habitat during field surveys in February 2012 (Lewis in prep).

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

The Green-thighed Frog inhabits rainforest, moist eucalypt forest, swamp forest, dry eucalypt forest and heath, typically within a few hundred metres of areas that gather surface water after rain (Mahony 1993; Barker *et al.* 1995; Cogger 1995; Lemckert *et al.* 1997; Lemckert 1999; Murphy and Turnbill 1999; Lewis 2000). Breeding is triggered following heavy rainfall (i.e. > 75 mm in 24 hrs or 150 mm in 72 hrs) in late spring, summer or autumn, with frogs aggregating around flooded ephemeral pools (Lewis 2012).The tadpole stage is relatively short lived with tadpoles undergoing metamorphosis normally in 35-50 days (B. Lewis unpub data).

Green-thighed Frog Habitat in the study area

Green-thighed Frog is known from Nambucca State Forest at ch.60065 and ch.60865 with historic records occurring in areas adjacent to these chainages (Figure A-1). A small number of male frogs were recorded calling at these locations and subsequent follow up surveys were unable to locate any metamorphs to confirm the success of the summer 2012 breeding event. It was concluded that these sites would require more prolonged rainfall events to enable successful breeding.

This species is considered likely to occur further to the south in Nambucca State Forest, particularly the low lying habitats between ch.57365 and ch.59365. Further north in the Nambucca to Urunga area, Green-thighed Frog is considered likely to inhabit the following areas:

5. The low flat area that supports wet forest with swamp forest associations between ch.74665 and ch.74965 – Newry State Forest between Cut 20 and Martells Road (Cryptic Orchid habitat).
6. The low lying area between ch.78765 and ch.78965 – north of the Kalang River and local access road 6.
7. The two low lying drainages between ch.79765 and ch.80765 – Riddel property.

Potential impacts of the Upgrade on this species

The Upgrade has the potential to affect the lifecycle of the Green-thighed Frog in a number of ways during the construction and operational phases of the project. During the construction stage the impacts will largely be centred on the removal of refuge and breeding habitat and interim changes to hydrological processes as the clearing and bulk earthworks progress. These interim changes may remove some breeding locations, alter others with altered overland flows and create new breeding areas. With regard to the removal of habitat the current clearing estimates for construction show the removal of 255 ha of native vegetation which consisting of dry sclerophyll forest (144.11 ha), moist sclerophyll forest (63.16 ha), swamp forest (45.54 ha), rainforest (0.58 ha) with the residual areas comprised of mangroves and wetlands. An estimated 50 ha of either known or suitable habitat for Green-thighed Frog would be removed to accommodate the carriageway with some residual and secondary impacts associated with changes to local hydrological processes. These impacts will be linear in their nature and are unlikely to remove complete home ranges or territories which tend to extend over a few hundred metres.

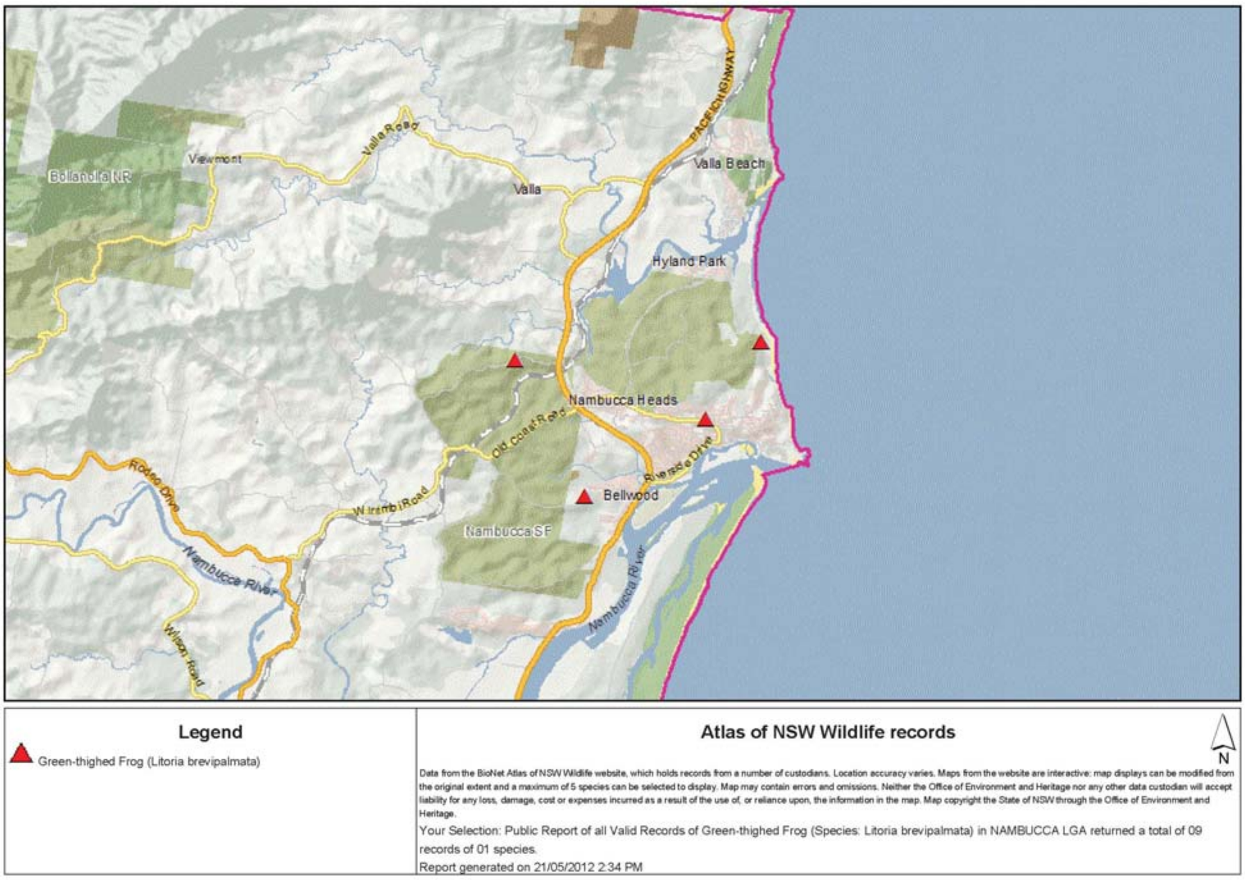

Figure A-1. Location of documented Green-thighed Frog records.

During the operational phase of the project there is some potential for populations to be severed by a paved carriageway or dramatically increase the risk of road strike. There will also be an incremental risk of pollutants entering these areas as a result of a motor vehicle accident thereby reducing overall habitat quality. Specific measures will reduce these risks with the current concept design providing for culvert structures (i.e. ch. 57650, 58395, 58970, 60280, 61115, 32075, 78670, 79715, 80095), protection of water courses, frog exclusion fencing and the provision of breeding ponds on either side of the carriageway. These later measures have been outlined in this management strategy for the Green-thighed Frog.

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

The Upgrade will affect the habitat of Green-thighed Frog via habitat removal, habitat modification and potentially the creation of barriers to habitat connectivity.

Habitat Removal

The Upgrade will remove an estimated 255 ha of native vegetation of which 50 ha is considered either known or potential habitat for the Green-thighed Frog. This impact will be linear in nature and seldom exceed 125 m in width, indicating it is unlikely to remove the entirety of a home range or territory which extends over a few hundred metres. The locating of access tracks, utilities redistribution, car parking facilities and other ancillary works including topsoil stock piles, lay down areas, wash down bays, site shedding and compound sites will avoid areas of known or potential Green-thighed Frog habitat. This approach will be in accordance with MCoA:

C1. The Proponent shall employ all feasible and reasonable measures to minimise the clearing of native vegetation to the greatest extent practicable during the construction of the project

C27 Unless otherwise approved by the Director General in accordance with this condition, the sites for ancillary facilities associated with the construction of the project shall (c) be located in areas of low ecological significance and require minimal clearing of native vegetation (not beyond that already required by the project).

Habitat Modification

Changes in the local hydrological processes are expected to occur during the construction of the Upgrade. At this time, some areas previously used as breeding sites may receive altered flow regimes and during heavy rainfall events (>50 mm in 24 hrs) increased sediment loads. The overall magnitude of these impacts are considered relatively benign for Green-thighed Frog which tends to display generalised habits in its selection of ephemeral breeding sites. Often roads, wheel ruts on seldom used tracks, earth bunds and borrow pits are selected as breeding sites on the mid north coast of NSW. The amount of vegetation surrounding these ponds does not appear to influence breeding site selection (B. Lewis unpub data).

Habitat pollution arising from hydrocarbons, chemical spills and other contaminants have the potential to reduce overall habitat suitability as breeding sites may become contaminated. Standard construction environmental management practices will reduce this risk during the construction phase of the project whilst the locating of multiple breeding ponds on either side of the carriageway at known locations will reduce the overall risk to any given frog population.

With respect to forecasting edge effects, the Upgrade is estimated to impact on 126 ha of vegetation with the most profound effects occurring in the moist forest types. Around 30 ha would be relevant to Green-thighed Frog habitat and the resultant changes in vegetation species composition and floristic structure will probably have little effect on the way Green-thighed Frogs use the residual habitat.

Summary

An estimated 50 ha of known and potential Green-thighed Frog habitat will be impacted by the Upgrade. These habitats are recognised as being widespread in the Nambucca, Newry and Kalang areas and shouldn't be considered significant at a local or regional scale. For example, the known records of Green-thighed Frog in the coastal lowlands and foothills around Nambucca Heads suggest a somewhat widespread distribution and this is consistent with the distribution of this species 30 km to the south at Eungai, Clybucca and Tamban.

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

The Green-thighed Frog is not at its distributional limit in the Warrell Creek to Urunga study area. This species inhabits coastal and sub coastal areas from near Bundaberg (Cordalba) in the north (Queensland) to Ourimbah (i.e. central coast NSW) in the south (Mahony 1993; Barker *et al.* 1995; Cogger 1995; Lemckert *et al.* 1997; Lemckert 1999; Murphy and Turnbill 1999; Lewis 2000).

How is the Proposal likely to affect current disturbance regimes?

A number of disturbance regimes are currently recognised in the study area and include:

- the loss of mature forest and tree hollows;
- weed invasion;
- inappropriate fire regimes;
- draining of wetlands;
- increased nutrient loads in aquatic habitats; and
- the presence of introduced predators.

The creation of a new road has the potential to affect the current disturbance regimes through vegetation clearing and altering hydrological regimes. The route selection process sought to minimise the severity of disturbance regimes by appropriate placement of the corridor. Further measures to reduce the residual impacts include construction and operational management practices, drainage design and sediment control, weed management and rehabilitation. The Upgrade is considered unlikely to significantly affect these current disturbance regimes.

How is the Proposal likely to affect habitat connectivity?

The coastal foothills and plains between Warrell Creek and Urunga support a mosaic of vegetation with numerous small patches in the 1-10 ha range occurring on private lands and larger contiguous patches (i.e. >100 ha) generally being confined to public lands of Nambucca and Newry State Forests and private lands to the north of the Kalang River. It is these patches that are recognised as providing habitat for the Green-thighed Frog.

The Upgrade would result in an increase of these smaller patches and a decrease in overall patch size. Assuming that populations or meta populations of Green-thighed Frog show some form of site fidelity to an area of breeding sites, then impacts may remain relatively begin provided the new carriageway doesn’t isolate known sites to isolated patches of <20 ha. Based on the current design and known occurrences of Green-thighed Frog this is unlikely to occur.

It is conceivable that the Upgrade will affect habitat connectivity as the newly constructed carriageway will have paved surfaces exceeding 50 m and accommodate high volumes of traffic, day and night. The use of frog fencing and culvert and bridge structures in areas of known and potential Green-thighed Frog habitat will increase the permeability of the carriageway with the current concept design providing suitable structures at ch. 57650, 58395, 58970, 60280, 61115, 32075, 78670, 79715, 80095. This should enable existing populations to remain as a single population, genetically unaffected by the Upgrade. Monitoring of these fauna underpasses combined with the monitoring of frog breeding ponds and frog fencing will determine the success of these as mitigation tools at maintaining habitat connectivity.

How is the Proposal likely to affect critical habitat?

None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW.

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Warrell Creek to Urunga

Report name	**Green-Thighed Frog Management Strategy (October 2012)**		
Agency name	**Department of Planning and Infrastructure**		
Date	**1 March 2013**		
Comment number	**Report section/ ref**	**Comment**	**RMS Response**
1.	2.1 Identification of Green-thighed frog habitat	Targeted survey was undertaken in the Nambucca Floodplain Investigation Area in October 2012 – please: • Identify the investigation area; and • Provide copy of the survey report.	No separate report was produced. The reference to Lewis inprep will be removed. The section now reads as *The northern part of the study area did not receive the required rainfall during the field survey period. It was still subject to field surveys between January and March 2012 to look for frogs and to identify suitable areas of breeding habitat.* The GTF management strategy was updated with any relevant information once surveys had been completed within the Nambucca Floodplain Investigation area. Apart from some small properties within the Nambucca Investigation area (which could be viewed from the road or surveys performed nearby) the whole WC2U footprint was surveyed.
2.		The northern section of the study area was not surveyed due to insufficient rainfall. The area is suspected to provide frog habitat. The department recommends survey of the area be undertaken to confirm presence/absence of the frog and the determination of appropriate/additional mitigation measures (i.e, fencing/breeding ponds).	Based on field surveys performed between January and March 2012 those areas suspected as containing green-thighed frog have been identified for frog fencing, breeding ponds etc. Refer to figure 2-3 and 2-4. The identification of this habitat in the absence of the site receiving enough rainfall is based on the author's expert knowledge of this species. The areas identified in Figure 2-3 and 2-4 would be very difficult to access once the site received >100 mm in 24 hrs. RMS has adopted the pre cautionary principal and accepted the advice of those areas as likely Green-thighed Frog habitat and proposes to install the appropriate frog mitigation measures (i.e. ponds + fencing)

Report name	**Green-Thighed Frog Management Strategy (October 2012)**		
Agency name	**Department of Planning and Infrastructure**		
Date	**1 March 2013**		
Comment number	**Report section / ref**	**Comment**	**RMS Response**
			The opportunity to undertake further addition surveys for this species has now lapsed. A suitable weather event occurred in the study area on the 26-27th January and again on the 21st February.
3.	Table 2-1	The Table refers to Figure 3-4, which is not included in the Strategy.	Amended to Figure 2-5
4.	Figure 2-6	The figure is hard to read – include a higher quality figure.	Figure quality presents fine in the word document. It might be a PDF formatting problem.
5.	2.6 Unexpected finds	This process is suitable for unexpected finds during construction. Additional targeted survey in the northern section should be undertaken following suitable rainfall and during the optimal season to determine the location of temporary fencing. The unexpected finds process would then be followed should frogs be encountered in the construction area.	See comments in relation to Comment 2 above
6.		Updating of the Strategy should be discussed in a separate section, and be considered when additional measures are required (fencing/breeding ponds) following unexpected finds or additional targeted surveys.	Amended and created section 2.7
7.	2.7.1 Stage 1	The reference site(s) should be identified in the relevant figure (2-1 – 2-4).	The strategy refers to a reference site at ch. 60065 which has been identified in figure 2-1 as green thighed frog habitat; this is also the approximate areas of where green thighed frog breeding ponds are proposed to be installed. It should also be noted that reference sites often change in response to localised rainfall conditions and can even respond in relation to roadside maintenance works such as the grading of a gravel road. Rather than pin point an area on one of the figures it is best left to the ecologist implementing the program to find an appropriate

Report name	Green-Thighed Frog Management Strategy (October 2012)		
Agency name	**Department of Planning and Infrastructure**		
Date	**1 March 2013**		
Comment number	**Report section / ref**	**Comment**	**RMS Response**
			reference location after taking into account the extent of rainfall and the localised site conditions. Past experience has shown that reference sites and their suitability may change over time or that multiple reference sites may be needed.
8.	Stage 2	The Strategy should include discussion of contingency measures should monitoring demonstrate the performance indicators of the mitigation measures are not being met.	Amended to show the following: • Absence of Green-thighed Frogs from sites 2S, 2N and 3. The corrective action for this would be to firstly, implement additional surveys of adjacent areas to confirm Green-thighed Frogs remain in that general area, and secondly, undertake a review and if deemed necessary modify the ponds to improve an site suitability problems. • Ponds not holding water for a sufficient time to enable tadpoles to reach metamorphosis. The corrective action for this would involve a review and if deemed necessary modify the ponds by placing a semi permeable layer or further excavation. • Ponds holding water for too long and representing unsuitable habitat (i.e. permanent versus ephemeral).The corrective action for this would be to improve drainage to ensure the ponds dries out. • Exotic fish fauna recorded in breeding ponds. The corrective action for this would be to improve drainage to ensure the pond dries out.

Warrell Creek to Urunga

Report name	**Green-Thighed Frog Management Strategy (October 2012)**		
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Comment number	**Report section/ ref**	**Comment**	**RMS Response**
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Appendix F
Microchiropteran Bat Management Strategy

PACIFIC HIGHWAY UPGRADE:

WARRELL CREEK TO URUNGA

MICROCHIROPTERAN BAT MANAGEMENT STRATEGY

OCTOBER 2014

PREPARED FOR ROADS AND MARITIME SERVICES BY:

LEWIS ECOLOGICAL SURVEYS

....
Author
Ben Lewis
(B. App Science – Hons)

...2nd October 2014......
Date

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ACKNOWLEDGEMENTS

Ben Lewis (Lewis Ecological Surveys) – Field surveys, report author.

Greg Ford (Balance Environmental) – Bat call analysis.

Kristy Harvey (Roads and Maritime Services) – Project management, background data and review tables.

Belinda Bock (Roads and Maritime Services) – Project management, background data.

Brett Hoffman (Roads and Maritime Services) – Project manager and logistics.

Josie Stokes (Roads and Maritime Services) – Document review.

Shayne Walker (Roads and Maritime Services) – Document review.

Andrew Mula (Roads and Maritime Services) – Document review.

Photography - Lewis Ecological Surveys © else stated

Top – The vulnerable Southern Myotis (*Myotis macropus*) from Culvert Structure 599306
Left to Right – Pacific Highway Bridge over Deep Creek; Southern Myotis using Culvert C – 599271 (Cow Creek) and Culvert 599205 (Deadman's Gully) also utilised by Southern Myotis.

Report to be cited as: Lewis, B.D (2014). Warrell Creek to Urunga: Microchiropteran Bat Management Strategy. Report prepared for Roads and Maritime Services by Lewis Ecological Surveys. ©

Distribution History:

Version	Date	Issued To	Position	Name
A	15.5.2012	Roads and Maritime Services	Environmental Officer	Kristy Harvey
B	19.6.2012	Roads and Maritime Services	Environmental Officer	Kristy Harvey
C	26.6.2012	Roads and Maritime Services	Environmental Officer	Kristy Harvey
D	29.6.2012	Roads and Maritime Services	Environmental Officer	Kristy Harvey
E*	26.10.2012	Roads and Maritime Services	Environmental Officer	Belinda Bock
F	10.1.2013	Roads and Maritime Services	Environmental Officer	Belinda Bock
G	16.1.2013	Roads and Maritime Services	Environmental Officer	Belinda Bock
H	18.1.2013	Roads and Maritime Services	Environmental Officer	Belinda Bock
I	25.1.2013	Roads and Maritime Services	Senior Biodiversity Specialist	Josie Stokes
J	10.2.2013	Roads and Maritime Services	Environmental Officer	Belinda Bock
K	15.4.2013	Roads and Maritime Services	Environmental Officer	Belinda Bock
L	22.4.2013	Roads and Maritime Services	Environmental Officer	Belinda Bock
M	11.9.2014	Roads and Maritime Services	Environmental Officer	Andrew Mula Shayne Walker
N	2.10.2014	Roads and Maritime Services	Environmental Officer	Andrew Mula Shayne Walker

* in response to field surveys on the Nambucca Floodplain Investigation area the management strategy has been updated to include new information.

Revision History:

Rev.	Description	Prepared By	Date	Reviewed By
A	Draft for comment	Ben Lewis (Lewis Ecological Surveys)	19.6.2012	Kristy Harvey
B	Submitted as Final	Ben Lewis (Lewis Ecological Surveys)	22.6.2012	Kristy Harvey
C	Final	Ben Lewis (Lewis Ecological Surveys)	26.6.2012	Kristy Harvey Craig Harre (EPA)
D	Final	Ben Lewis (Lewis Ecological Surveys)	29.6.2012	Belinda Bock (RMS) Josie Stokes (RMS)
F	Draft	Ben Lewis (Lewis Ecological Surveys)	10.1.2013	Belinda Bock (RMS) Josie Stokes (RMS)
G	Draft	Ben Lewis (Lewis Ecological Surveys)	18.1.2013	Belinda Bock (RMS) Josie Stokes (RMS) Tammie Tribe (RMS)
H	Draft	Ben Lewis (Lewis Ecological Surveys)	25.1.2013	Belinda Bock (RMS) Josie Stokes (RMS) Tammie Tribe (RMS)
J	Final	Ben Lewis (Lewis Ecological Surveys)	25.1.2013	Michael Young (DP&I)
K	Final	Ben Lewis (Lewis Ecological Surveys)	19.4.2013	Belinda Bock (RMS)
L	Final	Ben Lewis (Lewis Ecological Surveys)	13.8.2014	Shayne Walker (RMS)
M	Final	Ben Lewis (Lewis Ecological Surveys)	29.9.2014	Shayne Walker (RMS) Principal Contractor (AFJV)

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ABBREVIATIONS

Abbreviation	Description
RCBC	Reinforced Concrete Box Culvert
RCPC	Reinforced Concrete Pipe Culvert
WC2U	Warrell Creek to Urunga Pacific Highway Upgrade
WC2NH	Warrell Creek to Nambucca Heads staged Construction of the WC2U Approval
NH2U	Nambucca Heads to Urunga (northern section of WC2U Pacific Highway Upgrade)
MCoA	Ministers Condition of Approval
EPA	Environmental Protection Authority
RMS	Roads and Maritime Services
LES	Lewis Ecological Surveys
AFJV	Acconia Ferrovial Joint Venture
Vulnerable	Species listed as vulnerable under schedule two of the NSW *Threatened Species Conservation* Act (1995)

1.0 INTRODUCTION

1.1 Background

Lewis Ecological Surveys (LES) has been contracted by Roads and Maritime Services (RMS) to prepare a management strategy following the discovery of microchiropteran bats (hereafter micro bat) utilising bridge and culvert structures associated with the Warrell Creek to Urunga Pacific Highway Upgrade project (Figure 1-1). The preparation of this strategy addresses one component of MCoA **(B30)** Construction Environment Management Plan for the project and specifically part **(b)** *a Construction Flora and Fauna Management Plan to detail how construction impacts on ecology will be minimised and managed*. A component of this plan specifically relates to the management of micro bats **(iv)** *a micro-bat management strategy, in the case that micro bats or evidence of roosting are identified during pre-construction surveys. The strategy shall detail measures to avoid, minimise and mitigate impacts to these species and identified roost sites, including short and long term management measures*.

Sixty-nine (69) structures were surveyed for micro bats or evidence of roosting between December 2011 and October 2012 summarised here as:

- 13 Reinforced Concrete Box Culverts (RCBC);
- 50 Reinforced Concrete Pipe Culvert (RCPC); and
- 6 concrete bridges.

Nine (13%) of the surveyed structures showed evidence of use by three species summarised in Table 1-1.

Table 1-1. Summary of pre-construction field surveys for micro bats and evidence of roosting.
Note: Bold type denotes potential maternity sites

Bat Species	Culvert	Bridge
Southern Myotis (*Myotis macropus*)	• **599205 (Deadman's Gully);** • Culvert 599222; • **Culvert 599271 (Cow Creek);** • Culvert 599293; and • **Culvert 599306 (Dalhousie Creek).**	• **Crouches Creek (7881 at Donnellyville).**
Little Bent-wing Bat (*Miniopterus australis*)	-	• **Pacific Highway Bridge (1871) over Warrell Creek.**
Gould's Wattled Bat (*Chalinolobus gouldi*)	-	• Pacific Highway Bridge (6696) over North Coast Railway at Nambucca Heads; and • **Possibly Crouches Creek (7881 at Donnellyville)**
Unknown Species (Scats only)	• Culvert 599292.	-

Although there was no observations of bats breeding (i.e. maternity) in any of the surveyed structures, those highlighted in bold type in Table 1-1 are considered likely to be used as maternity sites and require due consideration as part of this management strategy.

Both the Southern Myotis and Little Bent-wing Bat are currently listed as vulnerable species pursuant to the NSW *Threatened Species Conservation* Act (1995). None of the recorded species are currently listed under the Commonwealth *Environmental Protection and Biodiversity Conservation* Act (1999). Consideration has been given to the potential occurrence of the Large-eared Pied Bat (*Chalinolobus dwyeri*) which is currently listed as vulnerable pursuant to the *EPBC* Act (1999).

The main limitation of the summer field surveys were that they did not account for temporal variation whereby some micro bats may actually select sites for over wintering or may simply utilise one or more of the structures in response to other seasonal gradients or environmental cues. For example, the flooding of a low lying bridge may force bats to utilise an alternative roost. To address this, an assessment on the roost sites suitability of each structure was undertaken with this resulting in the identification of 15 potential micro bat roost sites [1] (Appendix 1).

[1] A potential roost site provides the necessary attributes considered favourable or conducive to bats selecting the site as a roost (i.e. sufficiently high enough above the ground, overhanging water, at least 20 mm gaps but not overly large <100 mm).

Five of these occur south of the Nambucca Heads Interchange (ch. 61265) near the intersection of Old Coast Road (599237 and 599238) and Bald Hill Road (599228 and 599229) with the remainder occurring in the northern section of the upgrade works (i.e. 599265, Boggy Creek Bridge - 6697, 599272, 599274, 599276, 599282, 599291, 599302, 599323 and 599325). All of the above structures are depicted in Appendix 1 with highlighted 'white boxes'.

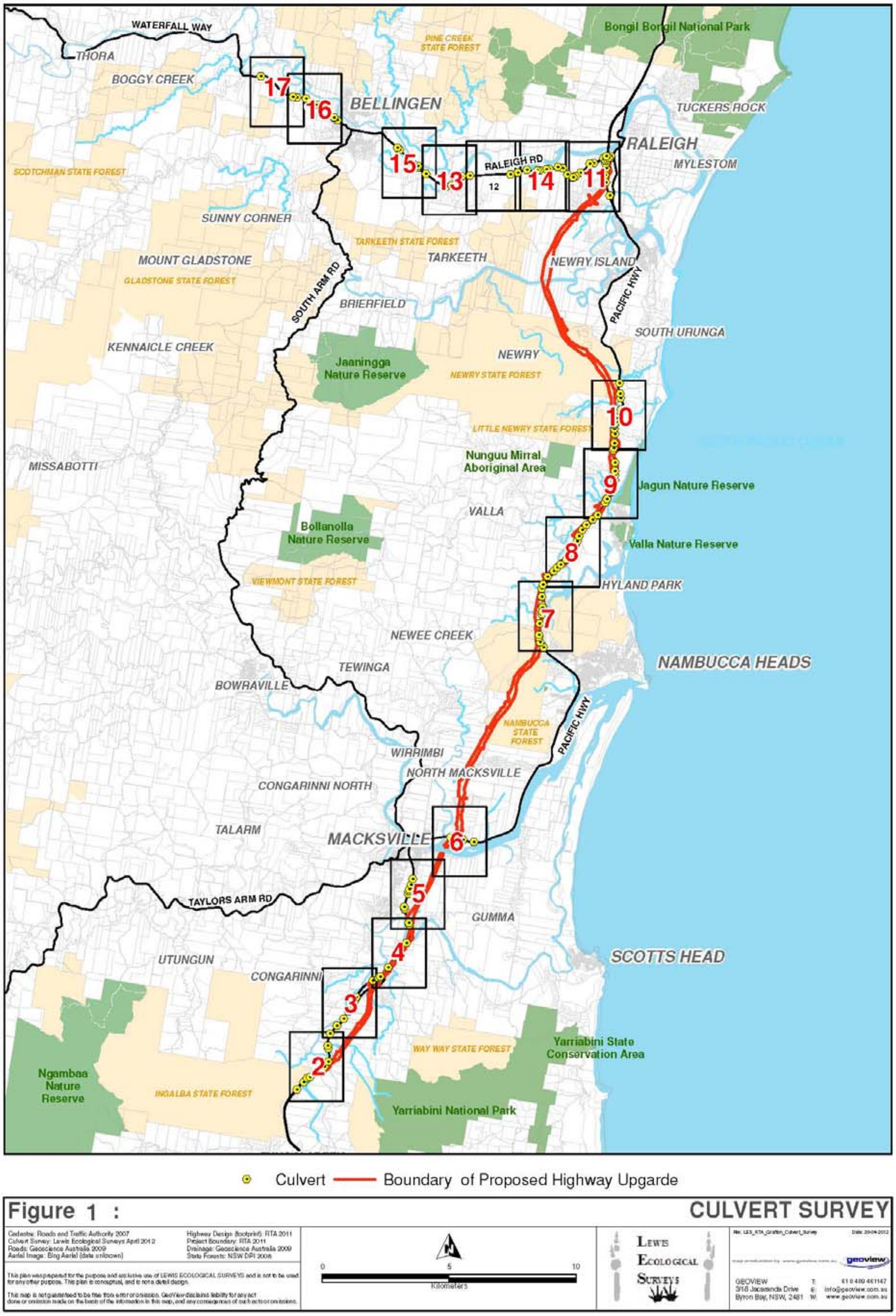

Figure 1-1. Location of culvert structures (inserts 1-11) relevant to this management strategy.

2.0 IMPORTANCE OF THE BAT ROOST

The field surveys identified that 22 of the 69 (32%) culvert and bridge structures provide either known or potential roost habitat for micro bats. Roost habitat and its overall importance is likely to vary between each of the structures and may even vary within the structure itself (i.e. multiple culverts), depending on the species using it, the season (i.e. summer versus winter) or the prevailing environmental conditions (i.e. flood or drought). The challenge for this management strategy is to adjust for varying needs of different species of micro bats that would utilise a particular structure for breeding, during migration, winter hibernation or simply as a temporary site within a broader area of roost site fidelity (i.e. bats may utilise a number of roost sites within close proximity to one another). The field surveys noted extensive areas of alternative potential roost sites at culvert and bridges on local road networks and the North Coast Railway. Many of these structures occurred on the same drainage line and were often within 1 kilometre of the existing Pacific Highway.

This section of the Strategy qualifies the relative importance of each structure (i.e. roost) and how this might be used over a seasonal gradient. They have been classified at three scales of Conservation Value:

- High Conservation Value
- Moderate Conservation Value
- Low Conservation Value.

2.1 High Conservation Value

A roost assigned to this category would require careful planning during the planned roost exclusion and may require additional monitoring if bats are found to be present throughout the year. For example, the Crouches Creek Bridge (7881) may require additional monitoring to evaluate the overall importance of this roost throughout the year. Sites assessed as being high conservation value roosts would also require at least some bat boxes to be installed more than 100 m away from the construction works. Bat boxes would be installed at least 6-12 months prior to construction.

Examples of high conservation value roost sites include:

- Breeding colonies of micro bats regardless of species legislative status (i.e. Southern Myotis at Cow Creek - 599271)
- Colonies of micro bats exceeding 50 individuals (Crouches Creek Bridge 7881)
- Over wintering colonies exceeding 20 individuals (reliance of Strategy B in this plan to provide more detail)
- One individual or more of the nationally vulnerable Large-eared Pied Bat (*Chalinolobus dwyeri*).

2.2 Moderate Conservation Value

A roost assigned to moderate conservation value is used by micro bats but its overall importance does not qualify it as high conservation value. In this instance, the roost is not being utilised for breeding, the roost is made up of relatively few individuals (<50 during warmer times of the year or <20 individuals in the case of an overwintering site) and could be considered a temporal roost. Whilst these may perform a relatively important function for bats during post breeding dispersal or as part of some other seasonal migration the Warrell Creek to Urunga study area supports numerous other roosting opportunities with numerous bridges over waterways, culverts on other roadways, North Coast Railway with bridges and culverts, historic mining works in Newry State Forest and potential sea caves at some of the coastal headlands. In this context, there appears to be an adequate number of 'moderate' conservation roosts in the WC2U study area.

2.3 Low Conservation Value

A low conservation value roost shows no sign of past or current use by micro bats and the roost habitat attributes are such that they could only contain a few individuals of any one species. For example, the 'vertical drainage holes' or 'lift points' in a culvert could theoretically provide habitat for only a few individuals (<5). Other considerations could include the overall configuration of the structure such as its height combined with only shallow or partial inundation of surface water would suggest that roost points would be susceptible to increased predatory pressure. Such roosts may only be used for short periods of time or in response to other roosts that may be disturbed or removed.

3.0 MANAGEMENT STRATEGIES

Seven management strategies have been proposed as a means to avoid, minimise and mitigate impacts to micro bats and identified roost sites, including short and long term management measures. They include:

- **A. Installation of additional roosts**
- **B. Implementing additional field surveys**
- **C. Planned roost exclusion**
- **D. Seasonal limitation of construction works**
- **E. Protection of existing habitat**
- **F. Previously unconsidered structures and unexpected finds**
- **G. Monitoring Requirements**

A summary of these actions and the associated technique is shown in Table 3-1.

Cumulative impacts/concerns are being managed by installing alternative roost sites at all of the other locations that represent known or potential roost sites. Moreover, numerous other roost sites exists in the immediate area and include the numerous rail bridges and culverts with the north coast railway running more or less parallel to many of the affected RMS structures. Notwithstanding this, local arterial roads managed by LGA's along with rural residual landscape provide numerous bat friendly structures in the form of shedding and housing, this can be seen in the maps provided within Appendix 1.

A. Installation of Additional Roosts (Bat Boxes)

The use of artificial bat roosts has proved a useful tool in bat management and mitigation in Australia and overseas. In Europe, retro-fitting of bat boxes on bridges and culverts is among standard environmental management for the construction and maintenance of road infrastructure (Halcrow 2006). It is increasingly used here in Australia with several recent examples on the Pacific Highway and use by local government and private developers. For example, bat roost boxes have been used as a management tool in the upgrading of several timber bridges in the Tweed Shire with success and there has been long term use of the slot design style box used at Koala Beach residential development (D. Hannah Tweed Shire Council Environmental Scientist pers. comm. February 2012).

The use of artificial bat roosts is considered a suitable means to encourage passive dispersal of the roost within a particular structure. The designs proposed have been limited to three designs:

1. Small slotted-style bat boxes
2. Wedge style
3. Tree mounted with removable slots.

Example of suppliers include but are not limited to hollow log homes (www.hollowloghomes.com.au) and NHBS (www.nhbs.com) with boxes constructed from a range of materials including hardwood, marine grade plywood and woodcrete.

Two mounting options are considered viable:

Option 1

For tree mounted roosts, the following considerations must be satisfied:

1. >2 m above ground and ideally 3-4 m;
2. Overhanging >100 mm of surface water;

3. Beneath tree canopy to reduce solar radiation;
4. Recipient tree considered robust and in good health (i.e. healthy tree canopy and unexposed roots);
5. Consideration is given to installing a number of boxes to provide a number of thermoregulatory options. For example, painting some boxes in different colours or positioning the boxes with differing aspects (i.e. one on southern side of a tree another on the northern side).

Option 2

Site considerations for bridge/culvert mounted roosts:

1. >1.5 m above ground;
2. Overhanging >100 mm of surface water; and
3. Culvert or bridge unlikely to fill to capacity during a 1:20 rainfall event.
4. Land tenure

Bat boxes should be installed by an ecologist at least 6-12 months prior to planned roost exclusion. The monitoring and maintenance of these boxes would continue until Year 6 (refer to Table 4-4).

B. Implementing Additional Field Surveys

Additional field surveys would be implemented for the following scenarios:

1. Qualified ecologist engaged by the Contractor to identify the conservation value of all 22 structures as over wintering habitat;
2. Qualified ecologist engaged by the Contractor to perform pre-clearing surveys to assess if bats are using a structure before planned construction works within 100 m of the structure; and
3. Surveys as part of planned roost exclusion procedures (see below).

C. Planned Roost Exclusion

Roost exclusion would be necessary at those structures requiring removal or substantial modification and only at those locations specified in Table 4.2 or as deemed necessary by the Project Ecologist. Planned roost exclusion would be used:

- Outside of the breeding season for Southern Myotis and any other species detected breeding by the Project Ecologist in the structure; and
- Outside over wintering times for the Little Bent-wing Bat, Eastern Horseshoe Bat and Southern Myotis.

Where required, roost boxes would be installed in adjacent habitat by an ecologist at least 6-12 months prior to the planned roost exclusion of micro bats. For example, the removal/upgrading of 599271 (Cow Creek) would require the installation of bat boxes at least 6-12 months before any such planned exclusion could occur.

The contractor would perform a pre clearing survey in accordance with strategy B in Table 3-1. The occupied roost(s) would be left *in situ* at this point in time whilst most (**not all**) of the remaining unoccupied potential roost points (i.e. grab holes, pipe join, crack, expansion joint, drainage hole) would be filled with an expandable foam filler or equivalent. It is important to leave some other alternative roost points (i.e. two) because these would be used as alternative or temporary roost sites whilst the main roost is decommissioned and thus provides a 'weaning' process of excluding micro bats from the structure. Moreover, the culvert egresses would not be blocked at any stage during the roost exclusion process.

On the evening the pre clearing survey is performed (i.e. strategy B), the main roost(s) would be inspected by an ecologist using a variable beam torch and/or an endoscope about 90 minutes after nightfall. Once all the bats have vacated the roost, the ecologist would then fill the roost with expandable foam or an equivalent. Where this cannot be achieved (i.e. due to an obscure cavity), one-way plastic flaps would need to be installed (*see* Mitchell-Jones 2004). Bats returning to the culvert would be left with two options; either seek refuge within one of the sub optimal roost points or seek an alternative site adjacent to the culvert. It is expected that some bats may:

- continue to roost within the alternative roost points (i.e. sub adults), or
- quickly abandon the structure and seek an alternative roost.

Alternate roosts may be the four bat roost boxes installed in the adjacent habitat, or alternatively the numerous other suitable roost habitat in the form of dwellings, culverts and bridges associated with the North Coast Railway and adjacent shire roads.

To improve the effectiveness of this as a management tool, planned roost exclusion would not be undertaken during forecast periods of heavy rainfall (i.e. >20 mm in 24 hours forecast on the Bureau of Meteorology Website www.bom.gov.au) when potential roost sites may be limited. i.e. bats unlikely to be roosting in scuppers during rainfall. The intended timing for planned roost exclusion is in autumn (mid April-May) and the start of spring (September). This would avoid both the breeding season and overwintering period for micro bats.

D. Seasonal Limitation of Construction Works

Seasonal limitation of construction works would be required at high conservation value sites (i.e. breeding or important overwintering habitat) for specific construction activities including clearing and grubbing operations, the dumping of oversize rock material on the bridge abutments, piling or any other activity deemed as inappropriate by the Project Ecologist. For example, a structure that supports a breeding colony of Southern Myotis, seasonal limitation of construction works would be required between November and February for the above construction activities whilst an overwintering colony of Little Bent-wing Bat would require seasonal limitation of between mid June and mid August. During seasonal limitation of construction works, the construction activities listed above must develop an attended noise and vibration monitoring program in consultation with the Project Ecologist. Provisions must also be made for the visual monitoring of the roost for signs of disturbance and a stop works procedure that includes a respite period as part of this program. The details of this monitoring must be recorded and submitted with the 6 monthly tracking compliance report.

Seasonal limitation of construction works would also apply to the bat boxes installed as part of Strategy A (i.e. Bat Box Installation). Therefore, it is important for bat boxes to be installed at nearby locations that would be unaffected by construction works.

E. Protection of Existing Habitat

The contractor would manage the integrity of drainage lines and associated riparian vegetation so as to not constrict micro bat flyways. This would include an:

- Ecological review/input from the Project Ecologist into the final design of bridges and culverts to ensure these structures do not constrict the existing flyway[2].
- Ecologist would monitor tree falls at the edge of the clearing footprint within the riparian zone as per Section H2 of this strategy.

The contractor would manage water quality and velocity of the adjoining waterways including creeks, rivers and dams would be maintained in accordance with the Environmental Protection Licence (EPL) issued for the two construction stages of the WC2U Upgrade.

F. Previously Unconsidered Structures and Unexpected Finds

This strategy 'previously unconsidered structures and unexpected finds' would address:

- Structures where surveys could not be undertaken as part of this study (i.e. undetected culverts; houses identified for demolition); or
- Account for unexpected finds arising from the implementation of strategy B in this plan (i.e. implementing additional field surveys).

[2] By default the design of bridge and culvert to mitigate against flooding would normally provide adequate flyways for the species considered in this management strategy.

If micro bats are found during a survey of previously unconsidered structures or unexpected finds, the Project Ecologist or bat ecologist should be guided by the RMS *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RMS 2011) and the use of strategies outlined in Table 3-1; Table 4-1 and 4-2.

G. Monitoring Requirements

Monitoring associated with this management strategy is divided into short term and long term commitments. Short term monitoring is required for roost exclusion activities which are expected to last for a number of nights at each structure and is dependent on the timing of the construction program. In contrast, long term monitoring is required up to Year 6 and provides an opportunity to rationally evaluate the management strategies outlined in this plan.

G1. Bat Roost Boxes

Monitoring of bat boxes would commence 6 months after their installation, followed by quarterly inspections for 2 years before addressing corrective actions. Monitoring of the boxes would continue up until Year 6 (i.e. 4 surveys per year for 5 years) with the boxes inspected to determine species presence/absence, an estimate or count of numbers of micro bats and breeding activity. Information would also be collected as to the roost identification number, date and time of the inspection. The value of data loggers would be investigated following the outcomes of analogous monitoring works on the Tintenbar to Ewingsdale Pacific Highway Upgrade project (*see* EcoLogical 2011).

G2. Habitat Monitoring

Habitat monitoring would focus on inspections of the riparian zone to assess whether flyways have been constricted as part of construction works. Therefore, on either side of the construction corridor a photo point would be installed and a visual assessment be undertaken to gauge whether the flyway has been maintained or is in need of corrective actions (i.e. vegetation management).

Monitoring of water quality would also be undertaken on both the upstream and downstream sides of the construction works. This monitoring would be undertaken on a monthly cycle in accordance with the Construction Environmental Management Plan (CEMP) and collect the following parameters: turbidity; total suspended solids; conductivity and pH at both upstream and downstream points.

G3. Monitoring of Bat Persistence and Behaviour

Monitoring of bat persistence and behaviour would be undertaken at the Crouches Creek Bridge (7881). This site has been selected because it contained the largest micro bat roost during the summer field survey and provides the greatest opportunity to examine the disturbance thresholds of micro bats. The monitoring program would be developed by the construction contractor and their Project Ecologist or another ecologist with sufficient experience and expertise. The monitoring must consider the differences in roost use between summer and winter along with the species that are likely to use it as a roost. For example, Southern Myotis during the summer months and Bent-wing Bats during the winter months.

Table 3-1. Micro bat management strategies for the Warrell Creek to Urunga Pacific Highway Upgrade.

Strategy	Definition	Techniques	Timing	Responsibility
A	Installation of additional roosts (bat boxes)	• The use of artificial bat roosts (3-4) to promote passive dispersal of the roost. Designs to be one or more of the following and that thermoregulatory considerations focus on aspect and paint/finish (i.e. bat friendly chemicals) of the box itself (i.e. black coloured box with absorb more heat than a neutral colour): **A** - small slotted-style bat boxes; **B** - wedge style; and **C** – tree mounted with removable slots. Two options are available: **Option 1** For tree mounted roosts, the following considerations must be satisfied: 1. >2 m above ground and ideally 3-4 m; 2. Overhanging >100 mm of surface water; 3. Beneath tree canopy to reduce solar radiation; 4. Recipient tree considered robust and in good health (i.e. healthy tree canopy and unexposed roots); 5. Consideration is given to installing a number of boxes to provide a number of thermoregulatory options. For example, painting some boxes in different colours or positioning the boxes with differing aspects (i.e. one on southern side of a tree another on the northern side). **Option 2** Site considerations for bridge/culvert mounted roosts: 1. >1.5 m above ground; 2. Overhanging >100 mm of surface water; and 3. Culvert or bridge unlikely to fill to capacity during a 1:20 rainfall event. Land tenure	Bat boxes should be installed by an ecologist at least 6-12 months prior to planned roost exclusion. The monitoring and maintenance of these boxes would continue until Year 6 (refer to Table 4-4). Pre construction and construction.	Roads and Maritime Services
B	Implementing Additional Field Surveys	Additional field surveys would be implemented for the following scenarios: • Qualified ecologist engaged by the Contractor to identify the conservation value of all 22 structures as over wintering habitat; • Qualified ecologist engaged by the Contractor to perform pre-clearing surveys to assess if bats are using a structure before planned construction works within 100 m of the structure; and • Surveys as part of planned roost exclusion procedures.	Prior to construction disturbance (i.e. works occurring within 200 m of the structure).	The Contractor
C	Planned Roost Exclusion	Roost exclusion would be necessary at those structures requiring removal or substantial modification (requirement for exclusion due to substantial modification is to be determined case by case via consultation between Roads & Maritime, Contractor / project ecologist and EPA) and only at those locations specified in Table 4.2 or as deemed necessary by the Project Ecologist. Planned roost exclusion would be used: • Outside of the breeding season for Southern Myotis and any other species detected breeding by the Project Ecologist in the structure; and • Outside over wintering times for the Little Bent-wing Bat, Eastern Horseshoe Bat and Southern Myotis. Once the conditions above have been satisfied the following 10 step process would occur: 1. Pre-clearing survey to identify presence/absence of the roost; 2. Once the roost(s) has been identified, record species and approximate number of individuals and assess importance of the roost; 3. Select two suitable alternative roost points (i.e. grab holes, pipe join, crack, expansion joint, drainage hole) with gaps of >25 mm and depths exceeding 50 mm; 4. For the remaining potential roost points the Project Ecologist/Bat Ecologist must be confident in ensuring the cavity is devoid of micro bats and other native vertebrate fauna. Once absence has been confirmed, the void/roost point is closed up (i.e. filled with expandable foam or some other equivalent material). 5. At no stage shall the culvert inlets/outlets be constricted or closed off in any way. 6. Where all of the roost point cannot be confidently inspected for signs of native vertebrate fauna then one-way plastic flaps must be installed at that point in time or a minimum of 1 hour before dusk. 7. The active roost points identified during the pre-clearing survey are re inspected around 90 minutes after dark. If all individuals have vacated the roost then at this point in time the roost is filled with expandable foam or similar material. Again, where this cannot be ascertained (i.e. obscure cavity) one-way plastic flaps would need to be installed and left in place for 48-72 hrs (*see* Mitchell-Jones 2004). The above procedure leaves micro bats with two options: **Option A** – Individuals seek refuge within one of the sub optimal roost points; **Option B** – Individuals abandon the site and seek an alternative roost. 8. Inspect the culvert on the following day for signs of use in the sub optimal roost points. If they are not being utilised then decommission by filling with expandable foam or equivalent. 9. If they are being utilised repeat point 7. 10. Once the one-way plastic flaps have been installed for at least 72 hrs re inspect with torch and endoscope and decommission with expandable foam or equivalent. Seasonal considerations associated with cool temperatures must be considered.	Southern Myotis "Likely Breeding Site": **November-February** Little Bent-wing Bat "Over Wintering Site": **mid June-mid August** Other Species: In consultation with Project Ecologist or EPA Opportunities to review on a site by site basis Optimum timing for roost exclusion is considered April and May or September.	The Contractor

Strategy	Definition	Techniques	Timing	Responsibility
D	Seasonal limitation of construction works	• Applied to sites/structure defined as high conservation value (i.e. breeding and important overwintering sites) for specific construction activities including clearing and grubbing operations, the dumping of oversize rock material on the bridge abutments, piling or any other activity deemed as inappropriate by the Project Ecologist. • During seasonal limitation of construction works, the construction activities listed above must develop an attended noise and vibration monitoring program in consultation with the Project Ecologist. Provisions must also be made for the visual monitoring of the roost for signs of disturbance and a stop works procedure that includes a respite period as part of this program. The details of this monitoring must be recorded and submitted with the 6 monthly tracking compliance report. • Seasonal limitation of construction works would also apply to the bat boxes installed as part of Strategy A (i.e. Bat Box Installation). Therefore, it is important for bat boxes to be installed at nearby locations that would be unaffected by construction works.	Southern Myotis "Likely Breeding Site": **November-February** Little Bent-wing Bat "Over Wintering Site": **mid June-mid August** Other Species: In consultation with Project Ecologist or EPA	The Contractor
E1	Protection of existing habitat	The contractor would manage the integrity of drainage lines and associated riparian vegetation so as to not constrict micro bat flyways. This would include an: • Ecological review/input from the Project Ecologist into the final design of bridges and culverts to ensure these structures do not constrict the existing flyway[3]. • Ecologist would monitor tree falls at the edge of the clearing footprint within the riparian zone as per Section H2 of this strategy.	Construction.	The Contractor
E2		The contractor would manage water quality and velocity of the adjoining waterways including creeks, rivers and dams would be maintained in accordance with the Environmental Protection Licence (EPL) issued for the two construction stages of the WC2U Upgrade.	Construction and post construction.	The Contractor
F	Previously unconsidered structures and unexpected finds	This strategy 'previously unconsidered structures and unexpected finds' would address: • Structures where surveys could not be undertaken as part of this study (i.e. undetected culverts; houses identified for demolition); or • Account for unexpected finds arising from the implementation of strategy B in this plan (i.e. implementing additional field surveys). Microbats found during a survey of previously unconsidered structures or unexpected finds, the Project Ecologist or bat ecologist should be guided by the RMS *Biodiversity Guidelines: Protecting and managing biodiversity on RTA projects* (RMS 2011) and the use of strategies outlined in Table 3-1; Table 4-1 and 4-2.	Pre-construction, during construction for both construction stages of the WC2U project (2012-2016)	The Contractor
G1	Monitoring Requirements (Habitat)	Habitat monitoring will focus on inspections of the riparian zone to assess whether flyways have been constricted as part of construction works. Therefore, on either side of the construction corridor a photo point will be installed and a visual assessment be undertaken to gauge whether the flyway has been maintained or is in need of corrective actions (i.e. vegetation management). Monitoring of water quality will also be undertaken on both the upstream and downstream sides of the construction works. This monitoring will be undertaken on a monthly cycle in accordance with the Construction Environmental Management Plan (CEMP) and collect the following parameters: turbidity; total suspended solids; conductivity and pH at both upstream and downstream points.	Once prior to construction and monthly during construction. Pre-construction sampling for baseline data and monthly during construction.	The Contractor
G2	Monitoring Requirements (Bat Roost Monitoring)	Short term monitoring associated with planned roost exclusion outlined as strategy C. The data collected in this strategy reflects a short term monitoring commitment to the project and should be tabled within a post clearing report compiled by the project ecologist or sub consultant bat ecologist. Monitoring of bat boxes would commence 6 months after their installation, followed by quarterly inspections for 2 years before addressing corrective actions. Monitoring of the boxes would continue up until Year 6 (i.e. 4 surveys per year for 5 years) with the boxes inspected to determine species presence/absence, an estimate or count of numbers of micro bats and breeding activity.	Within 7-14 days of planned construction activities impacting Commence monitoring 6 months after bat box installation followed by quarterly inspections for 2 years before addressing corrective actions. Monitoring of roosts up until Year 6 of this management strategy.	The Contractor
G3	Monitoring Requirements (Bat roost monitoring during construction to examine bat behaviour and roost persistence)	Microbat roost monitoring will focus on Crouches Creek Bridge (7881) during construction to evaluate the response of micro bats to a range of construction activities. The monitoring program should be developed by the Project Ecologist and ensure that a range of construction activities are monitored and there are provisions for this to occur during both the summer breeding period and also a winter period to capture different species which may use the bridge as a roost site.	Monitoring would commence once construction activities start within 100 m of the Crouches Creek Bridge Structure (7881). The timing and duration would be developed by the construction contractor's Project Ecologist or another ecologist. The timing is to take into account summer and winter seasons.	The Contractor

[3] By default the design of bridge and culvert to mitigate against flooding would normally provide adequate flyways for the species considered in this management strategy.

4.0 IMPLEMENTATION OF THE MANAGEMENT STRATEGIES

Using the management strategies summarised in Table 3-1 this section identifies what strategies are required at each of the 22 identified structures (Appendix 1). One limitation with identifying management strategies is that the design for the carriageway has not progressed from the concept design for either the Warrell Creek to Nambucca Heads or the Nambucca Heads to Urunga sections of the project. To overcome this, a matrix has been developed to address the potential nature of impacts at three scales:

- 100-200 m from the structure;
- <100 m of the structure; and
- Works on the structure itself.

In each instance, all construction works relating to the project that fall within 200 m of the structure would be subject to this management strategy.

A subjective scale has been developed to qualify the likelihood of a particular bat species using each of the culvert structures (Table 4-1). In this context, biological traits (i.e. breeding/overwintering) that have been assigned as 'moderate' or 'high' have a real possibility of occurring in the particular structure. The 'low' category translates to a key habitat attribute missing from the structure but it could still theoretically provide roost habitat, albeit of lower importance or conservation value. The 'very low' category indicates the roost/structure does not align with a particular species biological traits or the structure could not physically support the required microhabitat elements. For example, a roost that could not physically support thousands of bats associated with a maternity colony of bent-wing bats.

A summary of the required strategies for known and potential structures for micro bats is provided in Table 4-2 and Table 4-3 and the respective timing of key actions, responsibilities and documentation requirements is outlined in Table 4-4.

Table 4-1. Definitions of the subjective scale used to derive the likelihood of a species utilising the structure for a particular biological trait of breeding and over wintering.

Likelihood of species performing a particular biological trait	Description
Very Low	The structure provides unsuitable habitat attributes or does not align with the species' particular biological habits. For example, Bent-wing bats use regional maternity sites often found in caves where the structure can accommodate thousands of individuals. In contrast, the roost habitat within the identified structure could not physically support this requirement.
Low	There is normally a key habitat attribute missing but the structure could still physically provide roost points for this species. For example, a relatively small culvert (i.e. <1.5 m) that doesn't hold water and is relatively low but it contains suitable roost points for Southern Myotis. Another example is the structure lets too much light in to be considered suitable for Eastern Horseshoe Bat which generally prefers to roost in complete darkness.
Moderate	The structure provides the required attributes for the species but it is not considered 'ideal'. For example, a culvert that is <1.5 m in height, retains water and provides roost points with unconstricted inlets and outlets has a moderate chance of providing breeding habitat for Southern Myotis. In this context, the height of the culvert structure detracts slightly from its overall suitability.
High	The structure provides all the required roost attributes for the species to perform a particular biological trait such as breeding. For example, a culvert >1.5 m in height, permanent water and suitable roost points capable of holding >10 individuals with unconstricted inlets and outlets.
Known	Species was recorded during the survey.

Table 4-2. Proposed management strategies at bridges and culverts known to contain micro bats. na = not applicable.

Structure	Roost Site	Species Recorded	Other Species to Consider	Breeding Site	Overwintering Site	Works 100-200 m from roost	Works Within 100 m	Works on the structure	Expected Impact from WC2NH Project
Warrell Creek to Nambucca Heads						See Table 3-1.	See Table 3-1.	See Table 3-1.	
Culverts									
599205 (Deadman's Gully)  Known Southern Myotis habitat using expansion joints on western end	 Seven Southern Myotis using exposed expansion joint	Southern Myotis	-	High	Moderate	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2	No impact from current design
			Little Bent-wing Bat	Low	Moderate	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2	
			Eastern Horseshoe Bat	Low	Moderate	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2	
599222 (Donnellyville)  Known Southern Myotis habitat within vertical weep/drainage holes	 Vertical drainage/weep holes with earth cavities used by Southern Myotis	Southern Myotis	-	Low	Moderate	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2	May require clean out
			Little Bent-wing Bat	Low	Moderate	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2	
			Eastern Horseshoe Bat	Low	Low	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2	

Bridges									
Crouches Creek   Southern Myotis using expansion gaps in bridge deck	 Couches Creek and southern abutment	Southern Myotis	-	High	High	E1, E2	B, E1, E2, G3	A (option 2), B, C, E1, E2, G1, G2, G3	No impact from current design
		Gould's Wattled Bat	-	Moderate	Moderate	E1, E2	B, E1, E2, G3	A (option 2), B, C, E1, E2, G1, G2, G3	
			Little Bent-wing Bat	Low	Moderate	E1, E2	B, E1, E2, G3	A (option 2), B, C, E1, E2, G1, G2, G3	
			Eastern Horseshoe Bat	Low	Low	E1, E2	B, E1, E2, G3	A (option 2), B, C, E1, E2, G1, G2, G3	
Warrell Creek Bridge (1871) 	No pic	Little Bent-wing Bat	-	Low	High	E1, E2	B, E1, E2	B, C, E1, E2, G1, G2	No impact from current design
		Forest Bat (*Vespadelus spp*)	-	Low	Low	E1, E2	B, E1, E2	B, C, E1, E2, G1, G2	
			Southern Myotis	High	Moderate	E1, E2	B, E1, E2	A (option 2), B, C, E1, E2, G1, G2	
			Gould's Wattled Bat	Moderate	Moderate	E1, E2	B, E1, E2	A (option 2), B, C, E1, E2, G1, G2	
			Eastern Horseshoe Bat	Low	Low	E1, E2	B, E1, E2	B, C, E1, E2, G1, G2	
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Nambucca Heads to Urunga									
Culverts									
599271 (Cow Creek) No pic	 Southern Myotis using gaps in the expansion join	Southern Myotis	-	High	Moderate	E1, E2	B, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2	
			Little Bent-wing Bat	Low	Moderate	E1, E2	B, E1, E2	A (option 2), B, C, D, E1, E2, G1, G2	
			Eastern Horseshoe Bat	Low	Moderate	E1, E2	B, E1, E2	A (option 2), B, C, D, E1, E2, G1, G2	
599293  Box culvert with seasonal water flow	 Single Southern Myotis using gaps in the expansion join	Southern Myotis	-	Moderate	High	E1, E2	B, D, E1, E2	A (option 1), B, C, D, E1, E2, G1, G2	
			Little Bent-wing Bat	Low	Moderate	E1, E2	B, D, E1, E2	A (option 2), B, C, D, E1, E2, G1, G2	
			Eastern Horseshoe Bat	Low	Moderate	E1, E2	B, D, E1, E2	A (option 2), B, C, D, E1, E2, G1, G2	
599306 (Dalhousie Creek)  East side of culvert showing permanent water	 Likely breeding site for Southern Myotis	Southern Myotis	-	High	Moderate	A1, A2	na	na	
			Little Bent-wing Bat	Low	Moderate	A1, A2	na	na	
			Eastern Horseshoe Bat	Low	Moderate	A1, A2	na	na	

Bridges									
North Coast Railway Bridge (Nambucca Heads) 	No pic	Gould's Wattled Bat	-	Moderate	Moderate	E1	E1, A (option 2), B,	E1, A (option 2), B,	
			Little Bent-wing Bat	Low	High	E1	E1, A (option 2), B,	E1, A (option 2), B,	
			Eastern Horseshoe Bat	Low	Low	E1	E1, A (option 2), B,	E1, A (option 2), B,	

Table 4-3. Proposed management strategies at bridges and culverts that provide potential habitat for micro bats.

Structure	Roost Habitat	Species to Consider	Breeding Site	Overwintering	Works 100-200 m from roost	Works Within 100 m	Works on the structure	Expected Impact from WC2NH Project
Warrell Creek to Nambucca Heads					See Table 3-1.	See Table 3-1.	See Table 3-1.	
Culverts								
599228 	No pic	Little Bent-wing Bat	Low	High	E1, E2, B	E1, E2, B,	E1, E2, B, A, C, G1, G2	Not directly impacted (maintenance works may require cleaning)
		Southern Myotis	Low (typically have water beneath – this is a dry passage culvert)	Moderate	E1, E2, B	E1, E2, B,	E1, E2, B, A, C, ,G1, G2	
		Eastern Horseshoe Bat	Low	Moderate	E1, E2, B	E1, E2, B,	E1, E2, B, A, C, G1, G2	
599229 	No pic	Little Bent-wing Bat	Low	Moderate	E1, E2, B	E1, E2, B,	E1, E2, B, A, C, G1, G2	Not directly impacted (maintenance works may require cleaning)
		Southern Myotis	Low (most likely towards the eastern end where water tends to pool in the culvert)	Moderate	E1, E2, B	E1, E2, B,	E1, E2, B, A, C, G1, G2	
		Eastern Horseshoe Bat	Low	Moderate	E1, E2, B	E1, E2, B,	E1, E2, B, A, C, G1, G2	
599237 		Little Bent-wing Bat	Low	High	E1, E2, B	E1, E2, B,	E1, E2, B, A, C, , G1, G2	Not directly impacted (maintenance works may require cleaning)
		Southern Myotis	Low (typically have water beneath – this is a dry passage culvert with high cattle use)	Moderate	E1, E2, B	E1, E2, B,	E1, E2, B, A, C, G1, G2	
		Eastern Horseshoe Bat	Low	Moderate	E1, E2, B	E1, E2, B,	E1, E2, B, A, C, G1, G2	

599238 	No pic	Little Bent-wing Bat	Low	High	E1, E2, B	E1, E2, B,	E1, E2, B, A, C, G1, G2	Not directly impacted (maintenance works may require cleaning)
		Southern Myotis	Low (typically have water beneath – this is largely a dry passage culvert)	Moderate	E1, E2, B	E1, E2, B,	E1, E2, B, A, C, G1, G2	
		Eastern Horseshoe Bat	Low	Moderate	E1, E2, B	E1, E2, B,	E1, E2, B, A, C, G1, G2	
Bridges								
None identified								
Nambucca Heads to Urunga								
Culverts								
599265 	No pic	Little Bent-wing Bat	Very Low	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, D, G1, G2	
		Southern Myotis	Low (most likely towards the eastern end where water tends to pool in the culvert)	Moderate	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, D, G1, G2	
		Eastern Horseshoe Bat	Very Low	Very Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, D, G1, G2	
599272 	No pic	Little Bent-wing Bat	Very Low	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, D, G1, G2	
		Southern Myotis	Low	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, D, G1, G2	
		Eastern Horseshoe Bat	Very Low	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, D, G1, G2	

599274 	No pic	Little Bent-wing Bat	Very Low	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, D, G1, G2	
		Southern Myotis	Moderate	Moderate	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, D, G1, G2	
		Eastern Horseshoe Bat	Very Low	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, D, G1, G2	
599276 	No pic	Little Bent-wing Bat	Very Low	Moderate	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, D, G1, G2	
		Southern Myotis	Moderate	Moderate	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, D, G1, G2	
		Eastern Horseshoe Bat	Low	Moderate	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, D, G1, G2	
599282 		Little Bent-wing Bat	Very Low	Moderate	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, D, G1, G2	
		Southern Myotis	Moderate	Moderate	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, D, G1, G2	
		Eastern Horseshoe Bat	Low	Moderate	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, D, G1, G2	

599291 	No pic	Little Bent-wing Bat	Very Low	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, D, G1, G2	
		Southern Myotis	Low	Moderate	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, D, G1, G2	
		Eastern Horseshoe Bat	Very Low	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, D, G1, G2	
599302 	No pic	Little Bent-wing Bat	Very Low	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, D, G1, G2	
		Southern Myotis	Very Low	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, D, G1, G2	
		Eastern Horseshoe Bat	Very Low	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, D, G1, G2	
599323 	No pic	Little Bent-wing Bat	Very Low	Low	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, D, G1, G2	
		Southern Myotis	Moderate	Moderate	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, D, G1, G2	
		Eastern Horseshoe Bat	Very Low	Moderate	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, D, G1, G2	

599325 	No pic	Little Bent-wing Bat Southern Myotis Eastern Horseshoe Bat	Very Low Low Very Low	Low Moderate Low	E1, E2, B E1, E2, B E1, E2, B	E1, E2, B, D E1, E2, B, D E1, E2, B, D	E1, E2, B, A, C, D, G1, G2 E1, E2, B, A, C, D, G1, G2 E1, E2, B, A, C, D, G1, G2	
Bridges								
Boggy Creek Bridge (6696) 		Little Bent-wing Bat Southern Myotis Eastern Horseshoe Bat	Very Low Moderate Very Low	Moderate Moderate Low	E1, E2, B E1, E2, B E1, E2, B	E1, E2, B, D E1, E2, B, D E1, E2, B, D	E1, E2, B, A, C, D, G1, G2 E1, E2, B, A, C, D, G1, G2 E1, E2, B, A, C, D, G1, G2	

Table 4-4. Timing of key actions for this micro bat management plan, responsibilities and documentation requirements.

Management Action / Year Number	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Responsibility	Documentation Requirements
Pre Construction								
Prepare Micro Bat Management Strategy	√						RMS	Construction Environmental Management Plan
Construction	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**		
Commission Construction of Bat Boxes	√	√					Project Ecologist – Contractor responsibility	-
Install Bat Boxes	√	√					Project Ecologist – Contractor responsibility	Construction Environmental Management Plan
Survey 22 structures to assess over wintering habitat		√	√				A Project Ecologist – Contractor responsibility	Construction Environmental Management Plan
Planned Exclusion Works		√	√				Project Ecologist – Contractor responsibility	Construction Environmental Management Plan
Bat Box Monitoring	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**		
Summer		√	√	√	√	√	Project Ecologist – Contractor responsibility	Yearly reporting
Autumn		√	√	√	√	√	Project Ecologist – Contractor responsibility	Yearly reporting
Winter		√	√	√	√	√	Project Ecologist – Contractor responsibility	Yearly reporting
Spring		√	√	√	√	√	Project Ecologist – Contractor responsibility	Yearly reporting
Habitat Monitoring	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**		
Summer		√	√	√	√		Project Ecologist – Contractor responsibility	Yearly reporting
Autumn		√	√	√	√	√	Project Ecologist – Contractor responsibility	Yearly reporting
Winter		√	√	√	√		Project Ecologist – Contractor responsibility	Yearly reporting
Spring		√	√	√	√		Project Ecologist – Contractor responsibility	Yearly reporting
Roost Disturbance Monitoring	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**		
Summer			√	√			Project Ecologist – Contractor responsibility	Yearly reporting
Autumn			√	√			Project Ecologist – Contractor responsibility	Yearly reporting
Winter			√	√			Project Ecologist – Contractor responsibility	Yearly reporting
Spring			√	√			Project Ecologist –	Yearly reporting

							Contractor responsibility	
Maintenance								
Maintenance of boxes			√			√	Project Ecologist – Contractor responsibility	
Pre Handover Maintenance Inspection						√	Project Ecologist – Contractor responsibility	Yearly reporting

5.0 CONCLUSION

The Warrell Creek to Urunga bat management strategy incorporates seven management measures to adequately address MCoA **(B30b iv)** including:

- Installation of additional roosts
- Implementing additional field surveys
- Planned roost exclusion
- Seasonal limitation of construction works
- Protection of existing habitat
- Previously unconsidered structures and unexpected finds
- Monitoring requirements

Together, they are provided as bat management strategies A-G in this document with their implementation staged according to the proposed distance of construction works and the overall importance of the bat roost itself. Importantly, all construction works that fall within 200 m of the identified structures would be subject to management strategies outlined in this plan.

The use of bat boxes would provide opportunities for passive relocation of bat roosts and these would need to be installed at least 6-12 months prior to any planned roost exclusion and/or construction works. The monitoring framework would assess the overall performance of these measures and provide an opportunity to evaluate potential changes in habitat quality of flyways, water ways, the uptake of bat roost boxes and form part of the planned roost exclusion. In one instance and for the largest of the recorded micro bat roosts (Crouches Creek 7881) the use of monitoring during construction will allow for the examination on how micro bats respond to construction related disturbances.

This micro bat management strategy provides guidance to RMS and highlights the importance of planning ahead and acting in advance of the construction phase of the project. The strategic installation of additional roost sites followed by planned roost exclusion and monitoring at culvert structures during September and again in April-May would provide a more equitable outcome for both construction and the local ecology as micro bats should neither be breeding nor over wintering at these times.

6.0 REFERENCES

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7.0 APPENDIX 1 – CULVERT AND BRIDGE LOCATIONS

Note – White boxes around culverts depicts culverts representing micro bat habitat.

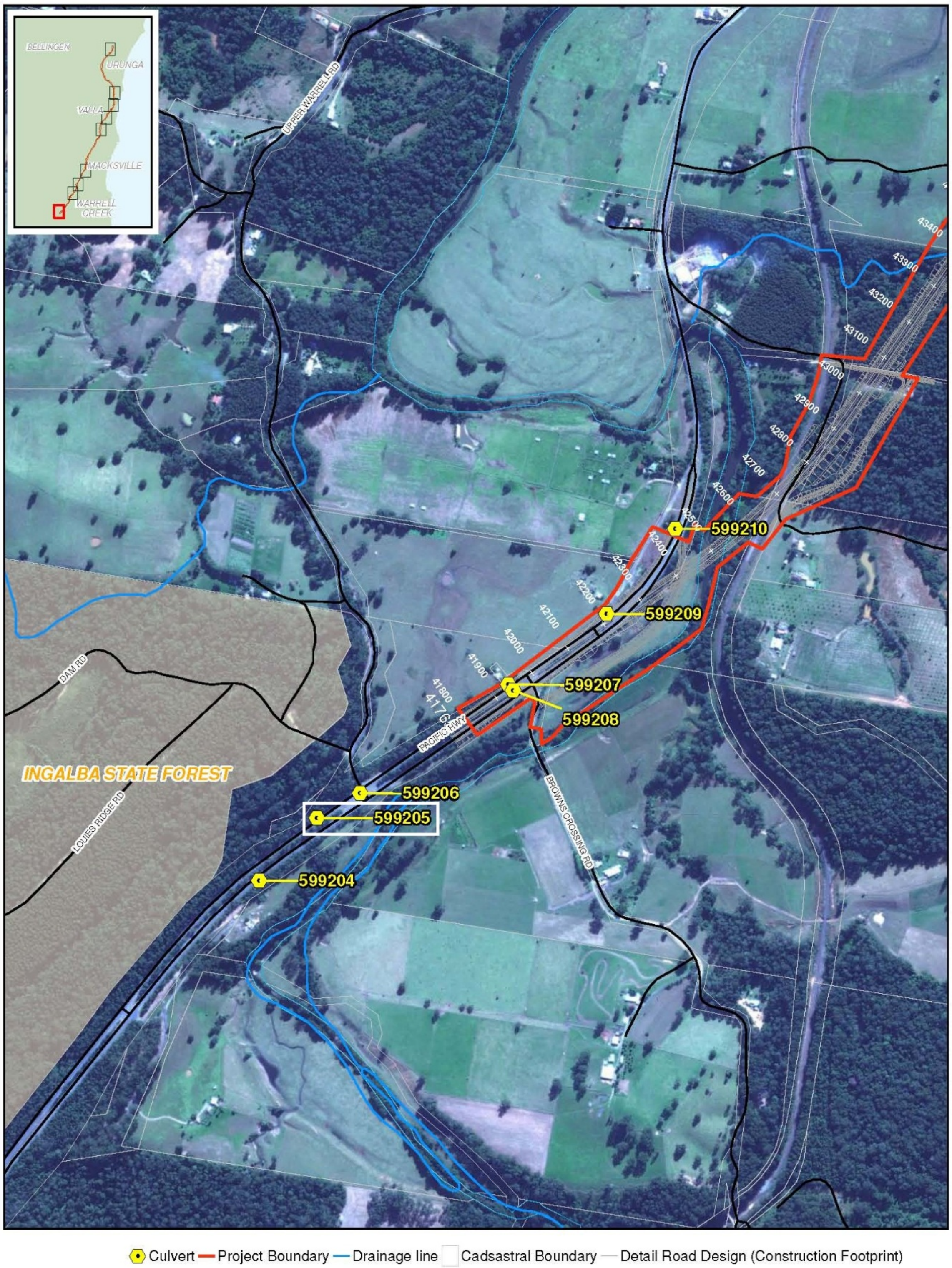

Figure 2 : CULVERT SURVEY

Cadastre: Roads and Traffic Authority 2007
Culvert Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009
Aerial Image: Bing Aerial (date unknown)

Highway Design (footprint): RTA 2011/2012
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2008

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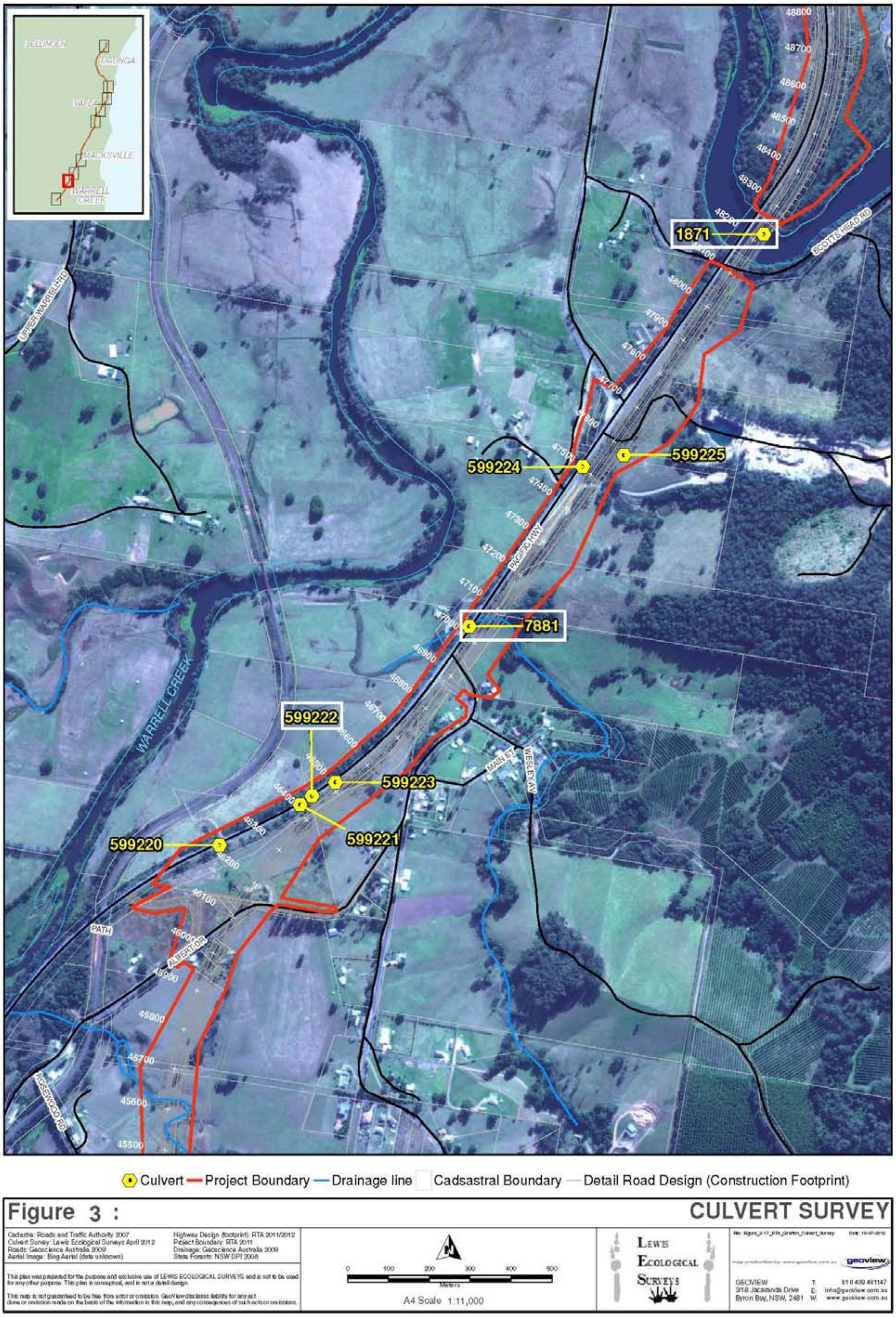

Figure 3 : CULVERT SURVEY

Cadastre: Roads and Traffic Authority 2007
Culvert Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009
Aerial Image: Bing Aerial (date unknown)
Highway Design (footprint): RTA 2011/2012
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2008

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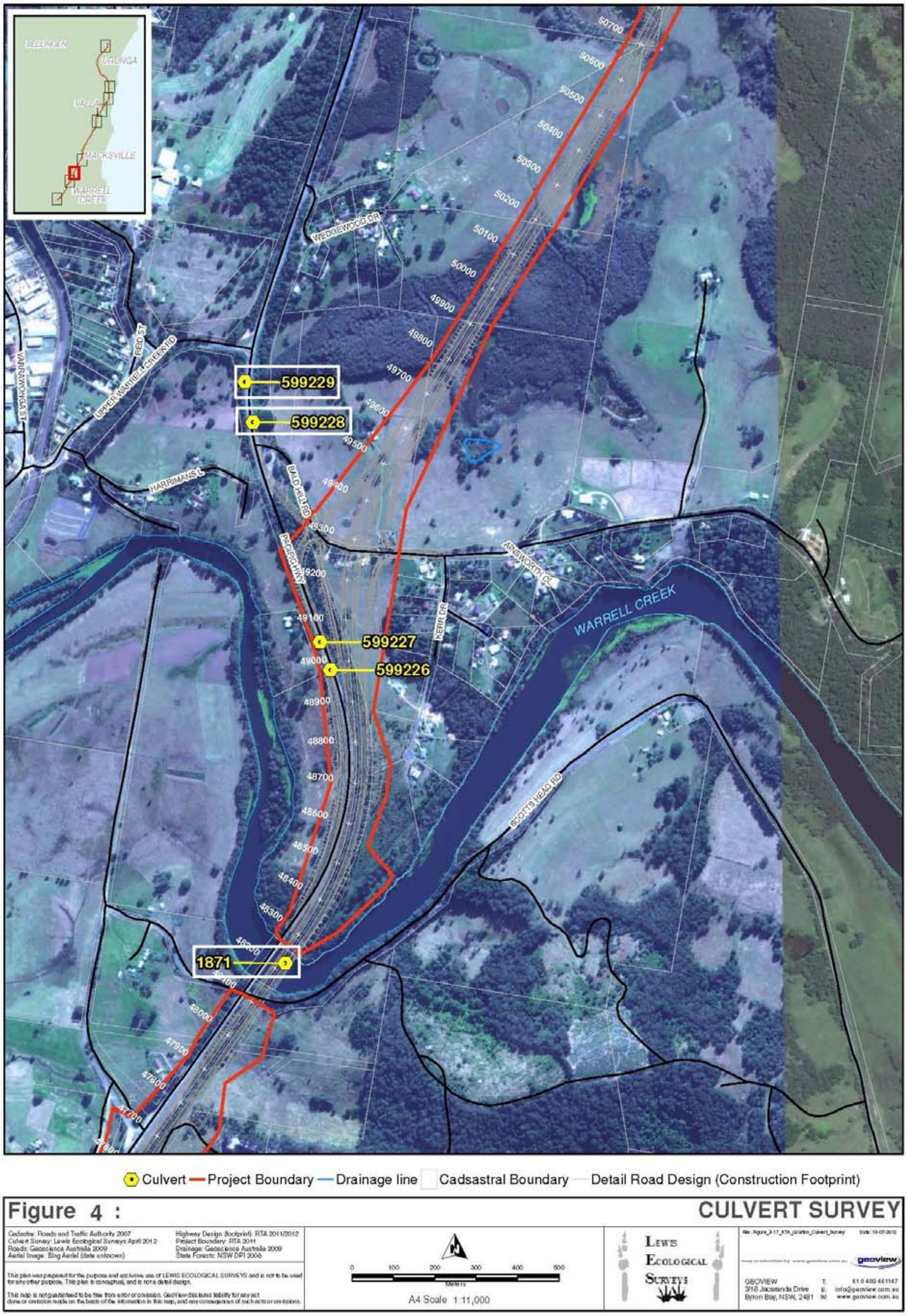

599229
599228
599227
599226
1871
WARRELL CREEK
PACIFIC HWY
BALD HILL RD
WEDGEWOOD DR
HARRIMANS L
UPPER WARRELL CREEK RD
YARRAWONGA ST
AINSWORTH CL
KERR DR
SCOTTS HEAD RD
URUNGA
MACKSVILLE
WARRELL CREEK
Culvert
Project Boundary
Drainage line
Cadsastral Boundary
Detail Road Design (Construction Footprint)
Figure 4 :
CULVERT SURVEY
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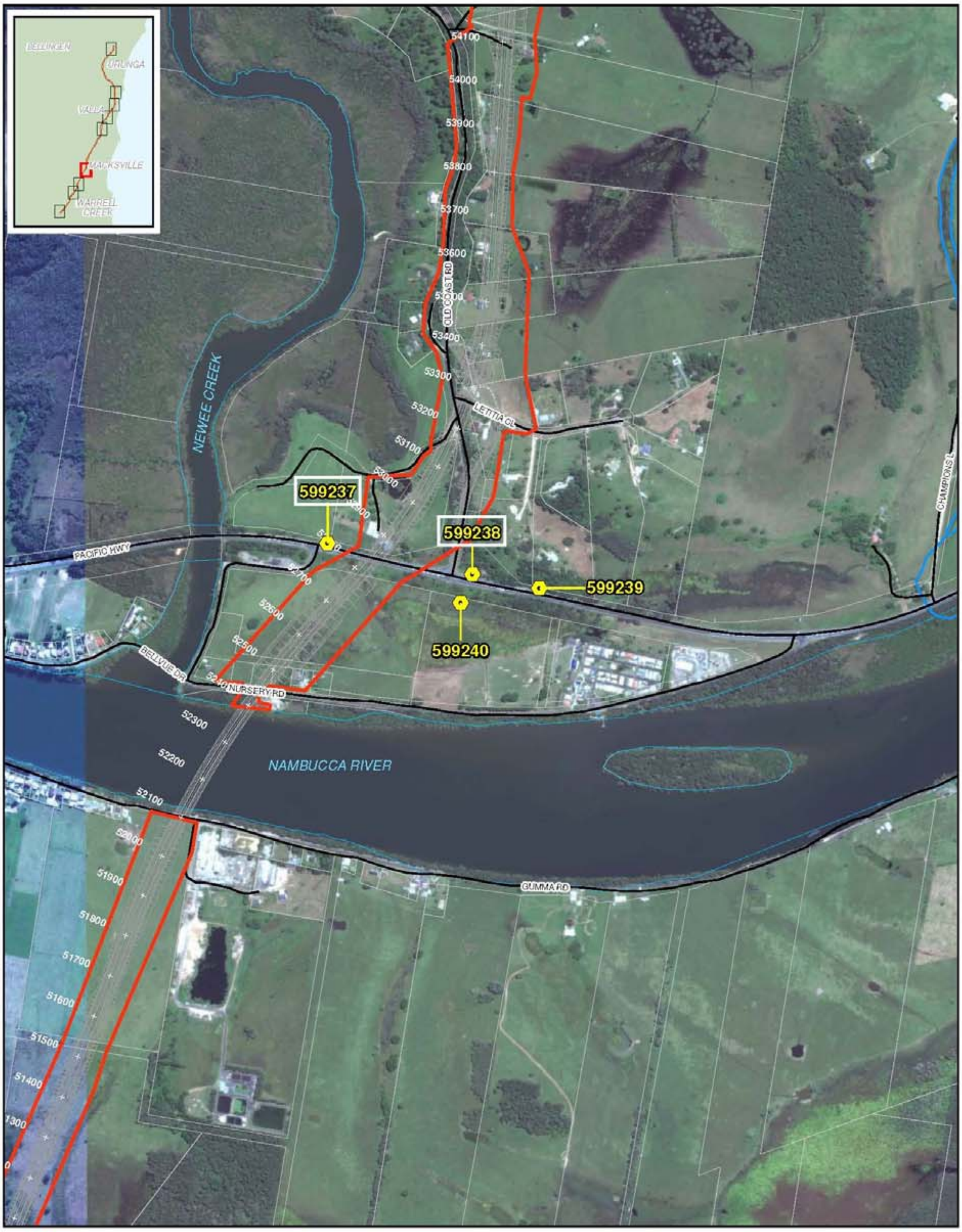

Culvert — Project Boundary — Drainage line — Cadsastral Boundary — Detail Road Design (Construction Footprint)

Figure 5 : **CULVERT SURVEY**

Cadastre: Roads and Traffic Authority 2007
Culvert Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009
Aerial Image: Bing Aerial (date unknown)

Highway Design (footprint): RTA 2011/2012
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2006

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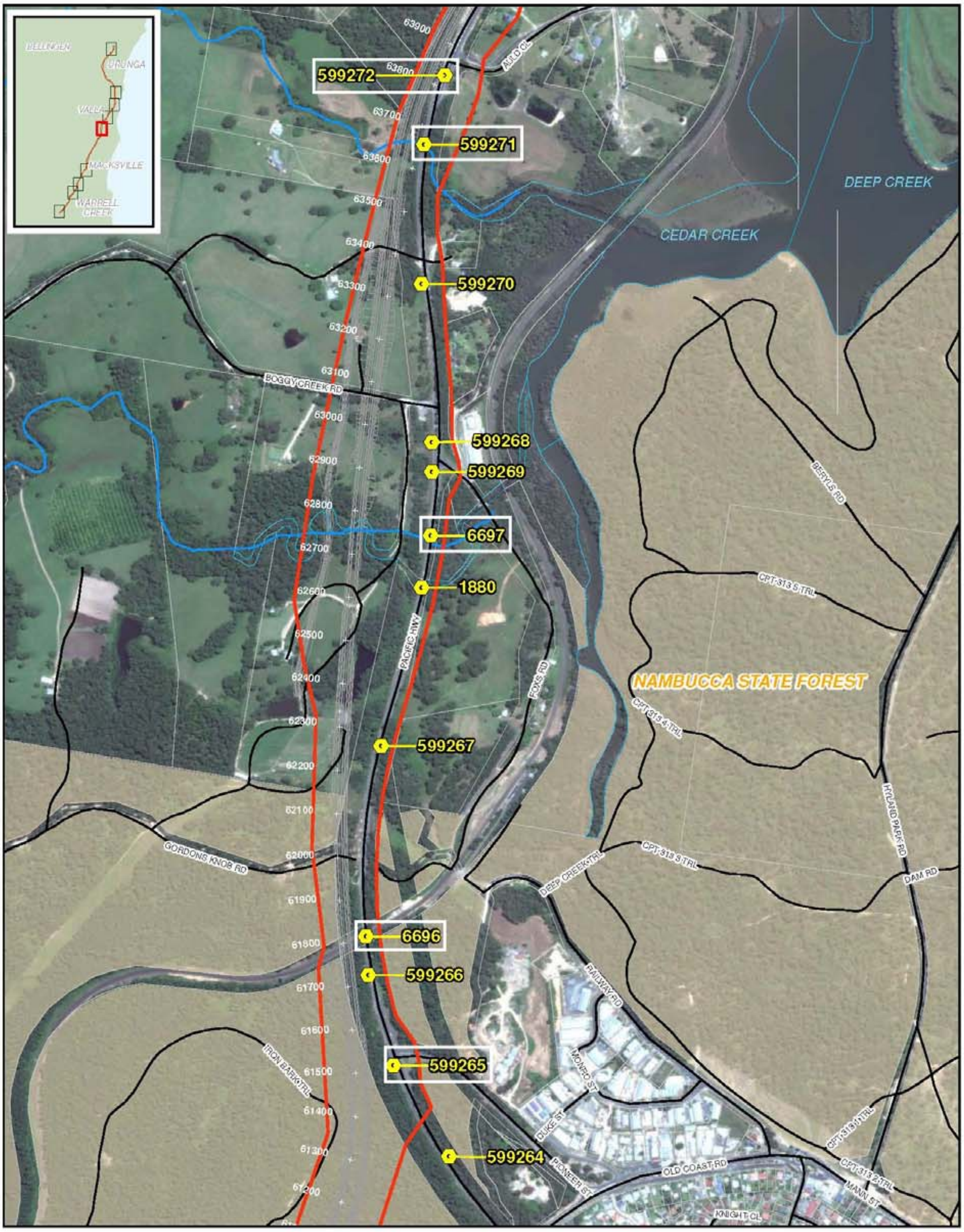

Culvert — Project Boundary — Drainage line — Cadsastral Boundary — Detail Road Design (Construction Footprint)

Figure 6 : CULVERT SURVEY

Cadastre: Roads and Traffic Authority 2007
Culvert Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009
Aerial Image: Bing Aerial (date unknown)

Highway Design (footprint): RTA 2011/2012
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2006

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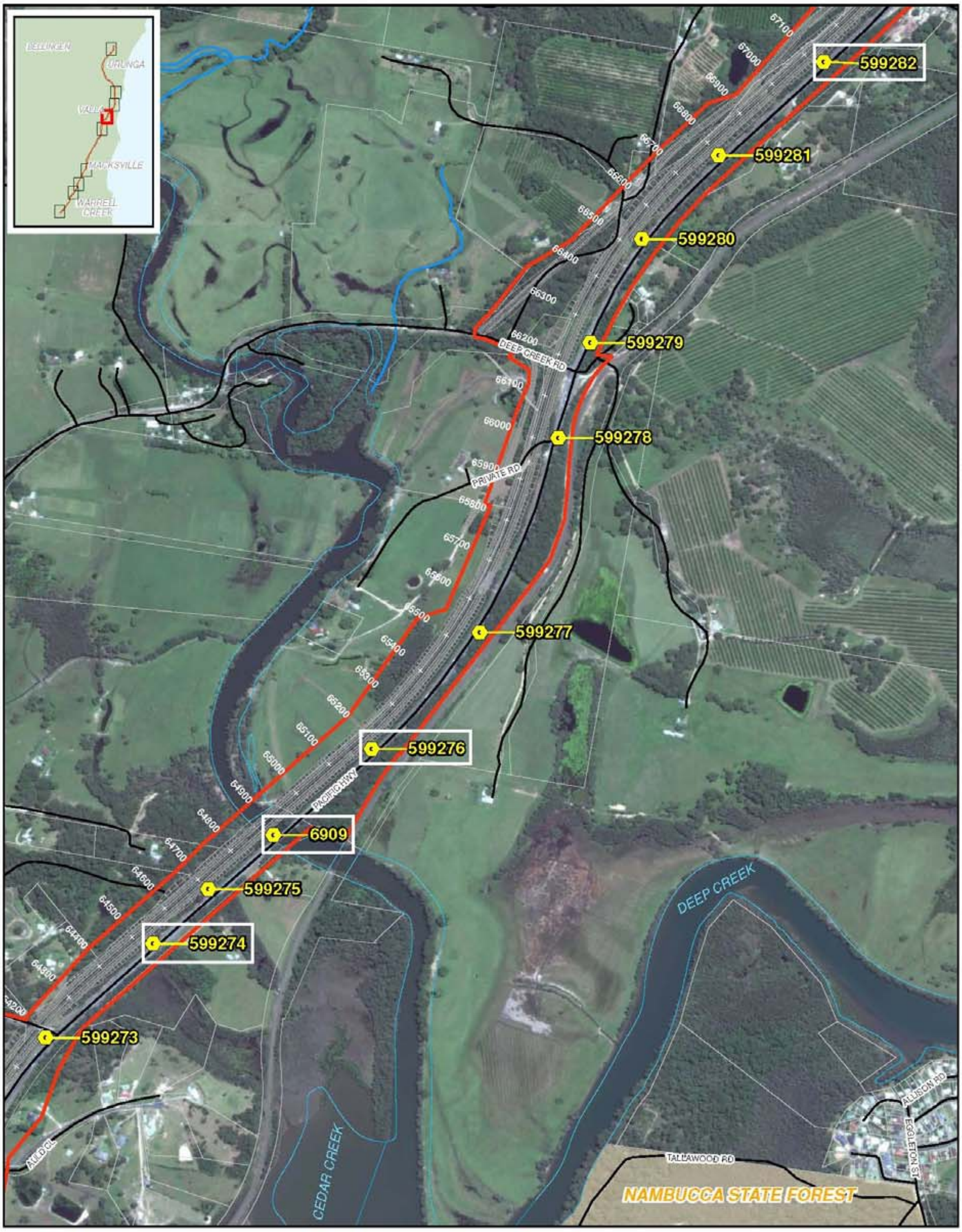

Culvert — Project Boundary — Drainage line Cadsastral Boundary — Detail Road Design (Construction Footprint)

Figure 7 : CULVERT SURVEY

Cadastre: Roads and Traffic Authority 2007
Culvert Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009
Aerial Image: Bing Aerial (date unknown)

Highway Design (footprint): RTA 2011/2012
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2006

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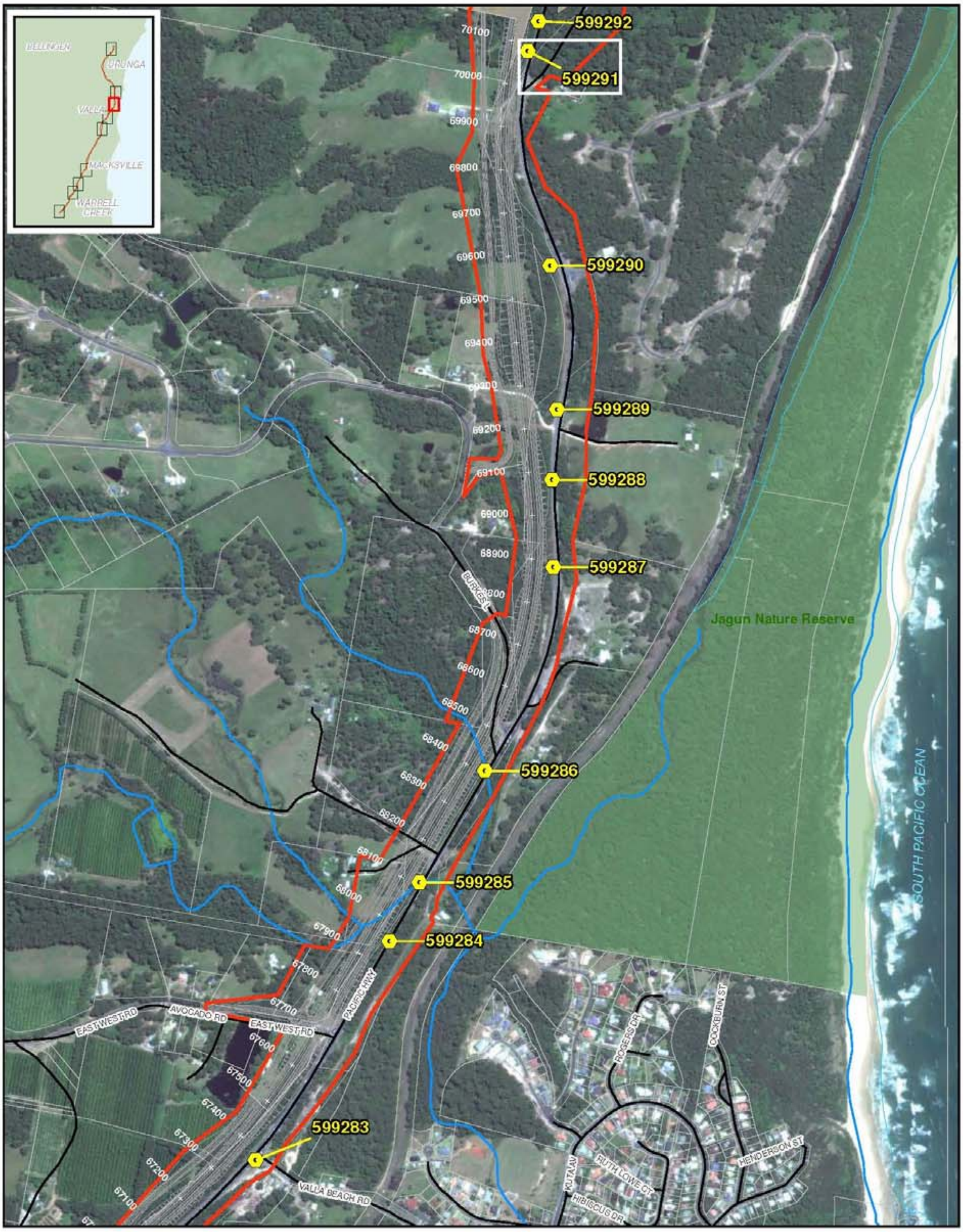

Culvert — Project Boundary — Drainage line — Cadsastral Boundary — Detail Road Design (Construction Footprint)

Figure 8 : CULVERT SURVEY

Cadastre: Roads and Traffic Authority 2007
Culvert Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009
Aerial Image: Bing Aerial (date unknown)

Highway Design (footprint): RTA 2011/2012
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2006

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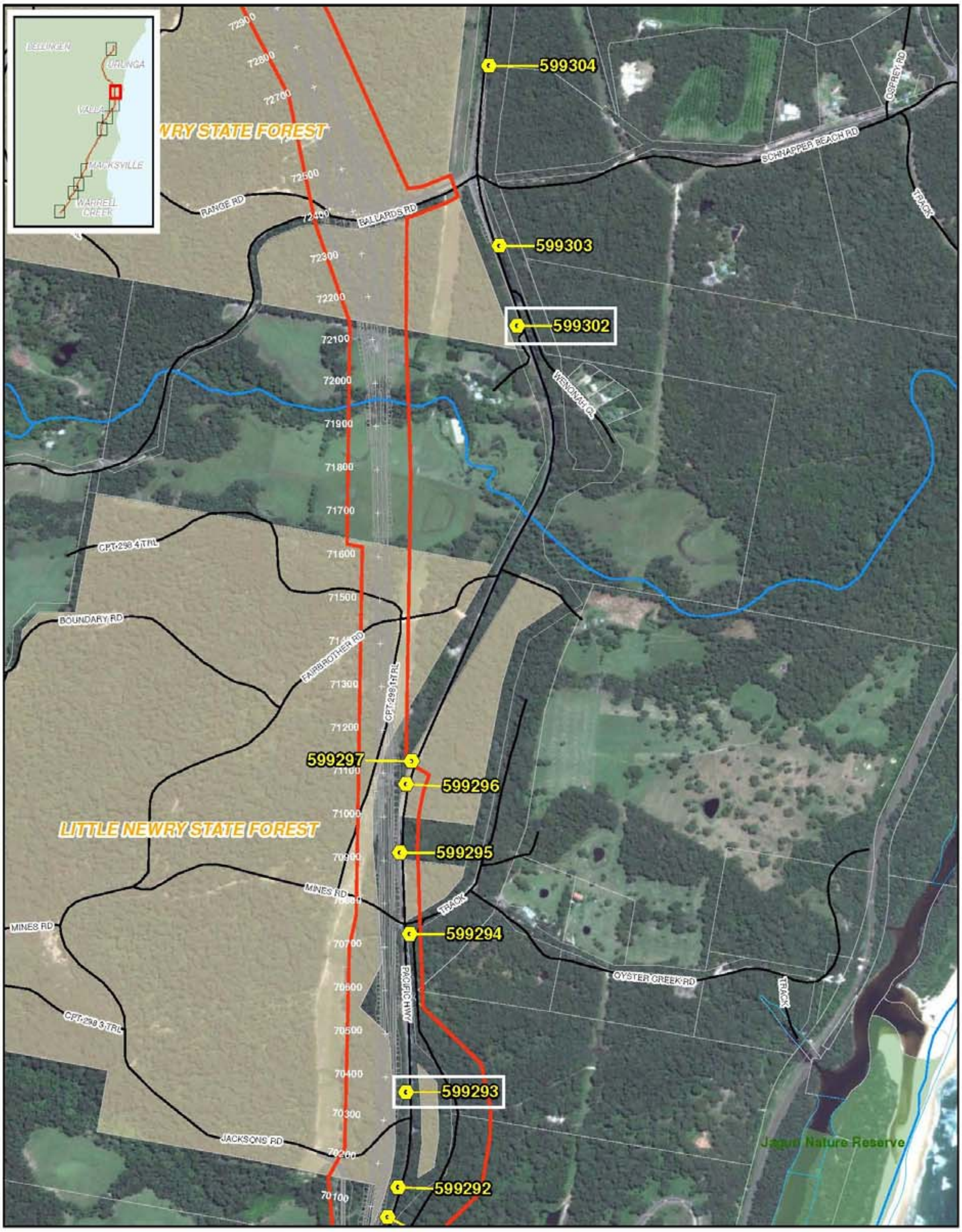
W: www.geoview.com.au



Culvert — Project Boundary — Drainage line — Cadsastral Boundary — Detail Road Design (Construction Footprint)

Figure 10 : CULVERT SURVEY

Cadastre: Roads and Traffic Authority 2007
Culvert Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009
Aerial Image: Bing Aerial (date unknown)

Highway Design (footprint): RTA 2011/2012
Project Boundary: RTA 2011
Drainage: Geoscience Australia 2009
State Forests: NSW DPI 2008

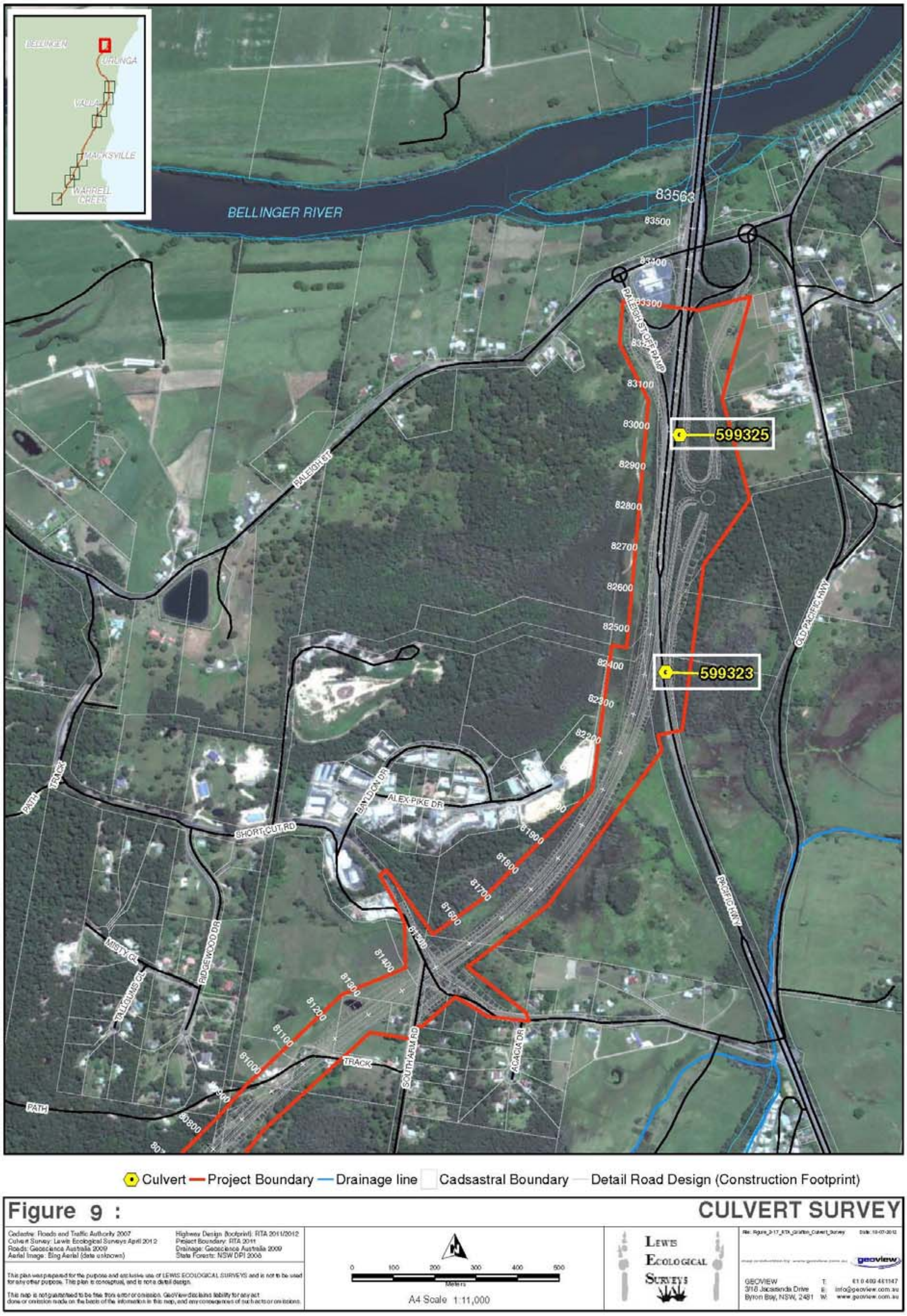
This plan was prepared for the purpose and exclusive use of LEWIS ECOLOGICAL SURVEYS and is not to be used for any other purpose. This plan is conceptual, and is not a detail design.

This map is not guaranteed to be free from error or omission. GeoView disclaims liability for any act done or omission made on the basis of the information in this map, and any consequences of such acts or omissions.

0 100 200 300 400 500 Meters
A4 Scale 1:11,000

Lewis Ecological Surveys

GEOVIEW
3/18 Jacaranda Drive
Byron Bay, NSW, 2481
T: 61 0 402 461147
E: info@geoview.com.au
W: www.geoview.com.au


BELLINGEN
URUNGA
VALLA
MACKSVILLE
WARRELL CREEK
BELLINGER RIVER
83563
83500
83300
RALEIGH ST
599325
599323
OLD PACIFIC HWY
ALEX PIKE DR
BAYLDON DR
SHORT CUT RD
TRACK
PATH
MISTY CL
RIDGEWOOD DR
SOUTH ARM RD
ACACIA DR
PACIFIC HWY
Culvert
Project Boundary
Drainage line
Cadsastral Boundary
Detail Road Design (Construction Footprint)
Figure 9 :
CULVERT SURVEY
A4 Scale 1:11,000
Meters
GEOVIEW
3/18 Jacaranda Drive
Byron Bay, NSW, 2481

Appendix G
Pre-clearing checklist

Pre-Clearing / Ground Disturbance Inspection Checklist

Project: Pacific Highway Upgrade – Warrell Creek to Nambucca Heads **Project No:**

Requested By: **Permit / Lot Number:**

Vegetation Clearing Start Date: **Expected Completion Date:**

VEGETATION CLEARING LOCATIONS – ATTACH DRAWINGS / SKETCHES IF NECESSARY

Ch. From	Ch. To	Carriageway	Location	Comments

This section to be completed by Project Ecologist and Environmental Officer

Has the vegetation to be cleared been clearly delineated? ☐ Yes ☐ No

All trees / vegetation to be retained identified by survey and exclusion areas fenced off? ☐ Yes ☐ No

State how identified:

Has the Project Boundary been flagged or fenced and clearly delineated? ☐ Yes ☐ No

(Check the EPL Premise Maps are up to date)

Have relevant fauna rescue organisation (WIRES/FAWNA) been contacted and advised of the proposed clearing to ensure adequate resources available? ☐ Yes ☐ No

Have habitat trees been identified and appropriately marked by the Project Ecologist and has the 48-hour wait period for habitat trees elapsed? ☐ Yes ☐ No ☐ N/A

State how identified:

Any specific targeted surveys required in this work area? (Refer to Ecological Monitoring Program) ☐ Yes ☐ No

Where required, state how survey was completed, including results?

Has weed management been undertaken?	☐ Yes ☐ No ☐ N/A
Is the Project Ecologist present?	☐ Yes ☐ No
Are any animals present? (If *Yes*, relocation required)	☐ Yes ☐ No
Are any active nests present? (If *Yes*, relocation required)	☐ Yes ☐ No
Have checks for animals occurred at the appropriate times? (Dawn, dusk etc)	☐ Yes ☐ No
Have relevant workers been toolboxed on limit of clearing, fauna handling procedures and any other issues?	☐ Yes ☐ No
If soil disturbance is to occur, has an PESCP Plan been created and have these controls been installed?	☐ Yes ☐ No
Are the proposed works covered by an existing Approval?	☐ Yes ☐ No

Which document covers the works?:

Comments:

APPROVALS

Inspection completed by Project Ecologist: **Date:**

Ecologist Signature Required

Approval by Environmental Officer / Environmental Manager: **Date:**

EO / EM Signature Required

Appendix H

Working Around Trees Guideline

Pacific Highway Upgrade:
Warrell Creek to Nambucca Heads

APPENDIX H: Working Around Trees Guideline
WC2NH-EN-FF-MPL_H Working Around Trees Rev 0

Rev	Description	Originator	Reviewed	Approved	Date
A	Appendix H: Working Around Trees Guidelines	Noelene Rutherford	RMS		23/09/14
0	Finalised and Approved	Noelene Rutherford	RMS	DPE	10/12/14

Details of Revision Amendments

Procedure Control

The latest approved version of this Procedure will be available for all Project personnel on the Electronic Document Management System - TeamBinder. The functional manager will maintain, review and update this Procedure in accordance with the Revision requirements of the Construction Environmental Management Plan (Refer to section 1.6 of the CEMP).

Amendments

Each new revision to the Procedure will be distributed to all required personnel for review and approval. The revision number is included at the end of the document number, which is noted in the footer of each page. The document will be allocated a new revision number each time a change is made to the document.

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The functional Manager is responsible for the implementation and review of the Procedure. The Project Director will approve new revisions of the Procedure via the review and approval process as detailed in the Document Control Procedure.

Functional Manager Authorisation	Distribution List	
Name: Noelene Rutherford Date: 11 December 2014 Position: Environment Manager Signature: NRutherford Comments: —	Project Director	
	Design Manager	
	Quality Manager	
	Procurement Manager	
	Construction Manager	
	Safety Manager	
	Commercial Manager	
	Environmental Manager	
Project Director Authorisation	Finance Manager	
Name: C. Guillermo Ripado Date: 11/12/14 Signature: Comments:	Engineer Manager	
	Area Manager	
	Human Resources Manager	
	Site Superintendents	
	Roads and Maritime Services	
	IMS Manager	
	Other:	

Contents

Terms and Abbreviations

AADJV	Arup and Aurecon Design Joint Venture
ACCIONA	ACCIONA Infrastructure Australia Pty Ltd
AFJV	ACCIONA and Ferrovial Joint Venture
AS/NZS	Australian and New Zealand Standard
ASM	Acid Sulfate Materials
ASMMP	Acid Sulfate Materials Management Plan
CEMP	Construction Environmental Management Plan
D&C	Design and Construction
DJV	Design Joint Venture
DoE	Department of Environment (Commonwealth)
EEC	Endangered Ecological Communities
EDMS	Electronic Document Management System (TeamBinder)
ENM	Excavated Natural Materials
EO	Environmental Officer
EPBC	Environmental Protection and Biodiversity Conservation
EPRM	Excavated public road material
EWMS	Environmental Works Method Statement
Ferrovial	Ferrovial Agroman (Australia) Pty Ltd
IMS	Integrated Management System
ISO	International Standards Organisation
KPI	Key Performance Indicator
MCoA	Minister's Conditions of Approval

MNES	Matters of National Environmental Significance
NSW	New South Wales
O&M	Operations and Maintenance
PCBU	Person Conducting a Business or Undertaking
PMT	Project Management Team
PV	Project Verifier
RMS	Roads and Maritime Services
FFMP	Flora and Fauna Management Sub-plan (CEMP Appendix B2 Flora and Fauna Management Sub Plan)
VENM	Virgin Excavated Natural Materials
WC2NH	Warrell Creek to Nambucca Heads (the Project)

Definitions

Client	An organisation inviting and receiving tenders and letting contracts. For the purposes of this project - Roads and Maritime Services
Contractor	An organisation that contracts with a client to carry out construction and related services. For the purposes of this Project - ACCIONA Ferrovial Joint Venture.
Deed	D&C Project Deed, IC-DC-C91-1, Pacific Highway Warrell Creek to Nambucca Heads
Design Joint Venture	Joint Venture consisting of Arup and Aurecon
Government Agency	NSW government department, authority, corporation or entity established by an Act of the NSW Parliament
Persons Conducting a Business or Undertaking	Is an employer, corporation, partnership, unincorporated association that has the primary duty of care for workplace health and safety - (AFJV and Contractors are a PCBU)
Principal Contractor	A person conducting a business or undertaking that commissions a construction project. For the purposes of this project - AFJV
Project	The design and construction of the upgrade to the Pacific Highway between Warrell Creek and Nambucca Heads
Project Verifier	For the purpose of the Project, this is Davis Langdon Australia Pty Ltd
Subcontractor	Organisation that contracts with a principal contractor as the client to carry out construction and related services
Supplier	Organisation that contracts with a client to provide a product and / or service.
TeamBinder	The project Electronic Document Management System software
Worker	Is anyone who carries out work for a PCBU and includes: an employee, contractor or sub-contractor or an employee of, labour hire personnel, apprentice or trainee, work experience student

1. Introduction

The Warrell Creek to Nambucca Heads Pacific Highway Upgrade project (the WC2NH Project) is being designed and constructed in a joint venture consisting of ACCIONA Infrastructures Pty Ltd (ACCIONA) and Ferrovial Agroman (Australia) Pty Ltd (Ferrovial), in liaison with various other pre-qualified construction contractors, with overall project management and site supervision of the project by Roads and Maritime Services (RMS).

1.1. Project Background

The WC2NH project consists of the detailed design and construction of 19.6 km of new dual carriageway road on the Pacific Highway between the northern end of the existing Allgomera Deviation south of Warrell Creek and the southern end of the Nambucca Heads to Urunga Pacific Highway upgrade project west of Nambucca Heads. The project includes:

- 19.6 km of new divided dual carriageway;
- two grade separated interchanges at Warrell Creek and Bald Hill Road south of Macksville. Roads and Maritime is also investigating the provision of north facing ramps at North Macksville;
- longitudinal bridges across Upper Warrell Creek (including North Coast Railway Line), Williamson Creek, Warrell Creek, Nambucca River floodplain (2 of) and Nambucca River;
- overbridges on Rosewood Road, Albert Drive, Scotts Heads Quarry access road, Bald Hill Road, Old Coast Road South, Mattick Road and Old Coast Road North;
- an underpass at Cockburns Lane;
- local roads and drainage and fauna crossing structures; and
- associated infrastructure.

2. Purpose

Many of the works to be undertaken for the WC2NH Project involve works within or near forests or bushland, including within endangered ecological communities (EEC). Damage to trees and roots from excavation or material /equipment storage can cause declining tree health leading to structural instability. Damage can also result in an increased risk to worker and public safety from unstable trees and possible fines for the AFJV and its subcontractors.

This guideline has been prepared to provide AFJV and its contractors with an easy to use guide to the minimum requirements for working around trees to reduce the risk of damage.

3. Induction/Training

Personnel involved in any aspect of working around trees will be trained in the requirements of this guideline. All personnel are to be inducted on the location of sensitive areas, exclusion zones, the associated fencing / signage delineating these areas and the relevant actions for them with regards to this guideline during the project induction, EWMS and regular toolbox talks.

4. Scope

This guideline is applicable to all activities relating to working around trees on the WC2NH Project.

5. Guidelines

5.1. Tree Protection

For trees identified specifically for protection are to be appropriately demarcated by environmental and construction personnel, under supervision of an ecologist where required. Signposting and maintenance is to take place to ensure no impact to these trees.

5.2. Site Material Storage

The storage of soils/material under trees can compact soil, limit water and oxygen uptake, damage roots and cause tree death. Therefore prior to the commencement of works near trees, the Foreman or other construction personnel should determine areas where machinery, materials and equipment can be stored that are outside the drip line of trees.

5.3. General Construction near trees

For all works to be undertaken near vegetation to be retained, the following points should be observed:

1. Prior to using machinery within or close to the drip line of trees, observe the location of trunks, roots and branches to ensure damage is avoided.
2. Some branches can be tied back if they are obstructing work. This depends on the flexibility and strength of the tree. Contact the Foreman who will get the EO (who may contact the ecologist or arborist if required) to undertake flexibility test prior to tying back branches.
3. Report any tree damage to the Foreman or EO. Quick remedial action can usually prevent long term damage to the tree.

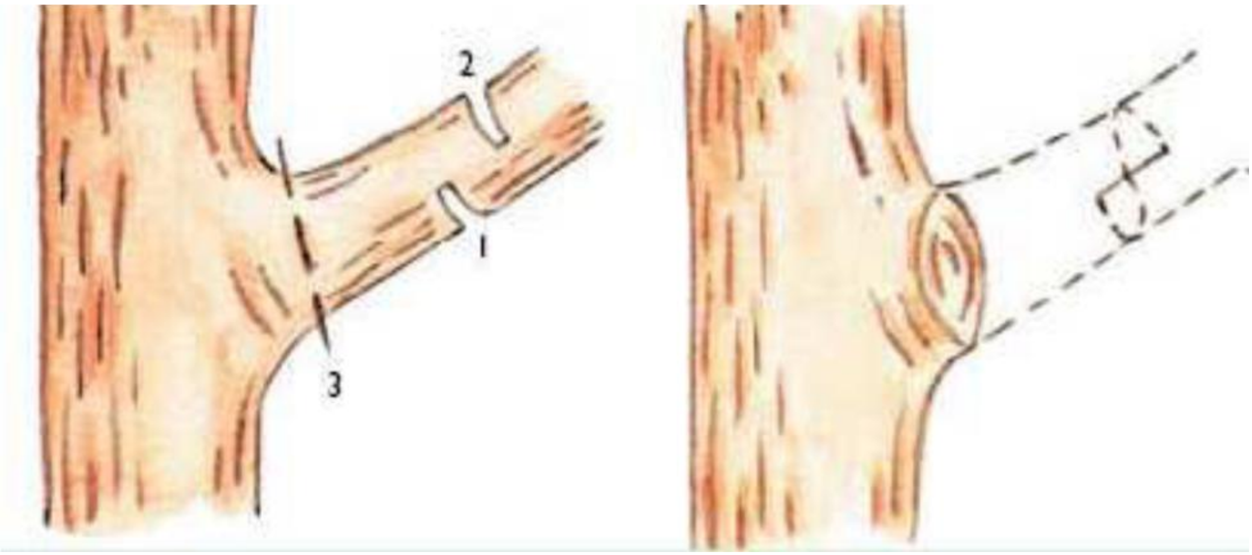
5.4. Tree trimming or removal

Some construction works will require tree removal or trimming that has not been included in the design. Where additional impacts to trees are proposed, the following process should be followed:

1. The Foreman should notify the EO of the location and need for the tree impact.
2. The EO should confirm that the tree (or other vegetation type) is not protected under relevant legislation and is able to be removed and/or trimmed as allowed under SWTC App 4.25.
3. If impact is permitted as per Step 2, and the tree is to be retained, the EO will contact an arborist to undertake the trimming of the tree(s) as required.
4. If impact is permitted as per Step 2, and the tree is to be removed, the EO will notify the Foreman that the tree can be removed.
5. The Foreman should await confirmation from the EO prior to re-commencing works around the tree(s).

Heavy machinery should not be used for pruning or trimming. Appropriate tools to use are loppers, chain saws and vehicle mounted saws. Larger limbs should generally be cut in accordance with the three cut method, shown below in Figure 1.

Limbs containing hollows should be retained wherever possible. If this is not possible, the hollow bearing limb should be inspected by the Project Ecologist, who supervises the felling operation, and placed in adjacent un-disturbed vegetation to provide fauna habitat.



1. The under cut.
2. The upper cut to remove the branch.
3. The final trim cut.

Figure 1 - Three cut method

Appendix I
Fauna Handling and Rescue Procedure

Pacific Highway Upgrade:
Warrell Creek to Nambucca Heads

APPENDIX I: Fauna Handling and Rescue Procedure
WC2NH-EN-FF-PRO_H Fauna Handling and Rescue Rev 0

Rev	Description	Originator	Reviewed	Approved	Date
A	Appendix I: Fauna Handling and Rescue Procedure	Noelene Rutherford	RMS		23/09/14
B	Updated to include comments made by Fisheries	Jack Henderson	Noelene Rutherford		02/12/14
0	Finalised and Approved	Noelene Rutherford	RMS	DPE	11/12/14

Details of Revision Amendments

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- an underpass at Cockburns Lane;
- local roads and drainage and fauna crossing structures; and
- associated infrastructure.

2. Purpose

This procedure explains the actions to be undertaken in the event fauna (including injured, shocked, juvenile or other animal) are discovered on the project site that require handling or rescue during vegetation and soil clearance and ongoing construction activities. Additionally this procedure explains the actions during the dewatering of dams and waterways where fish are present requiring relocation, taking into consideration relocation sites, euthanasia of pest species, logistics, etc.

3. Scope

This procedure is applicable to all native and introduced species that are found on the project site. Additionally, if it is suspected that there is the possibility of finding native and introduced aquatic species as the result of dewatering procedures this procedure is applicable.

4. Procedure

4.1 Non-Aquatic Fauna

If wildlife is discovered on the project site during site construction activities that may harm the animal or pose risk to site personnel, the following steps will be taken.

1. Stop all work in the vicinity of the fauna and immediately notify project Superintendent who is then to notify the Environmental Manager or Project Ecologist if the latter is present onsite.
2. Preferably allow fauna to leave an area without intervention.
3. Use a licensed fauna ecologist or wildlife carer with specific animal handling experience to carry out any fauna handling.
4. Where necessary, to minimise stress to native fauna and/or remove the risk of further injury before a licensed fauna handler arrives onsite, the Environmental Officer shall:
    a. Cover larger animals with a towel or blanket and place in a cardboard box and/or hessian bag;
    b. Place smaller animals in a cotton bag, tied at the top;
    c. Keep the animal quiet, warm, ventilated and in a dark location away from noisy construction activities; and
    d. Aquatic fauna to be placed in plastic aquaria or plastic bag with sufficient amount of water. Frogs would be transported without water or debris in recognition of the risk of transporting disease and the minimal transport time.

Note 1. Some animals require particular handling (e.g. venomous reptiles, raptors) and should only be handled by appropriately qualified personnel i.e. Project Ecologist or FAWNA / WIRES representative(s)

Note 2. If handling bats, the handler must be vaccinated against the Australian Bat Lyssavirus (ABL) which is a form of rabies.

Note 3. Any frog handling would be undertaken in accordance with the Hygiene Protocol for the Control of Disease in Frogs (DECC 2008). This protocol recommends onsite hygiene precautions be undertaken to minimise the transfer of disease between and within wild frog populations. Measures recommended include:

i) Thoroughly cleaning/disinfecting footwear and equipment when moving from one site to another;
ii) Where necessary in high risk areas, spraying/flushing vehicle tyres with a disinfecting solution;
iii) Cleaning/disinfecting hands between collecting samples/frogs (preference would be given to using bags, rather than bare hands to handle frogs); and
iv) Limiting one frog or tadpole to a bag. Bags should not be reused.

5. If the animal cannot be handled (i.e. venomous reptiles);
    a. Exclude all personnel from the vicinity with fencing and/or signage; and
    b. The exact location of the animals is to be recorded and provided to the Project Ecologist or appropriate rescue agency (i.e. FAWNA / WIRES).
6. Call the appropriate rescue agency immediately and follow any advice provided by the agency. Once the rescue agency arrives at the site, they are responsible for the animal. Any decisions regarding the care of the animal will be made by the rescue agency. The relevant fauna rescue services and local veterinary surgeries contact details are as follow:

Agency/business	Contact Number
Project Ecologist	*David Havilah 0407237985*
FAWNA / WIRES	*WIRES Nambucca and Mid North Coast 6564 8661*
RSPCA/Council Depot	*Nambucca Shire Council Ranger 6568 2555 or 0417 513 839 (Emergency Only)*

Veterinary Services	*Macksville Veterinary Clinic,* *21 Pacific Highway, North Macksville 6568 1252*
Port Macquarie Koala Hospital	*02 6584 1522*

In the event the rescue service and/or local veterinary service cannot be contacted, the injured animal will be delivered to the relevant agency as soon as practically possible.

7. If the fauna species is identified as a threatened species that is not a species identified in the FFMP, the Environmental Officer or Environmental Manager must:
    a. Immediately cease all work likely to affect the threatened species;
    b. The Environmental Manager shall contact the RMS Representative to inform of the situation.
    c. The Environmental Manger shall then contact the following stakeholders, in this order, to determine the appropriate corrective actions and additional safeguards to be undertaken:
        i. Project Ecologist 0407237985
        ii. EPA (131 555)
        iii. Environmental Representative
        iv. Others as instructed by the RMS Representative or EPA

    The adequacy of existing safeguards are to be reviewed in consultation with the above stakeholders.
8. Environmental Manager to record find in RMS Environmental Incident Report where required following consultation with the RMS Representative. All relevant characteristics of the fauna find should be recorded to the extent practicable (i.e. visual signs of behaviour; habitat; health signs; sex, time date, weather etc).
9. Following consultation with all relevant stakeholders, the Environmental Manager shall implement any corrective actions and additional safeguards.
10. Following confirmation by the Environmental Manager that all appropriate safeguards have been implemented, construction works shall recommence.
    a) Relocation of fauna along the footprint will be undertaken by the Project Ecologist or wildlife rescuer and will be recorded on the Weekly Environmental Inspection Checklist. If the animal is not injured or stressed, it may be released nearby in an area that is not to be disturbed by the project construction works, in accordance with the following procedures:
    b) Sites identified as suitable release points by the Project Ecologist or wildlife rescuer;
    c) Release site will contain similar habitat and occur as close to the original capture location as possible;
    d) If the species is nocturnal, release will be carried out at dusk; and
    e) Release would generally not be undertaken during periods of heavy rainfall.

The Project Ecologist will follow the relevant steps detailed below:

1. Surveys will be undertaken in accordance with the two stage clearing process
    a) During Stage 1 (under-scrubbing and non habitat tree removal) all fauna that can be physically captured during targeted works (i.e. active searches) will be relocated into areas of suitable habitat adjacent to the Project site (i.e. normally adjacent to the clearing footprint). The species, number, sex, age, class and general health of each individual is to be recorded for later reporting. The handling procedures are described below.

b) During Stage 2 (habitat tree removal at least 24 hours after Stage 1) all fauna captured will be relocated into areas of suitable habitat adjacent to the Project site. The species, number, sex, age, class and general health of each individual is to be recorded for later reporting. The handling procedures are described below.

2. To minimise stress to native fauna and/or remove the risk of further injury the Project Ecologist shall:
   a) Cover larger animals with a towel or blanket and place in a cardboard box and/or hessian bag;
   b) Place smaller animals in a cotton bag, tied at the top;
   c) Place frogs/tadpoles in a plastic bag with a small amount of water and/or vegetation;
   d) Fish and other aquatic life (i.e. turtles) place in plastic aquaria or plastic container with sufficient water; and
   e) For terrestrial fauna keep the animal in a quiet, warm, ventilated and dark place away from noisy construction activities.
   f) For aquatic fauna species ensure sufficient amount of water and ensure adequate aeration;

Note 1. Some animals require particular handling (e.g. venomous reptiles, raptors) and should only be handled by appropriately qualified personnel i.e. Project Ecologist or FAWNA / WIRES representative(s)

Note 2. If handling bats, the handler must be vaccinated against the Australian Bat Lyssavirus (ABL) which is a form of rabies.

Note 3. Any frog handling would be undertaken in accordance with the Hygiene Protocol for the Control of Disease in Frogs (DECC 2008).

3. Habitat trees are to be felled carefully using equipment that allows habitat trees to be lowered to the ground with minimal impact (eg claw extension).

4. In the event an animal is injured the following fauna rescue services and local veterinary surgeries contact details are as follows:

Agency/business	Contact Number
Project Ecologist	*David Havilah 0407237985*
FAWNA / WIRES	*WIRES Nambucca and Mid North Coast* *6564 8661*
RSPCA/Council Depot	*Nambucca Shire Council Ranger 6568 2555 or 0417 513 839 (Emergency Only)*
Veterinary Services	*Macksville Veterinary Clinic,* *21 Pacific Highway, North Macksville 6568 1252*
Port Macquarie Koala Hospital	*02 6584 1522*

In the event the rescue service and/or local veterinary service cannot be contacted, the most appropriate euthanasia will be administered by the Project Ecologist (i.e. cervical dislocation for small vertebrates, ice slurry for introduced fish). This is to occur in accordance with applicable guidelines and legislative requirements.

5. If the fauna species is identified as a threatened species that is not a species identified in the FFMP, notify the Environmental Officer or Environmental Manager who then must:
   a) Immediately cease all work likely to affect the threatened species;
   b) The Environmental Manager shall contact the RMS Representative to inform of the situation.
   c) The Environmental Manger shall then contact the following stakeholders, to determine the appropriate corrective actions and additional safeguards to be undertaken:
      i. EPA (131 555)
      ii. Environmental Representative
      iii. Others as instructed by RMS Representative or EPA
   d) Environmental Manager to record find in RMS Environmental Incident Report
   e) Following consultation with all relevant stakeholders, the Environmental Manager shall implement any corrective actions and additional safeguards.
   f) Following confirmation by the Environmental Manager that all appropriate safeguards have been implemented, construction works shall recommence.
6. Relocation of fauna captured during the clearing and associated works will generally take place in areas of suitable habitat immediately adjacent to the Project site taking into account:
   a) The release site contains similar habitat and occurs as close to the original area as possible;
   b) If the species is nocturnal, release will normally be carried out at dusk;
   c) Release would generally not be undertaken during periods of heavy rainfall expect for aquatic fauna; and
   d) Non-native fauna will not be translocated and will be euthanised.

   If the animal has been placed into care due to injury, age (i.e. young) or stress, upon its rehabilitation it will be released in an area that is not to be disturbed by the project construction works, at the discretion of the project ecologist taking the above into account. The Project Ecologist will record and provide the capture and relocation data in the post clearing report.

4.2 Aquatic Fauna

During the project it may be necessary to relocate aquatic fauna, in particular as a result of the dewatering of dams and sections of waterways with aquatic fauna present. In general to avoid the spread of diseases as well as plant and fish pest species should take place downstream and within the same catchment relative to the rescue point. A risk assessment should be conducted before the relocation of fish from an “offline” waterbody (not located in natural drainage system e.g. turkey nest dams) into a natural system as there is a heightened risk of disease and pest spread.

A permit is required to take prohibited size or protected fish, capture fish using non recreational fishing equipment or exceed bag limits under *Fisheries Management Act 1994* Section 37. Obtaining this permit from NSW DPI should be prioritised as the permit processing may take some time. If possibility exists as a result of activity to require relocation of Threatened fish species an assessment, as well as Species Impact Statement should be prepared if assessment indicates that there is likely to be an impact on the species (*Fisheries Management Act 1994*). Inclusion of these potential Threatened species should occur as part of the permit, which include a defence to take Threatened fish.

Commonwealth Department of Sustainability, Environment, Water, Population and Communities (DSEWPAC) should be consulted if any nationally listed Threatened species are present at the relocation or receiving site. Water removal to a lower pool or river bank works may require a permit from the Office of Water (NOW).

Logistical factors

- Access to site for machinery
- Ensure access for staff to safely capture fish and relocate
- Size of waterbody – how much water/ approximate volume required for treatment in sediment basins. Water quality testing will be used to inform the water that is able to released downstream if any, at some point of pumping suspended sediment levels will indicate when water will need to be treated prior to release
- Ecologist to establish the presence or absences as well as the abundance of native and pest fish as well as assessing the aquatic weeds present if any. Ecologist also will ascertain if there is suitable habitat for native fish to be relocated to and how many fish the relocation site would be able to support if any.
- Landholder should be consulted to ascertain if fish are present in the waterbody through stocking or otherwise
- Suitable disposal site should be identified for euthanized fish (usually landfill)
- Record kept of number and species of fish released as well as the number and species euthanised. NSW DPI permit requires this

Methodology for relocation

1. Siphon or pump the waterbody to a level to allow fish to be removed using environets or a combination of electro fishing and netting. Adequate meshing utilized on pump sumps to prevent ingress of aquatic species.
2. Divide fish into pest/non endemic fish for euthanasia in an ice slurry. Fish to be released are put into tubs of water and moved into aerated transport tank as soon as possible and the taken to the release location(s) and released into areas selected by the ecologist from the assessment. Monitor

3. Following relocation visual check should be conducted downstream for any injured or dead/dying fish which will then be removed. Habitat pools selected should also be visually inspected.

Equipment required

- Permit from NSW DPI. This should be given primary importance as the permit may take some time to obtain
- Pumps, pump sump screen/ syphons as required for the waterbody size
- Light Vehicle with: transport tank, aerators, O2 bottle, regulator, airline and airstones
- Sediment basin for treatment of unsuitable water
- Tubs and ice for euthanising pest/non-endemic species
- Environets for capturing fish
- Tubs to move fish from waterbody to transport vehicle

Checklist

Ensure the following aspects are considered prior to translocating aquatic fauna:

- What are the consequences of doing nothing?
- Does the expenditure justify the effort?
- Are the fish Threatened species?
- What are the community expectations?
- Can you physically and safely access the site with the appropriate equipment to capture the fish?
- Is a suitable relocation site available? Is it close by? Does it have same genetics, diseases, pests etc as the waterbody the fish are sourced from?
- What impact will the relocated fish have on populations at the relocation site? Will there be increased predation, competition for habitat, genetic impacts, or limited food availability?
- It is important to avoid of translocating non-endemic species.
- Are any diseases known to be present or are the fish in an area known to be affected by a particular disease?

- Are there any pest or translocation implications?
- Are pest fish likely to be encountered and in what quantities? Euthanasia will be required for pest fish and a suitable disposal site will be required. Dewatering may involve euthanasing large quantities of pest or non endemic fish and transport and disposal of them at an approved location.
- What time constraints are there and can you work within them?
- Can you manage water appropriately while conducting the works?(ersed, where does it go, is the water owned by irrigators, landholders etc, is the water discharge covered by an EPA EPL.
- What resources are required?
- Have you prepared a safe work method statement?
- Do you have land owners permission to conduct works?
- Have you obtained all legislative requirements?
- Are any diseases known to be present or are the fish in an area known to be affected by a particular disease?
- Will you need to treat water prior to release via sediment basins to prevent pollution of waters? Consult EPA to establish what if any water treatment will be required and if any licence is required.

The above information is to be included in a Site Specific EWMS for the translocation.

Appendix J
Unexpected Threatened Species / EECs Procedure

Pacific Highway Upgrade:
Warrell Creek to Nambucca Heads

APPENDIX J: Unexpected Threatened Species/EEC / MNES Procedure
WC2NH-EN-FF-PRO_J Unexpected Threatened Species/EEC /MNES Rev 0

Rev	Description	Originator	Reviewed	Approved	Date
A	Appendix J: Unexpected Threatened Species/EEC Procedure	Noelene Rutherford	RMS		23/09/14
B	Updated with Comments from DPE and incorporate EPBC Approval	Noelene Rutherford	RMS		09/12/14
0	Finalised and Approved	Noelene Rutherford	RMS	DPE	11/12/14

Details of Revision Amendments

Procedure Control

The latest approved version of this Procedure will be available for all Project personnel on the Electronic Document Management System - TeamBinder. The functional manager will maintain, review and update this Procedure in accordance with the Revision requirements of the Construction Environmental Management Plan (Refer to section 1.6 of the CEMP).

Amendments

Each new revision to the Procedure will be distributed to all required personnel for review and approval.
The revision number is included at the end of the document number, which is noted in the footer of each page.
The document will be allocated a new revision number each time a change is made to the document.

When a new revision to the document is available, a notification email will be distributed to all project personnel by the Document Control Team advising of the update.

The functional Manager is responsible for the implementation and review of the Procedure. The Project Director will approve new revisions of the Procedure via the review and approval process as detailed in the Document Control Procedure.

Functional Manager Authorisation	Distribution List	
Name: Noelene Rutherford Date: 11 December 2014 Position: Environment Manager Signature: N Rutherford Comments: —	Project Director	
	Design Manager	
	Quality Manager	
	Procurement Manager	
	Construction Manager	
	Safety Manager	
	Commercial Manager	
	Environmental Manager	
Project Director Authorisation	Finance Manager	
Name: L. Guillermo Ripado Date: 11/12/14 Signature: Comments:	Engineer Manager	
	Area Manager	
	Human Resources Manager	
	Site Superintendents	
	Roads and Maritime Services	
	IMS Manager	
	Other:	

Contents

Terms and Abbreviations

AADJV	Arup and Aurecon Design Joint Venture
ACCIONA	ACCIONA Infrastructure Australia Pty Ltd
AFJV	ACCIONA and Ferrovial Joint Venture
AS/NZS	Australian and New Zealand Standard
ASM	Acid Sulfate Materials
ASMMP	Acid Sulfate Materials Management Plan
CEMP	Construction Environmental Management Plan
D&C	Design and Construction
DJV	Design Joint Venture
DoE	Department of Environment (Commonwealth)
EEC	Endangered Ecological Communities
EDMS	Electronic Document Management System (TeamBinder)
ENM	Excavated Natural Materials
EO	Environmental Officer
EPBC	Environmental Protection and Biodiversity Conservation
EPRM	Excavated public road material
EWMS	Environmental Works Method Statement
Ferrovial	Ferrovial Agroman (Australia) Pty Ltd
IMS	Integrated Management System
ISO	International Standards Organisation
KPI	Key Performance Indicator
MCoA	Minister's Conditions of Approval
MNES	Matters of National Environmental Significance
NSW	New South Wales
O&M	Operations and Maintenance
PCBU	Person Conducting a Business or Undertaking
PMT	Project Management Team
PV	Project Verifier
RMS	Roads and Maritime Services

FFMP	Flora and Fauna Management Sub-plan (CEMP Appendix B2 Flora and Fauna Management Sub Plan)
VENM	Virgin Excavated Natural Materials
WC2NH	Warrell Creek to Nambucca Heads (the Project)

Definitions

Client	An organisation inviting and receiving tenders and letting contracts. For the purposes of this project - Roads and Maritime Services
Contractor	An organisation that contracts with a client to carry out construction and related services. For the purposes of this Project - ACCIONA Ferrovial Joint Venture.
Deed	D&C Project Deed, IC-DC-C91-1, Pacific Highway Warrell Creek to Nambucca Heads
Design Joint Venture	Joint Venture consisting of Arup and Aurecon
Government Agency	NSW government department, authority, corporation or entity established by an Act of the NSW Parliament
Persons Conducting a Business or Undertaking	Is an employer, corporation, partnership, unincorporated association that has the primary duty of care for workplace health and safety - (AFJV and Contractors are a PCBU)
Principal Contractor	A person conducting a business or undertaking that commissions a construction project. For the purposes of this project - AFJV
Project	The design and construction of the upgrade to the Pacific Highway between Warrell Creek and Nambucca Heads
Project Verifier	For the purpose of the Project, this is Davis Langdon Australia Pty Ltd
Subcontractor	Organisation that contracts with a principal contractor as the client to carry out construction and related services
Supplier	Organisation that contracts with a client to provide a product and / or service.
TeamBinder	The project Electronic Document Management System software
Worker	Is anyone who carries out work for a PCBU and includes: an employee, contractor or sub-contractor or an employee of, labour hire personnel, apprentice or trainee, work experience student

1. Introduction

The Warrell Creek to Nambucca Heads Pacific Highway Upgrade project (the WC2NH Project) is being designed and constructed in a joint venture consisting of ACCIONA Infrastructures Pty Ltd (ACCIONA) and Ferrovial Agroman (Australia) Pty Ltd (Ferrovial) trading as Pacifico – Acciona Ferrovial JV (Herein known as AFJV), in liaison with various other pre-qualified construction contractors, with overall project management and site supervision of the project by Roads and Maritime Services (RMS).

1.1. Project Background

The WC2NH project consists of the detailed design and construction of 19.6 km of new dual carriageway road on the Pacific Highway between the northern end of the existing Allgomera Deviation south of Warrell Creek and the southern end of the Nambucca Heads to Urunga Pacific Highway upgrade project west of Nambucca Heads. The project includes:

- 19.6 km of new divided dual carriageway;
- two grade separated interchanges at Warrell Creek and Bald Hill Road south of Macksville. Roads and Maritime is also investigating the provision of north facing ramps at North Macksville;
- longitudinal bridges across Upper Warrell Creek (including North Coast Railway Line), Williamson Creek, Warrell Creek, Nambucca River floodplain (2 of) and Nambucca River;
- overbridges on Rosewood Road, Albert Drive, Scotts Heads Quarry access road, Bald Hill Road, Old Coast Road South, Mattick Road and Old Coast Road North;
- an underpass at Cockburns Lane;
- local roads and drainage and fauna crossing structures; and
- associated infrastructure.

2. Purpose

This procedure details the actions to be taken when a threatened species / EEC / MNES is unexpectedly encountered during excavation / construction activities.

3. Induction/ training

Where required, personnel will be inducted on the identification of potential threatened species / EEC / MNES occurring on site and the relevant actions for them with regards to this procedure during the Project Induction, Site Inductions and regular Toolbox Talks.

4. Scope

This procedure is applicable to all activities conducted by personnel that have the potential to come into contact with threatened flora species. Where threatened fauna is unexpectedly encountered, refer to the **Fauna Handling and Rescue Procedure**.

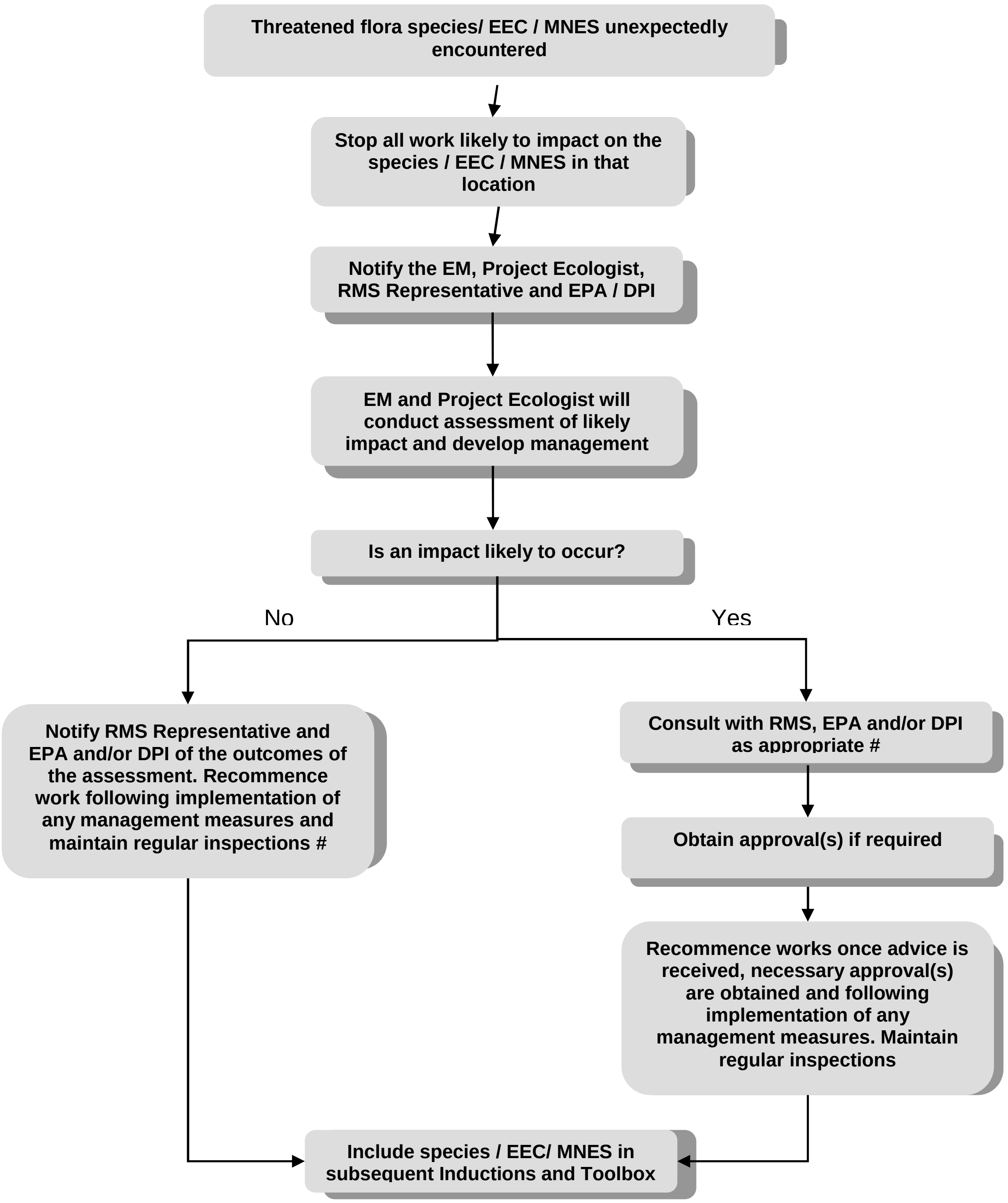
Unexpected threatened flora species / EEC/ MNES encountered (STOP WORK) → **Notify Environmental Manager (EM), Project Ecologist, RMS and the EPA** → **Assessment of potential impact and mitigation** → **Recommence works after clearance given**

Refer to **Figure 5.1** for Unexpected Threatened Flora Species / EEC / MNES Find Procedure flow chart.

5. Procedure

1. Threatened flora species / EEC / MNES unexpectedly encountered during excavation/construction activities
If a threatened flora species / EEC / MNES is unexpectedly encountered during excavation / construction activities: • **STOP ALL WORK** in the vicinity of the find Immediately notify the Environmental Manager (EM), or Environmental Officer (EO) who will notify the Project Ecologist, RMS and the EPA.
2. Assessment of Impact
An assessment is to be undertaken by the EM and the Project Ecologist to determine the likely impact to the threatened flora species / EEC / MNES and appropriate management options developed in consultation with RMS. If a significant impact is likely to occur, consultation will be undertaken with the EPA and / or DPI as appropriate. AFJV will discuss any changes to monitoring requirements and offsets with Roads and Maritime. The monitoring program and offset strategy will be updated if required and agreed with Roads and Maritime in consultation with the EPA, DPE and other relevant agencies.
3. Approvals
Obtain any relevant licences, permits or approvals required if the species / EEC is likely to be significantly impacted.
4. Recommencement of Works
Works will recommence once necessary advice has been sought and approval obtained if required. Include threatened flora species / EEC / MNES in subsequent Project Inductions and Toolbox Talks.

Figure 5.1 Unexpected Threatened Flora Species / EEC / MNES Find Procedure Flow Chart



Note: The Commonwealth Department of Sustainability, Environment, Water, Population and Communities is to be consulted if the flora species encountered is listed under the EPBC Act.

Appendix K
Weed and Pathogen Management Plan

Weed and Pathogen Management Plan

Warrell Creek to Nambucca Heads Upgrade of the Pacific Highway

quality solutions sustainable future

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Weed and Pathogen Management Plan

Warrell Creek to Nambucca Heads Upgrade of the Pacific Highway

Prepared for: Acciona and Ferrovial Joint Venture/
Roads and Maritime Services

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UPR	*Description*	*Date Issued*	*Issued By*
2378-1007	First issue	13/08/2014	DGH
2378-1030	Second issue	28/08/2014	DGH
2378-1044	Third issue	15/09/2014	DGH
2378-1046	Fourth issue	23/09/2014	DGH
2378-1057	Fifth issue	30/10/2014	DGH
2378-1080	Sixth issue	04/12/2014	DGH
2378-1083	Seventh issue	11/12/2014	DGH

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Introduction

1.1 Project Overview and Background to the Plan

The Pacific Highway Upgrade Program is a joint commitment by the Australian and New South Wales (NSW) governments to improve the standard and safety of the Pacific Highway between Hexham and the Queensland border.

The Warrell Creek to Urunga (WC2U) project forms part of the Pacific Highway Upgrade Program and comprises approximately 42 kilometres of dual carriageway road that would bypass the towns of Warrell Creek, Macksville, Nambucca Heads and Urunga on the Mid North Coast of NSW. The Project has been divided into two stages with Stage 1 consisting of the approximate 22.5 kilometre stretch from Nambucca Heads to Urunga (NH2U) and Stage 2 consisting of the remaining approximate 19.5 kilometres of dual carriageway between Warrell Creek and Nambucca Heads (WC2NH). This Weed Management Plan relates to Stage 2 (WC2NH) which is referred to throughout this report as 'the Project' (refer to Illustration 1.1).

The Acciona and Ferrovial Joint Venture (AFJV) has been awarded the contract to design and construct the WC2NH upgrade.

As part of the WC2NH project, effective and ongoing weed and pathogen control measures are to be identified and implemented to prevent the spread of weeds and soil-borne pathogens. Project requirements for weed and pathogen management on the project are provided in the following documents and summarised in Table 1.1:

- Ministers Conditions of Approval (MCoA).
- RMS Specifications: D&C G36 Environmental Protection – *Version for Pacific Highway Upgrade-Warrell Creek to Nambucca Heads (RMS, 2013*).
- RMS Specifications: D&C G40 Clearing and Grubbing – *Version for Pacific Highway Upgrade-Warrell Creek to Nambucca Heads (RMS, 2013*).

Table 1.1 RMS Specifications for Weed and Pathogen Control on the WC2NH Project

Reference	*Section*	*Requirement*
Minister's CoA	B31 (b)(v- part there of)	*As part of the Construction Environment Management Plan for the project required under condition B30 of this approval, the Proponent shall prepare and implement the following subplan(s)...including (b) a Construction Flora and Fauna Management Plan to detail how construction impacts on ecology will be minimised and managed.... including details of general work practices to minimise the potential for damage to native vegetation (particularly EECs) not proposed to be cleared as part of the project and native fauna during construction, including (but not necessary limited to)....appropriate topsoil management, construction worker education, weed management, erosion and sediment control and progressive re-vegetation...*
D&C Specification G36	4.11 (d)	*The Contractor must include procedures in the Construction Environment Management Plan (CEMP), Flora and Fauna Management Sub-plan (FFMP) for controlling the introduction and spreading of weeds caused by the Work Under the deed, including the arrangements for monitoring.*
	4.11.1	*Where weeds are present, consult relevant Authorities, and be guided by best practice removal and control techniques and any management procedures that may have been developed for particular noxious weeds.*

Reference	*Section*	*Requirement*
		All staff must be made aware of noxious weeds present on the Site and the other areas affected by the Contractor's Work and requirements related to the listing under the Noxious Weeds Act 1993.
D&C Specification G40	2.4.2	*Prior to the commencement of clearing and grubbing, prepare a Weed and Pathogen Management Plan in consultation with the Project Ecologist. The Weed and Pathogen Management Plan must adhere to best practice guidelines and be prepared and implemented in accordance with the Noxious Weeds Act 1993, and National Trust Weed Management Manual and incorporated into the Construction Flora and Fauna Management Plan.*
		The Weed and Pathogen Management Plan must include pre-construction, construction and post construction weed control works including the weed control works to be undertaken during the Landscape Maintenance Period, to control the spread of weeds and to reduce the levels of weed infestation within the Construction Site and adjoining areas, and include measures to improve the quality of habitat in retained vegetation.
		The Weed and Pathogen Management Plan must include controls to prevent the introduction or spread of Phytophthora cinnamomi in accordance with Planning and Infrastructure's condition of approval B.31(b)(iii).
		The Weed and Pathogen Management Plan must include requirements for monitoring through which the success of weed control is assessed and techniques modified where necessary, including measures to improve the quality of habitat in retained vegetation. The monitoring must include regular site visits, mapping and fixed point photographs of the Construction Site and adjoining areas.
		The frequency and duration of weed monitoring must be specific to the Construction Site and adjoining areas with the flexibility to respond to changes in the environment. As a minimum, undertake weed inspections on a monthly basis for the first six months after commencement of construction (or as necessary responding to seasonal and climatic conditions), then at least every two months for a further six months until the Date of Construction Completion.
		Submit a report to the Project Verifier, Environmental Representative and RMS Representative outlining the results of each monitoring inspection against the weed management objectives and activities in the Weed and Pathogen Management Plan.
		The Contractor must consult with the relevant local Weeds Authority Officer on the presence of any noxious weed in areas to be cleared and to ascertain if any special precautions are required. Should the presence of noxious weeds be confirmed, the Contractor must mark out their location and then treat them in accordance with the Weed and Pathogen Management Plan.
	2.4.3	*Prevent the spread of noxious weeds by managing the movement of contaminated plant and equipment into uninfested areas.*
		Site specific vehicle movement plans must to be prepared for each worksite that contains a noxious weed infestation/ or native/ or remnant vegetation that could be affected by the Contractor's Work. The vehicle movement plans must include identification of vehicles, plant, equipment, turning and parking areas and any vehicle, plant and equipment hygiene measure to ensure compliance with the Noxious Weeds Act 1993.

Reference	Section	Requirement
		Treat and dispose of any noxious weeds in accordance with their category under the Noxious Weeds Act 1993. Any spraying of noxious weeds must comply with RMS D&C G36 clause 6.12.2 and be carried out with care to avoid damage to adjacent native vegetation and to prevent overspray entering waterways or adjacent property.
		Where noxious weed areas are disturbed by your construction activities, weeds and topsoil potentially containing weed propagules must be removed and disposed of in accordance with the requirements of the Local Weeds Authority.
	5.1	*Under no circumstances must the extent of clearing and grubbing be extended or weeds or exotic species used to make up any shortfall of mulch.*

1.2 Purpose and Goals

This Weed and Pathogen Management Plan (WPMP) identifies how potential impacts associated with weed contamination, noxious and environmental weeds and plant pathogen spread will be managed during construction of the WC2NH project. The key objectives of this plan are to give direction to ensure the Project avoids, suppresses and controls the spread of all weeds, plant pathogens and invasive species to ensure that impacts to the environment are minimised. The specific goals of the weed and pathogen management on the project are as follows:

- Compliance with relevant legislation and project requirements.
- Identify listed noxious and significant infestations of environmental weeds growing within the project boundary and provide maps showing these areas.
- Treat and dispose of all noxious weeds in accordance with their category under the Noxious Weeds Act 1993 prior to and during clearing/ grubbing.
- No new weeds introduced to the project area.
- No increase in distribution of weeds currently existing within the project areas.
- Minimise adverse impacts to biodiversity from weed control works.
- No transfer of plant diseases or pathogens to or from the project work areas.
- Best practice weed/ pathogen hygiene protocols to be undertaken by personnel and applied to all plant/ machinery entering/ leaving site to minimise the spread of weeds and plant pathogens.
- Prevent the spread of weeds by best practice mulch and topsoil management.

The plan covers all areas within the approved WC2NH project boundary and incorporates the pre-construction, construction and post-construction (landscape maintenance period) stages of the project The plan has been prepared based on best practice weed/ pathogen management information and the RMS Biodiversity Guidelines (2011).

1.3 Management Structures and Plan Updates

This management plan has been presented using an adaptive management approach based on firstly identifying specific goals for management, implementation of management actions followed by monitoring of the performance of these measures against the goals and identified thresholds. As a final step the monitoring would evaluate the effectiveness of the management measures using identified thresholds for performance and implementing corrective actions to improve mitigation where required. To ensure the success of this approach the management goals presented in the plan have been based on the following SMART principles:

- Specific
- Measurable
- Achievable
- Results-based
- Time-based.

The WPMP has been prepared in consultation with RMS, the Environment Protection Authority (EPA) and Nambucca Shire Council (Weeds Officer). General responsibilities for environmental management would be outlined in the project specific Construction Environment Management Plan (CEMP), the Flora and Fauna Management Plan (FFMP), and the project specific Soil and Water Management Plan (SWMP). These management plans would be prepared prior to the commencement of construction. AFJV is responsible for implementing the measures in this WPMP and this would include the engagement of suitably qualified specialists to undertake weed control and monitoring activities where necessary.

1.4 Plan Authors

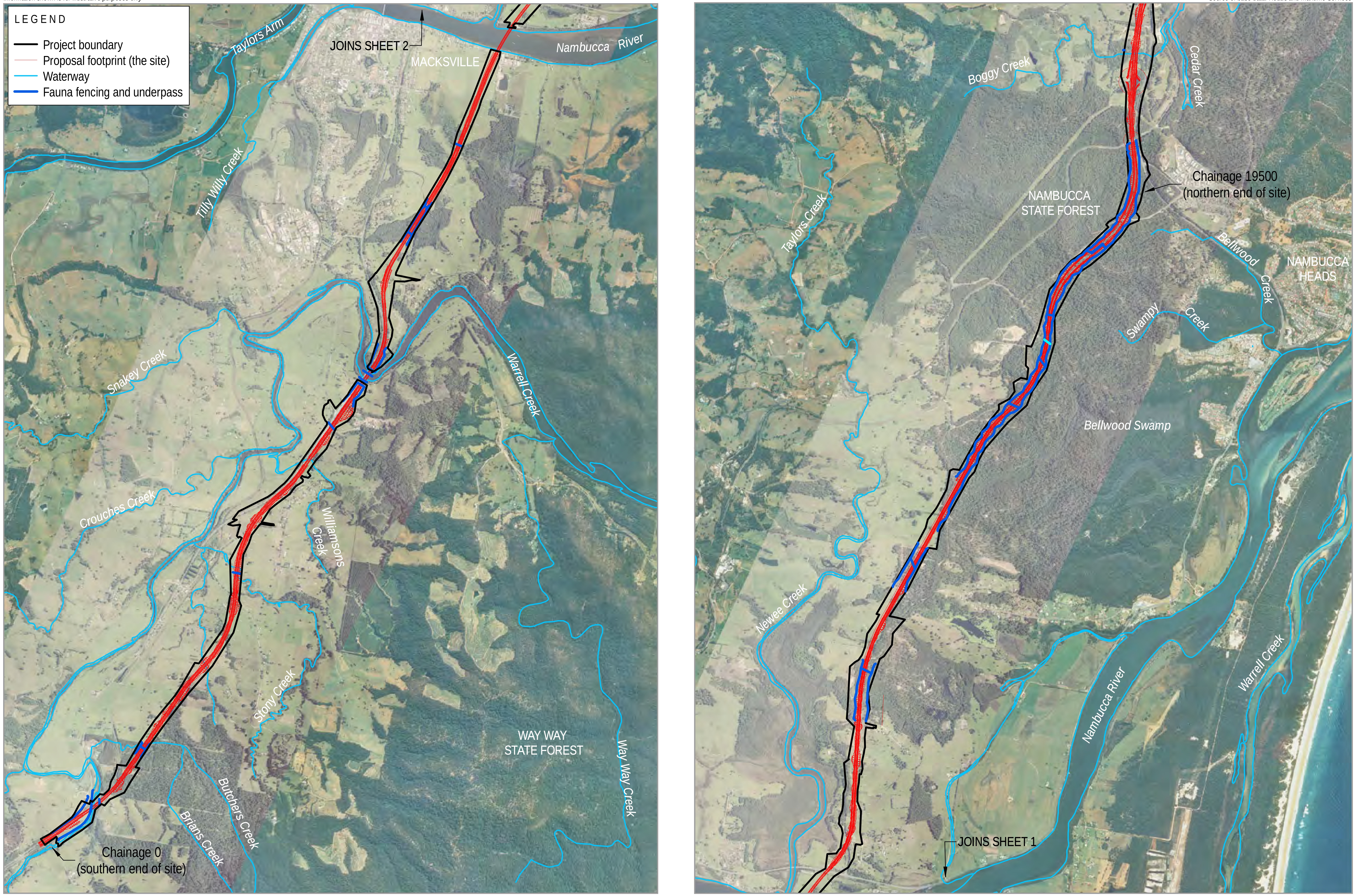
The Weed Management Plan has been prepared by the following personnel from Project Ecologist, GeoLINK:

- David Havilah (Senior Ecologist).
- Veronica Silver (Senior Ecologist – Peer Review).

Qualifications and experience of the plan authors are provided in Appendix A.

Information shown is for illustrative purposes only

Drawn by: GJM Checked by: RE Reviewed by: DGH Date: August 2014
Source of base data: Roads and Maritime Services



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WC2NH Weed and Pathogen Management Plan
2378-1018

The Project Site

Illustration 1.1

Weeds Occurring on the Site

2.1 Relevant Legislation

Legislation relevant to this plan includes:

- *Threatened Species and Conservation Act 1995* (TSC Act).
- *Noxious Weeds Act 1993* (NW Act).
- *Pesticides Act 1999.*
- *Environmental Protection and Biodiversity Conservation Act 1999* (Commonwealth) (EPBC Act).

2.2 Weed Classification

For the purposes of this report, a 'weed' is defined as a plant growing in a terrestrial or aquatic area where it is not wanted (RMS, 2011). Weeds are generally classed into broad groups depending on their characteristics and potential impacts. The main groups of weeds considered within this report are described in Table 2.1.

Table 2.1 Classification of Weeds in NSW

Classification	*Description*
Weeds of National Significance (WONS)	Listed under the National Weeds Strategy
National Environmental Alert List Weeds	Identified under the National Weeds Strategy
Noxious	Require control under the Noxious Weeds Act 1993 (NSW) – Noxious weed declarations, their control class and control requirements are different for each local Government Area
Environmental	Represent a threat to the conservation values of a natural ecosystem
Agricultural	Represent a threat to agricultural production

2.3 Survey Methodology

A database search of the NSW Department of Primary Industries (DPI) Noxious Weed Declarations for the Nambucca Shire Local Government Area (LGA) was undertaken to obtain a list of noxious weeds as listed under the *Noxious Weeds Act, 1993* known for the LGA (refer to Appendix B).

Field surveys of all areas within the WC2NH project boundary were undertaken during the period from 21 to 28 July 2014 by two ecologists from GeoLINK in conjunction with other ecological surveys being undertaken for the project.

Surveys involved undertaking walking transects throughout the entire project corridor and mapping the locations of noxious weed infestations with IPADs and IGIS software. Detailed notes were taken of the location, size and composition of weed occurrences as well as photographs of infestations. Weed infestations as identified in the field were mapped using ARCGIS software.

2.4 Survey Results

2.4.1 General Findings

The weed surveys identified 38 (noxious and environmental) weed species which are listed in Appendix C.

Of particular note among the non-noxious weeds is Coolatai Grass (*Hyparrhenia hirta*) which occurs over existing roadside verges associated with the site. This species was noted by Nambucca Shire Council's weed officer as being of particular concern locally. It is noted that Camphor Laurel (*Cinnamomum camphora*) has recently been removed from the list of Noxious Weeds for the Nambucca Control area although is still treated on Council owned land.

2.4.2 Noxious Weeds

Eight listed 'Noxious weeds' were detected during the survey (refer to Table 2.2). Three of these species, Lantana (*Lantana camara*), Salvinia (*Salvinia molesta*) and Fireweed (*Senecio madagascariensis*) are also listed as Weeds of National Significance (WoNS). The invasion, establishment and spread of Lantana is also listed as a Key Threatening Process under the TSC Act. Noxious weed infestations mapped on the site are shown on Illustrations 2.1 to 2.8.

Lantana was the most prevalent of these species with occurrences throughout the site including large infestations in the Nambucca State Forest area.

Table 2.2 Listed Noxious Weeds Identified on the Site

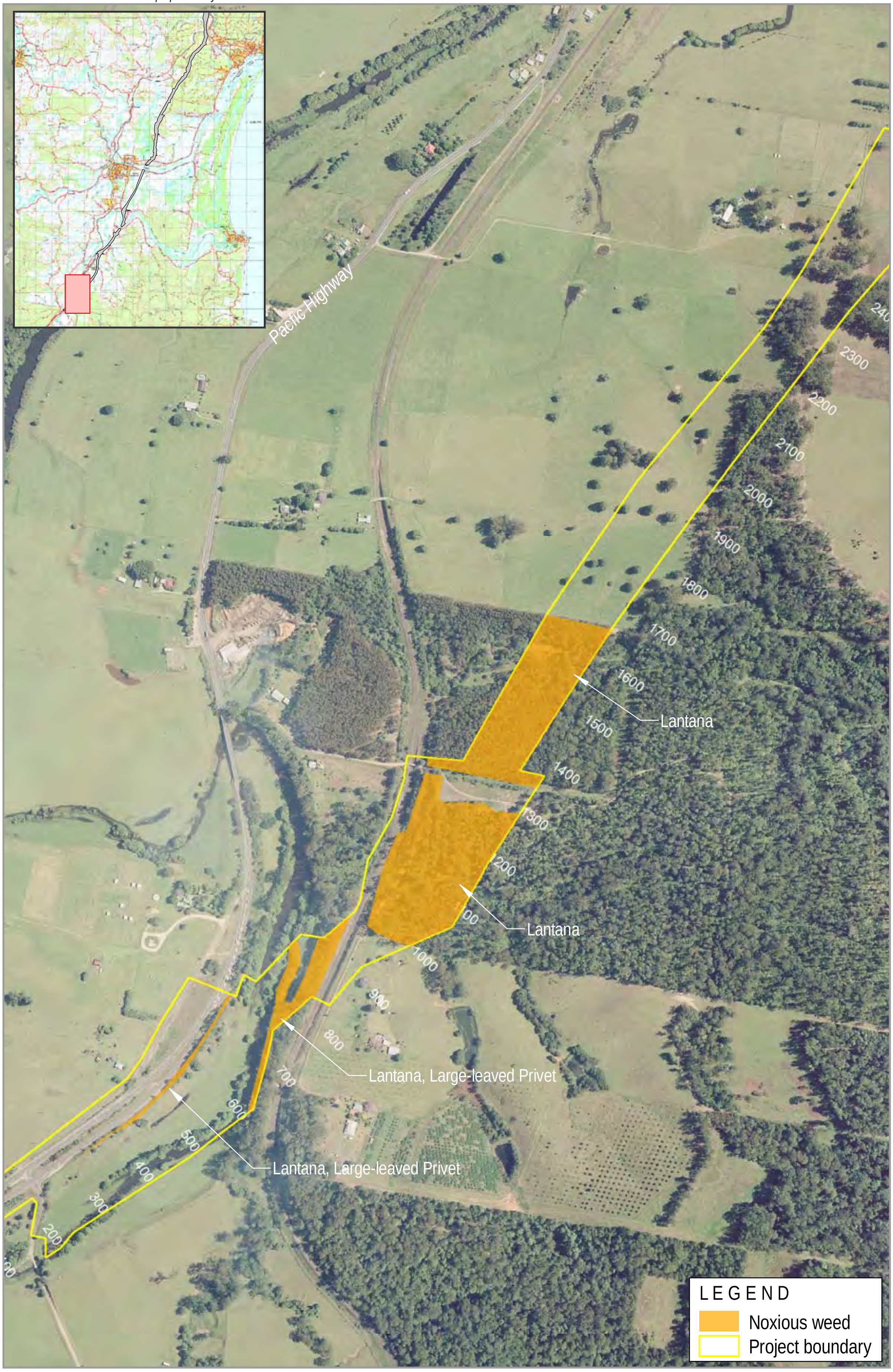
Scientific Name	*Common Name*	*Listing*	*Extent / Location*
Ambrosia artemisiifolia	Annual Ragweed	N5	Scattered occurrences along existing road reserve network
Baccharis halimifolia	Groundsel Bush	N3	A few scattered occurrences throughout the site
Senecio madagascariensis	Fireweed	N4	Common occurrence in cleared pasture areas associated with the site
Ligustrum lucidum	Broad-leafed Privet	N4	Primarily in a number of roadside areas (particularly in the south)
Ligustrum sinense	Narrow-leafed Privet	N4	Associated with a number of riparian zones within the site
Rubus fruticosus	Blackberry	N4	Scattered occurrences within cleared/ pasture lands
Salvinia molesta	Salvinia	N3 WoNS	Infestation associated with Swamp Sclerophyll forest occurring north of Bald Hill Road
Lantana camara	Lantana	N4, WoNS	Infestations scattered along the entire project site, particularly gullies and roadside areas within Nambucca State Forest

2.4.3 Control Requirements

Noxious weeds declared under the *Noxious Weeds Act,* are required by law to be controlled by all landholders within a given control area. The control requirements for Noxious weed classes identified on the site are provided below:

- N5: There are no requirements to control existing plants of Class N5 weeds. However, the weeds are "notifiable" and a range of restrictions on their sale and movement exists.
- N4: The growth and spread of the plant must be controlled according to the measures specified in a management plan published by the local control authority.
- N3: The plant must be fully and continuously suppressed and destroyed.

Drawn by: GJM Checked by: RE Reviewed by: DGH Date: September 2014
Information shown is for illustrative purposes only
Source of base data: Roads and Maritime Services



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Location of Noxious Weeds - Sheet 1 of 8

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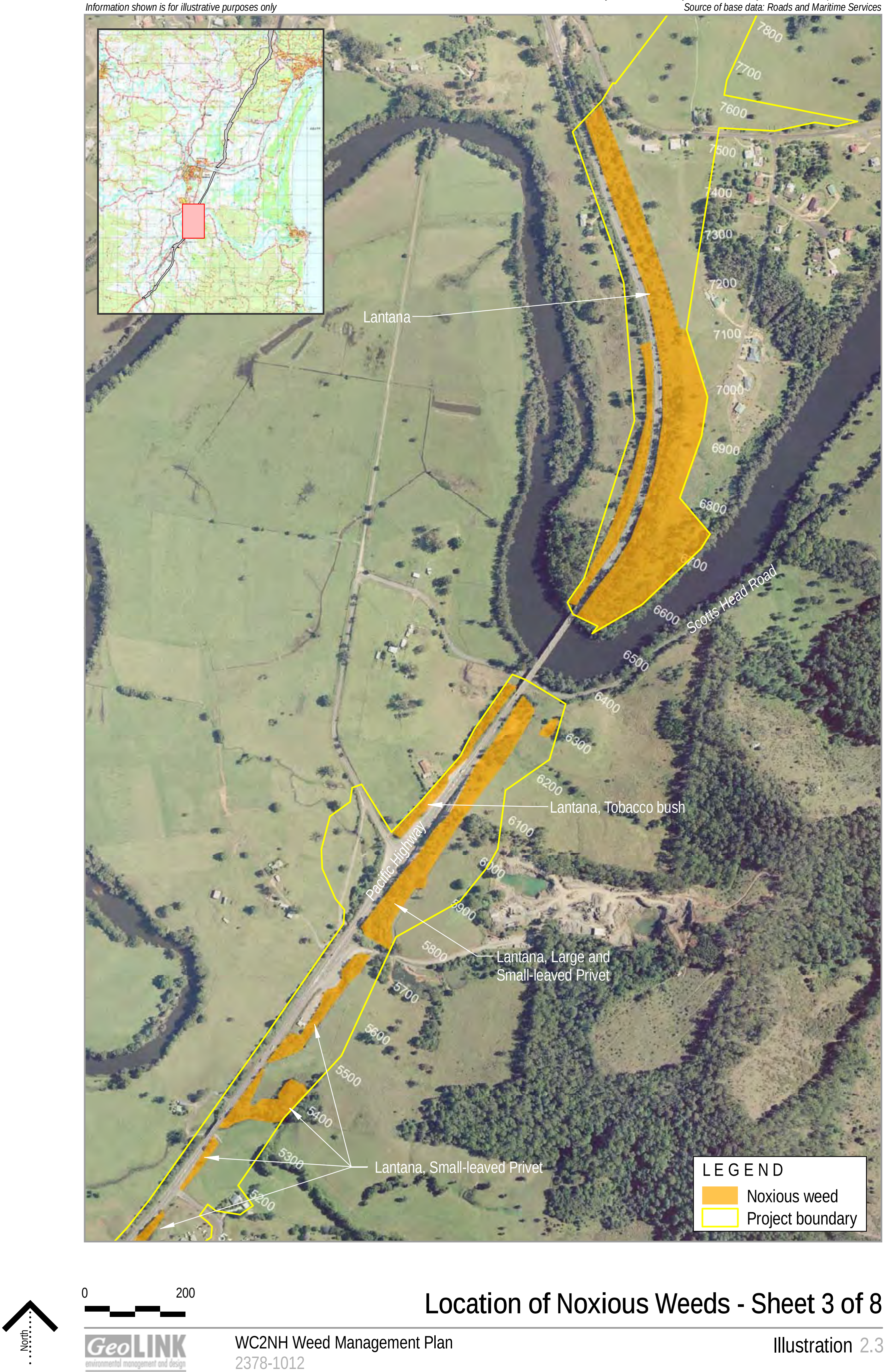
WC2NH Weed Management Plan
2378-1010

Illustration 2.1

Location of Noxious Weeds - Sheet 2 of 8

Drawn by: GJM Checked by: RE Reviewed by: DGH Date: September 2014
Source of base data: Roads and Maritime Services

Information shown is for illustrative purposes only



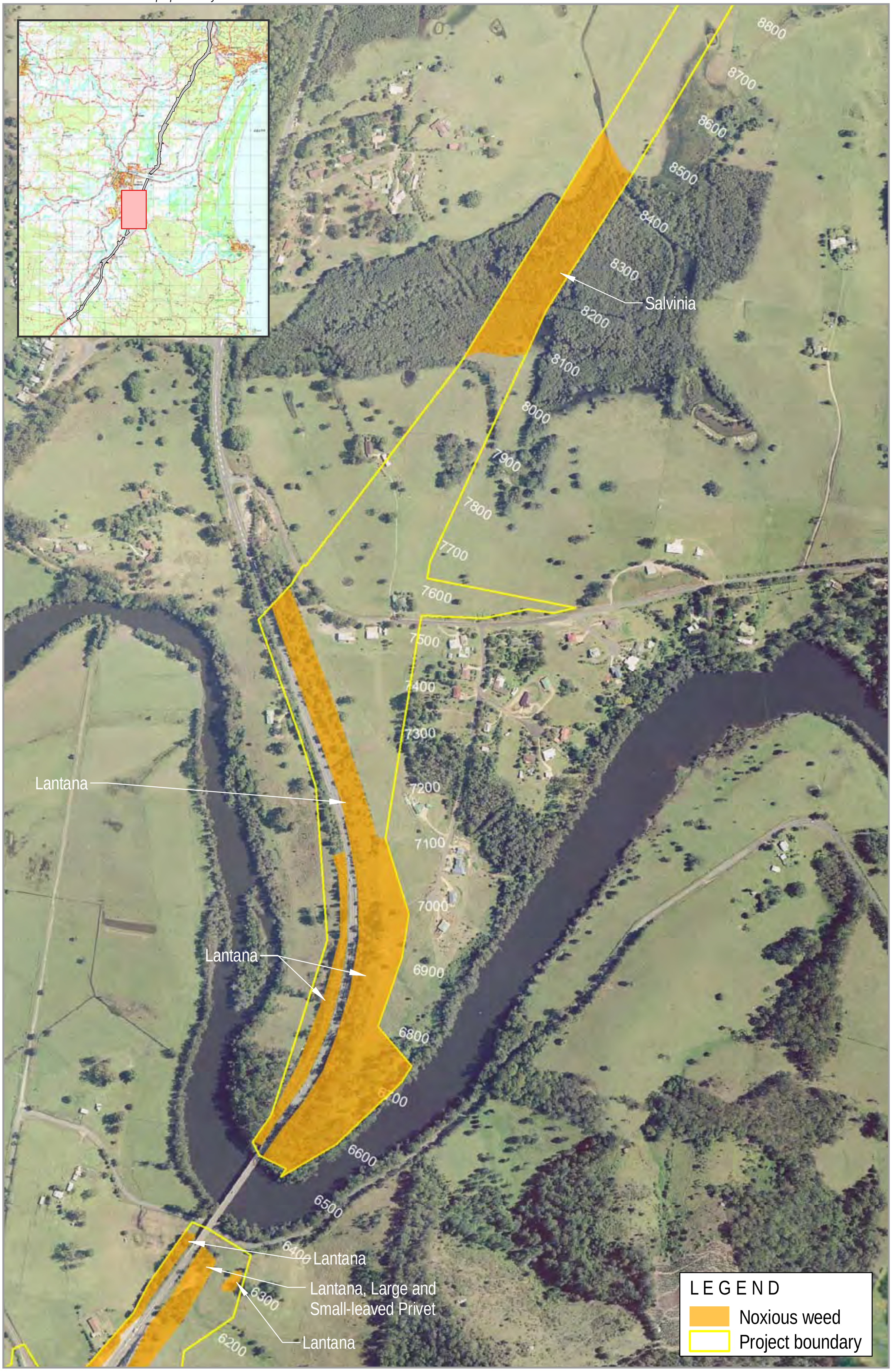
Location of Noxious Weeds - Sheet 3 of 8

WC2NH Weed Management Plan
2378-1012

Illustration 2.3

Information shown is for illustrative purposes only

Drawn by: GJM Checked by: RE Reviewed by: DGH Date: September 2014
Source of base data: Roads and Maritime Services



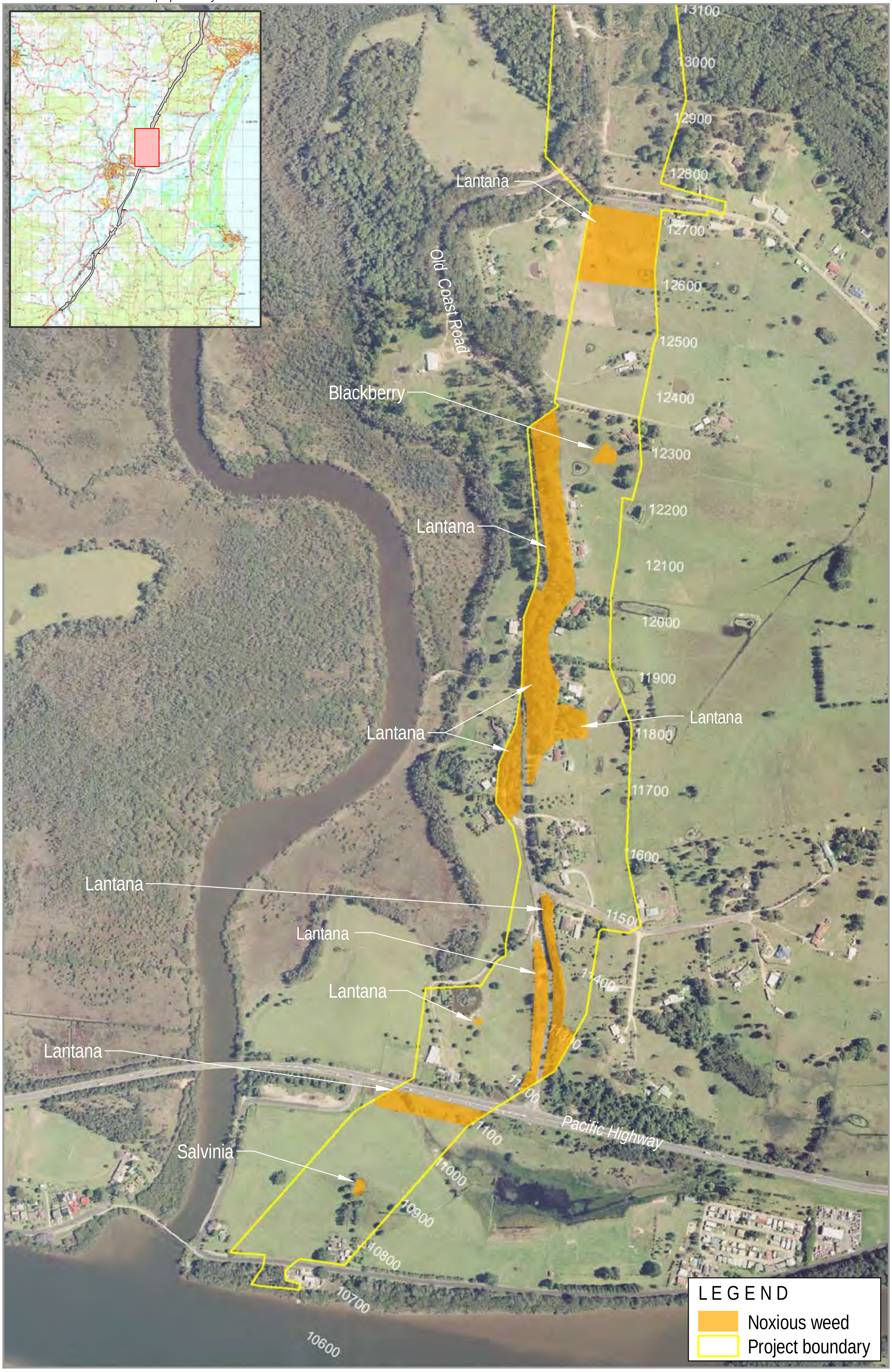
Location of Noxious Weeds - Sheet 4 of 8

GeoLINK environmental management and design

WC2NH Weed Management Plan
2378-1013

Illustration 2.4

Drawn by: GJM Checked by: RE Reviewed by: DGH Date: September 2014
Information shown is for illustrative purposes only
Source of base data: Roads and Maritime Services



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North

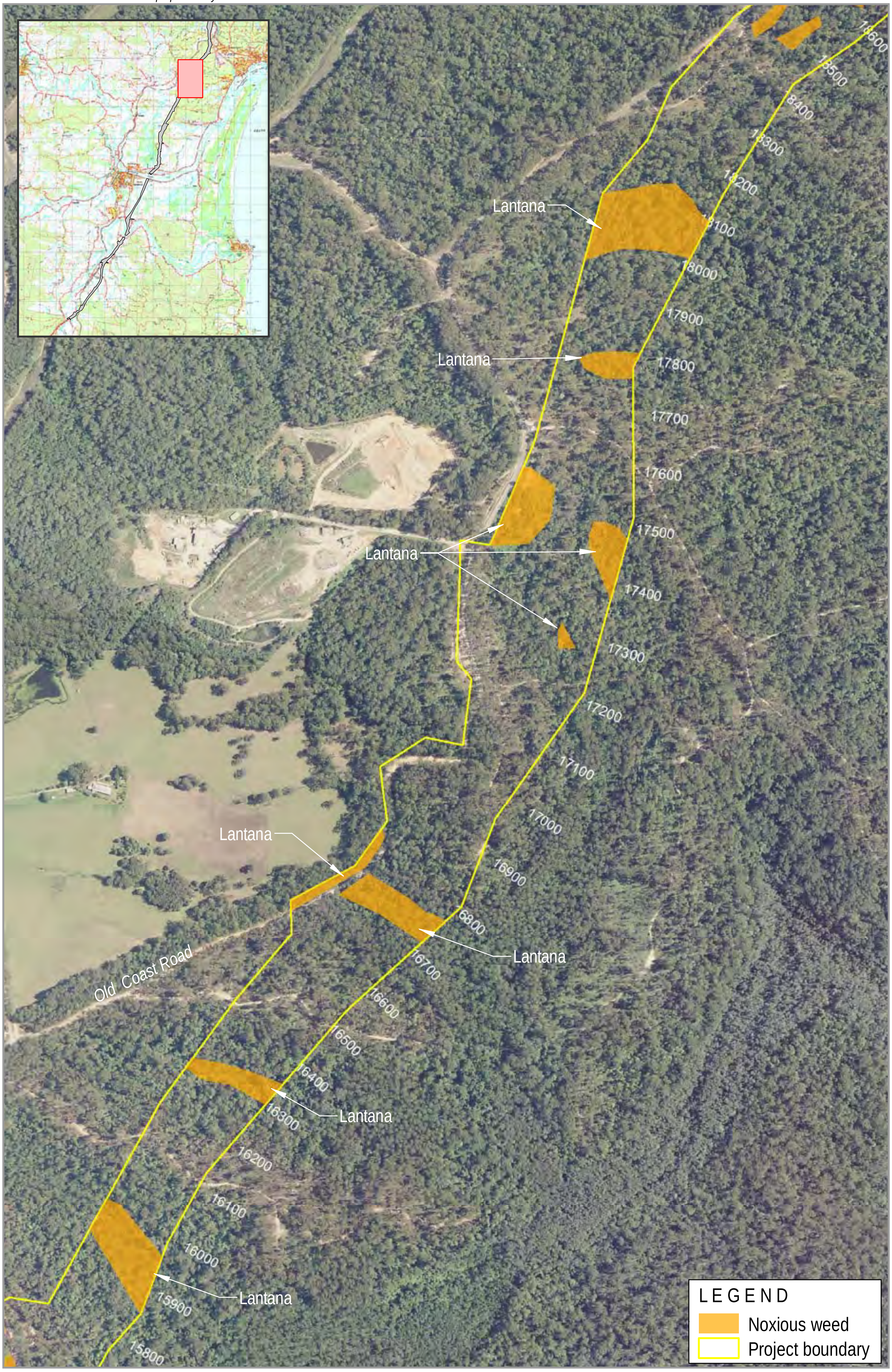
Location of Noxious Weeds - Sheet 5 of 8

GeoLINK environmental management and design

WC2NH Weed Management Plan
2378-1014

Illustration 2.5

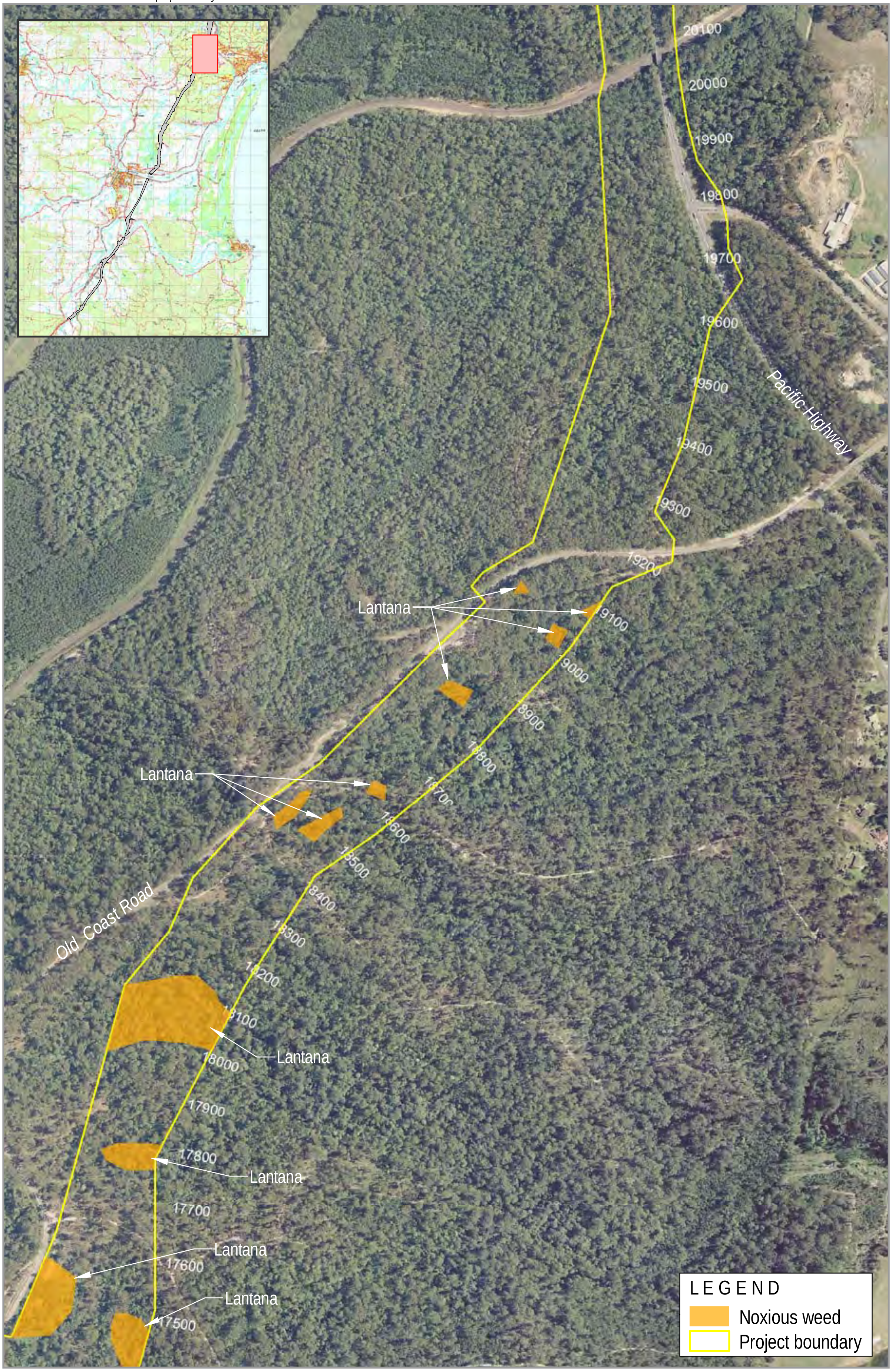
Location of Noxious Weeds - Sheet 6 of 8



Location of Noxious Weeds - Sheet 7 of 8

Drawn by: GJM Checked by: RE Reviewed by: DGH Date: September 2014
Source of base data: Roads and Maritime Services

Information shown is for illustrative purposes only



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North

Location of Noxious Weeds - Sheet 8 of 8

GeoLINK environmental management and design

WC2NH Weed Management Plan
2378-1018

Illustration 2.8

Potential Impacts of the Project

The following sections identify the potential impacts associated with weeds and pathogens relevant to the WC2NH Project.

3.1 Introduction and Spread of Weeds

The project has the potential to introduce/ spread weeds to/ from the site via the movement of weed seeds or weed propagules. The spread of weeds could potentially occur by the following mechanisms:

- Weed sources transported to/ from the site by vehicles/ plant.
- Weed sources transported to site from imported soil/ gravel materials.
- Weed sources introduced to the site via hydro seeding and other landscaping applications.
- Weed sources spread at the site via movement of weed affected topsoil/ mulch.
- Weed sources spread at the site from proliferation of weeds species due to ground disturbance and lack of weed treatment.

3.2 Spread of Chytrid Fungus

Chytridiomycosis is an infectious disease that affects amphibians worldwide. It is caused by the chytrid fungus (*Batrachochytrium dendrobatidis*), a fungus capable of causing sporadic deaths in some amphibian populations and 100 per cent mortality in others. The disease has been implicated in the mass die-offs and species extinctions of frogs since the 1990s (SEWPAC, undated). Little is currently known of the distribution of chytrid in Australian but it is likely to be present within most Australian frog populations (Michael Mahony pers. comms 2013) Infection of amphibians with chytrid fungus resulting in *Chytridiomycosis* is listed as a key threatening process under the Commonwealth EPBC Act.

The project has the potential to spread Chytrid fungus to/ from frog populations occurring on the site. A separate Chytrid Management Protocol has been prepared for the project by the AFJV which is included as Appendix D.

3.3 Spread of *Phytophthora Cinnamomi*

Phytophthora cinnamomi is a soil borne pathogen that spreads in plant roots in warm, moist conditions. The pathogen appears to be widespread in coastal forests, but may also occur at higher elevations. Susceptible flora species display a range of symptoms; some are killed, some are damaged but endure, and some show no apparent symptoms. In some cases *P. cinnamomi* may contribute to plant death where there are other stresses present (OEH, 2013).

The infection of native plants by *P. cinnamomi* is listed as a Key Threatening Process on Schedule 3 of the *Threatened Species Conservation Act 1995* (TSC Act). Additionally, dieback caused by *P. cinnamomi* is listed as a Key Threatening Process under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The project has the potential to spread *P. cinnamomi* through earthmoving and movements of vehicles/ plant to and from site. Pathogen hygiene management will be undertaken in accordance with the RMS biodiversity guideline requirements (refer to Appendix E).

3.4 Spread of Myrtle Rust

Myrtle Rust is a plant disease caused by the exotic fungus *Uredo rangelii*. It was first detected in Australia on 23 April 2010 on the NSW Central Coast. Myrtle Rust is now likely to spread rapidly to the extent of its biological range as the spores are dispersed by wind (OEH, 2011). The introduction and establishment of exotic rust fungi of the order *Pucciniales* pathogenic on plants of the family *Myrtaceae*' is listed as a Key Threatening Process under Section 3 of the TSC Act.

The project has the potential to spread Myrtle Rust through earthmoving and movements of vehicles/ plant to and from site. Pathogen hygiene management will be undertaken in accordance with the RMS biodiversity guideline requirements (refer to Appendix E).

Management Measures

The following sections provide the management measures to be implemented on the project in order to achieve the goals of this plan which are:

- Identify listed noxious and significant infestations of environmental weeds growing within the project boundary and provide maps showing these areas.
- Treat and dispose of all noxious weeds in accordance with their category under the Noxious Weeds Act 1993 prior to and during clearing/ grubbing activities.
- The ongoing suppression/ control of noxious and environmental weeds during the construction and post-construction (landscape maintenance period) stages.
- Minimise adverse impacts to biodiversity from weed control works.
- Best practice weed/ pathogen hygiene protocols to be undertaken for all plant/ machinery entering/ leaving site to minimise the spread of weeds and plant pathogens.
- Prevent the spread of weeds by best practice mulch and topsoil management.

4.1 Weed Control

4.1.1 General Approach

Nambucca Shire Council's Weed Officer has advised that the primary focus for weed control should be Noxious Weeds (Class 1, 2 and 3). It has been noted by Council's Weed Officer that Lantana is a low priority species given its prevalence in the area.

Initial weed control of Groundsel Bush and Salvinia infestations (Class 3 weeds) (refer to Illustration 2.1) would be undertaken prior to and during the clearing and grubbing stage of the project. Where possible, initial weed control would be undertaken by chemical treatment of weed infestations as discussed below. Where chemical treatment of weeds is not possible due to difficulties with access, mechanical removal of weeds would be undertaken.

Ongoing routine weed control is essential to successfully control any weed infestations associated with the project site. This weed control would target all noxious and environmental weeds to prevent the proliferation/ spread of such species during the project. Weed control will be undertaken by an experienced local weed contractor engaged by the AFJV at least every six months (when monitoring has determined that management is needed) during the construction stage of the project. Actions for weed control will be determined by weed monitoring to be undertaken by the project ecologist and AFJV environmental team (refer to Section 5).

Where serious weed concerns are identified on site (e.g. Class 1, 2 or 3 noxious weeds), consultation would be undertaken with Nambucca Shire Council's Weed Officer to determine the most appropriate form of weed control. Opportunities are to be explored with Council to collaboratively control weeds on the Project Site and on adjacent Council managed lands.

4.1.2 Weed Control Methods

4.1.2.1 Chemical Treatment of Weeds

Prior to clearing/ grubbing, infestations of noxious weeds (Class 1, 2 and 3) would be treated to avoid the spreading of live weed material and weed seed during clearing operations. Chemical treatment would also be the main method used to treat any noxious or environmental weeds following clearing operations. Chemical treatment methods would be as listed in the Noxious and Environmental Weeds Handbook (DPI, 2009) and summarised in Table 4.1 and would primarily involve foliar spraying. The measures outlined in Table 4.2 will be undertaken to ensure pesticides are managed and used appropriately on the Project Site.

Table 4.1 Noxious Weed Control Methods

Scientific Name	*Common Name*	*Listing*	*Control Method*
Ambrosia artemisiifolia	Annual Ragweed	N5	Foliar spray (Triclopyr + picloram + Aminopyralid 350 ml in 1 L of water)
Baccharis halimifolia	Groundsel Bush	N3	Seedlings: Scrape and paint (Glyphosate) or foliar spray + surfactant if required Trees: Cut stump stem inject or basal spray applications (Glyphosate)
Senecio madagascariensis	Fireweed	N4, WoNS	Foliar spray (Triclopyr + picloram + Aminopyralid 350 ml in 1 L of water)
Ligustrum lucidum	Broad-leafed Privet	N4	Foliar spray (Metsulfuron-methyl 10 g per 100 L of water) – complete coverage is essential
Ligustrum sinense	Narrow-leafed Privet	N4	
Rubus fruticosus	Blackberry	N4	Foliar spray (Glyphosate 10-13 ml per 1L of water) – use higher rates on old , dense infestations
Salvinia molesta	Salvinia	N3 WoNS	Foliar spray (bioactive Glyphosate 1 L per 100 L of water)
Lantana camara	Lantana	N4, WoNS	Foliar spray (Glyphosate) treat summer-autumn
Hyparrhenia hirta	Coolatai Grass	-	Spot spray (Fluproponate 300 ml/ 100 L water) in winter and Spring

Source: Control methods taken from Noxious and Environmental Weed Control Handbook (DPI, 2009)

Table 4.2 Protocol for Management/ Use of Pesticides

Action	
1	Any use of herbicide will be in accordance with the Pesticides Act, 1999
2	Notification of pesticides used on site will be undertaken in accordance with the RTA's Pesticide Use Notification Plan (refer to G36)
3	Weed control works are to be only undertaken by experienced personnel with ChemCert accreditation (AQF3) in accordance with WorkCover requirements
4	The weed contractor is to select the most appropriate herbicide based on the information within this plan and current best practices for weed control
5	A biodegradable red dye is to be included with foliar spray to allow a visualisation of areas sprayed
6	Foliar spraying is only to be undertaken during periods of low wind (i.e. <10 km/ hr) to reduce overspray
7	Weeds treated with herbicide are to be left in situ for at least two weeks prior to clearing to allow effective kill rates for weeds
8	The Material Safety Data Sheet (MSDS) for herbicides to be used is to be read and held by any personnel involved with weed control works during weed control activities

4.1.2.2 Mechanical Removal of Weeds

Mechanical removal of weeds would be undertaken during the clearing/ grubbing stage where chemical treatment of weeds cannot be undertaken due to difficulties with access. Mechanical removal techniques would include:

- Excavators or bulldozers to be used to remove weeds including root systems. This material will be mulched for reuse.
- Camphor Laurel will be separated from other vegetation to allow for separate mulching and reuse.
- Seedlings or regrowth of weed species can be slashed/ brushcut before they seed.

Any noxious weeds (Class 1, 2 and 3) removed by mechanical means will be collected and disposed of in accordance with the requirements within Table 4.3.

It is noted that the Nambucca Shire Council Weed Officer has advised that for lantana species, mechanical removal, mulching and subsequent reuse of mulch would be adequate weed suppression.

Table 4.3 Protocol for Disposal of Class 1, 2 and 3 Noxious Weeds

Action	
1	Noxious weed material (Class 1, 2 and 3) would be separated from native vegetation
2	Noxious weed material (Class 1, 2 and 3) would be disposed of at a licensed green waste facility or buried under non-structural fill
3	All loads containing Class 1, 2 and 3 noxious weed material are to be covered with heavy tarps and all efforts are to be employed by drivers to minimise the risk of spreading weed seeds and propagules on route to landfill

4.1.3 Control of Weeds in Ecologically Sensitive Areas

Ecologically Sensitive Areas within the Project Site include the following areas outside of the clearing limits:

- Endangered Ecological Communities (EECs).
- Locations of threatened flora.
- Threatened fauna habitat.
- Waterways and aquatic environments.

Given the sensitive nature of the above areas, additional care is required to minimise adverse impacts. The protocol provided in Table 4.4 describes measures to be undertaken within/ adjacent to Ecologically Sensitive Areas (refer to constraints mapped in CEMP Appendix A6 Sensitive Area Plans).

Table 4.4 Protocol for Weed Control of Ecologically Sensitive Areas

Action	
1	Environmental constraints mapping is to be reviewed prior to any weed control works commencing
2	Weed control contractor to be shown the locations of ecological constraints including undertaking an inspection of areas with a site Environmental Officer
3	Foliar spraying is only to be undertaken during periods of low wind (i.e. <10km/ hr) to reduce overspray
4	The use of Glyphosate biactive is to be used around all waterways and in sensitive areas as it has been formulated to reduce the toxicity of the product to certain organisms including frogs
5	The use of herbicide foliar spraying is to be minimised in and around waterways and in areas representing threatened frog habitat. Where possible cut/ paint methods should be used for woody weeds
6	A EWMS will be prepared for any weed control required within Ecologically Sensitive Areas
7	A Permit to Enter will be issued for any ‘No-go’ areas where weed control contractors are to work

4.2 Environmental Work Method Statements

Environmental Work Method Statements (EWMS) will be prepared for:

- General weed control works within the site.
- Weed control works to be undertaken within Ecologically Sensitive Areas.

The EWMS will include all relevant requirements contained within this WPMP.

4.3 Stabilisation of Areas

The use of cover crops is a highly effective method to reduce the establishment of weeds in disturbed areas of the site. Following vegetation removal, any bare soil areas should be stabilised as soon as practical using an appropriate sterile cover crop (rye grass in winter) to reduce erosion and further weed infestations.

4.4 Inductions and Site Awareness

An environmental induction will be prepared and delivered to all personnel involved with the project. Relevant points to be delivered in this induction in relation to weed management are as follows:

- Noxious weeds and weeds of significance with potential to occur on the site.
- Requirements for all personnel to report sightings (of noxious weeds) to the environmental team.
- Weed/ pathogen hygiene protocols to be implemented on the project including plant/ machinery wash down when entering and leaving the site. The location of wash down bays is to be explained.

Information on noxious and weeds of significance will be posted in site compounds and crib rooms to assist in developing awareness of reportable weeds on site.

4.5 Plant/ Machinery Wash Down Protocols

All plant/ machinery entering the site must be washed down/ cleaned prior to commencing work. This includes trucks, excavators, scrapers, site vehicles, backhoes and loaders. Cleaning shall be done with high pressure cleaners to remove soil and vegetative matter that may spread weeds or soil borne plant pathogens prior to entry of the site. A 'Clean Down Declaration' (refer to Appendix F) must be completed evidencing wash-down for plant entering or leaving the site. A summary of the wash-down protocol is provided in Table 4.5. Additional information related to specific wash-down procedures for Chytrid fungus and plant pathogens are provided in Appendix D and Appendix E respectively.

Table 4.5 Protocol for Plant/ Machinery Wash-down

Action	
1	Dedicated wash-down areas with high pressure cleaners will be established at the main site compounds
2	All vehicles/ plant commencing work on the site (and having worked on another construction site previously) are required to wash-down prior to entering the site. Site deliveries/ light vehicles would not be required to undertake vehicle wash-down/ declaration where they are remaining on formed access roads in areas cleared of Noxious weeds
3	A 'Clean Down Declaration' (refer to Appendix F) evidencing wash-down for plant entering the site is to be provided by the Plant Owner/ Operator to the AFJV Environmental team prior to plant/ machinery being permitted to commence work and kept with the item of plant/ machinery for its duration on site. The Clean Down Declaration is to be provided during the plant pre-acceptance process

Action	
4	Before leaving site all plant/ machinery is required to be washed down. A 'Clean Down Declaration' (refer to **Appendix F**) evidencing wash-down is to be provided to the AFJV Environmental team by the plant owner/ operator prior to plant/ machinery leaving the site
5	Additional wash-down will be required for any plant/ machinery working within areas of weed infestation (as identified within this plan and future weed monitoring reports) in order to prevent the spread of weeds within the site. The Clean Down Declaration system will be implemented for such areas
6	Rumble grids must be installed where appropriate at construction gates to minimise the risk of spreading weed seed/ plant pathogens via soil

4.6 Re-use of Topsoil/ Mulch

4.6.1 Mulch

All vegetation with the exception of noxious weeds would be mulched and reused in erosion and sediment controls and landscaping. In order to minimise the spread of weeds within mulch the following measures will be employed:

- Vegetation containing noxious weed material would not be mulched and reused with the exception of Lantana which Nambucca Shire Council's Weed Officer has agreed would not increase the risk of spreading this species.
- Camphor Laurel is to be separated from other vegetation, mulched and stockpiled separately.
- Camphor Laurel mulch is to be used in feature planting situations (such as interchanges) and not for batter treatments. This mulch can also be used in temporary applications such as erosion/ sediment control in areas away from waterways.
- All mulch is to be stockpiled and used only within the same landscape where it has been derived (e.g. forested areas within Nambucca State Forest, Floodplain etc).
- Mulch stockpiles are to be kept weed free by routine foliar spraying of emergent weeds as determined by ongoing monitoring (refer to **Section 5**).

4.6.2 Topsoil

The following measures are to be undertaken in order to minimise the spread of weed from the reuse of topsoil:

- Topsoil from areas of weed infestations (including noxious weeds) would not be reused with the exception of areas supporting Lantana which Nambucca Shire Council's Weed Officer has confirmed would be unlikely to increase the risk of spreading this species. Topsoil from weed infested areas will be isolated and either sterilised, encapsulated, or disposed of at an approved off site facility.
- Topsoil is to be stockpiled and used only within the same landscape where it has been derived (e.g. forested areas within Nambucca State Forest, Floodplain etc).
- Topsoil stockpiles are to be kept weed free by routine foliar spraying of emergent weeds as determined by ongoing monitoring (refer to **Section 5**).

4.7 Summary of Mitigation Measures, Responsibilities and Timing

Table 4.6 presents the main goals of weed management and includes a summary of the relevant mitigation measures that are to be employed. The table also describes who is responsible for implementing the measures and the timing/ frequency for the measure where applicable.

Table 4.6 Management Goals, Mitigation Measures, Responsibility and Timing

Management Goal	*Mitigation/ Control Measure*	*Responsibility*	*Timing/ Frequency*
▪ Identify listed noxious and significant infestations of environmental weeds growing within the project boundary and provide maps showing these areas.	Identify all noxious weeds occurring on the site prior to clearing/ grubbing commencing.	AFJV/ Project Ecologist (PE)	Completed as part of this WPMP
▪ Treat and dispose of all noxious weeds in accordance with their category under the *Noxious Weeds Act 1993* prior to clearing/ grubbing commencing. ▪ No new weeds introduced to the project area. ▪ No increase in distribution of weeds currently existing within the project areas.	Initial weed control of Groundsel Bush and Salvinia infestations (Class 3 weeds) (refer to **Illustration 2.1**) would be undertaken prior to and during the clearing and grubbing stage of the project. Where possible initial weed control would be undertaken by chemical treatment of weed infestations as discussed below. Where chemical treatment of weeds is not possible due to difficulties with access, mechanical removal of weeds would be undertaken.	AFJV/ Weed Contractor (WC)	Prior to and during clearing and grubbing stage
	Ongoing chemical treatment of weeds will be undertaken by an experienced local weed contractor engaged by the AFJV at least every six months if required during the construction stage of the project.	AFJV/ Weed Contractor (WC)	To be undertaken every six months after the commencement of construction if required
	Noxious weed material (Class 1, 2 and 3) would be separated from native vegetation and disposed of at a licensed waste facility.	AFJV	Where necessary
	Any use of herbicide will be in accordance with the Pesticides Act, 1999.	AFJV/ WC	
	Notification of pesticides used on site will be undertaken in accordance with the RMS' Pesticide Use Notification Plan.	AFJV	
	Weed control works are to be only undertaken by personnel with ChemCert accreditation (AQF3) in accordance with Workcover requirements.	AFJV/ WC	
	The weed contractor is to select the most appropriate herbicide based on the information within this plan and current best practices for weed control.	AFJV/ WC	
	A biodegradable red dye is to be included with foliar spray to allow a visualisation of areas sprayed.	AFJV/ WC	

Management Goal	*Mitigation/ Control Measure*	*Responsibility*	*Timing/ Frequency*
	Foliar spraying is only to be undertaken during periods of low wind (i.e. <10 km/ hr) to reduce overspray.	AFJV/ WC	
	Weeds treated with herbicide are to be left in situ for at least two weeks prior to clearing to allow effective kill rates for weeds.	AFJV	
	The Material Safety Data Sheet (MSDS) for herbicides to be used is to be read and held by any personnel involved with weed control works.	AFJV/ WC	
	An Environmental Work Method Statements (EWMS) will be prepared for general weed control works within the site; including specific measures for weed control works to be undertaken within Ecologically Sensitive Areas.	AFJV	
	Following vegetation removal, any bare soil areas should be stabilised as soon as practical using an appropriate sterile cover crop (rye grass in winter) to reduce erosion and further weed infestations.	AFJV	
	An environmental induction will be prepared and delivered to all personnel involved with the project on relevant weed management requirements.	AFJV	
	Information on noxious and weeds of significance will be posted in site compounds and crib rooms to assist in developing awareness of reportable weeds on site.	AFJV	
▪ Minimise adverse impacts to biodiversity from weed control works.	Environmental Constraints Mapping is to be reviewed prior to any weed control works commencing.	AFJV/ WC	Prior to weed control works commencing
	Weed control contractor to be shown the locations of ecological constraints including undertaking an inspection of areas with a site Environmental Officer.	AFJV/ WC	
	Foliar spraying is only to be undertaken during periods of low wind (i.e. <10 km/ hr) to reduce overspray.	AFJV/ WC	
	The use of Glyphosate biactive is to be used around all waterways and in sensitive areas as it has been formulated to reduce the toxicity of the product to certain organisms including frogs.	AFJV/ WC	
	The use of herbicide foliar spraying is to be minimised in and around waterways and in areas representing threatened frog habitat.	AFJV/ WC	
	An EWMS will be prepared for any weed control required within Ecologically Sensitive Areas.	AFJV/ WC	
	A Permit to Enter or Early Works Permit will be issued for any ‘No-go’ areas where weed control contractors are to work.	AFJV	

Management Goal	*Mitigation/ Control Measure*	*Responsibility*	*Timing/ Frequency*
▪ No transfer of plant diseases or pathogens to or from the project work areas. ▪ Best practice weed/ pathogen hygiene protocols to be undertaken by personnel and applied to all plant/ machinery entering/ leaving site to minimise the spread of weeds and plant pathogens.	Dedicated wash-down areas with high pressure cleaners will be established at the main site compounds.	AFJV	For the duration of the construction stage works
	All vehicles/ plant commencing work on the site (and having worked on another construction site previously) are required to wash-down thoroughly upon entering the site.	AFJV	
	A 'Clean Down Declaration' (refer to Appendix F) evidencing wash-down for plant entering the site is to be provided by the AFJV Environmental team prior to plant/ machinery commencing work and kept with the item of plant/ machinery for its duration on site. Site deliveries/ light vehicles would not be required to undertake vehicle wash-down/ declaration where they are remaining on formed access roads in areas cleared of Noxious weeds.	AFJV	
	Before leaving site all plant/ machinery is required to be washed down. A 'Clean Down Declaration' (refer to Appendix F) evidencing wash-down is to be provided by the AFJV Environmental team prior to plant/ machinery leaving the site.	AFJV	
	Rumble grids must be installed where appropriate at construction gates to minimise the risk of spreading weed seed/ plant pathogens via soil.	AFJV	
	Implement measures within the Chytrid Protocol (refer to Appendix D) and Plant Pathogen Protocol (refer to Appendix E) to prevent the spread of the chytrid fungus.	AFJV	
▪ Prevent the spread of weeds by best practice mulch and topsoil management.	Mulch Vegetation containing noxious weed material (with the exception of Lantana) would not be mulched and reused.	AFJV	
	Camphor Laurel is to be separated from other vegetation, mulched and stockpiled separately.		
	Camphor Laurel mulch is to be used in feature planting situations (such as interchanges) and not for batter treatments. This mulch can also be used in temporary applications such as erosion/ sediment control in areas away from waterways.	AFJV	
	Mulch is to be stockpiled and used only within the same landscape where it has been derived (e.g. forested areas within Nambucca State Forest, Floodplain etc).	AFJV	
	Mulch stockpiles are to be kept weed free by routine foliar spraying of emergent weeds as determined by ongoing monitoring (refer to Section 5).	AFJV	

Management Goal	*Mitigation/ Control Measure*	*Responsibility*	*Timing/ Frequency*
	Topsoil Topsoil from areas of weed infestations (including noxious weeds) would not be reused with the exception of areas supporting Lantana which Nambucca Shire Council's Weed Officer has confirmed would be unlikely to increase the risk of spreading this species. Topsoil from weed infested areas will be isolated and either sterilised, encapsulated, or disposed of at an approved off site facility.	AFJV	
	Topsoil is to be stockpiled and used only within the same landscape where it has been derived (e.g. forested areas within Nambucca State Forest, Floodplain etc).	AFJV	
	Topsoil stockpiles are to be kept weed free by routine foliar spraying of emergent weeds as determined by ongoing monitoring (refer to Section 5).	AFJV	
▪ Compliance with relevant legislation and project requirements.	All measures stated above.	AFJV	

5

Weed Monitoring Program

A weed monitoring program is to be implemented during the construction and post-construction (landscape maintenance period) of the project to measure the success of mitigation measures identified in Section 4 of this plan. The monitoring program aim is to identify any weed infestations or signs of plant pathogens and provide a mechanism for the development and implementation of additional management measures (e.g. additional weed control.

5.1 Methods

The monitoring program will involve routine inspections of all areas of the Project Site, to identify occurrences of noxious/ environmental weeds and signs of plant pathogens.

5.1.1 Fixed Point Photograph Points

Fixed photograph points are to be established at 15 locations within the project site to monitor the change in weed levels and detect any signs of plant pathogens. This number of sites is considered adequate to sample areas of native vegetation to be retained within the project site. Photo points are to be placed in areas of native vegetation outside the clearing limits (but inside the project boundary) and should be spread across different vegetation types, EEC and threatened flora/ fauna habitats associated with the site. The locations of photo points are to be determined by the project ecologist during the first weed monitoring session. A star picket and metal tag (with identification code) would be used to mark all locations with a photograph to be taken during monitoring sessions always facing in the same direction.

5.1.2 Weed Infestation/ Plant Pathogen Surveys

Surveys of the entire project site will be undertaken routinely by the project ecologist to identify noxious/ environmental weed infestations. Substantial weed infestations are to be mapped and provided to the AFJV Environmental team in a brief report. The AFJV will also monitor weed infestations on the construction site through the Weekly Environmental Checklist process.

Searches for signs of dieback (indicative of *P. cinnamoni*) and Myrtle Rust will be undertaken in areas of native vegetation retained within the project site. Any such signs are to be investigated further with testing to be undertaken if required.

5.2 Timing

Weed monitoring would commence at the start of the construction stage of the project which is anticipated to be in late-November 2015. It is envisaged that weed monitoring surveys would be undertaken on a monthly basis for the first six months after commencement of construction (or as necessary responding to seasonal and climatic conditions) and then every six months after that until the completion of the post-construction landscape maintenance period. The frequency of monitoring will be largely dependant on previous weed control efforts and seasonal factors and as such the project ecologist would determine the frequency of monitoring based on these factors.

5.3 Reporting and Adaptive Management

At the completion of each weed monitoring event a brief report would be prepared documenting the findings and any priority weed control actions to be implemented by the AFJV. These actions will be provided to the weed control contractor for implementation during weed control works to be undertaken every six months.

DoE (2013a). *EPBC Act Policy Statement 1.1 Significant Impact Guidelines*. Department of Environment and Heritage, Canberra.

DoPI (2013). *Project Approval (Modification 4 approved on 22 March 2013).* NSW Department of Planning and Infrastructure, Sydney.

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Appendix A

Plan Authors CVs

curriculum vitae

David HAVILAH

BSc (Biol)

Ecologist

Qualifications

Bachelor of Science (Biology), Sydney University, 2003

Professional Affiliations

Member, Ecological Consultants Association of NSW
Member, NSW Wildlife Information, Rescue and Education Services Inc (WIRES-Northern Rivers)

Experience

David is an experienced ecological consultant who has developed a broad range of skills from working on a variety of small and large-scale projects. He specialises in undertaking terrestrial flora and fauna surveys and providing high quality ecological reports within Queensland and New South Wales. This work has included designing and implementing threatened species management plans and ecological monitoring programs. David has a detailed working knowledge of environmental legislation relevant to ecological impact assessment and an ability to balance practical applications of environmental requirements with good environmental outcomes.

Key Experience and Skills

A large focus of David's work has been providing ecological services on large infrastructure projects. He has been engaged as the Project Ecologist for construction contractors on a number of sections of the NSW Pacific Highway upgrade project. This work has included providing technical advice, ecological surveys and assessments and managing threatened species on these projects.

David's skills and key areas of expertise include:

- Design, implementation and management of ecological monitoring programs.
- Determining and documenting best practice and innovative management plans for threatened species occurring on infrastructure projects.
- Undertaking detailed systematic terrestrial flora / fauna surveys and vegetation / weed mapping.
- Preparing high quality ecological / environmental assessments for a broad range of projects in accordance with NSW, QLD and Federal environmental legislation.
- Preparing vegetation management plans and environmental management plans.
- Providing peer reviews of ecological assessments.
- Providing technical advice, ecological surveys and reporting in the role of project ecologist for large-scale infrastructure projects.
- Supervising and delivering pre-clearing surveys and spotter / catcher (fauna capture / relocation services) as part of large infrastructure projects.
- Delivering environmental awareness presentations.

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curriculum vitae

Veronica SILVER

BEnvSc Grad Dip (UrbRegPlan)

Senior Associate / Ecologist / Planner

Qualifications

Bachelor of Environmental Science (Environmental Management),
The University of Newcastle, [2000]
Graduate Diploma of Urban and Regional Planning, The University of New England, [2007]

Professional Affiliations

Member, Planning Institute Australia
Member, Environment Institute of Australia and New Zealand
Member, Ecological Consultants Association of NSW Inc.
Member, Australian Network for Plant Conservation Inc.

Professional Short Courses

- Planning for Bushfire Prone Areas
- Certificate IV Bushland Regeneration
- Certificate IV Workplace Training and Assessment
- Certificate II Australian Land Conservation and Restoration
- Project Management, Chifley Business School
- Effective Communication, Negotiation and Mediation, Chifley Business School
- Urban Design, Chifley Business School
- Acid Sulfate Soils: Identification, Assessment and Management
- Woodland Birds Identification and Ecology
- Signed English, TAFE Newcastle

Licences

- Scientific Licence (SL100152) issued by the Office of Environment and Heritage.
- Animal Research Authority issued by the Animal Care and Ethics Committee of the Director-General of NSW Department of Primary Industries to undertake fauna surveys throughout NSW and SE Queensland.

Experience

Veronica has been a key member of GeoLINK's ecology team since 2004. She specialises in flora / fauna field surveys; ecological monitoring; bushfire assessment; environmental impact assessment and bushland regeneration.

Veronica has further diversified her skills and knowledge in the built environment, having completed a Graduate Diploma of Urban and Regional Planning through The University of New England in 2007.

Veronica possesses high level project management skills, developed through working with a broad range of public and private sector clients on challenging environmental projects. Having project managed a variety of ecological and planning projects; she has significant skills in liaison and the management of multidisciplinary teams.

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Appendix B

Noxious Weeds Declarations – Nambucca Shire LGA

Noxious weed declarations

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Noxious weed declarations for Nambucca Shire Council

Note: this control area includes the local council areas of - Nambucca

Weed	Class	Legal requirements
African boxthorn [Lycium ferocissimum]	4	The plant must not be sold, propagated or knowingly distributed
African feathergrass [Pennisetum macrourum]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
African turnip weed [Sisymbrium runcinatum]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
African turnip weed [Sisymbrium thellungii]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Aleman grass [Echinochloa polystachya]	2	The plant must be eradicated from the land and that land must be kept free of the plant
Alligator weed [Alternanthera philoxeroides]	2	The plant must be eradicated from the land and that land must be kept free of the plant
Anchored water hyacinth [Eichhornia azurea]	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
Annual ragweed [Ambrosia artemisiifolia]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Arrowhead [Sagittaria calycina variety calycina (syn. Sagittaria montevidensis subspecies calycina)]	4	The plant must not be sold, propagated or knowingly distributed
Artichoke thistle [Cynara cardunculus]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Asparagus [Asparagus species] Ex A.aethiopicus A.africanus A.asparagoides A.declinatus A.falcatus A.macowanii var. zuluensis A.officinalis A.plumosus A.racemosus A.virgatus	4	The plant must not be sold, propagated or knowingly distributed
Asparagus fern [Asparagus virgatus (syn. Protasparagus virgatus)] A Weed of National Significance	2	The plant must be eradicated from the land and that land must be kept free of the plant
Athel tree / Athel pine [Tamarix aphylla] A Weed of National Significance	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Bathurst/Noogoora/Hunter/South American/Californian/cockle burrs [Xanthium species]	4	The growth of the plant must be managed in a manner that continously inhibits the ability of the plant to spread

Bear-skin fescue [Festuca gautieri]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Bellyache bush [Jatropha gossypiifolia]	2	The plant must be eradicated from the land and that land must be kept free of the plant
Bitou bush [Chrysanthemoides monilifera subspecies rotundata] A Weed of National Significance	4	The growth of the plant must be managed in a manner that continously inhibits the ability of the plant to spread
Black knapweed [Centaurea xmoncktonii]	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
Black willow [Salix nigra] A Weed of National Significance	4	The growth of the plant must be managed in a manner that continously inhibits the ability of the plant to spread and the plant must not be sold, propagated or knowingly distributed
Blackberry [Rubus fruticosus aggregate species] except cultivars Black satin Chehalem Chester Thornless Dirksen Thornless Loch Ness Murrindindi Silvan Smooth stem Thornfree	4	The growth of the plant must be managed in a manner that continously inhibits the ability of the plant to spread and the plant must not be sold, propagated or knowingly distributed This is an All of NSW declaration
Boneseed [Chrysanthemoides monilifera subspecies monilifera] A Weed of National Significance	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
Bridal creeper [Asparagus asparagoides (syn. Myrisphyllum asparagoides, Asparagus medeoloides)]	4	The plant must not be sold, propagated or knowingly distributed
Bridal veil creeper [Asparagus declinatus (syn. Asparagus crispus, Myrsiphyllum declinatum)] A Weed of National Significance	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
Broad-leaf pepper tree [Schinus terebinthifolius]	3	The plant must be fully and continuously suppressed and destroyed
Broomrapes [Orobanche species except the native O. cernua variety australiana and O. minor]	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
Burr ragweed [Ambrosia confertiflora]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Cabomba [All Cabomba species except C. furcata]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Cat's claw creeper [Dolichandra unguis-cati (syn. Macfadyena unguis-cati)] A Weed of National Significance	3	The plant must be fully and continuously suppressed and destroyed
Cayenne snakeweed [Stachytarpheta cayennensis]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Cecropia [Cecropia species]	2	The plant must be eradicated from the land and that land must be kept free of the plant
Chilean needle grass [Nassella neesiana]	4	The growth of the plant must be managed in a manner that

A Weed of National Significance		continously inhibits the ability of the plant to spread and the plant must not be sold, propagated or knowingly distributed
Chinese celtis [Celtis sinensis]	3	The plant must be fully and continuously suppressed and destroyed and the plant must not be sold, propagated or knowingly distributed
Chinese tallow tree [Triadica sebifera]	3	The plant must be fully and continuously suppressed and destroyed
Chinese violet [Asystasia gangetica subspecies micrantha]	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
Climbing asparagus fern [Asparagus plumosus (syn. Protasparagus plumosus)] A Weed of National Significance	2	The plant must be eradicated from the land and that land must be kept free of the plant
Climbing asparagus fern [Asparagus plumosus (syn. Protasparagus plumosus)] A Weed of National Significance	4	The plant must not be sold, propagated or knowingly distributed
Clockweed [Gaura parviflora]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Cockspur coral tree [Erythrina crista-galli]	3	The plant must be fully and continuously suppressed and destroyed and the plant must not be sold, propagated or knowingly distributed
Corn sowthistle [Sonchus arvensis]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Dodder [All Cuscuta species except the native species C. australis, C. tasmanica and C. victoriana] Includes All Cuscuta species except the native species C. australis, C. tasmanica and C. victoriana	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
East Indian hygrophila / Hygro [Hygrophila polysperma]	3	The plant must be fully and continuously suppressed and destroyed and the plant must not be sold, propagated or knowingly distributed
Espartillo [Amelichloa brachychaeta, Amelichloa caudata]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Eurasian water milfoil [Myriophyllum spicatum]	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
Fine-bristled burr grass [Cenchrus brownii]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Fireweed [Senecio madagascariensis] A Weed of National Significance	4	The plant must not be sold, propagated or knowingly distributed
Flax-leaf broom [Genista linifolia] A Weed of National Significance	4	The plant must not be sold, propagated or knowingly distributed
Fountain grass [Pennisetum setaceum]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable

		weed must be complied with This is an All of NSW declaration
Frogbit / Spongeplant [Limnobium laevigatum and L. spongia]	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
Gallon's curse [Cenchrus biflorus]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Gamba grass [Andropogon gayanus]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Giant devils fig [Solanum chrysotrichum]	3	The plant must be fully and continuously suppressed and destroyed
Giant rat's tail grass [Sporobolus pyramidalis]	3	The plant must be fully and continuously suppressed and destroyed
Giant reed / Elephant grass [Arundo donax]	4	The plant must not be sold, propagated or knowingly distributed
Glaucous star thistle [Carthamus glaucus]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Golden thistle [Scolymus hispanicus]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Green cestrum [Cestrum parqui]	3	The plant must be fully and continuously suppressed and destroyed
Grey sallow [Salix cinerea] A Weed of National Significance	2	The plant must be eradicated from the land and that land must be kept free of the plant
Ground asparagus [Asparagus aethiopicus (syn. Protasparagus aethiopicus)]	4	The plant must not be sold, propagated or knowingly distributed
Groundsel bush [Baccharis halimifolia]	3	The plant must be fully and continuously suppressed and destroyed
Harrisia cactus [Harrisia species]	4	The growth of the plant must be managed in a manner that continously inhibits the ability of the plant to spread and the plant must not be sold, propagated or knowingly distributed
Hawkweed [Hieracium species]	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
Heteranthera / Kidneyleaf mud plantain [Heteranthera reniformis]	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
Honey locust [Gleditsia triacanthos]	3	The plant must be fully and continuously suppressed and destroyed and the plant must not be sold, propagated or knowingly distributed
Horsetail [Equisetum species]	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
Hydrocotyl / Water pennywort [Hydrocotyl	1	The plant must be eradicated from the land and that land must

ranunculoides]		be kept free of the plant This is an All of NSW declaration
Hygrophila [Hygrophila costata]	2	The plant must be eradicated from the land and that land must be kept free of the plant
Hymenachne [Hymenachne amplexicaulis and hybrids] A Weed of National Significance	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
Karroo thorn [Acacia karroo]	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
Kochia [Bassia scoparia (syn. Kochia scoparia) except B. scoparia subspecies trichophylla] except Bassia scoparia subspecies trichophylla	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
Koster's curse / Clidemia [Clidemia hirta]	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
Kudzu [Pueraria lobata]	3	The plant must be fully and continuously suppressed and destroyed
Lagarosiphon [Lagarosiphon major]	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
Lantana [Lantana species] A Weed of National Significance	4	The growth of the plant must be managed in a manner that continously inhibits the ability of the plant to spread
Leafy elodea / Dense waterweed / Egeria [Egeria densa (syn. Elodea densa)]	4	The plant must not be sold, propagated or knowingly distributed This is an All of NSW declaration
Lippia [Phyla canescens]	4	The plant must not be sold, propagated or knowingly distributed except incidentally in hay or lucerne This is an All of NSW declaration
Long-leaf willow primrose [Ludwigia longifolia]	3	The plant must be fully and continuously suppressed and destroyed and the plant must not be sold, propagated or knowingly distributed
Mahonia / Chinese holly [Berberis lomariifolia (syn. Mahonia lomariifolia)]	3	The plant must be fully and continuously suppressed and destroyed and the plant must not be sold, propagated or knowingly distributed
Mexican feather grass [Nassella tenuissima]	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
Mexican poppy [Argemone mexicana]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Miconia [Miconia species]	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
Mikania vine [Mikania micrantha]	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration

Mimosa [Mimosa pigra] A Weed of National Significance	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
Ming (Pom pom / Zig zag) asparagus fern [Asparagus macowanii var. zuluensis (syn. A. retrofractus)]	2	The plant must be eradicated from the land and that land must be kept free of the plant
Montopellier broom / Cape broom [Genista monspessulana] A Weed of National Significance	3	The plant must be fully and continuously suppressed and destroyed and the plant must not be sold, propagated or knowingly distributed
Mossman River grass [Cenchrus echinatus]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Mysore thorn [Caesalpinia decapetala]	3	The plant must be fully and continuously suppressed and destroyed
Pampas grass [Cortaderia species]	4	The growth of the plant must be managed in a manner that continously inhibits the ability of the plant to spread and the plant must not be sold, propagated or knowingly distributed
Paper mulberry [Broussonetia papyrifera]	2	The plant must be eradicated from the land and that land must be kept free of the plant
Parthenium weed [Parthenium hysterophorus] A Weed of National Significance	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
Pond apple [Annona glabra] A Weed of National Significance	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
Prickly acacia [Vachellia nilotica (syn. Acacia nilotica)] A Weed of National Significance	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
Prickly pear [Opuntia species except O. ficus-indica]	4	The growth of the plant must be managed in a manner that continously inhibits the ability of the plant to spread and the plant must not be sold, propagated or knowingly distributed
Prickly pear [Cylindropuntia species] A Weed of National Significance	4	The growth of the plant must be managed in a manner that continously inhibits the ability of the plant to spread and the plant must not be sold, propagated or knowingly distributed This is an All of NSW declaration
Privet (Broad-leaf) [Ligustrum lucidum]	4	The growth of the plant must be managed in a manner that continously inhibits the ability of the plant to spread
Privet (Narrow-leaf/Chinese) [Ligustrum sinense]	4	The growth of the plant must be managed in a manner that continously inhibits the ability of the plant to spread
Red rice [Oryza rufipogon]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Rhus tree [Toxicodendron succedaneum (syn. Toxicodendron succedanea, Rhus succedanea)]	4	The growth of the plant must be managed in a manner that continously inhibits the ability of the plant to spread and the plant must not be sold, propagated or knowingly distributed This is an All of NSW declaration
Rubber vine [Cryptostegia grandiflora]	1	The plant must be eradicated from the land and that land must

A Weed of National Significance		be kept free of the plant This is an All of NSW declaration
Sagittaria [Sagittaria platyphylla (syn. Sagittaria graminea variety platyphylla)] A Weed of National Significance	4	The plant must not be sold, propagated or knowingly distributed
Salvinia [Salvinia molesta] A Weed of National Significance	3	The plant must be fully and continuously suppressed and destroyed
Scotch broom / English broom [Cytisus scoparius subspecies scoparius] A Weed of National Significance	4	The plant must not be sold, propagated or knowingly distributed
Senegal tea plant [Gymnocoronis spilanthoides]	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
Serrated tussock [Nassella trichotoma] A Weed of National Significance	4	The growth of the plant must be managed in a manner that continously inhibits the ability of the plant to spread and the plant must not be sold, propagated or knowingly distributed
Siam weed [Chromolaena odorata]	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
Sicklethorn [Asparagus falcatus]	2	The plant must be eradicated from the land and that land must be kept free of the plant
Silver-leaf nightshade [Solanum elaeagnifolium] A Weed of National Significance	4	The plant must not be sold, propagated or knowingly distributed
Smooth-stemmed turnip [Brassica barrelieri subspecies oxyrrhina]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Soldier thistle [Picnomon acarna]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Spotted knapweed [Centaurea stoebe subspecies micranthos]	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
Texas blueweed [Helianthus ciliaris]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration
Tropical soda apple [Solanum viarum]	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
Water caltrop [Trapa species]	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
Water hyacinth [Eichhornia crassipes] A Weed of National Significance	3	The plant must be fully and continuously suppressed and destroyed
Water lettuce [Pistia stratiotes]	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration

Water soldier [Stratiotes aloides]	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
White blackberry / Mysore raspberry [Rubus niveus]	3	The plant must be fully and continuously suppressed and destroyed and the plant must not be sold, propagated or knowingly distributed
Willows [Salix species except S. babylonica, S. xreichardtii, S. xcalodendron, S. cinerea and S. nigra] Includes all Salix species except S. babylonica, S. x reichardtii, S. x calodendron	4	The plant must not be sold, propagated or knowingly distributed
Witchweed [Striga species except the native Striga parviflora]	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
Yellow bells [Tecoma stans]	3	The plant must be fully and continuously suppressed and destroyed
Yellow burrhead [Limnocharis flava]	1	The plant must be eradicated from the land and that land must be kept free of the plant This is an All of NSW declaration
Yellow nutgrass [Cyperus esculentus]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with This is an All of NSW declaration

Appendix C

Weeds Detected on the Project Site

Table C1 Weed Species Detected within the Project Corridor

Family	*Scientific Name*	*Common Name*	*Listing*
Noxious Weeds			
Asteraceae	*Ambrosia artemisiifolia*	Annual Ragweed	N5
Asteraceae	*Baccharis halimifolia*	Groundsel Bush	N3
Asteraceae	*Senecio madagascariensis*	Fireweed	N4
Oleaceae.	*Ligustrum lucidum*	Broad-leafed Privet	N4
Oleaceae.	*Ligustrum sinense*	Narrow-leafed Privet	N4
Rosaceae	*Rubus fruticosus*	Blackberry	N4
Salviniaceae	*Salvinia molesta*	Salvinia	N3. WoNS
Verbenaceae	*Lantana camara*	Lantana	N4, WoNS
Environmental/ Agricultural Weeds			
Apocynaceae	*Gomphocarpus physocarpus*	Balloon Cotton Bush	
Araliaceae	*Schefflera actinophylla*	Umbrella Tree	
Asparagaceae	*Asparagus aethiopicus*	Asparagus Fern	
Asteraceae	*Ageratum houstonianum*	Blue Billygoat Weed	
Asteraceae	*Bidens pilosa*	Cobbler's Pegs	
Asteraceae	*Onopordum acanthium subsp. acanthium**	Scotch Thistle	
Asteraceae	*Tagetes minuta*	Stinking Roger	
Basellaceae	*Anredera cordifolia*	Madeira Vine	
Commelinaceae	*Commelina benghalensis*	Hairy Commelina	
Commelinaceae	*Tradescantia fluminensis (albiflora)*	Wandering Jew	
Convolvulaceae	*Ipomoea cairica*	Coastal Morning Glory	
Davalliacea	*Nephrolepis cordifolia*	Fishbone Fern	
Dennstaedtiaceae	*Pteridium esculentum*	Bracken	
Fabaceae	*Desmodium uncinatum*	Silver-leaved Desmodium	
Fabaceae (Caesalpinioideae)	*Senna pendula var. glabrata*	Winter Senna	
Lauraceae	*Cinnamomum camphora*	Camphor Laurel	
Myrtaceae	*Psidium guajava*	Guava	
Ochnaceae	*Ochna serrulata*	Ochna	
Passifloraceae	*Passiflora subpeltata*	White Passionflower	
Poaceae	*Hyparrhenia hirta*	Coolatai Grass	
Poaceae	*Sporobolus fertilis*	Giant Parramatta Grass	
Poaceae	*Andropogon virginicus*	Whiskey Grass	
Poaceae	*Paspalum mandiocanum*	Broad-leafed Paspalum	
Poaceae	*Paspalum urvillei*	Vasey Grass	
Poaceae	*Setaria sphacelata*	South African Pigeon Grass	
Rutaceae	*Murraya paniculata*	Orange Jessamine	
Solanaceae	*Solanum mauritianum*	Wild Tobacco Bush	
Verbenaceae	*Verbena bonariensis*	Purpletop	

Family	*Scientific Name*	*Common Name*	*Listing*
Aquatic Weeds			
Haloragaceae	*Myriophyllum aquaticum*	Parrots Feather	
Salviniaceae	*Azolla filiculoides*	Red Azolla	

Appendix D

Chytrid Management Protocol

1.1 Frog Hygiene Protocols

Frog hygiene protocols aim to prevent the spread of amphibian chytrid fungus during the Warrell Creek to Nambucca Heads Pacific Highway Upgrade Project. Indications of this pathogen have to date not been detected within the local frog population. As the pathogen typically exists within water bodies, topsoil and the upper soil profile, this protocol focuses on controlling the potential spread of this pathogen during the "high risk stage" which is defined as being when in contact with the existing natural ground surface within the Giant Barred Frog and Green Thighed Frog hygiene management areas (as defined in Map 1 to Map 3 of this protocol).

1.1.1 Wash Down

- Wash down procedures for vehicles, plant and footwear are to be implemented when entering / exiting the frog hygiene management area (refer to Map 1 to Map 3) at any time when these items have been in contact with the existing natural ground surface. Once topsoil and vegetative material has been removed from the designated frog hygiene management zone, new plant and equipment entering the zone would not require wash-down whereas plant and equipment leaving the zone and having had contact with the natural ground surface will still require wash-down.
- Wash down bays will be implemented at appropriate entry / exit points.
- Wash down bays will incorporate an area for site personnel to disinfect boots when entering / leaving sterile zones during clearing / grubbing and stripping of topsoil.
- Wash down bays will be situated at least 100 m from waterways.
- Wash down areas will be contained with wash-down material (liquid and sediment) to be removed off site to a licensed waste facility.
- All construction personnel must be made aware of the requirements for wash down with this procedure to be a hold point for works commencing.
- Disinfection will be via the use of proprietary available Chloramine and Chlorhexidine based fungicides, cleaning products containing benzalkonium chloride or bleach and alcohol (ethanol or methanol).
- 70% isopropyl wipes may be suitable for the disinfection of small equipment.

1.1.2 Excavated Topsoil

- Excavated topsoil from the frog hygiene management zone must be either reused within the same creek catchment or buried on site.
- If the material is to be stockpiled and reused at a later date, the origin of this material must be tracked and wash-down procedures implemented when reuse occurs.

1.1.3 Entry into GBF / GTF Habitat (outside the Project Site)

- A "permit to enter" system will be established to regulate entry of personnel into areas of GBF / GFF habitat occurring outside of the Project Site.
- Any entry into areas of GBF / GTF habitat (outside the Project Site) will require personnel to disinfect boots before / after entering such areas. Portable spray packs with appropriate disinfectant (refer to Appendix A) will be made available at wash down bays.
- All personnel will be made aware of their responsibilities relating to Chytrid management on the site.

1.1.4 Vehicle Movements

- Vehicle movements will be restricted to designated tracks, trails and parking areas by a specific Vehicle Movement Plan (VMP) which will apply at all times throughout the works.
- Vehicle movements within the frog hygiene management areas will be kept to a minimum during excessively wet or muddy conditions.
- Designated parking and turn-around points must be provided on hard well-drained surfaces within the frog hygiene management zone.

1.1.5 Frog Handling

The Project Ecologist and personnel licensed / authorised to handle GBF / GTF are to adhere to the following hygiene protocols in accordance with the *Hygiene Protocols for the Control of Disease in Frogs* (NPWS, 2008) (refer to Appendix A): -

- New gloves / bags will be used for each frog captured;
- Individual bags / containers will be used for each frog held and containers (if reusable will be washed) prior to reuse. Containers will be labelled with the date and location);
- When moving between separate sites during frog surveys, footwear / waders will be thoroughly cleaned and disinfected;
- When moving between separate sites during frog surveys, equipment used (such as callipers, scales etc) will be thoroughly cleaned and disinfected; and
- Vehicle tyres will be washed / disinfected before and after visiting frog sites.
- Vehicle tyres can be disinfected with the aforementioned disinfectants or cleaning product s with active ingredient benzalkonium chloride (See Appendix A).
- Should a sick frog be identified the project environmental staff are to be notified to ensure that controls remain effective and that staff are reminded of their responsibilities. Manage the sick frog in accordance with the protocol.

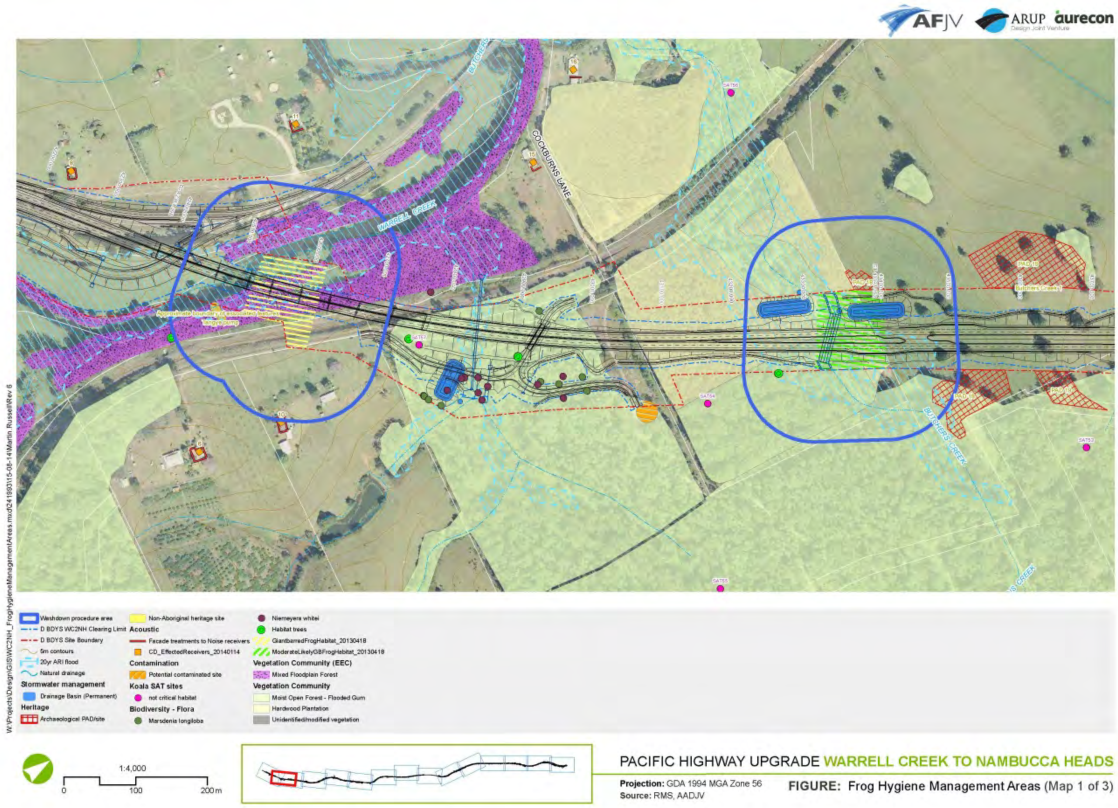
1.2 Frog Hygiene Management Areas

Frog hygiene management areas have been created based on previous ecological assessment and in locations that have been identified as one of the following:

- Green Thighed Frog habitat;
- Likely Green Thighed Frog habitat;
- Giant Barred Frog habitat; and
- Moderately likely Giant Barred Frog habitat.

The locations of the frog hygiene Management Areas are shown in the Frog Hygiene Management Area Maps (Figure 1 to Figure 3). The five locations are all between chainage 42400 and 61000, as identified below:

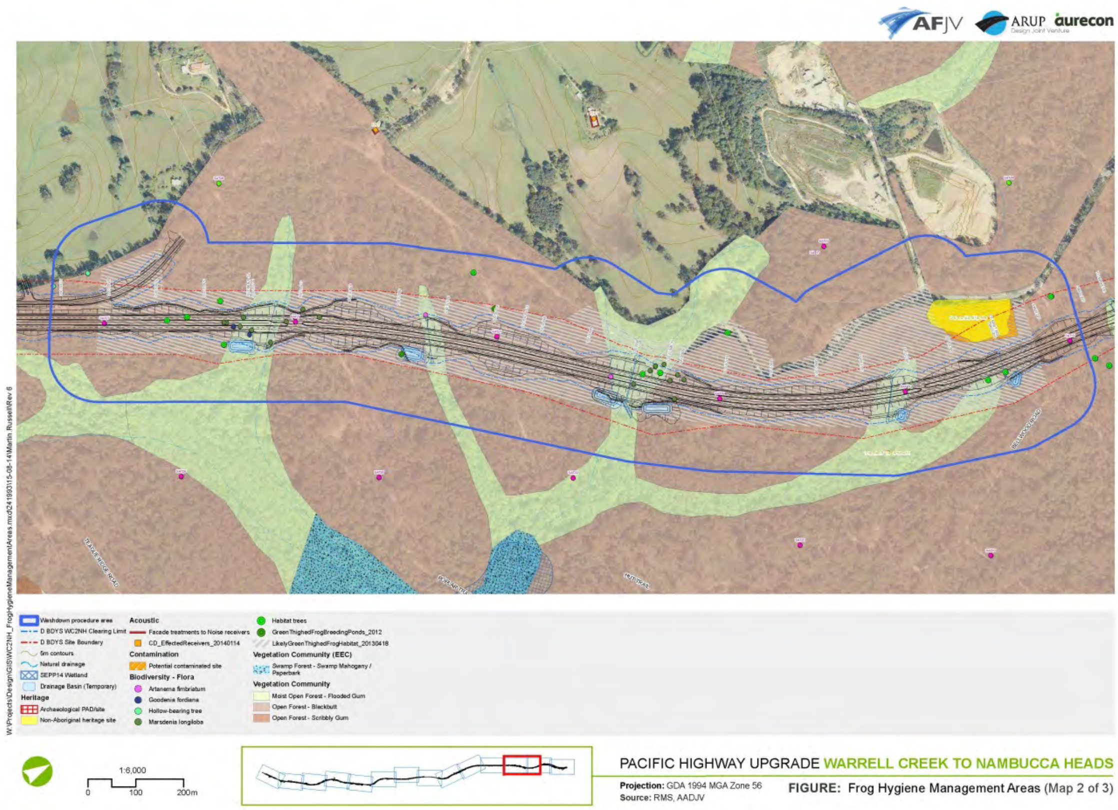
- Near Swampy Creek and CPT 318/3 Trail. Between chainage 59900 and 60300;
- Adjacent to Bellwood Creek. Between chainage 60700 and 61000;
- Between Teague Ridge Road and Belwood Road. Between chainage 57300 and 59500;
- On the eastern side of Warrell Creek. Between chainage 42400 and 42750; and
- Butchers Creek travels through the site. Between chainage 43200 and 43550.



PACIFIC HIGHWAY UPGRADE **WARRELL CREEK TO NAMBUCCA HEADS**

Projection: GDA 1994 MGA Zone 56
Source: RMS, AADJV

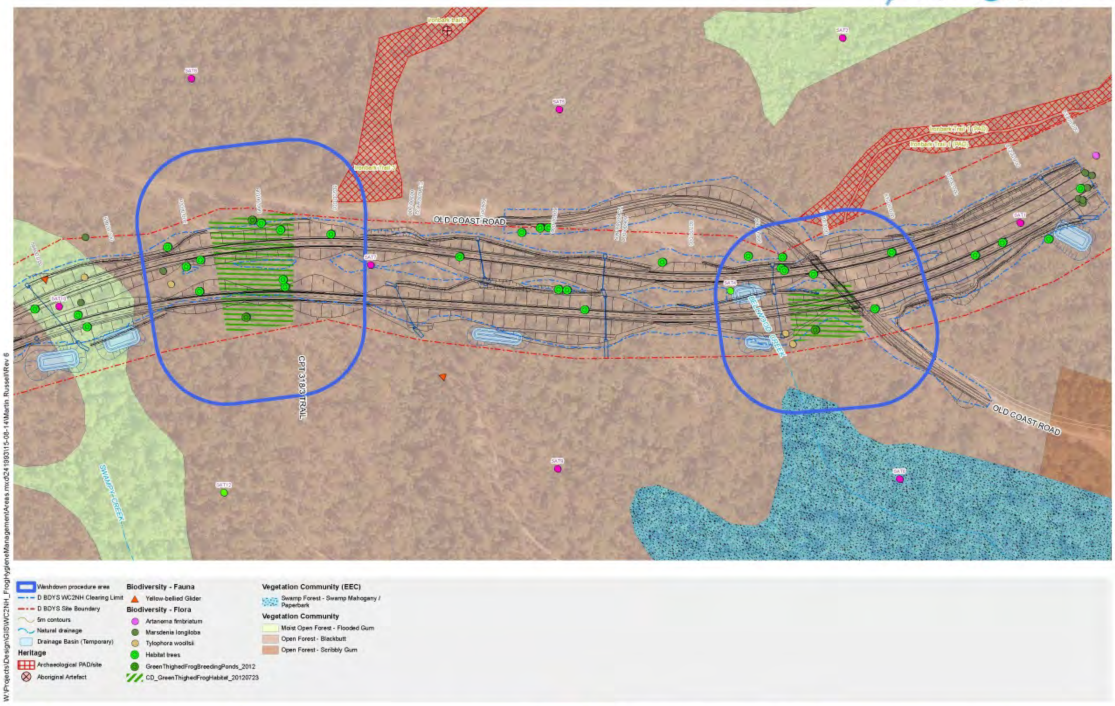
FIGURE: Frog Hygiene Management Areas (Map 1 of 3)



PACIFIC HIGHWAY UPGRADE **WARRELL CREEK TO NAMBUCCA HEADS**

Projection: GDA 1994 MGA Zone 56
Source: RMS, AADJV

FIGURE: Frog Hygiene Management Areas (Map 2 of 3)



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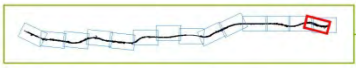


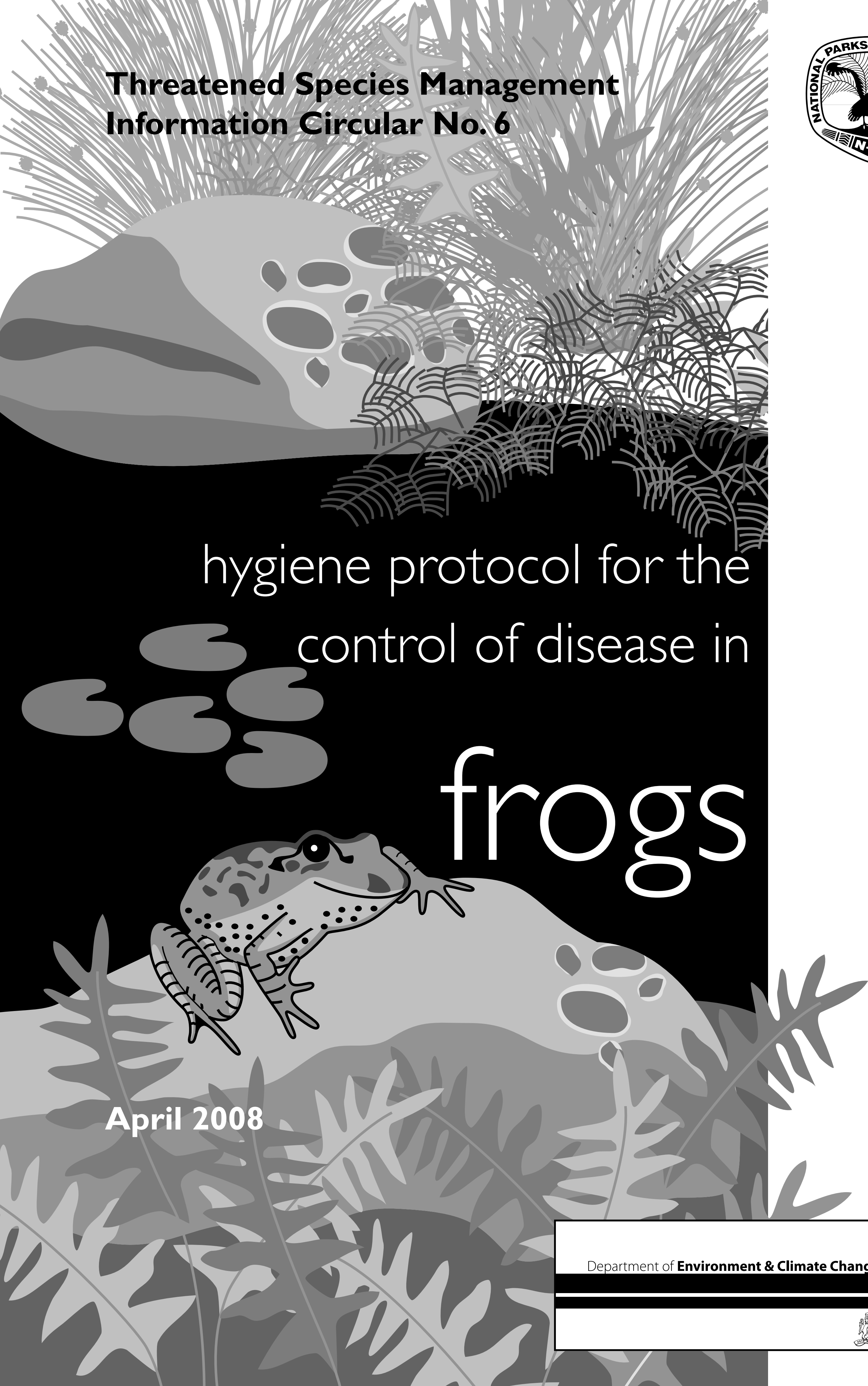
PACIFIC HIGHWAY UPGRADE WARRELL CREEK TO NAMBUCCA HEADS

Projection: GDA 1994 MGA Zone 56
Source: RMS, AADJV

FIGURE: Frog Hygiene Management Areas (Map 3 of 3)

APPENDIX A - HYGIENE PROTOCOLS FOR THE CONTROL OF DISEASE IN FROGS (NPWS, 2008)

Threatened Species Management Information Circular No. 6



hygiene protocol for the control of disease in frogs

April 2008

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This document can be sourced from the DECC website:
www.environment.nsw.gov.au/resources/nature/hypfrog.pdf

This document should be cited as:
Department of Environment and Climate Change (NSW) 2008. Hygiene protocol for the control of disease in frogs. Information Circular Number 6. DECC (NSW), Sydney South.

ISBN 0 7313 6372 8
DECC 2008/199

Acknowledgments

NSW National Parks and Wildlife Service Declining Frog Working Group who recommended the preparation and provided input into the development of this strategy.

Ross Wellington and Ron Haering (both DECC) the authors of this document.

Thanks to Jack Baker, Lee Berger, Mark Endersby, Jeff Hardy, Frances Hulst, Alex Hyatt, Keith McDougall, Diana Mendez, Deborah Pergolotti, Graham Pyke, Marjo Rauhala, Julie Ravallion, Karrie Rose, Lothar Voigt and Arthur White for their advice and/or technical review.

This hygiene protocol is an adaptation of the Declining Amphibian Population Task Force (DAPTF) Fieldwork Code of Practice and the recommendations of Speare et al. (1999) and has drawn on recommendations from earlier guidelines prepared by Environment ACT.

Foundation for National Parks and Wildlife funded the printing of this protocol.

hygiene protocol for the control of disease in frogs

1 introduction

This information circular outlines measures to:

- Prevent or reduce disease causing pathogens being transferred within and between wild populations of frogs.
- Ensure captive frogs are not infected prior to release.
- Deal safely with unintentionally transported frogs.
- Assist with the proper identification and management of sick and dead frogs in the wild.

1.1 Who should read this document?

This protocol is intended for use by all researchers, wildlife consultants, fauna surveyors and students undertaking frog field-work. In addition, the protocol should be read by Department of Environment and Climate Change (DECC) personnel, frog keepers, wildlife rescue and carer organisations, herpetological/frog interest groups/ societies, fauna park/zoo operators/workers and other individuals who regularly deal with or are likely to encounter frogs.

This protocol outlines the expectations of the DECC regarding precautionary procedures to be employed when working with frog populations. The intention is to promote implementation of hygiene procedures by all individuals working with frogs. New licences and licence renewals will be conditional upon incorporation of the protocol. The DECC recognises that some variation from the protocol may be appropriate for particular research and frog handling activities. Such variation proposals should accompany any licence application or renewal to the DECC.

1.2 Background

1.2.1 Amphibian Chytrid Fungus

The apparent decline of frogs, including extinctions of species and local populations, has attracted increased international and national concern. Many potential causes for frog declines have been proposed (eg see Pechmann et al., 1991; Ferrero and Bergin, 1993; Pechmann and Wilbur, 1994; Pounds and Crump, 1994; Pounds et al., 1997). However, the patterns of decline at many locations suggest that epidemic disease maybe the cause (Richards et al., 1993; Laurance et al., 1996; Alford and Richards, 1997). Recent research has implicated a water-borne fungal pathogen *Batrachochytrium dendrobatidis* as the likely specific causative agent in many of these declines both in Australia and elsewhere (Berger et al., 1998; 1999). This agent is commonly known as the amphibian or frog chytrid fungus and is responsible for the disease Chytridiomycosis (Berger et al., 1999).

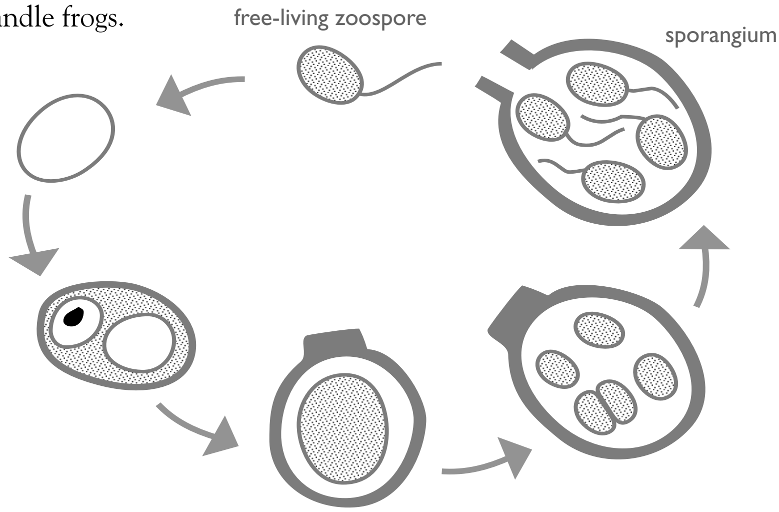
B. dendrobatidis is a form of fungus belonging to the phylum Chytridiomycota. Most species within this phylum occur as free-living saprophytic fungi in water and soil and have been found in almost every type of environment including deserts, artic tundra and rainforest and are considered important primary biodegraders (Powell 1993). *B. dendrobatidis* is a unique parasitic form of Chytridiomycete fungi, in that it invades the skin of amphibians, including tadpoles, often causing sporadic deaths with up to 100% mortality in some populations. Chytridiomycosis has been detected in over 40 species of native amphibian in Australia (Mahony and Workman 2000). However, it is not currently known whether the fungus is endemic or exotic to Australia.

The infective stage of *B. dendrobatidis* is the zoospore and transmission requires water (Berger et al.,1999). Zoospores released from an infected amphibian can potentially infect other amphibians in the same water. More research is needed on the dynamics of infection in the wild. *B. dendrobatidis* is known to be susceptible to seasonal temperature changes, dehydration, salinity, water pH, light, nutrition and dissolved oxygen (Berger et al., 1999).

1.3 Objectives

The objectives of the hygiene protocol are to:

- Recommend best-practice procedures for DECC personnel, researchers, consultants and other frog enthusiasts or individuals who handle frogs.
- Suggest workable strategies for those regularly working in the field with frogs or conducting fieldwork activities in wetlands and other aquatic environments where there is the potential for spreading pathogens such as the frog chytrid fungus.
- Provide background information and guidance to people who provide advice or supervise frog related activities.
- Provide standard licence conditions for workers engaged in frog related activities.
- Inform Animal Care and Ethics Committees (ACEC) for their consideration when granting research approvals.



Life cycle of frog chytrid fungus from infective free-living zoospore stage to sporangium (adapted from L. Berger).

2 site hygiene management

A checklist of risk management procedures and recommended standard hygiene kit is provided in Appendix 1. Please note Footnote 1 on page 4.

Individuals studying frogs often travel and collect samples of frogs from multiple sites. Some frog populations can be particularly sensitive to the introduction of infectious pathogens such as the frog chytrid fungus. Also, the arrangement of populations in the landscape may make frogs particularly vulnerable to transmission of infectious pathogens. Therefore, it is important that frog workers recognise the boundaries between sites and undertake measures which reduce the likelihood of spreading infection.

Where critically endangered species or populations of particular risk are known to occur, this protocol should be applied over very short distances ie a single site may need to be subdivided and treated as separate sites.

When planning to survey multiple sites, always start at a site where frog chytrid fungus is not known to be present before entering other infected areas.

2.1 Defining a site

Defining the boundary of a site maybe problematic. In some places, the boundary between sites will be obvious but in others, less so. Undertaking work at a number of sites or conducting routine monitoring at a series of sites within walking distance creates obvious difficulties with boundary definitions. It is likely that defining the boundary between sites will differ among localities. It may be that a natural or constructed feature forms a logical indicator of a site boundary eg a road/track, a large body of water such as a river or the sea, a marked habitat change or a catchment boundary.

As a guiding principle, each individual waterbody should be considered a separate site.

When working along a river or stream or around a wetland or a series of interconnecting ponds it is reasonable, in most instances, to treat such examples as a single site for the purposes of this protocol. Such a case would occur in areas where frogs are known to have free interchange between ponds.

Where a stream consists of a series of distinctive tributaries or sub-catchments or where there is an obvious break or division then they should be treated as separate sites, particularly if there is no known interchange of frogs between sites.

2.2 On-site hygiene

When travelling from site to site it is recommended that the following hygiene precautions be undertaken to minimise the transfer of disease from footwear, equipment and/or vehicles.

Footwear

Footwear must be thoroughly cleaned and disinfected at the commencement of fieldwork and between each sampling site.

This can be achieved by initially scraping boots clear of mud and standing the soles in a disinfecting solution. The remainder of the boot should be rinsed or sprayed with a disinfecting solution that contains *benzalkonium chloride* as the active ingredient. Disinfecting solutions should be prevented from entering any water bodies.

Rubber boots such as 'gum boots' or 'Wellingtons' are recommended because of the ease with which they can be cleaned and disinfected.

Several changes of footwear bagged between sites might be a practical alternative to cleaning.

Equipment

Equipment such as nets, balances, callipers, bags, scalpels, headlamps, torches, wetsuits and waders etc that are used at one site must be cleaned and disinfected before re-use at another site.

Disposable items should be used where possible. Non-disposable equipment should be used only once during a particular field exercise and disinfected later or disinfected at the site between uses using procedures outlined in 2.4 below.

Vehicles

Where necessary, vehicle tyres should be sprayed/flushed with a disinfecting solution in high-risk areas.

Transmission of disease from vehicles is unlikely to be a problem. However, if a vehicle is used to traverse a known frog site, which could result in mud and water being transferred to other bodies of water or frog sites, then wheels and tyres should undergo cleaning and disinfection. This should be carried out at a safe distance from water bodies, so that the disinfecting solution can infiltrate soil rather than run-off into a nearby water body.

Spraying with ‘toilet duck’ (active ingredient *benzalkonium chloride*) is recommended to disinfect car wheels and tyres.

Cleaning of footwear before getting back into the car will prevent the transfer of pathogens from/to vehicle floor and control pedals.

2.3 Handling of frogs in the field

The spread of pathogenic organisms, such as the frog chytrid fungus, may occur as a result of handling frogs.

Frogs should only be handled when necessary.

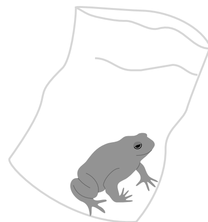
Where handling of frogs is necessary the risk of pathogen transfer should be minimised as follows:

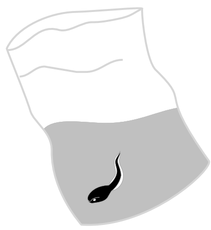
- Hands should be either cleaned and disinfected between samples or a new pair of disposable gloves used for each sample[1]. This may be achieved by commencing with a work area that has a dish containing a disinfecting solution and paper towels.
- A ‘one bag – one frog’ approach to frog handling should be used especially where several people are working together with one person processing frogs and others doing the collecting. Bags should not be reused.
- A ‘one bag – one sample’ approach to tadpole sampling should be used. Bags should not be reused.

Researchers who use toe clipping or Passive Integrated Transponder (PIT) tagging are likely to increase the risk of transmitting disease between frogs due to the possibility of directly introducing pathogens into the frogs’ system. This can be minimised by using:

- Disposable sterile instruments
- Instruments disinfected previously and used once
- Instruments disinfected in between each frog

Disinfecting solutions containing *benzalkonium chloride* are readily available from local supermarkets. Some brands include Toilet Duck, Sanpic, New Clenz and Pine Clean.





[1] As a principle, this protocol assumes that not all frogs in an infected pond will be contaminated by the frog chytrid fungus. The infective load of a body of water may not be high enough to cause cross contamination of individual frogs in the same pond. Therefore care should be taken to use separate gloves and bags and clean hands for each sample, to avoid transmission of high infective loads between individuals.

Open wounds from toe clipping and PIT tagging should be sealed with a cyanoacrylate compound such as *Vetbond©* to reduce the likelihood of entry of pathogens. The DECC ACEC further recommends the application of topical anaesthetic *Xylocaine©* cream and *Betadine©* disinfectant (1% solution) before and after any surgical procedure. This should then be followed by the wound sealant.

All used disinfecting solutions, gloves and other disposable items should be stored in a sharps or other waste container and disposed or sterilised appropriately at the completion of fieldwork. Disinfecting solutions must not come into contact with frogs or be permitted to contaminate any water bodies

2.4 Disinfection Methods

Disinfecting agents for hands and equipment must be effective against bacteria and both the vegetative and spore stages of fungi. The following agents are recommended:

- Chloramine and Chlorhexidine based products such as *Halamid©*, *Halasept©* or *Hexifoam©* are effective against both bacteria and fungi. These products are suitable for use on hands, footwear, instruments and other equipment. The manufacturers instructions should be followed when preparing these solutions.
- Bleach and alcohol (ethanol or methanol), diluted to appropriate concentrations can be effective against bacteria and fungi. However, these substances may be less practical because of their corrosive and hazardous nature.

  When using methanol either:

  - immerse in 70% methanol for 30 minutes or
  - dip in 100% methanol then flame for 10 seconds or boil in water for 10 minutes

Fresh bleach (5% concentration) may be also effective against other frog pathogens such as Rana Virus.

Some equipment not easily disinfected in these ways can be effectively cleaned using medical standard 70% isopropyl alcohol wipes – *Isowipes©*.

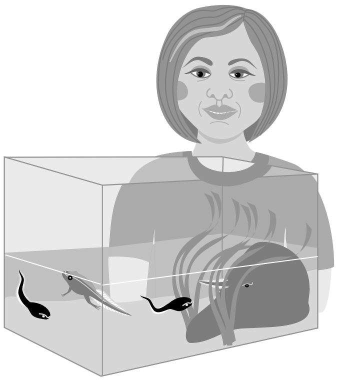
3 captive frog hygiene management

3.1 Housing frogs and tadpoles

Frogs and tadpoles should only be removed from a site when absolutely necessary.

When it is necessary for frogs or tadpoles to be collected and held for a period of time, the following measures should be undertaken:

- Animals obtained at different sites should be kept isolated from each other and from other captive animals.
- Aquaria set up to hold frogs should not share water, equipment or any filtration system. Splashes of water from adjacent enclosures or drops of water on nets may transfer pathogens between enclosures.
- Prior to housing frogs or tadpoles, ensure that tanks, aquaria and any associated equipment are disinfected.
- Tanks and equipment should be cleaned, disinfected and dried immediately after frogs/tadpoles are removed.



Careful maintenance of your enclosures will ensure a safe and hygienic environment for captive frogs and tadpoles.

When contemplating a release of captive bred tadpoles for conservation purposes a Translocation Proposal should be submitted to the DECC and pathological screening for disease should be undertaken (see also DECC Translocation Policy). Tadpoles can be tested by randomly removing 10 individuals at 6 weeks and again at 2 weeks before anticipated release. Testing could be undertaken by the pathology section at Taronga Zoo, Newcastle University, CSIRO Australian Animal Health Laboratories at Geelong and James Cook University at Townsville. Such an arrangement would need to be negotiated by contacting one of these institutions well before the anticipated release date. (see Appendix 2 for contact details)

DECC have licenced NSW Schools to allow students and/or teachers to remove tadpoles for classroom life cycle studies. They are authorised to remove individuals from only one location, each school also requires endorsement from Department of Education and Training Animal Care and Ethics Committee and comply with this protocol.

Tadpoles collected for these purposes are to be obtained from the local area of the school and are not to be obtained from DECC Reserves. As soon as tadpoles have transformed, froglets must be returned to the exact point of capture. Tadpoles from different locations are not to be mixed.

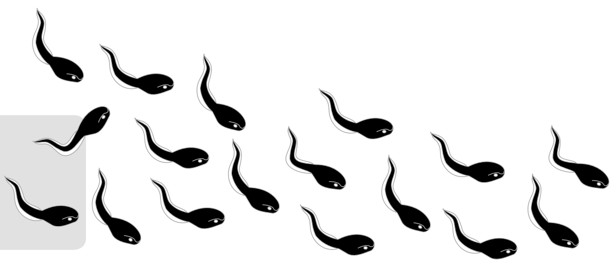
Antifungal cleansing treatments to clear tadpoles of the frog chytrid fungus are currently being trialed. In the future, such a treatment may be an added procedure required prior to froglet releases.

Detailed information on safely maintaining frogs in captivity is provided in Voigt (2001).

3.2 Tadpole treatment

In most instances:

Release to the wild of tadpoles held or bred in captivity should be avoided.



3.3 Frog treatment

The rigour with which frogs must be treated to ensure pathogens are not introduced to native populations means that any proposal for the removal of adult frogs (particularly threatened species) from wild populations should be given careful consideration.

When it is essential for frogs to be removed from the wild, the following should apply.

Individuals to be released should be quarantined for a period of 2 months and monitored for any signs of illness or disease.

Frogs must not be released if any evidence of illness or infection is detected. If illness is suspected, further advice must be sought from a designated frog recipient (Appendix 2) as soon as possible to determine the nature of the problem. Chytridiomycosis can be diagnosed in live frogs by microscopical examination of preserved toe clips or from shedding skin samples. Research is still in progress on the development of a simple technique for the detection of Chytridiomycosis and a treatment for infected frogs.

Current methods which may be used include:

- A technique for the treatment of potentially infected frogs is to place the frogs individually in a 1mg/L benzalkonium chloride solution for 1 hour on days 1, 3, 5, 9, 11 and 13 of the treatment period. Frogs are then isolated/quarantined for two months. This and other possible treatments are documented in Berger and Speare (1998)
- *Betadine©* and *Bactone©* treatments have also been used on adult frogs with some success (M. Mahony, Newcastle University pers. comm.)
- *Itraconazole©* is an expensive drug which has been used successfully (Lee Berger CSIRO Australian Animal Health Laboratory pers. comm.). Information on this method is available on the Website http://www.jcu.edu.au/school/PHTM/frogs/adms/attach6.pdf.

Frogs undergoing treatment should be housed individually and kept separate from non-infected individuals.

3.4 Displaced frogs

Displaced frogs are those native frog species and introduced Cane Toads (Bufo marinus) which have been unintentionally transported around the country with fresh produce, transported produce and landscaping supplies. Procedures to be undertaken when encountering introduced/displaced native frog species (as well as Cane Toads) are as follows.

3.4.1 Banana box frogs

'Banana Box' frog is the term used to describe several native frog species (usually Litoria gracilenta, L. infrafrenata, L. bicolor and L. caerulea) commonly transported in fruit and vegetable shipments and landscaping supplies. In the past, well meaning individuals have attempted to return these frogs to their place of origin but this is usually impossible to do accurately. There is risk of spread of disease if these frogs are transferred from place to place.

It is strongly recommended that:

Displaced Banana Box frogs should be treated as if they are infected and should not to be freighted anywhere for release to the wild unless specifically approved by DECC.

When encountering a displaced frog:

- Contact a licensed wildlife carer organisation to collect the animal. The frog should then undergo a quarantine period of 2 months along with an approved disinfection treatment.
- Post-quarantine, the frog (if one of the species identified above) may be transferred to a licensed frog keeper. All other species require the permission from DECC Wildlife Licensing and Management Unit (WLMU) prior to transfer. Licensed carer groups are to record and receipt frogs obtained and disposed of in this way.
- Licensed Frog Keepers are to list these frogs in their annual licence returns to DECC.

Frogs held by licensed frog keepers are not to be released to the wild except with specific DECC approval.

Displaced frogs may be made available to recognised institutions for research projects, display purposes or perhaps offered to the Australian Museum as scientific specimens once approval has been provided by the DECC WLMU.

Frogs are often unintentionally transported with fresh produce and landscaping supplies. They are collectively known as 'banana box' or displaced frogs.

3.4.2 Cane toads

Cane toads are known carriers of the Frog chytrid fungus and should not be knowingly transported or released to the wild.

If a cane toad is discovered outside of its normal range, it should be humanely euthanased in accordance with the recommended NSW Animal Welfare Advisory Council procedure (see Appendix 3). Care should be taken to avoid euthanasia of native species due to mistaken identity.

3.4.3 Local frog species

Frogs encountered on roads, around dwellings and gardens or in swimming pools should not be considered as displaced frogs.

Frogs encountered in these situations should be assisted off roads, away from dwellings, or out of swimming pools preferably to the nearest area of vegetation or suitable habitat.

Incidences of frogs spawning or tadpoles appearing in swimming pools should be referred to a wildlife carer/rescue organisation for assistance (see Appendix 4).

Contact the Frogwatch Helpline if you are unsure whether a frog is a local species or displaced.

An NPWS information brochure titled 'Cane Toads in NSW' provides further information on cane toads and assistance with identification of some of the commonly misidentified native species. This information is also available on the DECC website.

4 sick or dead frogs

Unless an obvious cause of illness or death is evident (eg predation or road mortality): Sick or dead frogs encountered in the wild should be collected and disposed of in accordance with the procedures described in section 4.2 below.

4.1 Symptoms of sick and dying frogs

Sick and dying frogs exhibit a range of symptoms characteristic of chytrid infection. Symptoms may be expressed in the external appearance or behaviour of the animal. A summary of these symptoms are described below. More detailed information can be found in Berger et al., (1999) or at the James Cook University Amphibian Disease website at: http://www/jcu.edu.au/school/phtm/PHTM/frogs/ampdis.htm.

Appearance (one or more symptoms)

- darker or blotchy upper (dorsal) surface
- reddish/pink-tinged lower (ventral) surface and/or legs and/or webbing or toes
- swollen hind limbs
- very thin or emaciated
- skin lesions (sores, lumps)
- infected eyes
- obvious asymmetric appearance

Behaviour (one or more symptoms)

- lethargic limb movements, especially hind limbs
- abnormal behaviour (eg a nocturnal, burrowing or arboreal frog sitting in the open during the day and making no vigorous attempt to escape when approached)
- little or no movement when touched

Great barred frog (*Mixophyes fasciolatus*) with severe Chytrid infection — note lethargic attitude and sloughing skin. Photo: L. Berger

Diagnostic behaviour tests

Sick frogs will fail one or more of the following tests:

test	healthy	sick
Gently touch with finger	Frog will blink	Frog will not blink above the eye
Turn frog on its back	Frog will flip back over	Frog will remain on its back
Hold frog gently by its mouth	Frog will use its forelimbs to try to remove grip	No response from frog

4.2 What to do with sick or dead frogs

A procedure for the preparation and transport of a sick or dead frog is given below[2]. Adherence to this procedure will ensure the animal is maintained in a suitable condition for pathological examination and assist the DECC and researchers to determine the extent of the disease and the number of species affected.

- Disposable gloves should be worn when handling sick or dead frogs. Avoid handling food and touching your mouth or eyes as this could transfer pathogens and toxic skin secretions from some frog species.
- New gloves and a clean plastic bag should be used for each frog specimen to prevent cross-contamination. When gloves are unavailable, use an implement to transfer the frog to a container rather than using bare hands.
- If the frog is dead, keep the specimen cool and preserve as soon as possible (as frogs decompose quickly after death making examination difficult). Specimens can be fixed/preserved in 70% ethanol or 10% buffered formalin.

Cut open the belly and place the frog in about 10 times its own volume of preservative. Alternatively, specimens can be frozen (although this makes tissues unsuitable for some tests). If numerous frogs are collected, some should be preserved and some should be frozen. Portions of a dead frog can be sent for analysis eg a preserved foot, leg or a portion of abdominal skin.

- The container should be labelled showing at least the species, date and location. A standardised collection form is provided in Appendix 5.
- If the frog is alive but unlikely to survive transportation (death appears imminent), euthanase the frog (see Appendix 3) and place the specimen in a freezer. Once frozen, the specimen is ready for shipment to the address provided below.
- If the frog is alive and likely to survive transportation, place the frog into either a moistened cloth bag with some damp leaf litter or into a plastic bag with damp leaf litter and partially inflated before sealing. Remember to keep all frogs separated during transportation.
- Preserved samples can be sent in jars or wrapped in wet cloth, sealed in bags and placed inside a padded box.
- Send frozen samples in an esky with dry ice (available from BOC/CIG Gas outlets).
- Place live or frozen specimens into a small styrafoam esky (available from K-Mart/Big W for approximately $2.50).
- Seal esky with packaging tape and address to one of the laboratories listed in Appendix 4.
- Send the package by courier.

Further information on sick and dying frogs is available on the Amphibian Disease Home Page at http://www.jcu.edu.au/dept/PHTM/frogs/ampidis.htm — in particular refer to *'What to do with dead or ill frogs'*.

[2] The measures described below are standard procedures and may vary slightly depending on the distance and time required to reach the intended recipient. Contact the intended recipient of the sick or dead frog prior to sending to confirm the appropriate procedure.

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appendix 1

hygiene protocol checklist and field kit

The following checklist and field kit are designed to assist with minimising the risk of transferring pathogens between frogs.

Have you considered the following questions before handling frogs in the field:

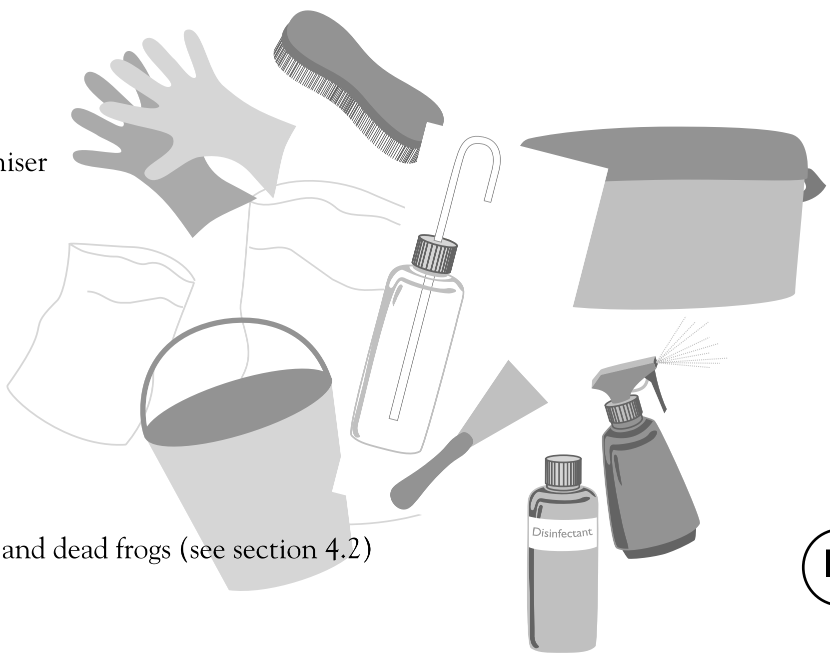
- Has your proposed field trip been sufficiently well planned to consider hygiene issues?
- Have you taken into account boundaries between sites (particularly where endangered species or populations at risk are known to occur)?
- Have footwear disinfection procedures been considered and a strategy adopted?
- Have you planned the equipment you will be using and developed a disinfection strategy?
- Are you are planning to visit sites where vehicle disinfection will be needed (consider both vehicle wheels/tyres and control pedals) and if so, do you have a plan to deal with vehicle disinfection?
- Have handling procedures been planned to minimise the risk of frog to frog pathogen transmission?
- Do you have a planned disinfection procedure to deal with equipment, apparel and direct contact with frogs?

If you answered NO to any of these questions please re-read the relevant section of the DECC Hygiene Protocol for the Control of Disease in Frogs and apply a suitable strategy.

Field hygiene kit

When planning to survey frogs in the field a portable field hygiene kit should be assembled to assist with implementing this protocol. Recommended contents of a field hygiene kit would include:

- Small styrofoam eski
- Disposable gloves
- Disinfectant spray bottle (atomiser spray) and/or wash bottle
- Disinfecting solutions
- Wash bottle
- Scraper or scrubbing brush
- Small bucket
- Plastic bags large and small
- Container for waste disposal
- Materials for dealing with sick and dead frogs (see section 4.2)



appendix 2

Always contact the relevant specialist prior to sending a sick or dead frog. In some cases, only wild frogs will be assessed for disease. Analysis may also attract a small fee per sample.

designated sick and dead frog recipients

Contact one of the following specialists to arrange receipt and analyse sick and dead frogs. Make contact prior to dispatching package:

Karrie Rose
Australian Registry if Wildlife Health
Taronga Conservation Society, Australia
PO Box 20
MOSMAN NSW 2088

Phone: 02 9978 4749
Fax: 02 9978 4516
Krose@zoo.nsw.gov.au

Diana Mendez or
Rick Speare
School of Public Health,
Tropical Medicine and
Rehabilitation Sciences
James Cook University
Douglas Campus
TOWNSVILLE QLD 4811

Phone: 07 4796 1735
Fax: 07 4796 1767
Diana.Mendez@jcu.edu.au
Richard.Speare@jcu.edu.au

Michael Mahony
School of Biological Sciences
University of Newcastle
CALLAGHAN NSW 2308

Phone: 02 4921 6014
Fax: 02 4921 6923
bimjm@cc.newcastle.edu.au

For information on frog keeping licences and approvals to move some species of displaced frog contact:

Co-ordinator, Wildlife Licensing
Wildlife Licensing and Management Unit
DECC
PO Box 1967
Hurstville NSW 1481
Ph 02 9585 6481
Fax 02 9585 6401
wildlife.licensing@environment.nsw.gov.au

For information on the possible identity of displaced frogs contact:

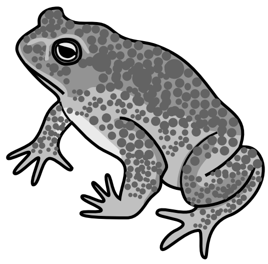
Frog and Tadpole Society (FATS)
Frogwatch Helpline

Ph: 0419 249 728

appendix 3

NSW Animal Welfare Advisory Council methodology

The NSW Animal Welfare Advisory Council procedure for humanely euthanasing cane toads or terminally ill frogs is stated as follows:



- Using gloves, or some other implement, place cane toad or terminally ill frog into a plastic bag.
- Cool in the refrigerator to 4°C.
- Crush cranium with a swift blow using a blunt instrument.

Note: Before killing any frog presumed to be a cane toad, ensure that it has been correctly identified and if outside the normal range for cane toads in NSW (north coast) that local DECC regional office is informed.

appendix 4

licensed wildlife carer and rescue organisations

Following is a list of wildlife rehabilitation groups licensed by Department of Environment and Climate Change (NSW):

Northern NSW

Australian Seabird Rescue
For Australian Wildlife Needing Aid (FAWNA)
Friends of the Koala
Friends of Waterways (Gunnedah)
Great Lakes Wildlife Rescue
Koala Preservation Society of NSW
Northern Rivers Wildlife Carers
Northern Tablelands Wildlife Carers
Tweed Valley Wildlife Carers
Seaworld Australia
WIRES branches in Northern NSW

Southern NSW

Looking After Our Kosciuszko Orphans (LAOKO)
Native Animal Network Association
Native Animal Rescue Group
Wildcare Queanbeyan
WIRES branches in Southern NSW

Sydney, Hunter and Illawarra

Hunter Koala Preservation Society
Ku-ring-gai Bat Colony Committee
Kangaroo Protection Co-operative
Native Animal Trust Fund
Organisation for the Rescue and Research of Cetaceans (ORRCA)
Sydney Metropolitan Wildlife Services
Wildlife Aid
Wildlife Animal Rescue and Care (Wildlife ARC)
Waterfall Springs Wildlife Park
Oceanworld
Wildlife Care Centre, John Moroney Correctional Centre
Koalas in Care
WIRES branches around Sydney, Hunter and Illawarra

Western NSW

Rescue and Rehabilitation of Australian Native Animals (RRANA)
RSPCA Australian Capital Territory Inc.
Wildlife Carers Network (Central West)
WIRES branches in Western NSW
Cudgegong Wildlife Carers

[4] Note: some of these organisations may not care for frogs.

appendix 5 — sick or dead frog collection form

Sender details:

name: address: postcode:

phone: (w) (h) fax: email:

Collector details: (where different to sender)

name: address: postcode:

phone: (w) (h) fax: email:

Specimen details:

record no: no. of specimens: species name: date collected:
day/month/year

time collected: sex: status at time of collection: date sent:
male/female healthy(H)/ sick(S)/ dead(D) day/month/year

location: map grid reference:
(easting) (northing)

reason for collection:

Batch details for multiple species collection:

species	no.	locality	(AMG)	date	sex	status (H/S/D)

habitat type: vegetation type: micro habitat:
eg creek, swamp, forest eg rainforest, sedgeland eg creek bank, under log, amongst emergent vegetation, on ground in the open

unusual behaviour of sick frogs:
eg lethargic, convulsions, sitting in the open during the day, showing little or no movement when touched.

dead frogs appearance:
eg thin, reddening of skin on belly and/or toes, red spots, sore, lumps or discolouration on skin

deformed frogs: dead/sick tadpoles:
eg limb(s) missing, abnormal shape or length eg numbers/behaviour

unusual appearance of egg masses: recent use of agricultural chemicals in area:
eg grey or white eggs eg pesticides, herbicides, fertilisers

other potential causes of sickness/mortality/comments/additional information:

NSW
NATIONAL
PARKS AND
WILDLIFE
SERVICE

General inquiries: PO Box A290 South Sydney 1232
Phone: 9995 5000 or 1300 361967
Fax: 02 9995 5999 **Web site:** www.environment.nsw.gov.au

Department of **Environment & Climate Change** NSW

Appendix E

Pathogen Management Protocol

TABLE 7.1: BEST PRACTICE HYGIENE PROTOCOLS TO PREVENT THE INTRODUCTION OR SPREAD OF PATHOGENS ON RTA PROJECT SITES AND DURING MAINTENANCE WORKS.

Best Practice Hygiene Protocols	Phytophthora (*Phytophthora cinnamomi*)	Chytrid (*Batrachochytrium dendrobatidis*)
Test for presence if determined in REF or environmental assessment	• Soil test by a **NATA approved laboratory.**	• Water test by a **NATA approved laboratory**.
Work programs	• Minimise work during excessively wet or muddy conditions. • Programming of works should always move from uninfected areas to infected areas.	• Minimise work during excessively wet or muddy conditions. • Programming of works should always move from uninfected areas to infected areas.
Restrict access	• Set up exclusion zones with fencing and signage to restrict access into contaminated areas.	• Set up exclusion zones with fencing and signage to restrict access into contaminated areas.
Inductions	• All personnel (including visitors) to be inducted on Phytophthora management measures for the site.	• All personnel (including visitors) to be inducted on chytrid management measures for the site.
Vehicles and machinery	• Provide vehicle wash down facility. • Restrict vehicles to designated tracks, trails and parking areas. • Provide parking and turn-around points on hard, well-drained surfaces.	• Provide vehicle wash down facility. • Restrict vehicles to designated tracks, trails and parking areas. • Provide parking and turn-around points on hard, well-drained surfaces.
Personnel and equipment	• Provide boot wash down facility. • Restrict personnel to designated tracks and trails.	• Provide boot wash down facility. • Disinfect with cleaning products containing benzalkonium chloride or 70 per cent methylated spirits in 30 per cent water. • Disinfect hands or change gloves between the handling of individual frogs and between each site. • Only handle frogs when necessary. Use the 'one bag-one frog' approach.
New material	• Use a certified supply of plants and soil that is disease-free.	• n/a
Disposing of material	• Retain all potentially affected materials within the contaminated area. • Ensure stockpiles of mulch, topsoil and fill material are separated to avoid potential contamination and spread.	• To avoid cross contamination, generally avoid transferring water between two or more separate waterbodies.
Further information	• National best practice guidelines for management of Phytophthora for biodiversity conservation in Australia (O'Gara et al. 2005).	• Hygiene protocol for the control of disease in frogs, Information Circular Number 6 (Wellington and Haering 2008).

Best Practice Hygiene Protocols	Fusarium wilt (eg Panama disease)	Myrtle rust (*Uredo rangelli*)
Test for presence if determined in REF or environmental assessment	• Contact **DPI** before carrying out the works in former banana sites to see if and where Fusarium wilt is present.	• Before carrying out works in bushland, consult: (a) The DPI Myrtle Rust Management Zone map (www.dpi.nsw.gov.au/biosecurity/plant/myrtle-rust/zones) to determine reporting required and whether you are working in a high risk area, and (b) Local offices of **OEH/NPWS** for additional rust records and risk assessments. • Photograph potentially infected plants and send to: biosecurity@industry.nsw.gov.au for confirmation.
Work programs	• No earth work should occur during heavy rainfall or after extended rainfall. • Programming of works should always move from uninfected areas to infected areas.	• Programming of works should always move from uninfected areas to infected areas.
Restrict access	• Set up exclusion zones with fencing and signage to restrict access into contaminated areas.	• Set up exclusion zones with fencing and signage to restrict access into contaminated areas.
Inductions	• All personnel (including visitors) to be inducted on Fusarium wilt management measures for the site.	• All personnel (including visitors) to be inducted on Myrtle rust management measures for the site.
Vehicles and machinery	• Provide vehicle wash down facility. • All vehicles to be washed with Truckwash® and then disinfected with Castrol Farmcleanse® (or equivalent). • For medium-long term projects, install a concrete wash down bay which will capture the water in a trench or bunded area. Water used for wash downs must not be used for dust control.	• Provide vehicle wash down facility. • All vehicles and machinery to be washed with Truckwash® (or equivalent). • Restrict vehicles to designated tracks, trails and parking areas. • For medium-long term projects, install a concrete wash down bay which will capture the water in a trench or bunded area. Water used for wash downs must not be used for dust control.
Personnel and equipment	• Provide boot wash down facility. • Remove mud/dirt from footwear and equipment and disinfect with Castrol Farmcleanse® (or equivalent).	• Personnel working in an infected site should shower and launder clothes (especially hats) before moving to another bushland site. • Provide boot wash down facility. • Footwear and equipment to be cleaned of soil/mud then sprayed with 70 per cent methylated spirits in 30 per cent water.
New material	• Ensure that new soil being brought onto the site is disease-free.	• Use a certified supply of plants and soil that is disease-free (the Australian Nursery Industry *Myrtle Rust Management Plan* (McDonald 2011) provides best practice Myrtle rust management that is to be expected from suppliers).
Disposing of material	• Run-off water must not be used for dust control or irrigation and it is not to be released. • Topsoil from potentially infected plantations must only be stockpiled and used within contaminated areas of the plantation.	• Plant material should be buried on site if possible. • Do not dispose of waste at another bushland site. • Buried material sites must be mapped to prevent re-exposure, especially if located near utility easements. • If material cannot be buried advice should be sought from **DPI.**
Further information	• Fusarium wilt management procedures should be included in the Construction Environmental Management Plan (CEMP) or associated plans.	• DPI handout prepared for Myrtle rust response 2010–11: *Preventing spread of Myrtle Rust in bushland.* Information on managing Myrtle rust can be obtained from: www.dpi.nsw.gov.au/biosecurity/plant/myrtle-rust • The OEH Interim management plan for Myrtle rust in bushland (2011).

Appendix F

Clean Down Declaration Certificate

Appendix L

Koala Management Plan

Koala Management Plan

Warrell Creek to Nambucca Heads Upgrade of the Pacific Highway

quality solutions **sustainable** future

Koala Management Plan

Warrell Creek to Nambucca Heads Upgrade of the Pacific Highway

Prepared for: Acciona and Ferrovial Joint Venture and
Roads and Maritime Services

GeoLINK
environmental management and design

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UPR	Description	Date Issued	Issued By
2378-1005	V1	01/08/2014	DGH
2378-1008	V2	08/08/2014	DGH
2378-1041	V3	03/10/2014	DGH
2378-1048	V4	15/10/2014	DGH
2378-1056	V5	30/10/2014	DGH
2378-1061	V6	31/10/2014	DGH
2378-1068	V7	4/11/2014	DGH
	V8	07/11/2014	NR
2378-1081	V9	08/12/2014	DGH
2378-1264	V10	06/09/2016	DGH
2378-1400	V11 DRAFT	14/11/2017	DGH
2378-1402	V11	15/11/2017	DGH

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1

Introduction

1.1 Project Overview and Background to the Plan

The Pacific Highway Upgrade Program is a joint commitment by the Australian and New South Wales (NSW) governments to improve the standard and safety of the Pacific Highway between Hexham and the Queensland border.

The Warrell Creek to Urunga (WC2U) Project forms part of the Pacific Highway Upgrade Program and comprises approximately 42 kilometres of dual carriageway road that will bypass the towns of Warrell Creek, Macksville, Nambucca Heads and Urunga on the Mid North Coast of NSW. The Project has been divided into two stages with Stage 1 consisting of the approximate 22.5 kilometre stretch from Nambucca Heads to Urunga (NH2U) and Stage 2 consisting of the remaining approximate 19.5 kilometres of dual carriageway between Warrell Creek and Nambucca Heads (WC2NH). This Koala Management Plan relates to Stage 2 (WC2NH) which is referred to throughout this report as ‘the Project’ (refer to **Illustration 1.1**).

The NSW Minister for Planning approved the WC2U Pacific Highway Upgrade Project under Part 3A (now repealed) of the *Environmental Planning and Assessment Act 1979* (EP&A Act) on 19 July 2011, subject to the Minister’s Conditions of Approval (CoA) being met. In accordance with transitional provisions included in Schedule 6A of the EP&A Act, the Project is characterised as a transitional Part 3A Project. It is noted that despite its repeal, Part 3A of the EP&A Act continues to apply in respect of transitional Part 3A projects. Under section 75C of the EP&A Act, the Minister for Planning declared, by Order dated 5 December 2006 and published in the NSW Government Gazette No. 175, that development for the purposes of upgrading segments of the Pacific Highway is a Project to which Part 3A of the EP&A Act applies (the declared Project). The Minister also declared by Order dated 8 December 2006 published in Gazette No. 175 that the same development is a critical infrastructure project under section 75C of the EP&A Act. This was subsequently modified through a further Ministerial Order gazetted on 3 December 2010 (Gazette No. 133).

Koalas (*Phascolarctos cinereus*) were assessed in the WC2U Environmental Assessment (EA) (Sinclair Knight Merz – SKM 2010a, SKM 2010b), in regard to relevant State legislation. At that time, the Koala was listed as a ‘Vulnerable’ species under the NSW Government *Threatened Species Conservation Act 1995* (TSC Act), however was not listed under Federal legislation. Since completion of the WC2U EA (SKM 2010a, SKM 2010b) and NSW State Government Project approval, Koala populations in Queensland (QLD), NSW and the Australian Capital Territory (ACT) were listed as ‘Vulnerable’ under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

An assessment of the impacts of the WC2NH Pacific Highway Upgrade on the Koala, in accordance with the *EPBC Act Policy Statement 1.1 Significant Impact Guidelines* (Department of Environment and Heritage – DoE 2013a) and *Interim Koala referral advice for proponents* (Department of Sustainability, Environment, Water, Population and Communities – DSEWPaC 2012) was prepared by GeoLINK (2013). This assessment found that the Project has the potential to cause negative (incremental and cumulative) impacts to the Koalas/ breeding aggregation/s whose home range encompass the Nambucca State Forest/ Old Coast Road area, mainly through habitat removal and fragmentation. The majority of Koalas and habitat that supports the subject important Koala population would not be affected by the Project. The Project, with effective implementation of the proposed mitigation measures, was found to be unlikely to result in a significant impact to the subject important local Koala population. Notwithstanding, as the Project adversely affects habitat that satisfies the DSEWPaC (2012) definition of ‘*habitat critical to the survival of the species*’ (including direct removal of approximately 86.5 hectares of vegetation that satisfies this criteria); the Project was considered to constitute a significant impact on the Koala as per the DSEWPaC (2012) and DoE (2013a) guidelines.

In accordance with sections 18 and 18A of the EPBC Act, the Koala is a matter of national environmental significance (MNES) and Roads and Maritime Services (Roads and Maritime) has prepared a referral seeking approval from the Australian Government for the Project. The referral was lodged with the Department of the Environment (DoE) on 20 December 2013. For further information refer to http://www.environment.gov.au/cgi-bin/epbc/epbc_ap.pl?name=current_referral_detail&proposal_id=7101. The referral provides detail on the Project, including a detailed description, proposed construction staging, excluded activities, description of impacts and measures to avoid or manage impacts, for Commonwealth MNES, including the Koala. The DoE have reviewed the referral (number 2013/7101) on 23 January 2014 and made the decision under section 75 of the EPBC Act that that the Project is a controlled action and requires approval under the EPBC Act.

1.2 Purpose and Objectives

This Management Plan identifies the potential impacts of the WC2NH Project on the local population of Koalas. It outlines the proposed management measures to be implemented for the Koala on the Project and a program for monitoring the effectiveness of these measures. The objective of the Management Plan is to provide measures that minimise impacts to Koalas on the Project.

The Plan covers pre-construction, construction and operational phases of the Project and applies to all areas within the WC2NH Project boundary.

1.3 Order of Precedence

In the event of any inconsistency, ambiguity or discrepancy between this Management Plan and the Flora and Fauna Management Plan for the Warrell Creek to Nambucca Heads Pacific Highway Upgrade Project, the following order of precedence must apply:

a. This Koala Management Plan.

b. The Flora and Fauna Management Plan for the Warrell Creek to Nambucca Heads Pacific Highway Upgrade Project.

1.4 Management Structures and Plan Updates

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

To ensure the success of this approach the management goals presented in the Plan have been based on the following SMART principles:

- Specific
- Measurable
- Achievable
- Results-based
- Time-based.

The Koala Management Plan has been prepared in consultation with Roads and Maritime, the Environment Protection Authority (EPA) and the Commonwealth Department of the Environment (DoE). General responsibilities for environmental management would be outlined in the Project specific Construction Environment Management Plan (CEMP) and CEMP sub plans including the Flora and Fauna Management Plan (FFMP). These management plans would be prepared prior to the commencement of construction. Roads and Maritime and the D&C Contractor for this Project (Acciona and Ferrovial Joint Venture [AFJV]) would be responsible for implementing the measures in this Koala Management Plan and this would include the engagement of suitably qualified specialists to undertake and oversee the Koala surveys and monitoring activities reported in the Plan.

1.5 Plan Authors

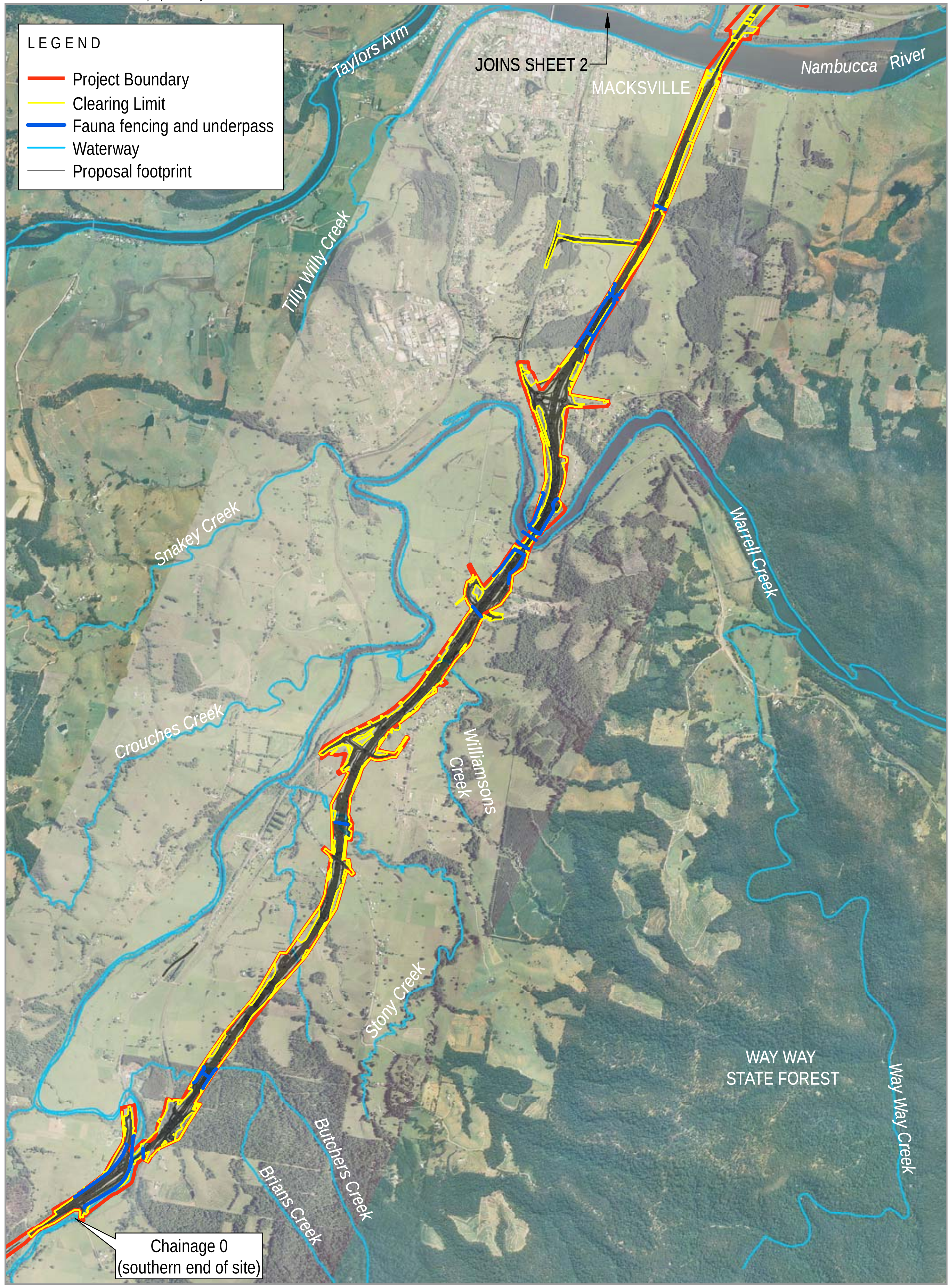
The Koala Management Plan has been prepared by the following personnel from AFJV Project Ecologist (GeoLINK):

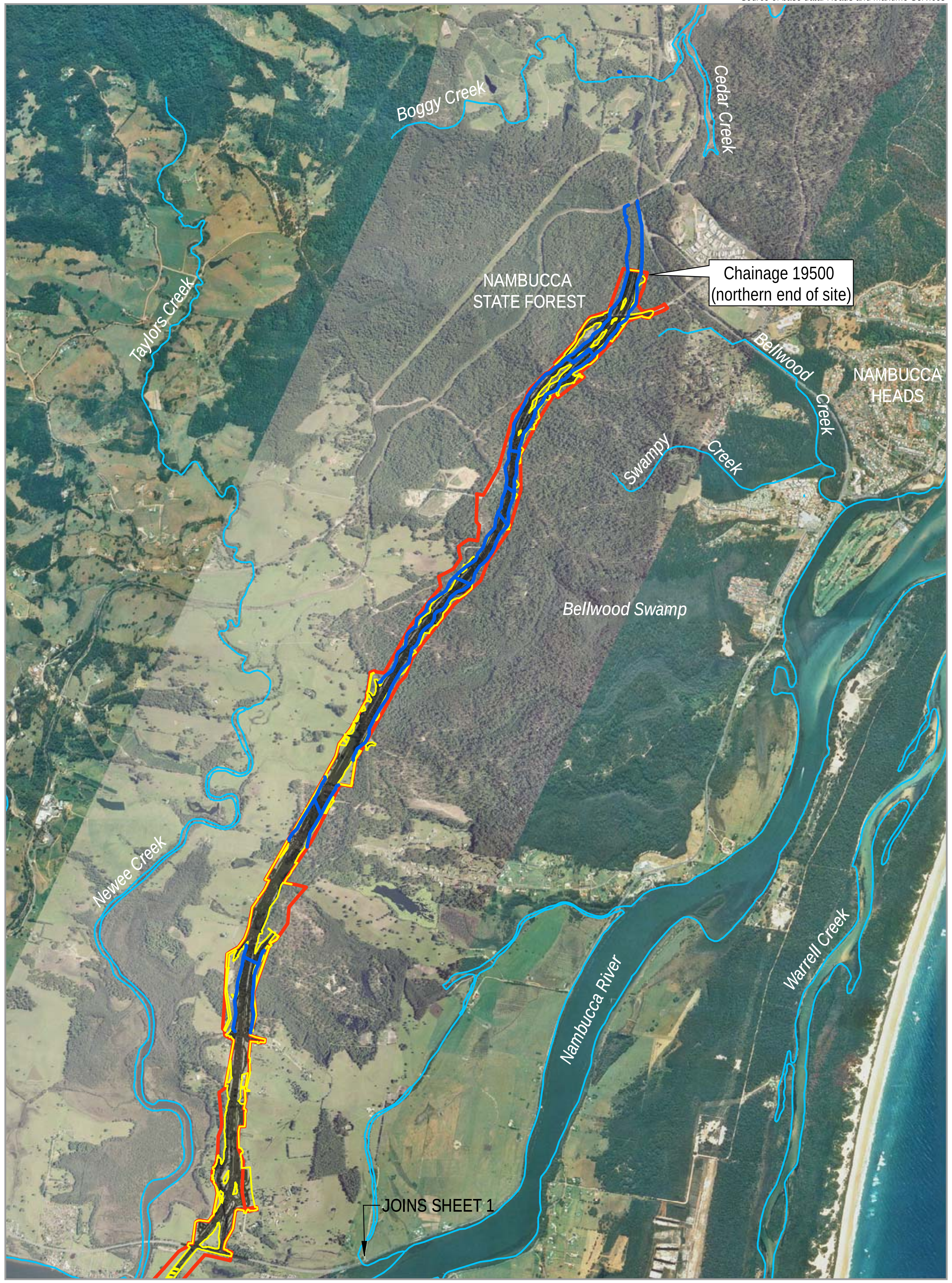
- David Havilah (Senior Ecologist).
- Veronica Silver (Senior Ecologist – Peer Review).

Qualifications and experience of the Plan authors are included in **Appendix A**.

Information shown is for illustrative purposes only

Drawn by: RE Checked by: GJM Reviewed by: JOL Date: 05/09/2016
Source of base data: Roads and Maritime Services





North

0 800

GeoLINK environmental management and design

WC2NH Pacific Highway Upgrade Project - EPBC Act Koala Impact Assessment

2378-1266

The Site

Illustration 1.1

Koala Population

2.1 Species Description

Detailed reviews of Koala biology and ecology based on recent research are provided on the Department of Environment (DoE) *Species Profile and Threats Database* (DoE 2013b) and the NSW *Recovery Plan for the Koala (Phascolarctos cinereus)* (DECC 2008). A summary of this information is provided below.

2.1.1 Habitat

Koalas inhabit a range of forest and woodland communities dominated by *Eucalyptus* species. Habitat quality depends on a range of environmental features, including vegetation species composition, soils, climate and disturbance history. The main factor influencing Koala occurrence is the presence of suitable food trees. Shelter trees also provide important habitat features, particularly in harsh climates (DoE 2013b, DECC 2013).

2.1.2 Feeding Requirements

The Koala's diet primarily comprises eucalypt leaves which are low in nutrients and energy, and high in indigestible components (e.g. lignin and cellulose) and toxic compounds (e.g. essential oils and tannins) (Cork *et al.* 1990; Cork and Sanson 1990). In a given area, the diets of individual Koalas/ sub-populations almost exclusively comprise a small number of preferred species to obtain their nutritional needs. Preferred food trees appear to be associated with the presence of formyl phloroglucinol compounds (FPCs) in the leaves (DECC 2008). Koala's also show strong preferences between individual trees of the same species at individual sites, which is believed to be associated with leaf anti-feedant chemicals (DoE 2013b). Foliage from non-preferred food trees are consumed at times to supplement their diet (DoE 2008, DECC 2008). Recognised Koala food tree species for the NSW North Coast region (which encompasses the study area) as identified within the Recovery Plan for the Koala (DECC, 2008) are listed in **Table 2.1** with species relevant to the Project Site noted. In addition to these Forest Oak (*Allocasuraina torrulosa*) and Sydney Blue Gum (*Eucalyptus salignus*) are also considered to be a very important Koala feed tree species within the NSW North Coast region (Smith, 2004 and Miller, 2013). Blackbutt is also locally considered a supplementary Koala food tree species in the region (Professor Rob Close, University of Western Sydney pers. comm. 2013).

Table 2.1 Recognised Koala Food Tree Species for the NSW North Coast Region (DECC, 2008)

Foraging Preference	*Species*	*Species Relevant to the Project Area*
Primary food tree species	Tallowwood (*Eucalyptus microcorys*)	✓
	Cabbage Gum (*E. amplifolia*)	
	Parramatta Red Gum (*E. parramattensis*)	
	Forest Red Gum (*E. tereticornis*)	✓
	Narrow-leaved Red Gum (*E. seeana*)	
	Craven Grey Box (*E. largeana*)	
	Orange Gum (*E. bancroftii*)	
	Swamp Mahogany (*E. robusta*)	✓
Secondary food tree species	Slaty Red Gum (*E. glaucina*)	
	Grey Gum (*E. biturbinata*)	

Foraging Preference	Species	Species Relevant to the Project Area
	Small-fruited Grey Gum (*E. propinqua*)	✓
	Large-fruited Grey Gum (*E. canaliculata*)	
	Red Mahogany (*E. resinifera*)	✓
	Steel Box (*E. rummeryi*)	
	Mountain Mahogany (*E. notabilis*)	
	Rudder's Box (*E. rudderi*)	
	Grey Box (*E. moluccana*)	
	White-topped box (*E. quadrangulata*)	
	Yellow box (*E. melliodora*)	
Stringybarks/supplementary species	Stringybark (*E. tindaliae*)	
	Blue-leaved Stringybark (*E. agglomerata*)	
	Thin-leaved Stringybark (*E. eugeniodes*)	
	Diehard Stringybark (*E. cameronii*)	
	White Stringybark (*E. globoidea*).	

Primary Koala food tree species are subject to a significantly higher level of usage than other *Eucalyptus* species, independent of tree density. Secondary and/or supplementary food trees are generally subject to lower levels of foraging by Koalas than that of primary food trees, except in areas where primary food trees are absent (DECC 2008).

2.1.3 Social Organisation and Reproduction

Koalas live in breeding aggregations which typically comprise a dominant male, a small number of mature females and juveniles of various ages (Phillips 1997). Home ranges vary in size depending on habitat quality and the number of available food trees, and have been recorded from 0.2 – 500 hectares (DECC 2008). Males generally have larger home ranges than females, with the home range of a dominant male overlapping extensively with the home range of females within its aggregation.

The Koala breeding season peaks between September and February, and comprises a period of heightened activity. Offspring rates typically range between 0.3 – 0.8 per year, with birth occurring during October and May (McLean 2003) following a 35 day gestation period (DECC 2008). Once born the young remain in the pouch for approximately six months, and remain dependent on their mother until about 12 months of age (Mitchell and Martin 1990). Sub-adult Koalas may remain in the mother's home range for a further two to three years, before young Koalas of both sexes disperse to establish their own home range areas (Ramsay 1999). Dispersal distances generally range from 1.0 – 11 kilometres (Mitchell and Martin 1990). Longevity in the wild is >15 years for females and >12 years for males (Martin and Handasyde 1999 cited in DoE 2013b).

2.2 Known Distribution

The Koala's distribution extends from north-eastern Queensland to the south-east corner of South Australia, covering coastal and inland areas (ANZECC 1998 cited in DoE 2013b, DECC 2013).

2.2.1 Database Records

The OEH Atlas of NSW Wildlife (OEH 2013) database shows 100 Koala records within 10 kilometres of the Proposal site. The main clusters of records are located in:

- Valla/ Little Newry State Forest/ Newry State Forest area approximately 3.5 kilometres to the north of Nambucca Heads (41 records).
- Ingalba State Forest area approximately two kilometres to the south-west of Warrell Creek (12 records).
- Way Way State Forest area approximately four kilometres to the south-east of Warrell Creek (10 records).

A small cluster of records (six records) occurs within Nambucca State Forest at the northern end of the Project. The remaining records are scattered at low densities throughout the locality, including around Warrell Creek, Scotts Head to Stuarts Point, Tamban State Forest and the Viewmont State Forest area.

Eight Koala records occur within two kilometres of the site as follows:

- Two Koala records within Nambucca State Forest (1998) between 150 and 350 metres to the east of the Project corridor.
- Four Koala records within Nambucca State Forest (2000, 2005, 2011, 2012) between one and two kilometres to the north-west of the Project corridor.
- One Koala record within Macksville (1974) approximately 800 metres to the west of the Project corridor.
- One Koala record next to Warrell Creek in the Bald Hill Road area (1984), approximately 700 metres to the east of the Project corridor.

No Koala database records occur within the Project boundary.

2.3 Habitat within the Project Footprint

The EPBC Koala Impact Assessment (GeoLINK 2013) included a detailed study of Koala usage of the Project study area and surrounds employing the Koala Spot Assessment Technique (SAT) and assessments of Koala habitat. The interim guidelines Koala referral advice for proponents (DSEWPaC, 2012) was used to assess the impacts of the Project on the local population of Koalas (GeoLINK, 2013). These guidelines have since been superseded by the Draft EPBC Act referral guidelines for the vulnerable Koala (DoE, 2013). The findings of this report are summarised in the Sections below in order to describe Koala habitat associated with the site.

2.3.1 Overview of the Koala Impact Assessment

The Project footprint is defined as:

- Concept design with 15 metre buffer.
- Operational water quality basins with 10 metre buffer.
- Adjustments to access roads within Nambucca State Forest with 10 metre buffer.
- Utility adjustments with clearing requirements of utility authorities.
- Three metre clearing width for boundary fencing – excluding within Nambucca State Forest and swamp forest where a flying fox camp is located.
- A 10 per cent contingency which includes provision for clearing for construction phase water quality basins, accesses to ancillary facilities, stockpile sites and design refinements.

The Project footprint supports approximately 106.6 hectares of potential Koala habitats (with primary and secondary Koala food tree species). The majority of habitat (81.8 hectares) is located north of the Nambucca River in the Nambucca State Forest/ Old Coast Road area, forming the main stand of intact habitat within the study area. Three (7.9 per cent) of the 38 SATs in this area were subject to medium (normal) Koala usage for a low density Koala population, indicating that part of the range of resident Koala/s or breeding aggregation/s overlaps the study area. Koala records from the field surveys associated with the WC2U Project Environmental Assessment (SKM 2010b) and the Atlas of NSW Wildlife (OEH 2013) support these findings. GeoLINK (2014a) considered that there is insufficient data available to provide an accurate Koala population estimate.

Considering the low levels of Koala usage detected the number of individual Koalas whose home range encompass the study area is likely to be small.

Potential Koala habitat within the remainder of the study area south of the Nambucca River comprises smaller fragmented patches of vegetation within a mostly cleared rural landscape (totalling 24.8 hectares within the Proposal footprint). This vegetation comprises mostly mature regrowth following historic clearing. These factors reduce the potential of this landscape to support a resident Koala population, particularly as a population on erosion/ residual soils would be expected to comprise a low density population as observed north of the Nambucca River, with large home range requirements (Biolink 2009, 2013). No evidence of Koala activity was recorded in this area during this survey and local records are scattered at very low densities. Overall the results of this SAT assessment, the Project EA surveys and the reviewed desktop information suggest that the study area south of the Nambucca River does not currently support a resident Koala population. Due to the Koala's high mobility, it is possible that Koalas may move east-west across this portion of the study area, though such movements are likely to be rare due to:

- The local landscape being predominantly cleared.
- The survey results, Project EA surveys and the reviewed desktop information which suggests an absence of a local Koala population within the study area south of the Nambucca River.
- The low density of Koala records and dominant soils landscapes (erosional/ residual) within the broader locality to the east and west, and potential populations within this area are likely to be low density populations.
- Largely contiguous habitat occurring south of the study area and offering better quality east-west habitat connectivity on a local and regional scale.

2.3.2 Important Population

In DSEWPaC (2012), a Koala population is '*defined by the capacity of individuals to move from one habitat patch to another*'. The resident Koalas/ breeding aggregation/s whose home ranges encompass the study area around Nambucca Heads State Forest/ Old Coast Road, are likely to form part of a local sub-population that is interconnected with sub-populations centred around Newry State Forest to the north and possibly Viewmont State Forest to the west. Key topographic features bounding this sub-population include the Pacific Ocean to the east, Nambucca River to the south and Deep Creek to the north. This sub-population forms part of the broader Nambucca Valley Koala population, which is bound by the Nambucca River to the south, Bellinger and Kalang Rivers to the north and Pacific Ocean to the east.

DoE (2013a) defines an 'important population' as a '*…population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are:*

- *Key source populations either for breeding or dispersal.*
- *Populations that are necessary for maintaining genetic diversity.*
- *Populations that are near the limit of the species' range.*

The study area is located in north-east NSW which is considered a stronghold for the species in the State (DoE 2013b). While the national Koala recovery plan is yet to be complete, the subject Nambucca Valley Koala population is considered an 'important population' as it provides a local source population for breeding or dispersal, and protection of this population helps maintain genetic diversity in the region.

The subject Nambucca Valley Koala population is situated between the Coffs Harbour and Port Macquarie populations which are regarded as important Koala population centres (DECC 2008). The eastern portions of this population are somewhat separated from the Coffs Harbour population due to the Bellinger River and Kalang River in the north and the Kempsey population by the Nambucca River to the south. The western portion of the subject population is however likely to support north-south Koala movements and contribute to the maintenance of genetic diversity between the abovementioned identified important Koala population centres.

2.3.3 Habitat Critical to the Survival of the Koala

DSEWPaC (2012) identifies habitat critical to the survival of the Koala as areas of '*forest or woodland where:*

- *Primary Koala food tree species comprise at least 30 per cent of the overstorey trees,*
- *Primary Koala food tree species comprise less than 30 per cent of the overstorey trees, but together with secondary food tree species comprise at least 50 per cent of the overstorey trees,*
- *Primary food tree species are absent but secondary food tree species alone comprise at least 50 per cent of the overstorey trees,*
- *The above qualities may be absent in a forest or woodland but other essential habitat features are present and adjacent to areas exhibiting the above qualities (e.g. Koalas in the Pilliga are known to escape the heat of the day by taking refuge in white cypress pines, which are not food trees), or*
- *A relatively high density of Koalas is supported, regardless of the presence of food tree species. Koala population densities vary across their range and regional data should be used to judge relative density.*

Habitat critical to the survival of the Koala is also considered to be any form of landscape corridor which is essential to the dispersal of Koalas between forest or woodland habitats'.

The criteria and how they relate to the study area are discussed below.

2.3.3.1 Proportion of Primary Koala food Trees

Localised areas estimated at 19 per cent of the forest habitats within the study area support proportions of Koala food trees within the overstorey that satisfy the criteria of habitat critical to the survival of the Koala (primary Koala feed trees > 30 per cent). They occur in a mosaic across the landscape and were found within three vegetation communities:

- Map Unit 1: Open Forest – Blackbutt: estimated at 29 per cent of this community.
- Map Unit 3: Moist Forest – White Mahogany/ Grey Gum/ Ironbark: estimated at 10 per cent of this community.
- Map Unit 6: Swamp Forest – Swamp Mahogany/ Paperbark: estimated at 14 per cent of this community.

2.3.3.2 Koala Usage

DECC (2008) states that Koala populations on the NSW North Coast are typically of medium density. As discussed previously, the assessment results indicate study area north of the Nambucca River is likely to support a low density Koala population. Therefore the DSEWPaC (2012) critical Koala habitat criterion of '*a relatively high density of Koalas is supported*' is not satisfied.

2.3.3.3 Habitat Connectivity

In relation to the DSEWPaC (2012) critical Koala habitat criterion '*Habitat critical to the survival of the Koala is also considered to be any form of landscape corridor which is essential to the dispersal of Koalas between forest or woodland habitats*'; the study area north of the Nambucca River meets this criteria. As discussed previously it forms part of a north-south regional corridor (Scotts 2003), bounded by the Nambucca River to the south and east (forming a habitat 'cul-de-sac' or edge). While it does not provide a link between Koala populations, it meets this criterion by being important for:

- The movement of Koalas that occupy this habitat as part of their home range.
- The dispersal of Koalas from this area to other habitats (e.g. to the north and west).
- The dispersal of Koalas from other habitats to this habitat.

Koala records south of the Nambucca River are sparse and connectivity between the main stands of forest in the locality to the west (Ingalba State Forest area) and east (Yarriabini National Park/ Way Way State Forest area) is provided by largely contiguous forest south of the study area. This and the assessment results of the population survey (refer to **Section 2.3.2**) suggest that the study area south of the Nambucca River does not satisfy the SEWPaC (2012) critical Koala habitat criterion in relation to connectivity/ corridor values.

2.3.3.4 Summary

In total approximately 86.5 hectares of habitat within the Proposal footprint comprises habitat critical to the survival of the Koala as per the DSEWPaC (2012) definition. Of this, 81.8 hectares occurs north of the Nambucca River (based on species composition and habitat connectivity values) and 4.7 hectares of which occurs south of the Nambucca River (based on species composition).

3

Key Threats and Potential Impacts of the Project

3.1 Key Threats to the Species

The main recognised threats to the Koala include habitat loss, fragmentation and degradation; mortality from vehicle strikes; disease; and predation by dogs (DoE 2013b). Other threats include fire, severe weather conditions, swimming pools and over browsing (DECC 2008). These threats are consistent with the assessment of the overall biodiversity impacts of the Proposal (SKM 2010a) which concluded that the main threats relevant to the Proposal include:

- Habitat loss, fragmentation and degradation.
- Mortality from vehicle strike.
- Disease.
- Fire.

Further details on these threats as they relate to the Project are provided in the following Sections.

3.2 Potential Impacts from the Project

3.2.1 Habitat Loss, Fragmentation and Degradation

The Project requires the direct removal of approximately 106.6 hectares of potential Koala habitat. Clearing areas are based on the SKM (2010b) GIS vegetation layer as derived from the vegetation surveys completed for the WC2U EA and are defined in **Section 2.3.1**:

Approximately 86.5 hectares of this vegetation comprises habitat critical to the survival of the Koala as per the DSEWPaC (2012) definition (refer to **Section 2.3.3**). This vegetation clearing represents a negative cumulative impact of habitat removal for the Koala and comprises a listed Key Threatening Process (KTP) responsible for the decline of the Koala.

Approximately 81.8 hectares of the potential Koala habitat requiring removal is located north of the Nambucca River and associated with Nambucca State Forest/ Old Coast Road area. Habitat removal in this area will:

- Result in fragmentation of this large stand of vegetation associated with Nambucca State Forest.
- Create new forest edges and increase edge effects in adjacent habitats (refer to SKM 2010b for details).
- Directly remove and fragment habitat subject to a low level of Koala usage as part of the range of resident individual Koala's/ breeding aggregates of the local low density Koala sub-population.

Approximately 24.8 hectares of the potential Koala habitat requiring removal is located south of the Nambucca River. This will include localised habitat fragmentation of some stands of forest, though the fragmentation will be less substantial than to the north of the Nambucca River due to the existing highly modified state of this landscape.

It is difficult to quantify the impacts of this habitat removal/ fragmentation/ degradation to the local Koala sub-population, especially due to the apparently low density of the local population and low levels of Koala activity detected within the study area. Some individuals whose home range encompasses the site will be affected by direct habitat loss and fragmentation, while other local resident Koalas based in adjacent habitats may be indirectly affected, through changes in Koala usage (e.g. home range configurations), adding increased pressure to the local Koala sub-population.

The number of individual Koalas and proportion of the total local important Koala population potentially affected by the Proposal is likely to be low, given:

- The presence of a low density Koala population and low levels of Koala activity recorded within the study area as part of Koala surveys undertaken for the impact assessment (GeoLINK, 2013) and the results of desktop studies.
- That the broader area surrounding the Project that is occupied by the identified local important Koala population is extensive.

The impacts of habitat fragmentation on wildlife are detailed in SKM (2010b). The main impacts relevant to the Koala include impacts on movement corridors, access to habitat to satisfy biological requirements, genetic exchange, increasing edge effects, and reduced ability for population recovery following stochastic events. While parts of the local landscape have already been fragmented from past clearing and development, the Proposal would contribute to this cumulative fragmentation through habitat clearing and construction of a major highway, approximately 16.5 kilometres of which deviates from the existing highway alignment. To counter these impacts the Proposal design includes a number of fauna underpasses with fauna fencing. The fauna underpass designs proposed have been recorded as being used by Koalas on other projects (SKM 2010b, 2010c). Therefore, while the Proposal without appropriate mitigation could lead to habitat fragmentation and reduced connectivity, opportunities for Koalas to move between habitats on opposing sides of the highway post construction would be available.

During the construction stage of the Proposal, there is a risk of Koala mortality/ injury during clearing works. Mitigation measures associated with the Proposal however aim to reduce the risk of such impacts, including Koala management protocols and procedures for fauna handling and rescue.

3.2.2 Road Kill

Vehicle strikes to the Koala have been well documented (DECC 2008) and pose a particular threat to low density Koala populations due to the large movements undertaken to satisfy their biological requirements (e.g. foraging, reproduction, dispersal, etc) and the low Koala numbers typically associated with such populations (Biolink 2009). Approximately 16.5 kilometres of the 19.5 kilometres WC2NH Pacific Highway upgrade will deviate from the existing Pacific Highway alignment.

The overall risk of vehicle strikes to Koala's locally is unlikely to significantly increase as:

- Extensive fauna fencing is proposed along the highway where it adjoins forest north of Nambucca River and at several locations south of the Nambucca River where the highway intersects vegetation (refer to **Appendix E**). In total approximately 12.1 kilometres of the new highway would support fauna exclusion fencing, approximately 6.7 kilometres of which is located north of the Nambucca River and 5.4 kilometres of which is located south of the Nambucca River.
- Fauna underpasses would be established to allow for safe passage across the highway.
- The study area north of the Nambucca River appears to be subject to a low level of Koala activity.
- South of the Nambucca River:
  - The study area is highly fragmented and does not appear to support a resident Koala population.
  - The potential frequency of east-west Koala movements is likely to be very low and better quality habitat connectivity occurs to the south of the study area.
  - The new highway alignment runs roughly parallel to the existing highway, therefore any Koalas potentially moving through the area are vulnerable to an existing road collision threat.

The use of fauna fencing and associated underpasses has been proven as effective measures to reduce road kill on other highway upgrade projects.

3.2.3 Disease

Disease is a recognised threat to the Koala (DECC 2008; DoE 2013b). The habitat removal/ fragmentation associated with the Proposal has potential to cause environmental pressure and therefore increase the occurrence or severity of disease in the local Koala population. The number of individual Koalas and proportion of the total local Koala population potentially susceptible to environmental stresses as a result of the Proposal is likely to be low.

3.2.4 Fire

The threat of fire to Koalas is documented in DECC (2008). The main area potentially susceptible to changes in fire patterns or where fauna fencing poses a risk of Koala entrapment during fire events is the Nambucca State Forest/ Old Coast Road area. The remainder of habitat in the study area is fragmented and comprises relatively small patches of vegetation. It is hard to quantify the potential changes in fire frequency or intensity as a result of the Proposal. For example, the increased human presences may increase the risk of fires starting (accidental or arson), though the fragmentation imposed by the highway may reduce the risk of stochastic events from wildfire. It is acknowledged however that there is potential for the Proposal to change the dynamics of the fire and Koalas response in the Nambucca State Forest/ Old Coast Road area.

Pre-construction Management Measures

4.1 Overview of Activities

Pre-construction activities would involve the following works:

- Survey works.
- Water quality monitoring.
- Translocation of threatened plants.
- Geotechnical investigations.
- Completion of utility relocations.
- Construction of sites accesses.

4.2 Timing

Pre-construction works are to be undertaken up until the commencement of construction stage works which are anticipated to commence in December 2014.

4.3 Summary of Potential Impacts

Pre-construction activities may have the following potential impacts to Koalas:

- Potential mortality to Koalas from pre-construction activities.
- Potential road strike and mortality of Koalas from pre-construction/ local traffic.

4.4 Main Goals for Management

The main goals for management are as follows:

- No habitat loss for the Koala from pre-construction activities.
- No injury/ mortality to Koalas from pre-construction activities.
- Minimise road strike of Koala during pre-construction activities.
- Ensure that appropriate habitat offsets have been identified for Koala conservation.

4.5 Mitigation Measures

4.5.1 Detailed Design Considerations

As detailed design progresses, a number of factors will be addressed to minimise the impacts on the Koala. These include:

- Avoiding and minimising vegetation removal where feasible and reasonable.
- Placement of ancillary facilities outside of Koala habitat.
- Maximising the suitability of fauna crossing structures and fauna exclusion fencing to reduce road kills and enhance habitat connectivity (refer to **Section 6** for further information).

4.5.2 Identifying Habitat Restoration/Connectivity Areas

It is proposed to enhance connectivity in the landscape wherever possible through the provision of strategic tree planting in road reserves and residual land acquired for the Project. A number of areas have been identified by the Project team (Roads and Maritime, Jacobs, AFJV and GeoLINK) and described within preliminary documentation submitted to DoE 9 September 2014 (refer to **Appendix B**). Of the areas identified, 12 of these sites are identified as areas with potential to be used by Koalas. These areas would be rehabilitated during the construction stage of the Project (refer to **Section 5.4.6**).

4.5.3 Controls on Habitat Clearing (Pre-construction)

During the pre-construction stage of the Project (prior to approval of the CEMP) only clearing defined as 'minor' (except where threatened species, populations or endangered ecological communities would be impacted) can be undertaken, unless approval is sought from the Director-General (refer to Approval Instrument Definitions for construction). Prior to any clearing taking place, a suitably qualified Project Ecologist will undertake an inspection of vegetation to be cleared to determine that only 'minor clearing' is to be undertaken. Minor clearing will be defined as the following:

- Vegetation that does not include mature trees >150 mm DBH.
- Vegetation that does not comprise known threatened fauna habitat. In the case of the Koala, this is defined as mature Koala feed trees or areas mapped as Koala habitat during pre-clearance ground-truthing surveys.
- Areas of vegetation that have ecological constraints (e.g. threatened flora habitat/ areas of EEC).

All areas to be cleared are to be delineated with flagging tape to clearly mark the clearing extents.

4.5.4 Pre-clearing Surveys

For any area of vegetation to be cleared during the pre-construction stage of the Project, a suitably qualified ecologist will undertake a search for native fauna (including Koalas) in the vicinity of clearing immediately prior to clearing commencing. In the event that a Koala is identified within 50 metres of a works area, works will be rescheduled to be initiated during the construction stage of the Project (refer to **Table 4.1**). Searches will take place no earlier than 48 hours prior to the removal of vegetation occurring in that area to ensure that the area is free of the Koala.

4.5.5 Environmental Work Method Statements

Environmental Work Method Statements (EWMS) will be prepared for all pre-construction tasks potentially impacting environmental sensitive areas. The EWMS will provide an opportunity to assess any risks to fauna (including Koalas) for the pre-construction activities and to incorporate mitigation measures into work methodologies where necessary to minimise the potential for impacts. Where an EWMS identifies risks to fauna, the Project Ecologist will be consulted to provide input where necessary.

4.5.6 Inductions

An environmental induction will be prepared and delivered to personnel involved with the pre-construction activities. Relevant points to be delivered in this induction in relation to Koala management are as follows:

- Potential presence on site (identification and potential habitat).
- Requirements for all personnel to report sightings (including road kill) immediately to the Environmental team (including the Project Ecologist).
- Requirements for works to cease within 50 metres of any live Koala detected on/near the site until authorisation has been given for works to commence from the Environmental Manager and other aspects of the Koala Management Protocol (refer to **Table 4.1**).

4.5.7 Koala Management Protocol

For all Koalas detected on/near the site the following protocol as shown in **Table 4.1** is to be implemented with compliance documented. As mentioned, for the pre-construction works, in the event that a Koala is identified within 50 metres of a works area, works will be rescheduled until the construction stage of the Project.

Table 4.1 Management Protocol for Koalas Observed on the Site

Action		*Personnel Responsible*	*Reporting*
1	Report sightings of any Koalas (including road kill) immediately to the Environmental team.	All personnel working on site	The Environmental Manager shall be advised of any Koala records immediately.
2	In the case that Koala road kill is detected, an assessment of future road kill risk for Koalas will be undertaken by a suitably qualified Project Ecologist who will aim to provide actions to mitigate the risk of future Koala road kill in this area. Additional measures to be considered will include (but not be limited to): ▪ Provision of Koala signage. ▪ Temporary fauna fence. ▪ Further escape points.	AFJV/ Roads and Maritime Services/ suitably qualified Project Ecologist	The Environmental Manager shall notify the Roads and Maritime Representative who will inform the EPA Project Officer. Adaptive management recommendations will be provided by a suitably qualified Project Ecologist to the AFJV/ Roads and Maritime for consideration.
3	Where a live Koala is detected on/near the site, no works are to be undertaken within 50 metres of the individual until the animal has relocated from the area and authorisation has been given by a suitably qualified Project Ecologist. Prior to the construction stage where a Koala is detected in the vicinity (within 50 metres) of pre-construction works, such works would be rescheduled to be initiated during the construction stage of the Project.	AFJV/ suitably qualified Project Ecologist	Actions of foreman to be reported to Environmental Manager.
4	A suitably qualified Project Ecologist will inspect the Koala and assess the health of the individual. If the animal is injured/ diseased it will be taken for treatment. Implementation of the FFMP Fauna Handling and Rescue Procedure (refer to FFMP Appendix I).	AFJV/ suitably qualified Project Ecologist	A suitably qualified Project Ecologist to contact Port Macquarie Koala Hospital/ WIRES if animal shows signs of injury/ disease.
5	A suitably qualified Project Ecologist is to assess if self-relocation or capture/ relocation is required based on a risk assessment of the animals welfare. The animal will either be allowed to self-relocate from the site or an ecologist with experience and approval to handle fauna will be engaged to capture/ relocate the animal in accordance with the Koala Capture Relocation Strategy included in **Appendix C**.	AFJV/ suitably qualified Project Ecologist	EPA/ Roads and Maritime to be consulted if capture/ relocation required.

Action		Personnel Responsible	Reporting
6	No works will proceed within 50 metres of the individual until authorisation has been provided by the AFJV (Environmental Manager) and a suitably qualified Project Ecologist. Prior to the construction stage where a Koala is detected in the vicinity (within 50 metres) of pre-construction works, such works would be rescheduled to be initiated during the construction stage of the Project.	AFJV/ suitably qualified Project Ecologist	A suitably qualified Project Ecologist will follow up with written confirmation that the area was free from Koalas enabling works to proceed.

4.5.8 Identifying Koala Habitat Offsets

As part of the habitat offset strategy currently being prepared for the Project, appropriate habitat offset properties are currently being investigated by Roads and Maritime Services. The investigation of such properties will include targeted Koala surveys including SAT plots, spotlighting and call-playback surveys in accordance with recognised survey approaches to confirm usage of these areas by Koalas.

4.5.9 Pre-construction Monitoring

Pre-construction Koala population monitoring has been undertaken to obtain baseline data on the local Koala population associated with the Project Site. The details of the monitoring program for Koalas are provided in **Section 7**.

4.6 Performance Measures and Corrective Actions

Table 4.2 presents the main goals of Koala management for pre-construction activities and includes the relevant mitigation measures for Koalas that are to be employed prior to the commencement of construction. The table also describes how the identified mitigation measures are to be monitored, the timing and frequency of monitoring, who is responsible for implementing the measures, the performance thresholds that each goal is measured against and the corrective actions if deviation from the performance criteria occurs.

Table 4.2 Pre-construction Management Goals, Mitigation Measures, Performance Thresholds and Corrective Actions

Management Goal	*Mitigation/Control Measure*	*Monitoring/Timing Frequency*	*Responsibility*	*Performance Threshold*	*Corrective Actions if Deviation from performance Criteria*
No habitat loss for the Koala from pre-construction activities.	▪ Minimise areas of Koala habitat to be cleared where feasible and reasonable during the detailed design phase.	▪ Constraints maps to include Koala habitat mapping (SAT results).	AFJV (Design team)/ suitably qualified Project Ecologist	▪ No Koala habitat to be cleared during the pre-construction stage.	▪ Consideration of additional offsets for habitat loss.
	▪ All ancillary sites to be located outside of mapped Koala habitat.	▪ Ecological assessments to be prepared for ancillary sites to verify minimal impacts to Koala habitat.	AFJV (Environmental team)/ suitably qualified Project Ecologist	▪ No areas of mapped Koala habitat to be impacted by the ancillary facilities.	▪ Consideration of additional offsets for habitat loss.
	▪ Prior to any clearing taking place, the Project Ecologist will undertake an inspection of vegetation, to be cleared, to determine if work activities do not constitute "Construction" as defined in the planning approval under the NSW EP&A Act and are excluded from the Referral under the Federal EPBC Act.	▪ Pre-clearing permits to be completed by the Project Ecologist prior to the clearing of areas of vegetation.	AFJV/ suitably qualified Project Ecologist	▪ No Koala habitat to be cleared during the pre-construction stage.	
	▪ The limits of clearing are to be clearly marked on all relevant work plans and protective fencing erected to mark these limits (i.e. 'no-go' areas).	▪ Limits of clearing will be marked out prior to clearing commencing in that area. Fencing installed prior to vegetation clearing activities commencing in that area. Fencing and no-go signage inspected weekly, until construction completion.	AFJV	▪ Final Sensitive Area Plans identify sensitive areas and 100% of clearing drawings identify clearing extents. ▪ Completion of pre-clearing survey prior to construction including mark out of clearing extents.	▪ Notification to DoE, EPA if over clearing occurs.

Management Goal	*Mitigation/Control Measure*	*Monitoring/Timing Frequency*	*Responsibility*	*Performance Threshold*	*Corrective Actions if Deviation from performance Criteria*
	▪ Areas for Koala habitat restoration/ connectivity are to be identified and included in the detailed design.	▪ Identified areas for Koala habitat restoration/ connectively have been determined (refer to **Appendix B**).	Roads and Maritime/ AFJV (Design team)	▪ All areas outlined as Koala habitat restoration opportunities are to be shown on the detailed design and planted appropriately.	
No injury/ mortality to Koalas from pre-construction activities.	▪ Preparation of an EWMS would be undertaken for all work activities and would include where necessary measures to minimise risk to Koalas. ▪ Induction of all personnel involved with pre-construction activities would be undertaken to advise on Koala management requirements. ▪ For any area of vegetation to be cleared during the pre-construction stage of the Project, a suitably qualified ecologist will undertake a search for native fauna (including Koalas) in the vicinity of clearing immediately prior to clearing commencing. ▪ In the event that a Koala is identified within 50 metres of a works area, works will be rescheduled until the construction stage of the Project. ▪ For all Koalas detected on/near the site the protocol as shown in **Table 4.1** is to be implemented. As mentioned, for the pre-construction works, in the event that a Koala is identified within 50 metres of a works area, works will be rescheduled until the construction stage of the Project.	▪ Pre-clearing permits to be completed by a suitably qualified Project Ecologist prior to the clearing of any vegetation. ▪ Post-clearing inspections to be undertaken of areas cleared to identify any animal (including Koalas) injured or killed during clearing.	AFJV (Environmental & Construction team)/ suitably qualified Project Ecologist	▪ No Koala injuries/ mortalities as a consequence of pre-construction activities.	▪ Notification to DoE, EPA if a Koala mortality is recorded on the Project. ▪ Adaptive management response plan to be provided by Project Ecologist if mortality recorded.

Management Goal	***Mitigation/Control Measure***	***Monitoring/Timing Frequency***	***Responsibility***	***Performance Threshold***	***Corrective Actions if Deviation from performance Criteria***
Minimise vehicle strike of Koala during pre-construction activities.	▪ Koala Management Protocol to be implemented requiring all personnel to report Koalas (including road kill). ▪ Assessment of future road kill risk including adaptive management actions to be provided by ecologist where Koala road kill is detected.	▪ Road kill monitoring to be undertaken (refer to **Section 7**).	AFJV/ Roads and Maritime	▪ No road kill of Koalas resulting from the Project.	▪ Where Koala road kill is detected in proximity to the Project the Project Ecologist will provide an assessment of future road kill risk for Koalas and adaptive management requirements where appropriate.
Ensure that appropriate habitat offsets have been identified for Koala conservation.	▪ Appropriate habitat offsets to be identified by including targeted Koala surveys (GeoLINK 2014) using recognised survey approaches to confirm usage of potential offset properties.	▪ Offset properties are currently being investigated by Roads and Maritime.	Roads and Maritime	▪ Suitable offset of Koala habitat in accordance with the EPBC Environmental Offsets Policy (2012).	

Construction Management Measures

5.1 Timing

Construction works are anticipated to commence in December 2014 and are expected to be completed in early 2018.

5.2 Summary of Potential Impacts

The construction stage works are anticipated to have the following potential impacts on Koalas:

- Habitat loss for the Koala from clearing works.
- Injury/ mortality to individuals from clearing/ construction works.
- Increased levels of vehicle strike on the existing highway from changed movement patterns in the locality of the site.
- Fragmentation of habitat and impacts to Koala movements.

5.3 Main Goals for Management

The main goals for management are as follows:

- Minimise habitat loss for the Koala from clearing.
- No injury/ mortality to Koalas from construction activities.
- Minimise vehicle strike of Koala during construction activities.
- Undertake habitat rehabilitation works within identified areas associated with the Project Site for to create additional Koala habitat.
- Ensure fauna crossing structures are constructed to maximise usage by fauna.

5.4 Mitigation Measures

5.4.1 Environmental Work Method Statements

Environmental Work Method Statements (EWMS) will be prepared for all construction activities potentially impacting fauna (including Koalas) as detailed in **Section 4.5.5**.

5.4.2 Inductions

An environmental induction will be prepared and delivered to all personnel involved with the construction stage as detailed in **Section 4.5.6**.

5.4.3 Controls on Habitat Clearing

The following controls will be implemented to ensure that no over clearing occurs on the Project:

- Clearing limits are to be marked out accurately with no-go delineation.
- Clearing limits to be checked prior to the commencement of clearing by survey and environmental team.

5.4.4 Pre-clearing Surveys and Staged Habitat Removal

Prior to vegetation clearing, a suitably qualified ecologist/ expert will survey all areas to be cleared and will mark out any areas of significant vegetation (EECs, threatened species, riparian vegetation and mangroves) to be fenced and protected. Pre-clearing surveys will also include spotlighting surveys within suitable habitat on the night prior to clearing operations commencing in a given area.

Immediately prior (within two hours) of clearing commencing an additional ecologist inspection is to be undertaken to confirm that clearing areas remain free of fauna (including Koalas). Where Koalas are identified no works would be undertaken within 50 metres of the animal and the measures within the Fauna Management Protocol for Koalas (refer to **Table 4.1**) would be implemented. This process will affect a two staged approach to clearing of known Koala habitat. Should relocation of Koalas be required, a Koala Relocation Strategy included in **Appendix C** would be implemented.

During the proposed clearing works, an experienced wildlife handler will be present to retrieve any displaced fauna and release the fauna into adjacent habitats safe from construction work.

5.4.5 Jersey Barrier Arrangement

The arrangement of Type F concrete barriers in a continuous line along one side (or centre) of the existing highway has the potential to create additional barriers to Koalas attempting to cross the highway and increase the risk of car strike. Prior to the construction of fauna passage locations and installation of fauna fence, where continuous lines of Type F concrete barriers are to be installed, gaps are to be provided to allow escape of any animals off the highway. The provision of these gaps is to be designed in consultation with the Project Ecologist. It is acknowledged that traffic safety requirements will need to be taken into account. Where continuous lines of Type F concrete barriers are required in Koala habitat, material is to be attached at strategic locations (as advised by the Project Ecologist) to allow Koalas to climb over barriers.

5.4.6 Habitat Rehabilitation Areas

Areas identified for additional Koala habitat/ connectivity (refer to **Appendix B**) would be rehabilitated during the construction stage works. Key rehabilitation measures will include:

- Progressive revegetation/ rehabilitation during the construction phase using collected topsoil and seed at specific sites and to develop different successional stages of rehabilitation.
- Planting of locally occurring species, including plants representative of groundcover, understorey and canopy strata.
- Planting of preferred food trees for native fauna, including appropriate eucalypt species for the Koala.
- Plantings are to be undertaken around fauna crossing structures to optimise utilisation of these structures.
- Monitoring and maintenance of plantings.
- Managing and controlling weeds.

The specific Koala food trees, associated with each of the vegetation map units, to be used in replanting areas are provided in **Table 5.1** below.

Table 5.1 Summary of Primary and Secondary Koala Feed Trees and Corresponding Vegetation Types

Vegetation Community	*Habitat Type*	*Primary Koala Food (DECC 2008)*	*Secondary Food Tree Species (DECC 2008)*
Map Unit 1: Open Forest – Blackbutt	Dry Sclerophyll Forest	Tallowwood	▪ Small-fruited Grey Gum. ▪ Red Mahogany. Note: Blackbutt may also be considered and is identified as a supplementary feed tree (Professor Rob Close, University of Western Sydney. pers. comm. 2013).
Map Unit 2: Mixed Floodplain Forest	Wet Sclerophyll Forest	Tallowwood	▪ Small-fruited Grey Gum. ▪ Red Mahogany.
Map Unit 3: Moist Forest – White Mahogany/ Grey Gum/ Ironbark	Wet Sclerophyll Forest	Tallowwood	▪ Small-fruited Grey Gum. ▪ Red Mahogany.
Map Unit 4: Moist Forest – Flooded Gum	Wet Sclerophyll Forest	Tallowwood	▪ Small-fruited Grey Gum. ▪ Red Mahogany.
Map Unit 6: Swamp Forest – Swamp Mahogany/Paperbark	Swamp Sclerophyll Forest	Swamp Mahogany	▪ Small-fruited Grey Gum. ▪ Red Mahogany.

5.4.7 Construction Stage Monitoring

Construction stage monitoring for Koalas will be undertaken. The details of this monitoring is summarised in **Section 7**.

5.5 Performance Measures and Corrective Actions

Table 5.2 presents the main goals of Koala management for construction activities and includes the relevant mitigation measures for Koalas that are to be completed during the construction phase of the Project. The table also describes how the identified mitigation measures are to be monitored, the timing and frequency of monitoring, who is responsible for implementing the measures, the performance thresholds that each goal is measured against and the corrective actions if deviation from the performance criteria occurs.

Table 5.2 Construction Management Goals, Mitigation Measures, Performance Thresholds and Corrective Actions

Management Goal	*Mitigation/Control Measure*	*Monitoring /Timing Frequency*	*Responsibility*	*Performance Threshold*	*Corrective Actions if Deviation from performance Criteria*
Minimise habitat loss for the Koala from clearing.	▪ Any design changes required during the construction stage would minimise clearing of Koala habitat where feasible and reasonable.	▪ Ecological Assessments to be prepared for additional areas to be cleared to verify minimal impacts to Koala habitat.	AFJV (Environmental team, Design team)	▪ Koala habitat to be cleared to not exceed areas detailed in **Section 3.2**.	▪ Notification to DoE, EPA if the performance thresholds cannot be met. ▪ Additional habitat rehabilitation works to be undertaken on the Project to offset losses.
	▪ The limits of clearing are to be clearly marked on all relevant work plans and protective fencing erected to mark these limits (i.e. 'no-go' areas).	▪ Clearing limits to be checked (at least five working days) prior to the commencement of clearing by survey and environmental team.	AFJV (Environmental team, Survey team)	▪ Final Sensitive Area Plans identify sensitive areas and 100% of clearing drawings identify clearing extents ▪ Clearing limit not exceeds areas detailed in **Section 3.2**.	
No injury/mortality to Koalas from construction activities.	▪ Preparation of an EWMS would be undertaken for all construction activities to clearly communicate relevant measures within this Plan to work crews. ▪ Ongoing induction of all personnel involved with construction activities would be undertaken to advise of Koala management requirements. ▪ A suitably qualified ecologist will undertake pre-clearing surveys for threatened fauna species (including Koalas) prior to any clearing commencing (within 48 hours). These are to include spotlighting surveys within suitable habitat on the night prior to clearing operations commencing in a given area.	▪ Pre-clearing permits to be completed by the Project Ecologist prior to the clearing of any vegetation. ▪ Post-clearing inspections to be undertaken of areas cleared to identify any animal (including Koalas) injured or killed during clearing.	AFJV (Environmental/ Construction team)/ suitably qualified Project Ecologist	▪ No Koalas injuries/ mortalities as a consequence of construction activities.	▪ Notification to DoE, EPA if a Koala mortality is recorded on the Project.

Management Goal	*Mitigation/Control Measure*	*Monitoring /Timing Frequency*	*Responsibility*	*Performance Threshold*	*Corrective Actions if Deviation from performance Criteria*
	▪ During the proposed clearing works, the suitably qualified expert or an experienced wildlife handler under the supervision of the suitably qualified expert will be available to retrieve and provide appropriate care of any displaced matters of NES and release the fauna into adjacent habitats safe from construction work. ▪ Immediately prior to (within two hours) of clearing commencing in a given area, an additional ecologist inspection is to be undertaken to confirm that clearing areas remain free of fauna (including Koalas). ▪ Where Koalas are identified no works would be undertaken within 50 metres of the animal and the measures within the Fauna Management Protocol for Koalas (refer to **Table 4.1**) would be implemented. ▪ Should relocation of Koalas be required, a Koala Relocation Strategy included in **Appendix C** would be implemented.				
Minimise road kill of Koala during construction activities.	▪ Prior to the construction of fauna passage locations and installation of fauna fence, where continuous lines of jersey barriers are to be installed, gaps are to be provided to allow escape of any animals off the highway. Where gaps cannot be provided, a suitable material will be placed over the barrier to allow Koalas to climb over the barrier. ▪ Koala Management Protocol to be implemented requiring all personnel to report Koalas (including road kill). ▪ An assessment of future road kill risks including	▪ Road kill monitoring to be undertaken (refer to **Section 7**).	AFJV (Environmental team/ suitably qualified Project Ecologist	▪ No road kill of Koalas resulting from the Project.	▪ An assessment of future road kill risk will be undertaken by the Project Ecologist for areas where Koala road kill have been detected. This assessment will aim to provide actions to mitigate the risk of future Koala road kill in

Management Goal	*Mitigation/Control Measure*	*Monitoring /Timing Frequency*	*Responsibility*	*Performance Threshold*	*Corrective Actions if Deviation from performance Criteria*
	adaptive management actions is to be provided by the Project Ecologist where: - A Koala is detected within/near the site, or - Koala road kill is detected.				such areas.
Undertake habitat rehabilitation works within identified areas associated with the Project Site for to create additional Koala habitat.	▪ Progressive rehabilitation of identified areas (refer to **Appendix B**) during the construction stage using collected topsoil and seed at specific sites and to develop different successional stages of rehabilitation. Key rehabilitation measures would include: - Progressive revegetation/ rehabilitation during the construction phase using collected topsoil and seed at specific sites and to develop different successional stages of rehabilitation. - Planting of locally occurring species, including plants representative of groundcover, understorey and canopy strata. - Planting of preferred food trees for native fauna, including appropriate eucalypt species for the Koala. - Plantings are to be undertaken around fauna crossing structures to optimise utilisation of these structures. - Monitoring and maintenance of plantings. - Managing and controlling weeds.	▪ Monitoring and maintenance of rehabilitation areas to be undertaken regularly as part of the Project landscaping contract. ▪ Weed monitoring would be undertaken on the site.	AFJV (Landscape Design/ Construction team)	▪ Successful establishment of Koala habitat in nominated areas.	▪ Consideration of additional landscaping/ habitat rehabilitation works.
Ensure fauna crossing structures are constructed to maximise usage by fauna.	▪ EPA will be consulted during the detailed design phase on fauna crossing structure specific requirements for fauna furniture and treatments in and around fauna crossing structures. This will include, but not necessarily be limited to	▪ To be undertaken during the detailed design phase.	AFJV/ Project Ecologist	▪ Concurrence from EPA on fauna furniture/ treatments in and around fauna	▪ None required as must be undertaken.

Management Goal	*Mitigation/Control Measure*	*Monitoring /Timing Frequency*	*Responsibility*	*Performance Threshold*	*Corrective Actions if Deviation from performance Criteria*
	requirements for refuge poles and/or horizontal rails, pathways and appropriate plantings and/or sizing/ placement of scour rock and treatment of the substrate e.g. soil and/or mulch over the concrete floor and apron. ▪ Advice will be provided by the Project Ecologist on fauna furniture to be installed within fauna crossing structures.			crossing structures	

Operational Management Measures

6.1 Summary of Potential Impacts

The operational stage of the Project has the potential to have the following impacts on Koalas:

- Fragmentation of habitat and impacts to Koala movements.
- Increased risk of vehicle strike associated with the upgrade.

6.2 Main Goals for Management

The main goals for management are as follows:

- Maintain connectivity for Koalas potentially utilising habitats on either side of the upgrade.
- Minimise vehicle strike of Koala during operational activities.
- Maintain habitat rehabilitation areas.

6.3 Mitigation Measures

6.3.1 Habitat Offset Strategy

This Strategy would be prepared and implemented to offset the biodiversity impacts of the Project to address the Minister's Conditions of Approval (MCoA B8) for the WC2U Upgrade Project to meet EPBC offset requirements.

6.3.2 Maintenance of Habitat Rehabilitation Areas

Areas identified for additional Koala habitat/ connectivity (refer to **Appendix B**) would be maintained by the AFJV during the landscape maintenance period, which extends into the operational stage of the Project. Maintenance would include weed control works and replacement plantings if necessary. Maintenance would also be undertaken near fauna crossing structures and fencing and in all cases would be undertaken until rehabilitation areas have become self-sustaining.

6.3.3 Fauna Connectivity/Passage

The Proposal design includes fauna underpass and fauna exclusion fencing to allow for safe passage of fauna (including the Koala) crossing the Pacific Highway and reduce the risk of injury/ road kill.

The location and sizes of fauna underpass structures had been identified in the Conditions of the Approval of the Project under the NSW Environmental Planning and Assessment Act 1979 (EP&A Act) issued by the Minister for Planning and Infrastructure on 19 July 2011.

In response to a request from DoE following submission of the Referral under the EPBC Act, these fauna crossing locations were subject to an independent review by the Koala expert[1] Dr Rod Kavanagh and were modified in response to the recommendations of the review. There are a number of differences between the underpass structures identified in the Conditions of Approval under the EP&A Act, those recommended in the independent review and those that would be required to comply with the comments received from DoE following review of the Referral.

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[1] Rod Kavanagh is an internationally recognised forest wildlife scientist with more than 35 years' experience in the design, implementation, analysis and reporting of ecological experiments, fauna surveys and biodiversity monitoring programs.

A workshop with NSW Environment Protection Authority (EPA), Rod Kavanagh, ecologists involved with the roject and other stakeholders was held to review the fauna underpass options developed, including additional options developed by the Project team, and to reach agreement on the most appropriate underpass option for each location. Details of the agreed fauna underpasses being constructed as part of the Project are provided in **Appendix D**.

Approximately 12.1 kilometres of the new highway (where it intersects/ adjoins the main areas of forest) would support fauna exclusion fencing. Most of this comprises 'floppy-top' fauna exclusion fencing design which was developed by Koala expert Casper Pieters and has been refined for fauna (including Koalas) to minimise road strike. Details of fauna fencing to be provided as part of the Project are provided in Attachment B of **Appendix E.** Attachment A of Appendix E is provided to give indicative locations of the fauna crossings and fauna fences. The Chainages in Attachment A reflect the WC2U EA chainages. To convert these to the referral chainages add 41765.

The majority of the remaining sections of highway where no fencing is proposed intersects or adjoins mostly cleared pastoral land. Ongoing maintenance and repair of the permanent fauna exclusion fencing would be undertaken to restrict Koala from crossing the Pacific Highway upgrade and facilitate the use of fauna crossings would be undertaken post construction under the operational environmental management system.

Following further consultation with EPA additional fauna fence requirements have been agreed to at the following locations:

- Ch 1600 (16365) to Ch 2500 (17265) (eastern side of carriageway) – additional length 900 metres.
- Floodplain and Bridges at Ch 8500 (23265) to 10300 (25065) (1800 metres both sides of the carriageway in both directions) – additional 3600 metres.

- Ch 13500 (28265) to 14400 (29165) (western side of carriageway) – additional length of 900 metres.

6.3.4 Ecological Monitoring

Operational stage monitoring for Koalas will be undertaken. The full methodology and timing for this monitoring is provided in **Section 7**.

6.4 Performance Measures and Corrective Actions

Table 6.1 presents the main goals of Koala management during operation of the WC2NH Upgrade and includes the relevant mitigation measures for Koalas that are to be completed during the operations phase of the Project. The table also describes how the identified mitigation measures are to be monitored, the timing and frequency of monitoring, who is responsible for implementing the measures, the performance thresholds that each goal is measured against and the corrective actions if deviation from the performance criteria occurs.

Table 6.1 Operational Management Goals, Mitigation Measures, Performance Thresholds and Corrective Actions

Main Goal	*Mitigation/Control Measure*	*Monitoring/Timing Frequency*	*Responsibility*	*Performance Threshold*	*Corrective Actions if Deviation from performance Criteria*
Maintain connectivity for Koalas potentially occurring either side of the upgrade.	▪ Fauna Crossing Structures. ▪ Fauna Fencing.	Monitoring of the use of fauna crossing structures (refer to **Section 7**).	Roads and Maritime Services	▪ No change to densities, distribution, habitat use and movement patterns compared to baseline Koala population data.	Consideration of the following options: ▪ Maintenance of the existing connectivity measures ▪ Additional planting around the entrances of fauna crossing structures ▪ Consider additional offset measures to improve connectivity elsewhere.
Minimise road kill of Koala during operation of the WC2NH Project.	▪ Fauna Fencing. ▪ Fauna Crossing Structures.	▪ Road kill monitoring undertaken (refer to **Section 7**). ▪ The Roads and Maritime Roads Asset Division will undertake monitoring of fauna fencing on a regular basis after contractual obligations.	Roads and Maritime Services	▪ All fauna fencing is installed at the minimum of locations as identified in the EPBC approval prior to the operational phase of the WC2NH Upgrade.	▪ Where road kill monitoring identifies a significant difference between the road kill numbers of the different treatments (transect types), DoE and EPA shall be notified, and a meeting will be set to discuss such differences with the relevant agencies, Roads and Maritime and the reporting ecologist.
Maintain habitat rehabilitation areas.	▪ Maintenance of habitat rehabilitation areas.	▪ Regular maintenance of habitat rehabilitation areas (refer to **Appendix B**) would be undertaken as part of the landscape maintenance works.	Roads and Maritime Services/ AFJV	▪ Self-sufficient areas of rehabilitated habitat for Koalas within all nominated areas.	▪ Further maintenance/ additional planting after the end of the landscape maintenance period.

Monitoring Program

Jacobs (2014) and Roads and Maritime have prepared a methodology for Koala Population monitoring on the WC2NH Project which is included as **Appendix F**. This methodology has been peer reviewed by Koala expert, Dr Rod Kavanagh and is summarised in this section of the report. Additionally, monitoring of fauna crossing structures for Koalas is proposed as part of the overarching WC2NH ecological monitoring program (Benchmark, 2014). Road kill monitoring is also proposed as part of this Management Plan.

7.1 Koala Population Monitoring

7.1.1 Objectives

The objective of the baseline Koala population monitoring was to establish baseline data relating to densities, distribution and current usage of habitats by the Koala within proximity to the WC2NH Project.

Ongoing monitoring aims to identify changes in resident Koala activity (abundance, home range and movements) in response to construction of WC2NH and the effectiveness of Koala habitat connectivity mitigation measures (i.e. fauna underpasses and exclusion fencing).

7.1.2 Methodology

The methods described below are to be undertaken over two events for each monitoring session.

Transects are to be established on each side of the Project footprint within the Nambucca State Forest/ Old Coast Road area between chainage 15,600 and 19,500. Twenty-five transects, 500 metres long (or to the limit of vegetation) are spaced approximately 150 metres apart running perpendicular to the proposed Project footprint on each side of the highway upgrade.

Each transect is to be surveyed by personnel experienced in Koala surveys to document Koala presence and occupation. Surveys are to be undertaken over two monitoring events as follows:

- Diurnal survey: One observer with binoculars walking the transect searching for Koalas (110 person hours in total).
- Nocturnal survey: One observer spotlighting the transect on foot searching for Koalas at a rate of 0.5 to 1.0 kilometre/ hour (depending on vegetation density) (120 person hours in total). Koala call playback to be undertaken on each transect during spotlighting to increase the chance of Koala detection.

Additional spotlighting is to be undertaken on tracks and easements across this area with the survey effort of five person spotlighting hours at a rate of two kilometres/ hour targeting each side of the highway (10 person hours in total over four nights). Koala call playback to be undertaken at regular intervals along these tracks and easements during spotlighting to increase the chance of Koala detection.

The following data are to be collected for any Koalas detected:

- Location (using global positioning system [GPS])
- Distance from transect line
- Occupied tree species
- Habitat type
- Tree height
- Diameter at breast height
- Koala's sex where discernible

- Behaviour
- Disease status where discernible
- Reproductive status where discernible.

In interpreting the results of the population monitoring program consideration will be given to abiotic factors (seasonal conditions etc) which will be recorded as part of the project.

7.1.3 Timing/Frequency

Pre-construction (baseline) surveys have been completed for autumn (2014) and spring (2014). The results of these surveys are summarised in **Section 7.1.5** below. Transect surveys would also be undertaken annually (in spring) throughout the construction stage of the project (years 1 and 3) and operational stage years 4, 6 and 8.

7.1.4 Performance Indicators

Performance indicators for Koala population monitoring are as follows:

- Koala abundance and distribution pre-construction are similar to post-construction and maintained in the vicinity of Nambucca State Forest/ Old Coast Road.

7.1.5 Results of Pre-construction (Baseline) Koala Population Monitoring

Pre-construction (baseline) monitoring has recently been completed for autumn (2014) and spring (2014).

- Autumn surveys were undertaken over two events (14/04/2014 – 17/04/2014 and 28/04/2014 – 01/05/2014).
- Spring surveys were undertaken over two events (15/09/2014 – 17/09/2014 and 29/09/2014 – 02/10/2014).

The Koala baseline monitoring reports are included as **Appendix G**.

7.1.5.1 Autumn 2014 Survey Results

Autumn diurnal and nocturnal transect surveys yielded no observations of Koalas. Additionally, no Koala faecal pellets or obvious scratches attributable to Koalas were observed during these surveys. One Koala was recorded during spotlighting surveys being conducted along the Old Coast Road in the vicinity of the Nambucca Heads waste facility, west of the highway alignment. This individual responded to call playback and is likely to be a resident male. Vegetation associated with this area is mapped as being predominantly Open Blackbutt forest with some moister gullies comprising Flooded Gum Moist Open Forest.

7.1.5.2 Spring 2014 Survey Results

Spring diurnal and nocturnal transect surveys again did not yield any observations of Koalas nor were any Koala faecal pellets or obvious scratches detected opportunistically. One male Koala was detected calling in response to call playback surveys whilst spotlighting along tracks. This individual was recorded in the southern portion of Nambucca State Forest to the east of the new alignment.

An additional record of a Koala was detected in proximity to this record during other monitoring activities, (Spotted-tail Quoll baseline) being undertaken on the WC2NH project prior to the spring surveys.

7.1.5.3 Conclusions

The results of the baseline Koala surveys confirm earlier studies undertaken as part of the Koala Impact Assessment (GeoLINK, 2013) that the Nambucca State Forest/ Old Coast Road area is subject to low level usage by Koalas. Insufficient data is available from both the previous SAT surveys and these targeted surveys to provide an accurate population estimate of Koalas in the area. However, given the low levels of Koala usage evidenced by the results of the baseline surveys and previous surveys and that the home range of Koalas in low density populations may exceed 100 hectares (Ellis *et al.* 2002 – cited in Biolink 2009), the number of individual Koalas whose home range encompass the study area is likely to be small.

Results to date indicate that Koalas are primarily using the moist gullies that primarily occur in the southern portion of Nambucca State Forest.

The results of the baseline transect surveys do not trigger the need for the provision of GPS/VHF fitted collaring and pit tagging Koalas or the establishment of additional transect survey control sites.

7.2 Monitoring of Fauna Underpasses/Fauna Fences

7.2.1 Objective of Monitoring Program

The objective of the monitoring program is to determine whether mitigation measures (fauna underpasses and fauna fence) are effective in maintaining connectivity for fauna (including Koalas) in the vicinity of the project.

7.2.2 Methodology

7.2.2.1 Fauna Underpasses

Monitoring of fauna underpasses would be undertaken in spring to coincide with the Koala breeding season and likely juvenile dispersal period and involve the use of remote camera surveys at fauna underpasses that include the Koala as a target species as agreed between Roads and Maritime and EPA (refer to **Table 7.1**). Monitoring of underpasses will be undertaken using the following techniques:

- A motion-detecting camera would be installed, at both ends of each crossing structure to be monitored. Cameras are to operate continuously for a period of 60 days during spring/ early summer.
- Sand-plots would be established at each end of each crossing structure to be monitored for a period of eight nights per monitoring event. Sand plots, at least one metre wide, will be established across the entire width of the underpass and will be inspected each following morning period for tracks each morning and then raked clean.
- Scat searches within crossing structures (approximately one to two metres from the end to minimise wind and rain disturbance) and in adjoining habitat would be undertaken. Searches to be undertaken when installing and checking sand plots (i.e. twice per monitoring period).

Table 7.1 Fauna Crossing Structures to be Monitored

Chainage	*Fauna Crossing Structure Type*	*Structure Form*	*Dimensions*
42500	Combined	Bridge over Warrell Ck	
55120	Dedicated	Box Culvert	3000x3000
56410	Combined	Box Culvert	2400x2400
57770	Dedicated	Box Culvert	3000x3000
58510	Combined	Box Culvert	3000x3000
58560	Dedicated	Box Culvert	3000x3000
59090	Dedicated	Box Culvert	3000x3000
59550	Dedicated	Box Culvert	3000x3000
59750 North Bound lanes	Dedicated	Box Culvert	24000x2400
59760 South Bound Lanes	Dedicated	Box Culvert	2400x2400
60600 North Bound Lanes	Dedicated	Box Culvert	2400x2400
60610 South Bound Lanes	Dedicated	Box Culvert	2400x2400

7.2.2.2 Adjacent Forested Areas

Forested habitats adjacent to fauna underpass entrances will be surveyed to assess the range of fauna species occurring in proximity to each underpass structure. These results will then be compared with underpass monitoring results to identify which species present in the immediate area are not utilising the underpass structure. A one hectare area adjacent to fauna underpass entrances (in forested areas) will be surveyed at the time of fauna underpass surveys and will include spotlighting, arboreal and ground-based trapping, hairtube sampling, timed diurnal and nocturnal searches and scat and track searches.

7.2.2.3 Fauna Fences

Fauna fence monitoring would be undertaken annually post construction as part of standard ongoing road maintenance to ensure that fences are not damaged. The contractor has a contractual period of 36 months to maintain fences. At the completion of this time period, Roads and Maritime Services Asset Division will continue to monitor and maintain fauna fencing in perpetuity.

7.2.3 Timing/Frequency

Fauna underpass monitoring (including surveys of adjacent forested areas) will commence upon completion of construction of the Project (year 4) and will be undertaken in spring/ early summer each year for a minimum of 60 days. Monitoring will continue in years 5 to 8 of the operational phase and additional monitoring may be required if fauna underpasses are determined to be ineffective.

7.2.4 Performance Indicators

Indicators of success for fauna underpasses/fauna fences are as follows:

- Demonstrated use of fauna crossing structures by Koalas with consideration of population estimates as derived from the Koala population monitoring surveys.

7.3 Road Kill Monitoring

7.3.1 Objective of Monitoring Program

The aim of the monitoring program is to:

- Report on any animal road kill on the project following the opening to traffic; and
- Assess the effectiveness of fauna fencing to prevent fauna being killed by vehicles while attempting to cross the WC2NH Upgrade.

A detailed methodology for road kill monitoring is included in **Appendix H**. The methodology and timing of this monitoring are summarised below.

7.3.2 Methodology

7.3.2.1 Monitoring Procedure

A two person team vehicle being driven along the entire length of the existing highway in the Project area and identifying dead wildlife (road kill) seen on the roads and within three metres of the road edge. Both driver and passenger will search the left-hand side of the road and its verge for road kill with the driver searching the road and shoulder and the passenger searching the verge. When a road kill is observed from the vehicle, a close visual inspection of the carcass will be undertaken where access is possible and where safely limitations permit. If safe access is not possible, due to local traffic conditions, binoculars will be used to try to identify and provide as detailed information as is possible on the carcass. Where there is any doubt to the identification of the carcass, photographs will be taken and forwarded to a qualified ecologist for identification/ confirmation of species.

7.3.2.2 Detailed Methodology

Specific details of the monitoring methodology are:

- The highway will be monitored using a two-person team traversing the upgrade in a vehicle to locate and identify road kills.
- The speed of travel will be the same in all cases to avoid confounding the data collection, and should be as slow as is safely possible.

- The highway will be surveyed weekly for 12 weeks commencing the week of opening each stage to traffic and for four weeks in spring, summer, autumn and winter (refer to Section 7.3.3).
- When possible, each survey shall be completed within two hours of sunrise in order to maximise the potential to record road kills before either carrion eating animals or traffic render and road kill unidentifiable.
- If possible, each survey will be carried out on the same day to remove the influence of varying environmental conditions and to ensure consistent temporal spacing.
- For each road kill observed, the following attributes will be recorded:
  a. Geographic Coordinates of any road kill.
  b. Whether fauna fencing was installed at the location.
  c. Species of road kill, however, where there is any doubt to the identification of the carcass, photographs shall be forwarded to a qualified ecologist for identification/confirmation of the species.
- If the animal is identified as an EPBC Act threatened species, the carcass will be photographed and the following information will also be recorded where possible and where safety considerations permit:
  a. Sex and age class (juvenile or adult).
  b. Presence of pouch young (for marsupials).
  c. Presence of flightless young (for flying-foxes or other bats).
  d. Distance to a fauna connectivity structure.
  e. Distance to drop down structure
  f. If fauna fencing was installed, is there any damage to the fence in the vicinity.
  g. Weather conditions at the time of the monitoring (from the Bureau of Meteorology) – including temperature, rainfall in the last 24 hours, moon phase.
  h. If the animal is identified as a flying-fox:
     i. Distance to nearest camp,
     ii. Distance to nearest canopy vegetation,
     iii. Presence of flowering food trees in neighbouring median or roadside vegetation; plants identified to species and referenced with diet list.

7.3.2.3 Data Analysis

The data to be collected will be analysed using a suitable non-parametric test such as a Kruskal-Wallis test. The aim will be to test both whether the fenced and unfenced locations have different mean numbers of road kills and if the amount of road kill varies through time in either or both of the two types of areas. Such information will indicate if the mitigation measures in the area are area working as expected to keep road kills to acceptable levels and that none of the target species are killed.

7.3.3 Timing/Frequency

The timing and frequency of road kill monitoring is summarised in **Table 7.2**

Table 7.2 Road Kill Monitoring Timing

Project Phase	*Timing of Surveys*	*Location*	*Responsibility*
During clearing operations.	Daily	Portion of existing Pacific Highway adjacent to clearing operations.	AFJV
One month following clearing operations	Daily	Portion of existing Pacific Highway adjacent to clearing operations.	AFJV
Duration of construction.	Weekly	Entire length of existing Highway in Project area.	AFJV/ Roads and Maritime Services
Upon opening of each stage of the Project to traffic (operational phase)	Weekly for 12 weeks commencing the week of opening each stage to traffic.	Entire length of opened stage	Roads and Maritime Services

Project Phase	*Timing of Surveys*	*Location*	*Responsibility*
Upon completion of the Project (operation phase)	Excluding the season/s covered by the initial 12 week monitoring period (refer above), weekly during October (spring), January (summer), April (autumn) and July (Winter) for up to five consecutive years post construction, or until mitigation measures have been demonstrated to be effective.	Entire length of completed Project	Roads and Maritime Services

7.3.4 Performance Indicators

Indicators of success for fauna underpasses/ fauna fences are as follows:

- Lower rates of road kill in proximity to fauna fencing (i.e. areas of the main carriageways within areas adjacent to installed fauna fencing) than in sections of the upgrade not near fauna fencing during monitoring events up to five years post construction phase, or until such time as mitigation measures have been demonstrated to be effective.

7.4 Summary of Monitoring Program

A summary of the monitoring program is provided in **Table 7.3**.

Table 7.3 Summary of Monitoring Program

Monitoring Component	*Main Goal*	*Timing/Frequency*	*Responsibility*	*Performance Threshold*	*Corrective Actions if Deviation from performance Criteria*
Koala population monitoring	To establish the numbers and distribution of individual Koalas, in relation to proposed mitigation structures, so that an informed assessment can be made of the impacts of the WC2NH Project on Koalas in the Nambucca State Forest/ Old Coast Road area.	▪ Pre-construction baseline surveys completed (autumn and spring). ▪ Ongoing established transect surveys annually (spring) at years 1 and 3 during construction, and years 4, 6 and 8 during operational.	Roads and Maritime Services/ AFJV	▪ Koala abundance and distribution pre-construction are similar to post-construction and maintained in the vicinity of Nambucca State Forest/ Old Coast Road. ▪ Demonstrated use of fauna crossing structures by Koalas with consideration of population estimates as derived from the Koala population monitoring surveys. ▪ No breaches in fauna exclusion fencing.	▪ Modify, if appropriate, design of existing measures where feasible and reasonable. ▪ Consider additional offset measures to provide additional compensation for animals and habitat lost due to the development.
Monitoring of fauna underpasses, fauna fences and adjacent forested habitat	To determine if possible whether mitigation measures (fauna underpasses and fauna fence) are effective in maintaining connectivity for fauna (including Koalas) in the vicinity of the project.	▪ Operational stage (spring/early summer - year 4 to 8).	Roads and Maritime Services		
Road Kill Monitoring	To effectively demonstrate that road kill rates are mitigated by the presence of fauna fencing by preventing fauna of concern from attempting to cross the WC2NH Upgrade.	▪ During clearing operations (up until one month after clearing is completed) – daily. ▪ Duration of construction (weekly). ▪ Upon opening of each stage of the Project to traffic (operational phase), weekly for 12 weeks commencing the week of opening each stage to traffic. . ▪ Operational stage - excluding the season/s covered by the initial 12 week monitoring period (refer	AFJV/ Roads and Maritime Services	▪ Lower rates of road kill in proximity to fauna fencing (i.e. areas of the main carriageways within areas adjacent to installed fauna fencing) than in sections of the upgrade not near fauna fencing during monitoring events up to five years post construction phase, or until such time as mitigation measures have been demonstrated to be effective.	▪ Where results identify a significant difference between the road kill numbers of the different treatments (transect types), DoE and EPA shall be notified, and a meeting will be set to discuss such differences with the relevant agencies, Roads and Maritime and the reporting ecologist.

Monitoring Component	*Main Goal*	*Timing/Frequency*	*Responsibility*	*Performance Threshold*	*Corrective Actions if Deviation from performance Criteria*
		above), weekly during October (spring), January (summer), April (autumn) and July (winter) for up to five consecutive years post construction, or until mitigation measures have been demonstrated to be effective.		▪ All fauna fencing is installed at the minimum of locations as identified in the EPBC approval prior to the operational phase of the WC2NH Upgrade.	

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Definitions and Acronyms

ACT	Australian Capital Territory
AKF	Australia Koala Foundation
CEMP	Construction Environmental Management Plan
DoE	Australian Government Department of Environment
DoPI	NSW Department of Planning and Infrastructure
DSEWPaC	Australian Government Department of Sustainability, Environment, Water, Population and Communities
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
EPA	NSW Environment Protection Authority
FFMP	Flora and Fauna Management Plan
NH2U	Nambucca Heads to Urunga Pacific Highway Upgrade Project
NSW	New South Wales
OEH	Office of Environment and Heritage
Project Ecologist	A suitably qualified ecologist engaged to advise on/undertake ecological management throughout the Project.
Project footprint	All areas to be cleared as part of the Project inclusive of permanent and temporary works.
QLD	Queensland
RCBC	Reinforced Concrete Box Culvert
SKM	Sinclair Knight Merz
TSC Act	NSW *Threatened Species Conservation Act 1995*
UDLP	Urban Design and Landscape Plan
WC2NH	Warrell Creek to Nambucca Heads Pacific Highway Upgrade Project
WC2U	Warrell Creek to Urunga Pacific Highway Upgrade Project (referred to throughout the document as 'the Project'.

Copyright and Usage

Appendix A

Plan Authors CVs

curriculum vitae

David HAVILAH

BSc (Biol)

Ecologist

Qualifications

Bachelor of Science (Biology), Sydney University, 2003

Professional Affiliations

Member, Ecological Consultants Association of NSW
Member, NSW Wildlife Information, Rescue and Education Services Inc (WIRES-Northern Rivers)

Experience

David is an experienced ecological consultant who has developed a broad range of skills from working on a variety of small and large-scale projects. He specialises in undertaking terrestrial flora and fauna surveys and providing high quality ecological reports within Queensland and New South Wales. This work has included designing and implementing threatened species management plans and ecological monitoring programs. David has a detailed working knowledge of environmental legislation relevant to ecological impact assessment and an ability to balance practical applications of environmental requirements with good environmental outcomes.

Key Experience and Skills

A large focus of David's work has been providing ecological services on large infrastructure projects. He has been engaged as the Project Ecologist for construction contractors on a number of sections of the NSW Pacific Highway upgrade project. This work has included providing technical advice, ecological surveys and assessments and managing threatened species on these projects.

David's skills and key areas of expertise include:

- Design, implementation and management of ecological monitoring programs.
- Determining and documenting best practice and innovative management plans for threatened species occurring on infrastructure projects.
- Undertaking detailed systematic terrestrial flora / fauna surveys and vegetation / weed mapping.
- Preparing high quality ecological / environmental assessments for a broad range of projects in accordance with NSW, QLD and Federal environmental legislation.
- Preparing vegetation management plans and environmental management plans.
- Providing peer reviews of ecological assessments.
- Providing technical advice, ecological surveys and reporting in the role of project ecologist for large-scale infrastructure projects.
- Supervising and delivering pre-clearing surveys and spotter / catcher (fauna capture / relocation services) as part of large infrastructure projects.
- Delivering environmental awareness presentations.

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curriculum vitae

Veronica SILVER

BEnvSc Grad Dip (UrbRegPlan)

Senior Associate / Ecologist / Planner

Qualifications

Bachelor of Environmental Science (Environmental Management),
The University of Newcastle, [2000]
Graduate Diploma of Urban and Regional Planning, The University of New England, [2007]

Professional Affiliations

Member, Planning Institute Australia
Member, Environment Institute of Australia and New Zealand
Member, Ecological Consultants Association of NSW Inc.
Member, Australian Network for Plant Conservation Inc.

Professional Short Courses

- Planning for Bushfire Prone Areas
- Certificate IV Bushland Regeneration
- Certificate IV Workplace Training and Assessment
- Certificate II Australian Land Conservation and Restoration
- Project Management, Chifley Business School
- Effective Communication, Negotiation and Mediation, Chifley Business School
- Urban Design, Chifley Business School
- Acid Sulfate Soils: Identification, Assessment and Management
- Woodland Birds Identification and Ecology
- Signed English, TAFE Newcastle

Licences

- Scientific Licence (SL100152) issued by the Office of Environment and Heritage.
- Animal Research Authority issued by the Animal Care and Ethics Committee of the Director-General of NSW Department of Primary Industries to undertake fauna surveys throughout NSW and SE Queensland.

Experience

Veronica has been a key member of GeoLINK's ecology team since 2004. She specialises in flora / fauna field surveys; ecological monitoring; bushfire assessment; environmental impact assessment and bushland regeneration.

Veronica has further diversified her skills and knowledge in the built environment, having completed a Graduate Diploma of Urban and Regional Planning through The University of New England in 2007.

Veronica possesses high level project management skills, developed through working with a broad range of public and private sector clients on challenging environmental projects. Having project managed a variety of ecological and planning projects; she has significant skills in liaison and the management of multidisciplinary teams.

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Appendix B

Connectivity Habitat Restoration Areas

DoE Information Request 3, Task 5 and 6 – Connectivity and fragmentation of habitat

Document: Item 2-1 Independent review Koala, Table 4-1.

DoE comment 5:

Given the likely residual impact from connectivity loss and increased fragmentation of the koala habitat/population, please demonstrate how connectivity will be increased in the landscape (e.g. through tree plantings) to compensate for this loss. Please include this information in the proposed Urban Design and Landscape Plan (UDLP) (see comment 6a below).

DoE comment 6:

Table 1.2:

(a) Habitat restoration and management –

- **(i) It is unclear what areas of the proposed action will require a targeted UDLP. Please show on a map the locations along the length of the highway where habitat restoration and management will occur and how this will result in connectivity for relevant threatened species (e.g. see comment 5 regarding the koala above). Additionally, to provide context, please overlay all fauna mitigation measures proposed on the same map.**
- **(ii) Please advise the likely timing for completion of the UDLP, noting that RMS must provide the plans to the Department for approval prior to commencement (Note: The submission of the plans can be staged to align with construction staging).**

Response Task 5:

Identification of potential opportunities to enhance connectivity

Roads and Maritime Services propose to enhance connectivity in the landscape wherever reasonable and feasible through the provision of strategic tree planting in road reserves and residual land acquired for the project. In a brief memorandum provided by GeoLINK environmental consultants (dated 24th July 2014), the ecologists involved in the baseline Koala surveys identified opportunities to enhance habitat / vegetation connectivity post-construction for fauna in general including the Koala, refer to Table 1 of **Attachment A**.

Further to this Roads and Maritime Services identified several small parcels of residual property acquired for the project and outside the road corridor that are also well suited to enhancing connectivity in the landscape. This includes

- Additional planting within the Roads and Maritime residual property on the eastern side of the project between chainages 1,600 / 43,365 and 1,900 / 43,665 with vegetation indicative of the Moist Open Forest Flooded Gum community to expand areas of habitat in this area.

- Additional planting within the Roads and Maritime residual property on the eastern side of the project between chainages 14,900 / 56,665 and 15,100 / 56,865 with vegetation indicative of the Blackbutt community to expand areas of habitat in this area.

Review of potential opportunities to enhance connectivity

Subsequent to the identification of connectivity sites along the project by GeoLINK reviews of the proposed areas of revegetation and planting from a flooding and visual impact perspective were undertaken. This included an assessment by Spackman Mossop Michaels of visual amenity impacts and an assessment by Arup to assess any potential flood afflux impacts and changes in roughness values as a result of increasing the planting density along creeks and rivers.

The results of the visual impact assessment of the proposed connectivity sites are summarised below:

- 735 / 42,500 - Upper Warrell Creek eastern bank: This area would benefit visually from as much re-vegetation and planting as can be provided to assist with visual mitigation of the interchange from multiple viewpoints (including road users).
- 3,140 / 44,905 – Rosewood Creek: This location south of the over bridge appears to be in fill, so road user views would be largely unaffected. Houses are approximately 500 metres away so visual mitigation can be addressed fairly easily. Re-vegetation and planting would form part of the visual mitigation approach in this area anyway.
- 9,220 / 50,985 - Floodplain Bridge No.2: This location is in a combination of open/ wooded landscape and is located in fill, so road user views would be largely unaffected. Houses are well away and few in number so visual mitigation can be addressed fairly easily.
- 10,600 / 52,365 - Nambucca River Bridge north bank: The north bank is currently reasonably well vegetated, additional planting here would have a positive visual impact.

In addition, Roads and Maritime Services made the following comments:

- 3,140 / 44,905 – Rosewood Creek – Roads and Maritime Services have no concerns with this location subject to any connectivity planting in this area being limited to replacement of vegetation removed for the project to minimise potential impacts on flooding.
- 5,235 / 47,000 Williamsons Creek - Roads and Maritime Services don't see the need / benefit of connectivity planting in this area noting that it is identified for fish passage only and that there is no native vegetation downstream of the old highway crossing.
- Ch.14800 - 15500 west of the alignment - Roads and Maritime Services don't see the need / benefit of connectivity planting in this area noting that there are no fauna underpasses between Ch.14645 (56,410) and Ch.16005 (57,770).
- Ch.13300 fauna underpass - Roads and Maritime Services don't have any concerns with the proposed connectivity planting in this area due to the extent of existing vegetation and noting that the natural surface slopes from west to east at this location.

The results of the flood afflux assessment of the proposed connectivity sites as completed by Arup is provided below. It should be noted that the assessment is very high level and has tried to identify if an increase in roughness would result in an increase in flood levels and afflux. In addition, no modelling has however been completed to date. Arup notes that assuming that the afflux of the project is calculated as the difference between the existing levels (with existing vegetation) and the design levels (with the improved vegetation) then it is possible that changing the roughness values (as a result of increasing the planting density) will impact on flood afflux.

The results of the high level assessment indicates that it is most likely that the areas around the culverts are not of major concern, however the areas around the major water way crossings may be more problematic. **Table 1** provides a summary of the structures / locations which may be sensitive.

Table 1 Summary of the connectivity areas identified by GeoLINK that may potentially be flood sensitive

Location	Existing roughness	Revised vegetation roughness	Possible impact
735 / 42,500 - Upper Warrell Creek	0.04	0.08	Probable impact as afflux here is sensitive to channel works and vegetation.
5,235 / 47,000 Williamsons Creek	0.04	0.08	Probable impact as afflux here is sensitive to channel works and vegetation.
6,510 / 48,275 Warrell Creek	0.08	0.08	Limited as out of bank and already high roughness
8,450 / 50,215 Floodplain Bridge 1	0.08	0.08	Limited as already high roughness
9,220 / 50,985 Floodplain Bridge 2	0.06	0.08	Possible impact as within the Nambucca floodplain and only 15mm allowable afflux
10,600 / 52,365 Nambucca Bridge north bank	0.04	0.08	Possible impact as within the Nambucca floodplain and only 15mm allowable afflux

Roads and Maritime Services concurred with Arup regarding the potential flooding impacts identified in **Table 1** with the possible exception of:

- 735 / 42,500 - Upper Warrell Creek eastern bank: subject to any connectivity planting in this area being limited to replacement of vegetation removed for the project and planting of vegetation suitable for Giant Barred Frog.
- 735 / 42,500 - Upper Warrell Creek western bank: subject to any connectivity planting in this area being limited to planting of vegetation suitable for Giant Barred Frog.
- 9,220 / 50,985 - Floodplain Bridge No.2: due to the very low velocities in this area (noting the 15mm afflux limit) and 10,600 / 52,365 - Nambucca River Bridge north bank: subject to any connectivity planting in this area would be limited to replacement of vegetation removed for the project.

Based on the analysis completed above, the connectivity sites identified by GeoLINK in Table 1 of **Appendix A** would be modified as follows:

- Connectivity plantings would not be included at:
  - 5,235 / 47,000 Williamsons Creek due to visual impacts and lack of vegetation connectivity.
  - Ch.14800 - 15500 west of the alignment due to visual impacts and lack of vegetation connectivity.

- Connectivity planting would be limited to replacement of vegetation removed for the project in the following areas:
  - 735 / 42,500 - Upper Warrell Creek eastern bank due to flooding impacts.
  - 3,140 / 44,905 - Rosewood Creek (visual impacts)
  - 9,220 / 50,985 -Floodplain Bridge No.2 due to flooding and visual impacts.
  - 10,600 / 52,365 -Nambucca River Bridge north bank due to flooding and visual impacts.

Selected locations for planting to enhance connectivity

The updated locations for connectivity planting are provided in the map series included as **Attachment B**. In summary, 14 separate locations across the 19 kilometre upgrade have been identified where there is opportunity to conduct strategic planting to enhance connectivity. The areas identified are generally associated with riparian zones as they are viewed to present the best opportunity to enhance connectivity. The locations selected within these zones include future road reserve.

Of the areas identified, twelve of these sites are identified as areas with potential to be used by Koalas. In these locations it is recommended that the use of primary Koala feed trees be targeted in the planting mixes. The specific Koala food trees associated with each of the vegetation map unit impacted are summarised in **Table 2**.

Table 2. Summary of primary and secondary Koala feed trees and corresponding vegetation type

Vegetation Community	Habitat Type	Primary Koala Food (DECC 2008)	Secondary Food Tree Species (DECC 2008)
Map Unit 1: Open Forest – Blackbutt	Dry Sclerophyll Forest	Tallowwood (*Eucalyptus microcorys*)	• Small-fruited Grey Gum (*E. propinqua*). • Red Mahogany (*E. resinifera*). Note Blackbutt (*E. pilularis*) may also be considered and is identified as a supplementary feed tree (Professor Rob Close, University of Western Sydney. pers. comm. 2013).
Map Unit 2: Mixed Floodplain Forest	Wet Sclerophyll Forest	Tallowwood (*E. microcorys*)	• Small-fruited Grey Gum (*E. propinqua*). • Red Mahogany (*E. resinifera*).
Map Unit 3: Moist Forest – White Mahogany/ Grey Gum/ Ironbark	Wet Sclerophyll Forest	Tallowwood (*E. microcorys*)	• Small-fruited Grey Gum (*E. propinqua*). • Red Mahogany (*E. resinifera*).

Vegetation Community	Habitat Type	Primary Koala Food (DECC 2008)	Secondary Food Tree Species (DECC 2008)
Map Unit 4: Moist Forest – Flooded Gum	Wet Sclerophyll Forest	Tallowwood (*E. microcorys*)	• Small-fruited Grey Gum (*E. propinqua*). • Red Mahogany (*E. resinifera*).
Map Unit 6: Swamp Forest – Swamp Mahogany/ Paperbark	Swamp Sclerophyll Forest	Swamp Mahogany (*E. robusta*)	• Small-fruited Grey Gum • (*E. propinqua*). • Red Mahogany (*E. resinífera).*

It is noted that five of the connectivity sites are located within Nambucca State Forest which is associated with the known Koala population in this location. A review of Koala records for the study area from the Atlas of NSW Wildlife identifies a low number of records between Warrell Creek and Macksville, both to the east and west of the project. Given the high degree of fragmentation between chainage 0 / 41,765 to 7,500 / 49,265 the corridor south of Macksville represents the best opportunities for enhancement of connectivity.

Of the combined number of proposed habitat planting locations, three of these sites are located between chainage 5,200 / 46,965 and 6,600 / 48,365 and are associated with where the road alignment occurs immediately adjacent to the existing Pacific Highway. This includes the riparian corridors along Warrell Creek. There are very limited opportunities for Koalas to cross the existing highway in this location due to the lack of connectivity structures on the existing highway and extensive habitat fragmentation. The proposed strategic plantings in this location are therefore considered to present a substantial improvement or enhancement over the current situation.

Response Task 6:

In regards to the Department of the Environment (DoE) comment to include this information in the proposed Urban Design and Landscape Plan (UDLP) the following is noted. During a discussion between Colette Boraso from the DoE and Chris Clark from Roads and Maritime Services on the 10 July 2014, it was agreed that the UDLP was not the appropriate document to identify measures to improve connectivity in the landscape, including the locations of habitat restoration and management measures. It was agreed that these measures were best identified in the five individual species management plans that are being prepared to address the requirements of Attachment A2 of the DoE letter provided to Roads and Maritime Services on the 27 June 2014. As such this information will be included in these management plans which will be available for review by DoE in the near future.

The map series included as **Attachment B** shows all proposed fauna mitigation measures on the same map.

ATTACHMENT A GeoLINK Memorandum Koala Connectivity (24th July 2014)

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Attention: Alex Dwyer

WC2NH: Assessment of Opportunities to Enhance Vegetation/ Habitat Connectivity as part of the Project

GeoLINK has been requested to undertake an assessment to identify opportunities to enhance habitat/ vegetation connectivity as part of the landscaping and urban design plan to be adopted for the WC2NH project. This assessment involved a desktop review of the following information:

- Aerial imagery of vegetation surrounding the project site;
- Vegetation mapping for the project site and surrounds;
- Current locations and designs of fauna crossing structures; and
- WC2U Urban Landscape Design Plan.

Areas identified as opportunities to enhance habitat/ vegetation connectivity are shown on a series of mark ups contained within Appendix A. These areas are summarised in Table 1.1.

Identified areas are generally associated with bridges/ culverts, as riparian zones throughout the broader landscape provide the best opportunity to provide fauna habitat connectivity. Additionally, a small number of areas were identified where planting of endemic vegetation communities have the potential to create additional linkages between fragmented patches of vegetation occurring within the local landscape.

A number of recommendations were made for identified areas which are included in Table 1.1.

Feel free to contact me if you require any additional information.

Yours sincerely
GeoLINK

David Havilah
Ecologist/ Associate

Table 1.1 Proposed Habitat Connectivity Focus Areas

Area	*Chainages*	*Connectivity Opportunity*	*Recommendation*
Upper Warrell Creek (bridge site and fauna crossing location)	200 - 900	▪ A section of primarily cleared grazing land adjacent to Warrell Creek (between CH 200-700). Revegetation of this area would improve habitat/ vegetation connectivity along a relatively large portion of Warrell Creek. Additional benefits to improving aquatic fauna habitat. ▪ Areas associated with the fauna passage (CH 800) inlet/ outlet could be enhanced with additional planting of native vegetation in these areas to encourage fauna usage	▪ Riparian restoration planting along the western side of Warrell Creek (CH 200-700) with endemic species recommended. ▪ Habitat enhancement planting using appropriate endemic species proposed in areas either side of the fauna crossing culvert (CH 800) to maximise the potential use of this structure. ▪ As this area has potential to be used by Koalas the use of primary Koala feed trees in planting mixes (e.g. Tallowwood, Forest Red Gum, Grey Gum) is recommended.
Butchers Creek (combined culvert with fauna underpass)	1,450 – 1,600	▪ Areas associated with the fauna passage (CH 1,550) inlet/ outlet could be enhanced with additional planting of native vegetation in these areas to encourage fauna usage	▪ Habitat enhancement planting using appropriate endemic species proposed in areas either side of the fauna crossing culvert (CH 800) to maximise the potential use of this structure. ▪ As this area has potential to be used by Koalas the use of primary Koala feed trees in planting mixes (e.g. Tallowwood, Forest Red Gum, Grey Gum) is recommended.
Rosewood Creek (combined culvert with fauna underpass)	3,100	▪ A combined culvert with fauna underpass is to be provided at this location. The creek line is currently vegetated with Camphor Laurel forest. Connectivity could be enhanced by bush restoration works being undertaken along sections of Rosewood Creek occurring within the project site with the aim of maximising use of the culvert by fauna.	▪ Riparian plantings using endemic flora species recommended along Rosewood Creek (within the project site) as well as control of Camphor Laurel.
Unnamed tributary (incidental fauna passage)	3,800	▪ Tributary largely cleared with little vegetation/ habitat connectivity currently.	▪ No major gains to be made by restoration plantings in this area as little connectivity is currently present.

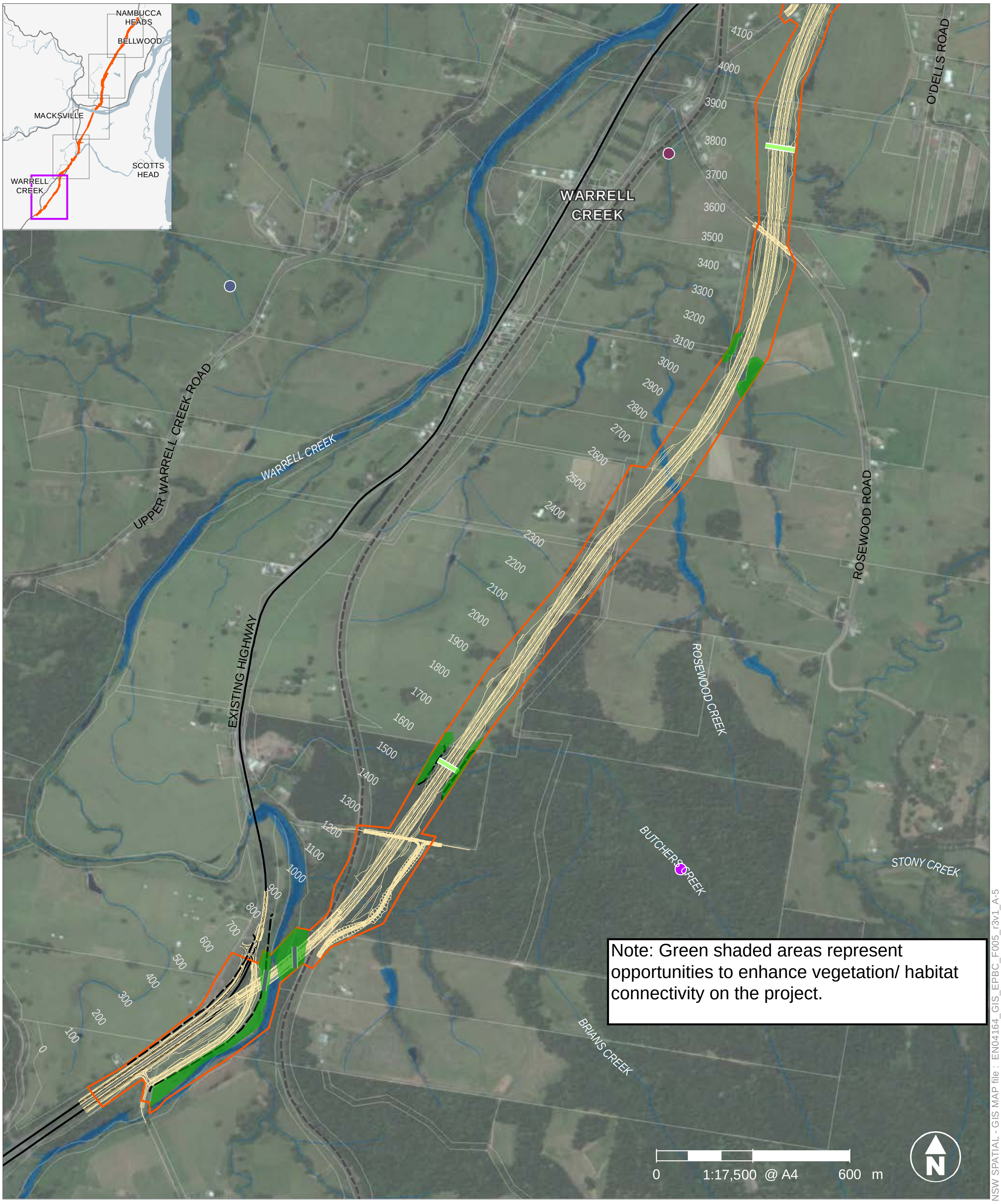
Williamsons Creek (bridge site and eastern side of the alignment)	5,200 - 5,700	▪ Habitat/ vegetation connectivity could be enhanced along Williamsons Creek by providing additional planting of appropriate riparian vegetation which would improve the likelihood of fauna movements along Williamsons Creek. ▪ Planting of a corridor of native vegetation on the eastern side of the alignment between Williamsons Creek and the unnamed tributary to the north (Ch 5,750) would improve connectivity between fragmented patches of forest in the locality.	▪ Habitat enhancement and additional riparian plantings are recommended along Williamsons Creek to improve connectivity. ▪ Planting of a corridor of native plantings including primary Koala feed trees (Tallowwood, Forest Red Gum, Grey Gum) are recommended along the eastern edge of the site between CH 5,200 and 5,700 to link fragmented patches of vegetation.
Lower Warrell Creek (areas associated with southern and northern abutment of new bridge.	6,400 - 6,800	▪ Only minor opportunities exist on the southern bank of Warrell Creek either side of the bridge footprint to enhance connectivity by a small amount of native plantings along the riparian zone. ▪ Restoration plantings within an area to the east of the new bridge site (northern bank) where vegetation is sparse and fragmented would improve connectivity by enhancing habitat values within the riparian zone	▪ Minor additional riparian plantings recommended along the southern bank either side of the bridge site where possible. ▪ Restoration/ regeneration of vegetation recommended in an area on the northern side of Warrell Creek (to the east of the new bridge site). This area is currently highly disturbed with scattered mature trees and dense weeds in the understorey.
Floodplain Plank Bridges and incidental fauna passage locations	8,000 - 9,400	▪ Minor opportunities to enhance and extend areas of EEC/ fauna habitat either side of the alignment primarily associated with fauna crossing structures and plank bridges.	▪ Recommend planting of Broad-leaved Paperbark/ Swamp Oak to enhance/ extend areas of habitat where possible and improve the likelihood of fauna movement at fauna crossing locations.
Nambucca River Bridge (northern bank)	10,600	▪ Additional planting/ restoration along the riparian corridor would enhance connectivity under the bridge which forms a linkage with large areas of vegetation associated with Newee Creek.	▪ Recommend planting of Swamp Oak, Forest Red Gums and other appropriate riparian plantings either side of the new bridge (within the riparian zone).

Area on the western side of the alignment, north of Mattick road (combined fauna passage)	13,100 – 13,450	▪ Areas associated with the fauna passage (CH 13,350) inlet/ outlet could be enhanced with additional planting of native vegetation in these areas to encourage fauna usage. ▪ Additional planting associated with Old Coast Road as it occurs within the project site would extend and enhance habitat values and linkages to large areas of vegetation to the west (Newee Creek).	▪ Habitat enhancement planting using appropriate endemic species proposed in areas either side of the fauna crossing culvert (CH 800) to maximise the potential use of this structure. ▪ Additional planting of endemic vegetation to the west of the alignment to improve connectivity. ▪ As this area has potential to be used by Koalas the use of primary Koala feed trees in planting mixes (e.g. Tallowwood, Forest Red Gum, Grey Gum) is recommended.
Nambucca State Forest (south) – fauna passage combined.	14,600 - 14,700	▪ Areas associated with the fauna passage inlet/ outlet could be enhanced with additional planting of native vegetation in these areas to encourage fauna usage.	▪ Habitat enhancement planting using appropriate endemic species proposed in areas either side of the fauna crossing culvert to maximise the potential use of this structure. ▪ As this area has potential to be used by Koalas the use of primary Koala feed trees in planting mixes (e.g. Tallowwood, Forest Red Gum, Grey Gum) is recommended.
Nambucca State Forest – six fauna crossing locations between CH 16,600 and 18,800.	16,600 – 18,800	▪ Minimal opportunities exist within this part of the project site to enhance vegetation/ habitat connectivity given the already heavily forested nature of this part of the site. ▪ Areas associated with the fauna passage inlets/ outlets could be enhanced with additional planting of native vegetation in these areas to encourage fauna usage, including the use of Koala feed trees where possible.	▪ Habitat enhancement planting using appropriate endemic species proposed in areas either side of the fauna crossing culvert to maximise the potential use of this structure. ▪ As this area has potential to be used by Koalas the use of primary Koala feed trees in planting mixes (e.g. Tallowwood, Forest Red Gum, Grey Gum) is recommended.

Appendix A

Proposed Habitat Connectivity Focus Areas

Attachment A Figure 5-1 Threatened fauna, exclusion fencing and underpasses



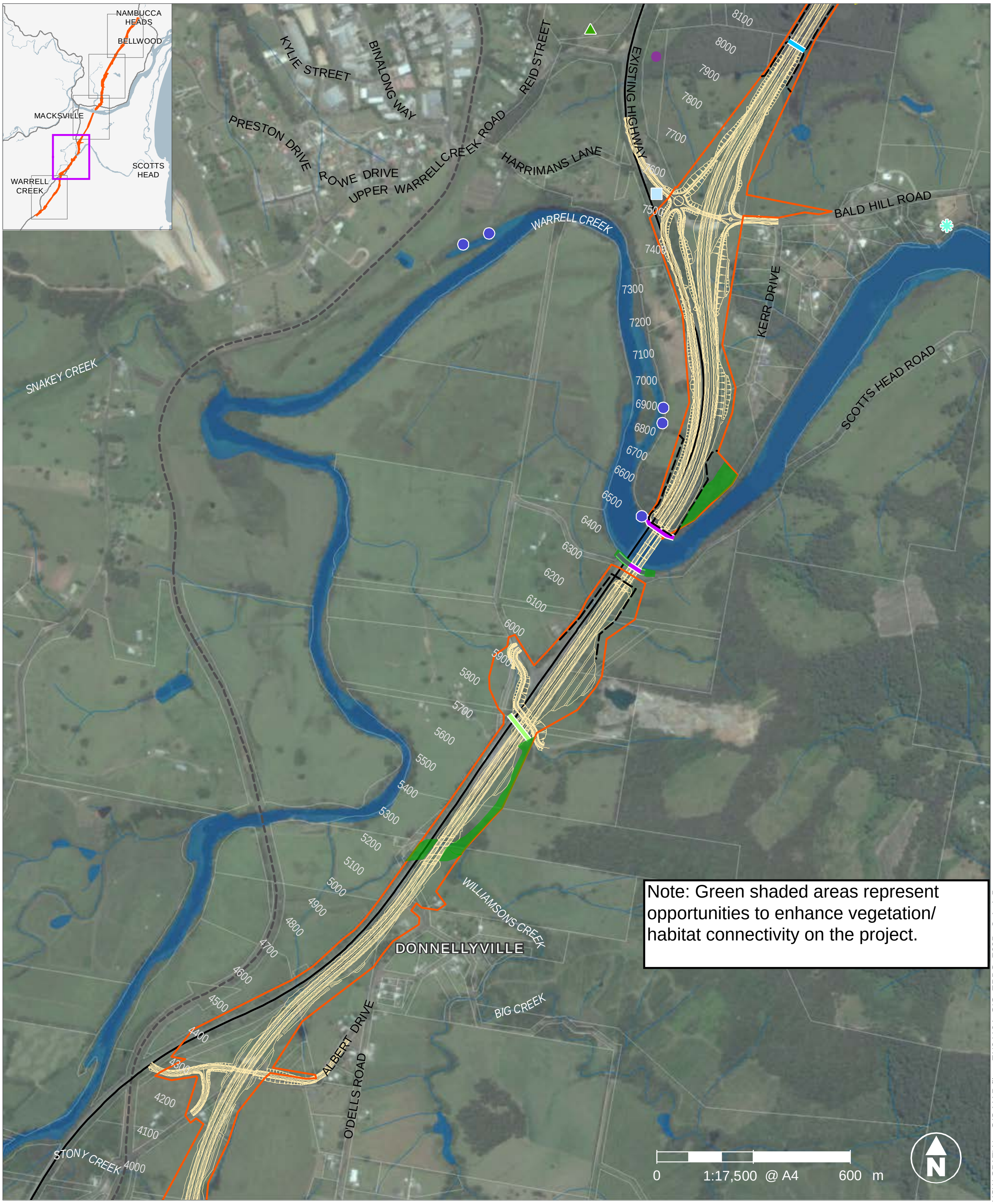
Road boundary
Road design
Temporary construction road boundary
Temporary construction road
November 2013 Flying-fox camp footprint
Combined culvert with fauna underpass
Dedicated fauna underpass
Fauna passage
Fauna fence

Threatened fauna

Black Bittern
Black Grass-dart Butterfly
Black-necked Stork
Brolga
Brush-tailed Phascogale
Cattle Egret
Common Greenshank
Eastern Bentwing-bat
Eastern Freetail-bat
Eastern Osprey
Glossy Black-Cockatoo
Glossy Ibis
Greater Broad-nosed Bat
Green and Golden Bell Frog
Grey-headed Flying-fox
Koala
Latham's Snipe
Little Bentwing-bat
Masked Owl
Oriental Pratincole
Osprey (nest site)
Pacific Golden Plover
Powerful Owl
Rainbow Bee-eater
Regent Honeyeater
Sooty Owl
Southern Myotis
Spotted-tailed Quoll
Square-tailed Kite
Squirrel Glider
White-bellied Sea-Eagle
Yellow-bellied Glider

DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information

Figure 5-2 Threatened fauna, exclusion fencing and underpasses



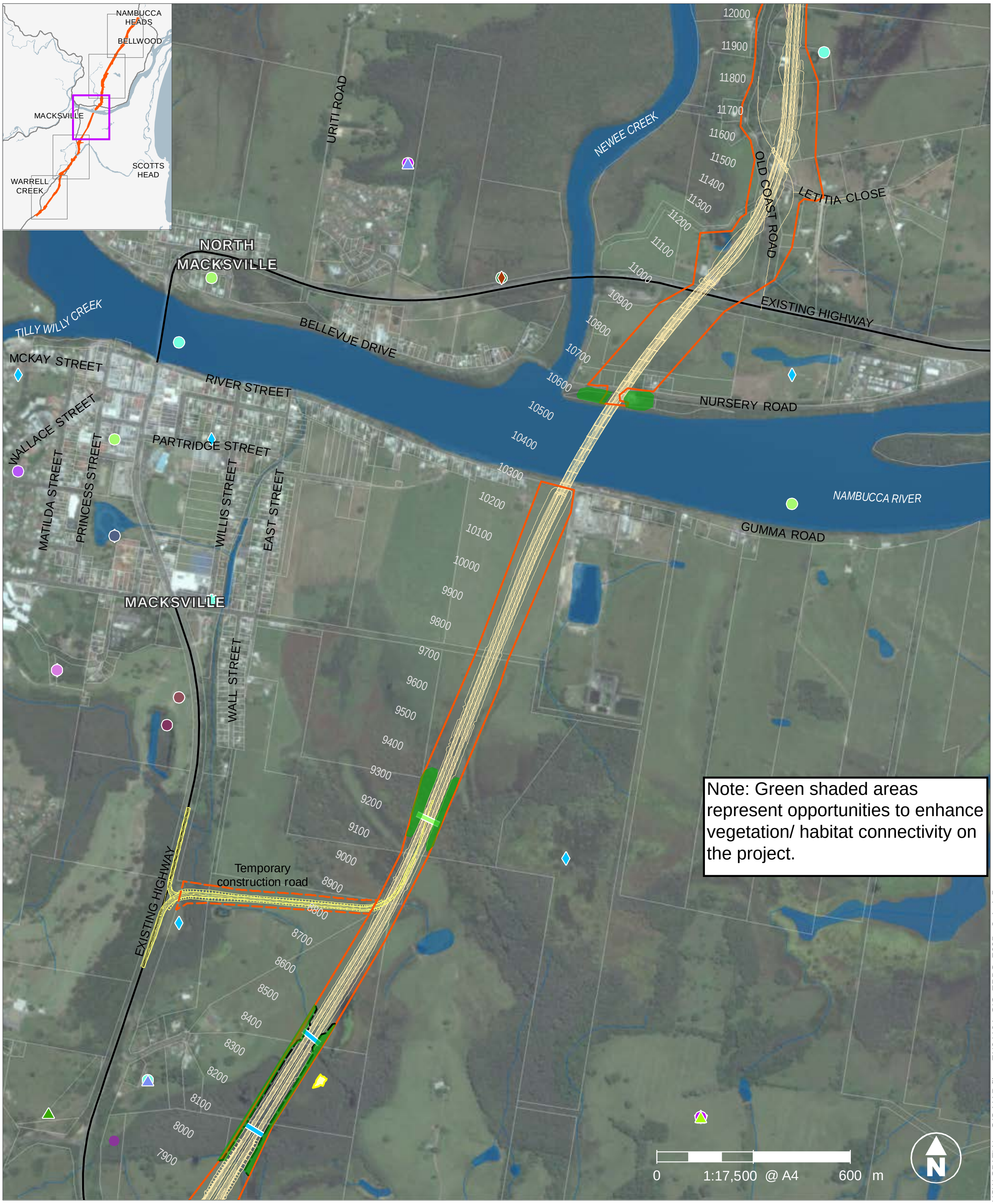
Road boundary
Road design
Temporary construction road boundary
Temporary construction road
November 2013 Flying-fox camp footprint
Combined culvert with fauna underpass
Dedicated fauna underpass
Fauna passage
Fauna fence

Threatened fauna

- Black Bittern
- Black Grass-dart Butterfly
- Black-necked Stork
- Brolga
- Brush-tailed Phascogale
- Cattle Egret
- Common Greenshank
- Eastern Bentwing-bat
- Eastern Freetail-bat
- Eastern Osprey
- Glossy Black-Cockatoo
- Glossy Ibis
- Greater Broad-nosed Bat
- Green and Golden Bell Frog
- Grey-headed Flying-fox
- Koala
- Latham's Snipe
- Little Bentwing-bat
- Masked Owl
- Oriental Pratincole
- Osprey (nest site)
- Pacific Golden Plover
- Powerful Owl
- Rainbow Bee-eater
- Regent Honeyeater
- Sooty Owl
- Southern Myotis
- Spotted-tailed Quoll
- Square-tailed Kite
- Squirrel Glider
- White-bellied Sea-Eagle
- Yellow-bellied Glider

DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information

Attachment A Figure 5-3 Threatened fauna, exclusion fencing and underpasses



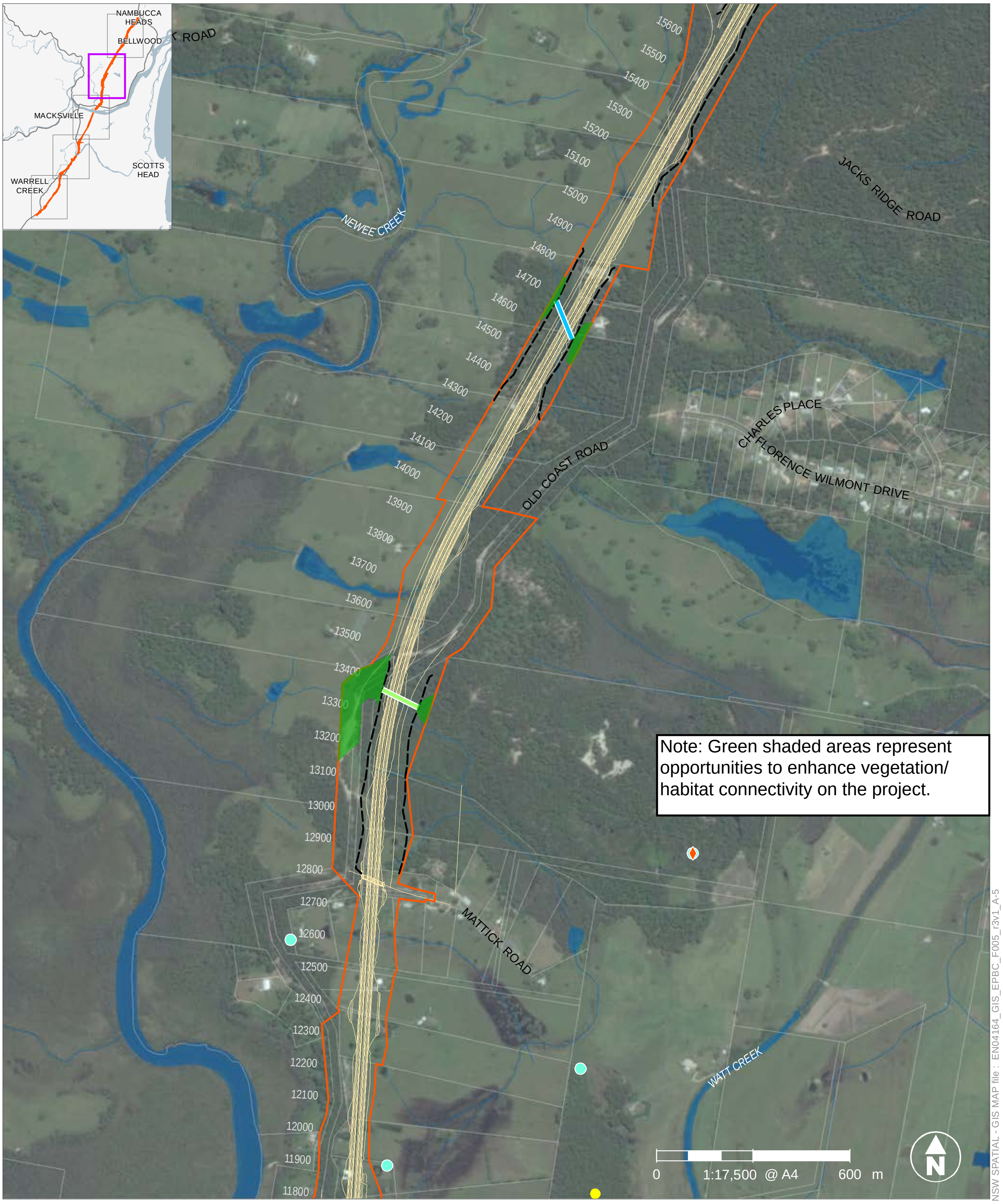
Road boundary
Road design
Temporary construction road boundary
Temporary construction road
November 2013 Flying-fox camp footprint
Combined culvert with fauna underpass
Dedicated fauna underpass
Fauna passage
Fauna fence

Threatened fauna

- Black Bittern
- Black Grass-dart Butterfly
- Black-necked Stork
- Brolga
- Brush-tailed Phascogale
- Cattle Egret
- Common Greenshank
- Eastern Bentwing-bat
- Eastern Freetail-bat
- Eastern Osprey
- Glossy Black-Cockatoo
- Glossy Ibis
- Greater Broad-nosed Bat
- Green and Golden Bell Frog
- Grey-headed Flying-fox
- Koala
- Latham's Snipe
- Little Bentwing-bat
- Masked Owl
- Oriental Pratincole
- Osprey (nest site)
- Pacific Golden Plover
- Powerful Owl
- Rainbow Bee-eater
- Regent Honeyeater
- Sooty Owl
- Southern Myotis
- Spotted-tailed Quoll
- Square-tailed Kite
- Squirrel Glider
- White-bellied Sea-Eagle
- Yellow-bellied Glider

DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information

NSW GOVERNMENT Transport Roads & Maritime Services
SKM



Road boundary
Road design
Temporary construction road boundary
Temporary construction road
November 2013 Flying-fox camp footprint
Combined culvert with fauna underpass
Dedicated fauna underpass
Fauna passage
Fauna fence

Threatened fauna

Black Bittern
Black Grass-dart Butterfly
Black-necked Stork
Brolga
Brush-tailed Phascogale
Cattle Egret
Common Greenshank
Eastern Bentwing-bat
Eastern Freetail-bat
Eastern Osprey
Glossy Black-Cockatoo
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Greater Broad-nosed Bat
Green and Golden Bell Frog
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Koala
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Rainbow Bee-eater
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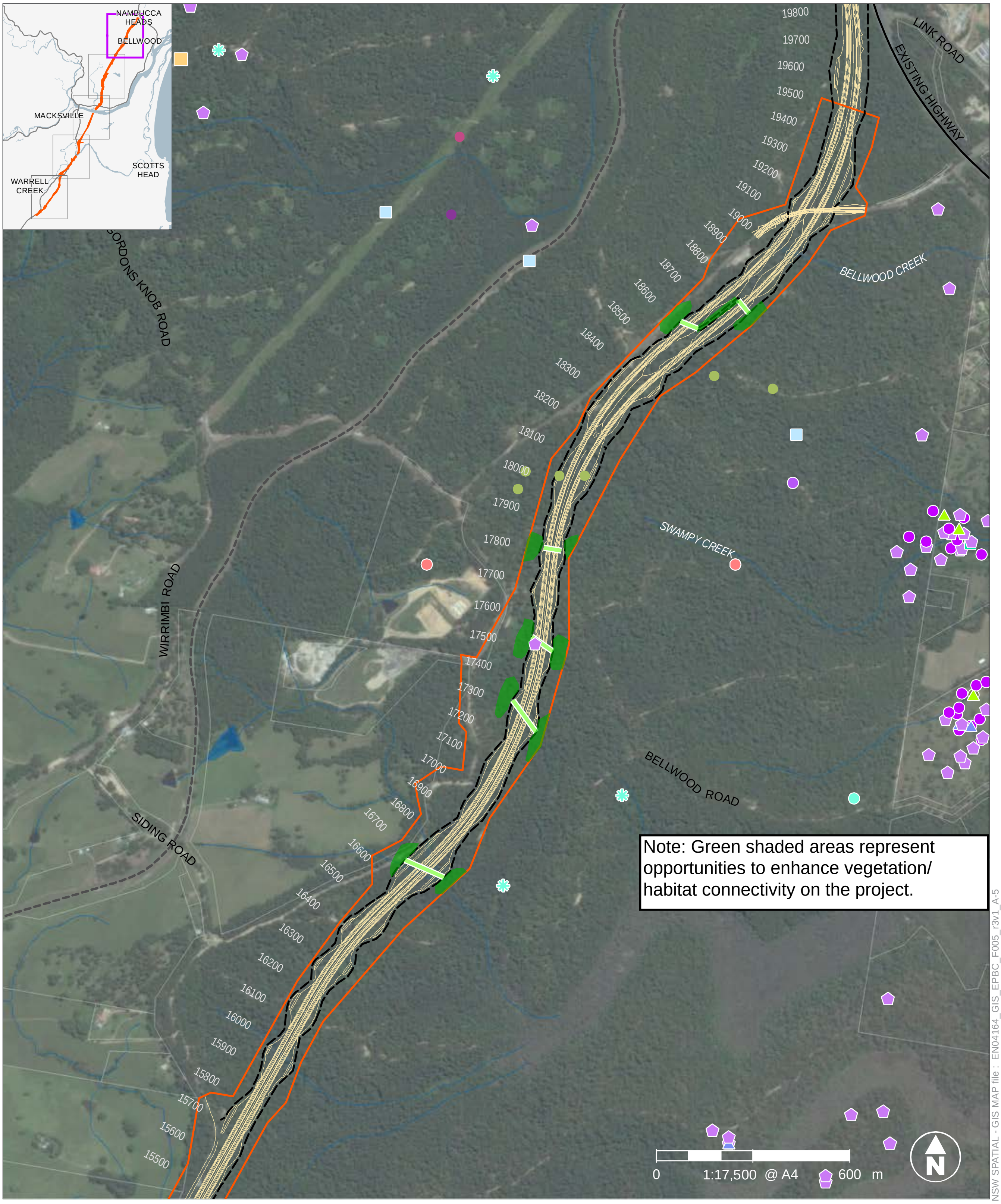
Sooty Owl
Southern Myotis
Spotted-tailed Quoll
Square-tailed Kite
Squirrel Glider
White-bellied Sea-Eagle
Yellow-bellied Glider

DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information

 Figure 5-5 Threatened fauna, exclusion fencing and underpasses



Road boundary
Road design
Temporary construction road boundary
Temporary construction road
November 2013 Flying-fox camp footprint
Combined culvert with fauna underpass
Dedicated fauna underpass
Fauna passage
Fauna fence

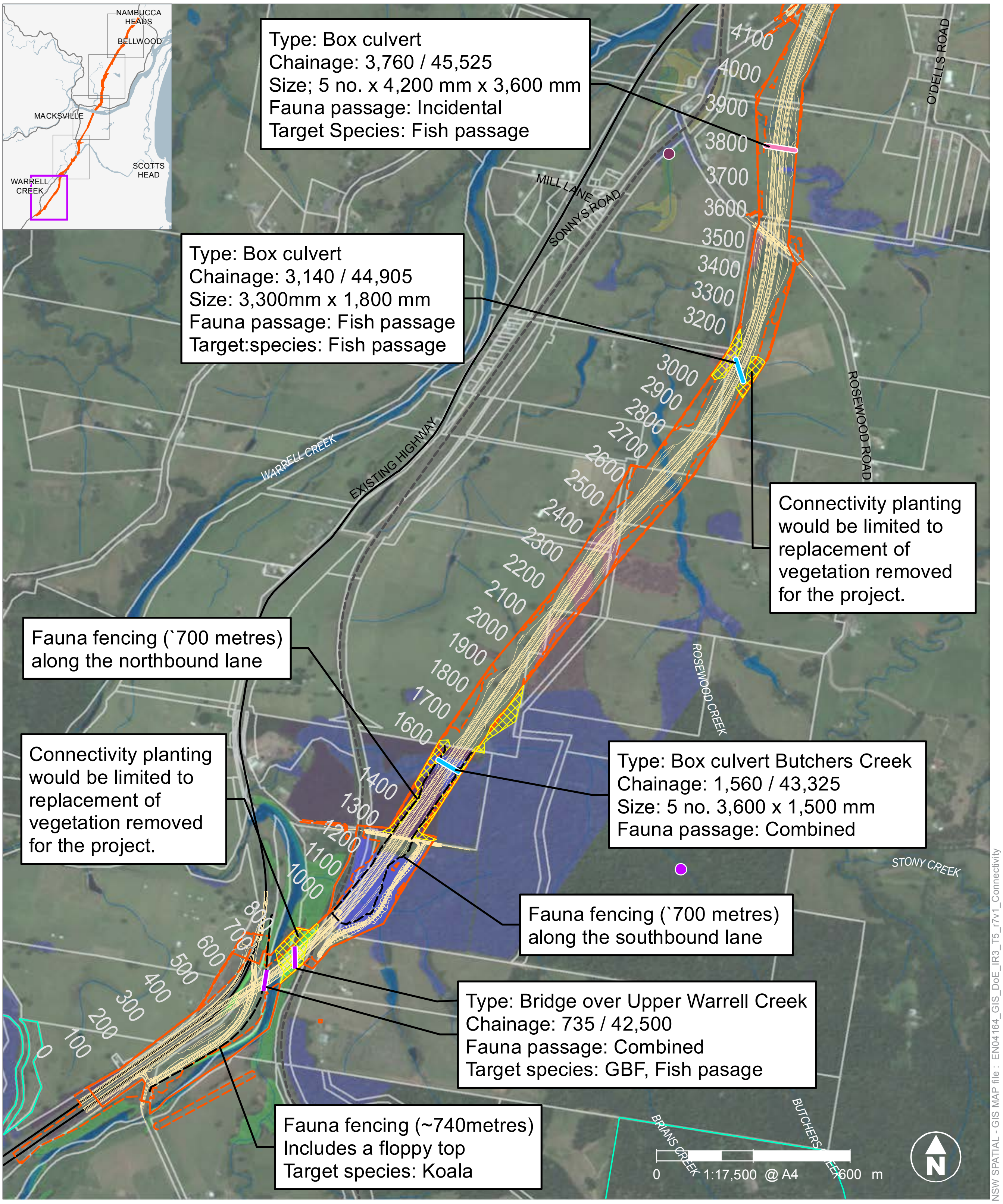
Threatened fauna

Black Bittern	Cattle Egret	Glossy Black-Cockatoo	Koala	Osprey (nest site)	Sooty Owl
Black Grass-dart Butterfly	Common Greenshank	Glossy Ibis	Latham's Snipe	Pacific Golden Plover	Southern Myotis
Black-necked Stork	Eastern Bentwing-bat	Greater Broad-nosed Bat	Little Bentwing-bat	Powerful Owl	Spotted-tailed Quoll
Brolga	Eastern Freetail-bat	Green and Golden Bell Frog	Masked Owl	Rainbow Bee-eater	Square-tailed Kite
Brush-tailed Phascogale	Eastern Osprey	Grey-headed Flying-fox	Oriental Pratincole	Regent Honeyeater	Squirrel Glider
					White-bellied Sea-Eagle
					Yellow-bellied Glider

DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information

NSW GOVERNMENT Transport Roads & Maritime Services
SKM

ATTACHMENT B Map Series of Connectivity / Habitat Restoration Areas



Legend

- Proposed areas of connectivity and habitat restoration
- Road boundary
- Road design
- Service Road - Old Coast Road
- Clearing boundary
- State Forest boundary
- Lot (survey)
- Combined culvert with fauna underpass
- Dedicated fauna underpass
- Fauna fence
- Bridge with fauna passage
- Incidental fauna passage

Vegetation map units (WC2U EA, RTA 2010)

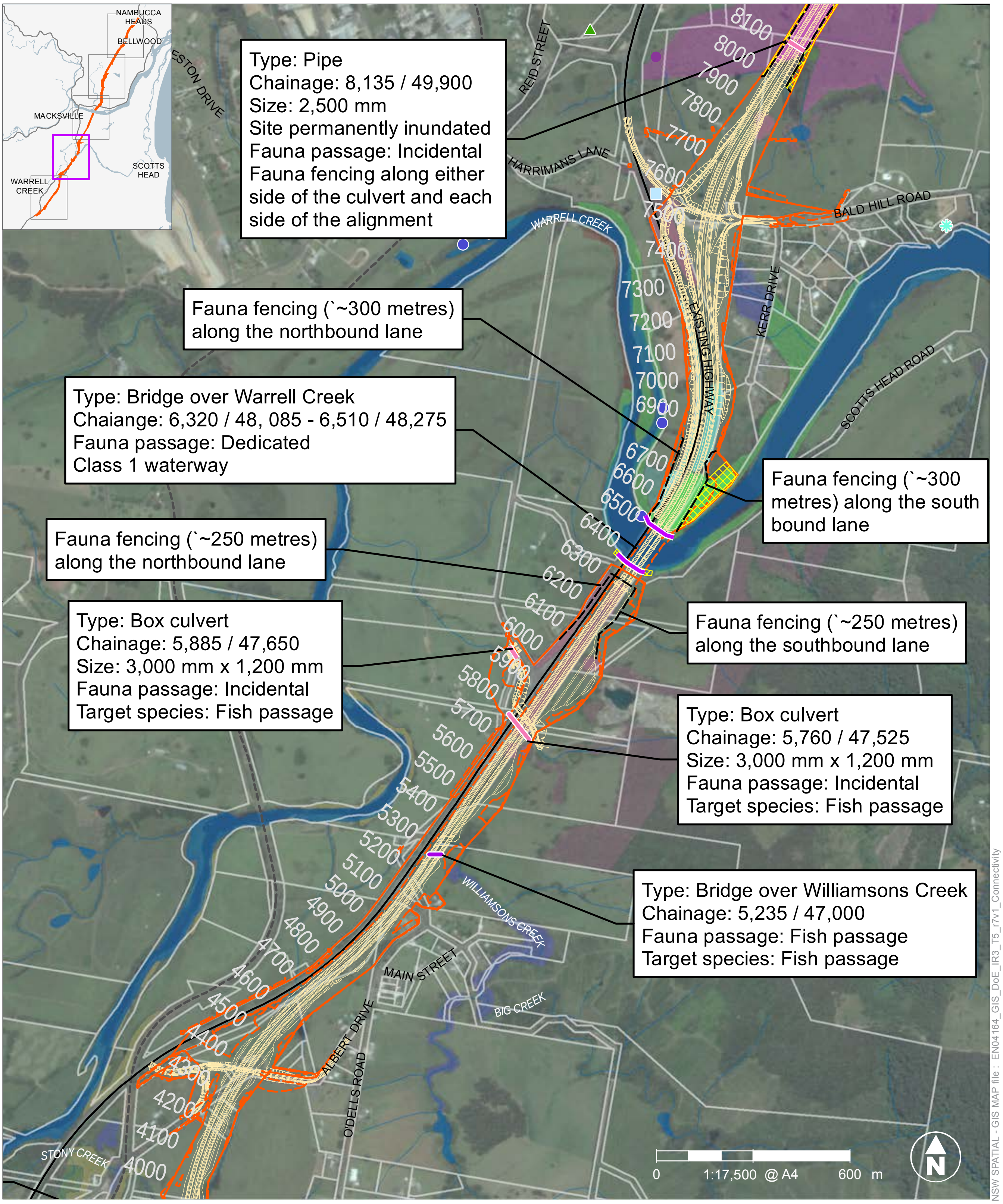
- Map Unit 1: Open Forest - Blackbutt
- Map Unit 2: Mixed Floodplain Forest (Subtropical Coastal Floodplain Forest (EEC – TSC Act)
- Map Unit 3: Moist Open Forest - White Mahogany/Grey Gum/Ironbark
- Map Unit 4: Moist Open Forest - Flooded Gum
- Map Unit 5: Lowland Rainforest (EEC – EPBC Act and the TSC Act)
- Map Unit 6: Swamp Forest - Swamp Mahogany/Paperbark (Swamp Sclerophyll Forest (EEC – TSC Act)
- Map Unit 7: Swamp Forest - Swamp Oak (Swamp Oak Floodplain Forest (EEC – TSC Act)
- Map Unit 8: Freshwater Wetlands (TEC – TSC Act)
- Map Unit 9: Mangrove Forest
- Map Unit 10: Coastal Saltmarsh (VEC – EPBC Act and TSC Act)
- Map Unit 11: Open Forest - Scribbly Gum
- Map Unit 12: Hardwood plantation
- Map Unit 13: Softwood plantation

NOTES

- The chainages in this figure reflect the WC2U EA chainages. To convert these to the referral chainages add 41765.
- The locations of the fauna crossings and fauna fences are indicative only.

DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information

NSW GOVERNMENT Transport Roads & Maritime Services JACOBS



Legend

- Proposed areas of connectivity and habitat restoration
- Road boundary
- Road design
- Service Road - Old Coast Road
- Clearing boundary
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- Incidental fauna passage

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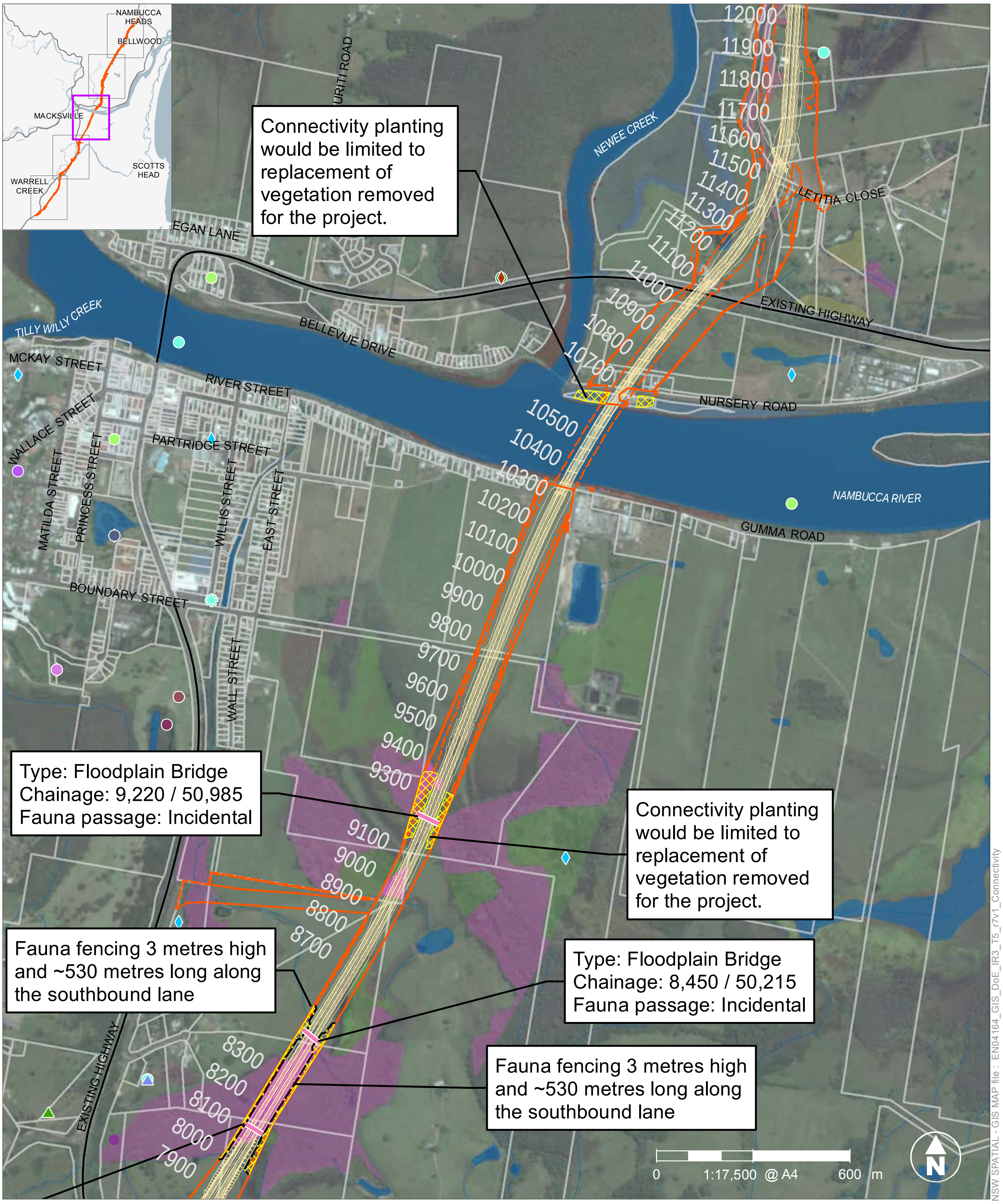

Legend

- Proposed areas of connectivity and habitat restoration
- Road boundary
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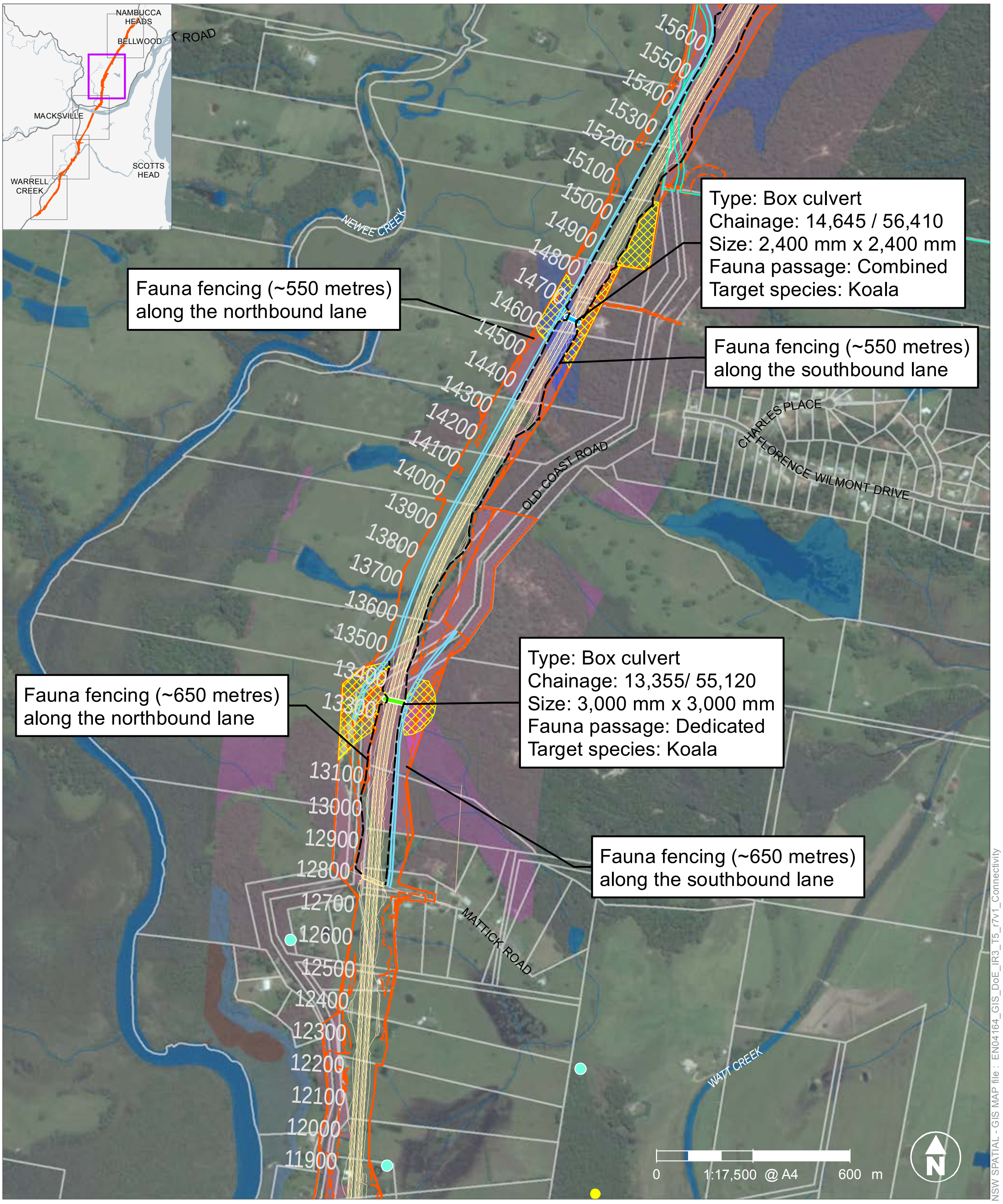

Legend

- Proposed areas of connectivity and habitat restoration
- Road boundary
- Road design
- Service Road - Old Coast Road
- Clearing boundary
- State Forest boundary
- Lot (survey)
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- Dedicated fauna underpass
- Fauna fence
- Bridge with fauna passage
- Incidental fauna passage

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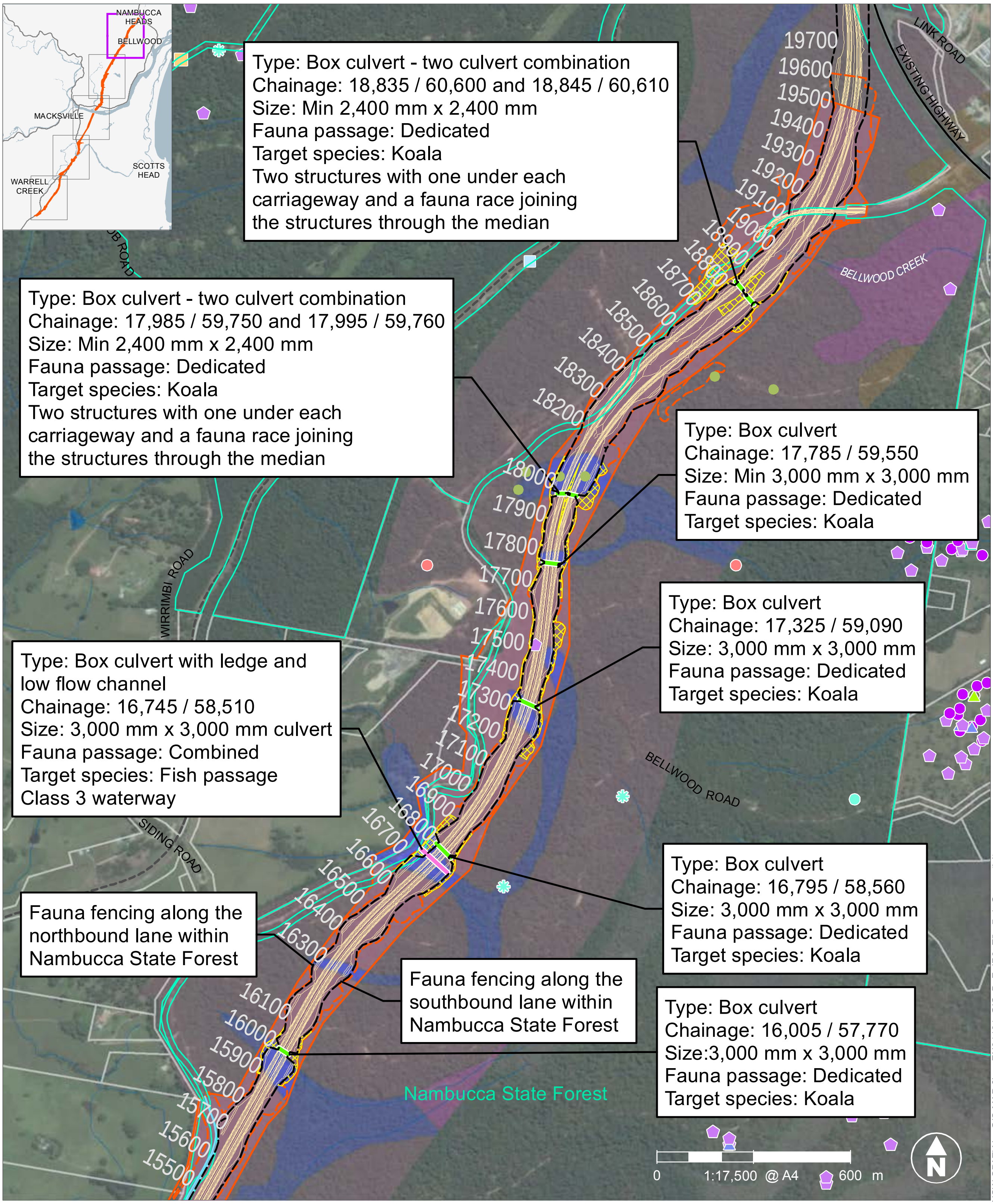
This mapping is current as at December 2013 and could be refined with updated survey information

NSW Transport Roads & Maritime Services JACOBS



Legend

- Proposed areas of connectivity and habitat restoration
- Road boundary
- Road design
- Service Road - Old Coast Road
- Clearing boundary
- State Forest boundary
- Lot (survey)
- Combined culvert with fauna underpass
- Dedicated fauna underpass
- Fauna fence
- Bridge with fauna passage
- Incidental fauna passage

Vegetation map units (WC2U EA, RTA 2010)

- Map Unit 1: Open Forest - Blackbutt
- Map Unit 2: Mixed Floodplain Forest (Subtropical Coastal Floodplain Forest (EEC – TSC Act)
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- Map Unit 11: Open Forest - Scribbly Gum
- Map Unit 12: Hardwood plantation
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NOTES

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DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information

NSW Transport Roads & Maritime Services JACOBS

Appendix C

Koala Capture Relocation Strategy

Warrell Creek to Nambucca Heads (WC2NH) Pacific Hwy Upgrade Koala Capture and Relocation Strategy

The Koala *(Phascolarctos cinereus*) is listed as threatened (vulnerable) under NSW (*Threatened Species Conservation Act* 1995) and Commonwealth (*Environment Protection and Biodiversity Conservation Act* 1999) legislation. The following strategy has been prepared to minimise impacts on Koalas during the construction phase of the Warrell Creek to Nambucca Heads Pacific Highway Upgrade and satisfy standard pre-clearing protocols. The strategy establishes a procedure to be followed during the clearing phase and guidelines for the capture and relocation of Koalas that are encountered during clearing and grubbing operations.

Background information on the distribution of Koalas within and adjoining the WC2NH upgrade alignment will be obtained from the baseline surveys conducted to satisfy EPBC Act conditions of approval. This data will identify areas of Koala habitat and will compliment targeted surveys during the clearing phase.

1. <u>Surveys for Koalas during clearing operations:</u>
   a. In areas containing potential Koala habitat, foot-based, observational surveys for Koalas ('Koala Surveys') will be conducted the night before (using spotlights) and in the morning immediately prior to clearing in all areas of habitat. Potential Koala habitat is defined as areas where scats have been collected, where Koalas have been sighted, or where primary and secondary feed trees meet the appropriate thresholds of 30 per cent and 50 per cent.
   b. Koala Surveys will cover the area scheduled for clearing that day ('Day Clearing Zone') and immediately adjacent habitat.
   c. Koala Surveys may extend beyond the Day Clearing Zone to establish the presence or otherwise of Koalas ahead of the clearing front.
   d. Clearing contractors and site staff will be asked to provide any sightings of Koalas to the Environment Team.

NB: Pre-clearing surveys will concentrate on habitat within the Limit of Clearing (LoC) and Koalas outside that area will be recorded incidentally.

2. <u>Koala identified in tree within Day Clearing Zone and within LoC in area of contiguous habitat:</u>
   a. Immediately enforce a 50 metre-radius Exclusion Zone (refer Point 6) around occupied tree.
   b. Install Koala pen trap, unless sighting occurs on a Friday when individuals would be left to move unassisted.
   c. Capture Koala and assess health status.
   d. Sick and/or injured Koalas transported to Port Macquarie Koala hospital.
   e. Healthy and un-injured Koalas relocated as per Point 5 below.
   f. Koalas would only be removed from site if they require treatment or hospitalisation.

NB: In some instances it may take several days to capture a Koala, and capture time may be influenced by stress. Pen traps would be installed for 72 hours before alternate methods are applied. Standard alternate procedure would involve the use of flags to force Koalas to descend the tree where they are hand captured. A tree climber may be required in some instances.

3. <u>Koala identified in tree within Day Clearing Zone and within LoC in isolated remnant (no suitable release habitat within 200 metres of site):</u>
   a. Clearing of remnant would cease and Koala allowed to move unassisted – no trapping would occur.
   b. Periodic daytime observation and spotlighting would occur to track Koala movement within remnant.

4. <u>Koala identified in tree up to 50 metres outside the LoC and adjacent Day Clearing Zone:</u>
   a. Immediately enforce a 50 metre-radius Exclusion Zone (refer Point 6) around occupied tree.
   b. Assess the site and ecologist to determine an appropriate course of action. Options include:
      i. Retain Exclusion Zone and avoid clearing the buffer until Koala has relocated.
      ii. Implement trapping protocol (Point 2).
      iii. Continue clearing whilst spotter observes Koala.

5. Retention and relocation:
   a. Captured individuals shall be relocated within their predicted home range, and:
      i. Behind the clearing front.
      ii. Outside LoC.
      iii. Away from source of mortality.
      iv. Within suitable habitat as identified by the ecologist.
   b. Captured individuals will be released at dusk or cessation of days clearing operations (whichever is later) on the day of capture. Until release, Koalas will be moved from the pen trap into a large nest box (owl size) where they will be kept in a cool, dark location. If Koalas are captured in the early hours of the morning they shall be released immediately.
   c. Where possible a captured Koala would be released within the Project boundary. However, the suitability of the release site must be carefully assessed and it may be necessary to release the animal in adjoining habitat. If the capture site adjoins private land contact the Communications Manager to organize access.
   d. Key points to consider in identifying a suitable release site include: sex (female Koalas have smaller home ranges than males); predicted home range in the locality (has there been any home range studies nearby?); location and proximity of busy roads or other potential sources of mortality/ disturbance; extent of forest and degree of fragmentation; area to be cleared and direction of clearing; presence of suitable feed trees.

6. Exclusion (Buffer) Zone restrictions:
   a. No clearing or grubbing operations within Exclusion Zone with the exceptions outlined below.
   b. Hand felling of small shrubs around occupied tree (i.e. shrubs with interlocking canopy or within two metres of trunk) is permissible to improve effectiveness of pen trap.
   c. Plant and equipment may be 'walked' through Exclusion Zone under supervision of Project Ecologist. Machinery must be walked as far from the occupied tree as possible and clearing would be limited to vegetation <150 mm diameter.
   d. Clearing outside the buffer must be done in such a manner to ensure that felled timber does not enter the buffer zone.

7. Incidental Observations of Koalas:
   a. All site personnel to be instructed (weekly tool box, staff notifications) to report Koala sightings to the Project Ecologist or Environmental Manager and to immediately enforce a 50 metre Exclusion Zone around sighted individual(s).
   b. Environmental staff and plant and machinery operators conducting clearing operations shall be tool boxed on key aspects of the Koala Capture and Relocation Strategy, particularly Exclusion Zone restrictions and areas of known or predicted high Koala activity.
   c. All contractors and staff must be aware of Koala presence when moving around the site at dawn or dusk (periods of increased Koala activity) particularly during the winter months when site work overlaps these periods.

8. Data management and review:
   a. Project Ecologist to maintain record of Koala sightings, captures, relocations and transfers to Koala hospital.
   b. Koala Capture and Relocation Strategy to be reviewed by ecologist prior to 2014 Koala breeding season (Jul – Dec).

Appendix D

Fauna Crossing Structures

Appendix A Summary of the fauna crossing locations for the upgrade of the Pacific Highway, WC2NH.

Chainage Referral	Chainage WC2U EA	Fauna Crossing Structure Type	Structure Form	Number and Dimensions	Fish Passage Requirements	Additional Requirements
42km500	735	Combined	Bridge over Upper Warrell Creek	(-)	Class 1 waterway[3]	Minimum 3 metre wide fauna passage required at each abutment. Giant Barred Frog and fish included as target species.
43km325	1,560	Combined	Box culvert Butchers Creek	Minimum 5 no. x 3600mm x 1500mm high	Class 2 waterway[3] Set one culvert cell 200mm (minimum) below existing bed level. Continue low flow channel through scour protection	Two outside cells must provide dry passage during a 1 in 1 year ARI, 3 day (72 hour) storm event and must not have wet sections that retain water for longer than three days.. No refuge poles required. Approximate culvert length is 47 m.
44km905	3,140	Fish passage	Box culvert	Minimum 3300 mm wide x 1800 mm high	Class 3 waterway [3]. Include low flow channel 200 mm (minimum) below existing bed level and 450 mm wide. Continue low flow channel	Waterway realignment must ensure bed stability; and maintain existing flow velocity. Fish passage.
45km525	3,760	Incidental	Box culvert	Minimum 5 no. x 4200 mm wide x 3600 mm high	Class 3 waterway [3]. Set one culvert cell 200 mm (minimum) below existing bed level. Continue low flow channel through scour protection	Waterway realignment must ensure bed stability; minimise increasing or decreasing existing waterway length; and maintain existing flow velocity. Fish passage.

Chainage Referral	Chainage WC2U EA	Fauna Crossing Structure Type	Structure Form	Number and Dimensions	Fish Passage Requirements	Additional Requirements
47km000	5,235	Fish passage	Bridge over Williamsons Creek	(-)	Class 3 waterway[3]	
47km525	5,760	Incidental	Box culvert	Minimum 3000 mm wide x 1200 mm high	Class 3 waterway [3]. Include low flow channel 200 mm (minimum) below existing bed level and 450 mm wide. Continue low flow channel through scour protection	Must extend under existing Pacific Highway. Fish passage.
47km650	5,885	Incidental	Box culvert	Minimum 3000 mm wide x 1200 mm high	Fish passage.	
48km085	6,320	Dedicated	Bridge	(-)		Fauna corridor listed is under southern end span of bridge. Minimum 3 metre wide fauna passage required.
48km215	6,450	Dedicated	Bridge	(-)	Class 1 waterway[3]	
48km275	6,510	Dedicated	Bridge	(-)		Fauna corridor listed is under northern end span. Minimum 3 metre wide fauna passage required
49km900	8,135	Incidental	Pipe	2,500 mm diameter	No	Must provide water connectivity across Main carriageways. Site permanently inundated.

Chainage Referral	Chainage WC2U EA	Fauna Crossing Structure Type	Structure Form	Number and Dimensions	Fish Passage Requirements	Additional Requirements
50km215	8,450	Incidental	Bridge	Minimum width between the intersection of the scour protection and the finished ground level under the bridge to be 50.4m (see Note 1). Minimum vertical clearance to be 2.0 m (subject to detailed design).	No	
50km985	9,220	Incidental	Bridge	Minimum width between the intersection of the scour protection and the finished ground level under the bridge to be 50.4m (see Note 1). Minimum vertical clearance to be 2.0 m (subject to detailed design).	No	

Chainage Referral	Chainage WC2U EA	Fauna Crossing Structure Type	Structure Form	Number and Dimensions	Fish Passage Requirements	Additional Requirements
55km120	13,355	Dedicated	Box culvert	3000 mm x 3000 mm	No	Approximate length of culvert under main carriageway is 50 m. No culvert is to be provided under the service road but detailed design to investigate lowering the service road to provide better visibility across the service road from the culvert. Fauna fencing to be provided along the bottom of the batter slope between the highway and the service road to prevent fauna accessing the main highway. Koala included as target species
56km410	14,645	Combined	Box culvert	Minimum 2400 mm x 2400 mm	No	Approximate culvert length under main carriageway is 45 m. No fauna underpass is required under the service road. Koala included as target species. Provide ledge for dry passage during a 1 in 1 year ARI, 3 day (72 hour) storm event and must not have wet sections that retain water for longer than three days.
57km770	16,005	Dedicated	Box culvert	3000 mm x 3000 mm	No	Maximum culvert length is 50 m. Koala included as target species

Chainage Referral	Chainage WC2U EA	Fauna Crossing Structure Type	Structure Form	Number and Dimensions	Fish Passage Requirements	Additional Requirements
58km510	16,745	Combined	Box culvert	3000 mm x 3000 mm	Class 3 waterway3 Include low flow channel 1200mm wide x 200mm deep below existing bed level. Continue low flow channel through scour protection. Fish passage.	Approximate culvert length is 84m. Provide ledge for dry passage during a 1 in 1 year ARI, 3 day (72 hour) storm event and must not have wet sections that retain water for longer than three days. Adjacent box or pipe culvert to also be provided for drainage.
58km560	16,795	Dedicated	Box culvert	3000 mm x 3000 mm	No	Maximum culvert length is 50 m. Koala included as target species
59km090	17,325	Dedicated	Box culvert	3000 mm x 3000mm	No	Culvert length is 58 m. Length slightly in excess of 50 metres however was agreed to be acceptable if needed to achieve desired location. Koala included as target species
59km550	17,785	Dedicated	Box culvert	Minimum 3000 mm x 3000 mm	No	Approximate culvert length is 50 m. Koala included as target species
59km750 (northbound carriageway)	17,985	Dedicated	Box culvert	2400 mm x 2400 mm	No	Approximate culvert length is 38 m. Culvert to be moved up the bank to achieve the 1 in 100 year ARI flood immunity. Koala included as target species

Chainage Referral	Chainage WC2U EA	Fauna Crossing Structure Type	Structure Form	Number and Dimensions	Fish Passage Requirements	Additional Requirements
59km760 (southbound carriageway)	17,995	Dedicated	Box culvert	Minimum 2400 mm x 2400 mm	No	Approximate culvert length is 25 m. Combined length of the northbound and southbound underpasses is around 63 m. Carriageway separation is approximately 10 m with a fauna fenced race in between underpasses. Koala included as target species
60km615 (northbound carriageway)	18,850	Dedicated	Box culvert	2400 mm x 2400 mm	No	Approximate culvert length is 29 m. Structure to be shifted to the north around 15 metres to align with southbound carriageway. Koala included as target species.
60km600 (southbound carriageway)	18,835	Dedicated	Box culvert	Minimum 2400 mm x 2400 mm	No	Approximate culvert length is 30 m. Combined length of the northbound and southbound underpasses is around 59 m. Carriageway separation is approximately 19 m with a fauna fenced race in between underpasses. Koala included as target species.

1 A bridge may be provided in lieu of a box culvert provided that the total width between the intersection of the scour protection and the finished ground level under the bridge is at least equivalent to the total clear width of the cells of the replaced box culvert.

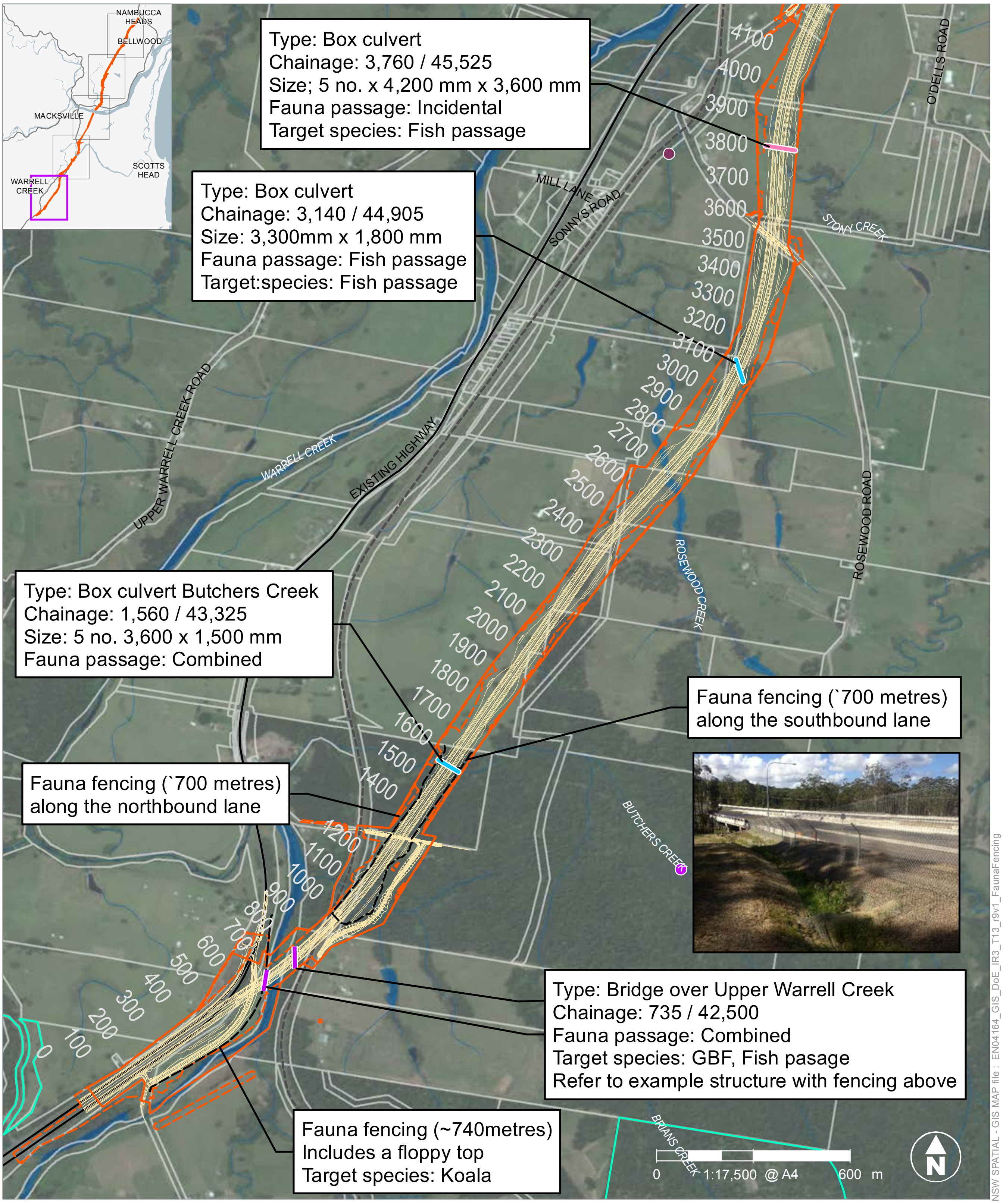
2 Separate fauna crossing structures must be provided for the Main Carriageways and Service Road to provide daylight between the Main Carriageways and Service Road structures.

3 Classification identified in consultation with DPI (Fisheries Conservation and Aquaculture)

Appendix E

Fauna Exclusion Fencing

Attachment A Figure 1 | Threatened species, proposed fauna fencing and underpass locations



Legend

- Road design
- Service Road - Old Coast Road
- Road boundary
- Clearing boundary
- Lot (survey)
- State Forest boundary
- Combined culvert with fauna underpass
- Dedicated fauna underpass
- Fauna fence
- Bridge with fauna passage
- Incidental fauna passage

Threatened fauna

- Black Bittern
- Black Grass-dart Butterfly
- Black-necked Stork
- Brolga
- Brush-tailed Phascogale
- Cattle Egret
- Common Greenshank
- Eastern Bentwing-bat
- Eastern Freetail-bat
- Eastern Osprey
- Glossy Black-Cockatoo
- Glossy Ibis
- Greater Broad-nosed Bat
- Green and Golden Bell Frog
- Grey-headed Flying-fox
- Koala
- Latham's Snipe
- Little Bentwing-bat
- Masked Owl
- Oriental Pratincole
- Osprey (nest site)
- Pacific Golden Plover
- Powerful Owl
- Rainbow Bee-eater
- Regent Honeyeater
- Sooty Owl
- Southern Myotis
- Spotted-tailed Quoll
- Square-tailed Kite
- Squirrel Glider
- White-bellied Sea-Eagle
- Yellow-bellied Glider

NOTES

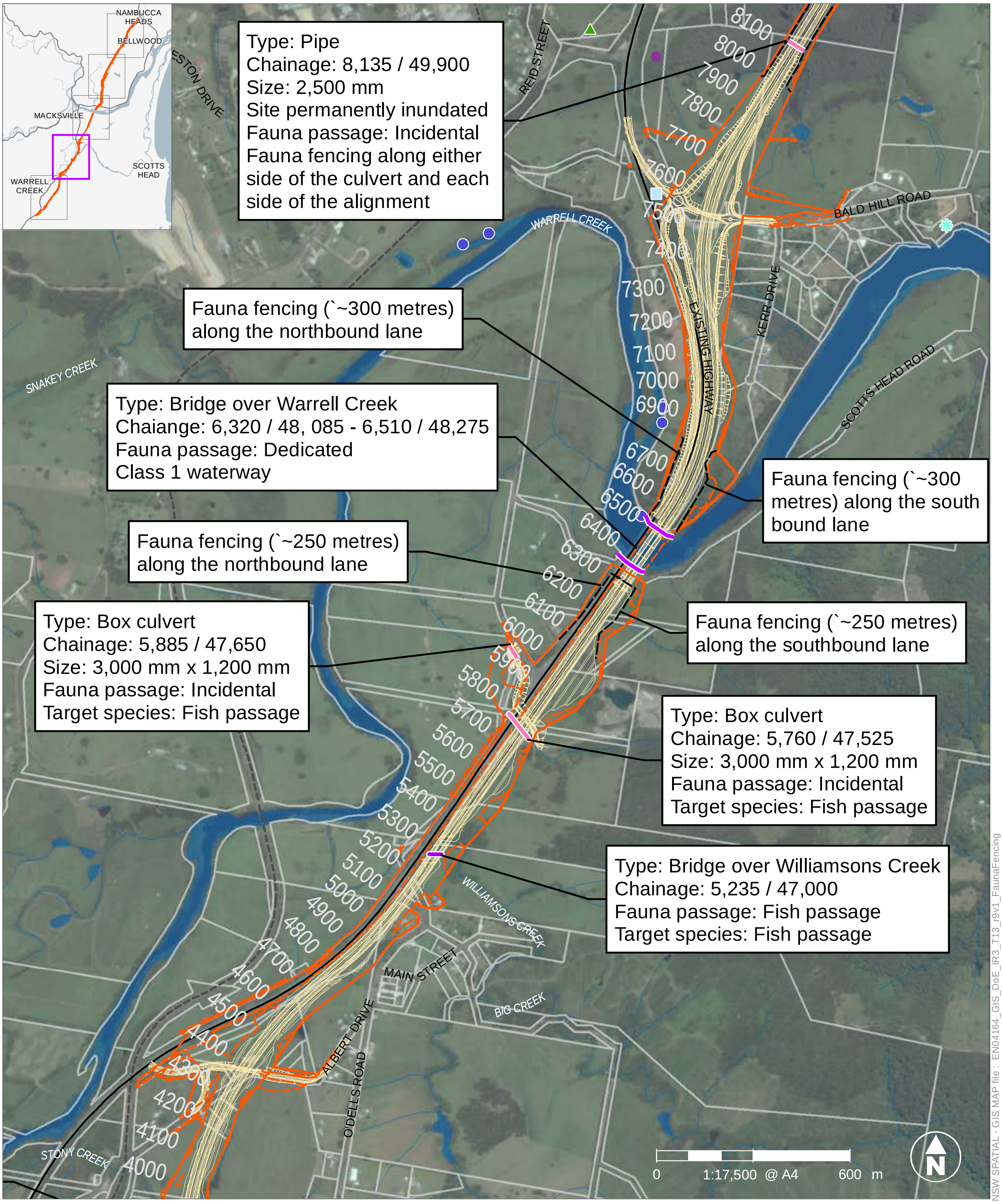
- The chainages in this figure reflect the WC2U EA chainages. To convert these to the referral chainages add 41765.
- The locations of the fauna crossings and fauna fences are indicative only.

DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information

EPBC REFERRAL
Upgrade of the Pacific Highway, Warrell Creek to Nambucca Heads

NSW GOVERNMENT Transport Roads & Maritime Services JACOBS

Attachment A Figure 2 | Threatened species, proposed fauna fencing and underpass locations



Legend

- Road design
- Service Road - Old Coast Road
- Road boundary
- Clearing boundary
- Lot (survey)
- State Forest boundary
- Combined culvert with fauna underpass
- Dedicated fauna underpass
- Fauna fence
- Bridge with fauna passage
- Incidental fauna passage

Threatened fauna

- Black Bittern
- Black Grass-dart Butterfly
- Black-necked Stork
- Brolga
- Brush-tailed Phascogale
- Cattle Egret
- Common Greenshank
- Eastern Bentwing-bat
- Eastern Freetail-bat
- Eastern Osprey
- Glossy Black-Cockatoo
- Glossy Ibis
- Greater Broad-nosed Bat
- Green and Golden Bell Frog
- Grey-headed Flying-fox
- Koala
- Latham's Snipe
- Little Bentwing-bat
- Masked Owl
- Oriental Pratincole
- Osprey (nest site)
- Pacific Golden Plover
- Powerful Owl
- Rainbow Bee-eater
- Regent Honeyeater
- Sooty Owl
- Southern Myotis
- Spotted-tailed Quoll
- Square-tailed Kite
- Squirrel Glider
- White-bellied Sea-Eagle
- Yellow-bellied Glider

NOTES

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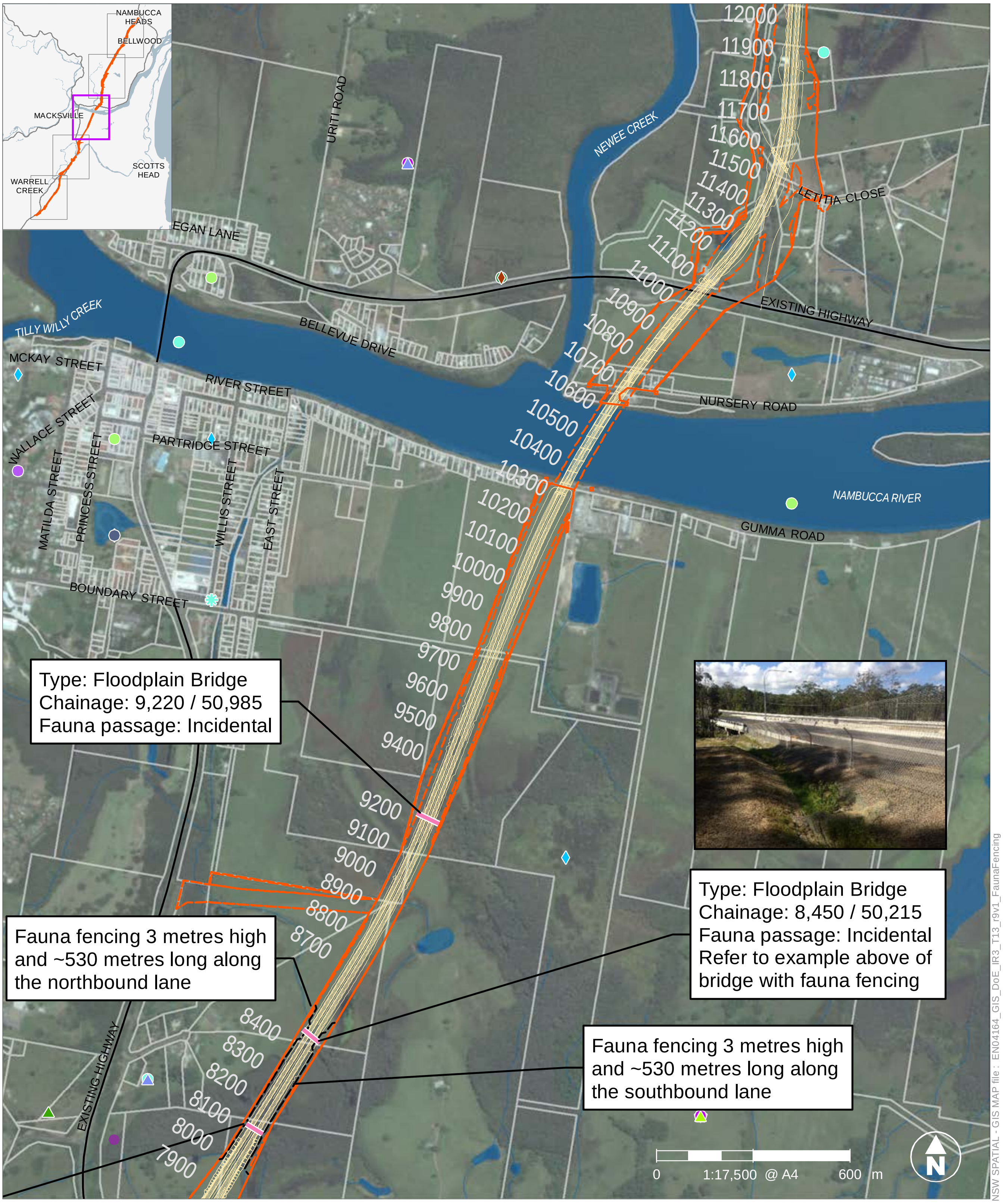
- The locations of the fauna crossings and fauna fences are indicative only.

DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information

NSW GOVERNMENT Transport Roads & Maritime Services JACOBS

Attachment A Figure 3 | Threatened species, proposed fauna fencing and underpass locations



Legend

- Road design
- Service Road - Old Coast Road
- Road boundary
- Clearing boundary
- Lot (survey)
- State Forest boundary
- Combined culvert with fauna underpass
- Dedicated fauna underpass
- Fauna fence
- Bridge with fauna passage
- Incidental fauna passage

Threatened fauna

- Black Bittern
- Black Grass-dart Butterfly
- Black-necked Stork
- Brolga
- Brush-tailed Phascogale
- Cattle Egret
- Common Greenshank
- Eastern Bentwing-bat
- Eastern Freetail-bat
- Eastern Osprey
- Glossy Black-Cockatoo
- Glossy Ibis
- Greater Broad-nosed Bat
- Green and Golden Bell Frog
- Grey-headed Flying-fox
- Koala
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- Masked Owl
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- Powerful Owl
- Rainbow Bee-eater
- Regent Honeyeater
- Sooty Owl
- Southern Myotis
- Spotted-tailed Quoll
- Square-tailed Kite
- Squirrel Glider
- White-bellied Sea-Eagle
- Yellow-bellied Glider

NOTES

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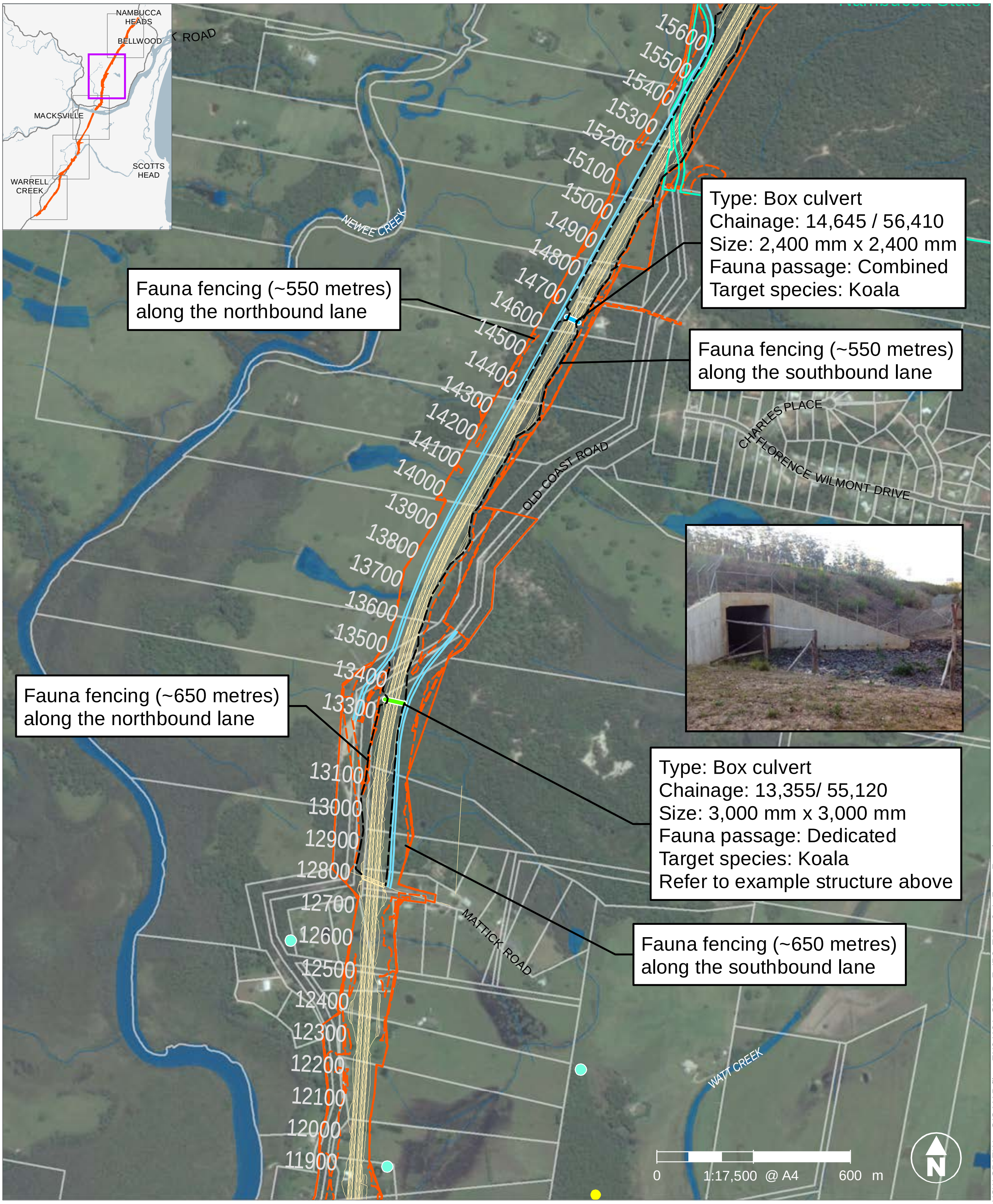
- The locations of the fauna crossings and fauna fences are indicative only.

DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information



NSW SPATIAL - GIS MAP file : EN04164_GIS_DoE_IR3_T13_r9v1_FaunaFencing

Legend

Road design
Service Road - Old Coast Road
Road boundary
Clearing boundary
Lot (survey)
State Forest boundary
Combined culvert with fauna underpass
Dedicated fauna underpass
Fauna fence
Bridge with fauna passage
Incidental fauna passage

Threatened fauna

- Black Bittern
- Black Grass-dart Butterfly
- Black-necked Stork
- Brolga
- Brush-tailed Phascogale
- Cattle Egret
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- Southern Myotis
- Spotted-tailed Quoll
- Square-tailed Kite
- Squirrel Glider
- White-bellied Sea-Eagle
- Yellow-bellied Glider

NOTES

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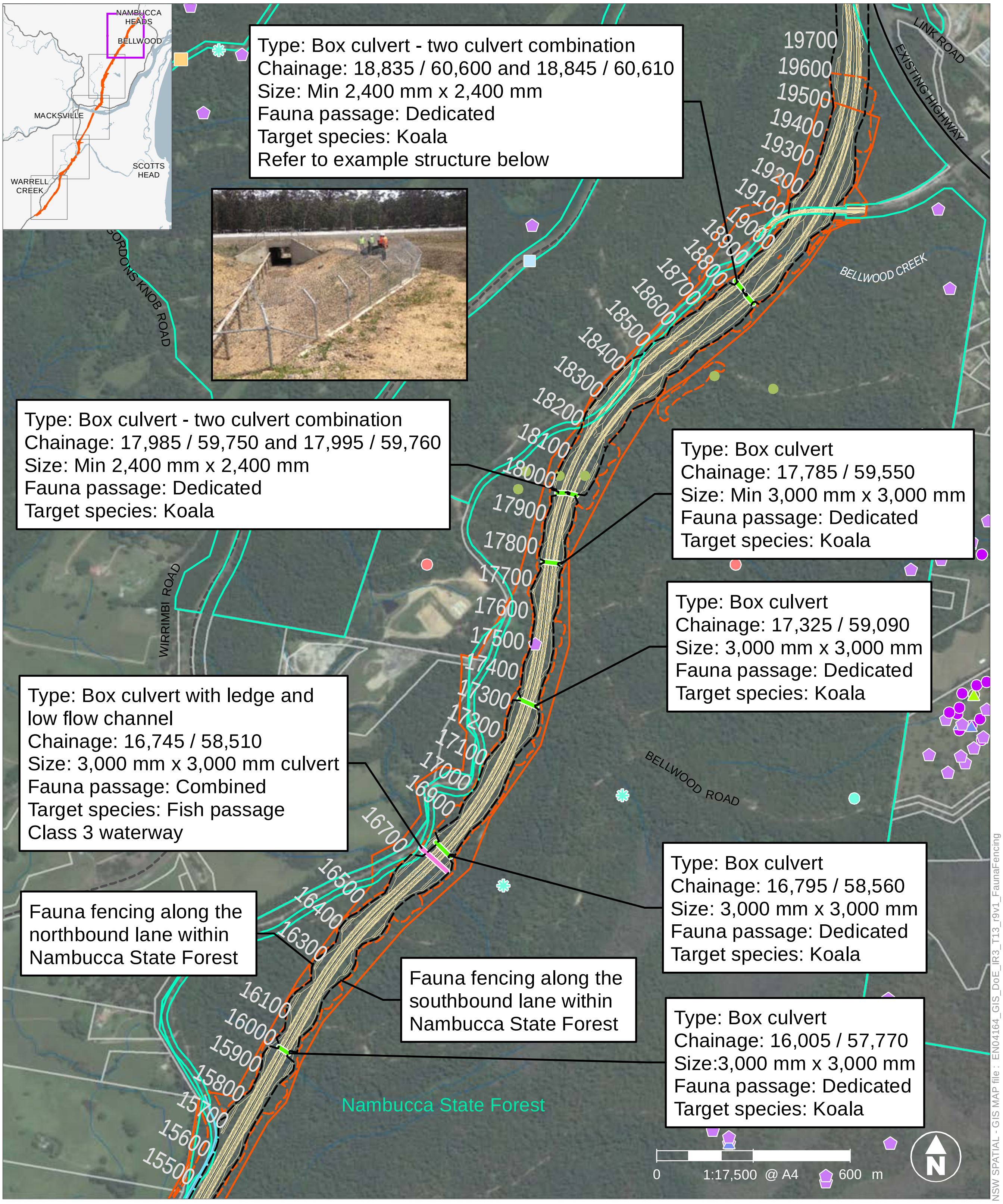
- The locations of the fauna crossings and fauna fences are indicative only.

DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information

Attachment A Figure 5 | Threatened species, proposed fauna fencing and underpass locations



Legend

- Road design
- Service Road - Old Coast Road
- Road boundary
- Clearing boundary
- Lot (survey)
- State Forest boundary
- Combined culvert with fauna underpass
- Dedicated fauna underpass
- Fauna fence
- Bridge with fauna passage
- Incidental fauna passage

Threatened fauna

- Black Bittern
- Black Grass-dart Butterfly
- Black-necked Stork
- Brolga
- Brush-tailed Phascogale
- Cattle Egret
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- Grey-headed Flying-fox
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- Spotted-tailed Quoll
- Square-tailed Kite
- Squirrel Glider
- White-bellied Sea-Eagle
- Yellow-bellied Glider

NOTES

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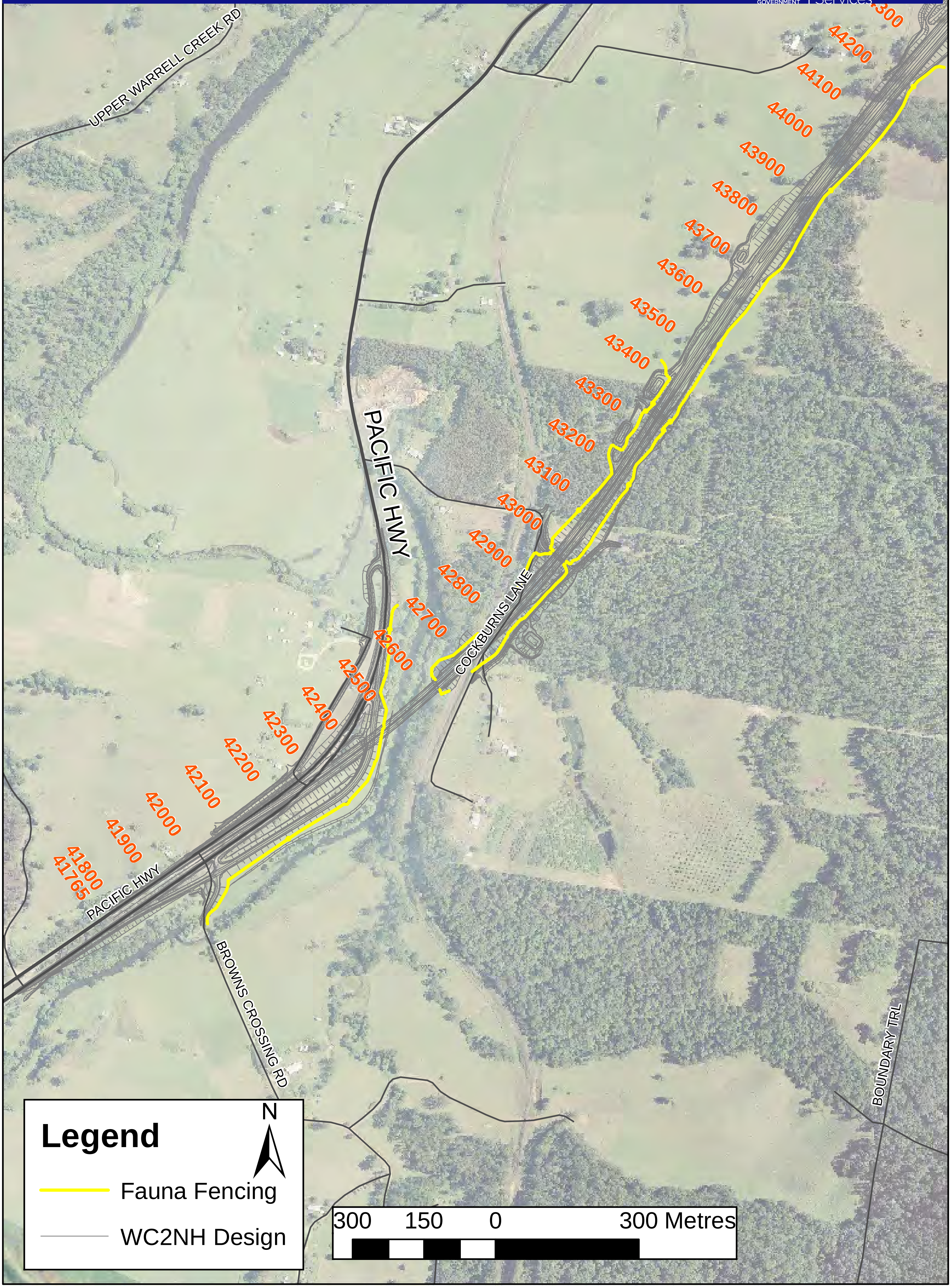
- The locations of the fauna crossings and fauna fences are indicative only.

DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information

PACIFIC HIGHWAY UPGRADE - Warrell Creek to Nambucca Heads

Attachment B Figure 1 Fauna Fencing locations



PACIFIC HIGHWAY UPGRADE - Warrell Creek to Nambucca Heads

Attachment B Figure 2 Fauna Fencing locations

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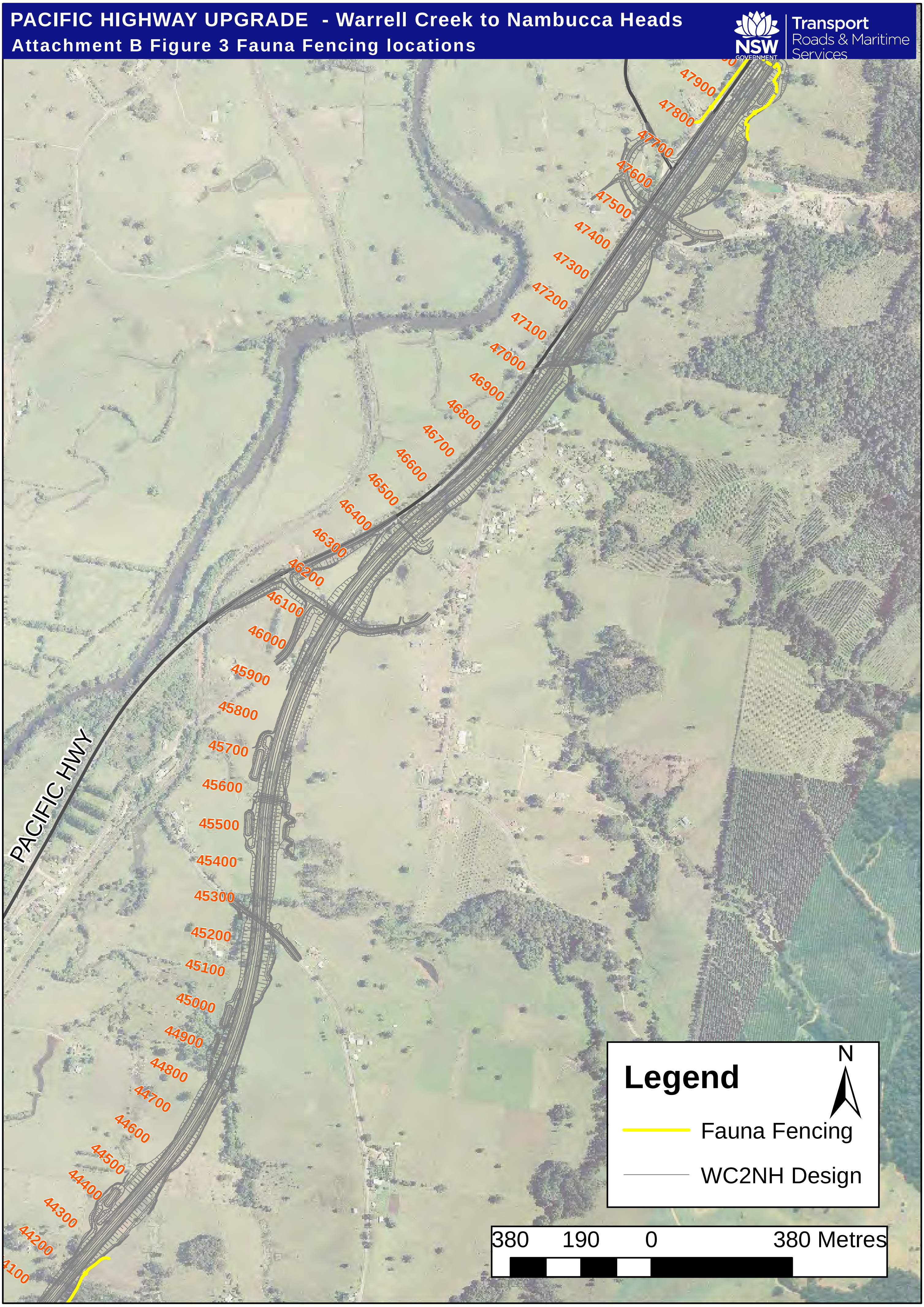
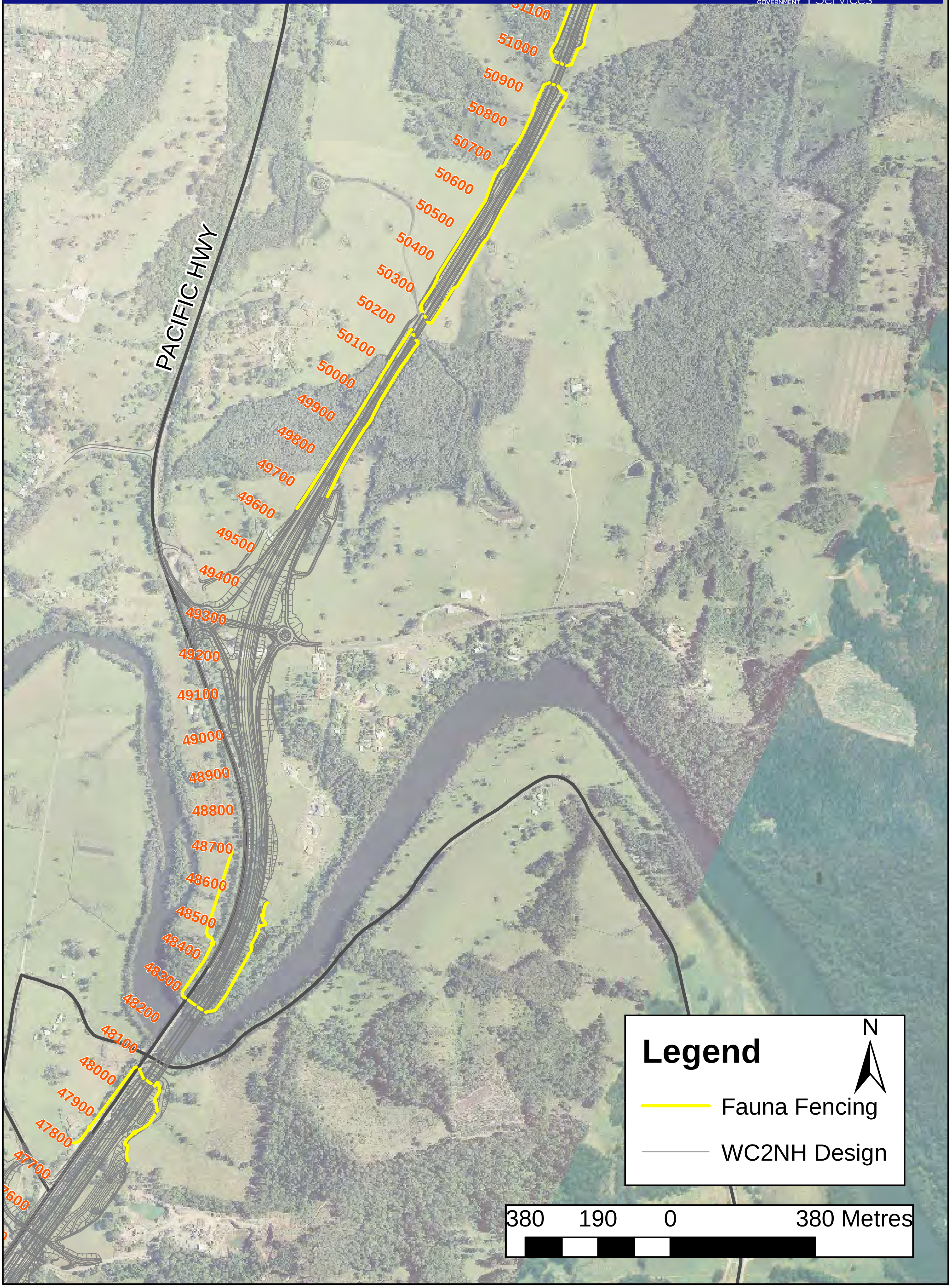
PACIFIC HIGHWAY UPGRADE - Warrell Creek to Nambucca Heads

Attachment B Figure 3 Fauna Fencing locations



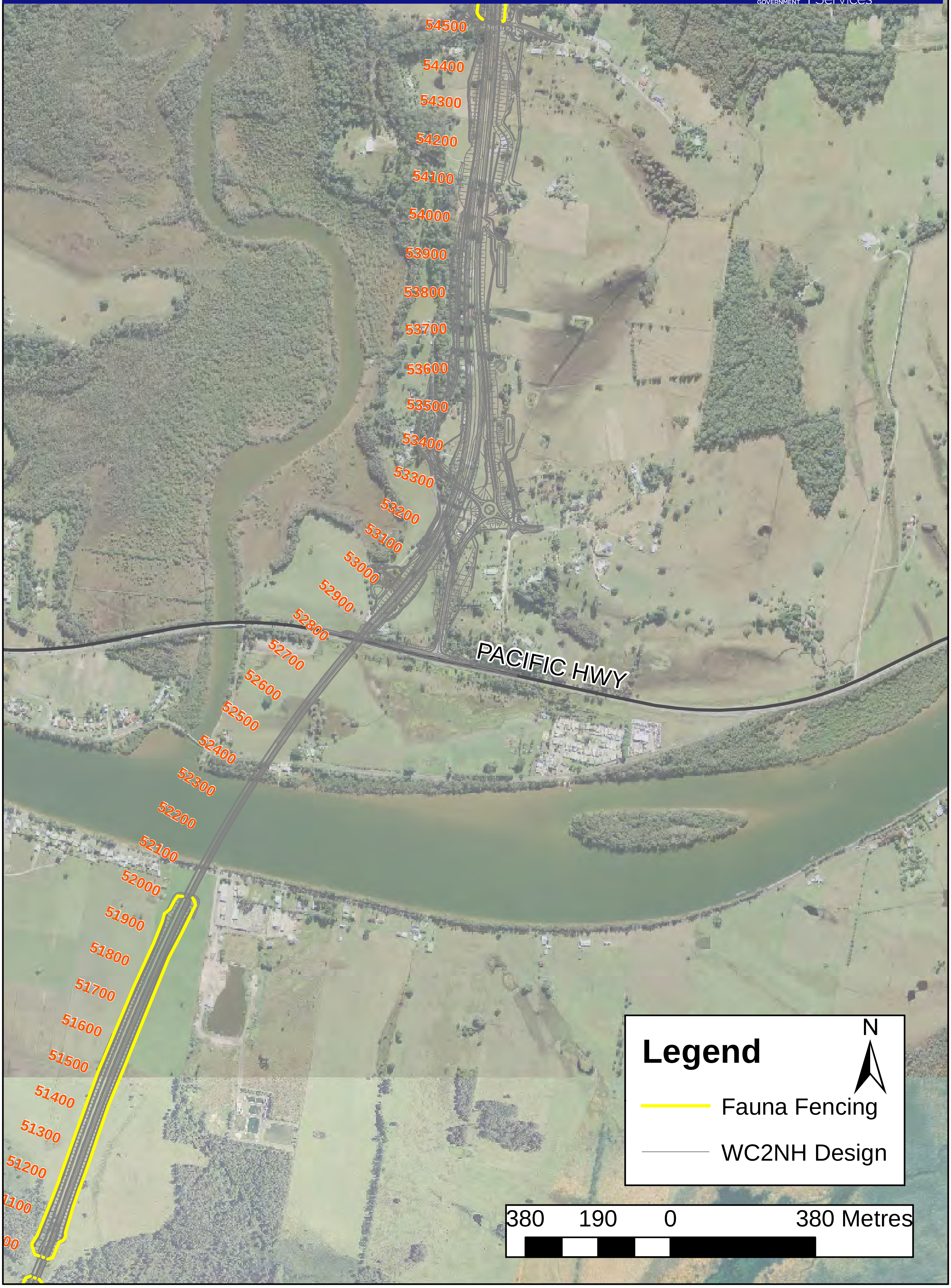
PACIFIC HIGHWAY UPGRADE - Warrell Creek to Nambucca Heads

Attachment B Figure 4 Fauna Fencing locations



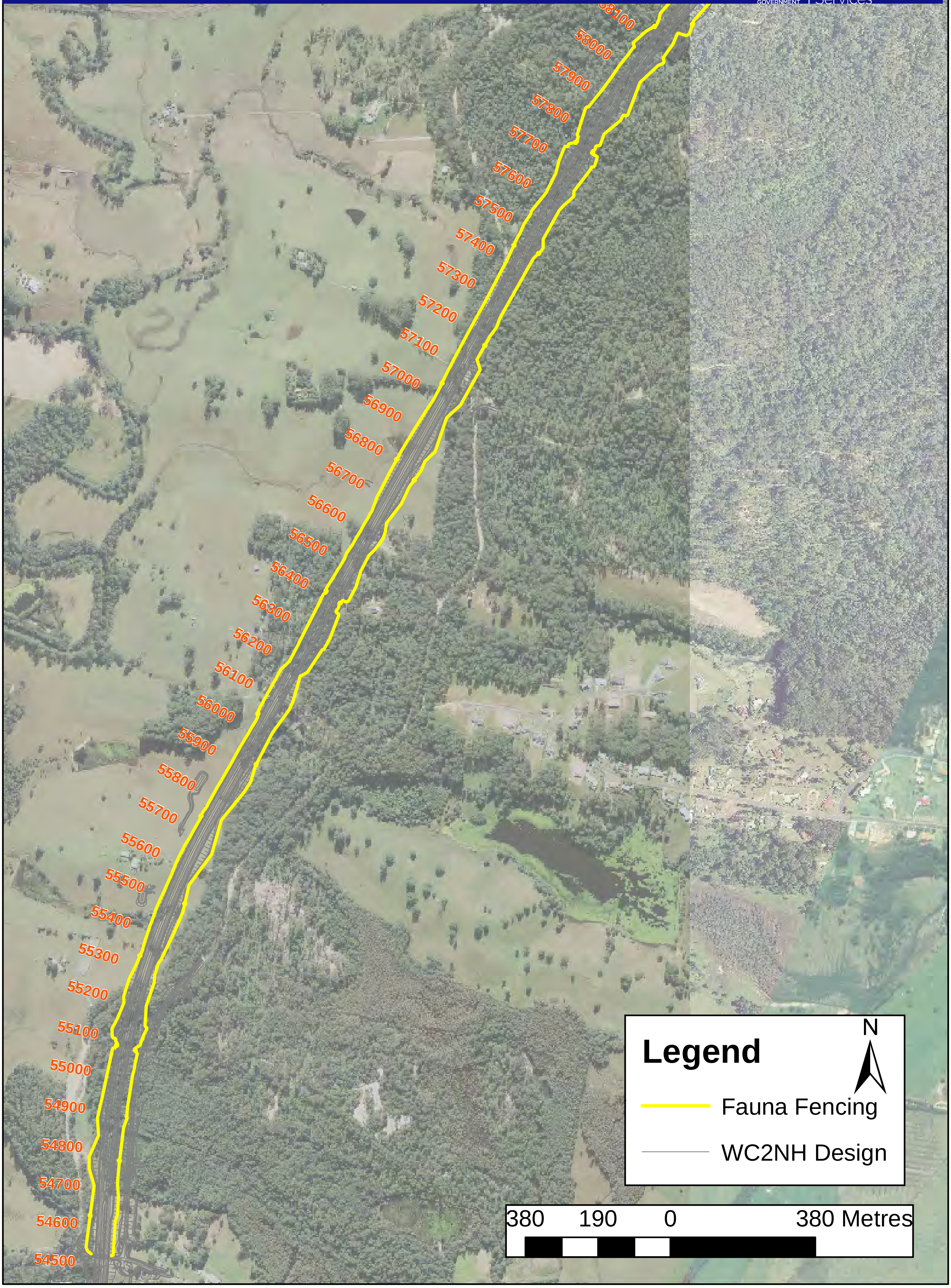
PACIFIC HIGHWAY UPGRADE - Warrell Creek to Nambucca Heads

Attachment B Figure 5 Fauna Fencing locations



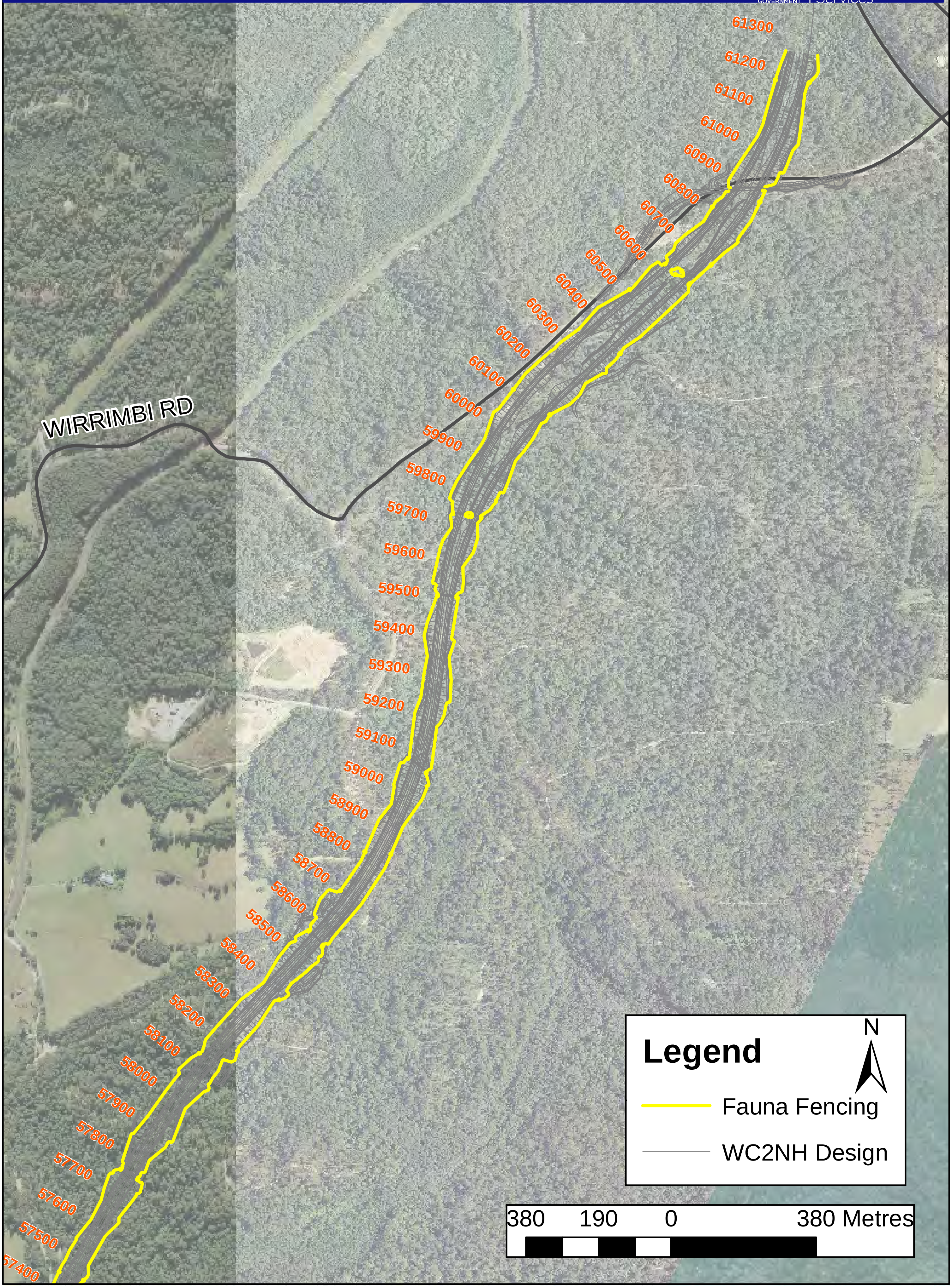
PACIFIC HIGHWAY UPGRADE - Warrell Creek to Nambucca Heads

Attachment B Figure 6 Fauna Fencing locations



PACIFIC HIGHWAY UPGRADE - Warrell Creek to Nambucca Heads
Attachment B Figure 7 Fauna Fencing locations

Transport Roads & Maritime Services



Appendix F

Koala Monitoring Methodology

Draft Pre-clearance Baseline Koala Monitoring Methodology

Objectives

The objective of the pre-clearance baseline Koala monitoring is to establish the numbers and distribution of individual Koalas, in relation to proposed mitigation structures, so that an informed assessment can be made of the impacts of the upgrade of the Pacific Highway Warrell Creek to Nambucca Heads (WC2NH) on Koalas in the Nambucca State Forest/ Old Coast Road area. Monitoring would be undertaken to provide reliable information such that sound conclusions can be drawn in relation to management of Koalas at WC2NH and help inform other future road infrastructure projects. Specifically, the monitoring aims to identify changes in resident Koala activity (abundance, home range and movements) in response to construction of WC2NH and the effectiveness of Koala habitat connectivity mitigation measures (i.e. fauna underpasses and exclusion fencing).

Scope

The following Koala monitoring would be undertaken targeting the Nambucca State Forest/ Old Coast Road area:

- Standard monitoring items:
  - Transect surveys (diurnal and nocturnal surveys).
  - Fauna underpass monitoring (remote cameras).
  - Fauna exclusion fence monitoring.
  - Road kill monitoring.
- Provisional monitoring items:
  - Koala Global Positioning System (GPS) receiver/Very High Frequency (VHF) transmitter attachment and pit-tagging.

Timing

Monitoring would be undertaken pre-construction (baseline data), during and post-construction until such time as the management measures have proven to be effective or up to a maximum of 5 years post-construction. A summary of the proposed timing is provided in **Table 1.**

Baseline Koala surveys would be completed during the pre-construction phase to determine the presence and approximate abundance of Koalas in the Nambucca State Forest/Old Coast Road section of WC2NH. These surveys would commence as soon as possible to maximise the duration and effectiveness of the pre-construction monitoring. The outcomes of the initial transect surveys would determine the future direction of the monitoring program and need for provisional monitoring items. Specifically, should three or more Koalas be recorded, the provisional monitoring items of GPS/VHF fitted collaring and pit-tagging of recorded Koalas would be triggered.

Standard Koala monitoring items (fauna underpass and fence monitoring) would be undertaken at all structures designed specifically for the Koala (i.e. not just those in the Nambucca State Forest/Old Coast Road area) irrespective of the results of the baseline Koala surveys. This would comprise:

- Underpass monitoring: Would be undertaken post-construction and coincide with the breeding season and likely juvenile dispersal period of the Koala (September to February and July to August) and involve remote camera surveys at fauna underpasses that include the Koala as a target species. Koala movements would be expected to be more frequent and extensive during the breeding season and dispersal periods due to expansion of home ranges and movement of juveniles away from natal areas. Therefore, these periods would be likely to represent peaks in fauna movement, resulting in higher rates of usage of connectivity structures and thus higher detection rates.

- Fauna fence monitoring: Would be undertaken annually post construction as part of standard ongoing road maintenance. The contractor has a contractual period of 36 months to maintain fences. At the completion of this time period, Roads and Maritime Services Asset Division will continue to maintain fauna fencing.
- Road kill monitoring: Monitoring of all road kills forms part of the Roads and Maritime Services Asset Division regular inspection program.

Should the provisions for GPS/VHF and pit-tag Koala monitoring be triggered, initial collaring and pit-tagging would occur as soon as possible, with the animals re-captured every 6 months so that the GPS data can be downloaded. During re-captures, the animals would be inspected (and treated) to ensure their welfare is maintained, and GPS and VHF batteries replaced. This would continue during construction and until 3 years post-construction. Three transect surveys would be undertaken post-construction.

Table 1 Summary of Monitoring Timing

Monitoring Type	Objective	Pre-construction (Baseline)	During Construction		Post-construction				
			Year 1	Years 2 and 3 (if required)	Year 1	Year 2	Year 3	Year 4	Year 5
Transect Surveys	Record resident population presence and occupation/ density	Yes	-	-	Yes	-	Yes	-	Yes
Fauna underpass Monitoring – Camera Monitoring	Record Koala use of fauna underpasses as identified in **Appendix A**	-	-	-	-	Yes	Yes	-	Yes
Road Kill Monitoring	Record any Koala mortalities	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fauna Exclusion Fence Monitoring	Ensure exclusion fences are functional	-	-	-	Yes	Yes	Yes	Yes	Yes
GPS/VHF fitted transmitters and pit-tagging	Observe individual Koala impacts and monitor interactions with connectivity structures and fences	Provisional	Provisional	Provisional	Provisional	Provisional	Provisional	-	-
Update Reporting	Update RMS on monitoring progress	-	-	Provisional	-	Provisional	Yes	-	-
Formal Reporting	Analysis and document monitoring findings	Yes	-	Provisional	Yes	-	Provisional	-	Yes

Pre-construction monitoring

Initial transect surveys would be undertaken to document Koala presence and occupation. Should adequate data be obtained, population estimates would also be made based on the 'Strip (fixed-width) transect' or 'Line-transect' method described in Dique *et al*., (2003). Specifically, transects would be established on each side of the Proposal footprint within the Nambucca State Forest/ Old Coast Road area between chainage 15,600 and 19,500 where Koalas or Koala activity has previously been recorded (GeoLINK, 2013). Twenty-five transects 500 metre long (or to the limit of vegetation if <500 metres) would be spaced approximately 150 metres apart running perpendicular to the proposed project footprint on each side of the highway upgrade. Each transect would be surveyed as follows:

- Diurnal survey: One observer with binoculars walking the transect searching for Koalas.
- Nocturnal survey: One observer spotlight the transect on foot searching for Koalas at a rate of 0.5 to 1.0 kilometres/hour (depending on vegetation density). Koala call playback would also be undertaken on each transect during spotlighting to increase the chance of Koala detection.

If a Koala is identified, the following information would be recorded: location (GPS), distance from transect line, occupied tree species, habitat type, tree height, diameter at breast height (DBH), and if possible the Koala's sex, behaviour, disease status and reproductive status. The transect surveys must be undertaken by personnel experienced in Koala surveys.

Additional spotlighting would follow tracks and easements across this area (exact locations to be determined on site); with the survey effort of five person spotlighting hours at a rate of one kilometres/hour targeting each side of the highway (10 person hours in total over four nights). Koala call playback would be undertaken at regular intervals along these tracks and easements during spotlighting to increase the chance of Koala detection.

Transect surveys would be repeated twice per event with a minimum one week separation between monitoring events pre-construction and one month separation between monitoring events post-construction.

Should three or more Koalas be recorded during the transect surveys, the provisions for GPS/VHF fitted collaring and pit-tagging recorded Koalas and establishing transect surveys control sites would be triggered. This would encompass the following additional pre-construction monitoring activities:

- GPS/VHF collar-fitted receiver and transmitter and pit-tagging: Locating, capturing and fitting Koalas with GPS receiver/VHF transmitters; capturing the collared animals after six months or prior to the start of construction (whichever occurs first) to download GPS data, inspect the animals welfare (take any necessary action) and replace collar batteries. The GPS would be set to record the maximum number of location fixes for six months. The VHF transmitter will allow for easier Koala re-location during subsequent capture events. VHF transmitter batteries would be replaced every time the animal is recaptured.
- Transect surveys: Establish 'control' transect survey sites greater than 500 metres from the Pacific Highway upgrade alignment to complement 'impact' transect survey sites.

Construction monitoring

Koala monitoring during construction would relate to management of GPS/VHF fitted receiver/transmitters and pit-tagged Koalas and only be required if provisional monitoring items are triggered. This includes:

- Six monthly capturing of the collared animals to download GPS data, inspect the animals welfare (take any necessary action) and replace transmitter batteries.
- Pit-tagging Koalas during the capture event before fauna underpasses are operational.
- Installing pit-tag scanners at both ends of each Koala fauna underpass structure.

Post construction monitoring

Standard post-construction Koala monitoring relates to fauna underpass and exclusion fence monitoring, and would include:

- Detection with automated (remote) cameras (minimum 40 sampling nights per camera per monitoring event) for three or five years post-construction. Cameras would be installed at both ends of each target underpass (refer to **Appendix** A) with cameras set to ensure each underpass cell is monitored (i.e. multiple cameras may be required in some locations based on final underpass designs).
- Transect surveys (diurnal and nocturnal) during the first, third and fifth years. Monitoring of fauna exclusion fencing.
- Road kill monitoring. Should any Koala mortalities occur, the location and likely cause would be investigated and documented.

Provisional post-construction Koala monitoring activities would include:

- Six monthly capturing of the collared animals to download GPS data, inspect the animals welfare (take any necessary action) and replace collar batteries for three years.
- Downloading pit-tag scanner data should this provisional item be triggered.

Reporting

The results of the monitoring would be documented and provided to RMS in two key forms: Update Reporting and Formal Reporting. Update Reporting would be in a short report format and include monitoring undertaken to date, monitoring results and a brief discussion of results. Formal Reporting would be in a comprehensive report format and include details of monitoring progress updates, methodologies, results and discussion including a pre/post-construction and impact/control site analysis and a discussion of the results in relation to the monitoring objectives to date where appropriate. The need for revision to the monitoring methodology or corrective actions would also be identified.

Performance measures

The objectives of the fauna underpass structures and exclusion fencing are to provide a safe passage for the movement of wildlife, including Koalas, across the highway and to minimise wildlife morality due to vehicle strike. Specifically, Koalas should maintain their existing population size and distribution in the local area and the opportunity for genetic exchange between animals living either side of the highway should be demonstrated. Performance of the underpass structures and associated fauna fencing would be measured by achievement of the following possible outcomes:

- Koala abundance and distribution are maintained in the vicinity of Nambucca State Forest/Old Coast Road.
- Evidence of usage of the designated underpasses by the Koala is confirmed at a frequency which maintains population viability.
- Zero or minimal Koala vehicle strikes in the Nambucca State Forest/Old Coast Road area.
- No breaches in fauna exclusion fencing or encroachment of shrub or canopy vegetation within three metres of fauna exclusion fencing.

Corrective actions

There is the potential for natural variation in Koala populations for a range of reasons. Further monitoring/assessment would be undertaken if a decline of Koala population numbers is identified as being attributable to the construction and operation of the project. The monitoring / assessment to determine the cause of the decline and/or remedial actions would be commenced as necessary, taking into account potential causes such as dry seasons, population fluctuations and other natural variation, hence the requirement for use of unmitigated control sites. The monitoring / assessment would be dependent upon the monitoring already conducted prior to the decline being noted. Any contingency measures to be implemented would be agreed to by the relevant regulatory authorities prior to commencement.

If during the operational phase Koalas are found to be unable or unwilling to use designated crossing structures, provisional options would be developed that could be implemented if research and/or monitoring identify that additional or alternative measures are required. Depending on the outcome of the monitoring of crossing structures the following options would be considered:

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

References

Dique, D. S., de Villiers, D. L., & Preece, H. J. (2003) Evaluation of line-transect sampling for estimating koala abundance in the Pine Rivers Shire, south-east Queensland, *Wildlife Research*, 30: 127-133.

GeoLINK (2013). *Warrell Creek to Nambucca Heads Pacific Highway Upgrade: EPBC Act Koala Impact Assessment*. Unpublished report to NSW Roads and Maritime Services. GeoLINK Consulting, Coffs Harbour.

Appendix A Summary of the fauna crossing locations for the upgrade of the Pacific Highway, WC2NH.

Chainage Referral	Chainage WC2U EA	Fauna Crossing Structure Type	Structure Form	Number and Dimensions	Fish Passage Requirements	Additional Requirements
42km500	735	Combined	Bridge over Upper Warrell Creek	(-)	Class 1 waterway[3]	Minimum 3 metre wide fauna passage required at each abutment. Giant Barred Frog and fish included as target species.
43km325	1,560	Combined	Box culvert Butchers Creek	Minimum 5 no. x 3600mm x 1500mm high	Class 2 waterway[3] Set one culvert cell 200mm (minimum) below existing bed level. Continue low flow channel through scour protection	Two outside cells must provide dry passage during a 1 in 1 year ARI, 3 day (72 hour) storm event and must not have wet sections that retain water for longer than three days.. No refuge poles required. Approximate culvert length is 47 m.
44km905	3,140	Fish passage	Box culvert	Minimum 3300 mm wide x 1800 mm high	Class 3 waterway [3]. Include low flow channel 200 mm (minimum) below existing bed level and 450 mm wide. Continue low flow channel	Waterway realignment must ensure bed stability; and maintain existing flow velocity. Fish passage.
45km525	3,760	Incidental	Box culvert	Minimum 5 no. x 4200 mm wide x 3600 mm high	Class 3 waterway [3]. Set one culvert cell 200 mm (minimum) below existing bed level. Continue low flow channel through scour protection	Waterway realignment must ensure bed stability; minimise increasing or decreasing existing waterway length; and maintain existing flow velocity. Fish passage.

Chainage Referral	Chainage WC2U EA	Fauna Crossing Structure Type	Structure Form	Number and Dimensions	Fish Passage Requirements	Additional Requirements
47km000	5,235	Fish passage	Bridge over Williamsons Creek	(-)	Class 3 waterway[3]	
47km525	5,760	Incidental	Box culvert	Minimum 3000 mm wide x 1200 mm high	Class 3 waterway [3]. Include low flow channel 200 mm (minimum) below existing bed level and 450 mm wide. Continue low flow channel through scour protection	Must extend under existing Pacific Highway. Fish passage.
47km650	5,885	Incidental	Box culvert	Minimum 3000 mm wide x 1200 mm high	Fish passage.	
48km085	6,320	Dedicated	Bridge	(-)		Fauna corridor listed is under southern end span of bridge. Minimum 3 metre wide fauna passage required.
48km215	6,450	Dedicated	Bridge	(-)	Class 1 waterway[3]	
48km275	6,510	Dedicated	Bridge	(-)		Fauna corridor listed is under northern end span. Minimum 3 metre wide fauna passage required
49km900	8,135	Incidental	Pipe	2,500 mm diameter	No	Must provide water connectivity across Main carriageways. Site permanently inundated.

Chainage Referral	Chainage WC2U EA	Fauna Crossing Structure Type	Structure Form	Number and Dimensions	Fish Passage Requirements	Additional Requirements
50km215	8,450	Incidental	Bridge	Minimum width between the intersection of the scour protection and the finished ground level under the bridge to be 50.4m (see Note 1). Minimum vertical clearance to be 2.0 m (subject to detailed design).	No	
50km985	9,220	Incidental	Bridge	Minimum width between the intersection of the scour protection and the finished ground level under the bridge to be 50.4m (see Note 1). Minimum vertical clearance to be 2.0 m (subject to detailed design).	No	

Chainage Referral	Chainage WC2U EA	Fauna Crossing Structure Type	Structure Form	Number and Dimensions	Fish Passage Requirements	Additional Requirements
55km120	13,355	Dedicated	Box culvert	3000 mm x 3000 mm	No	Approximate length of culvert under main carriageway is 50 m. No culvert is to be provided under the service road but detailed design to investigate lowering the service road to provide better visibility across the service road from the culvert. Fauna fencing to be provided along the bottom of the batter slope between the highway and the service road to prevent fauna accessing the main highway. Koala included as target species
56km410	14,645	Combined	Box culvert	Minimum 2400 mm x 2400 mm	No	Approximate culvert length under main carriageway is 45 m. No fauna underpass is required under the service road. Koala included as target species. Provide ledge for dry passage during a 1 in 1 year ARI, 3 day (72 hour) storm event and must not have wet sections that retain water for longer than three days.
57km770	16,005	Dedicated	Box culvert	3000 mm x 3000 mm	No	Maximum culvert length is 50 m. Koala included as target species

Chainage Referral	Chainage WC2U EA	Fauna Crossing Structure Type	Structure Form	Number and Dimensions	Fish Passage Requirements	Additional Requirements
58km510	16,745	Combined	Box culvert	3000 mm x 3000 mm	Class 3 waterway3 Include low flow channel 1200mm wide x 200mm deep below existing bed level. Continue low flow channel through scour protection. Fish passage.	Approximate culvert length is 84m. Provide ledge for dry passage during a 1 in 1 year ARI, 3 day (72 hour) storm event and must not have wet sections that retain water for longer than three days. Adjacent box or pipe culvert to also be provided for drainage.
58km560	16,795	Dedicated	Box culvert	3000 mm x 3000 mm	No	Maximum culvert length is 50 m. Koala included as target species
59km090	17,325	Dedicated	Box culvert	3000 mm x 3000mm	No	Culvert length is 58 m. Length slightly in excess of 50 metres however was agreed to be acceptable if needed to achieve desired location. Koala included as target species
59km550	17,785	Dedicated	Box culvert	Minimum 3000 mm x 3000 mm	No	Approximate culvert length is 50 m. Koala included as target species
59km750 (northbound carriageway)	17,985	Dedicated	Box culvert	2400 mm x 2400 mm	No	Approximate culvert length is 38 m. Culvert to be moved up the bank to achieve the 1 in 100 year ARI flood immunity. Koala included as target species

Chainage Referral	Chainage WC2U EA	Fauna Crossing Structure Type	Structure Form	Number and Dimensions	Fish Passage Requirements	Additional Requirements
59km760 (southbound carriageway)	17,995	Dedicated	Box culvert	Minimum 2400 mm x 2400 mm	No	Approximate culvert length is 25 m. Combined length of the northbound and southbound underpasses is around 63 m. Carriageway separation is approximately 10 m with a fauna fenced race in between underpasses. Koala included as target species
60km615 (northbound carriageway)	18,850	Dedicated	Box culvert	2400 mm x 2400 mm	No	Approximate culvert length is 29 m. Structure to be shifted to the north around 15 metres to align with southbound carriageway. Koala included as target species.
60km600 (southbound carriageway)	18,835	Dedicated	Box culvert	Minimum 2400 mm x 2400 mm	No	Approximate culvert length is 30 m. Combined length of the northbound and southbound underpasses is around 59 m. Carriageway separation is approximately 19 m with a fauna fenced race in between underpasses. Koala included as target species.

1 A bridge may be provided in lieu of a box culvert provided that the total width between the intersection of the scour protection and the finished ground level under the bridge is at least equivalent to the total clear width of the cells of the replaced box culvert.

2 Separate fauna crossing structures must be provided for the Main Carriageways and Service Road to provide daylight between the Main Carriageways and Service Road structures.

3 Classification identified in consultation with DPI (Fisheries Conservation and Aquaculture)

Appendix G

Koala Baseline Monitoring Reports

Warrell Creek to Nambucca Heads Pacific Highway Upgrade

Baseline Koala Surveys

quality solutions sustainable future

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Warrell Creek to Nambucca Heads Pacific Highway Upgrade

Baseline Koala Surveys

Prepared for: NSW Roads and Maritime Services

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UPR	*Description*	*Date Issued*	*Issued By*
2364-1007	First issue	19/05/2014	David Havilah
2364-1008	Second issue	02/06/2014	David Havilah
2364-1009	Third issue	17/06/2014	David Havilah

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Introduction

1.1 Introduction

The Pacific Highway Upgrade Program is a joint commitment by the Australian and New South Wales governments to improve the standard and safety of the Pacific Highway between Hexham and the Queensland border.

The NSW Minister for Planning approved the Warrell Creek to Urunga (WC2U) Pacific Highway Upgrade Project (the Project) under Part 3A (now repealed) of the *Environmental Planning and Assessment Act 1979* (EP&A Act) on 19 July 2011, subject to the Minister's Conditions of Approval (CoA) being met.

The WC2U Project comprises approximately 42 km of dual carriageway road that would bypass the towns of Warrell Creek, Macksville, Nambucca Heads and Urunga on the Mid North Coast of NSW. The Project has been divided into two stages with Stage 1 consisting of approximately 22.5 km from Nambucca Heads to Urunga (NH2U) and Stage 2 consisting of the remaining 19.5 km of dual carriageway between Warrell Creek and Nambucca Heads (WC2NH). This report relates to Stage 2 (WC2NH) as 'the Proposal' which is shown in Illustration 1.1.

Koalas were assessed in the Project Environmental Assessment (Sinclair Knight Merz [SKM] 2010a, SKM 2010b), in regard to relevant State and Federal legislation. At that time, the Koala was listed as a 'Vulnerable' species under the NSW Government *Threatened Species Conservation Act 1995* (TSC Act), however was not listed under Federal legislation. Since completion of the Project Environmental Assessment (SKM 2010a, SKM 2010b) and NSW State Government Project approval, Koala (*Phascolarctos cinereus*) populations in Queensland, NSW and the Australian Capital Territory have been listed as 'Vulnerable' under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

An assessment of the impacts of the WC2NH Pacific Highway Upgrade Proposal on the Koala, in accordance with the *EPBC Act Policy Statement 1.1 Significant Impact Guidelines* (Department of Environment and Heritage – DoE 2013a) and *Interim Koala referral advice for proponents* (Department of Sustainability, Environment, Water, Population and Communities – DSEWPaC 2012) was prepared by GeoLINK (2014). This assessment found that the Proposal will have some substantial negative (incremental and cumulative) impacts to the Koalas/ breeding aggregation/s whose home range encompass the Nambucca State Forest/ Old Coast Road area, mainly through habitat removal and fragmentation. The majority of Koalas and habitat that supports the subject important Koala population would not be affected by the Proposal. The Project, with effective implementation of the proposed mitigation measures, was found to be unlikely to result in a significant impact to the subject important local Koala population. Notwithstanding, as the Project adversely affects habitat that satisfy the SEWPaC (2012) definition of '*habitat critical to the survival of the species*' (including direct removal of approximately 86.5 ha of vegetation that satisfies this criteria); the Project was considered to constitute a significant impact on the Koala as per the DSEWPaC (2012) and DoE (2013a) guidelines.

1.2 The Monitoring Program

The WC2NH Project includes a number of mitigation measures to minimise impacts on biodiversity. These include:

- Ecological monitoring to be implemented to monitor the effectiveness of the ecological mitigation measures undertaken as part of the Project.
- Fauna crossing and fauna exclusion fencing to allow for safe passage of fauna (including the Koala) crossing the Pacific Highway.

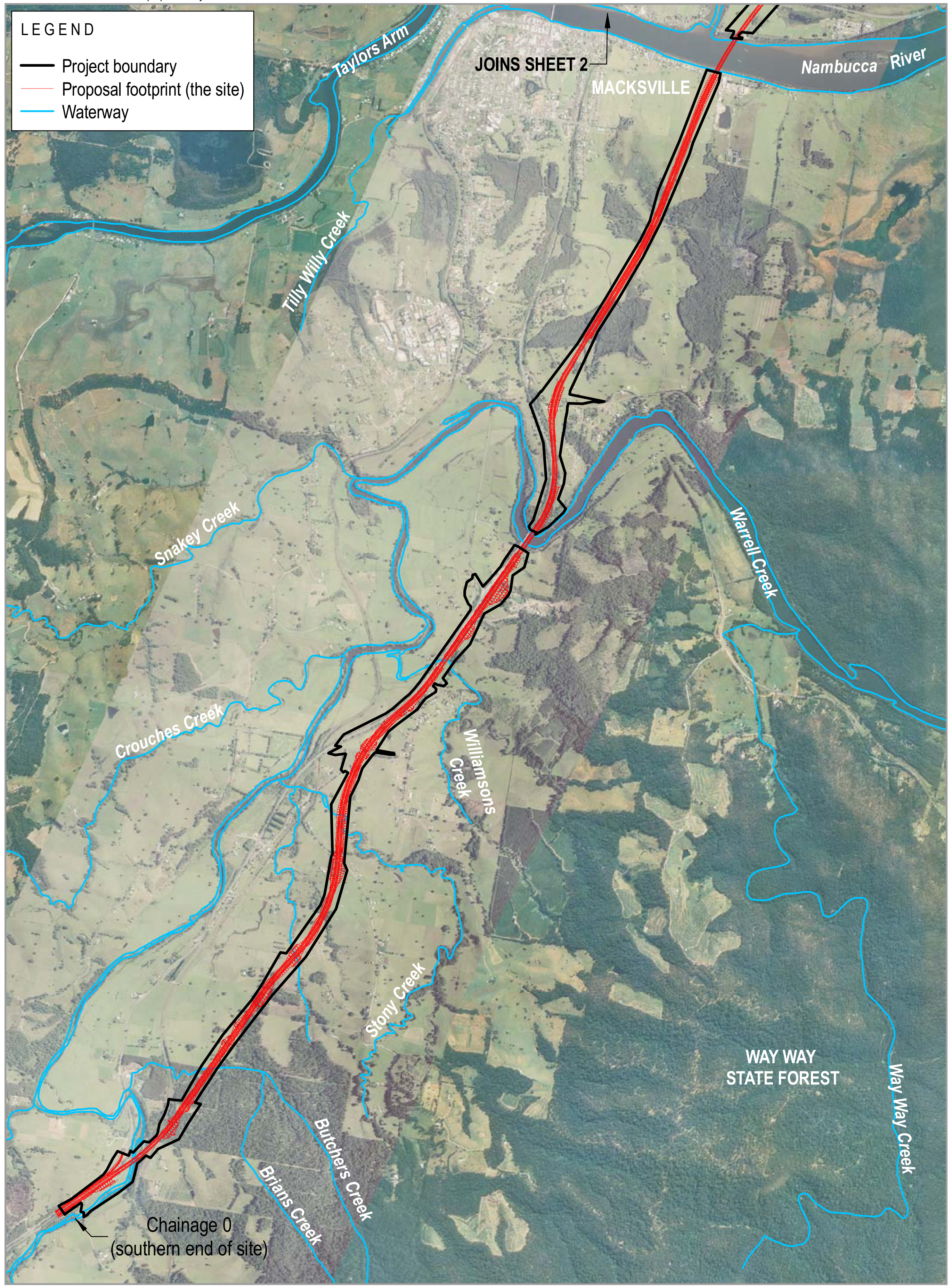
- Large areas of ‘floppy-top’ fauna exclusion fencing design which was developed by Koala expert Casper Pieters and has been refined for fauna (including Koalas) to minimise road strike.

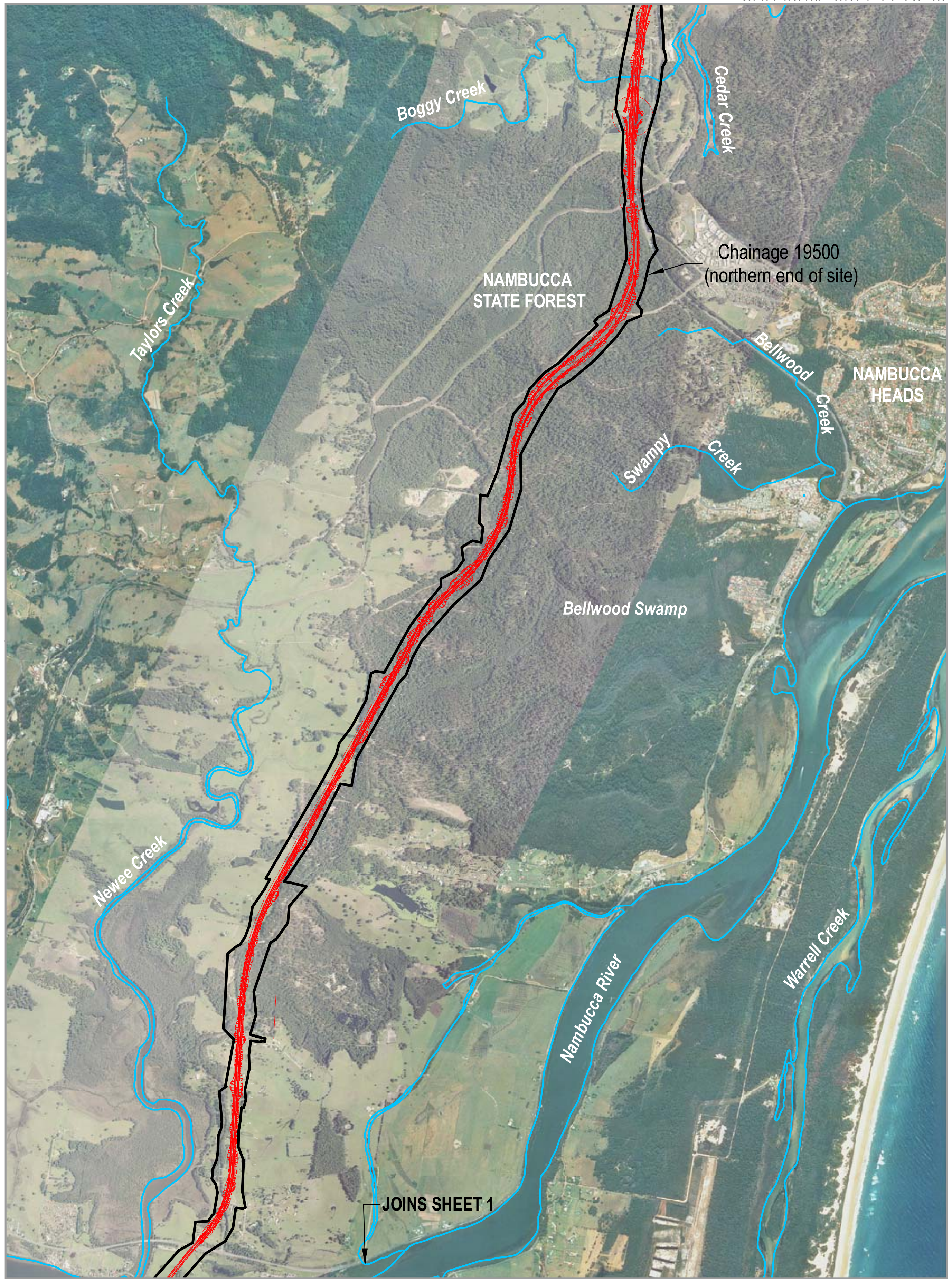
A Draft Pre-clearance Baseline Koala Monitoring Methodology has been prepared by SKM (2014) in consultation with GeoLINK for the WC2NH Project. The objective of the baseline monitoring is to supplement previous surveys and provide a more robust estimate of the numbers and distribution of individual Koalas, in relation to proposed mitigation structures, so that a more informed assessment can be made of the impacts of the project on Koalas in the Nambucca State Forest/ Old Coast Road area.

The additional monitoring would be undertaken to provide more reliable information such that more robust conclusions can be drawn in relation to management of Koalas at WC2NH and help inform other future road infrastructure projects. Specifically, the monitoring aims to identify changes in resident Koala activity (abundance, home range and movements) in response to construction of WC2NH Project and the effectiveness of Koala habitat connectivity mitigation measures (ie fauna underpasses and exclusion fencing).

Information shown is for illustrative purposes only

Drawn by: GJM Checked by: RE Reviewed by: DGH Date: May 2014
Source of base data: Roads and Maritime Services





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GeoLINK environmental management and design

WC2NH Pacific Highway Upgrade Project - Koala Baseline Surveys

2364-1004

The Site

Illustration 1.1

2

Koala Biology and Ecology

2.1 Introduction

Detailed reviews of Koala biology and ecology based on recent research are provided on the Department of Environment (DoE) *Species Profile and Threats Database* (DoE 2013b) and the NSW *Recovery Plan for the Koala (Phascolarctos cinereus)* (DECC 2008). A summary of this information is provided below.

2.2 Distribution and Habitat

The Koala's distribution extends from north-eastern Queensland to the south-east corner of South Australia, covering coastal and inland areas (ANZECC 1998 cited in DoE 2013b, DECC 2013). They inhabit a range of forest and woodland communities dominated by *Eucalyptus* species. Habitat quality depends on a range of environmental features, including vegetation species composition, soils, climate and disturbance history. The main factor influencing Koala occurrence is the presence of suitable food trees. Shelter trees also provide important habitat features, particularly in harsh climates (DoE 2013b, DECC 2013).

2.3 Feeding Requirements

The Koala's diet primarily comprises eucalypt leaves which are low in nutrients and energy, and high in indigestible components (eg lignin and cellulose) and toxic compounds (eg essential oils and tannins) (Cork *et al*. 1990; Cork and Sanson 1990 cited in DECC 2008). In a given area, the diets of individual Koalas/ subpopulations almost exclusively comprise a small number of preferred species to obtain their nutritional needs. Preferred food trees appear to be associated with the presence of formyl phloroglucinol compounds in the leaves (DECC 2008). Koala's also show strong preferences between individual trees of the same species at individual sites, which is believed to be associated with leaf anti-feedant chemicals (DoE 2013b). Foliage from non-preferred food trees are consumed at times to supplement their diet (DoE 2008, DECC 2008). Recognised Koala food tree species for the NSW North Coast region (which encompasses the study area) are listed in **Table 2.1**. Blackbutt is also locally considered a supplementary Koala food tree species in the region (Professor Rob Close, University of Western Sydney. pers. comm. 2013).

Table 2.1 Potential Koala Habitats for the NSW North Coast Region

Foraging Preference	*Species*
Primary food tree species	▪ Tallowwood (*Eucalyptus microcorys*). ▪ Parramatta Red Gum (*E. parramattensis*). ▪ Forest Red Gum (*E. tereticornis*). ▪ Orange Gum (*E. bancroftii*). ▪ Swamp Mahogany (*E. robusta*). ▪ Cabbage Gum (*E. amplifolia*).

Foraging Preference	*Species*
Secondary food tree species	▪ Narrow-leaved Red Gum (*E. seeana*). ▪ Craven Grey Box (*E. largeana*). ▪ Slaty Red Gum (*E. glaucina*). ▪ Grey Gum (*E. biturbinata*). ▪ Small-fruited Grey Gum (*E. propinqua*). ▪ Large-fruited Grey Gum (*E. canaliculata*) ▪ Red Mahogany (*E. resinifera*). ▪ Steel Box (*E. rummeryi*). ▪ Mountain Mahogany (*E. notabilis*). ▪ Rudder's Box (*E. rudderi*). ▪ Grey Box (*E. moluccana*). ▪ White-topped box (*E. quadrangulata*). ▪ Yellow box (*E. melliodora*).
Stringybarks/ supplementary species	▪ Stringybark (*E. tindaliae*). ▪ Blue-leaved Stringybark (*E. agglomerata*). ▪ Thin-leaved Stringybark (*E. eugeniodes*). ▪ Diehard Stringybark (*E. cameronii*). ▪ White Stringybark (*E. globoidea*).

(Source: DECC 2008)

Primary Koala food tree species are subject to a significantly higher level of usage than other Eucalyptus species, independent of tree density. Secondary and/ or supplementary food trees are generally subject to lower levels of foraging by Koalas than that of primary food trees, except where primary food trees are absent (DECC 2008).

2.4 Social Organisation and Reproduction

Koalas live in breeding aggregations which typically comprise a dominant male, a small number of mature females and juveniles of various ages (Phillips 1997, cited in DECC 2008). Home ranges vary in size depending on habitat quality and the number of available food trees, and have been recorded from 0.2 – 500 ha (DECC 2008). Males generally have larger home ranges than females, with the home range of a dominant male overlapping extensively with the home range of females within its aggregation.

The Koala breeding season peaks between September and February, and comprises a period of heightened activity. Offspring rates typically range between 0.3 – 0.8 per year, with birth occurring during October and May (McLean 2003 cited in DoE 2013b) following a 35 day gestation period (DECC 2008). Once born the young remain in the pouch for approximately six months, and remain dependent on their mother until about 12 months of age (Mitchell and Martin 1990 cited in DECC 2008). Sub-adult Koalas may remain in the mother's home range for a further two to three years, before young Koalas of both sexes disperse to establish their own home range areas (Ramsay 1999 cited in DECC 2008). Dispersal distances generally range from 1.0 – 11 km (Mitchell and Martin 1990 cited in DECC 2008). Longevity in the wild is >15 years for females and >12 years for males (Martin and Handasyde 1999 cited in DoE 2013b).

3

Methodology

3.1 Transect Surveys

Transects were established on each side of the Project footprint within the Nambucca State Forest/ Old Coast Road area between chainage 15,600 and 19,500. Twenty-five transects, 500 m long (or to the limit of vegetation) were spaced approximately 150 m apart running perpendicular to the proposed project footprint on each side of the highway upgrade. The location of transects is shown on Illustration 3.1.

Each transect was surveyed by personnel experienced in Koala surveys (David Havilah, David Andrighetto, Tony Coyle and Craig Faulkner) to document Koala presence and occupation. Relevant experience of survey personnel is summarised in Appendix A. Surveys were undertaken over two monitoring events (14/04/2014-17/04/2014 and 28/04/2014-01/05/2014) as follows:

- Diurnal survey: One observer with binoculars walking the transect searching for Koalas (110 person hours in total).
- Nocturnal survey: One observer spotlighting the transect on foot searching for Koalas at a rate of 0.5 to 1.0 km/hour (depending on vegetation density132) (120 person hours in total). Koala call playback was also undertaken on each transect during spotlighting to increase the chance of Koala detection.

Additional spotlighting was undertaken on tracks and easements across this area with the survey effort of five person spotlighting hours at a rate of 2 km/hour targeting each side of the highway (10 person hours in total over four nights). Koala call playback was undertaken at regular intervals along these tracks and easements during spotlighting to increase the chance of Koala detection.

The following data was to be collected for any Koalas detected:

- Location (using global positioning system [GPS]).
- Distance from transect line.
- Occupied tree species.
- Habitat type.
- Tree height.
- Diameter at breast height.
- Koala's sex.
- Behaviour.
- Disease status.
- Reproductive status.

3.2 Survey Limitations

A number of small areas associated with the transects were unable to be accessed at the time of survey due to property access restrictions. These include:

- Council owned land around the Nambucca Heads waste facility where access was not provided.
- Part of three transects west of the highway, in the State Forest north-west of the Bowraville turn off from Old Coast Road where a very wary individual was camping in the forest.

Dense lower storey vegetation associated with the site created some obstacles to viewing the tree canopy within parts of some transects, particularly during nocturnal surveys. Notwithstanding this, the combination of diurnal/ nocturnal target searches, call playback and track surveys were considered appropriate to identify resident Koalas if present.

3.3 Monitoring Triggers

Should adequate data be obtained, population estimates are to be made based on the ‘strip (fixed width) transect’ or ‘line transect’ method described in Dique *et al.* (2003).

In the event that three or more Koalas are recorded during the transect surveys, the provision for GPS/ VHF fitted collars and pit tagging of recorded Koalas and establishment of transect survey control sites would be triggered. This would encompass the following additional pre-construction monitoring activities:

- GPS/ VHF collar-fitted receiver and transmitter and pit-tagging: Locating, capturing and fitting Koalas with GPS receiver/VHF transmitters; capturing the collared animals after six months or prior to the start of construction (whichever occurs first) to download GPS data, inspect the animals welfare (take any necessary action) and replace collar batteries. The GPS would be set to record the maximum number of location fixes for six months. The VHF transmitter will allow for easier Koala re-location during subsequent capture events. VHF transmitter batteries would be replaced every time the animal is recaptured.
- Transect surveys: Establish ‘control’ transect survey sites greater than 500 m from the Pacific Highway upgrade alignment to complement ‘impact’ transect survey sites.

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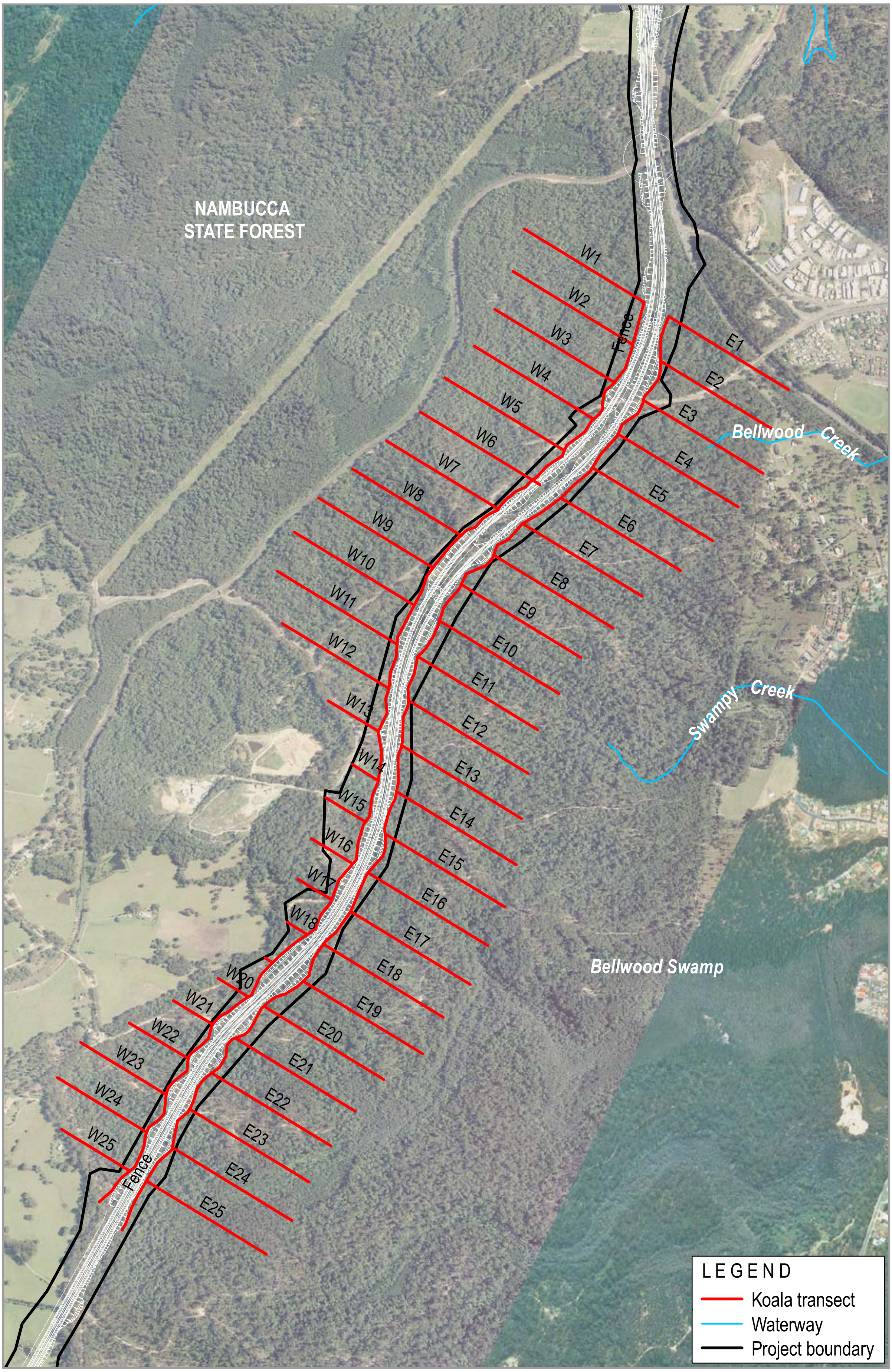
Source of base data: Roads and Maritime Services



Transect Locations

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WC2NH Pacific Highway Upgrade Project - Koala Baseline Surveys
2364-1005

Illustration 3.1

4

Results and Discussion

4.1 Field Survey Results

4.1.1 Transect Surveys

Diurnal and nocturnal transect surveys conducted over both monitoring events yielded no observations of Koalas. Additionally, no Koala faecal pellets or obvious scratches attributable to Koalas were observed during these surveys

Survey conditions for both monitoring events were generally fine with some scattered showers falling mostly late at night. Weather conditions at all times were considered to be appropriate for observing Koalas.

4.1.2 Spotlighting Surveys on Tracks/ Easements

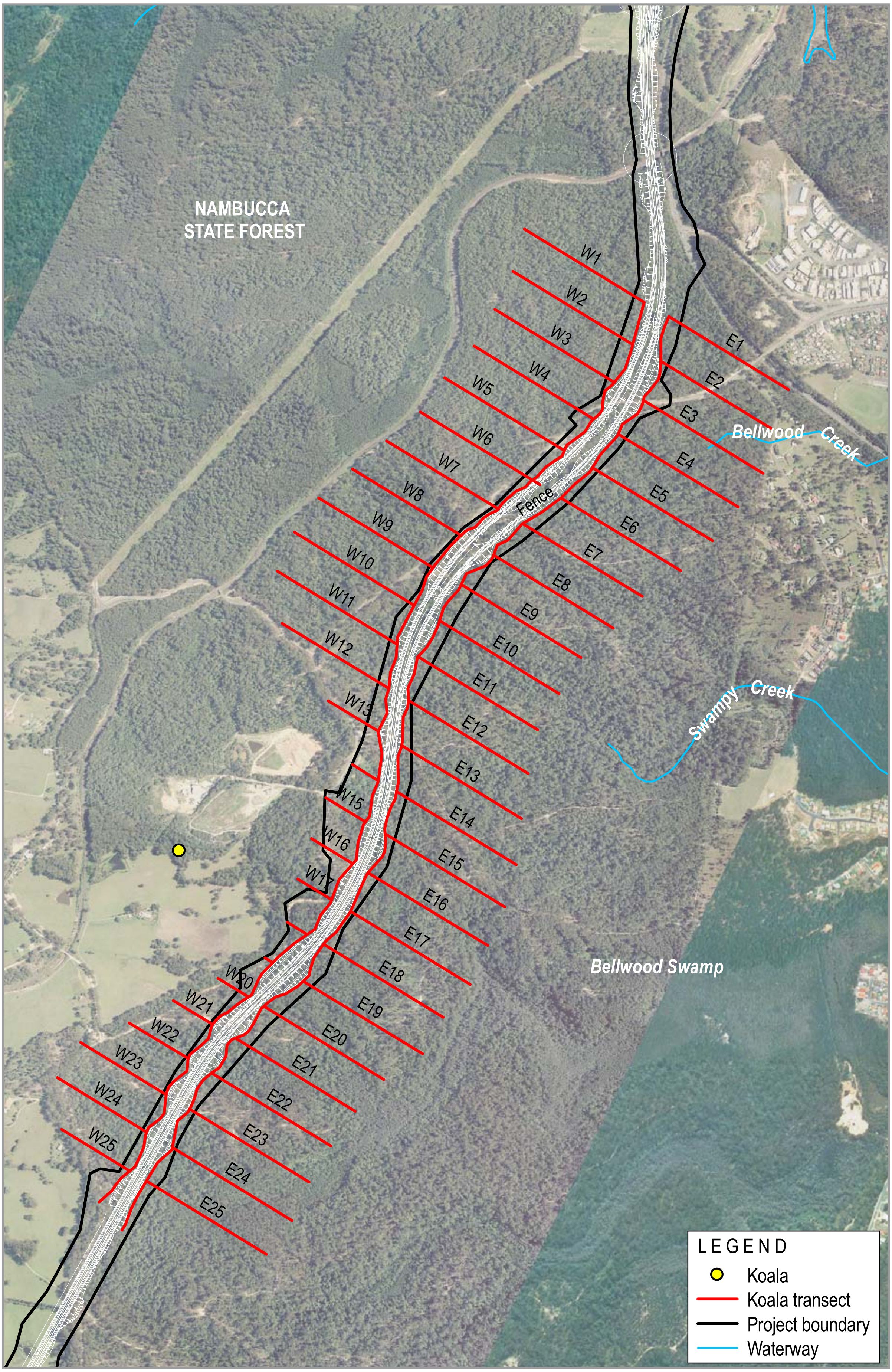
One Koala was recorded during spotlighting surveys being conducted along the Old Coast Road in the vicinity of the Nambucca Heads waste facility, west of the highway alignment (refer to **Illustration 4.1**). This individual responded to call playback and is likely to be a resident male. Vegetation associated with this area is mapped as being predominantly Open Blackbutt forest with some moister gullies comprising Flooded Gum Moist Open Forest.

4.2 Koala Population – Discussion and Summary

Previous Koala surveys undertaken by GeoLINK (2013) as part of the Koala impact assessment for the WC2NH Project surveyed 38 Koala Spot Analysis Technique (SAT) plots within the Nambucca State Forest/ Old Coast Road area. Three (7.9 %) of the 38 SAT plots surveyed in this area were subject to medium (normal) Koala usage for a low density Koala population, indicating that part of the range of resident Koala/s or breeding aggregation/s overlaps the study area (GeoLINK 2013). Koala records from field surveys associated with the WC2U Project Environmental Assessment (SKM 2010b) and the Atlas of NSW Wildlife (OEH 2013) supported these findings.

The results of the baseline Koala surveys confirm that the Nambucca State Forest/ Old Coast Road area is subject to low level usage by Koalas. Insufficient data is available from both the previous SAT surveys and these targeted surveys to provide an accurate population estimate of Koalas in the area. However, given the low levels of Koala usage evidenced by the results of the baseline surveys and previous surveys and that the home range of Koalas in low density populations may exceed 100 ha (Ellis *et al.* 2002 – cited in Biolink 2009), the number of individual Koalas whose home range encompass the study area is likely to be small.

The results of the transect surveys do not trigger the need for the provision of GPS/VHF fitted collaring and pit tagging Koalas or establishing transect survey control sites.



Koala Records

5

Conclusions

The baseline Koala monitoring surveys located only one Koala during spotlighting surveys being conducted along the Old Coast Road in the vicinity of the Nambucca Heads waste facility, west of the highway alignment. This individual responded to call playback and is likely to be a resident male. These results confirm the previous findings of Koala SAT surveys undertaken as part of the Koala impact assessment (GeoLINK 2013) which found three SAT plots subject to medium (normal) Koala usage for a low density Koala population. Insufficient data from this survey and previous SAT surveys preclude an accurate estimate of the size of the population although all available data suggests that this population is low.

The results of the baseline monitoring do not trigger the need for the provision of GPS/VHF fitted collaring and pit tagging Koalas or establishing transect survey control sites.

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Appendix A

Experience of Survey Team Relevant to Koalas

Table A.1 Experience of Survey Personnel

Survey Personnel	*Years of Experience as an Ecologist*	*Projects involving Koala surveys (spotlighting, call playbacks, and/or SAT plots):*
David Andrighetto	8	▪ Comprehensive Koala surveys and impact assessment for the Koala on the WC2NH Project. ▪ Surveys and advice relating to Koalas for the Devils Pulpit Pacific Highway Upgrade project. ▪ RMS projects including habitat assessments at Camerons Corner, Waterfall Way and Martells Road intersection, Pacific Highway; ▪ Full flora and fauna assessment including SAT plots at Karangi Quarry, Karangi, NSW. ▪ Surveys and Assessments for the Koala as part of the Old Glenn Innes Road subdivision Koala Plan of Management. ▪ Lanham Halfway Creek Subdivision (SEPP 44) Koala Habitat Assessment. ▪ Sawtell Rail Corridor Koala Habitat Assessment.
David Havilah	7	▪ Comprehensive Koala surveys and impact assessment for the Koala on the WC2NH Project. ▪ Koala surveys and assessments for a number of residential development sites within various Local Government Areas. ▪ RMS projects including habitat assessments at Camerons Corner, Waterfall Way and Martells Road intersection, Pacific Highway. ▪ Extensive Koala habitat mapping and monitoring associated with the development of the Coffs Harbour water supply project, Grafton, NSW.
Tony Coyle	14	▪ Subdivision of a 60 ha site including remnant open forest near Lismore, NSW. ▪ Upgrade of the Pacific Highway (Devil Pulpit section). ▪ RMS projects including habitat assessments at Camerons Corner, Waterfall Way and Martells Road intersection, Pacific Highway. ▪ Full flora and fauna assessment including SAT plots at Karangi Quarry, Karangi, NSW. ▪ SAT plot assessments with Biolink (Steve Phillips) associated with mapping of Koala habitat, Tweed Shire, NSW. ▪ Extensive Koala habitat mapping and monitoring associated with the development of the Coffs Harbour water supply project, Grafton, NSW.
Craig Faulkner	10	▪ Field surveys for the development of the Gunnedah Koala Plan of Management (on behalf of Greenloaning Biostudies). ▪ Field surveys for comprehensive ongoing koala monitoring for the Shannon Creek water storage facility south of Grafton (on behalf of Greenloaning Biostudies). ▪ Extensive koala surveys for the proposed Kings Forest development near Kingscliff (on behalf of Aspect North Pty Ltd [now Landapartners]). ▪ Field survey and drafting of Koala Plan of Management for a caravan park/retirement village near Evans Head (on behalf of Aspect North Pty Ltd [now Landpartners]). ▪ Koala surveys and drafting of Koala Plan of Management for proposed development at Myocum (on behalf of Stephen Fletcher and Associates town planners). ▪ Targeted Koala surveys for the proposed extension to Batson's Quarry at Suffolk Park (on behalf of Greenloaning Biostudies Pty Ltd).

Warrell Creek to Nambucca Heads Pacific Highway Upgrade

Baseline (Spring) Koala Surveys

quality solutions sustainable future

Warrell Creek to Nambucca Heads Pacific Highway Upgrade

Baseline (Spring) Koala Surveys

Prepared for: NSW Roads and Maritime Services

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UPR	Description	Date Issued	Issued By
2364-1013	First issue	31/10/2014	David Havilah

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Introduction

1.1 Introduction

The Pacific Highway Upgrade Program is a joint commitment by the Australian and New South Wales governments to improve the standard and safety of the Pacific Highway between Hexham and the Queensland border.

The NSW Minister for Planning approved the Warrell Creek to Urunga (WC2U) Pacific Highway Upgrade Project (the Project) under Part 3A (now repealed) of the *Environmental Planning and Assessment Act 1979* (EP&A Act) on 19 July 2011, subject to the Minister's Conditions of Approval (CoA) being met.

The WC2U Project comprises approximately 42 km of dual carriageway road that would bypass the towns of Warrell Creek, Macksville, Nambucca Heads and Urunga on the Mid North Coast of NSW. The Project has been divided into two stages with Stage 1 consisting of approximately 22.5 km from Nambucca Heads to Urunga (NH2U) and Stage 2 consisting of the remaining 19.5 km of dual carriageway between Warrell Creek and Nambucca Heads (WC2NH). This report relates to Stage 2 (WC2NH) as 'the Proposal' which is shown in Illustration 1.1.

Koalas were assessed in the Project Environmental Assessment (Sinclair Knight Merz [SKM] 2010a, SKM 2010b), in regard to relevant State and Federal legislation. At that time, the Koala was listed as a 'Vulnerable' species under the NSW Government *Threatened Species Conservation Act 1995* (TSC Act), however was not listed under Federal legislation. Since completion of the Project Environmental Assessment (SKM 2010a, SKM 2010b) and NSW State Government Project approval, Koala (*Phascolarctos cinereus*) populations in Queensland, NSW and the Australian Capital Territory have been listed as 'Vulnerable' under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

An assessment of the impacts of the WC2NH Pacific Highway Upgrade Proposal on the Koala, in accordance with the *EPBC Act Policy Statement 1.1 Significant Impact Guidelines* (Department of Environment and Heritage – DoE 2013a) and *Interim Koala referral advice for proponents* (Department of Sustainability, Environment, Water, Population and Communities – DSEWPaC 2012) was prepared by GeoLINK (2013). This assessment found that the Proposal will have some substantial negative (incremental and cumulative) impacts to the Koalas/ breeding aggregation/s whose home range encompass the Nambucca State Forest/ Old Coast Road area, mainly through habitat removal and fragmentation. The majority of Koalas and habitat that supports the subject important Koala population would not be affected by the Proposal. The Project, with effective implementation of the proposed mitigation measures, was found to be unlikely to result in a significant impact to the subject important local Koala population. Notwithstanding, as the Project adversely affects habitat that satisfy the SEWPaC (2012) definition of '*habitat critical to the survival of the species*' (including direct removal of approximately 86.5 ha of vegetation that satisfies this criteria); the Project was considered to constitute a significant impact on the Koala as per the DSEWPaC (2012) and DoE (2013a) guidelines.

1.2 The Monitoring Program

The WC2NH Project includes a number of mitigation measures to minimise impacts on biodiversity. These include:

- Ecological monitoring to be implemented to monitor the effectiveness of the ecological mitigation measures undertaken as part of the Project.
- Fauna crossing and fauna exclusion fencing to allow for safe passage of fauna (including the Koala) crossing the Pacific Highway.
- Large areas of 'floppy-top' fauna exclusion fencing design which was developed by Koala expert Casper Pieters and has been refined for fauna (including Koalas) to minimise road strike.

A Draft Pre-clearance Baseline Koala Monitoring Methodology has been prepared by SKM (2014) in consultation with GeoLINK for the WC2NH Project. The objective of the baseline monitoring is to supplement previous surveys and provide a more robust estimate of the numbers and distribution of individual Koalas, in relation to proposed mitigation structures, so that a more informed assessment can be made of the impacts of the project on Koalas in the Nambucca State Forest/ Old Coast Road area.

The additional monitoring would be undertaken to provide more reliable information such that more robust conclusions can be drawn in relation to management of Koalas at WC2NH and help inform other future road infrastructure projects. Specifically, the monitoring aims to identify changes in resident Koala activity (abundance, home range and movements) in response to construction of WC2NH Project and the effectiveness of Koala habitat connectivity mitigation measures (ie fauna underpasses and exclusion fencing).

The baseline monitoring program comprised of surveys in Autumn and Spring. Autumn surveys have been completed previously and the results of these surveys are summarised in this report. This report also documents the results of the Spring surveys and discusses findings of the baseline Koala surveys in general.

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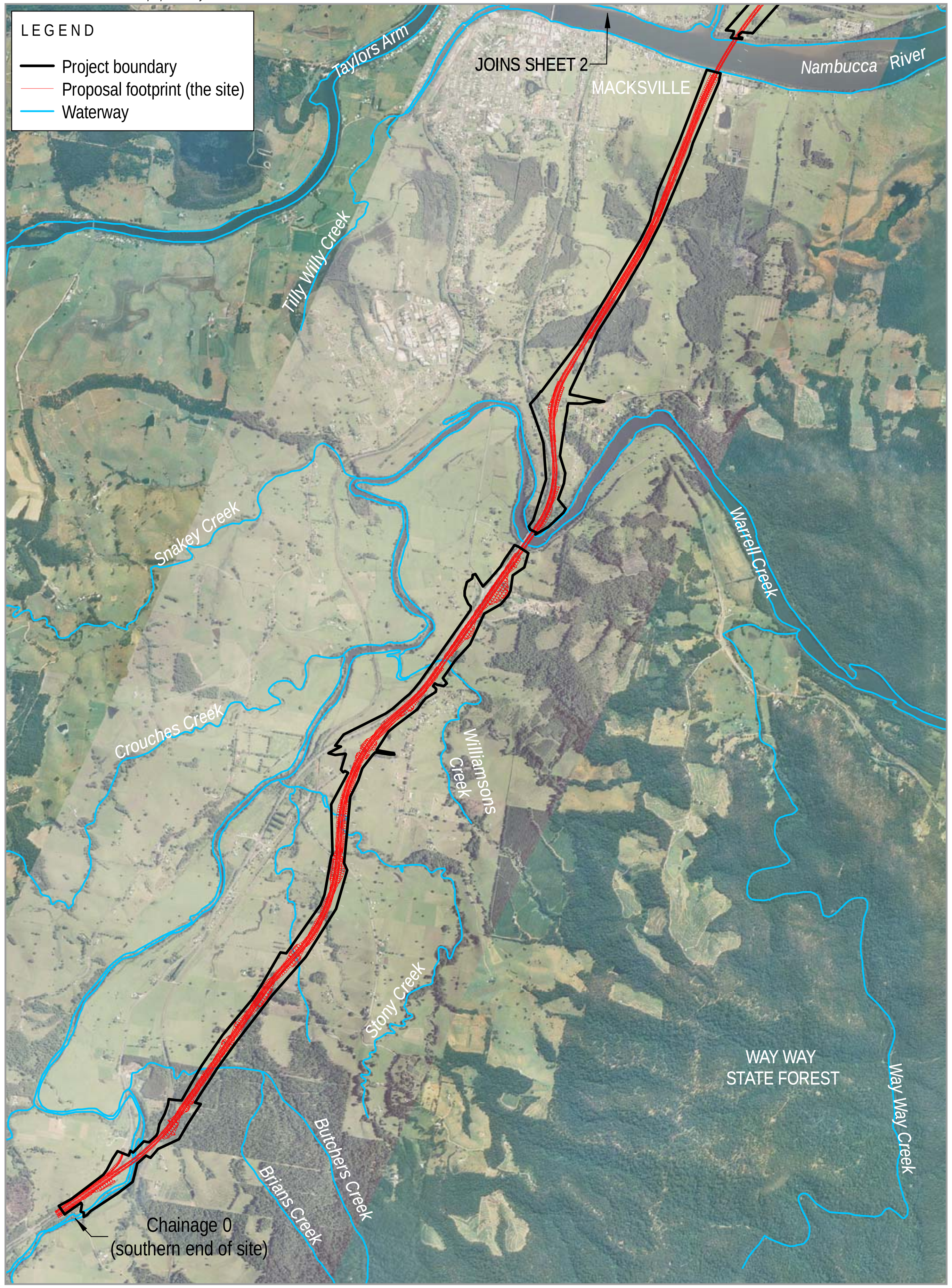

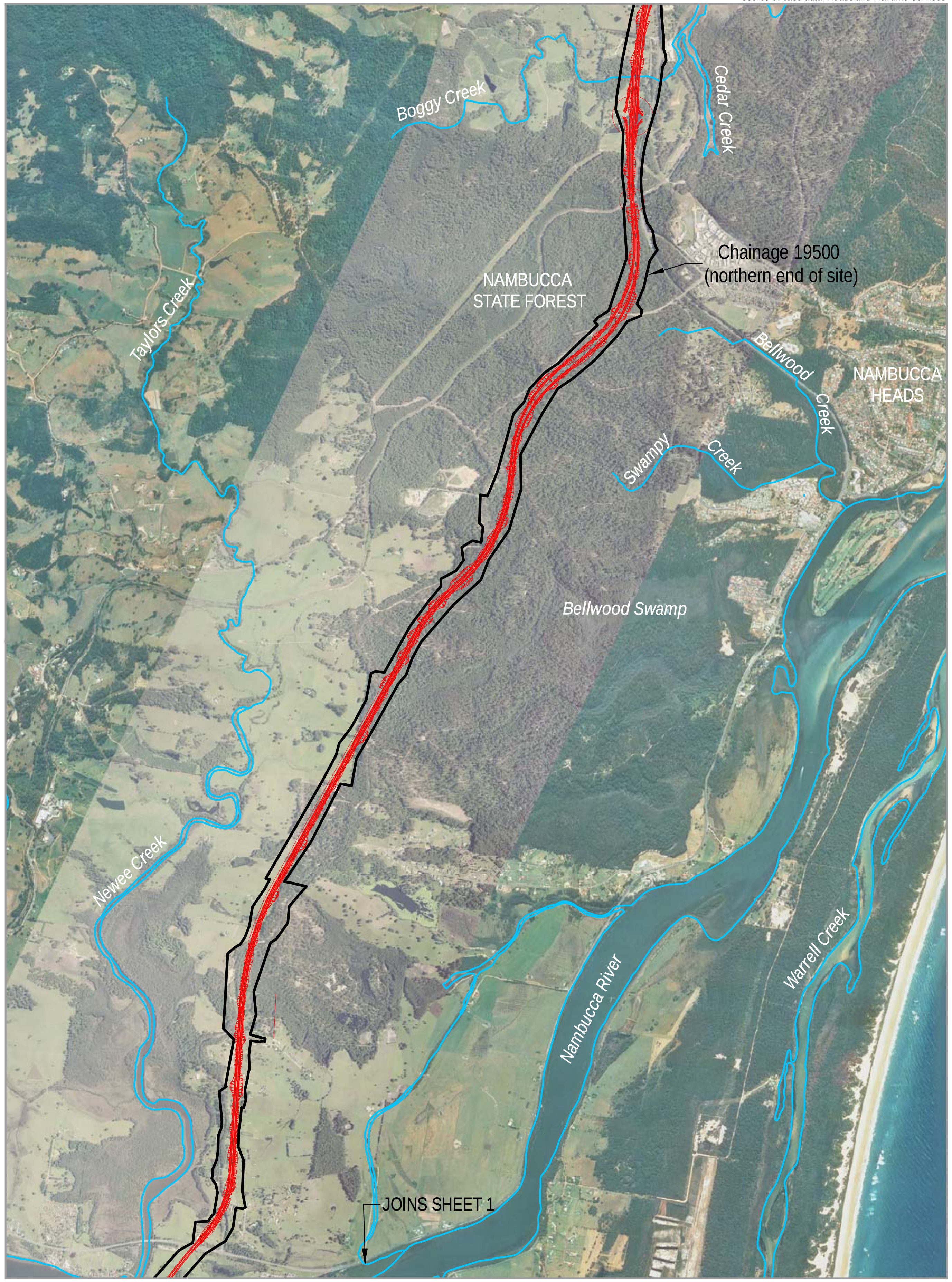

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GeoLINK environmental management and design

WC2NH Pacific Highway Upgrade Project - Koala Baseline (Spring) Surveys
2364-1004

The Site

Illustration 1.1

2

Koala Biology and Ecology

2.1 Introduction

Detailed reviews of Koala biology and ecology based on recent research are provided on the Department of Environment (DoE) *Species Profile and Threats Database* (DoE 2013b) and the NSW *Recovery Plan for the Koala (Phascolarctos cinereus)* (DECC 2008). A summary of this information is provided below.

2.2 Distribution and Habitat

The Koala's distribution extends from north-eastern Queensland to the south-east corner of South Australia, covering coastal and inland areas (ANZECC 1998 cited in DoE 2013b, DECC 2013). They inhabit a range of forest and woodland communities dominated by *Eucalyptus* species. Habitat quality depends on a range of environmental features, including vegetation species composition, soils, climate and disturbance history. The main factor influencing Koala occurrence is the presence of suitable food trees. Shelter trees also provide important habitat features, particularly in harsh climates (DoE 2013b, DECC 2013).

2.3 Feeding Requirements

The Koala's diet primarily comprises eucalypt leaves which are low in nutrients and energy, and high in indigestible components (eg lignin and cellulose) and toxic compounds (eg essential oils and tannins) (Cork *et al*. 1990; Cork and Sanson 1990 cited in DECC 2008). In a given area, the diets of individual Koalas/ subpopulations almost exclusively comprise a small number of preferred species to obtain their nutritional needs. Preferred food trees appear to be associated with the presence of formyl phloroglucinol compounds in the leaves (DECC 2008). Koala's also show strong preferences between individual trees of the same species at individual sites, which is believed to be associated with leaf anti-feedant chemicals (DoE 2013b). Foliage from non-preferred food trees are consumed at times to supplement their diet (DoE 2008, DECC 2008). Recognised Koala food tree species for the NSW North Coast region (which encompasses the study area) are listed in Table 2.1. Blackbutt is also locally considered a supplementary Koala food tree species in the region (Professor Rob Close, University of Western Sydney. pers. comm. 2013).

Table 2.1 Potential Koala Habitats for the NSW North Coast Region

Foraging Preference	*Species*
Primary food tree species	▪ Tallowwood (*Eucalyptus microcorys*). ▪ Parramatta Red Gum (*E. parramattensis*). ▪ Forest Red Gum (*E. tereticornis*). ▪ Orange Gum (*E. bancroftii*). ▪ Swamp Mahogany (*E. robusta*). ▪ Cabbage Gum (*E. amplifolia*).

Foraging Preference	*Species*
Secondary food tree species	▪ Narrow-leaved Red Gum (*E. seeana*). ▪ Craven Grey Box (*E. largeana*). ▪ Slaty Red Gum (*E. glaucina*). ▪ Grey Gum (*E. biturbinata*). ▪ Small-fruited Grey Gum (*E. propinqua*). ▪ Large-fruited Grey Gum (*E. canaliculata*) ▪ Red Mahogany (*E. resinifera*). ▪ Steel Box (*E. rummeryi*). ▪ Mountain Mahogany (*E. notabilis*). ▪ Rudder's Box (*E. rudderi*). ▪ Grey Box (*E. moluccana*). ▪ White-topped box (*E. quadrangulata*). ▪ Yellow box (*E. melliodora*).
Stringybarks/ supplementary species	▪ Stringybark (*E. tindaliae*). ▪ Blue-leaved Stringybark (*E. agglomerata*). ▪ Thin-leaved Stringybark (*E. eugeniodes*). ▪ Diehard Stringybark (*E. cameronii*). ▪ White Stringybark (*E. globoidea*).

(Source: DECC 2008)

Primary Koala food tree species are subject to a significantly higher level of usage than other Eucalyptus species, independent of tree density. Secondary and/ or supplementary food trees are generally subject to lower levels of foraging by Koalas than that of primary food trees, except where primary food trees are absent (DECC 2008).

2.4 Social Organisation and Reproduction

Koalas live in breeding aggregations which typically comprise a dominant male, a small number of mature females and juveniles of various ages (Phillips 1997, cited in DECC 2008). Home ranges vary in size depending on habitat quality and the number of available food trees, and have been recorded from 0.2 – 500 ha (DECC 2008). Males generally have larger home ranges than females, with the home range of a dominant male overlapping extensively with the home range of females within its aggregation.

The Koala breeding season peaks between September and February, and comprises a period of heightened activity. Offspring rates typically range between 0.3 – 0.8 per year, with birth occurring during October and May (McLean 2003 cited in DoE 2013b) following a 35 day gestation period (DECC 2008). Once born the young remain in the pouch for approximately six months, and remain dependent on their mother until about 12 months of age (Mitchell and Martin 1990 cited in DECC 2008). Sub-adult Koalas may remain in the mother's home range for a further two to three years, before young Koalas of both sexes disperse to establish their own home range areas (Ramsay 1999 cited in DECC 2008). Dispersal distances generally range from 1.0 – 11 km (Mitchell and Martin 1990 cited in DECC 2008). Longevity in the wild is >15 years for females and >12 years for males (Martin and Handasyde 1999 cited in DoE 2013b).

3

Methodology

3.1 Transect Surveys

Transects were established on each side of the Project footprint within the Nambucca State Forest/ Old Coast Road area between chainage 15,600 and 19,500. Twenty-five transects, 500 m long (or to the limit of vegetation) were spaced approximately 150 m apart running perpendicular to the proposed project footprint on each side of the highway upgrade. The location of transects is shown on Illustration 3.1.

Each transect was surveyed by personnel experienced in Koala surveys (David Havilah, Tony Coyle and Craig Faulkner) to document Koala presence and occupation. Relevant experience of survey personnel is summarised in Appendix A. Surveys were undertaken over two monitoring events (15/09/2014-17/09/2014 and 29/09/2014-02/10/2014) as follows:

- Diurnal survey: One observer with binoculars walking the transect searching for Koalas (110 person hours in total).
- Nocturnal survey: One observer spotlighting the transect on foot searching for Koalas at a rate of 0.5 to 1.0 km/hour (depending on vegetation density) (120 person hours in total). Koala call playback was also undertaken on each transect during spotlighting to increase the chance of Koala detection.

Additional spotlighting was undertaken on tracks and easements across this area with the survey effort of five person spotlighting hours at a rate of 2 km/hour targeting each side of the highway (10 person hours in total over four nights). Koala call playback was undertaken at regular intervals along these tracks and easements during spotlighting to increase the chance of Koala detection.

The following data was to be collected for any Koalas detected:

- Location (using global positioning system [GPS]).
- Distance from transect line.
- Occupied tree species.
- Habitat type.
- Tree height.
- Diameter at breast height.
- Koala's sex.
- Behaviour.
- Disease status.
- Reproductive status.

3.2 Survey Limitations

A number of small areas associated with the transects were unable to be accessed at the time of survey due to property access restrictions. These include:

- Council owned land around the Nambucca Heads waste facility where access was not provided.
- Part of three transects west of the highway, in the State Forest north-west of the Bowraville turn off from Old Coast Road where a very wary individual was camping in the forest.

Dense lower storey vegetation associated with the site created some obstacles to viewing the tree canopy within parts of some transects, particularly during nocturnal surveys. Notwithstanding this, the combination of diurnal/ nocturnal target searches, call playback and track surveys were considered appropriate to identify resident Koalas if present.

3.3 Monitoring Triggers

Should adequate data be obtained, population estimates are to be made based on the 'strip (fixed width) transect' or 'line transect' method described in Dique *et al.* (2003).

In the event that three or more Koalas are recorded during the transect surveys, the provision for GPS/ VHF fitted collars and pit tagging of recorded Koalas and establishment of transect survey control sites would be triggered. This would encompass the following additional pre-construction monitoring activities:

- GPS/ VHF collar-fitted receiver and transmitter and pit-tagging: Locating, capturing and fitting Koalas with GPS receiver/VHF transmitters; capturing the collared animals after six months or prior to the start of construction (whichever occurs first) to download GPS data, inspect the animals welfare (take any necessary action) and replace collar batteries. The GPS would be set to record the maximum number of location fixes for six months. The VHF transmitter will allow for easier Koala re-location during subsequent capture events. VHF transmitter batteries would be replaced every time the animal is recaptured.
- Transect surveys: Establish 'control' transect survey sites greater than 500 m from the Pacific Highway upgrade alignment to complement 'impact' transect survey sites.

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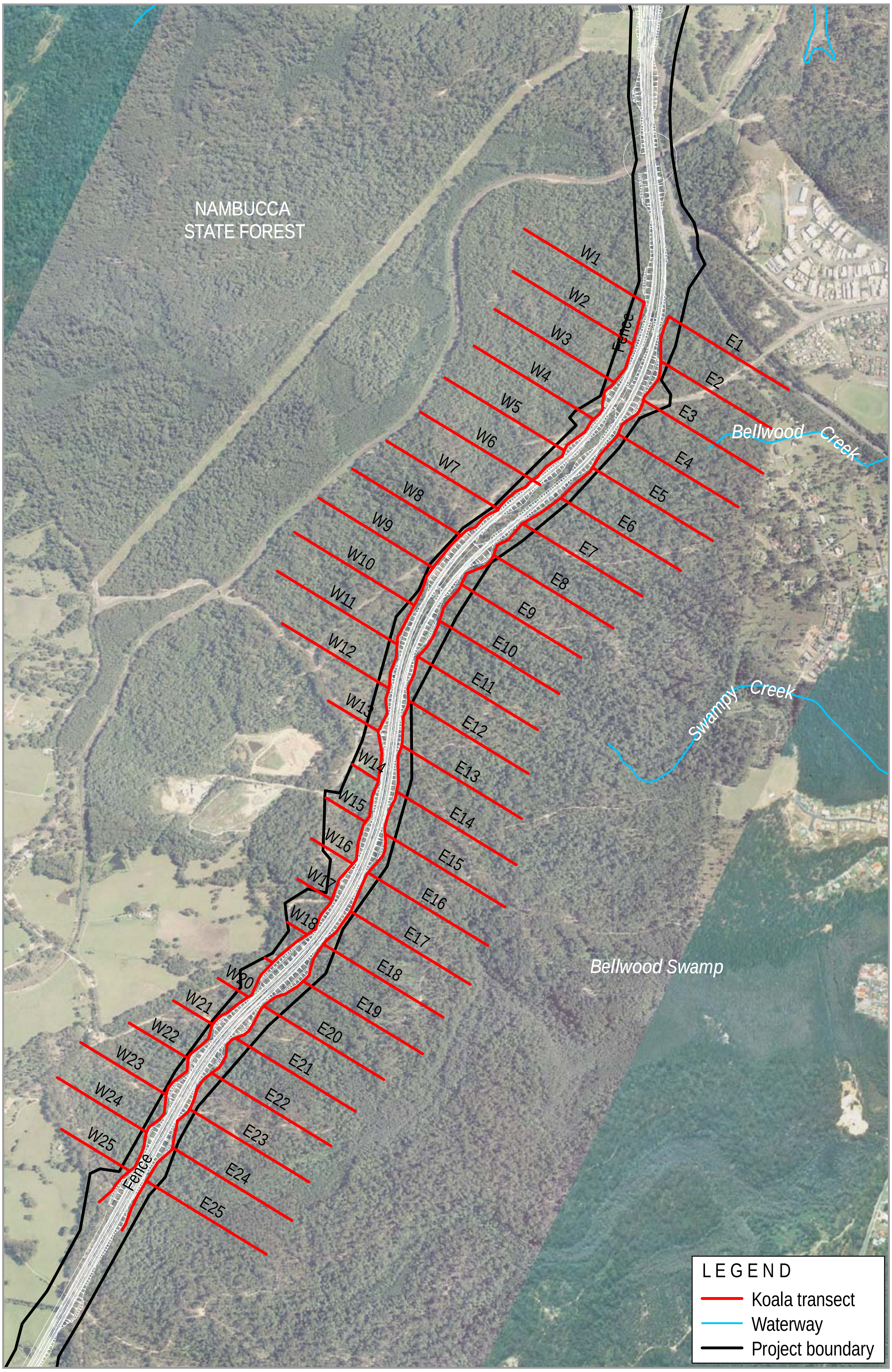

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Transect Locations

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WC2NH Pacific Highway Upgrade Project - Koala Baseline (Spring) Surveys
2364-1005

Illustration 3.1

4

Results and Discussion

4.1 Field Survey Results

4.1.1 Spring 2014 Surveys

4.1.1.1 Transect Surveys

Surveys of transects undertaken diurnally and nocturnally did not locate any Koalas during both Spring monitoring events. No Koala faecal pellets or other obvious sign of usage were detected during the Spring surveys. Survey conditions were fine for both events.

4.1.1.2 Spotlighting Surveys on Tracks/ Easements

No Koalas were observed during spotlighting surveys on tracks/ easements. One Koala was heard calling in response to call playback in the vicinity of transect E21 (refer to **Illustration 4.1**) in the southern portion of Nambucca State Forest, to the east of the new alignment. A search was undertaken for the animal however the Koala could not be located. Vegetation associated with this area comprises Flooded Gum Moist Open Forest.

4.1.2 Autumn 2014 Surveys

4.1.2.1 Transect Surveys

Diurnal and nocturnal transect surveys conducted over both monitoring events yielded no observations of Koalas. Additionally, no Koala faecal pellets or obvious scratches attributable to Koalas were observed during these surveys Survey conditions for both monitoring events were generally fine with some scattered showers falling mostly late at night. Weather conditions at all times were considered to be appropriate for observing Koalas.

4.1.2.2 Spotlighting Surveys on Tracks/ Easements

One Koala was recorded during spotlighting surveys being conducted along the Old Coast Road in the vicinity of the Nambucca Heads waste facility, west of the highway alignment (refer to **Illustration 4.1**). This individual responded to call playback and is likely to be a resident male. Vegetation associated with this area is mapped as being predominantly Open Blackbutt forest with some moister gullies comprising Flooded Gum Moist Open Forest.

4.2 Koala Population – Discussion and Summary

The results of baseline Koala surveys confirm that the Nambucca State Forest/ Old Coast Road area is subject to low level usage by Koalas. The results to date indicate that Koalas are occasionally using the moist gullies that occur predominantly in the southern portion of the study site. An additional Koala record was detected in Winter 2014 during ecological monitoring surveys being undertaken for the WC2NH project, in the vicinity of the recent spring monitoring record, supporting the primary use of the southern portions of Nambucca State Forest. Whilst areas of similar habitat do occur in the northern part of the study site, the moist gullies in this area are not as extensive as those in the southern portion. There is potential that the dry upper slopes and ridges associated with the northern portion of Nambucca State Forest are utilised by Koalas, however currently there is no evidence to suggest this is the case.

Previous Koala surveys undertaken by GeoLINK (2013) as part of the Koala impact assessment for the WC2NH Project surveyed 38 Koala Spot Analysis Technique (SAT) plots within the Nambucca State Forest/ Old Coast Road area. Three (7.9 %) of the 38 SAT plots surveyed in this area were subject to medium (normal) Koala usage for a low density Koala population, indicating that part of the range of resident Koala/s or breeding aggregation/s overlaps the study area (GeoLINK 2013). Koala records from field surveys associated with the WC2U Project Environmental Assessment (SKM 2010b) and the Atlas of NSW Wildlife (OEH 2013) support these findings.

Insufficient data is available from both the previous SAT surveys and baseline monitoring to provide an accurate population estimate of Koalas in the area. However, given the low levels of Koala usage evidenced by the results of the baseline surveys and previous surveys and that the home range of Koalas in low density populations may exceed 100 ha (Ellis *et al.* 2002 – cited in Biolink 2009), the number of individual Koalas whose home range encompass the study area is likely to be small (estimated at 1-2 animals).

The results of the transect surveys to date do not trigger the need for the provision of GPS/VHF fitted collaring and pit tagging Koalas or establishing transect survey control sites.

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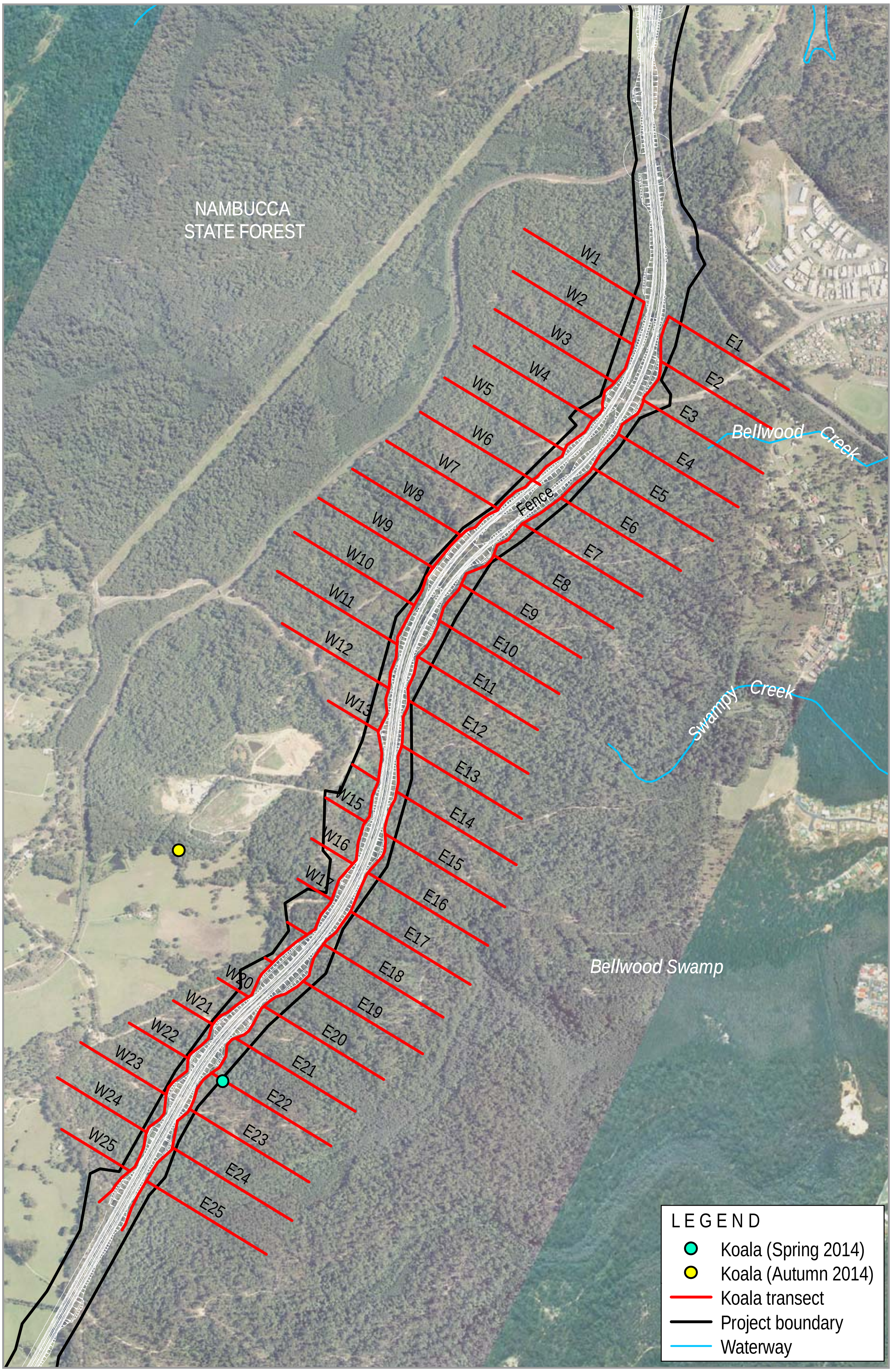

Koala Records

WC2NH Pacific Highway Upgrade Project - Koala Baseline (Spring) Surveys
2364-1006

Illustration 4.1

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5

Conclusions

The spring baseline Koala monitoring surveys located only one Koala during spotlighting surveys in the southern portion of Nambucca State Forest. This individual responded to call playback and is likely to be a resident male. This result is similar to the survey results from the autumn baseline surveys which detected one Koala in the vicinity of the Nambucca Heads waste facility, west of the highway alignment.

The results of spring and autumn monitoring events support the results of previous Koala surveys, undertaken as part of the WC2NH Koala Impact assessment and confirm that the southern parts of the Nambucca State forest are subject to low level usage by a small number of Koalas (estimated at 1-2 animals).

The results of the baseline monitoring do not trigger the need for the provision of GPS/VHF fitted collaring and pit tagging Koalas or establishing transect survey control sites.

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Appendix A

Experience of Survey Team Relevant to Koalas

Table A.1 Experience of Survey Personnel

Survey Personnel	*Years of Experience as an Ecologist*	*Projects involving Koala surveys (spotlighting, call playbacks, and/or SAT plots):*
David Andrighetto	8	▪ Comprehensive Koala surveys and impact assessment for the Koala on the WC2NH Project. ▪ Surveys and advice relating to Koalas for the Devils Pulpit Pacific Highway Upgrade project. ▪ RMS projects including habitat assessments at Camerons Corner, Waterfall Way and Martells Road intersection, Pacific Highway; ▪ Full flora and fauna assessment including SAT plots at Karangi Quarry, Karangi, NSW. ▪ Surveys and Assessments for the Koala as part of the Old Glenn Innes Road subdivision Koala Plan of Management. ▪ Lanham Halfway Creek Subdivision (SEPP 44) Koala Habitat Assessment. ▪ Sawtell Rail Corridor Koala Habitat Assessment.
David Havilah	7	▪ Comprehensive Koala surveys and impact assessment for the Koala on the WC2NH Project. ▪ Koala surveys and assessments for a number of residential development sites within various Local Government Areas. ▪ RMS projects including habitat assessments at Camerons Corner, Waterfall Way and Martells Road intersection, Pacific Highway. ▪ Extensive Koala habitat mapping and monitoring associated with the development of the Coffs Harbour water supply project, Grafton, NSW.
Tony Coyle	14	▪ Subdivision of a 60 ha site including remnant open forest near Lismore, NSW. ▪ Upgrade of the Pacific Highway (Devil Pulpit section). ▪ RMS projects including habitat assessments at Camerons Corner, Waterfall Way and Martells Road intersection, Pacific Highway. ▪ Full flora and fauna assessment including SAT plots at Karangi Quarry, Karangi, NSW. ▪ SAT plot assessments with Biolink (Steve Phillips) associated with mapping of Koala habitat, Tweed Shire, NSW. ▪ Extensive Koala habitat mapping and monitoring associated with the development of the Coffs Harbour water supply project, Grafton, NSW.
Craig Faulkner	10	▪ Field surveys for the development of the Gunnedah Koala Plan of Management (on behalf of Greenloaning Biostudies). ▪ Field surveys for comprehensive ongoing koala monitoring for the Shannon Creek water storage facility south of Grafton (on behalf of Greenloaning Biostudies). ▪ Extensive koala surveys for the proposed Kings Forest development near Kingscliff (on behalf of Aspect North Pty Ltd [now Landapartners]). ▪ Field survey and drafting of Koala Plan of Management for a caravan park/retirement village near Evans Head (on behalf of Aspect North Pty Ltd [now Landpartners]). ▪ Koala surveys and drafting of Koala Plan of Management for proposed development at Myocum (on behalf of Stephen Fletcher and Associates town planners). ▪ Targeted Koala surveys for the proposed extension to Batson's Quarry at Suffolk Park (on behalf of Greenloaning Biostudies Pty Ltd).

Appendix H

Road Kill Monitoring Methodology

WC2NH Road Kill Monitoring Program

1.1 Timing of Monitoring

Timing of road kill surveys for the WC2NH Project is described in Table 1.

Table 1 – Timings and locations of road kill surveys

Project Phase	Timing of Survey	Location
During clearing operations	Daily	Portion of existing Pacific Highway adjacent to clearing operations
One month following clearing operations	Daily	Portion of existing Pacific Highway adjacent to clearing operations
Duration of construction	Weekly	Entire length of existing Highway in Project area
Upon opening of each stage of the Project to traffic (operational phase)	Weekly for 12 weeks commencing the week of opening each stage to traffic.	Entire length of opened stage.
Upon completion of the Project (operation phase)	Excluding the season/s covered by the initial 12 week monitoring period (refer above), weekly during October (spring), January (summer), April (autumn) and July (Winter) for up to five consecutive years post construction, or until mitigation measures have been demonstrated to be effective.	Entire length of completed Project

1.2 Monitoring Program Objectives

The aim of the monitoring program is to;

- report on any animal road kill on the project following the opening to traffic; and
- assess the effectiveness of the presence of fauna fencing to prevent fauna being killed by vehicles while attempting to cross the WC2NH Upgrade.

1.3 Monitoring Procedure

A two-person team vehicle being driven along the entire length of the highway in the Project area and identifying dead wildlife (road kill) seen on the road and within three metres of the road edge. The passenger will search the road and its verge for road kill. When a road kill is observed from the vehicle, a closer visual inspection of the carcass will be undertaken where safe access is available. If safe access is not possible, due to local traffic conditions, binoculars will be used to try to identify and provide as detailed information as is possible on the carcass.

Road kill fauna will be identified to species level where possible, with reference to field guides. Where there is any doubt to the identification of the carcass, photographs will be taken and forwarded to a qualified ecologist for identification/ confirmation of species. Those too seriously damaged to be accurately identified will be recorded as “unknown”.

To assist with the correct identification of road kills, the following will be undertaken –

a. The provision of a qualified ecologist (shall be a recognised expert in mammal identification in coastal northern NSW) to undertake the initial phase of operational monitoring (first season) with relevant Roads and Maritime team members providing appropriate detailed training and a baseline of expert monitoring of road kills;
b. The provision of specialist training (to be provided by an expert as above in point a) in fauna identification for Contractors and Roads and Maritime staff involved in the construction phase monitoring of road kill; and
c. Where there is any doubt to the identification of the carcass, the provision of photographs of road kill to be sent to a qualified ecologist (an expert as above in point a) to confirm the identity of road kill and to maintain a permanent record of road kill for further comparisons, if needed.

1.4 Monitoring Methodology

- The highway will be monitored using the method previously indicated (section 1.3) consisting of a two-person team traversing the upgrade in a vehicle to locate and identify road kills;
- The speed of travel will be the same in all cases to avoid confounding the data collection, and should be as slow as is safely possible;
- The highway will be surveyed weekly for four weeks in spring, summer, autumn and winter (see Table 1);
- Where possible, each survey shall be completed within two hours of sunrise in order to maximise the potential to record road kills before either carrion eating animals or traffic render any road kill unidentifiable;
- if possible, each survey will be carried out on the same day of the week to remove the influence of varying environmental conditions and to ensure consistent temporal spacing;
- For each road kill observed, the following attributes will be recorded
  a. Geographic Coordinates of any road kill.
  b. Whether fauna fencing was installed at/near the location.
  c. Species of road kill where possible, however, where there is any doubt as to the identification of the carcass, photographs shall be forwarded to a qualified ecologist for identification/ confirmation of the species.

If the animal is identified as an EPBC Act threatened species, the carcass will be photographed and the following information will also be recorded where possible and safety considerations permit

a. Sex and age class (juvenile or adult).
b. Presence of pouch young (for marsupials).
c. Presence of flightless young (for flying-foxes or other bats).
d. Distance to a fauna connectivity structure.
e. Distance to drop down structure.
f. If fauna fencing was installed, is there any damage to the fence in the vicinity.
g. Weather conditions at the time of the monitoring (from the Bureau of Meteorology) – including temperature, rainfall in the last 24 hours, moon phase.
h. If the animal is identified as a flying-fox:
   - Distance to nearest camp,
   - Distance to nearest canopy vegetation,
   - Presence of flowering food trees in neighbouring median or roadside vegetation; plants identified to species and referenced with diet list.

1.5 Analysis of data

The data to be collected will be analysed using a suitable non-parametric test such as a Kruskal-Wallis test. The aim will be to test both whether the fenced and unfenced locations have different mean numbers of road kills and if the amount of road kill varies through time in either or both of the two types of areas. Associations with other measured variables will be described as data allow, including sex, age class, presence of dependent young and, in the case of flying-foxes, proximity to roost sites or flowering food trees. Such information will indicate if the mitigation measures in the area are working as expected to keep road kills to acceptable levels and that none of the target species are killed.

1.6 Reporting

1.6.1 Quarterly reports

A report will be prepared by the ecologist following the initial 12 week monitoring period (after opening for each stage) to identify any roadkill hotspots and review the mitigation measures. The initial report and ongoing seasonal reports of the data collected will be provided to Roads and Maritime. This will include graphs of the data and any previously collected data to provide simple visual comparisons of road kill. This will also include overall road kill counts as well as separate graphs for each of the target species (if deaths have occurred).

Anecdotal road kill information collected on days that are not monitored as part of this program may be added as a note for discussion.

1.6.2 Annual Reports

The annual report will be prepared in consultation with a qualified ecologist and provided to DoEE and EPA within one month of completion of the fourth monitoring season. From then on it will be provided within one month of the same monitoring season in subsequent years until monitoring is completed (Table 1).

Analysis of the data itself shall be included in an annual monitoring report. This report will include a statistical analysis of all of the data collected to that time including graphical representations of the road kill that is recorded.

Annual reports will record any potential or obvious failures in road kill mitigation identified in the monitoring program and provide a date by which meetings will take place to discuss any such adverse findings. This will include at least:

- where statistically larger number numbers of road killed animals are detected on fenced sections compared to unfenced sections;
- where any of the target threatened fauna are recorded as killed;
- where there is a clear pattern of unexpected road kill at any point on the Upgrade.

1.7 Performance Measures

Lower rates of road kill in proximity to fauna fencing (i.e. areas of the main carriageways within areas adjacent to installed fauna fencing) than in sections of the upgrade not near fauna fencing during monitoring events up to five years post construction phase, or until such time as mitigation measures have been demonstrated to be effective.

1.8 Adaptive Management

Where any annual report identifies a significant difference between the road kill numbers of the fenced and unfenced areas, DoEE and EPA shall be notified, and a meeting will be set to discuss such differences with the relevant agencies and Roads and Maritime.

Such a meeting would occur within one month of completion of the annual report, which should ensure sufficient time to consider/review the response to any recorded significant differences.

Appendix M

Spotted-Tailed Quoll Management Plan

Spotted-tailed Quoll Management Plan

Warrell Creek to Nambucca Heads Upgrade of the Pacific Highway

Spotted-tailed Quoll Management Plan

Warrell Creek to Nambucca Heads Upgrade of the Pacific Highway

Prepared for: Acciona and Ferrovial Joint Venture and Roads and Maritime Services

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UPR	*Description*	*Date Issued*	*Issued By*
2378-1006	V1	06/08/2014	DGH
2378-1009	V2	08/08/2014	DGH
2378-1042	V3	08/10/2014	DGH
2378-1049	V4	16/10/2014	DGH
2378-1058	V5	30/10/2014	DGH
2378-1060	V6	31/10/2014	DGH
2378-1067	V7	4/11/2014	DGH
	V8	7/11/2014	NR
2378-1082	V9	8/12/2014	DGH
2378-1263	V10	06/09/2016	DGH
2378-1401	V11 DRAFT	14/11/2017	DGH
2378-1403	V11	15/11/2017	DGH

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1

Introduction

1.1 Project Overview and Background to the Plan

The Pacific Highway Upgrade Program is a joint commitment by the Australian and New South Wales (NSW) governments to improve the standard and safety of the Pacific Highway between Hexham and the Queensland border.

The Warrell Creek to Urunga (WC2U) project forms part of the Pacific Highway Upgrade Program and comprises approximately 42 kilometres of dual carriageway road that would bypass the towns of Warrell Creek, Macksville, Nambucca Heads and Urunga on the Mid North Coast of NSW. The Project has been divided into two stages with Stage 1 consisting of the approximate 22.5 kilometres stretch from Nambucca Heads to Urunga (NH2U) and Stage 2 consisting of the remaining approximate 19.5 kilometres of dual carriageway between Warrell Creek and Nambucca Heads (WC2NH). This Spotted-tailed Quoll Management Plan relates to Stage 2 (WC2NH) which is referred to throughout this report as 'the Project' (refer to **Illustration 1.1**).

The NSW Minister for Planning approved the WC2U Pacific Highway Upgrade Project (the Project) under Part 3A (now repealed) of the *Environmental Planning and Assessment Act 1979* (EP&A Act) on 19 July 2011, subject to the Minister's Conditions of Approval (CoA) being met. In accordance with transitional provisions included in Schedule 6A of the EP&A Act, the Project is characterised as a transitional Part 3A project. It is noted that despite its repeal, Part 3A of the EP&A Act continues to apply in respect of transitional Part 3A projects. Under section 75C of the EP&A Act, the Minister for Planning declared, by Order dated 5 December 2006 and published in the NSW Government Gazette No. 175, that development for the purposes of upgrading segments of the Pacific Highway is a project to which Part 3A of the EP&A Act applies (the declared Project). The Minister also declared by Order dated 8 December 2006 published in Gazette No. 175 that the same development is a critical infrastructure project under section 75C of the EP&A Act. This was subsequently modified through a further Ministerial Order gazetted on 3 December 2010 (Gazette No. 133).

Impacts to the Spotted-tailed Quoll (*Dasyurus maculatus*) were assessed in the WC2U Environmental Assessment (EA) (Sinclair Knight Merz – SKM 2010a, SKM 2010b), in regard to relevant State and Federal legislation. The Spotted-tailed Quoll is listed as a 'Vulnerable' species under the NSW Government *Threatened Species Conservation Act 1995* (TSC Act) and as Endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). In relation to the Spotted-tailed Quoll, the Assessment of Significance completed for the WC2U EA concluded that "*the proposal WC2U Project will remove potential habitat for the species and its prey, leading to further fragmentation of habitat, a known threat to the species. Measures to conserve fauna corridors and movement avenues for terrestrial fauna have been incorporated into the design for the proposed action. Breeding, foraging and movement life-cycle opportunities would remain in the region and are likely to sustain a local population. It is concluded that the WC2U Project is unlikely to have a significant impact on the Spotted-tailed Quoll.*"

The Roads and Maritime Services has prepared a referral seeking approval from the Australian Government for the Project. The referral was lodged with the Department of the Environment (DoE) on 20 December 2013. For further information refer to http://www.environment.gov.au/cgi-bin/epbc/epbc_ap.pl?name=current_referral_detail&proposal_id=7101. The referral provides detail on the Project, including a detailed description, proposed construction staging, excluded activities, description of impacts and measures to avoid or manage impacts, for Commonwealth Matters of National Environmental Significance (MNES), including the Spotted-tailed Quoll. The DoE have reviewed the referral (number 2013/7101) on 23 January 2014 and made the decision under section 75 of the EPBC Act that that the Project is a controlled action and requires approval under the EPBC Act.

1.2 Purpose and Objectives

This management plan identifies the potential impacts of the WC2NH project on the local population of Spotted-tailed Quoll, hereafter referred to as the STQ. It outlines the proposed management measures to be implemented for the STQ on the project and a program for monitoring the effectiveness of these measures. The objective of the management plan is to provide measures that minimise impacts to the STQ on the Project.

The plan covers pre-construction, construction and operational phases of the project and applies to all areas within the WC2NH project boundary.

1.3 Order of Precedence

In the event of any inconsistency, ambiguity or discrepancy between this Management Plan and the Flora and Fauna Management Plan for the Warrell Creek to Nambucca Heads Pacific Highway upgrade project, the following order of precedence must apply:

a. This Spotted-tailed Quoll Management Plan.

b. The Flora and Fauna Management Plan for the Warrell Creek to Nambucca Heads Pacific Highway upgrade project.

1.4 Management Structures and Plan Updates

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

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

- Specific
- Measurable
- Achievable
- Results-based
- Time-based.

The STQ management plan has been prepared in consultation with Roads and Maritime Services, the Environment Protection Authority (EPA) and the Commonwealth DoE. General responsibilities for environmental management would be outlined in the project specific Construction Environment Management Plan (CEMP) and CEMP sub plans including the Flora and Fauna Management Plan (FFMP). These management plans would be prepared prior to the commencement of construction. Roads and Maritime and the D&C Contractor for this project (Acciona and Ferrovial Joint Venture [AFJV]) would be responsible for implementing the measures in this STQ Management Plan and this would include the engagement of suitably qualified specialists to undertake and oversee surveys and monitoring activities where necessary.

1.5 Plan Authors

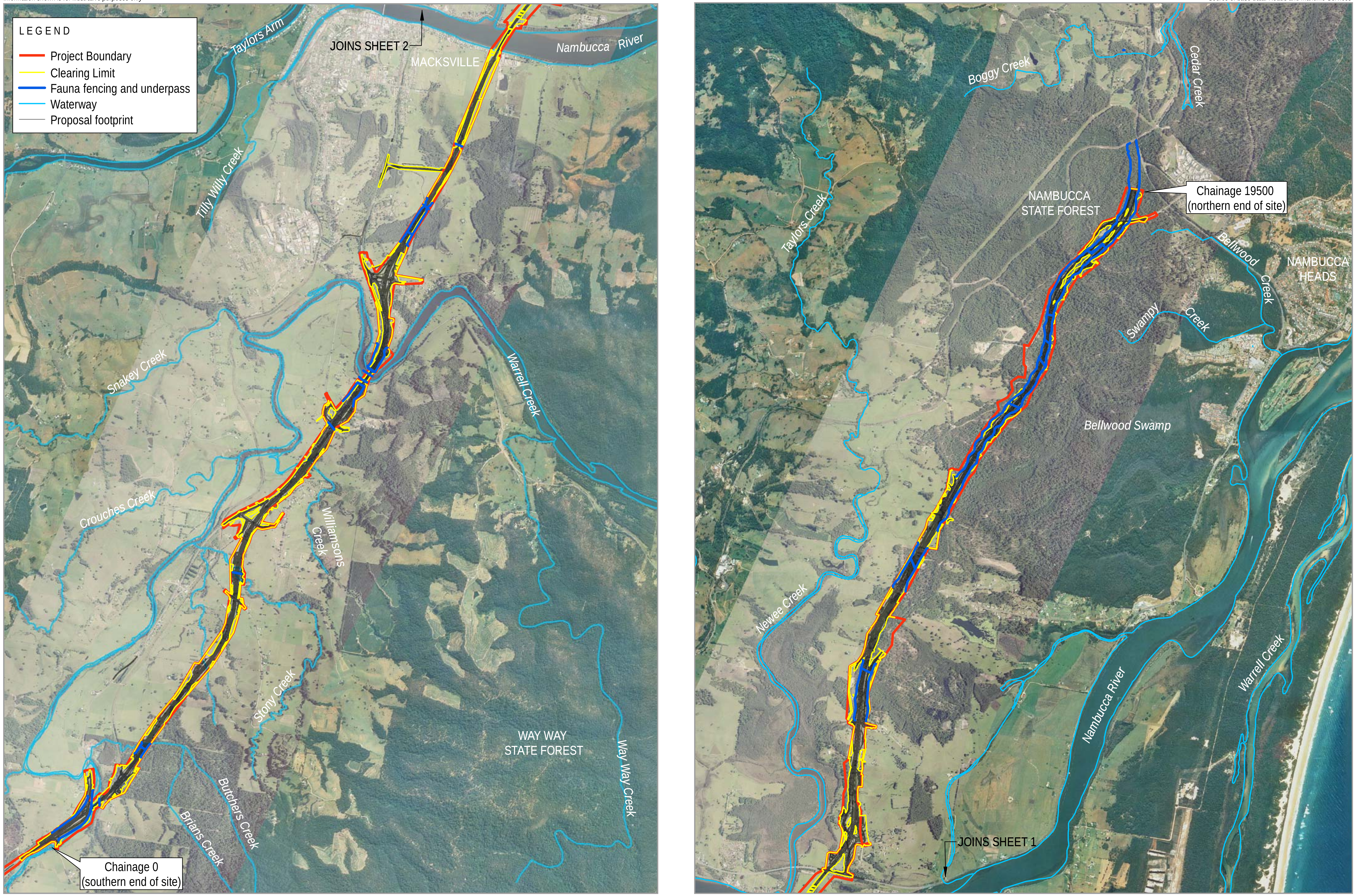
The STQ Management Plan has been prepared by the following personnel from the AFJV Project Ecologist GeoLINK:

- David Havilah (Senior Ecologist).
- Veronica Silver (Senior Ecologist – Peer Review).

Qualifications and experience of the plan authors are included in **Appendix A**.

Information shown is for illustrative purposes only

Drawn by: RE Checked by: GJM Reviewed by: JOL Date: 05/09/2016
Source of base data: Roads and Maritime Services



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North

GeoLINK

WC2NH Spotted-tailed Quoll Management Plan
2378-1267

The Site

Illustration 1.1

Spotted-tailed Quoll Population

2.1 Species Description

Detailed reviews of STQ biology and ecology based on recent research are provided on the DoE *Species Profile and Threats Database* (DoE 2013b) and the *National Recovery Plan for the Spotted-tailed Quoll (Dasyurus maculatus)* (Department of Sustainability and Environment [DoSE], 2008). A summary of this information is provided below.

2.1.1 Biology/Ecology

The STQ is one of Australia's largest extant marsupial carnivores (Belcher, Burnett and Jones 2008) with fur which is sandy to rufous or dark brown with irregular white spots covering the animals back, sides and extending down the tail, and it's stomach is cream to white (Belcher, 2000 cited in DoSE, 2008). Males can grow to 1.3 metres in length (including the tail) and weigh up to 7.0 kilograms (average 2.6 – 4.6 kilograms) while females are smaller, to about 85 centimetres in length and 4.0 kilograms in weight (average 1.5 – 2.2 kilograms) (DoSE, 2008).

The STQ typically occurs at low densities, as adults are solitary and occupy large home ranges. Female home ranges are generally non-overlapping and 350 – 500 hectares in size. Male home ranges are much larger, approximately 2000 hectares in size and overlap and encompass multiple female home ranges (Belcher & Darrant, 2004). The species is capable of covering large distances in a short period of time, with animals recorded moving at least 8.0 kilometres in a day and 19 kilometres in a week (Andrew, 2005 cited in DoSE, 2008) and is known to traverse their home ranges along densely vegetated creek lines.

The species is known to use communal 'latrine sites' often on flat rocks among boulder fields, rocky cliff faces or along rocky stream beds or banks. Such sites may be visited by multiple individuals and be recognised by the accumulation of the sometimes 'twisty shaped' faeces deposited by animals (Office of Environment and Heritage (OEH), 2014).

2.1.2 Habitat

The STQ has a preference for mature wet forest habitat (Belcher, 2000 cited in DoSE, 2008) where it occupies home ranges of several hundred to several thousand hectares in size. The Spotted-tailed Quoll may be largely diurnal or a mix of nocturnal and diurnal depending on major prey (Belcher and Darrant, 2004). Habitat requirements include suitable den sites such as hollow logs, tree hollows, rock outcrops or caves (DoSE, 2008). STQs use multiple dens (possibly in excess of 20) and usually move between them every one to four days. Dietary studies have found that medium sized mammals are the majority prey (Belcher et al 2007) with birds and small mammals a minor component of the diet. This species is moderately arboreal and approximately 11 per cent of travelling is done in trees (Jones et al. 2001, cited in DoSE, 2008). At many sites arboreal mammals are the main prey and STQ take prey such as Greater Gliders in tree hollows and have been observed and radio tracked over 30 metres up trees hunting/feeding (Belcher pers. comm. 2014).

2.1.3 Diet

The species is a generalist predator with a preference for medium sized (500 grams – 5.0 kilograms) mammals. It consumes a variety of prey, including gliders, possums, small wallabies, rats, birds, bandicoots, rabbits, reptiles and insects. It will also eat carrion and domestic fowl (OEH, 2014).

2.2 Known Distribution

The STQ is widely but patchily distributed in eastern Australia, occurring from north-eastern Queensland to Tasmania although is apparently absent from central Queensland. The mainland population of the species occurs from near Gladstone in south-eastern Queensland, through NSW to western Victoria, but is now presumed to be extinct in South Australia (DoSE, 2008).

2.2.1 Database Records

The OEH Atlas of NSW Wildlife (OEH, 2013) database shows ten STQ records occurring within the Project Site locality. Typically these records occupy a network of habitat patches to the north of the Project Site associated with large tracts of native vegetation (i.e. Newry and Nambucca State Forest) and extending west to the Great Dividing Range. Records have been made both within Nambucca State Forest and along riparian habitat found alongside the Nambucca River and Warrell Creek. The nearest Atlas record to the Project Site (recorded in September 2004) is around 1.1 kilometres form the Project Site in the vicinity of the Nambucca River.

2.2.2 Field Surveys

Field surveys undertaken as part of the WC2U EA (SKM, 2010) did not record any STQs from targeted surveys undertaken for ground-dwelling and arboreal mammal species. The WC2NH EA (SKM, 2010) concluded "*that despite not being recorded on the site, the STQ was likely to occur*".

Baseline STQ monitoring surveys have recently been completed and did not identify any STQ individuals (refer to **Section 7** for further details). One road kill record was however recently detected near the southern end of the Project associated with the existing Pacific Highway near Butchers Creek. The nearby database record and recent road kill record suggest that the STQ occurs at a low density within the locality.

2.3 Habitat within the Project Footprint

Suitable habitat for the STQ is well represented in the larger forested areas associated with the Project Site, particularly the Nambucca State Forest and adjoining vegetation occurring on private properties. Gullies and riparian zones within this area provide suitable habitat and areas for movement of the species throughout the surrounding landscape.

The population of STQs occurring throughout the broader area surrounding the Project Site is difficult to ascertain due to the large home ranges held by this species and associated difficulties in surveying for this species. Given that recent records have been recorded within habitat associated with the Project Site, it is likely that the Project Site provides potential habitat for a population of STQs occurring within broader areas encompassing the study area.

3

Key Threats and Potential Impacts of the Project

3.1 Key Threats to the Species

The main recognised threats to the STQ (DoSE, 2008) include:

- Loss, fragmentation and degradation of habitat.
- Competition with introduced predators such as cats and dogs.
- Deliberate poisoning, shooting and trapping primarily in response to predation of chickens.
- Mortality from vehicle strike.
- Climate Change.
- Poisoning from Cane Toads.
- Weeds and feral animals.
- Fire.

SKM (2010a) provides a detailed assessment of the overall biodiversity impacts of the Project on biodiversity. The main threats identified which are relevant to the STQ for the WC2NH Project include:

- Habitat loss, fragmentation and degradation.
- Mortality from vehicle strike.

3.2 Potential Impacts from the Project

3.2.1 Habitat Loss, Fragmentation and Degradation

An assessment of the area of habitat affected by direct clearing and damage to vegetation during construction of the Warrell Creek to Nambucca Heads upgrade was undertaken based on vegetation surveys completed for the WC2U EA (SKM, 2010) and based on the following:

- Concept design with 15 metre buffer.
- Construction/operational water quality basins with 10 metre buffer.
- Adjustments to access roads within Nambucca State Forest with 10 metre buffer.
- Utility adjustments with clearing requirements of utility authorities.
- Three metre clearing width for boundary fencing – excluding within Nambucca State Forest and swamp forest where flying fox camp is located.

The area identified for clearing includes a 10 per cent contingency which allows provision for clearing construction phase water quality basins, accesses to ancillary facilities, stockpile sites and design refinements.

The Project would remove 114.1 hectares of potential habitat for the species and its prey, leading to further fragmentation of habitat, a known threat to the species. These impacts are likely to result in an estimated 0.6 per cent loss of Spotted-tailed Quoll habitat within the locality. The total area of habitat directly impacted is comprised of the following:

- Map Unit 1 – Blackbutt Open Forest – 75.2 hectares.
- Map Unit 2 – Mixed Floodplain Forest – 4.0 hectares.
- Map Unit 3 – White Mahogany/Grey Gum/Ironbark Moist Open Forest – 7.3 hectares.
- Map Unit 4 – Flooded Gum Moist Open Forest – 14.8 hectares.
- Map Unit 6 – Swamp Mahogany /Paperbark Swamp Forest – 5.3 hectares.
- Map Unit 7 – Swamp Forest - Swamp Oak – 0.4 hectares.
- Map Unit 8 – Freshwater Wetlands – 0.64 hectares.
- Map Unit 9 – Mangrove Forest – 0.1 hectares.
- Map Unit 12 – Hardwood plantation – 3.6 hectares.

This area contains vegetation providing foraging, denning and movement/partial movement habitat. In terms of habitat loss, it is considered that individual females are comparatively more sensitive to this habitat loss than males due to their smaller home range, higher energy requirements for breeding and habitat centred on areas containing high prey densities.

The Project would increase the fragmentation of habitat in the surrounding landscape by impacting on contiguous forested areas, particularly the larger fragments associated with Nambucca State Forest. The impacts of habitat fragmentation on wildlife are detailed in SKM (2010b). The main impacts relevant to the STQ include impacts on movement corridors, access to habitat to satisfy biological requirements, genetic exchange, increasing edge effects, and reduced ability for population recovery following stochastic events. While parts of the local landscape have already been fragmented from past clearing and development, the Project would contribute to this cumulative fragmentation through habitat clearing and construction of a major highway, approximately 16.5 kilometres of which deviates from the existing highway alignment.

To counter these impacts the Project design includes a number of dedicated and combined fauna underpasses with fauna fencing. Therefore while the Project will lead to habitat fragmentation and reduced connectivity, opportunities for the STQ to move between habitats on opposing sides of the highway post construction would be available. During the construction stage of the Project, there is some risk of STQ mortality/injury during clearing. However mitigation measures associated with the Project aim to reduce the risk of such impacts.

3.2.2 Road Kill

Like other large carnivorous marsupials, STQs are susceptible to road mortality because they scavenge the carcasses of other road kill fauna. Males, particularly dispersing juveniles, are probably at greatest risk because of their extensive ranging behaviour which means that they encounter roads more frequently (DoSE, 2008).

Approximately 16.5 kilometres of the 19.5 kilometres WC2NH Pacific Highway upgrade will deviate from the existing Pacific Highway alignment. The overall risk of STQ road kill locally is however unlikely to be significantly increased as:

- Extensive fauna fencing is proposed along the highway where it adjoins forest north of Nambucca River and at several locations south of the Nambucca River where the highway intersects vegetation (refer to **Appendix B**).. In total, approximately 12.1 kilometres of the new highway would support fauna exclusion fencing, approximately 6.7 kilometres of which is located north of the Nambucca River and 5.4 kilometres of which is located south of the Nambucca River. Details of fauna fencing to be provided on the project are included in **Appendix B.**
- Dedicated and combined fauna underpasses would be established to allow for safe passage across the highway.
- The study area north of the Nambucca River is subject to a low level of STQ activity.
- South of the Nambucca River:
  - The study area is highly fragmented.

- The potential frequency of east-west STQ movements is likely to be very low and better quality habitat connectivity occurs to the south of the study area.
- The new highway alignment runs roughly parallel to the existing highway therefore any STQs potentially moving through the area are vulnerable to an existing road collision threat.

The use of fauna fencing and associated underpasses has been proven as effective measures to reduce road kill on other highway upgrade projects.

4

Pre-construction Management Measures

4.1 Overview of Activities

Pre-construction activities would involve the following works:

- Survey works.
- Water quality monitoring.
- Translocation of threatened plants.
- Geotechnical investigations.
- Completion of utility relocations.
- Construction of site accesses.

4.2 Timing

Pre-construction works are to be undertaken up until the commencement of construction stage works which are anticipated to commence in December 2014.

4.3 Summary of Potential Impacts

Pre-construction activities may have the following potential impacts to STQs:

- Habitat loss from minor clearing associated with early works.
- Potential mortality to STQs from pre-construction activities/local traffic.

4.4 Main Goals for Management

The main goals for management are as follows:

- No habitat loss for the STQ from pre-construction activities.
- No injury/mortality to STQ from pre-construction activities/local traffic.

4.5 Mitigation Measures

4.5.1 **Detailed Design Considerations**

As detailed design progresses, a number of factors will be addressed to minimise the impacts of the Project on the STQ. These include:

- Avoiding and minimising vegetation/habitat removal where feasible and reasonable.
- Placement of ancillary facilities outside of vegetated areas (STQ habitat).
- Maximising the suitability of fauna crossing structures and fauna exclusion fencing to reduce road kills and enhance habitat connectivity (refer to **Section 6** for further information).

4.5.2 Identifying Habitat Restoration/Connectivity Areas

It is proposed to enhance connectivity in the landscape wherever possible through the provision of strategic tree planting in road reserves and residual land acquired for the Project. A number of areas have been identified by the Project team (Roads and Maritime, Jacobs, AFJV and GeoLINK) and described within preliminary documentation submitted to DoE on 9 September 2014 (refer to **Appendix C**). Of the areas identified, most of these have potential to be used by the STQ. These areas would be rehabilitated during the construction stage of the Project (refer to **Section 5.4.7**).

4.5.3 Controls on Habitat Clearing (Pre-construction)

During the pre-construction stage of the Project (prior to approval of the CEMP) only clearing defined as 'minor' (refer to Approval Instrument – Definitions for Construction) can be undertaken, unless approval is sought from the Director-General. Prior to any clearing taking place, the Project Ecologist will undertake an inspection of vegetation to be cleared to determine that only 'minor clearing' is to be undertaken. Minor clearing will be defined as the following:

- Vegetation that does not include mature trees >150mm DBH.
- Vegetation that does not comprise known threatened fauna habitat. In the case of the STQ, this is defined as potential denning habitat.
- Areas of vegetation that have ecological constraints (e.g. threatened flora habitat/areas of EEC).

All areas to be cleared are to be delineated with flagging tape to clearly mark the clearing extents.

4.5.4 Pre-clearing Surveys

For any area of vegetation to be cleared during the pre-construction stage of the Project, a suitably qualified ecologist will undertake a search for native fauna (including STQs) in the vicinity of clearing immediately prior to clearing commencing. In the event that a STQ is identified, no works would be undertaken within a 200 metre radius of this sighting and works within this area would be rescheduled to be initiated until the construction stage of the Project.

4.5.5 Environmental Work Method Statements

Environmental Work Method Statements (EWMS) will be prepared for all pre-construction tasks potentially impacting environmentally sensitive areas. The EWMS will provide an opportunity to assess any risks to fauna (including STQs) for the pre-construction activities and to incorporate mitigation measures into work methodologies where necessary to minimise the potential for impacts. Where an EWMS identifies risks to fauna, the Project Ecologist will be consulted to provide input where necessary.

4.5.6 Inductions

An environmental induction will be prepared and delivered to personnel involved with the pre-construction activities. Relevant points to be delivered in this induction in relation to STQ management are as follows:

- Potential presence on site (identification and potential habitat).
- Requirements for all personnel to report sightings (including road kill) immediately to the Environmental team.
- Requirement for works to cease within a 200 metre radius of any live STQ detected on/near the site until authorisation has been given for works to commence from the Environmental Manager/Project Ecologist.
- Other aspects of the Fauna Management Protocol for STQs (refer to **Table 4.1**).

4.5.7 STQ Management Protocol

For all STQs detected on/near the site the following protocol as shown in **Table 4.1** is to be implemented with compliance documented.

Table 4.1 STQ Management Protocol

Action		*Personnel Responsible*	*Reporting*
1	Report sightings of any STQs (including road kill) immediately to the Environmental team.	All personnel working on site	Environmental Manager to be notified immediately.
2	In the case that STQ road kill is detected, an assessment of future road kill risk will be undertaken by a suitably qualified Project Ecologist who will aim to provide actions to mitigate the risk of future road kill in this area. Additional measures to be considered will include (but not be limited to): ▪ Provision of signage. ▪ Temporary fauna fence.	AFJV/Roads and Maritime/ suitably qualified Project Ecologist	Adaptive management recommendations will be provided by a suitably qualified Project Ecologist to the AFJV/Roads and Maritime for consideration. The Environmental Manager shall notify the RMS Authorised Representative who will inform the EPA project officer.
3	Where a live STQ is detected on/near the site, no works are to be undertaken within 200 metres of the individual until the animal has relocated from the area and authorisation has been given by the Project Ecologist.	AFJV/suitably qualified Project Ecologist	Actions of foreman to be reported to Environmental Manager.
4	A suitably qualified Project Ecologist will inspect the STQ and assess the health of the individual. If the animal is injured/diseased it will be taken to a local vet or WIRES Wildlife Carer for treatment.	AFJV/suitably qualified Project Ecologist	A suitably qualified Project Ecologist to contact WIRES if animal shows signs of injury/disease.
5	A suitably qualified Project Ecologist is to assess if self-relocation or capture/relocation is required based on a risk assessment of the animals' welfare. The animal will either be allowed to self-relocate from the site or an ecologist with experience and approval to handle fauna will be engaged to capture/relocate the animal.	AFJV/suitably qualified Project Ecologist	EPA/Roads and Maritime to be consulted if capture/relocation required.
6	No works will proceed within 200 metres of the individual until authorisation has been provided by the AFJV (Environmental Manager) and the Project Ecologist. For pre-construction works where a STQ has been detected, works within this area would be rescheduled to be initiated until the construction stage of the Project.	AFJV/suitably qualified Project Ecologist	The suitably qualified Project Ecologist will provide written confirmation that the area is free from STQs and works can proceed.

4.5.8 Pre-construction Monitoring

Pre-construction STQ monitoring has been undertaken to obtain baseline data relating to current usage of habitats by the STQ within proximity to the WC2NH Project. The details of this monitoring are summarised in **Section 7** with the baseline monitoring report included in **Appendix D**.

4.6 Performance Measures and Corrective Actions

Table 4.2 presents the main goals of STQ management for pre-construction activities and includes relevant mitigation measures for the STQ that are to be employed prior to the commencement of construction. The table also describes how the identified mitigation measures are to be monitored, the timing and frequency of monitoring, the parties responsible for implementing the measures, the performance thresholds that each goal is measured against and the corrective actions if deviation from the performance criteria occurs.

Table 4.2 Pre-construction Management Goals, Mitigation Measures, Performance Thresholds and Corrective Actions

Management Goal	*Mitigation/Control Measure*	*Monitoring /Timing Frequency*	*Responsibility*	*Performance Threshold*	*Corrective Actions if Deviation from performance Criteria*
No habitat loss for the STQ from pre-construction activities.	▪ Minimise areas of vegetation (STQ habitat) to be cleared where feasible and reasonable during the detailed design phase.	▪ Design team to reference vegetation mapping for the project to minimise impacts.	AFJV (Design and construction team)/suitably qualified Project Ecologist	▪ No STQ habitat to be cleared during the pre-construction stage.	▪ Consideration of additional offsets for habitat loss.
	▪ All ancillary sites to be located outside of STQ habitat.	▪ Ecological assessments to be prepared for ancillary sites to verify minimal impacts to STQ habitat.	AFJV (Environmental team)/suitably qualified Project Ecologist	▪ No areas of STQ habitat to be impacted by the ancillary facilities.	▪ Consideration of additional offsets for habitat loss.
	▪ Prior to any clearing taking place, the Project Ecologist will undertake an inspection of vegetation to be cleared to determine if work activities do not constitute "Construction" as defined in the planning approval under the NSW EP&A Act and are excluded from the Referral under the Federal EPBC Act.	▪ Pre-clearing permits to be completed by the Project Ecologist prior to the clearing of areas of vegetation.	AFJV/suitably qualified Project Ecologist	▪ No STQ habitat to be cleared during the pre-construction stage.	
	▪ The limits of clearing are to be clearly marked on all relevant work plans and protective fencing erected to mark these limits (i.e. no-go areas).	▪ Limits of clearing will be marked out prior to clearing commencing in each works area. ▪ No-go fencing will be installed prior to vegetation clearing activities commencing in each works area. ▪ Fencing and no-go signage will be inspected weekly, until construction is completed.	AFJV (Environmental team, Survey team)	▪ Final Sensitive Area Plans identify sensitive areas and 100% of clearing drawings identify clearing extents. ▪ Completion of pre-clearing survey prior to construction including mark out of clearing extents.	▪ Notification to DoE, EPA if over clearing occurs.

Management Goal	Mitigation/Control Measure	Monitoring /Timing Frequency	Responsibility	Performance Threshold	Corrective Actions if Deviation from performance Criteria
	▪ Areas for STQ habitat restoration/connectivity are to be identified and included in the detailed design.	▪ Identified areas for habitat restoration/connectively have been determined (refer to **Appendix C**).	Roads and Maritime/AFJV (Design team)	▪ All areas outlined as habitat restoration opportunities are to be shown on the detailed design and planted appropriately.	▪ Areas for habitat restoration/connectivity are to be identified and included in the detailed design.
No injury/mortality to the STQ from pre-construction activities.	▪ Preparation of an EWMS would be undertaken for all work activities and would include where necessary measures to minimise risk to the STQ. ▪ Induction of all personnel involved with pre-construction activities would be undertaken to advise of STQ management requirements. ▪ For any area of vegetation to be cleared during the pre-construction stage of the project, a suitably qualified ecologist will undertake a search for native fauna (including STQ) in the vicinity of clearing immediately prior to clearing commencing. ▪ For any STQ detected on/near the site the protocol shown in **Table 4.1** is to be implemented. As mentioned, for the pre-construction works, in the event that a STQ is identified no works would be undertaken within a 200 metre radius of this sighting until the construction stage of the Project.	▪ Pre-clearing permits to be completed by the suitably qualified Project Ecologist prior to the clearing of any vegetation. ▪ Post-clearing inspections to be undertaken of areas cleared to identify any animal (including STQ) injured or killed during clearing.	AFJV (Environmental and Construction team)/suitably qualified Project Ecologist	▪ No STQ injuries/mortalities as a consequence of pre-construction activities.	▪ Notification to DoE, EPA if a STQ mortality is recorded on the Project. ▪ Adaptive management response plan to be provided by Project Ecologist if mortality recorded.

Management Goal	***Mitigation/Control Measure***	***Monitoring /Timing Frequency***	***Responsibility***	***Performance Threshold***	***Corrective Actions if Deviation from performance Criteria***
Minimise vehicle strike of STQs during pre-construction activities.	▪ STQ Management Protocol (**Table 4-1**) to be implemented requiring all personnel to report STQs (including road kill). ▪ Assessment of future road kill risk including adaptive management actions to be provided by Project Ecologist where STQ road kill is detected.	▪ Road kill monitoring to be undertaken (refer to **Section 7**).	AFJV/Roads and Maritime	▪ No road kill of STQs resulting from the Project.	▪ Where STQ road kill is detected in proximity to the Project the Project Ecologist will provide an assessment of future road kill risk for STQs and adaptive management requirements where appropriate.

5

Construction Management Measures

5.1 Timing

Construction works are anticipated to commence in December 2014 and are expected to be completed in early 2018.

5.2 Summary of Potential Impacts

The construction stage works are anticipated to have the following potential impacts on STQs:

- Habitat loss for the STQ from clearing works.
- Fragmentation of habitat and impacts to quoll movements.
- Injury/mortality to individuals from clearing/construction works.
- Increased levels of vehicle strike on the existing highway from changed movement patterns in the locality of the site.

5.3 Main Goals for Management

The main goals for management are as follows:

- Minimise habitat loss for the STQ from clearing.
- Undertake habitat rehabilitation works within identified areas associated with the Project Site for to create additional STQ habitat.
- No injury/mortality to STQ from construction activities.
- Minimise vehicle strike of STQ during construction activities.

5.4 Mitigation Measures

5.4.1 Environmental Work Method Statements

Environmental Work Method Statements (EWMS) will be prepared for all construction activities potentially impacting fauna (including STQ). The EWMS will provide an opportunity to assess any risks to fauna (including STQs) from the works and to incorporate mitigation measures into work methodologies to minimise the potential for impacts. Where an EWMS identifies risks to fauna, the project ecologist will be consulted to provide input where necessary.

5.4.2 Inductions

An environmental induction will be prepared and delivered to all personnel involved with the construction stage as detailed in **Section 4.5.3**.

5.4.3 Controls on Habitat Clearing

The following controls will be implemented to ensure that no over clearing occurs on the project:

- Clearing limits are to be marked out accurately with no-go delineation.
- Clearing limits to be checked prior to the commencement of clearing by survey and environmental team and routinely during the construction stage of the project.

5.4.4 Habitat Rehabilitation Areas

Areas identified for additional habitat/connectivity (refer to **Appendix C**) would be rehabilitated during the construction stage works. Key rehabilitation measures will include:

- Progressive revegetation/rehabilitation during the construction phase using collected topsoil and seed at specific sites and to develop different successional stages of rehabilitation.
- Planting of locally occurring species, including plants representative of groundcover, understorey and canopy strata.
- Plantings are to be undertaken around fauna crossing structures to optimise utilisation of these structures.
- Appropriate hollow logs and other large woody material (e.g. root balls and logs) identified during pre-clearing surveys would be placed within rehabilitation areas in order to provide habitat.
- Monitoring and maintenance of plantings.
- Managing and controlling weeds.

A planting list for habitat rehabilitation is to be determined in consultation with the project ecologist.

Ongoing weed management along the edge of cleared areas and post construction habitat restoration and landscape rehabilitation within the project boundary would be undertaken as part of the Project.

5.4.5 Pre-clearing Surveys

A suitably qualified ecologist will undertake pre-clearing surveys for threatened fauna species (including STQs) prior to (within 5 days) any clearing commencing. For the STQ, these would focus on dens, large hollow-bearing trees, scats and any other potential habitat features such as rock formations.

During pre-clearing surveys, the ecologist will identify and mark (spray paint with a white H) all habitat features, which consist of large fallen logs (greater than 300mm diameter and not in an advanced stage of decay). AFJV will relocate these habitat features to areas adjacent to the clearing footprint and within the Project boundary. Key areas where these habitat features will be relocated include:

- Around the inlet/outlet of fauna crossing structures.
- Native vegetation rehabilitation areas.
- Areas of retained vegetation within the project boundary (particularly within the Nambucca State Forest).

Immediately prior (within 2 hours) of clearing commencing within a given clearing area, an additional ecologist inspection is to be undertaken to confirm that clearing areas remain free of fauna (including STQs). In the event that a STQ is identified, no works would be undertaken within 200 metres of the animal and the measures within the Fauna Management Protocol for STQs (refer to **Table 4.1**) would be implemented. This process will affect a two staged approach to clearing of habitat.

5.4.6 STQ Management Protocol

The STQ Management Protocol outlined in **Table 4.1** will be undertaken in the event that a STQ (including road kill) is detected on or near to the site.

5.4.7 Type F Barrier Arrangement

The arrangement of Type F concrete barriers in a continuous line along one side (or centre) of the existing highway has the potential to create additional barriers to STQs attempting to cross the highway and increase the risk of car strike. Prior to the construction of fauna passage locations and installation of fauna fence, where continuous lines of Type F concrete barriers are to be installed, gaps are to be provided to allow escape of any animals off the highway. The provision of these gaps is to be designed in consultation with the Project Ecologist. It is acknowledged that traffic safety requirements will need to be taken into account. Where continuous lines of Type F concrete barriers are required in STQ habitat, material is to be attached at strategic locations (as advised by the Project Ecologist) to allow STQ's to climb over barriers.

5.4.8 Construction Stage Monitoring

Construction stage monitoring will be undertaken. The details of this monitoring are summarised in **Section 7**.

5.5 Performance Measures and Corrective Actions

Table 5.1 presents the main goals of STQ management for construction activities and includes a summary of the relevant mitigation measures for STQs that are to be completed during the construction phase of the Project. The table also describes how the identified mitigation measures are to be monitored, the timing and frequency of monitoring, the parties responsible for implementing the measures, the performance thresholds that each goal is measured against and the corrective actions if deviation from the performance criteria occurs.

Table 5.1 Construction Management Goals, Mitigation Measures, Performance Thresholds and Corrective Actions

Management Goal	*Mitigation/Control Measure*	*Monitoring/Timing Frequency*	*Responsibility*	*Performance Threshold*	*Corrective Actions if Deviation from performance Criteria*
Minimise habitat loss for the STQ from clearing.	▪ Minimise clearing of vegetation (STQ habitat) where feasible and reasonable. ▪ Design changes (e.g. additional ancillary facilities, batch plants etc to) avoid clearing of vegetation (STQ habitat).	▪ Ecological assessments to be prepared for additional areas to be cleared to verify minimal impacts to STQ habitat.	AFJV (Environmental team, Design team)	▪ STQ habitat to be cleared to not exceed areas detailed in **Section 3.2**.	▪ Notification to DoE, EPA if the performance thresholds cannot be met. ▪ Additional habitat rehabilitation works to be undertaken on the Project to offset losses.
	▪ The limits of clearing are to be clearly marked on all relevant work plans and protective fencing erected to mark these limits (i.e. no-go areas).	▪ Limits of clearing will be marked out prior to clearing commencing in each works area. ▪ No-go fencing will be installed prior to vegetation clearing activities commencing in each works area. ▪ Fencing and no-go signage will be inspected weekly, until construction is completed.	AFJV (Environmental team, Survey team)	▪ Final Sensitive Area Plans identify sensitive areas and 100% of clearing drawings identify clearing extents. ▪ Completion of pre-clearing survey prior to construction including mark out of clearing extents.	▪ Rehabilitation of inadvertently cleared area. ▪ Notification to DoE, EPA if over clearing occurs. ▪ Consideration of additional offsets for habitat loss.
	▪ Fauna habitat resources for the STQ to be marked by the ecologist and retained within areas adjacent to the clearing footprint and within the Project boundary where appropriate.	▪ Fauna habitat resources re-used on the project to be recorded and documented in the Clearing/Pre-clearing report to be prepared at the completion of clearing activities.	AFJV (Environmental team) Project Ecologist	▪ Suitable habitat features relocated into appropriate areas.	▪ Consideration of additional offsets for habitat loss. ▪ Additional habitat rehabilitation works to be undertaken on the Project to offset losses.

Management Goal	***Mitigation/Control Measure***	***Monitoring/Timing Frequency***	***Responsibility***	***Performance Threshold***	***Corrective Actions if Deviation from performance Criteria***
Undertake habitat rehabilitation works within identified areas associated with the Project Site to create additional STQ habitat.	▪ Progressive rehabilitation of identified areas (refer to **Appendix C**) during the construction stage using collected topsoil and seed at specific sites and to develop different successional stages of rehabilitation. Key rehabilitation measures would include: – Progressive revegetation/rehabilitation during the construction phase using collected topsoil and seed at specific sites and to develop different successional stages of rehabilitation. – Planting of locally occurring species, including plants representative of groundcover, understorey and canopy strata. – Plantings are to be undertaken around fauna crossing structures to optimise utilisation of these structures. – Monitoring and maintenance of plantings. – Managing and controlling weeds.	▪ Monitoring and maintenance of rehabilitation areas to be undertaken regularly as part of the project landscaping contract. ▪ Weed monitoring would be undertaken on the site.	AFJV (Landscape Design/ Construction team)	▪ Successful establishment of STQ habitat in nominated areas.	▪ Consideration of additional landscaping/habitat rehabilitation works.

Management Goal	***Mitigation/Control Measure***	***Monitoring/Timing Frequency***	***Responsibility***	***Performance Threshold***	***Corrective Actions if Deviation from performance Criteria***
No injury/mortality to STQs from construction activities.	▪ Preparation of an EWMS would be undertaken for all pre-construction activities and where necessary, would include measures to minimise risk to STQs. ▪ Induction of all personnel involved with construction activities would be undertaken to communicate STQ management requirements. ▪ A suitably qualified ecologist will undertake pre-clearing surveys for threatened fauna species (including STQs) prior to (within 48 hours) any clearing commencing. For the STQ, these would focus on dens, large hollow-bearing trees, scats and any other potential habitat features such as rock formations. ▪ Immediately prior to (within 2 hours) of clearing commencing within a given clearing area an additional ecologist inspection is to be undertaken to confirm that clearing areas remain free of fauna (including STQs). In the event that a STQ is identified, no works would be undertaken within 200 metres of the animal and the measures within the Fauna Management Protocol for STQs (refer to **Table 4.1**) would be implemented.	▪ Pre-clearing permits to be completed by the Project Ecologist prior to the clearing of any vegetation. ▪ Within 24 hours after the completion of clearing within a given area, post-clearing inspections to be undertaken of areas cleared to identify any animal (STQs) injured or killed during clearing.	AFJV (Environmental/ Construction team)/Project Ecologist	▪ No STQ injuries/mortalities as a consequence of construction activities.	▪ Notification and consultation to DoE, EPA if a STQ mortality is recorded on the project. ▪ Adaptive management response plan to be provided by Project Ecologist if mortality recorded.

Management Goal	*Mitigation/Control Measure*	*Monitoring/Timing Frequency*	*Responsibility*	*Performance Threshold*	*Corrective Actions if Deviation from performance Criteria*
Minimise vehicle strike of STQ during construction activities.	▪ STQ Management Protocol to be implemented requiring all personnel to report STQs (including road kill) (refer **Table 4-1**). ▪ An assessment of future road kill risks including adaptive management actions is to be provided by the Project Ecologist where: – A STQ is detected within/near the site, or – STQ road kill is detected.	▪ Road kill monitoring to be undertaken (refer to **Section 7**).	AFJV (Environmental team/Project Ecologist	▪ No road kill of STQs resulting from the project.	▪ An assessment of future road kill risk will be undertaken by the Project Ecologist for areas where STQ road kill have been detected. This assessment will aim to provide actions to mitigate the risk of future STQ road kill in such areas.
Ensure fauna crossing structures are constructed to maximise usage by fauna.	▪ EPA will be consulted during the detailed design phase on fauna crossing structure specific requirements for fauna furniture and treatments in and around fauna crossing structures. This will include, but not necessarily be limited to requirements for refuge poles and/or horizontal rails, pathways and appropriate plantings and/or sizing/ placement of scour rock & treatment of the substrate e.g. soil and/or mulch over the concrete floor and apron. ▪ Advice will be provided by the project ecologist on fauna furniture to be installed within fauna crossing structures.	▪ To be undertaken during the detailed design phase.	AFJV/Project Ecologist	▪ Concurrence from EPA on fauna furniture/treatments in and around fauna crossing structures.	▪ Ensure fauna crossing structures are constructed to maximise usage by fauna.

Operational Management Measures

6.1 Summary of Potential Impacts

The operational stage of the project is anticipated to have the following potential impacts on STQs:

- Fragmentation of habitat and impacts to quoll movements.
- Increased risk of vehicle strike associated with the upgrade

6.2 Main Goals for Management

The main goals for management are as follows:

- Maintain connectivity for STQs potentially utilising habitats on either side of the upgrade.
- Minimise vehicle strike of STQs during operational activities.
- Maintain habitat rehabilitation areas.

6.3 Mitigation Measures

6.3.1 Habitat Offset Strategy

This Strategy (the WC2NH Biodiversity Offset Strategy) is currently being prepared and would be implemented to offset the biodiversity impacts of the project to address the Minister's Conditions of Approval (MCoA B8) for the WC2U Upgrade Project to meet EPBC offset requirements.

6.3.2 Maintenance of Habitat Rehabilitation Areas

Areas identified for additional habitat/connectivity (refer to **Appendix C**) would be maintained by the AFJV during the landscape maintenance period, which extends into the operational stage of the project. Maintenance would include weed control works and replacement plantings if necessary. Maintenance would also be undertaken near fauna crossing structures and fencing and in all cases would be undertaken until rehabilitation areas have become self-sustaining.

6.3.3 Fauna Connectivity/Passage

The Proposal design includes fauna underpass and fauna exclusion fencing to allow for safe passage of fauna (including the STQ) crossing the Pacific Highway and reduce the risk of injury/road kill.

The location and sizes of fauna underpass structures had been identified in the Conditions of the Approval of the project under the NSW Environmental Planning and Assessment Act 1979 (EP&A Act) issued by the Minister for Planning and Infrastructure on 19 July 2011.

In response to a request from DoE following submission of the Referral under the EPBC Act, these fauna crossing locations were subject to an independent review by the STQ expert Chris Belcher and were modified in response to the recommendations of the review. There are a number of differences between the underpass structures identified in the Conditions of Approval under the EP&A Act, those recommended in the independent review and those that would be required to comply with the comments received from DoE following review of the Referral.

A workshop with NSW Environment Protection Authority (EPA), Chris Belcher, ecologists involved with the project and other stakeholders was held to review the fauna underpass options developed, including additional options developed by the project team, and to reach agreement on the most appropriate underpass option for each location. Details of the agreed fauna underpasses being constructed as part of the project are provided in **Appendix E**.

Approximately 12.1 kilometres of the new highway (where it intersects/adjoins the main areas of forest) would support fauna exclusion fencing. Most of this comprises 'floppy-top' fauna exclusion fencing design which was developed by Koala expert Casper Pieters and has been refined for fauna (including STQs) to minimise road strike. Details of fauna fencing to be provided as part of the project are provided in Attachment B of **Appendix B.** Attachment A of **Appendix B** is provided to give indicative locations of the fauna crossings and fauna fences. The Chainages in Attachment A reflect the WC2U EA chainages. To convert these to the referral chainages add 41765.

The majority of the remaining sections of highway where no fencing is proposed intersects or adjoins mostly cleared pastoral land. Ongoing maintenance and repair of the permanent fauna exclusion fencing would be undertaken to restrict STQ from crossing the Pacific Highway upgrade and facilitate the use of fauna crossings would be undertaken post construction under the operational environmental management system.

Following further consultation with EPA additional fauna fence requirements have been agreed to at the following locations:

- Ch 1600 (16365) to Ch 2500 (17265) (eastern side of carriageway) – additional length of 900 metres.
- Floodplain and Bridges at Ch 8500 (23265) to 10300 (25065) (1800m both sides of the carriageway in both directions) – additional 3600 metres.
- Ch 13500 (28265) to 14400 (29165) (western side of carriageway) – additional length of 900 metres.

6.3.4 Ecological Monitoring

Operational stage monitoring for STQs will be undertaken. The full methodology and timing for this monitoring is provided in **Section 7**.

6.4 Performance Measures and Corrective Actions

Table 6.1 presents the main goals of STQ management during operation of the WC2NH Upgrade and includes a summary of the relevant mitigation measures for STQs that are to be completed during the construction phase of the project. The table also describes how the identified mitigation measures are to be monitored, the timing and frequency of monitoring, nominates the parties responsible for implementing the measures, the performance thresholds that each goal is measured against and the corrective actions if deviation from the performance criteria occurs.

Table 6.1 Operational Management Goals, Mitigation Measures, Performance Thresholds and Corrective Actions

Main Goal	*Mitigation/Control Measure*	*Monitoring/Timing Frequency*	*Responsibility*	*Performance Threshold*	*Corrective Actions if Deviation from performance Criteria*
Maintain connectivity for STQs potentially occurring either side of the upgrade.	▪ Fauna Crossing Structures.	▪ Monitoring of the use of fauna crossing structures (refer to **Section 7**).	Roads and Maritime Services	▪ No change to densities, distribution, habitat use and movement patterns compared to baseline STQ population data.	▪ Consideration of the following options: – Maintenance of the existing connectivity measures. – Additional planting around the entrances of fauna crossing structures. – Consider additional offset measures to improve connectivity elsewhere.
Minimise road kill of STQ during operation of the WC2NH project.	▪ Fauna Fencing.	▪ The Roads and Maritime Services Roads Asset Division will undertake monitoring of fauna fencing on a regular basis after contractual obligations (refer to **Appendix F**). ▪ Road kill/injury monitoring will be undertaken during the operational stage (refer to **Section 7.4**.	Roads and Maritime Services	▪ No STQs recorded in road kill monitoring during operation.	▪ Where results identify a significant difference between the road kill numbers of the different treatments (transect types), DoE and EPA shall be notified, and a meeting will be set to discuss such differences with the relevant agencies, Roads and Maritime Services and the reporting Ecologist.
Maintain habitat rehabilitation areas.	▪ Maintenance of plantings until self-sufficient.	▪ Regular maintenance of habitat rehabilitation areas (refer to **Appendix C**) would be undertaken as part of the landscape maintenance works.	Roads and Maritime Services /AFJV (for maintenance period only)	▪ Self-sufficient areas of rehabilitated habitat for STQ within all nominated areas.	▪ Further maintenance/additional planting after the end of the landscape maintenance period.

7

Monitoring Program

A pre-construction (baseline) monitoring program has been prepared by Roads and Maritime Services, and peer reviewed/endorsed by STQ expert, Dr Chris Belcher. This program is summarised in **Section 7.1** and aims to compliment the monitoring of fauna crossing structures for the STQ to be undertaken as part of the WC2NH Monitoring Program (Benchmark, 2013) which is summarised within **Section 7.2**. Additional road kill monitoring is proposed as part of this management plan.

7.1 STQ Population Monitoring

7.1.1 Objective of Monitoring Program

The objective of the STQ Population Monitoring Program (Winter, 2014) was to establish baseline data relating to densities, distribution and current usage of habitats by the STQ within proximity to the WC2NH Project. Specifically, the baseline monitoring aimed to attain robust data to assist in the identification of changes in STQ densities, distribution and usage of habitats in response to the completion of WC2NH Project, and also to assist with determination of the effectiveness of STQ habitat connectivity mitigation structures.

7.1.2 Methodology

Pre-construction (baseline) monitoring was completed between mid-July and mid-August 2014, three months prior to construction commencing. Dr Chris Belcher provided concurrence with the methodology implemented which is summarised below.

7.1.2.1 Fauna Underpass Locations

Eleven locations where fauna underpasses are to be provided were surveyed with the use of baited camera traps and hair tubes in order to detect STQs.

Camera traps were deployed for three weeks at each site in winter (July/August) to coincide with the peak period for detection of STQs. Each camera trap consisted of one Scoutguard SG560K camera aimed at a caged bait station. The camera was set 3.0 – 4.0 metres from a small bait cage attached to a steel pole, approximately 1.5 metres above the ground and baited with a mixture of chicken and tuna oil. Additionally, tuna oil was drizzled on nearby features (e.g. rocks, logs) as a further attractant. Cameras were set to record during the day and night as quolls are known to range throughout both periods.

In addition, hair tubes were deployed at each of these locations for three weeks along transects centred on the location of each fauna crossing structure. Transects comprised ten tubes/transect placed 20 metres apart and were baited with a mixture of flour, sardines and tuna oil.

Opportunistic scat surveys were also undertaken at the time of collecting the cameras after the completion of the 21 day survey period.

7.1.2.2 Habitat Associated with the Project Site

Further to above, broader areas associated with the WC2NH Project Site were surveyed to determine the usage of habitats by the STQ. Two baited camera traps were placed every 100 hectare/1.0 kilometre square grid with one camera and bait at each site as per the methodology detailed in **Section 7.1.2.1** to detect STQs. The rationale for camera placement for the monitoring program is provided below:

- Two baited camera traps would be placed every 100 hectare/1.0 kilometre square grid, with one camera and bait at each site.

- Camera traps are to be located within 2.0 kilometres of the proposal, predominantly in larger blocks of vegetation (e.g. Nambucca State Forest, Ingalba State Forest), but also in some narrow patches of remnant vegetation situated within the partially cleared farmland mosaic that is contiguous with these larger blocks of forested vegetation.
- Moist forest along riparian zones adjacent to creek lines would primarily be targeted.
- Small areas of fragmented vegetation in otherwise cleared farmland would not be targeted (e.g. most of the area between Macksville and Warrell Creek).
- No camera traps are proposed within the Saltmarsh/Swamp Oak forest in low-lying areas to the north of the Nambucca River due to a lack of suitable habitat features for STQ.

A total of 50 survey sites were identified and utilised for the broader habitat assessment. Opportunistic scat surveys were also undertaken at the time of collecting the cameras after the completion of the 21 day survey period.

Photograph analysis of the images recorded by the cameras and hair analysis from hair tubes traps were undertaken at the completion of the surveys.

7.1.3 Results of Pre-construction (Baseline) STQ Population Monitoring

The baseline STQ Monitoring Report is included as **Appendix D**. Analysis of the images captured on the 61 deployed remote cameras showed that no STQ visited the bait stations over the three week period that cameras were deployed. The cameras captured images of a range of other native and exotic fauna species. The three most commonly encountered species were Red-necked Wallaby (captured at 49.2 per cent of camera traps), Bush Rat (captured at 36.1 per cent of camera traps), and Common Brushtail Possum (Recorded at 32.8 per cent of camera traps).

Identification of hair left behind in deployed hair tubes at the fauna underpass sites indicated no presence of STQ. Hair from a range of other mammals was present consisting mainly of Bush Rat and Brown Antechinus. Despite not recording STQ by either the remote cameras or hair tube methods used in the monitoring, a previous local OEH BioNet record and a recent 2014 road kill record in the vicinity of the southern end of the Project suggest that the STQ occurs at a low density within the locality.

7.2 Monitoring of Fauna Underpasses/Fauna Fences

7.2.1 Objective of Monitoring Program

The objective of the monitoring program is to determine whether mitigation measures (fauna underpasses and fauna fence) are effective in maintaining connectivity for fauna (including STQs in the vicinity of the project.

7.2.2 Methodology

7.2.2.1 Fauna Underpasses

Monitoring of fauna underpasses would be undertaken in winter (July/August) to coincide with the peak period of detection for STQs and involve the use of remote camera surveys at fauna underpasses as agreed between Roads and Maritime and EPA (refer to **Table 7.1**). Monitoring of underpasses will be undertaken using the following techniques:

- A motion-detecting camera would be installed at both ends of each crossing structure to be monitored. Cameras are to operate continuously for a period of 60 days during winter.
- Sand-plots would be established at each end of each crossing structure to be monitored for a period of eight nights per monitoring event. Sand plots, at least 1.0 metre wide, will be established across the entire width of the underpass and will be inspected each following morning period for tracks each morning and then raked clean.
- Scat searches within crossing structures (approximately 1.0 to 2.0 metres from the end to minimise wind and rain disturbance) and in adjoining habitat would be undertaken. Searches to be undertaken when installing and checking sand plots (i.e. twice per monitoring period).

Table 7.1 Fauna Crossing Structures to be Monitored

Chainage	*Fauna Crossing Structure Type*	*Structure Form*	*Dimensions*
42500	Combined	Bridge over Warrell Ck	
55120	Dedicated	Box Culvert	3000x3000
56410	Combined	Box Culvert	2400x2400
57770	Dedicated	Box Culvert	3000x3000
58510	Combined	Box Culvert	3000x3000
58560	Dedicated	Box Culvert	3000x3000
59090	Dedicated	Box Culvert	3000x3000
59550	Dedicated	Box Culvert	3000x3000
59750 North Bound lanes	Dedicated	Box Culvert	24000x2400
59760 South Bound Lanes	Dedicated	Box Culvert	2400x2400
60600 North Bound Lanes	Dedicated	Box Culvert	2400x2400
60610 South Bound Lanes	Dedicated	Box Culvert	2400x2400

7.2.2.2 Adjacent Forested Areas

Forested habitats adjacent to fauna underpass entrances will be surveyed to assess the range of fauna species occurring in proximity to each underpass structure. These results will then be compared with underpass monitoring results to identify which species present in the immediate area are not utilising the underpass structure. A one hectare area adjacent to fauna underpass entrances (in forested areas) will be surveyed at the time of fauna underpass surveys and will include spotlighting, arboreal and ground-based trapping, hairtube sampling, timed diurnal and nocturnal searches and scat and track searches.

7.2.2.3 Fauna Fences

Fauna fence monitoring would be undertaken frequently post construction as part of standard ongoing road maintenance to ensure that fences are not damaged. The contractor has a contractual period of 36 months to maintain fences. At the completion of this time period, Roads and Maritime Services Asset Division will continue to monitor and maintain fauna fencing in perpetuity.

7.2.3 Timing/Frequency

Fauna underpass monitoring (including surveys of adjacent forested areas) will commence upon completion of construction of the Project (year 4) and will be undertaken in winter each year for a minimum of 60 days. Monitoring will continue in years 5 to 8 of the operational phase and additional monitoring may be required if fauna underpasses are determined to be ineffective.

7.2.4 Performance Indicators

Indicators of success for fauna underpasses/fauna fences are as follows:

- Demonstrated use of fauna crossing structures by STQs with consideration of population estimates as derived from the STQ population monitoring surveys.

7.3 Road Kill Monitoring

7.3.1 Objective of Monitoring Program

The aim of the monitoring program is to :

- Report on any animal road kill on the project following the opening to traffic; and
- Assess the effectiveness of the presence of fauna fencing to prevent fauna being killed by vehicles while attempting to cross the WC2NH Upgrade.

A detailed methodology for road kill monitoring to achieve this objective is included in **Appendix F**. The methodology and timing of this monitoring are summarised below.

7.3.2 Methodology

7.3.2.1 Monitoring Procedure

A two person team vehicle being driven along the entire length of the existing highway in the Project area and identifying dead wildlife (road kill) seen on the roads and within three metres of the road edge. Both driver and passenger will search the left-hand side of the road and its verge for road kill with the driver searching the road and shoulder and the passenger searching the verge. When a road kill is observed from the vehicle, a close visual inspection of the carcass will be undertaken where access is possible and where safely limitations permit. If safe access is not possible, due to local traffic conditions, binoculars will be used to try to identify and provide as detailed information as is possible on the carcass. Where there is any doubt to the identification of the carcass, photographs will be taken and forwarded to a qualified ecologist for identification/confirmation of species.

7.3.2.2 Detailed Methodology

Specific details of the monitoring methodology are:

- The highway will be monitored using a two-person team traversing the Upgrade in a vehicle to locate and identify road kills.
- The speed of travel will be the same in all cases to avoid confounding the data collection, and should be as slow as is safely possible.
- The highway will be surveyed weekly for 12 weeks commencing the week of opening each stage to traffic and for four weeks in spring, summer, autumn and winter (refer to **Section 7.3.3**).
- When possible, each survey shall be completed within two hours of sunrise in order to maximise the potential to record road kills before either carrion eating animals or traffic render and road kill unidentifiable.
- If possible, each survey will be carried out on the same day to remove the influence of varying environmental conditions and to ensure consistent temporal spacing.
- For each road kill observed, the following attributes will be recorded:
  a. Geographic Coordinates of any road kill.
  b. Whether fauna fencing was installed at the location.
  c. Species of road kill, however, where there is any doubt to the identification of the carcass, photographs shall be forwarded to a qualified ecologist for identification/confirmation of the species.
- If the animal is identified as an EPBC Act threatened species, the carcass will be photographed and the following information will also be recorded where possible and where safety considerations permit:
  a. Sex and age class (juvenile or adult).
  b. Presence of pouch young (for marsupials).
  c. Presence of flightless young (for flying-foxes or other bats).
  d. Distance to a fauna connectivity structure.
  e. Distance to drop down structure
  f. If fauna fencing was installed, is there any damage to the fence in the vicinity.
  g. Weather conditions at the time of the monitoring (from the Bureau of Meteorology) – including temperature, rainfall in the last 24 hours, moon phase.
  h. If the animal is identified as a flying-fox:
     i. Distance to nearest camp,
     ii. Distance to nearest canopy vegetation,
     iii. Presence of flowering food trees in neighbouring median or roadside vegetation; plants identified to species and referenced with diet list.

7.3.2.3 Data Analysis

The data to be collected will be analysed using a suitable non-parametric test such as a Kruskal-Wallis test. The aim will be to test both whether the fenced and unfenced locations have different mean numbers of road kills and if the amount of road kill varies through time in either or both of the two types of areas. Such information will indicate if the mitigation measures in the area are working as expected to keep road kills to acceptable levels and that none of the target species are killed.

7.3.3 Timing/Frequency

The timing and frequency of road kill monitoring is summarised in **Table 7.2**

Table 7.2 Road Kill Monitoring Timing

Project Phase	*Timing of Surveys*	*Location*	*Responsibility*
During clearing operations.	Daily	Portion of existing Pacific Hwy adjacent to clearing operations.	AFJV
One month following clearing operations	Daily	Portion of existing Pacific Hwy adjacent to clearing operations.	AFJV
Duration of construction.	Weekly	Entire length of existing Hwy in Project area.	AFJV/Roads and Maritime Services
Upon opening of each stage of the Project to traffic (operational phase)	Weekly for 12 weeks commencing the week of opening each stage to traffic..	Entire length of opened stage.	Roads and Maritime Services
Upon completion of the Project (operational phase)	Excluding the season/s covered by the initial 12 week monitoring period (refer above), weekly during October (spring), January (summer), April (autumn) and July (Winter) for up to 5 consecutive years post construction, or until mitigation measures have been demonstrated to be effective.	Entire length of completed Project	Roads and Maritime Services

7.3.4 Performance Indicators

Indicators of success for fauna underpasses/fauna fences are as follows:

- Lower rates of road kill in proximity to fauna fencing (i.e. areas of the main carriageways within areas adjacent to installed fauna fencing) than in sections of the upgrade not near fauna fencing during monitoring events up to five years post construction phase, or until such time as mitigation measures have been demonstrated to be effective.

7.4 Summary of Monitoring Program

A summary of the monitoring program relevant to the STQ is provided in **Table 7.3**.

Table 7.3 Summary of Monitoring Program

Monitoring Component	*Main Goal*	*Timing/Frequency*	*Responsibility*	*Performance Threshold*	*Corrective Actions if Deviation from Performance Criteria*
STQ population monitoring.	To provide baseline data relating to densities, distribution and current usage of habitats by the STQ.	▪ Pre-construction baseline surveys completed (winter 2014).	Roads and Maritime Services	▪ Accurate/robust survey design and information interpretation.	▪ NA as the survey design has been confirmed as appropriate by STQ expert Dr Chris Belcher.
Monitoring of fauna underpasses, fauna fences and adjacent forested habitat.	To determine if possible whether mitigation measures (fauna underpasses and fauna fence) are effective in maintaining connectivity for fauna (including STQs) in the vicinity of the project.	▪ Operational stage (winter - year 4, to 8).	Roads and Maritime Services	▪ Demonstrated use of fauna crossing structures by STQs with consideration of population estimates as derived from the STQ baseline monitoring surveys. ▪ No breaches in fauna exclusion fencing.	▪ Consideration of the following options: – Maintenance of the existing connectivity measures. – Investigate habitat adjoining the structure, consider improving habitat and connectivity – Modify design of existing measures where feasible and reasonable. – Consider additional offset measures to improve connectivity elsewhere.
Road kill monitoring	To effectively demonstrate that road kill rates are mitigated by the presence of fauna fencing by preventing fauna of concern from attempting to cross the WC2NH Upgrade.	▪ During clearing operations (up until one month after clearing is completed) – daily. ▪ Duration of construction (weekly). ▪ Upon opening of each stage of the Project to traffic (operational phase), weekly for 12 weeks commencing the week of opening each stage to	Roads and Maritime Services/AFJV	▪ Lower rates of road kill in proximity to fauna fencing (i.e. areas of the main carriageways within areas adjacent to installed fauna fencing) than in sections of the upgrade not near fauna fencing during monitoring events up to 5 years post construction phase, or until such time as mitigation measures have been	▪ Where results identify a significant difference between the road kill numbers of the different treatments (transect types), DoE and EPA shall be notified, and a meeting will be set to discuss such differences with the relevant agencies, Roads and Maritime Services and the reporting Ecologist.

Monitoring Component	*Main Goal*	*Timing/Frequency*	*Responsibility*	*Performance Threshold*	*Corrective Actions if Deviation from Performance Criteria*
		traffic. ▪ Operational stage - Excluding the season/s covered by the initial 12 week monitoring period (refer above), wweekly during October (spring), January (summer), April (autumn) and July (winter) for up to 5 consecutive years post construction, or until mitigation measures have been demonstrated to be effective.		demonstrated to be effective. ▪ All fauna fencing is installed at the minimum of locations as identified in the EPBC approval prior to the operational phase of the WC2NH Upgrade.	

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Definitions and Acrynoms

ACT	Australian Capital Territory
CEMP	Construction Environmental Management Plan
DoE	Australian Government Department of Environment
DoPI	NSW Department of Planning and Infrastructure
DSEWPaC	Australian Government Department of Sustainability, Environment, Water, Population and Communities
EP&A Act	NSW *Environmental Planning and Assessment Act 1979*
EPA	NSW Environment Protection Authority
FFMP	Flora and Fauna Management Plan
NH2U	Nambucca Heads to Urunga Pacific Highway Upgrade Project
NSW	New South Wales
OEH	Office of Environment and Heritage
Project Ecologist	A suitably qualified ecologist engaged to advise on/undertake ecological management throughout the project
Project footprint	All areas to be cleared as part of the project inclusive of permanent and temporary works
QLD	Queensland
RCBC	Reinforced Concrete Box Culvert
SKM	Sinclair Knight Merz
STQ	Spotted-tailed Quoll
TSC Act	NSW *Threatened Species Conservation Act 1995*
WC2NH	Warrell Creek to Nambucca Heads Pacific Highway Upgrade Project
WC2U	Warrell Creek to Urunga Pacific Highway Upgrade Project (referred to throughout the document as 'the Project')

Copyright and Usage

Appendix A

Plan Authors CVs

curriculum vitae

David HAVILAH

BSc (Biol)

Ecologist

Qualifications

Bachelor of Science (Biology), Sydney University, 2003

Professional Affiliations

Member, Ecological Consultants Association of NSW
Member, NSW Wildlife Information, Rescue and Education Services Inc (WIRES-Northern Rivers)

Experience

David is an experienced ecological consultant who has developed a broad range of skills from working on a variety of small and large-scale projects. He specialises in undertaking terrestrial flora and fauna surveys and providing high quality ecological reports within Queensland and New South Wales. This work has included designing and implementing threatened species management plans and ecological monitoring programs. David has a detailed working knowledge of environmental legislation relevant to ecological impact assessment and an ability to balance practical applications of environmental requirements with good environmental outcomes.

Key Experience and Skills

A large focus of David's work has been providing ecological services on large infrastructure projects. He has been engaged as the Project Ecologist for construction contractors on a number of sections of the NSW Pacific Highway upgrade project. This work has included providing technical advice, ecological surveys and assessments and managing threatened species on these projects.

David's skills and key areas of expertise include:

- Design, implementation and management of ecological monitoring programs.
- Determining and documenting best practice and innovative management plans for threatened species occurring on infrastructure projects.
- Undertaking detailed systematic terrestrial flora / fauna surveys and vegetation / weed mapping.
- Preparing high quality ecological / environmental assessments for a broad range of projects in accordance with NSW, QLD and Federal environmental legislation.
- Preparing vegetation management plans and environmental management plans.
- Providing peer reviews of ecological assessments.
- Providing technical advice, ecological surveys and reporting in the role of project ecologist for large-scale infrastructure projects.
- Supervising and delivering pre-clearing surveys and spotter / catcher (fauna capture / relocation services) as part of large infrastructure projects.
- Delivering environmental awareness presentations.

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curriculum vitae

Veronica SILVER

BEnvSc Grad Dip (UrbRegPlan)

Senior Associate / Ecologist / Planner

CPP
CERTIFIED PRACTISING PLANNER

ECA ECOLOGICAL CONSULTANTS ASSOCIATION of NSW Inc.

CERTIFIED ENVIRONMENTAL PRACTITIONER

Qualifications

Bachelor of Environmental Science (Environmental Management),
The University of Newcastle, [2000]
Graduate Diploma of Urban and Regional Planning, The University of New England, [2007]

Professional Affiliations

Member, Planning Institute Australia
Member, Environment Institute of Australia and New Zealand
Member, Ecological Consultants Association of NSW Inc.
Member, Australian Network for Plant Conservation Inc.

Professional Short Courses

- Planning for Bushfire Prone Areas
- Certificate IV Bushland Regeneration
- Certificate IV Workplace Training and Assessment
- Certificate II Australian Land Conservation and Restoration
- Project Management, Chifley Business School
- Effective Communication, Negotiation and Mediation, Chifley Business School
- Urban Design, Chifley Business School
- Acid Sulfate Soils: Identification, Assessment and Management
- Woodland Birds Identification and Ecology
- Signed English, TAFE Newcastle

Licences

- Scientific Licence (SL100152) issued by the Office of Environment and Heritage.
- Animal Research Authority issued by the Animal Care and Ethics Committee of the Director-General of NSW Department of Primary Industries to undertake fauna surveys throughout NSW and SE Queensland.

Experience

Veronica has been a key member of GeoLINK's ecology team since 2004. She specialises in flora / fauna field surveys; ecological monitoring; bushfire assessment; environmental impact assessment and bushland regeneration.

Veronica has further diversified her skills and knowledge in the built environment, having completed a Graduate Diploma of Urban and Regional Planning through The University of New England in 2007.

Veronica possesses high level project management skills, developed through working with a broad range of public and private sector clients on challenging environmental projects. Having project managed a variety of ecological and planning projects; she has significant skills in liaison and the management of multidisciplinary teams.

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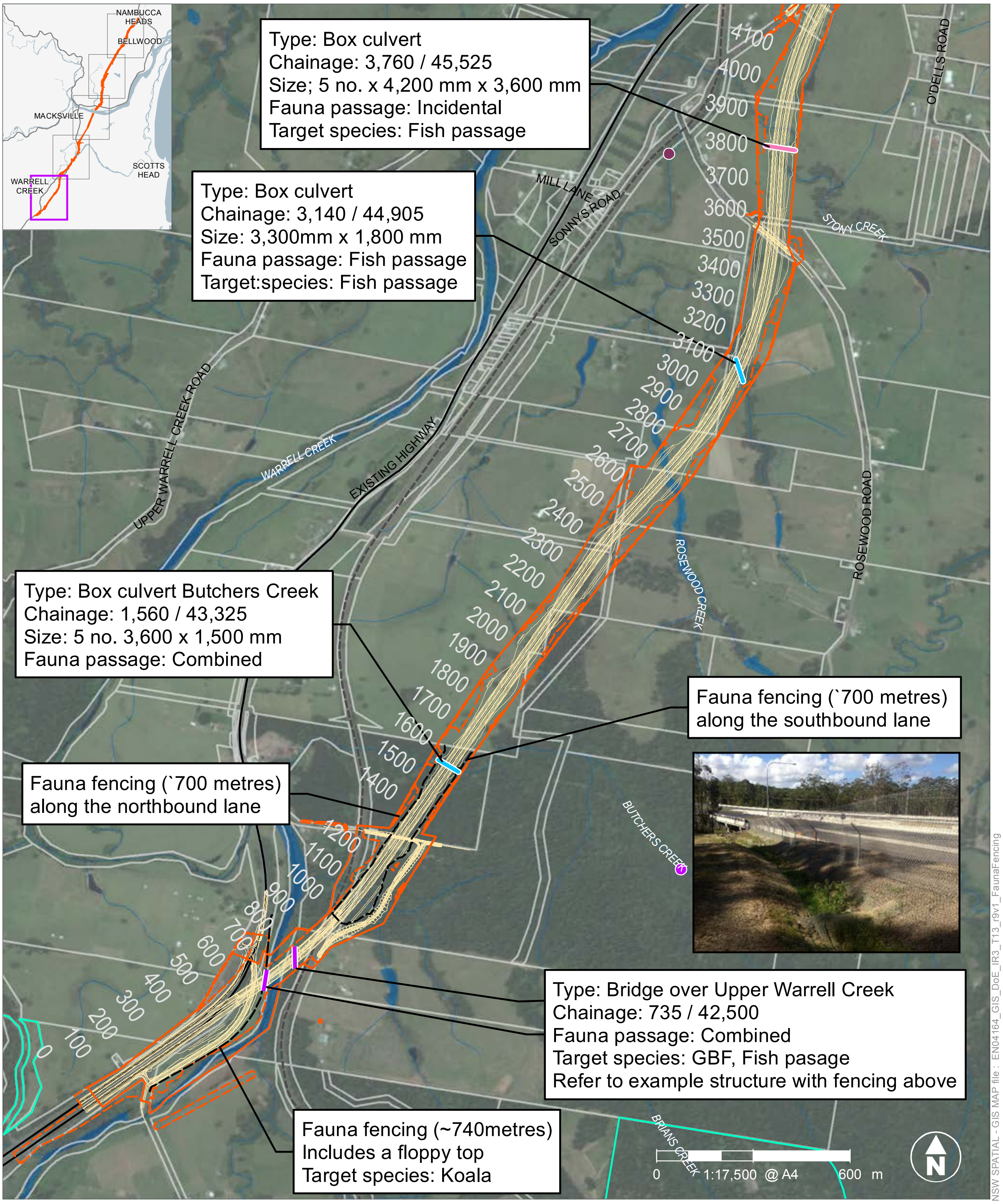
Appendix B

Fauna Exclusion Fencing



Legend

- Road design
- Service Road - Old Coast Road
- Road boundary
- Clearing boundary
- Lot (survey)
- State Forest boundary
- Combined culvert with fauna underpass
- Dedicated fauna underpass
- Fauna fence
- Bridge with fauna passage
- Incidental fauna passage

Threatened fauna

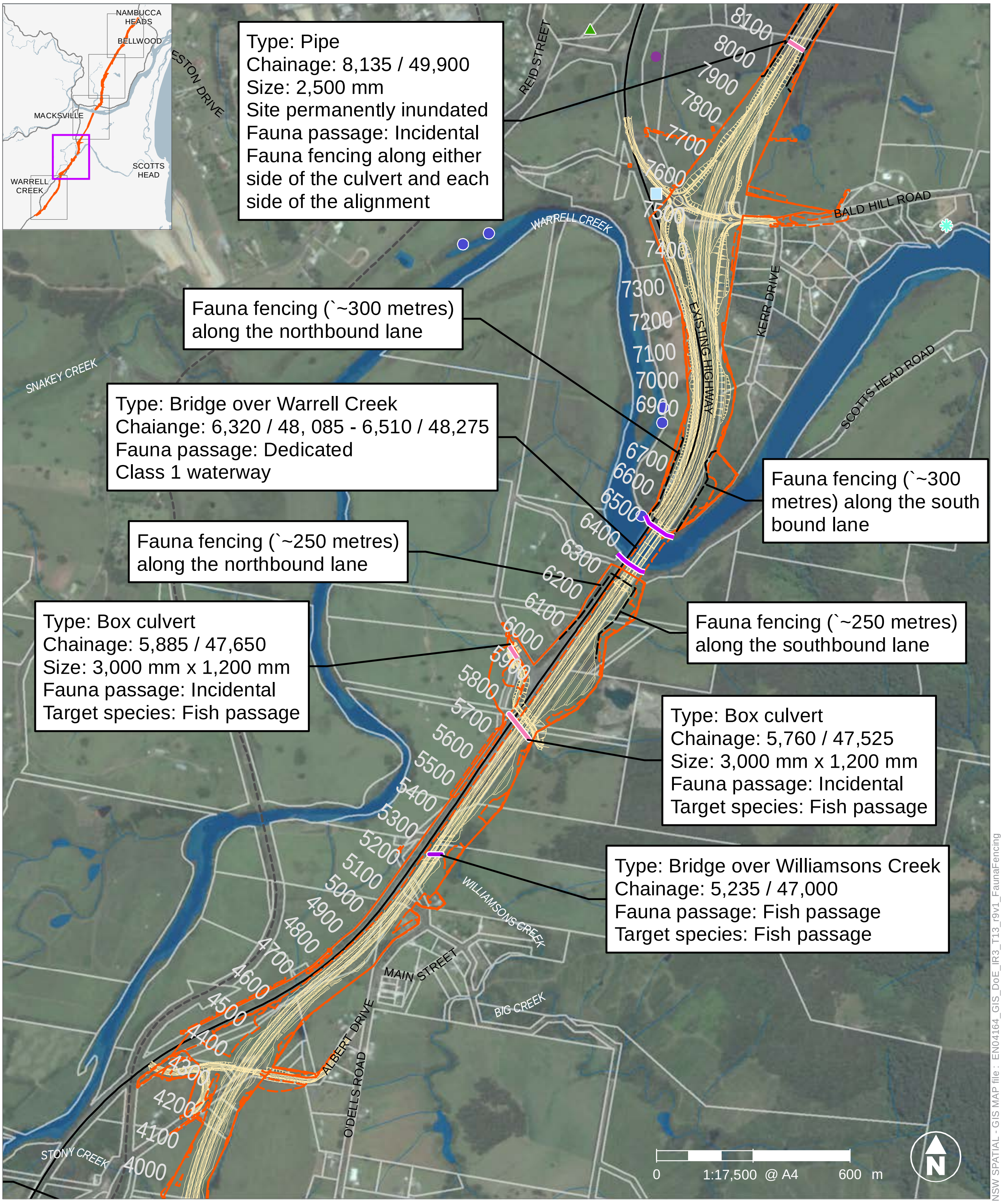
- Black Bittern
- Black Grass-dart Butterfly
- Black-necked Stork
- Brolga
- Brush-tailed Phascogale
- Cattle Egret
- Common Greenshank
- Eastern Bentwing-bat
- Eastern Freetail-bat
- Eastern Osprey
- Glossy Black-Cockatoo
- Glossy Ibis
- Greater Broad-nosed Bat
- Green and Golden Bell Frog
- Grey-headed Flying-fox
- Koala
- Latham's Snipe
- Little Bentwing-bat
- Masked Owl
- Oriental Pratincole
- Osprey (nest site)
- Pacific Golden Plover
- Powerful Owl
- Rainbow Bee-eater
- Regent Honeyeater
- Sooty Owl
- Southern Myotis
- Spotted-tailed Quoll
- Square-tailed Kite
- Squirrel Glider
- White-bellied Sea-Eagle
- Yellow-bellied Glider

NOTES

- The chainages in this figure reflect the WC2U EA chainages. To convert these to the referral chainages add 41765.
- The locations of the fauna crossings and fauna fences are indicative only.

DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information

NSW GOVERNMENT Transport Roads & Maritime Services JACOBS



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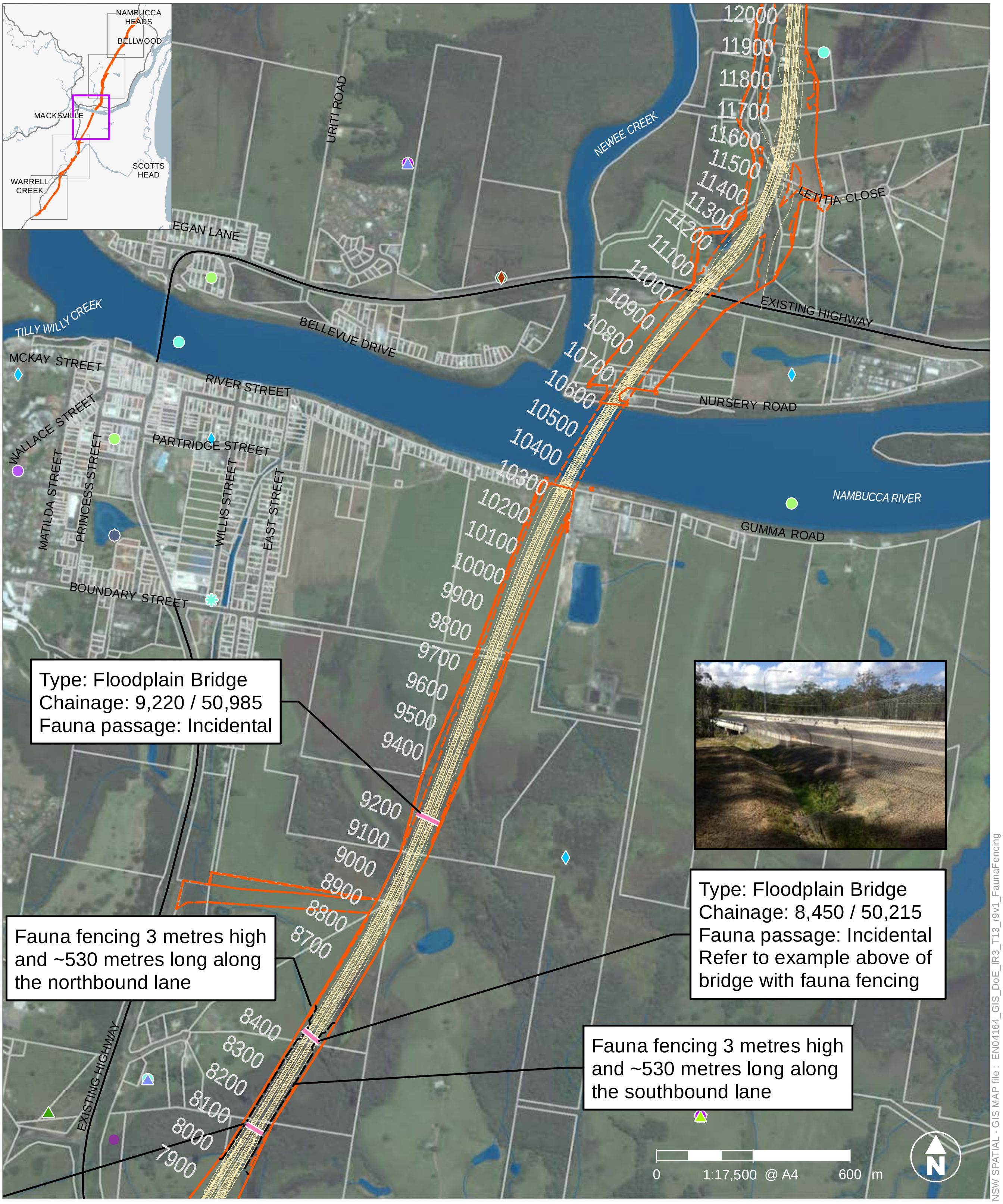

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- Fauna fence
- Bridge with fauna passage
- Incidental fauna passage

Threatened fauna

Black Bittern	Cattle Egret	Glossy Black-Cockatoo	Koala	Osprey (nest site)	Sooty Owl
Black Grass-dart Butterfly	Common Greenshank	Glossy Ibis	Latham's Snipe	Pacific Golden Plover	Southern Myotis
Black-necked Stork	Eastern Bentwing-bat	Greater Broad-nosed Bat	Little Bentwing-bat	Powerful Owl	Spotted-tailed Quoll
Brolga	Eastern Freetail-bat	Green and Golden Bell Frog	Masked Owl	Rainbow Bee-eater	Square-tailed Kite
Brush-tailed Phascogale	Eastern Osprey	Grey-headed Flying-fox	Oriental Pratincole	Regent Honeyeater	Squirrel Glider
					White-bellied Sea-Eagle
					Yellow-bellied Glider

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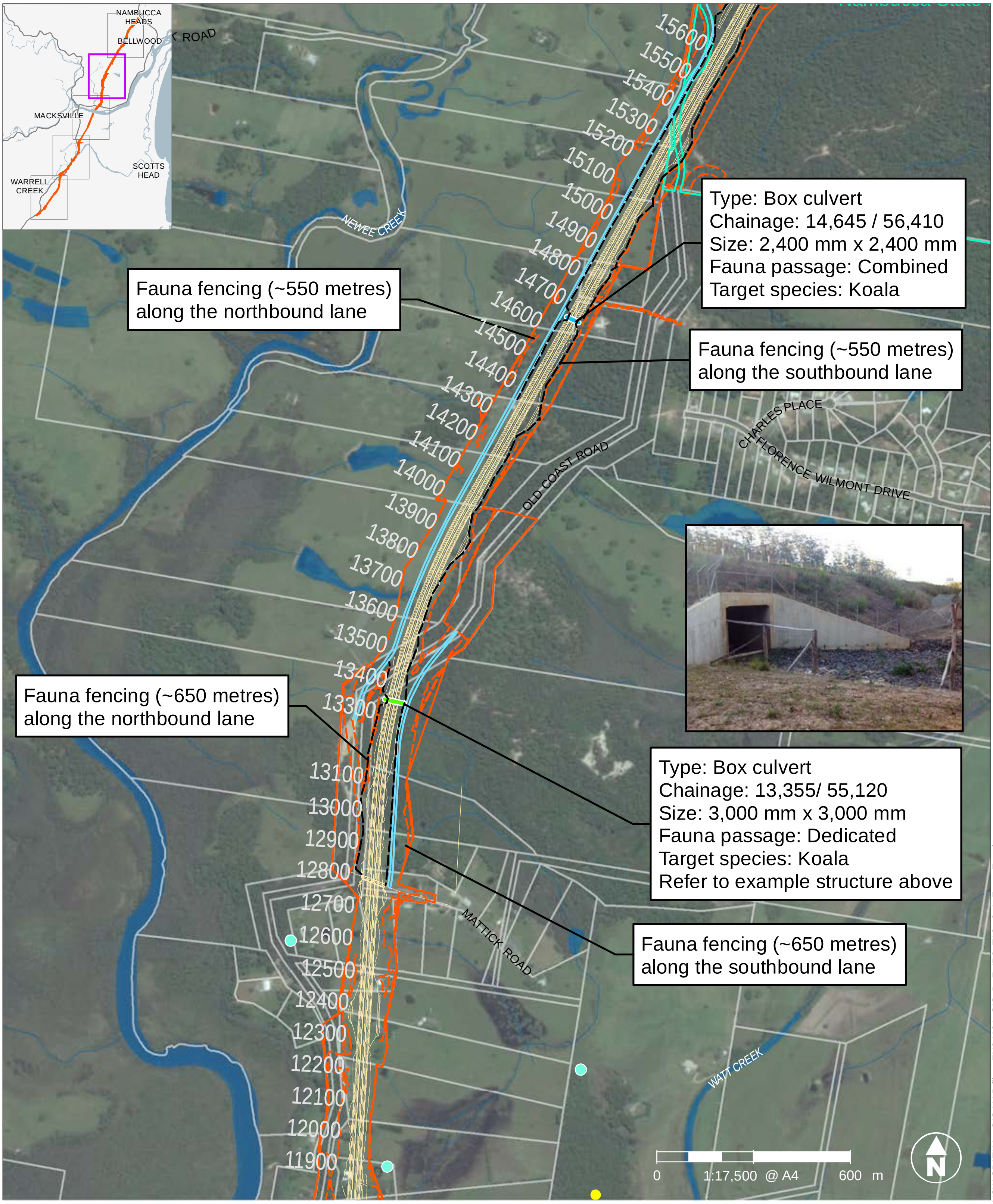
Attachment A Figure 4 | Threatened species, proposed fauna fencing and underpass locations



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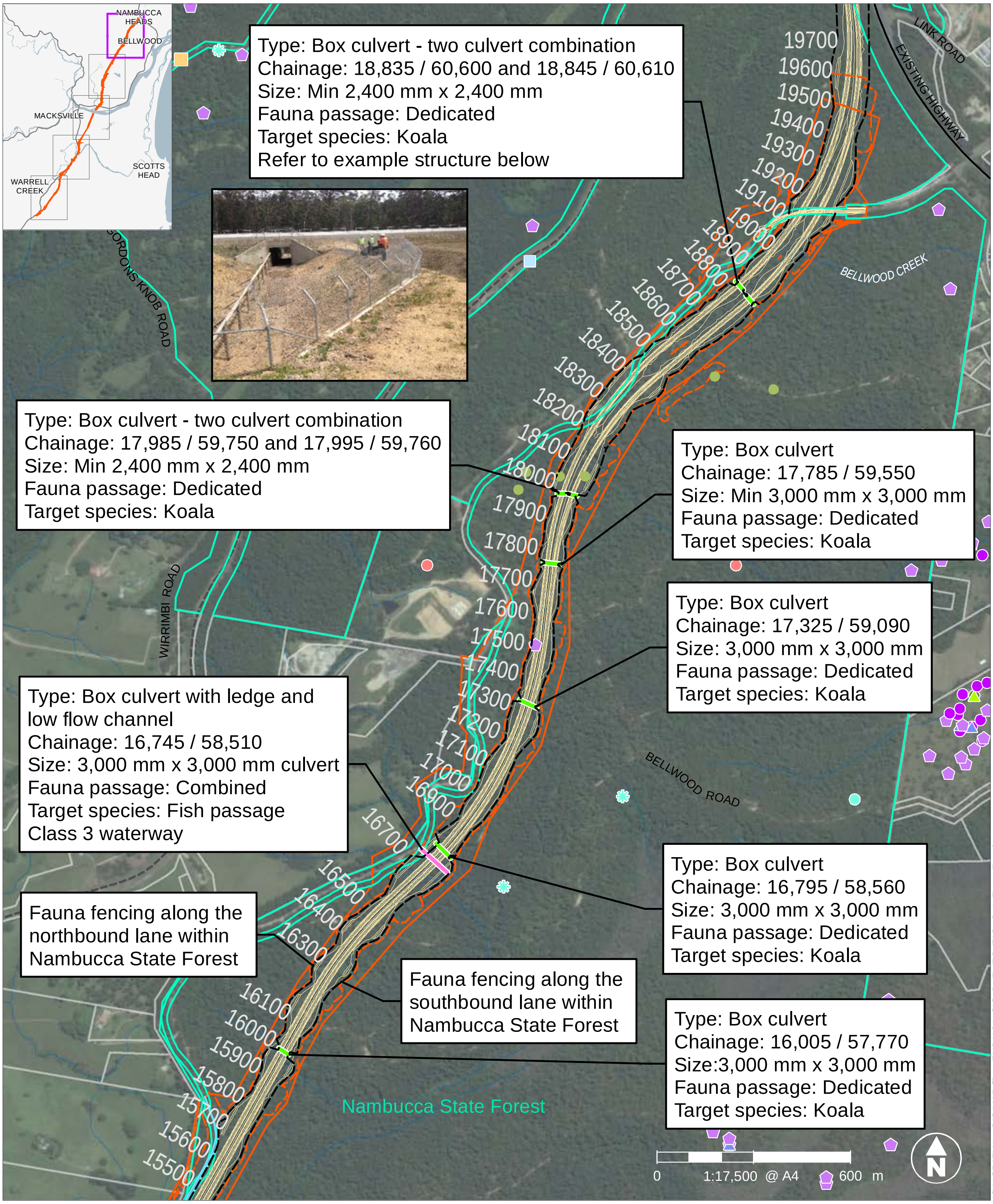

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- Lot (survey)
- State Forest boundary
- Combined culvert with fauna underpass
- Dedicated fauna underpass
- Fauna fence
- Bridge with fauna passage
- Incidental fauna passage

Threatened fauna

- Black Bittern
- Black Grass-dart Butterfly
- Black-necked Stork
- Brolga
- Brush-tailed Phascogale
- Cattle Egret
- Common Greenshank
- Eastern Bentwing-bat
- Eastern Freetail-bat
- Eastern Osprey
- Glossy Black-Cockatoo
- Glossy Ibis
- Greater Broad-nosed Bat
- Green and Golden Bell Frog
- Grey-headed Flying-fox
- Koala
- Latham's Snipe
- Little Bentwing-bat
- Masked Owl
- Oriental Pratincole
- Osprey (nest site)
- Pacific Golden Plover
- Powerful Owl
- Rainbow Bee-eater
- Regent Honeyeater
- Sooty Owl
- Southern Myotis
- Spotted-tailed Quoll
- Square-tailed Kite
- Squirrel Glider
- White-bellied Sea-Eagle
- Yellow-bellied Glider

NOTES

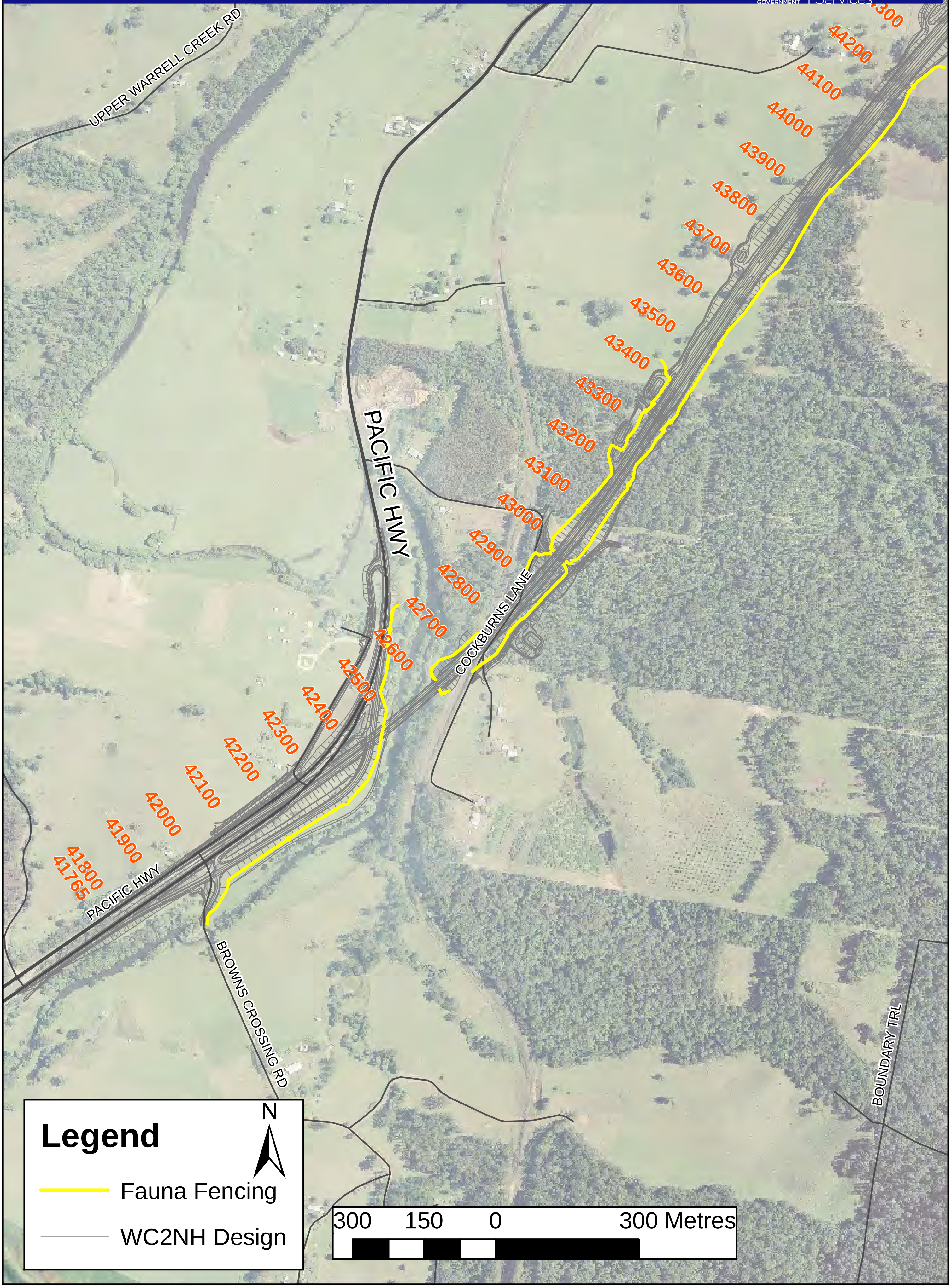
- The chainages in this figure reflect the WC2U EA chainages. To convert these to the referral chainages add 41765.
- The locations of the fauna crossings and fauna fences are indicative only.

DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information

NSW Transport Roads & Maritime Services JACOBS

PACIFIC HIGHWAY UPGRADE - Warrell Creek to Nambucca Heads

Attachment B Figure 1 Fauna Fencing locations

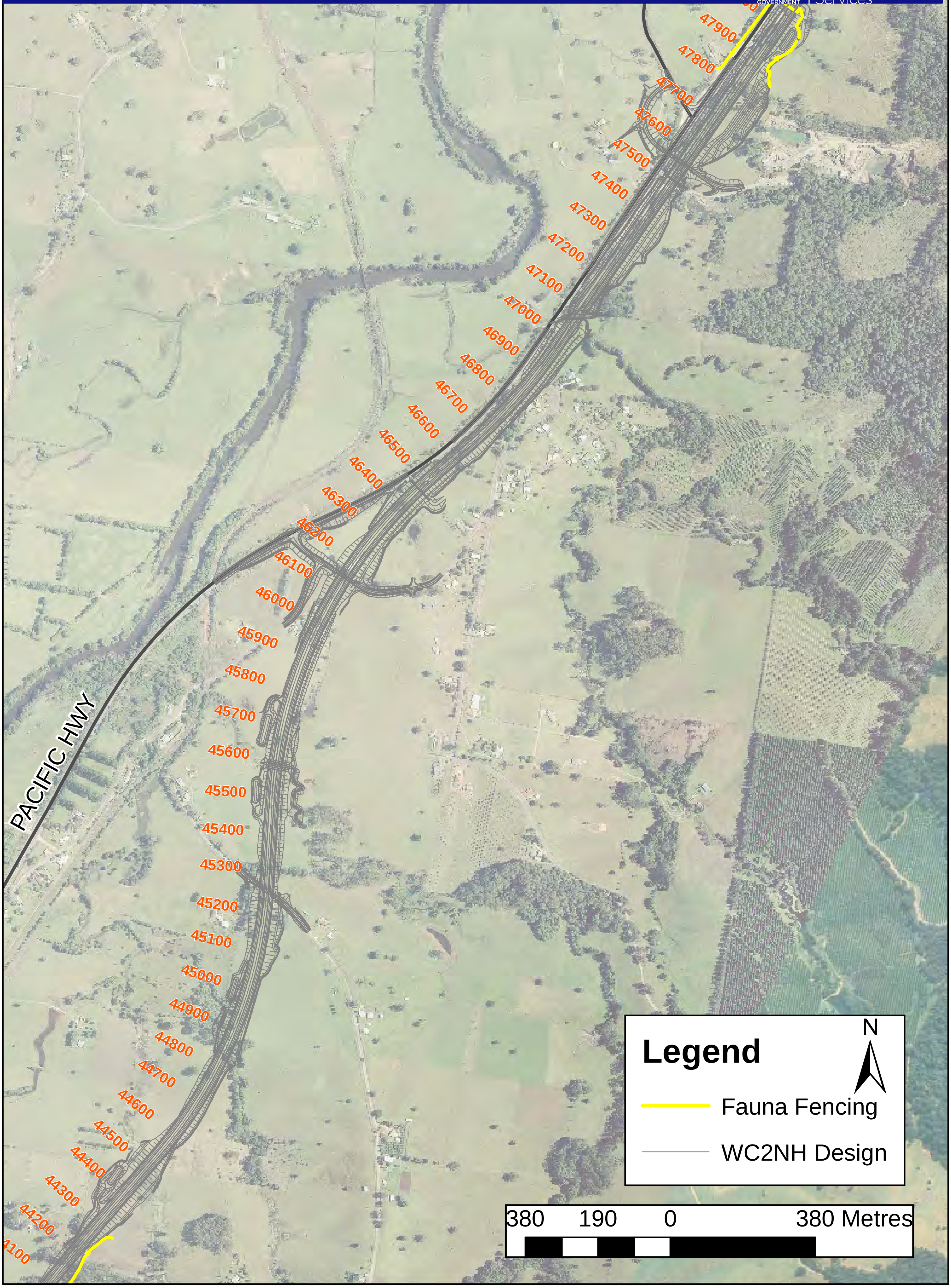


PACIFIC HIGHWAY UPGRADE - Warrell Creek to Nambucca Heads

Attachment B Figure 2 Fauna Fencing locations

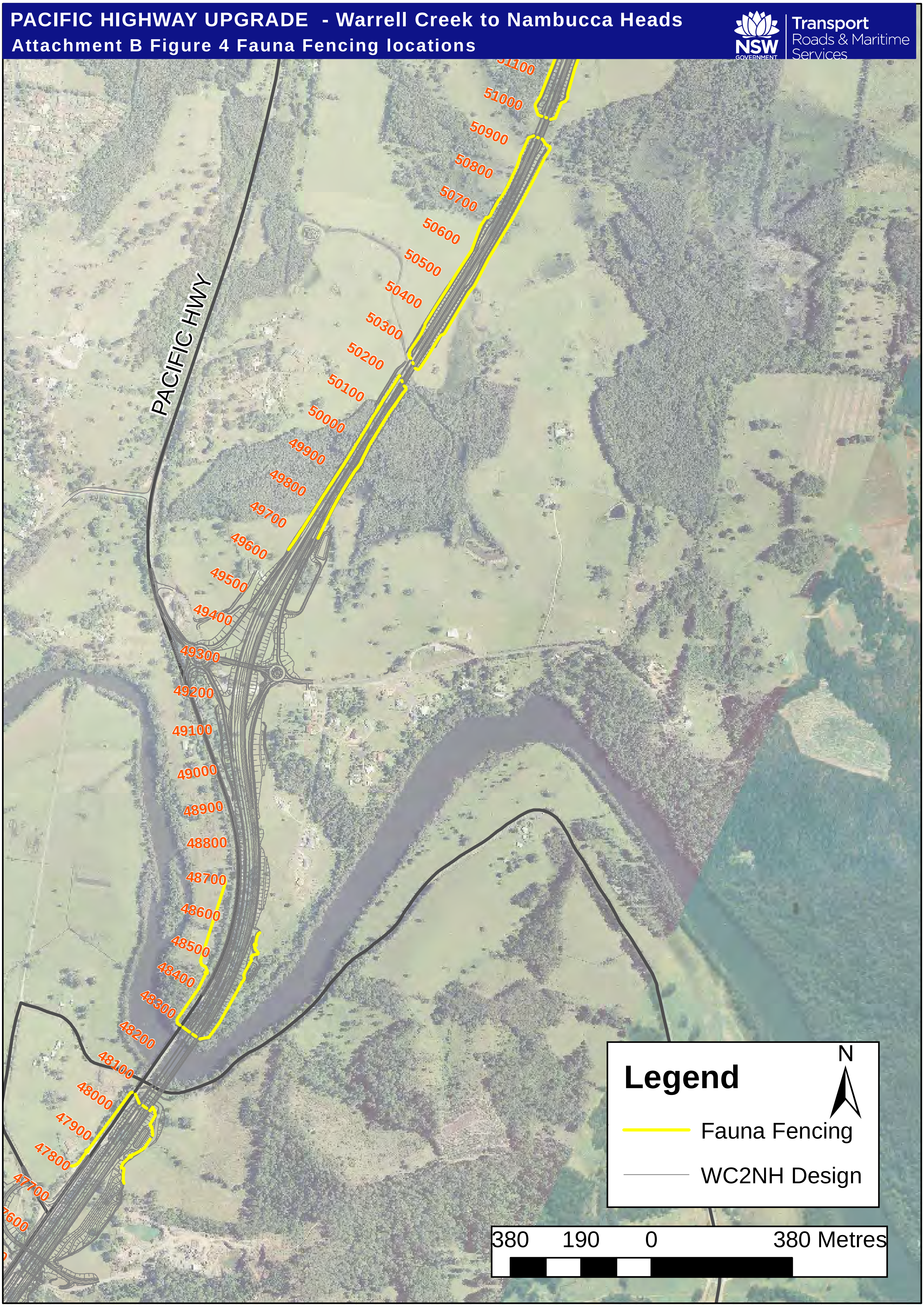
PACIFIC HIGHWAY UPGRADE - Warrell Creek to Nambucca Heads

Attachment B Figure 3 Fauna Fencing locations



PACIFIC HIGHWAY UPGRADE - Warrell Creek to Nambucca Heads

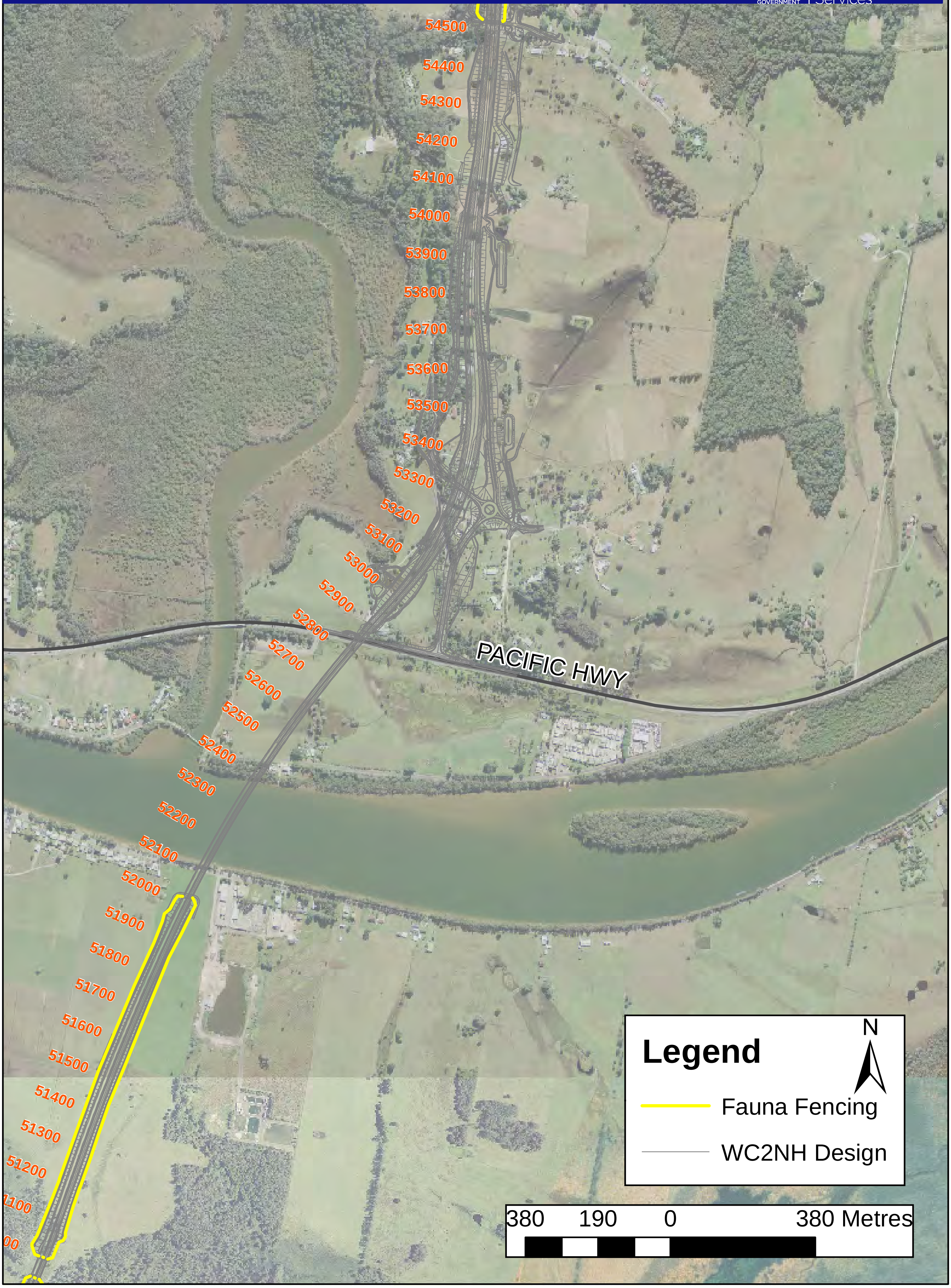
Attachment B Figure 4 Fauna Fencing locations



PACIFIC HIGHWAY UPGRADE - Warrell Creek to Nambucca Heads

Attachment B Figure 5 Fauna Fencing locations

Transport
Roads & Maritime
Services



PACIFIC HIGHWAY UPGRADE - Warrell Creek to Nambucca Heads

Attachment B Figure 6 Fauna Fencing locations

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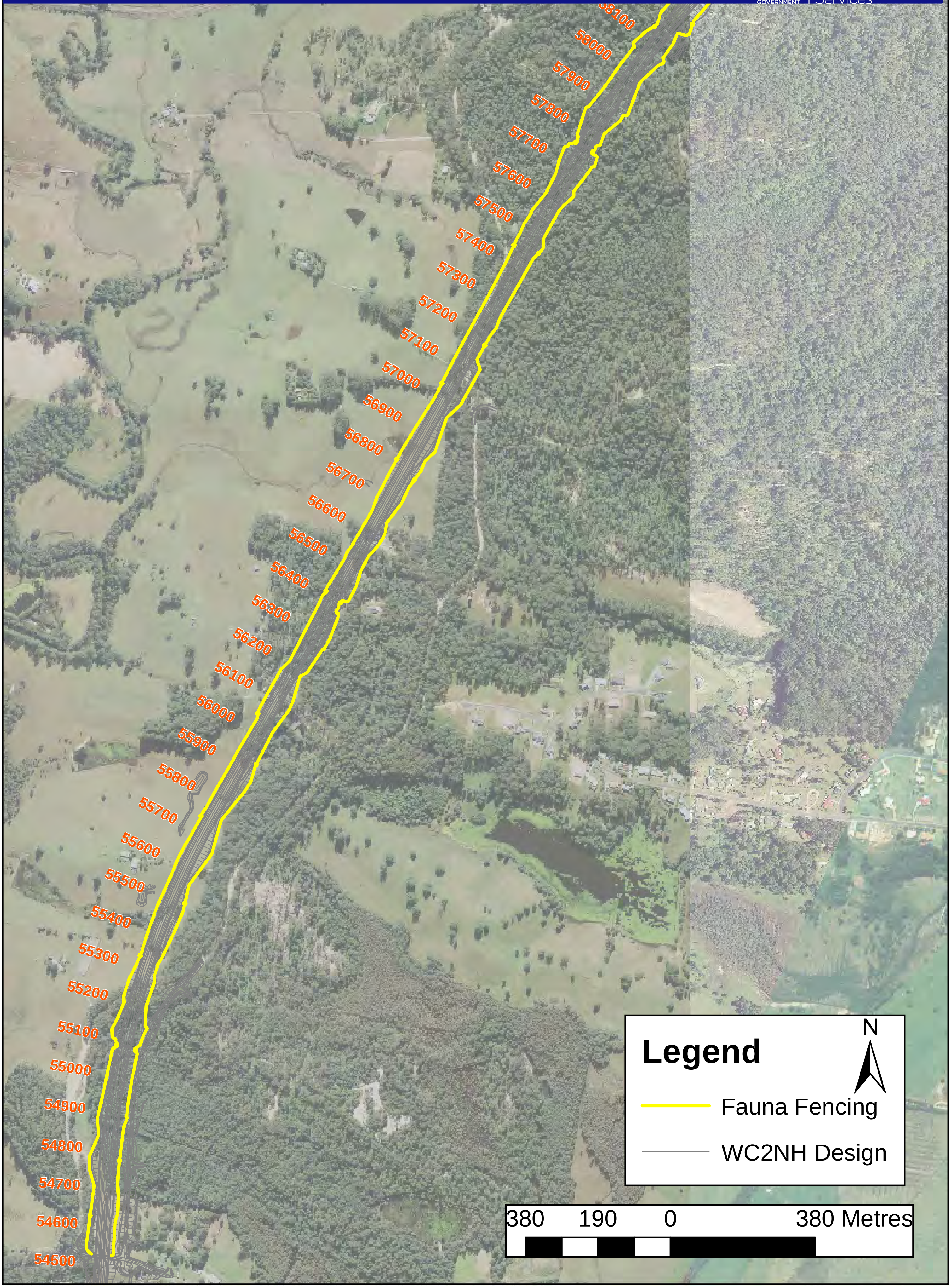
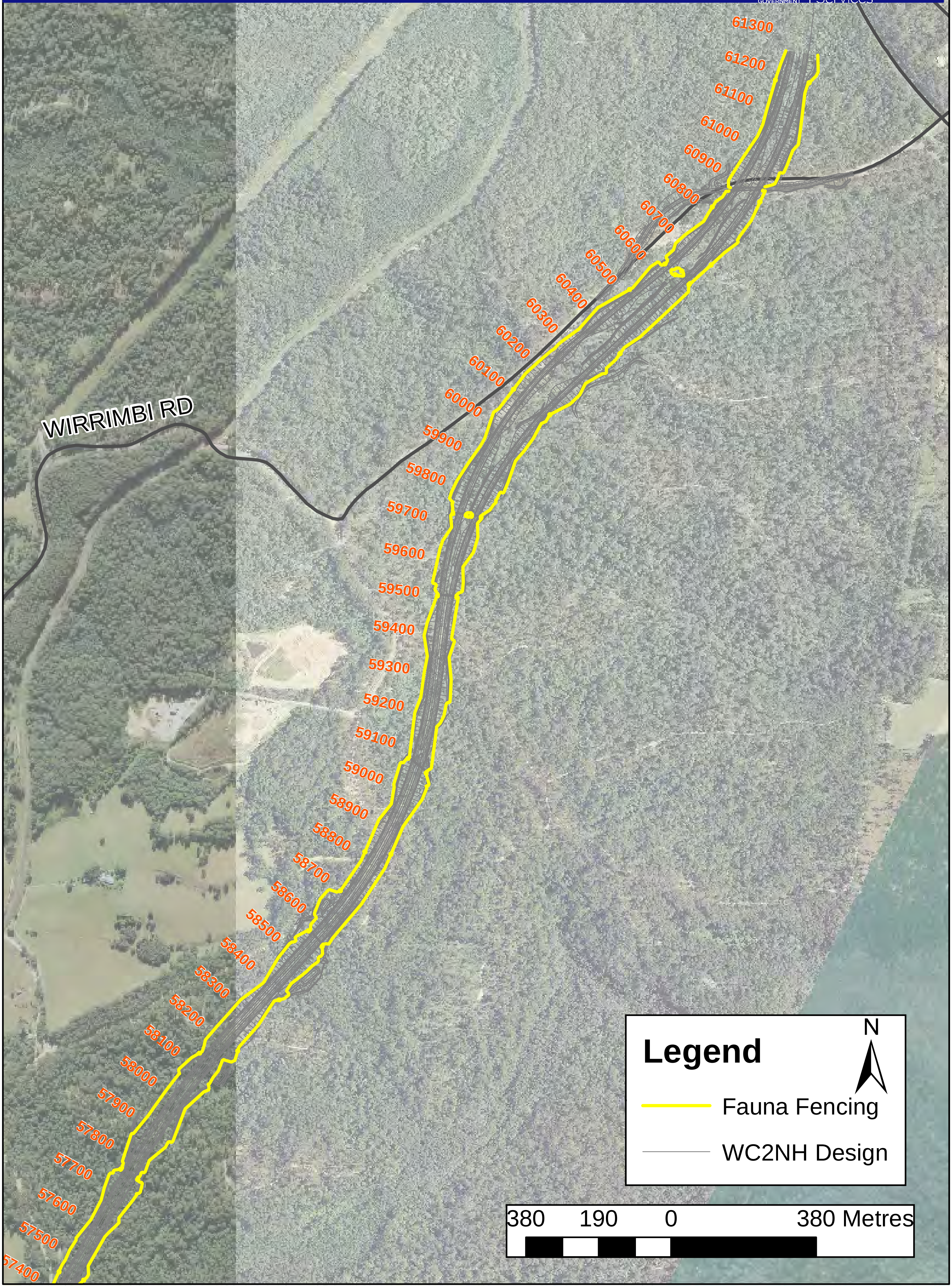


PACIFIC HIGHWAY UPGRADE - Warrell Creek to Nambucca Heads

Attachment B Figure 7 Fauna Fencing locations

Transport
Roads & Maritime Services



Appendix C

Connectivity Habitat Restoration Areas

DoE Information Request 3, Task 5 and 6 – Connectivity and fragmentation of habitat

Document: Item 2-1 Independent review Koala, Table 4-1.

DoE comment 5:

Given the likely residual impact from connectivity loss and increased fragmentation of the koala habitat/population, please demonstrate how connectivity will be increased in the landscape (e.g. through tree plantings) to compensate for this loss. Please include this information in the proposed Urban Design and Landscape Plan (UDLP) (see comment 6a below).

DoE comment 6:

Table 1.2:

(a) Habitat restoration and management –

- **(i) It is unclear what areas of the proposed action will require a targeted UDLP. Please show on a map the locations along the length of the highway where habitat restoration and management will occur and how this will result in connectivity for relevant threatened species (e.g. see comment 5 regarding the koala above). Additionally, to provide context, please overlay all fauna mitigation measures proposed on the same map.**
- **(ii) Please advise the likely timing for completion of the UDLP, noting that RMS must provide the plans to the Department for approval prior to commencement (Note: The submission of the plans can be staged to align with construction staging).**

Response Task 5:

Identification of potential opportunities to enhance connectivity

Roads and Maritime Services propose to enhance connectivity in the landscape wherever reasonable and feasible through the provision of strategic tree planting in road reserves and residual land acquired for the project. In a brief memorandum provided by GeoLINK environmental consultants (dated 24th July 2014), the ecologists involved in the baseline Koala surveys identified opportunities to enhance habitat / vegetation connectivity post-construction for fauna in general including the Koala, refer to Table 1 of **Attachment A**.

Further to this Roads and Maritime Services identified several small parcels of residual property acquired for the project and outside the road corridor that are also well suited to enhancing connectivity in the landscape. This includes

- Additional planting within the Roads and Maritime residual property on the eastern side of the project between chainages 1,600 / 43,365 and 1,900 / 43,665 with vegetation indicative of the Moist Open Forest Flooded Gum community to expand areas of habitat in this area.

- Additional planting within the Roads and Maritime residual property on the eastern side of the project between chainages 14,900 / 56,665 and 15,100 / 56,865 with vegetation indicative of the Blackbutt community to expand areas of habitat in this area.

Review of potential opportunities to enhance connectivity

Subsequent to the identification of connectivity sites along the project by GeoLINK reviews of the proposed areas of revegetation and planting from a flooding and visual impact perspective were undertaken. This included an assessment by Spackman Mossop Michaels of visual amenity impacts and an assessment by Arup to assess any potential flood afflux impacts and changes in roughness values as a result of increasing the planting density along creeks and rivers.

The results of the visual impact assessment of the proposed connectivity sites are summarised below:

- 735 / 42,500 - Upper Warrell Creek eastern bank: This area would benefit visually from as much re-vegetation and planting as can be provided to assist with visual mitigation of the interchange from multiple viewpoints (including road users).
- 3,140 / 44,905 – Rosewood Creek: This location south of the over bridge appears to be in fill, so road user views would be largely unaffected. Houses are approximately 500 metres away so visual mitigation can be addressed fairly easily. Re-vegetation and planting would form part of the visual mitigation approach in this area anyway.
- 9,220 / 50,985 - Floodplain Bridge No.2: This location is in a combination of open/ wooded landscape and is located in fill, so road user views would be largely unaffected. Houses are well away and few in number so visual mitigation can be addressed fairly easily.
- 10,600 / 52,365 - Nambucca River Bridge north bank: The north bank is currently reasonably well vegetated, additional planting here would have a positive visual impact.

In addition, Roads and Maritime Services made the following comments:

- 3,140 / 44,905 – Rosewood Creek – Roads and Maritime Services have no concerns with this location subject to any connectivity planting in this area being limited to replacement of vegetation removed for the project to minimise potential impacts on flooding.
- 5,235 / 47,000 Williamsons Creek - Roads and Maritime Services don't see the need / benefit of connectivity planting in this area noting that it is identified for fish passage only and that there is no native vegetation downstream of the old highway crossing.
- Ch.14800 - 15500 west of the alignment - Roads and Maritime Services don't see the need / benefit of connectivity planting in this area noting that there are no fauna underpasses between Ch.14645 (56,410) and Ch.16005 (57,770).
- Ch.13300 fauna underpass - Roads and Maritime Services don't have any concerns with the proposed connectivity planting in this area due to the extent of existing vegetation and noting that the natural surface slopes from west to east at this location.

The results of the flood afflux assessment of the proposed connectivity sites as completed by Arup is provided below. It should be noted that the assessment is very high level and has tried to identify if an increase in roughness would result in an increase in flood levels and afflux. In addition, no modelling has however been completed to date. Arup notes that assuming that the afflux of the project is calculated as the difference between the existing levels (with existing vegetation) and the design levels (with the improved vegetation) then it is possible that changing the roughness values (as a result of increasing the planting density) will impact on flood afflux.

The results of the high level assessment indicates that it is most likely that the areas around the culverts are not of major concern, however the areas around the major water way crossings may be more problematic. **Table 1** provides a summary of the structures / locations which may be sensitive.

Table 1 Summary of the connectivity areas identified by GeoLINK that may potentially be flood sensitive

Location	Existing roughness	Revised vegetation roughness	Possible impact
735 / 42,500 - Upper Warrell Creek	0.04	0.08	Probable impact as afflux here is sensitive to channel works and vegetation.
5,235 / 47,000 Williamsons Creek	0.04	0.08	Probable impact as afflux here is sensitive to channel works and vegetation.
6,510 / 48,275 Warrell Creek	0.08	0.08	Limited as out of bank and already high roughness
8,450 / 50,215 Floodplain Bridge 1	0.08	0.08	Limited as already high roughness
9,220 / 50,985 Floodplain Bridge 2	0.06	0.08	Possible impact as within the Nambucca floodplain and only 15mm allowable afflux
10,600 / 52,365 Nambucca Bridge north bank	0.04	0.08	Possible impact as within the Nambucca floodplain and only 15mm allowable afflux

Roads and Maritime Services concurred with Arup regarding the potential flooding impacts identified in **Table 1** with the possible exception of:

- 735 / 42,500 - Upper Warrell Creek eastern bank: subject to any connectivity planting in this area being limited to replacement of vegetation removed for the project and planting of vegetation suitable for Giant Barred Frog.
- 735 / 42,500 - Upper Warrell Creek western bank: subject to any connectivity planting in this area being limited to planting of vegetation suitable for Giant Barred Frog.
- 9,220 / 50,985 - Floodplain Bridge No.2: due to the very low velocities in this area (noting the 15mm afflux limit) and 10,600 / 52,365 - Nambucca River Bridge north bank: subject to any connectivity planting in this area would be limited to replacement of vegetation removed for the project.

Based on the analysis completed above, the connectivity sites identified by GeoLINK in Table 1 of **Appendix A** would be modified as follows:

- Connectivity plantings would not be included at:
  - 5,235 / 47,000 Williamsons Creek due to visual impacts and lack of vegetation connectivity.
  - Ch.14800 - 15500 west of the alignment due to visual impacts and lack of vegetation connectivity.

- Connectivity planting would be limited to replacement of vegetation removed for the project in the following areas:
  - 735 / 42,500 - Upper Warrell Creek eastern bank due to flooding impacts.
  - 3,140 / 44,905 - Rosewood Creek (visual impacts)
  - 9,220 / 50,985 -Floodplain Bridge No.2 due to flooding and visual impacts.
  - 10,600 / 52,365 -Nambucca River Bridge north bank due to flooding and visual impacts.

Selected locations for planting to enhance connectivity

The updated locations for connectivity planting are provided in the map series included as **Attachment B**. In summary, 14 separate locations across the 19 kilometre upgrade have been identified where there is opportunity to conduct strategic planting to enhance connectivity. The areas identified are generally associated with riparian zones as they are viewed to present the best opportunity to enhance connectivity. The locations selected within these zones include future road reserve.

Of the areas identified, twelve of these sites are identified as areas with potential to be used by Koalas. In these locations it is recommended that the use of primary Koala feed trees be targeted in the planting mixes. The specific Koala food trees associated with each of the vegetation map unit impacted are summarised in **Table 2**.

Table 2. Summary of primary and secondary Koala feed trees and corresponding vegetation type

Vegetation Community	Habitat Type	Primary Koala Food (DECC 2008)	Secondary Food Tree Species (DECC 2008)
Map Unit 1: Open Forest – Blackbutt	Dry Sclerophyll Forest	Tallowwood (*Eucalyptus microcorys*)	• Small-fruited Grey Gum (*E. propinqua*). • Red Mahogany (*E. resinifera*). Note Blackbutt (*E. pilularis*) may also be considered and is identified as a supplementary feed tree (Professor Rob Close, University of Western Sydney. pers. comm. 2013).
Map Unit 2: Mixed Floodplain Forest	Wet Sclerophyll Forest	Tallowwood (*E. microcorys*)	• Small-fruited Grey Gum (*E. propinqua*). • Red Mahogany (*E. resinifera*).
Map Unit 3: Moist Forest – White Mahogany/ Grey Gum/ Ironbark	Wet Sclerophyll Forest	Tallowwood (*E. microcorys*)	• Small-fruited Grey Gum (*E. propinqua*). • Red Mahogany (*E. resinifera*).

Vegetation Community	Habitat Type	Primary Koala Food (DECC 2008)	Secondary Food Tree Species (DECC 2008)
Map Unit 4: Moist Forest – Flooded Gum	Wet Sclerophyll Forest	Tallowwood (*E. microcorys*)	• Small-fruited Grey Gum (*E. propinqua*). • Red Mahogany (*E. resinifera*).
Map Unit 6: Swamp Forest – Swamp Mahogany/ Paperbark	Swamp Sclerophyll Forest	Swamp Mahogany (*E. robusta*)	• Small-fruited Grey Gum • (*E. propinqua*). • Red Mahogany (*E. resinífera).*

It is noted that five of the connectivity sites are located within Nambucca State Forest which is associated with the known Koala population in this location. A review of Koala records for the study area from the Atlas of NSW Wildlife identifies a low number of records between Warrell Creek and Macksville, both to the east and west of the project. Given the high degree of fragmentation between chainage 0 / 41,765 to 7,500 / 49,265 the corridor south of Macksville represents the best opportunities for enhancement of connectivity.

Of the combined number of proposed habitat planting locations, three of these sites are located between chainage 5,200 / 46,965 and 6,600 / 48,365 and are associated with where the road alignment occurs immediately adjacent to the existing Pacific Highway. This includes the riparian corridors along Warrell Creek. There are very limited opportunities for Koalas to cross the existing highway in this location due to the lack of connectivity structures on the existing highway and extensive habitat fragmentation. The proposed strategic plantings in this location are therefore considered to present a substantial improvement or enhancement over the current situation.

Response Task 6:

In regards to the Department of the Environment (DoE) comment to include this information in the proposed Urban Design and Landscape Plan (UDLP) the following is noted. During a discussion between Colette Boraso from the DoE and Chris Clark from Roads and Maritime Services on the 10 July 2014, it was agreed that the UDLP was not the appropriate document to identify measures to improve connectivity in the landscape, including the locations of habitat restoration and management measures. It was agreed that these measures were best identified in the five individual species management plans that are being prepared to address the requirements of Attachment A2 of the DoE letter provided to Roads and Maritime Services on the 27 June 2014. As such this information will be included in these management plans which will be available for review by DoE in the near future.

The map series included as **Attachment B** shows all proposed fauna mitigation measures on the same map.

ATTACHMENT A GeoLINK Memorandum Koala Connectivity (24th July 2014)

GeoLINK environmental management and design

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24 July 2014
Ref No: 2378-1004

Acciona and Ferrovial Joint Venture (AFJV)
Level 10, 207 Kent St
Sydney, NSW 2000

Attention: Alex Dwyer

WC2NH: Assessment of Opportunities to Enhance Vegetation/ Habitat Connectivity as part of the Project

GeoLINK has been requested to undertake an assessment to identify opportunities to enhance habitat/ vegetation connectivity as part of the landscaping and urban design plan to be adopted for the WC2NH project. This assessment involved a desktop review of the following information:

- Aerial imagery of vegetation surrounding the project site;
- Vegetation mapping for the project site and surrounds;
- Current locations and designs of fauna crossing structures; and
- WC2U Urban Landscape Design Plan.

Areas identified as opportunities to enhance habitat/ vegetation connectivity are shown on a series of mark ups contained within Appendix A. These areas are summarised in Table 1.1.

Identified areas are generally associated with bridges/ culverts, as riparian zones throughout the broader landscape provide the best opportunity to provide fauna habitat connectivity. Additionally, a small number of areas were identified where planting of endemic vegetation communities have the potential to create additional linkages between fragmented patches of vegetation occurring within the local landscape.

A number of recommendations were made for identified areas which are included in Table 1.1.

Feel free to contact me if you require any additional information.

Yours sincerely
GeoLINK

David Havilah
Ecologist/ Associate

Table 1.1 Proposed Habitat Connectivity Focus Areas

Area	*Chainages*	*Connectivity Opportunity*	*Recommendation*
Upper Warrell Creek (bridge site and fauna crossing location)	200 - 900	▪ A section of primarily cleared grazing land adjacent to Warrell Creek (between CH 200-700). Revegetation of this area would improve habitat/ vegetation connectivity along a relatively large portion of Warrell Creek. Additional benefits to improving aquatic fauna habitat. ▪ Areas associated with the fauna passage (CH 800) inlet/ outlet could be enhanced with additional planting of native vegetation in these areas to encourage fauna usage	▪ Riparian restoration planting along the western side of Warrell Creek (CH 200-700) with endemic species recommended. ▪ Habitat enhancement planting using appropriate endemic species proposed in areas either side of the fauna crossing culvert (CH 800) to maximise the potential use of this structure. ▪ As this area has potential to be used by Koalas the use of primary Koala feed trees in planting mixes (e.g. Tallowwood, Forest Red Gum, Grey Gum) is recommended.
Butchers Creek (combined culvert with fauna underpass)	1,450 – 1,600	▪ Areas associated with the fauna passage (CH 1,550) inlet/ outlet could be enhanced with additional planting of native vegetation in these areas to encourage fauna usage	▪ Habitat enhancement planting using appropriate endemic species proposed in areas either side of the fauna crossing culvert (CH 800) to maximise the potential use of this structure. ▪ As this area has potential to be used by Koalas the use of primary Koala feed trees in planting mixes (e.g. Tallowwood, Forest Red Gum, Grey Gum) is recommended.
Rosewood Creek (combined culvert with fauna underpass)	3,100	▪ A combined culvert with fauna underpass is to be provided at this location. The creek line is currently vegetated with Camphor Laurel forest. Connectivity could be enhanced by bush restoration works being undertaken along sections of Rosewood Creek occurring within the project site with the aim of maximising use of the culvert by fauna.	▪ Riparian plantings using endemic flora species recommended along Rosewood Creek (within the project site) as well as control of Camphor Laurel.
Unnamed tributary (incidental fauna passage)	3,800	▪ Tributary largely cleared with little vegetation/ habitat connectivity currently.	▪ No major gains to be made by restoration plantings in this area as little connectivity is currently present.

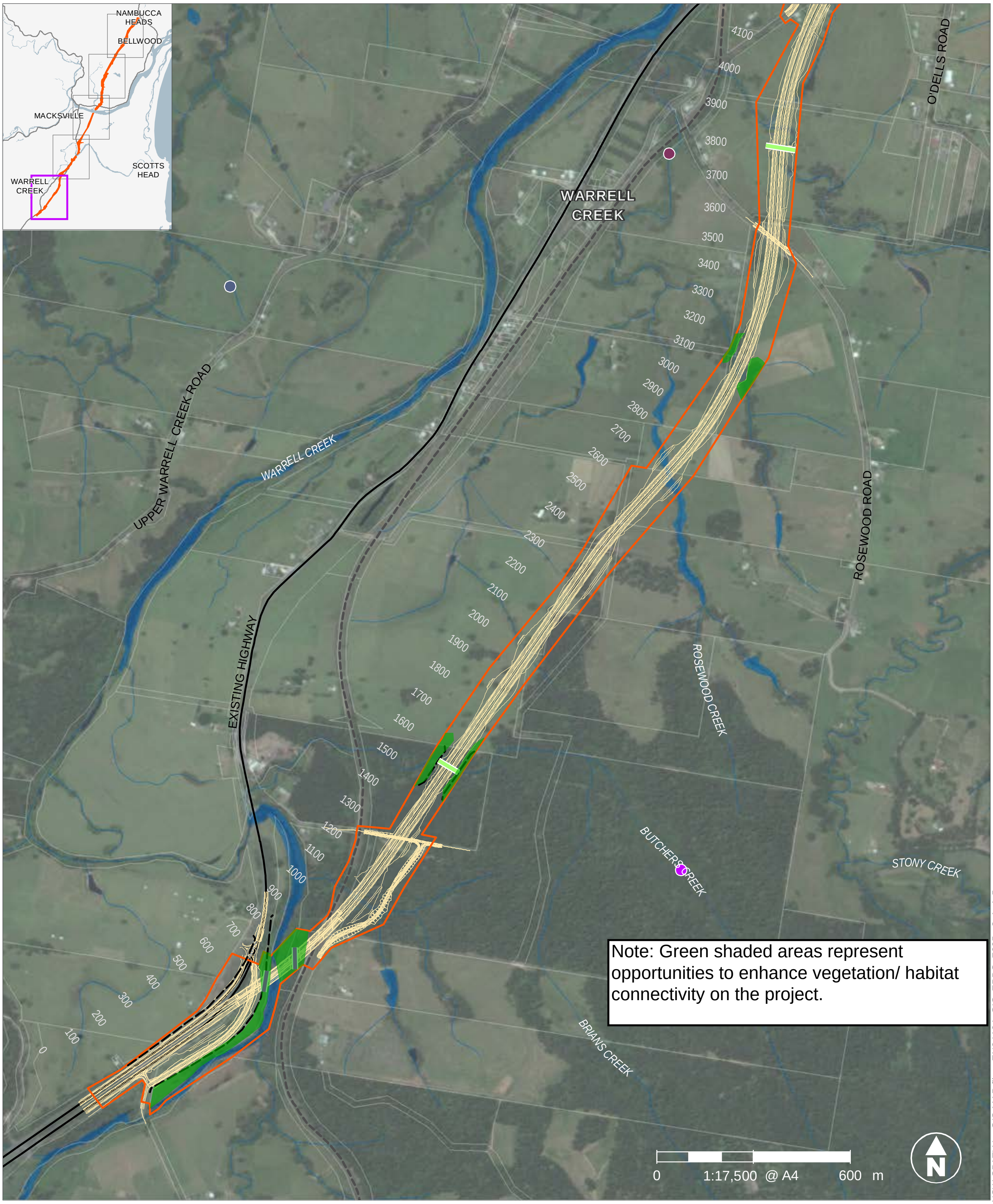
Williamsons Creek (bridge site and eastern side of the alignment)	5,200 - 5,700	▪ Habitat/ vegetation connectivity could be enhanced along Williamsons Creek by providing additional planting of appropriate riparian vegetation which would improve the likelihood of fauna movements along Williamsons Creek. ▪ Planting of a corridor of native vegetation on the eastern side of the alignment between Williamsons Creek and the unnamed tributary to the north (Ch 5,750) would improve connectivity between fragmented patches of forest in the locality.	▪ Habitat enhancement and additional riparian plantings are recommended along Williamsons Creek to improve connectivity. ▪ Planting of a corridor of native plantings including primary Koala feed trees (Tallowwood, Forest Red Gum, Grey Gum) are recommended along the eastern edge of the site between CH 5,200 and 5,700 to link fragmented patches of vegetation.
Lower Warrell Creek (areas associated with southern and northern abutment of new bridge.	6,400 - 6,800	▪ Only minor opportunities exist on the southern bank of Warrell Creek either side of the bridge footprint to enhance connectivity by a small amount of native plantings along the riparian zone. ▪ Restoration plantings within an area to the east of the new bridge site (northern bank) where vegetation is sparse and fragmented would improve connectivity by enhancing habitat values within the riparian zone	▪ Minor additional riparian plantings recommended along the southern bank either side of the bridge site where possible. ▪ Restoration/ regeneration of vegetation recommended in an area on the northern side of Warrell Creek (to the east of the new bridge site). This area is currently highly disturbed with scattered mature trees and dense weeds in the understorey.
Floodplain Plank Bridges and incidental fauna passage locations	8,000 - 9,400	▪ Minor opportunities to enhance and extend areas of EEC/ fauna habitat either side of the alignment primarily associated with fauna crossing structures and plank bridges.	▪ Recommend planting of Broad-leaved Paperbark/ Swamp Oak to enhance/ extend areas of habitat where possible and improve the likelihood of fauna movement at fauna crossing locations.
Nambucca River Bridge (northern bank)	10,600	▪ Additional planting/ restoration along the riparian corridor would enhance connectivity under the bridge which forms a linkage with large areas of vegetation associated with Newee Creek.	▪ Recommend planting of Swamp Oak, Forest Red Gums and other appropriate riparian plantings either side of the new bridge (within the riparian zone).

Area on the western side of the alignment, north of Mattick road (combined fauna passage)	13,100 – 13,450	▪ Areas associated with the fauna passage (CH 13,350) inlet/ outlet could be enhanced with additional planting of native vegetation in these areas to encourage fauna usage. ▪ Additional planting associated with Old Coast Road as it occurs within the project site would extend and enhance habitat values and linkages to large areas of vegetation to the west (Newee Creek).	▪ Habitat enhancement planting using appropriate endemic species proposed in areas either side of the fauna crossing culvert (CH 800) to maximise the potential use of this structure. ▪ Additional planting of endemic vegetation to the west of the alignment to improve connectivity. ▪ As this area has potential to be used by Koalas the use of primary Koala feed trees in planting mixes (e.g. Tallowwood, Forest Red Gum, Grey Gum) is recommended.
Nambucca State Forest (south) – fauna passage combined.	14,600 - 14,700	▪ Areas associated with the fauna passage inlet/ outlet could be enhanced with additional planting of native vegetation in these areas to encourage fauna usage.	▪ Habitat enhancement planting using appropriate endemic species proposed in areas either side of the fauna crossing culvert to maximise the potential use of this structure. ▪ As this area has potential to be used by Koalas the use of primary Koala feed trees in planting mixes (e.g. Tallowwood, Forest Red Gum, Grey Gum) is recommended.
Nambucca State Forest – six fauna crossing locations between CH 16,600 and 18,800.	16,600 – 18,800	▪ Minimal opportunities exist within this part of the project site to enhance vegetation/ habitat connectivity given the already heavily forested nature of this part of the site. ▪ Areas associated with the fauna passage inlets/ outlets could be enhanced with additional planting of native vegetation in these areas to encourage fauna usage, including the use of Koala feed trees where possible.	▪ Habitat enhancement planting using appropriate endemic species proposed in areas either side of the fauna crossing culvert to maximise the potential use of this structure. ▪ As this area has potential to be used by Koalas the use of primary Koala feed trees in planting mixes (e.g. Tallowwood, Forest Red Gum, Grey Gum) is recommended.

Appendix A

Proposed Habitat Connectivity Focus Areas

Attachment A Figure 5-1 Threatened fauna, exclusion fencing and underpasses

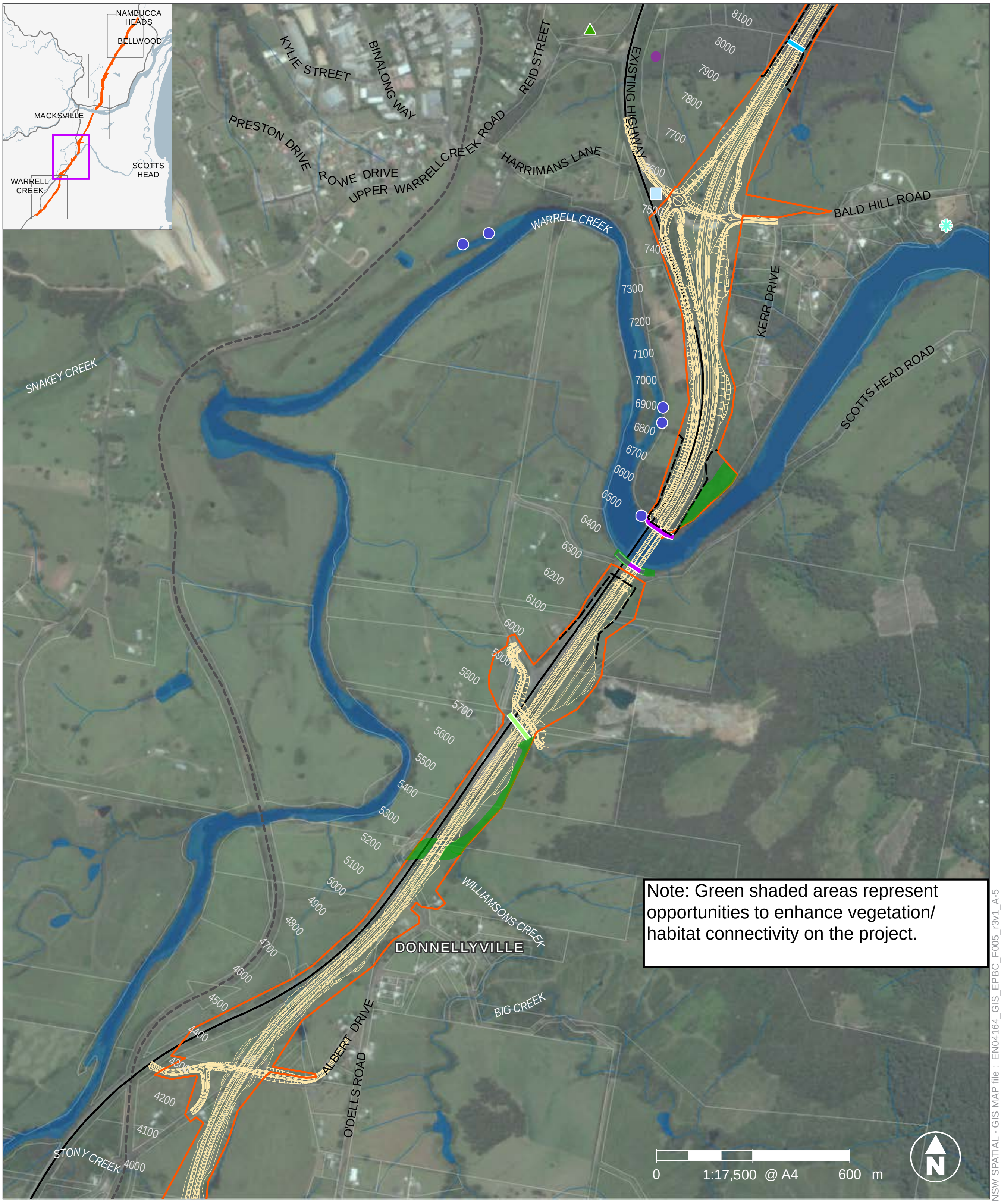


Road boundary
Road design
Temporary construction road boundary
Temporary construction road
November 2013 Flying-fox camp footprint
Combined culvert with fauna underpass
Dedicated fauna underpass
Fauna passage
Fauna fence

Threatened fauna

Black Bittern
Black Grass-dart Butterfly
Black-necked Stork
Brolga
Brush-tailed Phascogale
Cattle Egret
Common Greenshank
Eastern Bentwing-bat
Eastern Freetail-bat
Eastern Osprey
Glossy Black-Cockatoo
Glossy Ibis
Greater Broad-nosed Bat
Green and Golden Bell Frog
Grey-headed Flying-fox
Koala
Latham's Snipe
Little Bentwing-bat
Masked Owl
Oriental Pratincole
Osprey (nest site)
Pacific Golden Plover
Powerful Owl
Rainbow Bee-eater
Regent Honeyeater
Sooty Owl
Southern Myotis
Spotted-tailed Quoll
Square-tailed Kite
Squirrel Glider
White-bellied Sea-Eagle
Yellow-bellied Glider

DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information



Road boundary
Road design
Temporary construction road boundary
Temporary construction road
November 2013 Flying-fox camp footprint
Combined culvert with fauna underpass
Dedicated fauna underpass
Fauna passage
Fauna fence

Threatened fauna

- Black Bittern
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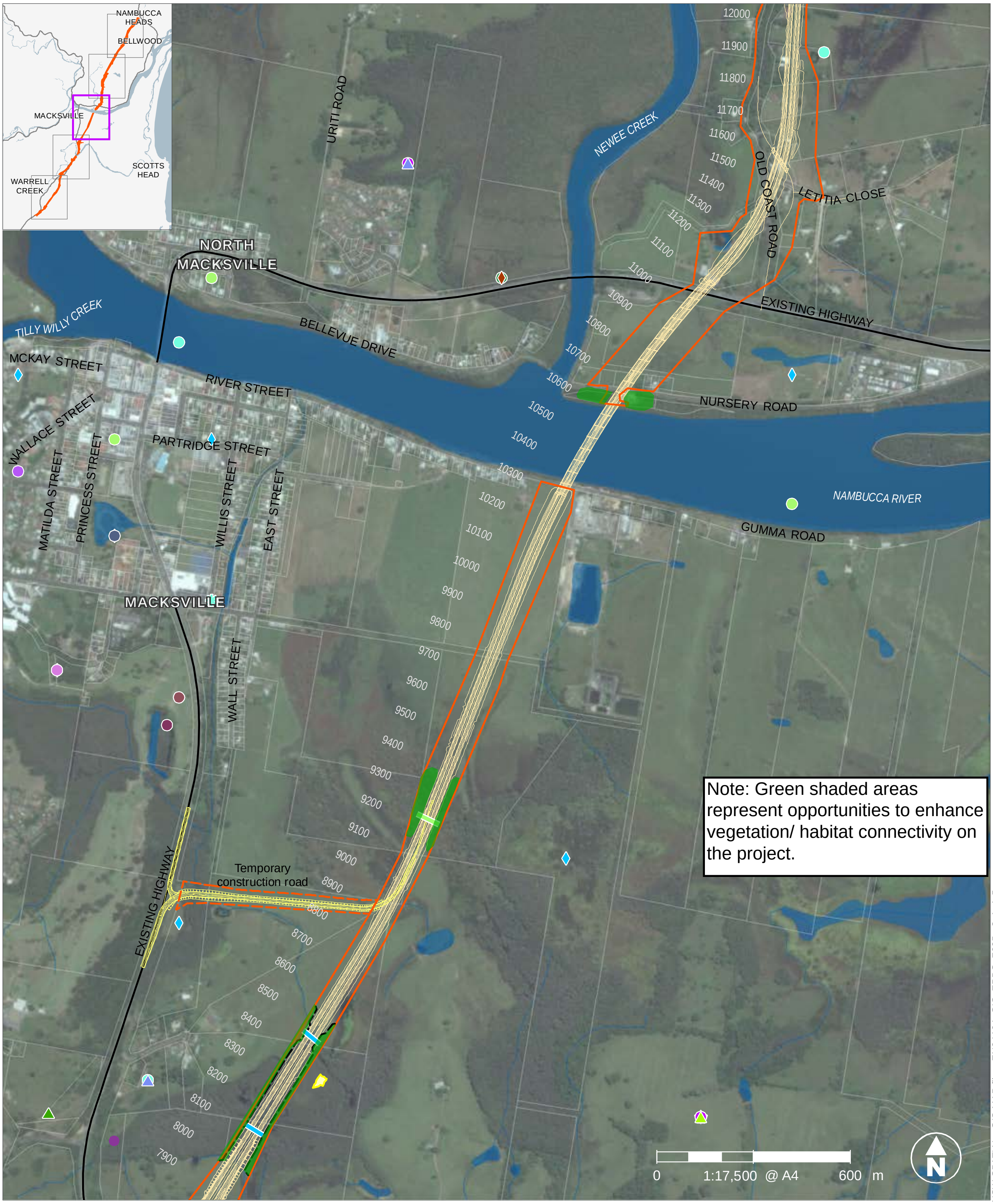
- Square-tailed Kite
- Squirrel Glider
- White-bellied Sea-Eagle
- Yellow-bellied Glider

DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information

NSW GOVERNMENT Transport Roads & Maritime Services
SKM

Attachment A Figure 5-3 Threatened fauna, exclusion fencing and underpasses



NSW SPATIAL - GIS MAP file : EN04164_GIS_EPBC_F005_r3v1_A-5

- Road boundary
- Road design
- Temporary construction road boundary
- Temporary construction road
- November 2013 Flying-fox camp footprint
- Combined culvert with fauna underpass
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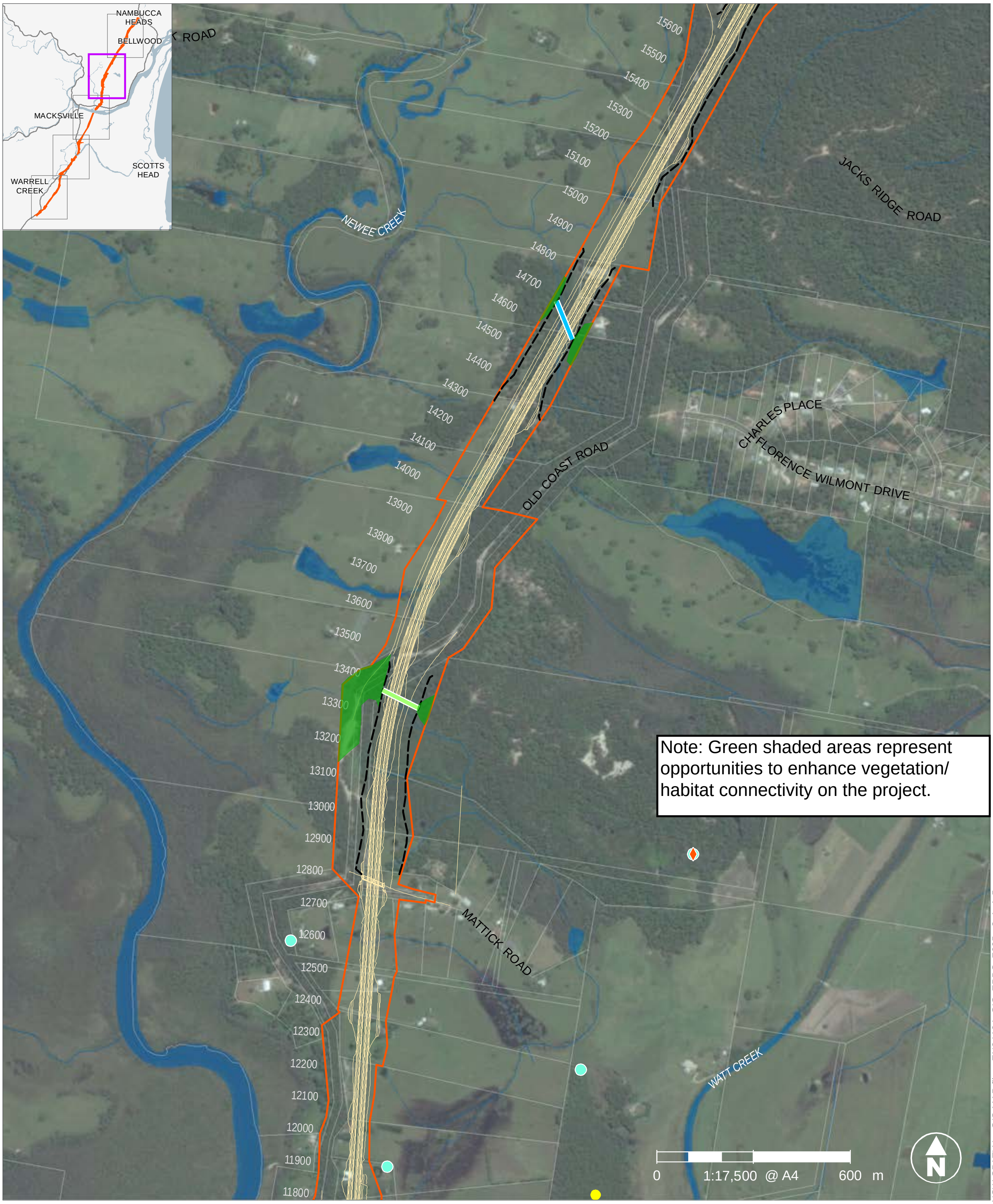
DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information

NSW GOVERNMENT Transport Roads & Maritime Services
SKM

Attachment A Figure 5-4 Threatened fauna, exclusion fencing and underpasses



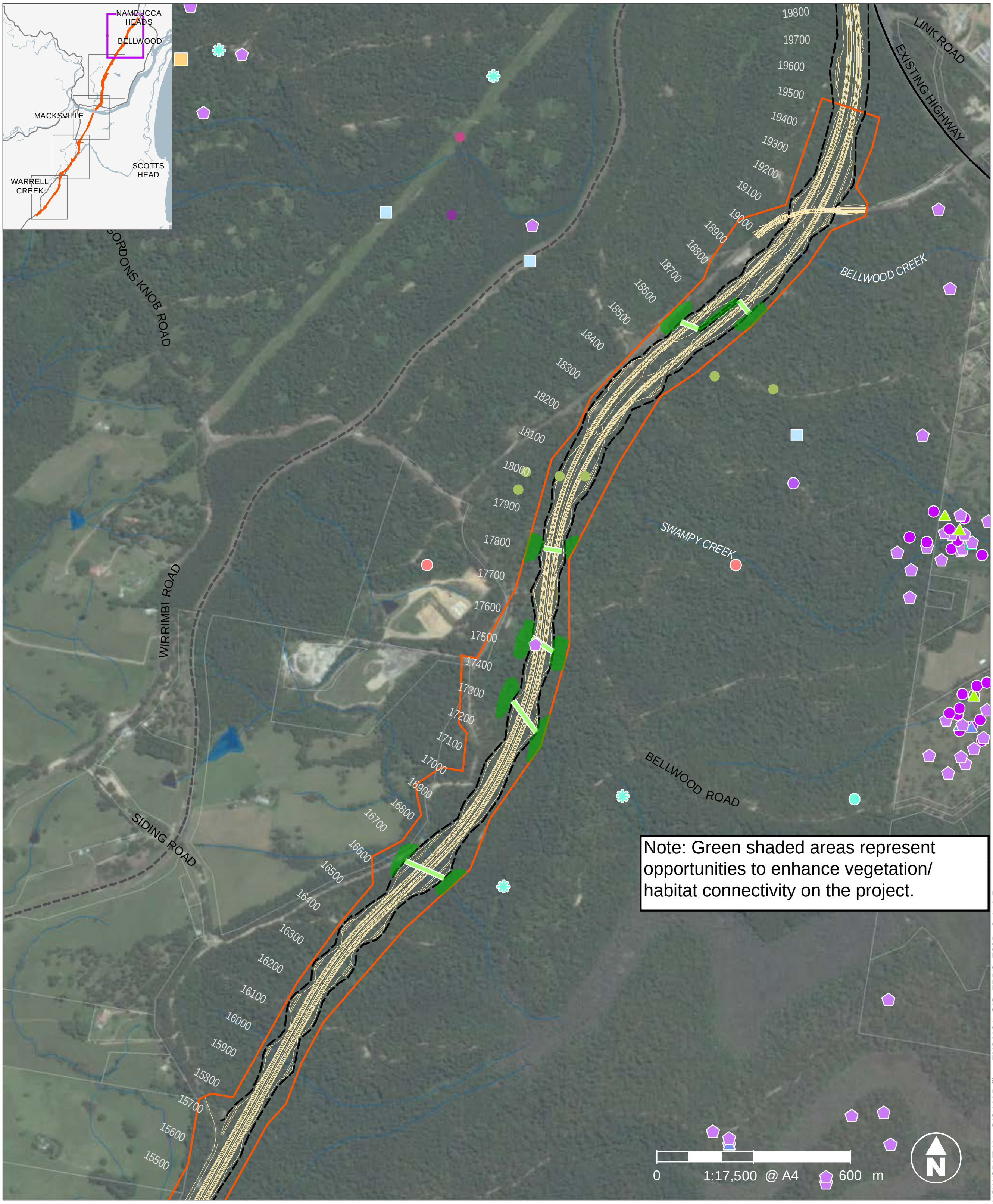
Road boundary
Road design
Temporary construction road boundary
Temporary construction road
November 2013 Flying-fox camp footprint
Combined culvert with fauna underpass
Dedicated fauna underpass
Fauna passage
Fauna fence

Threatened fauna

Black Bittern
Black Grass-dart Butterfly
Black-necked Stork
Brolga
Brush-tailed Phascogale
Cattle Egret
Common Greenshank
Eastern Bentwing-bat
Eastern Freetail-bat
Eastern Osprey
Glossy Black-Cockatoo
Glossy Ibis
Greater Broad-nosed Bat
Green and Golden Bell Frog
Grey-headed Flying-fox
Koala
Latham's Snipe
Little Bentwing-bat
Masked Owl
Oriental Pratincole
Osprey (nest site)
Pacific Golden Plover
Powerful Owl
Rainbow Bee-eater
Regent Honeyeater
Sooty Owl
Southern Myotis
Spotted-tailed Quoll
Square-tailed Kite
Squirrel Glider
White-bellied Sea-Eagle
Yellow-bellied Glider

DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information

Attachment A Figure 5-5 Threatened fauna, exclusion fencing and underpasses



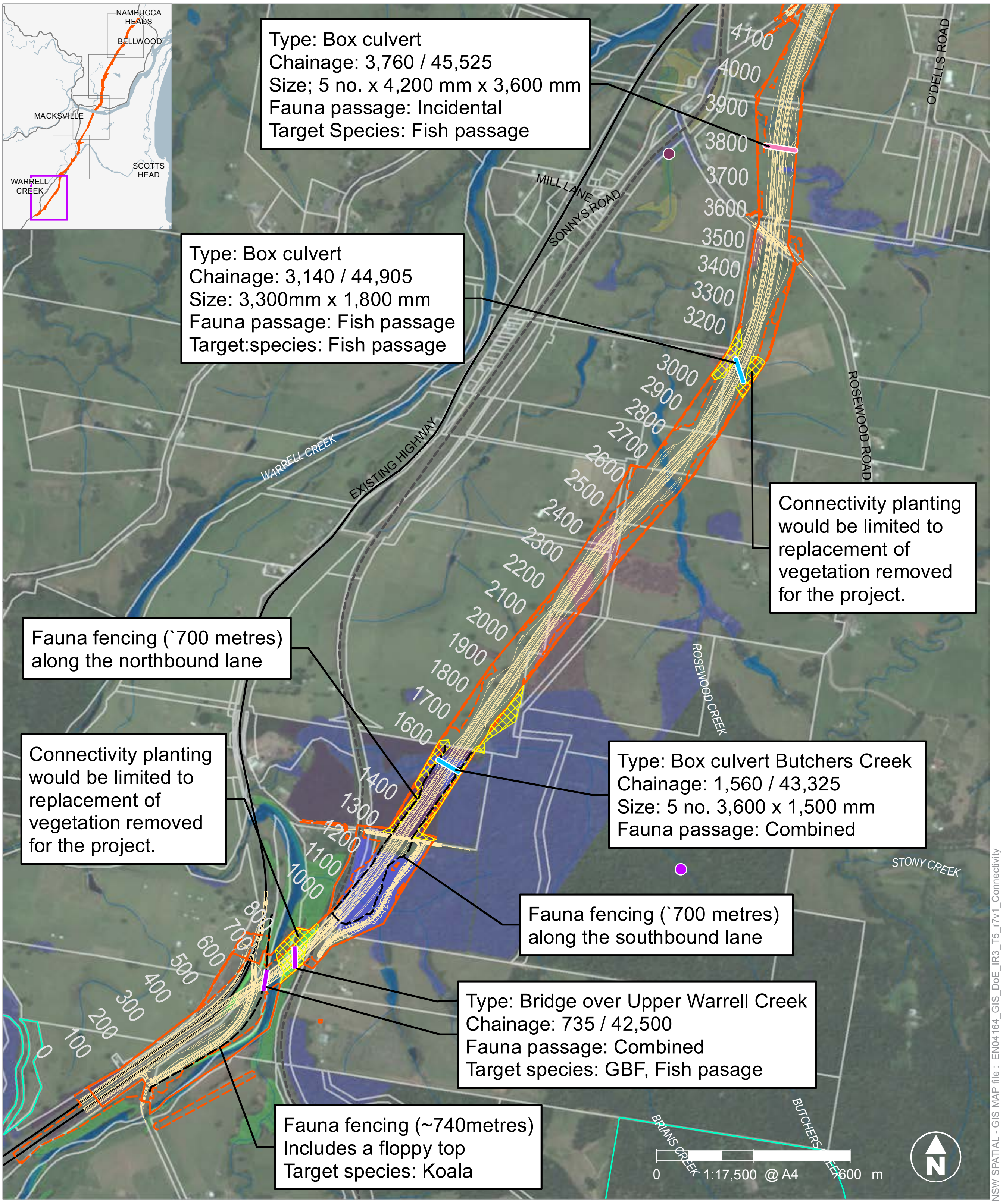
Road boundary
Road design
Temporary construction road boundary
Temporary construction road
November 2013 Flying-fox camp footprint
Combined culvert with fauna underpass
Dedicated fauna underpass
Fauna passage
Fauna fence

Threatened fauna

Black Bittern	Cattle Egret	Glossy Black-Cockatoo	Koala	Osprey (nest site)	Sooty Owl
Black Grass-dart Butterfly	Common Greenshank	Glossy Ibis	Latham's Snipe	Pacific Golden Plover	Southern Myotis
Black-necked Stork	Eastern Bentwing-bat	Greater Broad-nosed Bat	Little Bentwing-bat	Powerful Owl	Spotted-tailed Quoll
Brolga	Eastern Freetail-bat	Green and Golden Bell Frog	Masked Owl	Rainbow Bee-eater	Square-tailed Kite
Brush-tailed Phascogale	Eastern Osprey	Grey-headed Flying-fox	Oriental Pratincole	Regent Honeyeater	Squirrel Glider
					White-bellied Sea-Eagle
					Yellow-bellied Glider

DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information

ATTACHMENT B Map Series of Connectivity / Habitat Restoration Areas



Legend

- Proposed areas of connectivity and habitat restoration
- Road boundary
- Road design
- Service Road - Old Coast Road
- Clearing boundary
- State Forest boundary
- Lot (survey)
- Combined culvert with fauna underpass
- Dedicated fauna underpass
- Fauna fence
- Bridge with fauna passage
- Incidental fauna passage

Vegetation map units (WC2U EA, RTA 2010)

- Map Unit 1: Open Forest - Blackbutt
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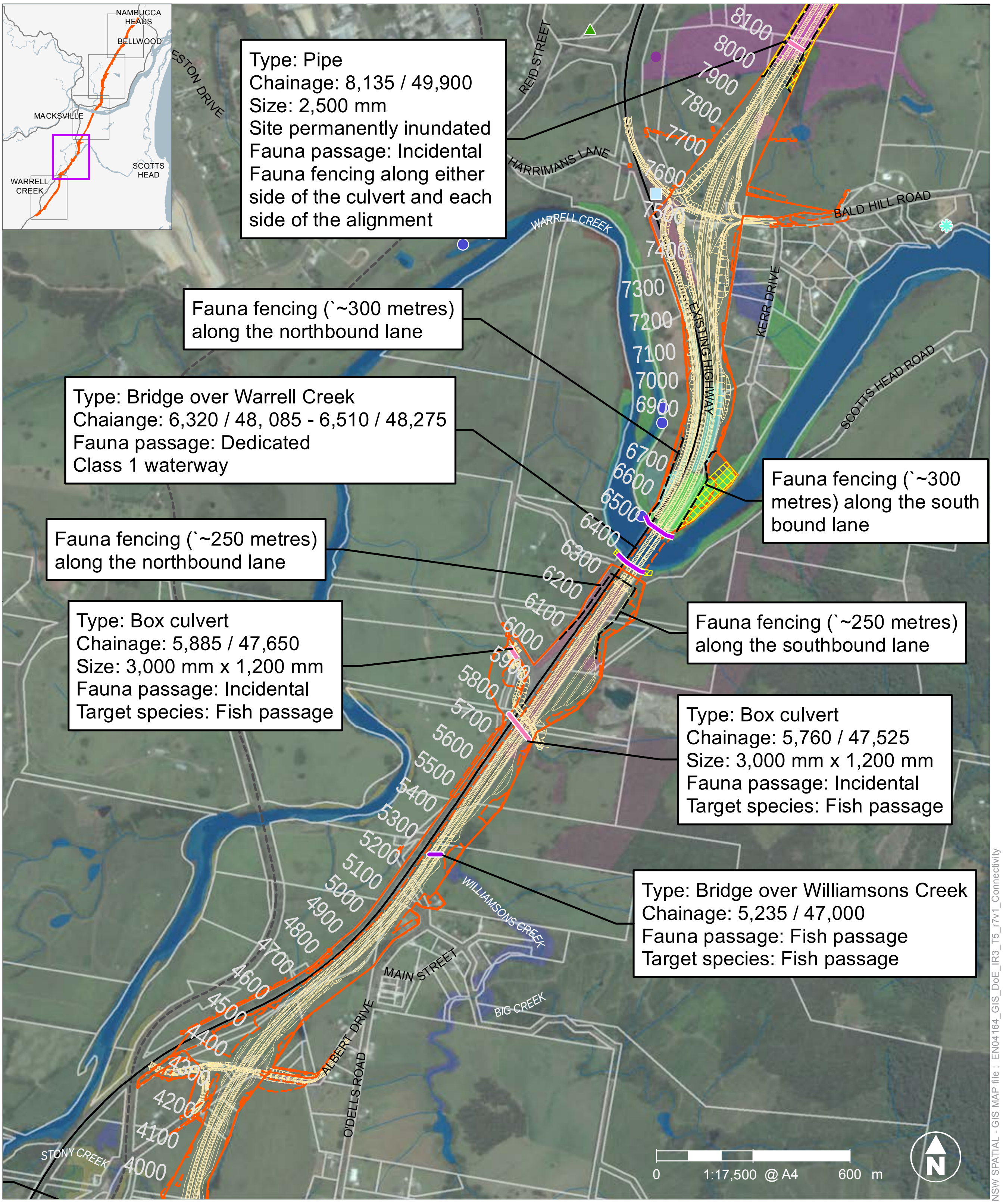
- Map Unit 10: Coastal Saltmarsh (VEC – EPBC Act and TSC Act)
- Map Unit 11: Open Forest - Scribbly Gum
- Map Unit 12: Hardwood plantation
- Map Unit 13: Softwood plantation

NOTES

- The chainages in this figure reflect the WC2U EA chainages. To convert these to the referral chainages add 41765.
- The locations of the fauna crossings and fauna fences are indicative only.

DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information



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- Proposed areas of connectivity and habitat restoration
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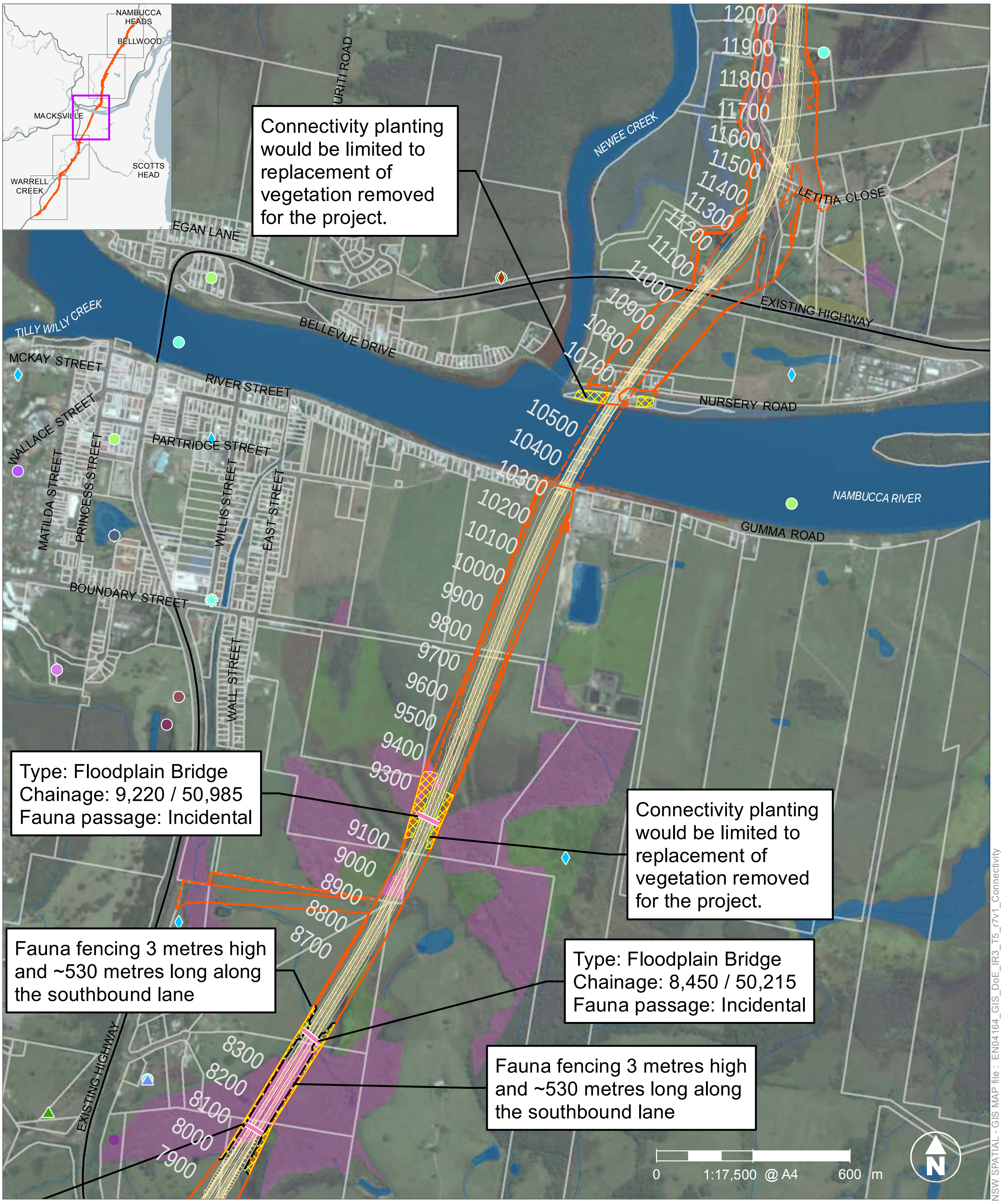

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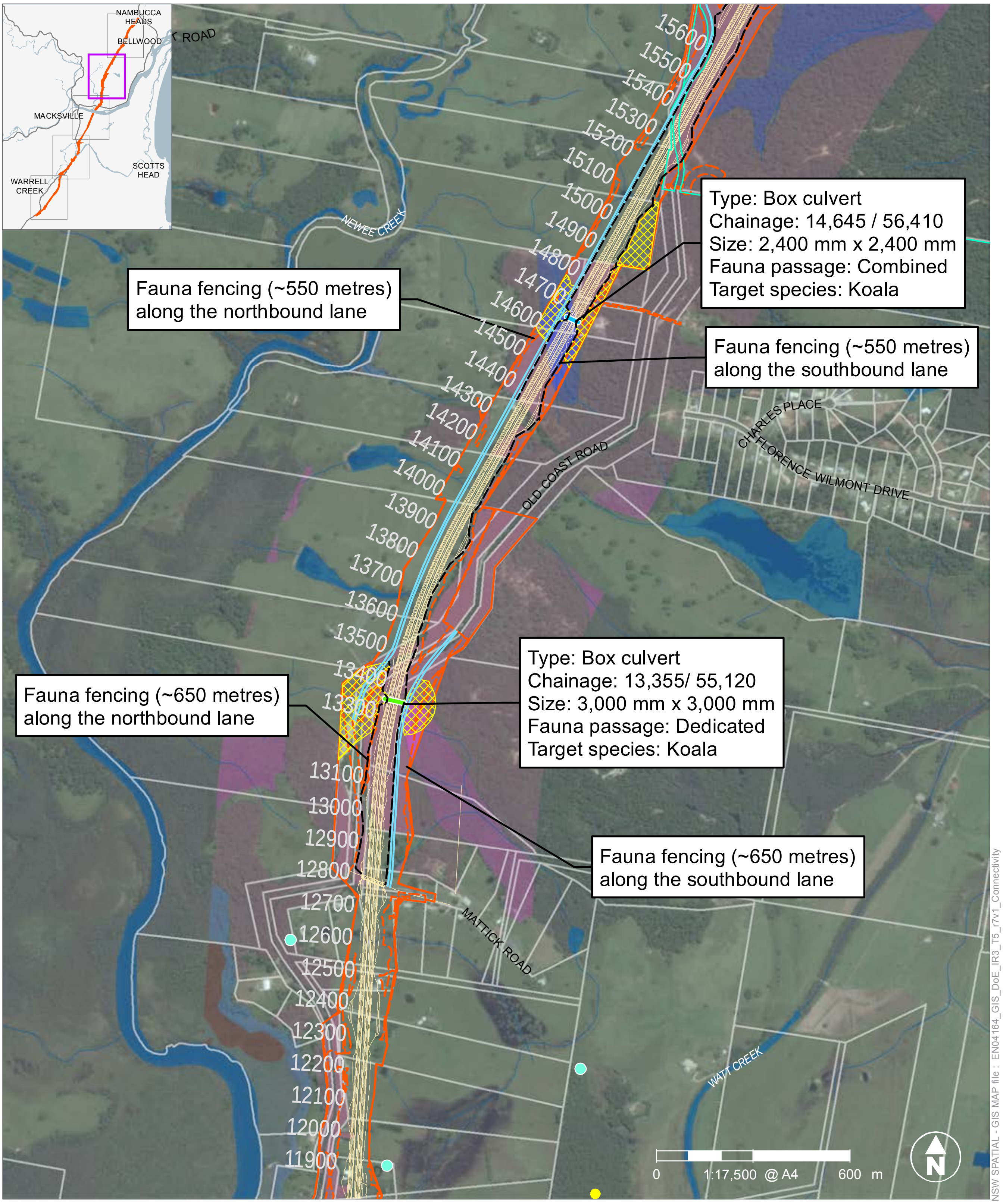
NSW Government Transport Roads & Maritime Services JACOBS



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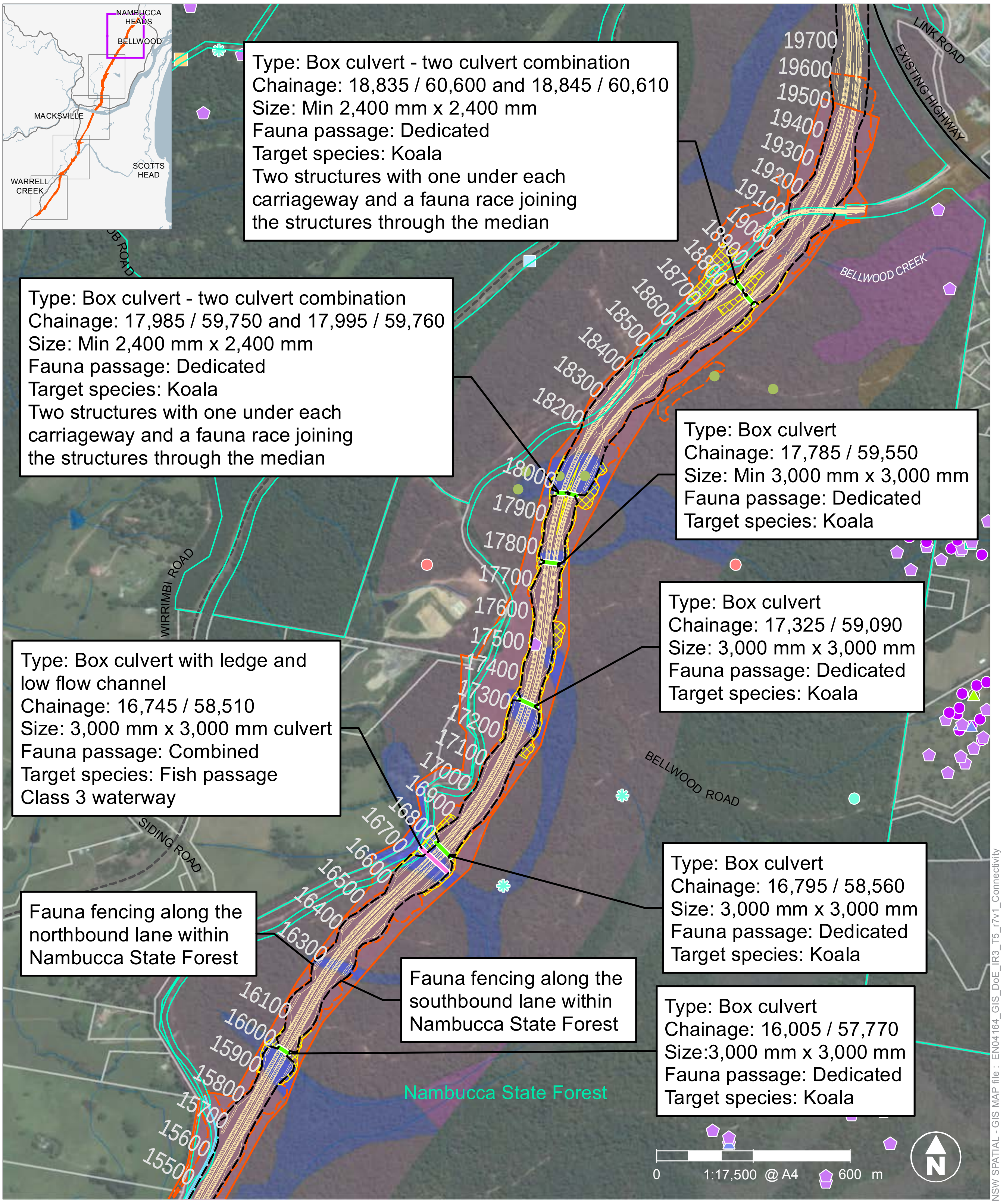

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This mapping is current as at December 2013 and could be refined with updated survey information

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Appendix D

WC2NH STQ Baseline Monitoring

Spotted-tailed Quoll Monitoring

Warrell Creek to Nambucca Heads
Pacific Highway Upgrade

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Spotted-tailed Quoll Monitoring

Warrell Creek to Nambucca Heads
Pacific Highway Upgrade

Prepared for: Roads and Maritime Services

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UPR	Description	Date Issued	Issued By
2394-1005	First issue	25/09/2014	Tom Pollard
2394-1013	Second issue	24/10/2014	Tom Pollard

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Introduction

1.1 Introduction

The Pacific Highway Upgrade Program is a joint commitment by the Australian and New South Wales governments to improve the standard and safety of the Pacific Highway between Hexham and the Queensland border.

The NSW Minister for Planning approved the Warrell Creek to Urunga (WC2U) Pacific Highway Upgrade Project (the Project) under Part 3A (now repealed) of the *Environmental Planning and Assessment Act 1979* (EP&A Act) on 19 July 2011, subject to the Minister's Conditions of Approval (CoA) being met.

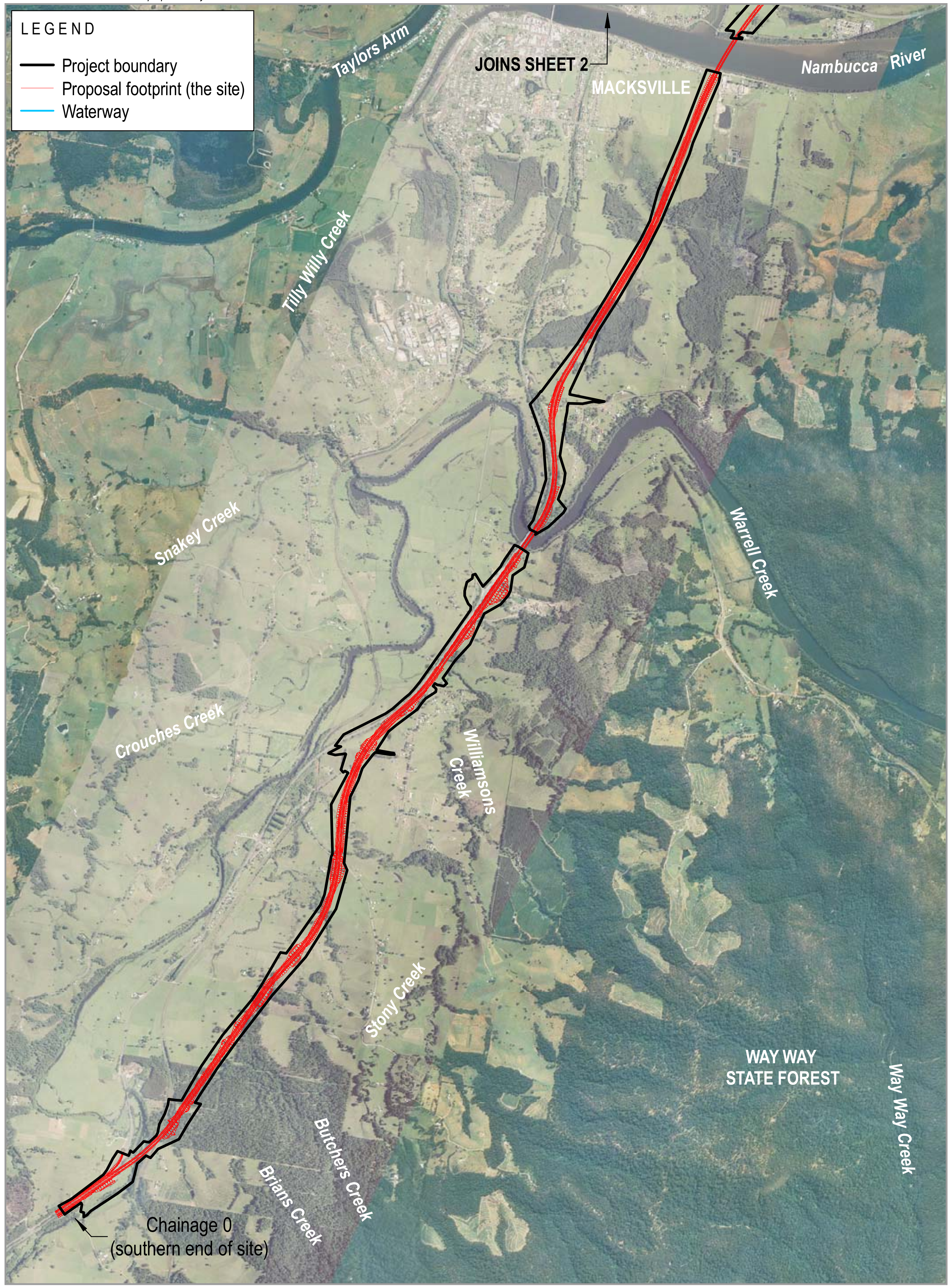
The Project comprises approximately 42 kilometres of dual carriageway road that would bypass the towns of Warrell Creek, Macksville, Nambucca Heads and Urunga on the Mid North Coast of NSW. The Project has been divided into two stages with Stage 1 consisting of approximately 22.5 kilometres from Nambucca Heads to Urunga (NH2U) and Stage 2 consisting of the remaining 19.5 kilometres of dual carriageway between Warrell Creek and Nambucca Heads (WC2NH) (refer to Illustration 1.1).

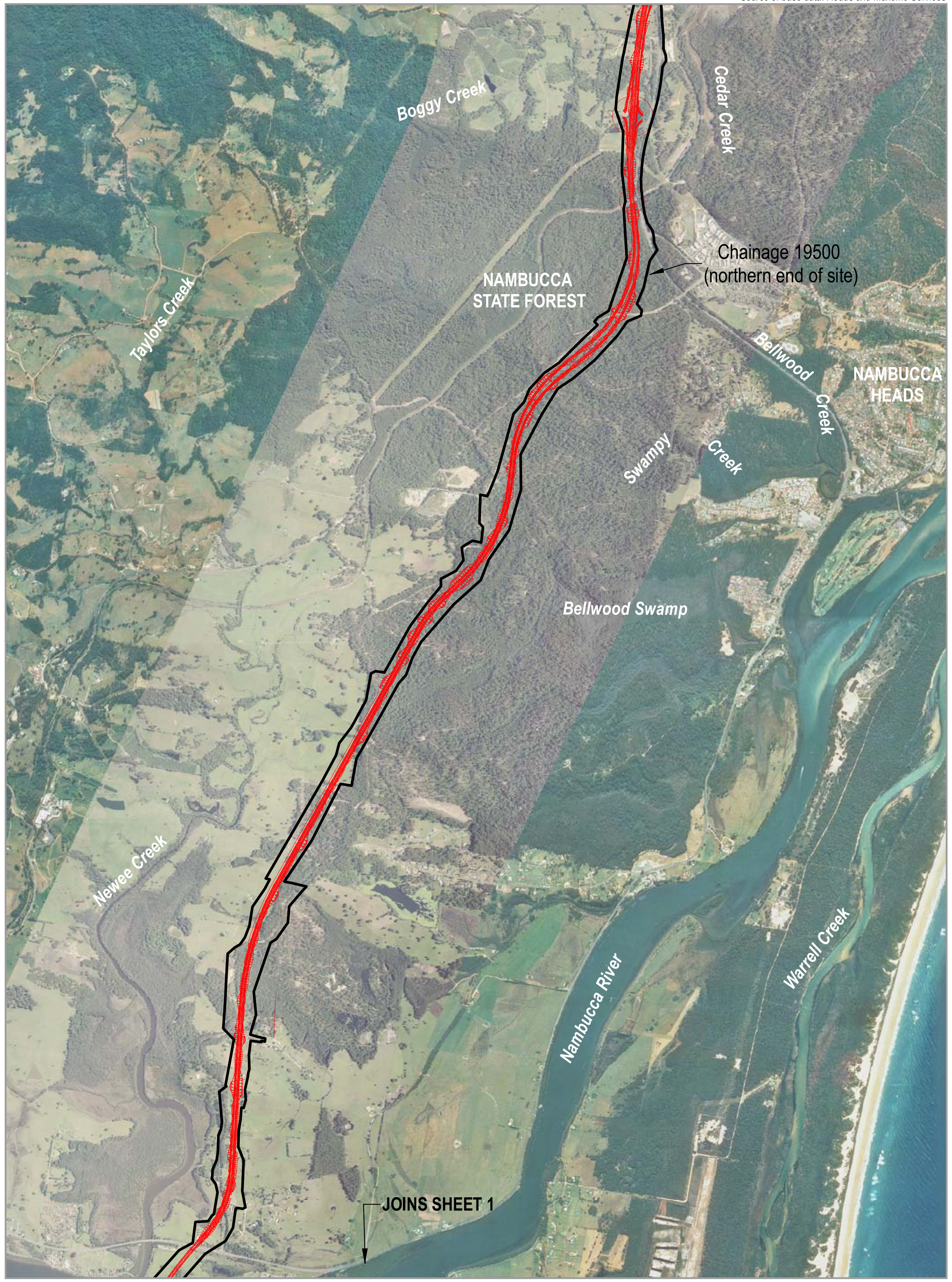
GeoLINK has been engaged to undertake baseline Spotted-tailed Quoll (STQ) monitoring for the WC2NH Project during winter 2014, prior to commencement of clearing of vegetation. As indicated in Belcher (2014) monitoring for a minimum of three weeks during winter is recommended as *"males move between female territories during the breeding season, monitoring female reproductive status. Monitoring suggests that it usually takes males approximately three weeks to visit the available females. Three weeks is also the length of the female oestrous cycle".*

This monitoring is for the purpose of providing data on the pre-construction usage by STQ of habitats within vicinity to the WC2NH Project, with particular focus of determining potential usage at proposed fauna underpass locations.

Information shown is for illustrative purposes only

Drawn by: TJP Checked by: GJM Reviewed by: DGH Date: October 2014
Source of base data: Roads and Maritime Services





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North

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WC2NH Spotted-tailed Quoll Monitoring
2394-1011

The Site

Illustration 1.1

2

Methodology

The methodology utilised for this STQ monitoring was reviewed by Spotted-tailed Quoll expert Chris Belcher and is described in detail in the following section.

2.1 Field Surveys

2.1.1 Remote Cameras

2.1.1.1 Determination of camera trap locations

Remote camera traps were established at 61 locations consisting of:

- Eleven fauna underpass sites.
- Fourteen survey sites previously surveyed by Benchmark for the NH2U Project within Nambucca State Forest.
- Thirty-six additional sites not previously surveyed.

The location of fauna underpass sites and previously established Benchmark sites were pre-determined and essentially fixed. The most appropriate location for the additional sites needed to be established (via aerial imagery), and was based on the following criteria:

- Sites were located within two kilometres of the proposal, predominantly in larger blocks of vegetation (e.g. Nambucca State Forest, Ingalba SF), but also in some narrow patches of remnant vegetation situated within the partially cleared farmland mosaic that is contiguous with these larger blocks of forested vegetation.
- Moist forest along riparian zones adjacent to creek lines was targeted.
- Small areas of fragmented vegetation in otherwise cleared farmland were not targeted (e.g. most of the area between Macksville and Warrell Creek).
- No sites were located within the Saltmarsh/ Swamp Oak forest in low-lying areas to the north of the Nambucca River due to a lack of suitable habitat features.
- Sites were located so that where suitable forested habitat occurred (as determined by the four dot points above) two camera traps were deployed for every 100 hectare/one kilometre square grid (including the fauna underpass sites and previously established Benchmark sites).

In the field, some site locations were found to be impractical and therefore minor adjustment was made to these locations (e.g. to avoid particularly dense Lantana patches etc.).

The final locations of deployed remote cameras are displayed in Illustration 2.1 to Illustration 2.5 and corresponding GPS coordinates are provided in Appendix A.

2.1.1.2 Camera trap setup

Remote cameras used for the monitoring consisted of Bushnell 8MP Natureview Cam HD for the 11 fauna underpass sites and Scoutguard SG560K for the remaining sites.

Camera setup was as follows:

- Mode – camera.
- Image size – 8M pixel.
- Image format – Wide screen.
- Capture number – 3 photos.
- LED control – high.
- Length – 10S.
- Interval – 10S.

- Sensor level – auto.
- NV shutter – medium.
- Camera mode – 24 hours.
- Time stamp – on.

At each location a remote camera trap (refer to **Plate 2.1**) was established using the following procedure:

- A remote camera was attached to a tree and pointed at an open area located three to four metres away.
- In this area a steel pole was driven in and a small bait cage attached approximately 1.5 metres above the ground.
- This bait cage was baited with chicken necks soaked in tuna oil.
- Tuna oil was also drizzled on exposed areas such as rocks or logs nearby as an extra attractant.
- Cameras were set to record during the day and night as quolls are known to range throughout both periods.

Cameras were deployed for a minimum period of three weeks from mid-July to mid-August 2014. This winter period (between late May and August) coincides with the peak period for detection of the STQ.

Plate 2.1 Typical Camera Trap Set-up

2.1.1.3 Hair funnels

Faunatech hair funnels (refer to **Plate 2.2**) were deployed at fauna underpass sites for a minimum period of three weeks from mid-July to mid-August 2014. Hair funnels were located along transects centred on the location of each fauna crossing structure with each transect consisting of 10 tubes/transect placed 20 metres apart. The bait used consisted of a mixture of flour, sardines and tuna oil.

The location of fauna underpass sites at which hair funnels were deployed are displayed in **Illustration 2.1** to **Illustration 2.5** and corresponding GPS coordinates are provided in **Appendix A.**

As for the camera traps, hair funnels were deployed for a minimum period of three weeks from mid-July to mid-August 2014, coinciding with the peak detection period for STQ in winter (between late May and August).

Fauna hairs collected in the hair funnels were identified by Scats About (Georgeanna Story).

Plate 2.2 Hair Funnel

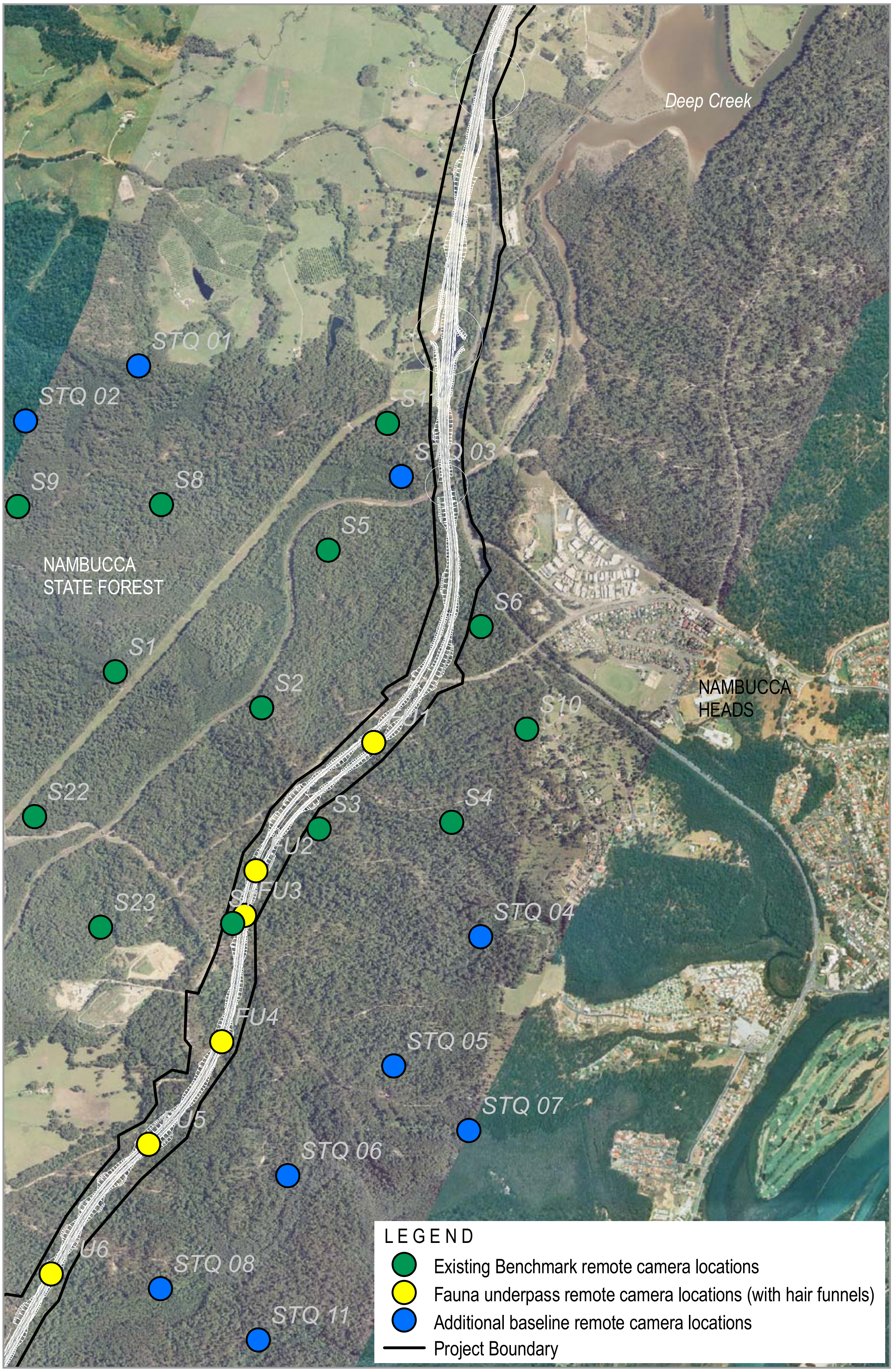
2.2 Survey Limitations

Remote cameras were not able to be deployed at nine potential locations due to property access restrictions and/ or the inability to contact the relevant landholder. These locations are identified in Illustration 2.1 to Illustration 2.5. Despite this, the survey effort was considered appropriate to adequately undertake the monitoring.

At two of the fauna underpass sites hair funnels were not deployed (FU9 and FU10). These locations are identified in Illustration 2.1 to Illustration 2.5. These sites consisted of open cattle paddocks, with a high probability that the hair funnels would be damaged/ destroyed by the hooves of browsing cattle.

Information shown is for illustrative purposes only

Drawn by: TJP Checked by: GJM Reviewed by: DGH Date: September 2014
Source of base data: Roads and Maritime Services



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North

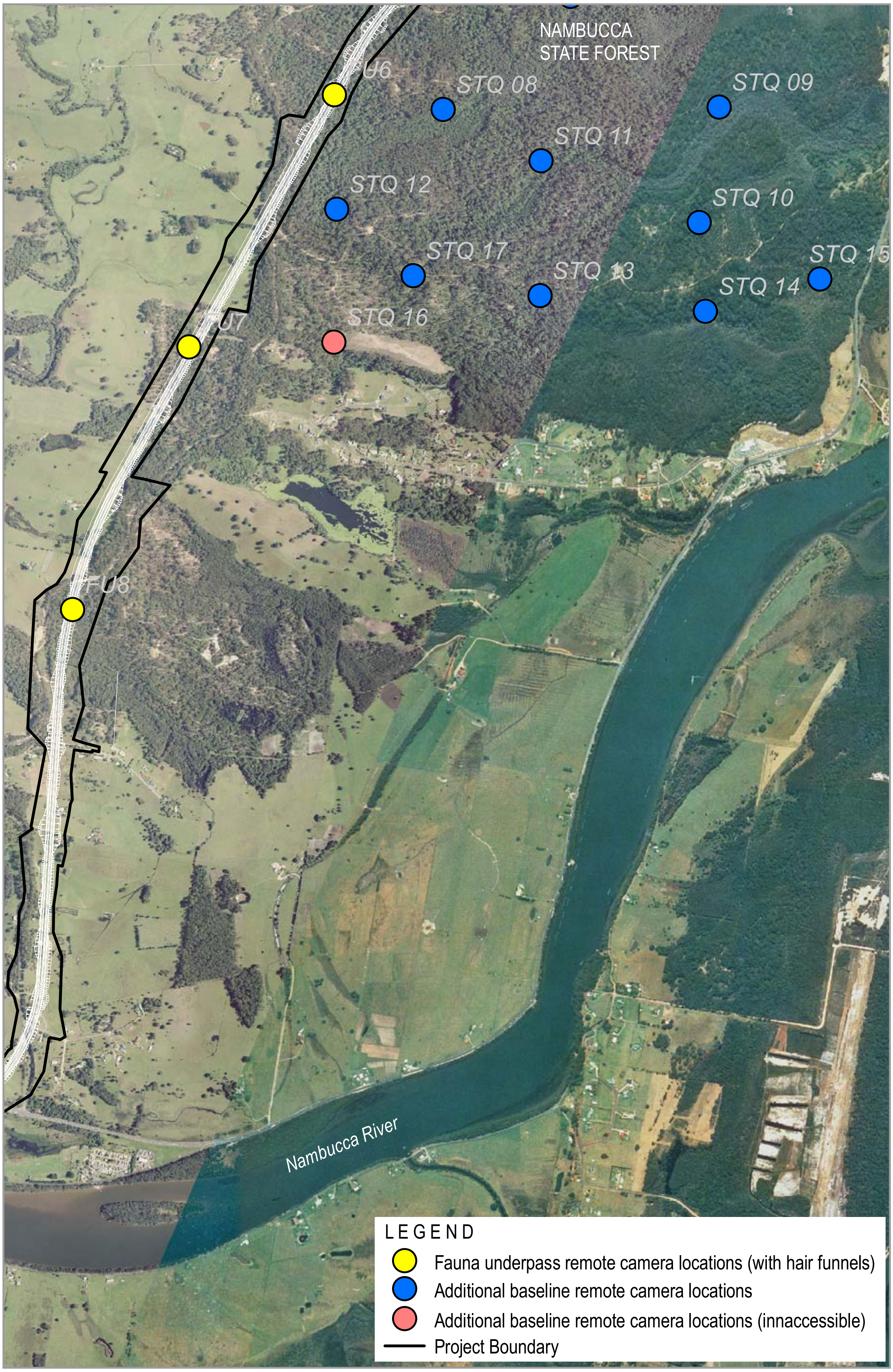
Location of Remote Cameras and Hair Funnels (Sheet 1 of 5)

GeoLINK environmental management and design

WC2NH Spotted-tailed Quoll Monitoring
2394-1006

Illustration 2.1

Drawn by: TJP Checked by: GJM Reviewed by: DGH Date: September 2014
Information shown is for illustrative purposes only
Source of base data: Roads and Maritime Services



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North

Location of Remote Cameras and Hair Funnels (Sheet 2 of 5)

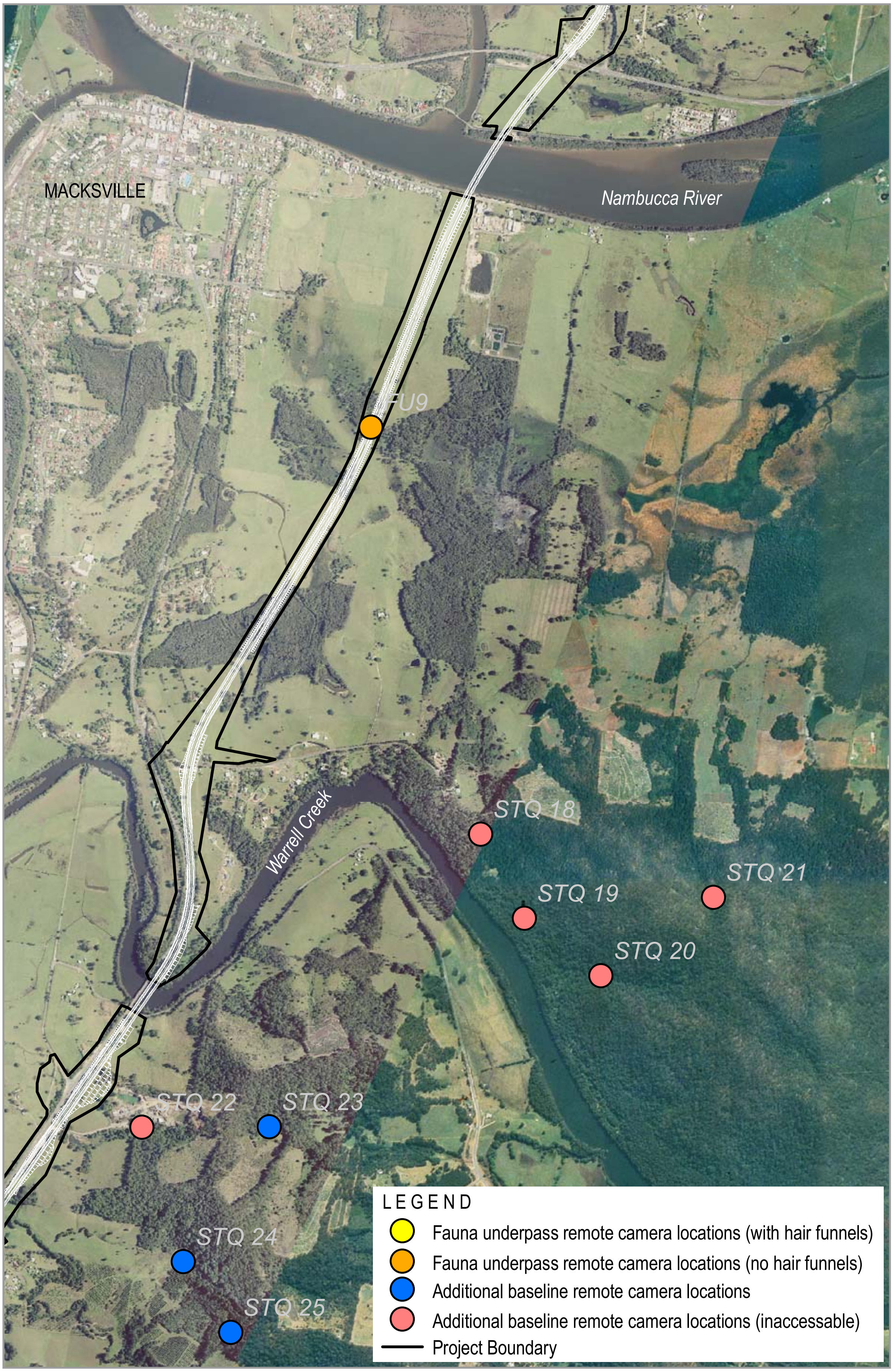
GeoLINK environmental management and design

WC2NH Spotted-tailed Quoll Monitoring
2394-1007

Illustration 2.2

Information shown is for illustrative purposes only

Drawn by: TJP Checked by: GJM Reviewed by: DGH Date: September 2014
Source of base data: Roads and Maritime Services



0 500

North

Location of Remote Cameras (Sheet 3 of 5)

GeoLINK environmental management and design

WC2NH Spotted-tailed Quoll Monitoring
2394-1008

Illustration 2.3

Information shown is for illustrative purposes only

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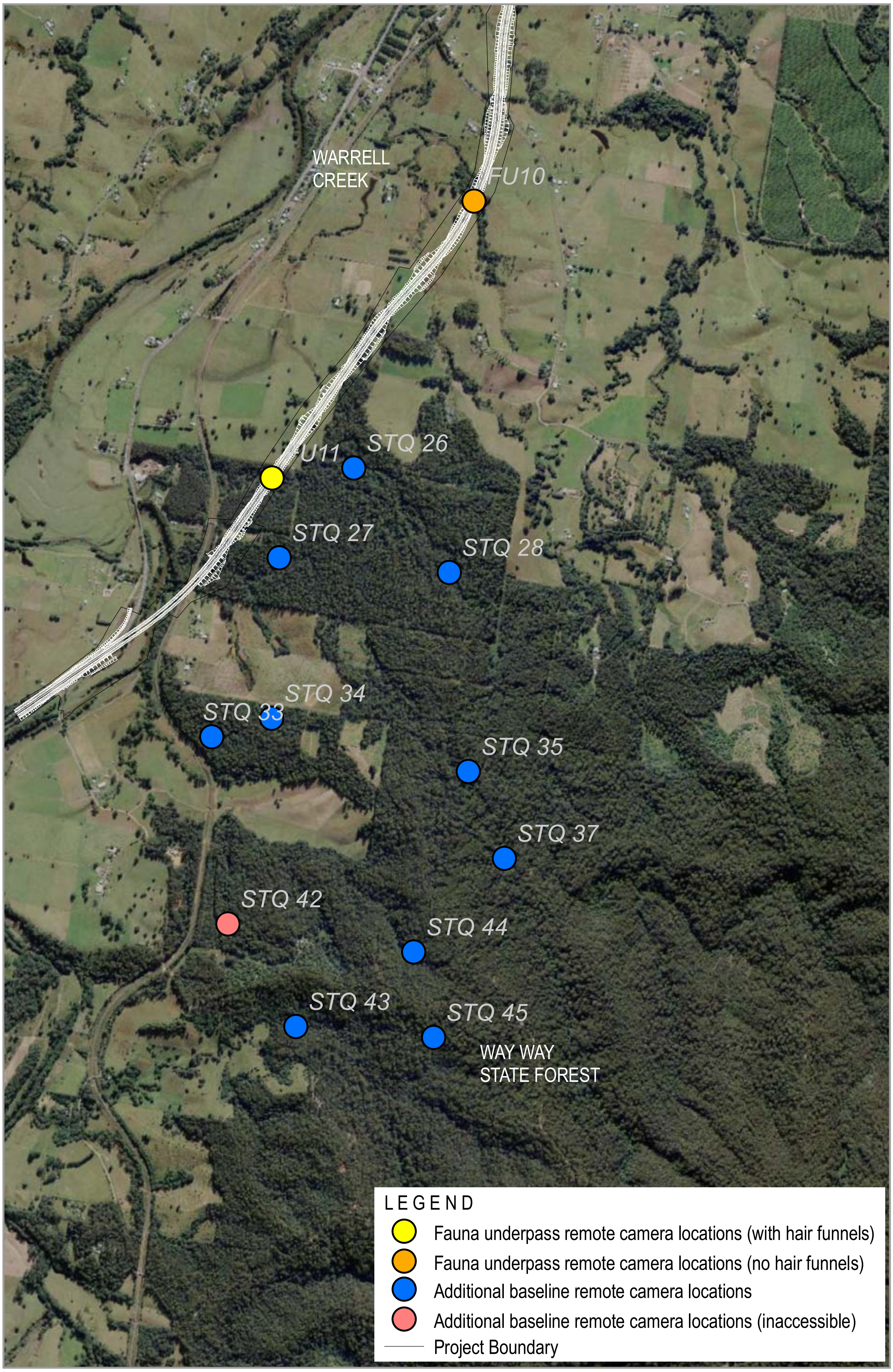
Source of base data: Roads and Maritime Services and Sixmaps Imagery



North

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Location of Remote Cameras and Hair Funnels (Sheet 4 of 5)

GeoLINK environmental management and design

WC2NH Spotted-tailed Quoll Monitoring
2394-1009

Illustration 2.4

Information shown is for illustrative purposes only

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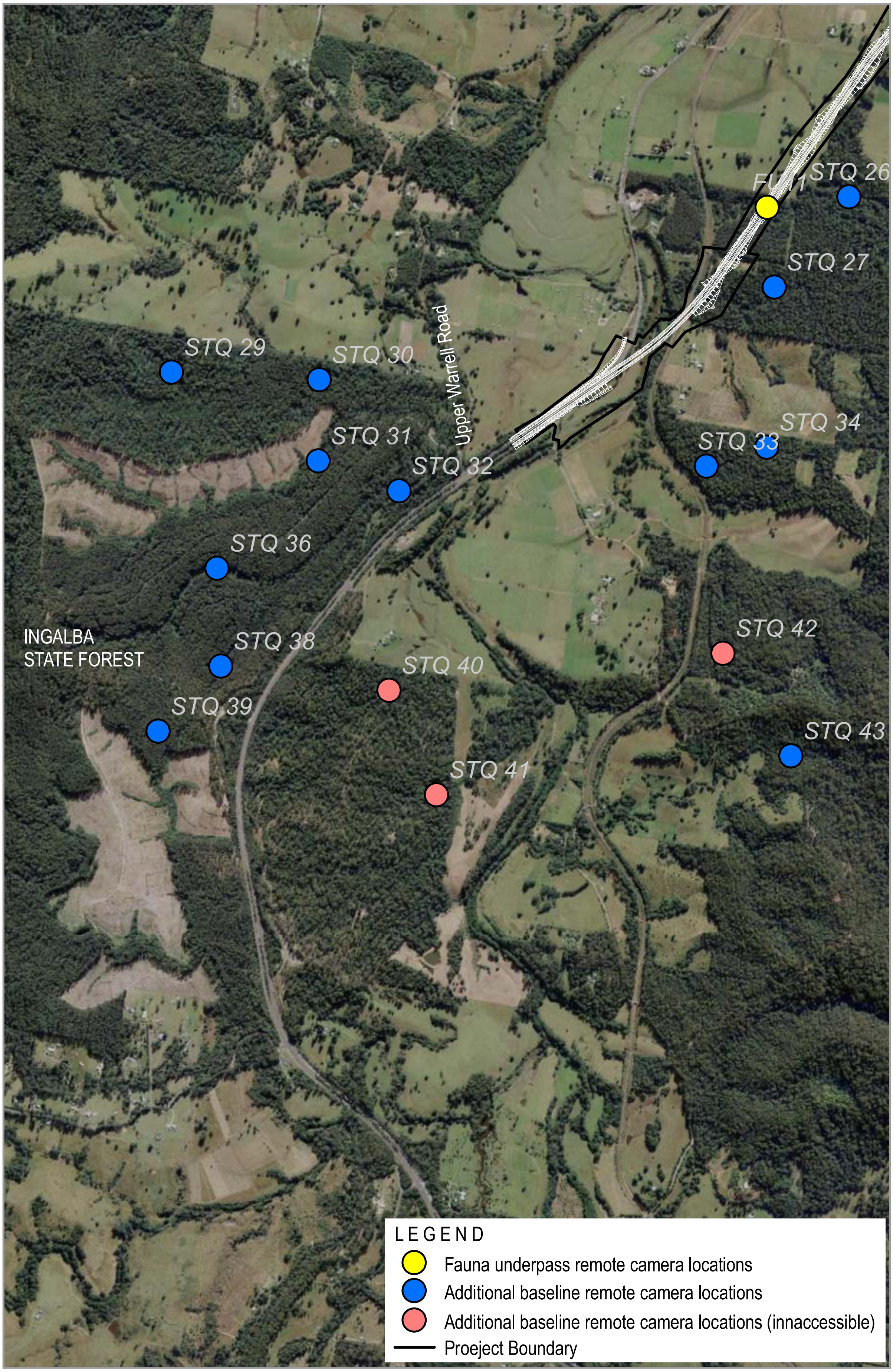
Source of base data: Roads and Maritime Services



Location of Remote Cameras and Hair Funnels (Sheet 5 of 5)

GeoLINK environmental management and design

WC2NH Spotted-tailed Quoll Monitoring
2394-1009

Illustration 2.5

3

Results and Discussion

3.1 Desktop Review

3.1.1 Previous Monitoring at Broader Locality

Baseline monitoring for Spotted-tailed Quoll using equivalent remote camera methodology was undertaken for the adjacent NH2U Project (Benchmark 2014).

The main findings of this monitoring were:

- No spotted-tailed quolls were photographed or evidence (scats or tracks) of quolls recorded.
- Three records of koala; one on private property east of the highway and two in Newry State Forest west of the upgrade.
- Records of four recognised prey species: common brushtail possum, short-eared brushtail possum, northern brown bandicoot and long-nosed bandicoot.
- Similar occurrence of brushtail possums between north and central sites but lower occurrence in south and trend of decreasing abundance of bandicoots from north to south.
- Presence of three introduced predators, dog, fox and cat, with variable occurrence between sample locations.
- Inverse pattern of occurrence between dog and red fox. Dog recorded at 30% of north sites, 19.6% of central and 4.2% of southern sites and red fox recorded at no north sites, 3.9% central and 25% of south sites.
- Moderate occurrence (20-35%) of small ground mammals (*Rattus* spp., *Antechinus* spp., *Melomys* spp.).
- Lace monitor was the most commonly recorded species in all three zones, with occurrence ranging from 79.2% to 85%.
- Macropods, particularly swamp wallaby, were commonly recorded, with a general trend of increasing occurrence from north to south.
- Most birds were recorded infrequently, with the exception of scrub turkey (16.7-41.2% of sites), wonga pigeon (4.2-20%) and superb lyrebird (7.8-10%).

3.1.2 OEH BioNet Atlas of NSW Wildlife Records

An online search of OEH BioNet records (undertaken 19 September 2014) showed eight records of STQ within approximately five kilometres of the WC2NH Project. Of these records, seven are from the Dan Lunney Community Wildlife Survey dataset and are potentially of limited reliability. The remaining record is more reliable, being from a Scientific Licences dataset and was made in 2004 near Bald Hill Road, Macksville.

3.1.3 Other Incidental Records

During August 2014, a road-kill STQ was recorded near the Pacific Highway-Scotts Head Road intersection at Warrell Creek and verified by ecologist Ross Goldingay from Southern Cross University (refer to Illustration 3.1).

Drawn by: TJP Checked by: GJM Reviewed by: DGH Date: October 2014
Source of base data: Roads and Maritime Services, Ross Goldingay

Information shown is for illustrative purposes only

Location of STQ Road Kill

GeoLINK environmental management and design

WC2NH Spotted-tailed Quoll Monitoring
2394-1012

Illustration 3.1

3.2 Remote Camera Images

Analysis of the images captured on the 61 deployed remote cameras showed that no STQ visited the bait stations over the three week period that cameras were deployed.

The cameras captured images of a range of other native and exotic fauna species as detailed in **Table 3.1**. The three most commonly encountered species were Red-necked Wallaby (captured at 49.2% of camera traps), Bush Rat (captured at 36.1% of camera traps), and Common Brushtail Possum (Recorded at 32.8% of camera traps).

Main prey items for STQ generally consist of medium-sized mammals (Belcher *et al.* 2008). Such species that were recorded at camera traps included Common Brushtail Possum, Northern Brown Bandicoot and Long-nosed Bandicoot.

Four exotic fauna species were recorded, consisting of three carnivores; the Feral Dog, Feral Cat and European Red Fox, along with Domestic Cattle at farmland locations.

A single threatened species, the Koala, was recorded at two camera traps (camera locations FU6 and STQ-11; refer to **Plate 3.1**). The Koala is listed as vulnerable under both the *Threatened Species Conservation Act 1995* (TSC Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). These two camera locations are separated by a relatively small distance of approximately one kilometre. Koala dispersal distances between natal and breeding home ranges are typically at least several kilometres (Dique *et al.* 2003). Therefore, although the images may be of two Koala individuals, it is also possible that the images are of a single dispersing individual.

Table 3.1 Remote Camera Captures

Common Name	*Scientific Name*	*% Camera Stations Recorded*
Birds		
Eastern Yellow Robin	*Eopsaltria australis*	1.6
Eastern Whipbird	*Psophodes olivaceus*	1.6
Torresian Crow	*Corvus orru*	1.6
Australian Magpie	*Cracticus tibicen*	1.6
Wonga Pigeon	*Leucosarcia melanoleuca*	6.6
Satin Bowerbird	*Ptilonorhynchus violaceus*	1.6
Grey Shrike-thrush	*Colluricincla harmonica*	3.3
Green Catbird	*Ailuroedus crassirostris*	18.0
Australian Brush Turkey	*Alectura lathami*	13.1
Grey Goshawk	*Accipiter novaehollandiae*	1.6
Superb Lyrebird	*Menura novaehollandiae*	1.6
Unidentified bird spp.	n/a	4.9
Mammals		
Common Brushtail Possum	*Trichosurus vulpecula*	32.8
Common Ringtail Possum	*Pseudocheirus peregrinus*	3.3
Bush Rat	*Rattus fuscipes*	36.1
Unidentified rodent/ Antechinus spp.	n/a	31.1
Long-nosed Bandicoot	*Perameles nasuta*	21.3
Northern Brown Bandicoot	*Isoodon macrourus*	9.8
Unidentified small mammal spp.	n/a	21.3

Common Name	Scientific Name	% Camera Stations Recorded
#Koala	*Phascolarctos cinereus*	3.3
Red-necked Wallaby		49.2
Unidentified macropod spp.	n/a	18.0
*Feral Cat	*Felis Catus*	11.5
*Feral Dog	*Canis familiaris*	4.9
*European Red Fox	*Vulpes vulpes*	13.1
*Domestic Cattle	*Bos taurus*	3.3
Monotremes		
Short-beaked Echidna	*Tachyglossus aculeatus*	24.6
Reptiles		
Lace Monitor	*Varanus varius*	4.9

* Denotes exotic/ pest fauna species
# Denotes threatened species listed under the TSC Act or EPBC Act

3.3 Hair Funnels

Identification of hair left behind in deployed hair funnels at the fauna underpass sites indicated no presence of STQ. Hair from a range of other mammals was present consisting mainly of Bush Rat and Brown Antechinus (refer to **Table 3.2**). No hair was collected in any of the hair funnels at site FU7.

Table 3.2 Results of Hair Analysis

Site	Common Name	Scientific Name
FU1	Bush Rat	*Rattus fuscipes*
	Brown Antechinus	*Antechinus stuartii*
FU2	Brown Antechinus	*Antechinus stuartii*
	an Antechinus	*Antechinus* sp.
	Bush Rat	*Rattus fuscipes*
	Northern Brown Bandicoot/ Long-nosed Bandicoot	*Isoodon macrourus/ Peremales nasuta*
FU3	Bush Rat	*Rattus fuscipes*
	Brown Antechinus	*Antechinus stuartii*
	an Antechinus	*Antechinus sp.*
FU4	Bush Rat	*Rattus fuscipes*
	a Rat	*Rattus* sp.
	Brown Antechinus	*Antechinus stuartii*
FU5	Bush Rat	*Rattus fuscipes*
	Brown Antechinus	*Antechinus stuartii*
	an Antechinus	*Antechinus sp.*
FU6	*House Mouse	*Mus musculus*
	Bush Rat	*Rattus fuscipes*
	a Rat	*Rattus* sp.
FU8	Brown Antechinus	*Antechinus stuartii*
	Bush Rat	*Rattus fuscipes*
	a Rat	*Rattus* sp.
	Northern Brown Bandicoot/ Long-nosed Bandicoot	*Isoodon macrourus/ Peremales nasuta*

Site	*Common Name*	*Scientific Name*
FU11	Bush Rat	*Rattus fuscipes*
	*Black Rat	*Rattus rattus*
	Brown Antechinus	*Antechinus stuartii*

* Denotes exotic/ pest fauna species

Plate 3.1 Koala Captured on Camera at FU6

3.4 Discussion

Despite not recording STQ by either the remote cameras or hair funnel methods used in the monitoring, a previous local OEH BioNet record and the recent 2014 road-kill record suggest that STQ occurs at a low density within the locality. Considering this, the fauna underpass structures that are to be constructed for the WC2NH Project will be an important management measure to minimise potential impacts on STQ by allowing connectivity between areas of STQ habitat that will be dissected by the upgraded highway.

4

Summary

- The results of the monitoring did not provide evidence of occurrence of STQ in habitats within vicinity of the WC2NH Project.
- A small number of previous OEH BioNet records are within five kilometres of the WC2NH project, and along with a verified 2014 road-kill record on the current Pacific Highway within the study area, this suggests a low density STQ population occurs at the locality.
- A variety of native fauna species were recorded at the camera traps, including a main prey item for STQ; the Brushtail Possum, which was recorded at 32.8% of camera locations.
- Exotic carnivores including the Feral Dog, Feral Cat and Eurpoean Red Fox were also recorded on up to 13.1% of camera traps.
- A single threatened species, the Koala, was recorded at two camera traps during the monitoring.
- No STQ hair was found in the deployed hair funnels, with *Rattus* spp. and *Antechinus* spp. dominating.
- Provision of fauna underpass structures on the WC2NH Project to enable for STQ movement to be retained between habitat areas will be an important mitigating measure aimed at minimising adverse impacts of the WC2NH Project on STQ.

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Topographic information presented on the drawings is suitable only for the purpose of the document as stated above. No reliance should be placed upon topographic information contained in this report for any purpose other than that stated above.

Appendix A

Locations of Remote Cameras and Hair Funnel Transects

Table 1 GPS Coordinates of Remote Cameras and Hair Funnel Transects (UTM Zone 56)

Remote Camera site ID	*Site Type*	*Easting*	*Northing*
*FU1	Fauna Underpass	497135	6610002
*FU2	Fauna Underpass	496611	6609431
*FU3	Fauna Underpass	496560	6609232
*FU4	Fauna Underpass	496458	6608668
*FU5	Fauna Underpass	496132	6608212
*FU6	Fauna Underpass	495700	6607634
*FU7	Fauna Underpass	495054	6606511
*FU8	Fauna Underpass	494535	6605340
FU9	Fauna Underpass	493273	6601511
FU10	Fauna Underpass	490717	6596130
*FU11	Fauna Underpass	489817	6594896
S1	Benchmark	495985	6610316
S2	Benchmark	496636	6610157
S3	Benchmark	496892	6609616
S4	Benchmark	497482	6609647
S5	Benchmark	496932	6610859
S6	Benchmark	497613	6610517
S7	Benchmark	496507	6609196
S8	Benchmark	496190	6611062
S9	Benchmark	495550	6611054
S10	Benchmark	497816	6610061
S11	Benchmark	497196	6611424
S21	Benchmark	495066	6610604
S22	Benchmark	495624	6609672
S23	Benchmark	495919	6609179
STQ 01	Additional Baseline	496088	6611680
STQ 02	Additional Baseline	495585	6611434
STQ 03	Additional Baseline	497259	6611187
STQ 04	Additional Baseline	497611	6609137
STQ 05	Additional Baseline	497225	6608560
STQ 06	Additional Baseline	496753	6608071
STQ 07	Additional Baseline	497559	6608274
STQ 08	Additional Baseline	496186	6607568
STQ 09	Additional Baseline	497415	6607579
STQ 10	Additional Baseline	497326	6607064
STQ 11	Additional Baseline	496621	6607340
STQ 12	Additional Baseline	495712	6607124
STQ 13	Additional Baseline	496617	6606739
STQ 14	Additional Baseline	497354	6606668
STQ 15	Additional Baseline	497864	6606813
#STQ 16	Additional Baseline	495699	6606532
STQ 17	Additional Baseline	496051	6606828
#STQ 18	Additional Baseline	493761	6599699

Remote Camera site ID	*Site Type*	*Easting*	*Northing*
#STQ 19	Additional Baseline	493957	6599323
#STQ 20	Additional Baseline	494298	6599067
#STQ 21	Additional Baseline	494799	6599417
#STQ 22	Additional Baseline	492254	6598392
STQ 23	Additional Baseline	492821	6598395
STQ 24	Additional Baseline	492437	6597795
STQ 25	Additional Baseline	492649	6597479
STQ 26	Additional Baseline	490181	6594941
STQ 27	Additional Baseline	489848	6594540
STQ 28	Additional Baseline	490606	6594475
STQ 29	Additional Baseline	487163	6594161
STQ 30	Additional Baseline	487821	6594128
STQ 31	Additional Baseline	487818	6593766
STQ 32	Additional Baseline	488178	6593632
STQ 33	Additional Baseline	489547	6593742
STQ 34	Additional Baseline	489815	6593826
STQ 35	Additional Baseline	490691	6593588
STQ 36	Additional Baseline	487367	6593288
STQ 37	Additional Baseline	490850	6593201
STQ 38	Additional Baseline	487384	6592851
STQ 39	Additional Baseline	487105	6592562
#STQ 40	Additional Baseline	488132	6592744
#STQ 41	Additional Baseline	488344	6592279
#STQ 42	Additional Baseline	489620	6592909
STQ 43	Additional Baseline	489922	6592452
STQ 44	Additional Baseline	490446	6592784
STQ 45	Additional Baseline	490536	6592404
*FU1	Fauna Underpass	497135	6610002
*FU2	Fauna Underpass	496611	6609431
*FU3	Fauna Underpass	496560	6609232
*FU4	Fauna Underpass	496458	6608668
*FU5	Fauna Underpass	496132	6608212
*FU6	Fauna Underpass	495700	6607634
*FU7	Fauna Underpass	495054	6606511
*FU8	Fauna Underpass	494535	6605340
FU9	Fauna Underpass	493273	6601511
FU10	Fauna Underpass	490717	6596130
*FU11	Fauna Underpass	489817	6594896
S1	Benchmark	495985	6610316
S2	Benchmark	496636	6610157
S3	Benchmark	496892	6609616
S4	Benchmark	497482	6609647
S5	Benchmark	496932	6610859
S6	Benchmark	497613	6610517

Remote Camera site ID	*Site Type*	*Easting*	*Northing*
S7	Benchmark	496507	6609196
S8	Benchmark	496190	6611062
S9	Benchmark	495550	6611054
S10	Benchmark	497816	6610061
S11	Benchmark	497196	6611424
S21	Benchmark	495066	6610604
S22	Benchmark	495624	6609672
S23	Benchmark	495919	6609179

Appendix E

Fauna Crossing Structures

Appendix A Summary of the fauna crossing locations for the upgrade of the Pacific Highway, WC2NH.

Chainage Referral	Chainage WC2U EA	Fauna Crossing Structure Type	Structure Form	Number and Dimensions	Fish Passage Requirements	Additional Requirements
42km500	735	Combined	Bridge over Upper Warrell Creek	(-)	Class 1 waterway[3]	Minimum 3 metre wide fauna passage required at each abutment. Giant Barred Frog and fish included as target species.
43km325	1,560	Combined	Box culvert Butchers Creek	Minimum 5 no. x 3600mm x 1500mm high	Class 2 waterway[3] Set one culvert cell 200mm (minimum) below existing bed level. Continue low flow channel through scour protection	Two outside cells must provide dry passage during a 1 in 1 year ARI, 3 day (72 hour) storm event and must not have wet sections that retain water for longer than three days.. No refuge poles required. Approximate culvert length is 47 m.
44km905	3,140	Fish passage	Box culvert	Minimum 3300 mm wide x 1800 mm high	Class 3 waterway [3]. Include low flow channel 200 mm (minimum) below existing bed level and 450 mm wide. Continue low flow channel	Waterway realignment must ensure bed stability; and maintain existing flow velocity. Fish passage.
45km525	3,760	Incidental	Box culvert	Minimum 5 no. x 4200 mm wide x 3600 mm high	Class 3 waterway [3]. Set one culvert cell 200 mm (minimum) below existing bed level. Continue low flow channel through scour protection	Waterway realignment must ensure bed stability; minimise increasing or decreasing existing waterway length; and maintain existing flow velocity. Fish passage.

Chainage Referral	Chainage WC2U EA	Fauna Crossing Structure Type	Structure Form	Number and Dimensions	Fish Passage Requirements	Additional Requirements
47km000	5,235	Fish passage	Bridge over Williamsons Creek	(-)	Class 3 waterway[3]	
47km525	5,760	Incidental	Box culvert	Minimum 3000 mm wide x 1200 mm high	Class 3 waterway [3]. Include low flow channel 200 mm (minimum) below existing bed level and 450 mm wide. Continue low flow channel through scour protection	Must extend under existing Pacific Highway. Fish passage.
47km650	5,885	Incidental	Box culvert	Minimum 3000 mm wide x 1200 mm high	Fish passage.	
48km085	6,320	Dedicated	Bridge	(-)		Fauna corridor listed is under southern end span of bridge. Minimum 3 metre wide fauna passage required.
48km215	6,450	Dedicated	Bridge	(-)	Class 1 waterway[3]	
48km275	6,510	Dedicated	Bridge	(-)		Fauna corridor listed is under northern end span. Minimum 3 metre wide fauna passage required
49km900	8,135	Incidental	Pipe	2,500 mm diameter	No	Must provide water connectivity across Main carriageways. Site permanently inundated.

Chainage Referral	Chainage WC2U EA	Fauna Crossing Structure Type	Structure Form	Number and Dimensions	Fish Passage Requirements	Additional Requirements
50km215	8,450	Incidental	Bridge	Minimum width between the intersection of the scour protection and the finished ground level under the bridge to be 50.4m (see Note 1). Minimum vertical clearance to be 2.0 m (subject to detailed design).	No	
50km985	9,220	Incidental	Bridge	Minimum width between the intersection of the scour protection and the finished ground level under the bridge to be 50.4m (see Note 1). Minimum vertical clearance to be 2.0 m (subject to detailed design).	No	

Chainage Referral	Chainage WC2U EA	Fauna Crossing Structure Type	Structure Form	Number and Dimensions	Fish Passage Requirements	Additional Requirements
55km120	13,355	Dedicated	Box culvert	3000 mm x 3000 mm	No	Approximate length of culvert under main carriageway is 50 m. No culvert is to be provided under the service road but detailed design to investigate lowering the service road to provide better visibility across the service road from the culvert. Fauna fencing to be provided along the bottom of the batter slope between the highway and the service road to prevent fauna accessing the main highway. Koala included as target species
56km410	14,645	Combined	Box culvert	Minimum 2400 mm x 2400 mm	No	Approximate culvert length under main carriageway is 45 m. No fauna underpass is required under the service road. Koala included as target species. Provide ledge for dry passage during a 1 in 1 year ARI, 3 day (72 hour) storm event and must not have wet sections that retain water for longer than three days.
57km770	16,005	Dedicated	Box culvert	3000 mm x 3000 mm	No	Maximum culvert length is 50 m. Koala included as target species

Chainage Referral	Chainage WC2U EA	Fauna Crossing Structure Type	Structure Form	Number and Dimensions	Fish Passage Requirements	Additional Requirements
58km510	16,745	Combined	Box culvert	3000 mm x 3000 mm	Class 3 waterway3 Include low flow channel 1200mm wide x 200mm deep below existing bed level. Continue low flow channel through scour protection. Fish passage.	Approximate culvert length is 84m. Provide ledge for dry passage during a 1 in 1 year ARI, 3 day (72 hour) storm event and must not have wet sections that retain water for longer than three days. Adjacent box or pipe culvert to also be provided for drainage.
58km560	16,795	Dedicated	Box culvert	3000 mm x 3000 mm	No	Maximum culvert length is 50 m. Koala included as target species
59km090	17,325	Dedicated	Box culvert	3000 mm x 3000mm	No	Culvert length is 58 m. Length slightly in excess of 50 metres however was agreed to be acceptable if needed to achieve desired location. Koala included as target species
59km550	17,785	Dedicated	Box culvert	Minimum 3000 mm x 3000 mm	No	Approximate culvert length is 50 m. Koala included as target species
59km750 (northbound carriageway)	17,985	Dedicated	Box culvert	2400 mm x 2400 mm	No	Approximate culvert length is 38 m. Culvert to be moved up the bank to achieve the 1 in 100 year ARI flood immunity. Koala included as target species

Chainage Referral	Chainage WC2U EA	Fauna Crossing Structure Type	Structure Form	Number and Dimensions	Fish Passage Requirements	Additional Requirements
59km760 (southbound carriageway)	17,995	Dedicated	Box culvert	Minimum 2400 mm x 2400 mm	No	Approximate culvert length is 25 m. Combined length of the northbound and southbound underpasses is around 63 m. Carriageway separation is approximately 10 m with a fauna fenced race in between underpasses. Koala included as target species
60km615 (northbound carriageway)	18,850	Dedicated	Box culvert	2400 mm x 2400 mm	No	Approximate culvert length is 29 m. Structure to be shifted to the north around 15 metres to align with southbound carriageway. Koala included as target species.
60km600 (southbound carriageway)	18,835	Dedicated	Box culvert	Minimum 2400 mm x 2400 mm	No	Approximate culvert length is 30 m. Combined length of the northbound and southbound underpasses is around 59 m. Carriageway separation is approximately 19 m with a fauna fenced race in between underpasses. Koala included as target species.

1 A bridge may be provided in lieu of a box culvert provided that the total width between the intersection of the scour protection and the finished ground level under the bridge is at least equivalent to the total clear width of the cells of the replaced box culvert.

2 Separate fauna crossing structures must be provided for the Main Carriageways and Service Road to provide daylight between the Main Carriageways and Service Road structures.

3 Classification identified in consultation with DPI (Fisheries Conservation and Aquaculture)

Appendix F

Road Kill Monitoring Methodology

WC2NH Road Kill Monitoring Program

1.1 Timing of Monitoring

Timing of road kill surveys for the WC2NH Project is described in Table 1.

Table 1 – Timings and locations of road kill surveys

Project Phase	Timing of Survey	Location
During clearing operations	Daily	Portion of existing Pacific Highwayadjacent to clearing operations
One month following clearing operations	Daily	Portion of existing Pacific HwHighwayy adjacent to clearing operations
Duration of construction	Weekly	Entire length of existing Highwayin Project area
Upon opening of each stage of the Project to traffic (operational phase)	Weekly for 12 weeks commencing the week of opening each stage to traffic.	Entire length of opened stage.
Upon completion of the Project (operation phase)	Excluding the season/s covered by the initial 12 week monitoring period (refer above), weekly during October (spring), January (summer), April (autumn) and July (Winter) for up to five consecutive years post construction, or until mitigation measures have been demonstrated to be effective.	Entire length of completed Project

1.2 Monitoring Program Objectives

The aim of the monitoring program is to;

- report on any animal road kill on the project following the opening to traffic; and
- assess the effectiveness of the presence of fauna fencing to prevent fauna being killed by vehicles while attempting to cross the WC2NH Upgrade.

1.3 Monitoring Procedure

A two-person team vehicle being driven along the entire length of the highway in the Project area and identifying dead wildlife (road kill) seen on the road and within three metres of the road edge. The passenger will search the road and its verge for road kill. When a road kill is observed from the vehicle, a closer visual inspection of the carcass will be undertaken where safe access is available. If safe access is not possible, due to local traffic conditions, binoculars will be used to try to identify and provide as detailed information as is possible on the carcass.

Road kill fauna will be identified to species level where possible, with reference to field guides. Where there is any doubt to the identification of the carcass, photographs will be taken and forwarded to a qualified ecologist for identification /confirmation of species. Those too seriously damaged to be accurately identified will be recorded as “unknown”.

To assist with the correct identification of road kills, the following will be undertaken –

a. The provision of a qualified ecologist (shall be a recognised expert in mammal identification in coastal northern NSW) to undertake the initial phase of operational monitoring (first season) with relevant Roads and Maritime team members providing appropriate detailed training and a baseline of expert monitoring of road kills;

b. The provision of specialist training (to be provided by an expert as above in point a) in fauna identification for Contractors and Roads and Maritime staff involved in the construction phase monitoring of road kill; and

c. Where there is any doubt to the identification of the carcass, the provision of photographs of road kill to be sent to a qualified ecologist (an expert as above in point a) to confirm the identity of road kill and to maintain a permanent record of road kill for further comparisons, if needed.

1.4 Monitoring Methodology

- The highway will be monitored using the method previously indicated (section 1.3) consisting of a two-person team traversing the upgrade in a vehicle to locate and identify road kills;
- The speed of travel will be the same in all cases to avoid confounding the data collection, and should be as slow as is safely possible;
- The highway will be surveyed weekly for four weeks in spring, summer, autumn and winter (see Table 1);
- Where possible, each survey shall be completed within two hours of sunrise in order to maximise the potential to record road kills before either carrion eating animals or traffic render any road kill unidentifiable;
- if possible, each survey will be carried out on the same day of the week to remove the influence of varying environmental conditions and to ensure consistent temporal spacing;
- For each road kill observed, the following attributes will be recorded
  a. Geographic Coordinates of any road kill.
  b. Whether fauna fencing was installed at/near the location.
  c. Species of road kill where possible, however, where there is any doubt as to the identification of the carcass, photographs shall be forwarded to a qualified ecologist for identification /confirmation of the species.

If the animal is identified as an EPBC Act threatened species, the carcass will be photographed and the following information will also be recorded where possible and safety considerations permit

a. Sex and age class (juvenile or adult).

b. Presence of pouch young (for marsupials).

c. Presence of flightless young (for flying-foxes or other bats).

d. Distance to a fauna connectivity structure.

e. Distance to drop down structure.

f. If fauna fencing was installed, is there any damage to the fence in the vicinity.

g. Weather conditions at the time of the monitoring (from the Bureau of Meteorology) – including temperature, rainfall in the last 24 hours, moon phase.

h. If the animal is identified as a flying-fox:
   - Distance to nearest camp,
   - Distance to nearest canopy vegetation,
   - Presence of flowering food trees in neighbouring median or roadside vegetation; plants identified to species and referenced with diet list.

1.5 Analysis of data

The data to be collected will be analysed using a suitable nonparametric test such as a Kruskal-Wallis test. The aim will be to test both whether the fenced and unfenced locations have different mean numbers of road kills and if the amount of road kill varies through time in either or both of the two types of areas. Associations with other measured variables will be described as data allow, including sex, age class, presence of dependent young and, in the case of flying-foxes, proximity to roost sites or flowering food trees. Such information will indicate if the mitigation measures in the area are working as expected to keep road kills to acceptable levels and that none of the target species are killed.

1.6 Reporting

1.6.1 Quarterly reports

A report will be prepared by the ecologist following the initial 12 week monitoring period (after opening for each stage) to identify any roadkill hotspots and review the mitigation measures. The initial report and ongoing seasonal reports of the data collected will be provided to Roads and Maritime. This will include graphs of the data and any previously collected data to provide simple visual comparisons of road kill. This will also include overall road kill counts as well as separate graphs for each of the target species (if deaths have occurred).

Anecdotal road kill information collected on days that are not monitored as part of this program may be added as a note for discussion.

1.6.2 Annual Reports

The annual report will be prepared in consultation with a qualified ecologist and provided to DoEE and EPA within one month of completion of the fourth monitoring season. From then on it will be provided within one month of the same monitoring season in subsequent years until monitoring is completed (Table 1).

Analysis of the data itself shall be included in an annual monitoring report. This report will include a statistical analysis of all of the data collected to that time including graphical representations of the road kill that is recorded.

Annual reports will record any potential or obvious failures in road kill mitigation identified in the monitoring program and provide a date by which meetings will take place to discuss any such adverse findings. This will include at least:

- where statistically larger number numbers of road killed animals are detected on fenced sections compared to unfenced sections;
- where any of the target threatened fauna are recorded as killed;
- where there is a clear pattern of unexpected road kill at any point on the Upgrade.

1.7 Performance Measures

Lower rates of road kill in proximity to fauna fencing (i.e. areas of the main carriageways within areas adjacent to installed fauna fencing) than in sections of the upgrade not near fauna fencing during monitoring events up to five years post construction phase, or until such time as mitigation measures have been demonstrated to be effective.

1.8 Adaptive Management

Where any annual report identifies a significant difference between the road kill numbers of the fenced and unfenced areas, DoEE and EPA shall be notified, and a meeting will be set to discuss such differences with the relevant agencies and Roads and Maritime.

Such a meeting would occur within one month of completion of the annual report, which should ensure sufficient time to consider/review the response to any recorded significant differences.

Appendix N

Grey Headed Flying Fox Management Plan

Warrell Creek to Nambucca Heads Upgrade of the Pacific Highway

ROADS AND MARITIME SERVICES

Flying-fox Management Plan

EN04164 | Ver12

R278

15 November 2017

Warrell Creek to Urunga Upgrade of the Pacific Highway

Project no:	EN04164
Document title:	Flying-fox Management Plan
Document no:	EN04164
Revision:	Version 12
Date:	12 November 2017
Client name:	Roads and Maritime Services
Client no:	R278
Project manager:	Rachel Vazey
Author:	Vanessa Gorecki, Rachel Vazey, Chris Thomson, Dr Peggy Eby
File name:	I:\ENVR\Projects\EN04164\Deliverables\Reports\Management Plan\Rev J\2014-11-06_EN04164_FFMP_Final_RevJ_Final.doc

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Document history and status

Revision	Date	Description	By	Review	Approved
V01	16/12/12	Internal practice review	Dr Peggy Eby	18/12/2013	Rachel Vazey
V02	24/01/12	Practice review	Chris Thomson	24/01/12	Andrew Spinks
V03	06/02/2014	Project manager review	Rachel Vazey	06/02/2013	Rachel Vazey
V04	21/02/2014	Practice review	Chris Thomson	21/02/2013	Rachel Vazey
V05	25/02/2014	Project manager review	Rachel Vazey	25/02/2014	Rachel Vazey
V06	28/3/2014	EPA and DoE review	Rachel Vazey	28/03/2014	Rachel Vazey
V07	7/04/2014	Update following client review	Rachel Vazey	7/04/2014	Rachel Vazey
V08	18/06/2014	Update following review by Dr Peggy Eby	Rachel Vazey	18/06/2014	Rachel Vazey
V09	10/10/2014	Update following client review	Rachel Vazey	10/10/2014	Rachel Vazey
V10 (J)	6/11/2014	Update following client review	Rachel Vazey	6/11/2014	Rachel Vazey
V10 (k)	16/3/2016	Update following AFJV request	Chris Wicks	7/06/2016	Chris Clark
V11	19/8/16	Update following DoE review	Chris Wicks	7/9/2016	Chris Clark
V12	15/11/17	Update Road Kill Monitoring to increase the relevance of the monitoring program to flying-foxes.	Sean Hardiman	10/11/17	Chris Clark

Acronyms and abbreviations

Acronym	Definition
ABL	Australian Bat Lyssavirus
ACT	Australian Capital Territory
AHD	Australian Height Datum
ANU	Australian National University
BFF	Black Flying-fox
CEMP	Construction Environmental Management Plan
CMS	Construction Method Statement
DECC	Department of Environment and Climate Change NSW
DECCW	Department of Environment, Climate Change and Water NSW
DoEE	(Commonwealth) Department of the Environment and Energy
EEC	Endangered Ecological Community
EMR	Environmental Management Representative
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPA	Environment Protection Authority (NSW)
EWMS	Environmental Work Method Statements
FFMP	Flora and Fauna Management Plan
GHFF	Grey-headed Flying-fox
GIS	Geographical Information Systems
GPS	Global Positioning System
LRFF	Little Red Flying-fox
MNES	Matters of National Environmental Significance
NSW	New South Wales
OEH	Office of Environment and Heritage (NSW)
P&I	Planning and Infrastructure (NSW)
QLD	Queensland
RTA	Roads and Traffic Authority
SEQ	South-east Queensland
SKM	Sinclair Knight Merz
SMART	Specific, measurable, achievable, results-based, time-based
TSC Act	*Threatened Species Conservation Act 1995*
WIRES	Wildlife Information and Rescue Service

Contents

1. Introduction

1.1 Project overview and background to the plan

The Pacific Highway Upgrade Program is a joint commitment by the Australian and New South Wales (NSW) governments to improve the standard and safety of the Pacific Highway between Hexham and the Queensland border. The Pacific Highway Upgrade Program includes the upgrade of the Pacific Highway between Warrell Creek and Urunga (WC2U) comprised of approximately 42 kilometres of dual carriageway road that would bypass the towns of Warrell Creek, Macksville, Nambucca Heads and Urunga on the Mid North Coast of NSW. The WC2U Project has been divided into two stages and includes the following:

- Stage 1 consisting of the northern 22.5 kilometres of the Project between Nambucca Heads and Urunga (NH2U).
- Stage 2 consisting of the southern 19.5 kilometres of the Project between Warrell Creek and Nambucca Heads (WC2NH) (refer to **Figure 1-1**).

This Management Plan relates to Stage 2 (WC2NH). An Environmental Assessment (EA) was prepared for the WC2U Project by the Roads and Traffic Authority (RTA) in 2010 under Part 3A (now repealed) of the *Environmental Planning and Assessment Act 1979* (EP&A Act). The NSW Minister for Planning and Infrastructure approved the WC2U Pacific Highway Upgrade Project (the Project) under Part 3A (now repealed) of the EP&A Act on 19 July 2011, subject to the Minister's Conditions of Approval (CoA) being met. In accordance with transitional provisions included in Schedule 6A of the EP&A Act, the Project is characterised as a transitional Part 3A Project. It is noted that despite its repeal, Part 3A of the EP&A Act continues to apply in respect of transitional Part 3A Projects. Under section 75C of the EP&A Act, the Minister for Planning declared, by Order dated 5 December 2006 and published in the NSW Government Gazette No. 175, that development for the purposes of upgrading segments of the Pacific Highway is a Project to which Part 3A of the EP&A Act applies (the declared Project). The Minister also declared, by Order dated 8 December 2006 published in Gazette No. 175, that the same development is a critical infrastructure Project under section 75C of the EP&A Act. This was subsequently modified through a further Ministerial Order gazetted on 3 December 2010 (Gazette No. 133).

In late November and early December 2011, subsequent to the WC2U Project approval, Grey-headed Flying-foxes (*Pteropus poliocephalus*) established a camp within the approved alignment of Stage 2 WC2NH of the Project. No flying-fox camps were identified in the study area in the WC2U EA (RTA, 2010) for the Project. The Grey-headed Flying-fox camp (hereafter referred to as the 'Macksville flying-fox camp') is located in a 23.5 hectare (ha) isolated remnant of Swamp Sclerophyll Forest on freehold land 1.9 kilometres south of the Nambucca River and 0.5 kilometres north of Warrell Creek (refer to **Figure 1-2**). The flying-foxes roost in dense stands of permanently inundated Broad-leaved Paperbark (*Melaleuca quinquenervia*) in the central area of the swamp.

Roads and Maritime Services (Roads and Maritime) explored alternative route options to reduce the impact of the alignment on the flying fox colony, and released four alternative options and the original approved alignment for community comment in mid-September 2013. The release of these options triggered media coverage, which was critical of the need to explore alternative route options.

On 26 September 2013, the Premier's Office informed Roads and Maritime it should proceed with planning the new highway on the approved alignment.

The Grey-headed Flying-fox is listed as a 'Vulnerable' species under the NSW Government *Threatened Species Conservation Act 1995* (TSC Act) and the *Environment Protection and Biodiversity Conservation 1999* (EPBC Act). The colony roosting in the Macksville flying-fox camp is considered to be an 'important population' as defined under the EPBC Act as it is likely to be a key source population for breeding and dispersal. In addition, the Swamp Sclerophyll Forest where the camp is located meets the criteria for Roosting Habitat Critical to Survival of Grey-headed Flying-foxes as defined in the *Draft National Recovery Plan for Grey-headed Flying-foxes* (DECC, 2009). Forest vegetation located within the area to be cleared for the Project meets criteria for Foraging Habitat Critical to Survival of Grey-headed Flying-foxes as defined in DECC (2009).

Following the establishment of the Macksville flying-fox camp within the approved alignment of Stage 2 WC2NH, additional assessments of the impacts on this threatened species were completed by Eby (2012), SKM (2013) and GeoLINK (2013a to 2014r). An Assessment of Significance (EPBC Act) completed by SKM in 2013 found that the Project would likely have a significant impact on the Grey-headed Flying-fox due to the following:

- Direct impacts on foraging habitat considered critical to the survival of the species (DECC, 2009). The loss of critical foraging habitat equates to 106.6 hectares (ha) (including a 10 per cent contingency) (Roads and Maritime 2013) and consists of:
  - Map Unit 1 - Blackbutt Open Forest – 75.2F ha.
  - Map Unit 2 - Mixed Floodplain Forest – 4.0 ha.
  - Map Unit 3 - White Mahogany/Grey Gum/Ironbark Moist Open Forest – 7.3 ha.
  - Map Unit 4 - Flooded Gum Moist Open Forest – 14.8 ha.
  - Map Unit 6 - Swamp Mahogany /Paperbark Swamp Forest – 5.3 ha.
- Direct impacts associated with the removal of 3.1 hectares of roosting habitat considered to be critical to the survival of the species (DECC, 2009) and which is a seasonal camp for an important Grey-headed Flying-Fox population. There would also be indirect impacts to the remaining patch of Swamp Sclerophyll Forest. As such there would be impacts (direct and indirect) to a total of 23.5 hectares of critical roosting habitat as defined in the Draft Recovery Plan (DECC, 2009).
- The Project would likely displace the flying-foxes from their current roosting site, which could lead to stress and reduced fecundity due to potential disruption of the breeding cycle of this important population. The long-term impact on the population would depend on the ability of the flying-foxes to find an alternate camp site. In the event the flying-foxes continue to roost in the surrounding swamp forest, other indirect impacts could include the suppression of the ability to raise young to adulthood and collision with vehicles. It would be possible for some females to lose young when carried in flight, due to a perceived lack of manoeuvrability around highway traffic. Inexperienced young may also be unable to avoid vehicles when learning to fly.
- The Project would also likely interfere substantially with the recovery of the species due to removal of identified critical roosting habitat.

In accordance with Sections 18 and 18A of the EPBC Act, the Grey-headed Flying-fox is a matter of national environmental significance (MNES) and Roads and Maritime has prepared a referral seeking approval from the Australian Government for the Project. The referral was lodged with the Department of the Environment (DoE) on 20 December 2013. For further information refer to http://www.environment.gov.au/cgi-bin/epbc/epbc_ap.pl?name=current_referral_detail&proposal_id=7101. The referral provides detail on the Project, including a detailed description, proposed construction staging, excluded activities, description of impacts and measures to avoid or manage impacts, for Commonwealth MNES, including Grey-headed Flying-fox. The DoEEhave reviewed the referral (number 2013/7101) on the 23 January 2014 and made the decision under section 75 of the EPBC Act that that the Project is a controlled action and requires approval under the EPBC Act.

Construction of the Project would occur in two stages to facilitate meeting the targeted end of 2016 opening milestone date, in accordance with undertakings by both the NSW and Federal Governments, while ensuring that impacts on the flying-fox camp-site are minimised. This construction schedule would also facilitate access to the crossing of the southern floodplain of the Nambucca River.

The proposed construction stages are:

- **Stage 2.1** - Construction in the vicinity of the flying-fox colony south of Macksville prior to the commencement of construction of the remainder of the Warrell Creek to Nambucca Heads upgrade. Key Stage 2.1 construction activities would include:
  - Construction of the upgrade within the 300 metre and 500 metre buffer zones for the flying-fox colony south of Macksville.
  - Construction of a temporary construction access road from the existing highway to the approved alignment north of the flying fox camp.
  - Establishment and operation of Ancillary facilities, stockpile sites (including associated environmental management measures) for Stage 2.1 south of the Flying fox camp.
- **Stage 2.2** - Construction of the remainder of the Warrell Creek to Nambucca Heads upgrade.

1.2 Purpose and objectives

This management plan identifies the potential impacts of the WC2NH Pacific Highway upgrade on the Macksville flying-fox camp. It outlines the proposed management measures to be implemented for the flying-foxes and a program for monitoring the effectiveness of these measures. The objective of this management plan is to provide measures that minimise impacts to flying-foxes.

1.3 Order of precedence

In the event of any inconsistency, ambiguity or discrepancy between this Management Plan and the Flora and Fauna Management Plan for the Warrell Creek to Nambucca Heads Pacific Highway upgrade Project, the following order of precedence must apply:

(a) This Flying-fox Management Plan.

(b) The Flora and Fauna Management Plan for the Warrell Creek to Nambucca Heads Pacific Highway upgrade Project.

1.4 Management structure and plan updates

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

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

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

Roads and Maritime have prepared this flying-fox management plan in consultation with the Environment Protection Authority (EPA) and the Commonwealth Department of the Environment (DoE). Comments received and Roads and Maritime's responses are documented in **Appendix E**.

General responsibilities for environmental management would be outlined in the Project specific Construction Environment Management Plan (CEMP) and sub-plans, including the Flora and Fauna Management Plan (FFMP). These management plans would be prepared prior to the commencement of construction. Roads and Maritime Service and the contractor engaged to construct the Project would be responsible for implementing the activities in this Flying-fox Management Plan and would include the engagement of suitably qualified specialists to undertake and oversee surveys and monitoring activities.

1.5 Plan authors and expert review

Table 1-1 Qualifications and experience of authors of this flying-fox management plan.

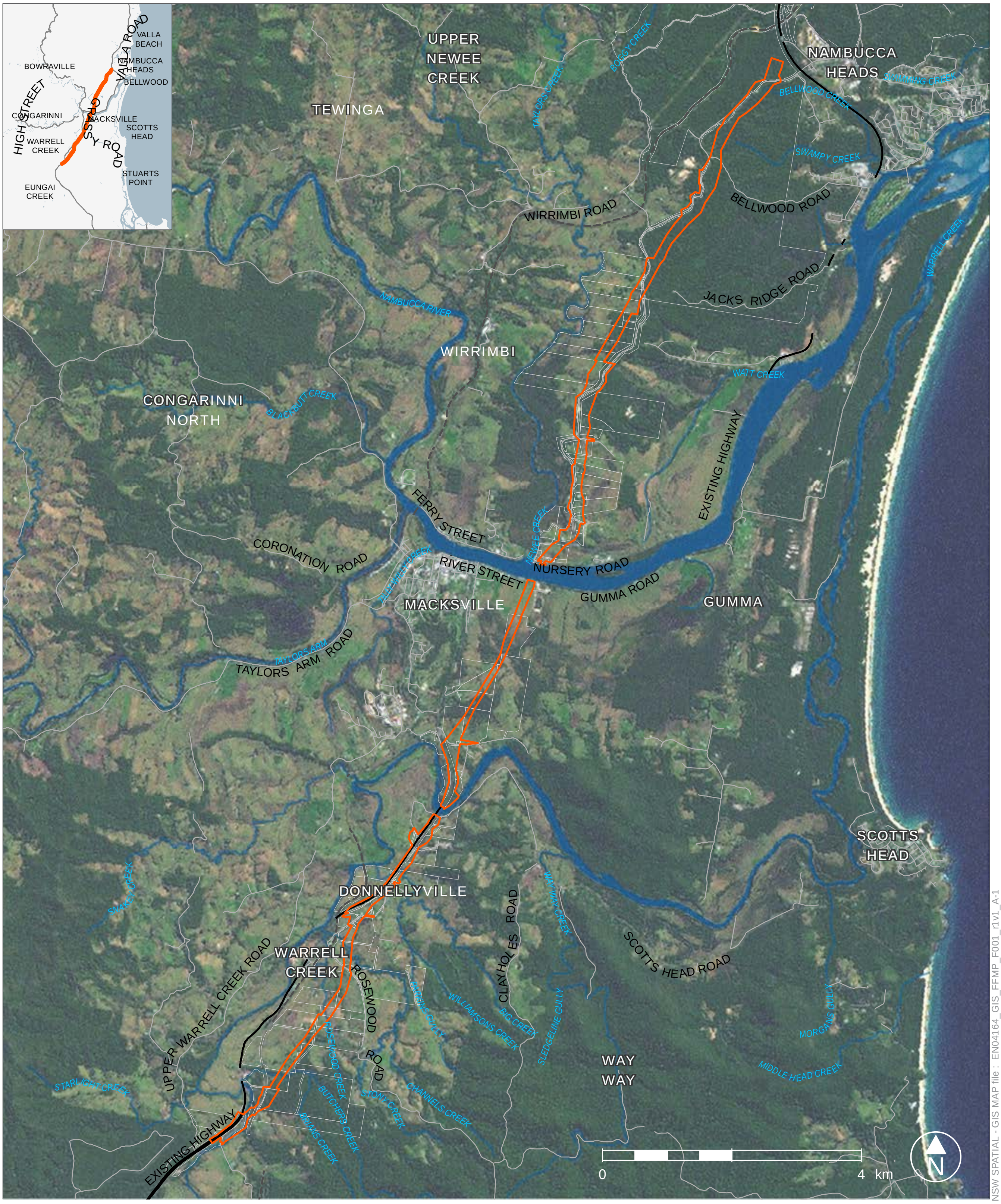
Personnel	Qualifications	Experience
Vanessa Gorecki	Masters of Science with Honours, Macquarie University Bachelor of Applied Science (Ecology and Environmental Science), University of Canberra	Vanessa is an ecologist with seven years of research and consultancy experience. Vanessa is experienced in ecological survey and monitoring, ecological assessment, management and approvals, and Project management. Vanessa is competent in conducting baseline flora and fauna surveys, vegetation mapping, assessing impacts on ecological values, developing management plans and monitoring strategies for threatened species, ecological communities, weeds and pest animals and rehabilitation. Vanessa is also an experienced spotter catcher and wildlife rehabilitator.
Rachel Vazey	Bachelor of Science (Honours) Earth Science – University of Newcastle	Rachel Vazey is an Environmental Planner and Geographical Information Systems (GIS) Analyst. Rachel has an in depth understanding of NSW and Commonwealth environmental planning legislation and is particularly familiar with the preparation of environmental assessments under Part 5 of the *Environmental Planning and Assessment Act (1979)* (EP&A Act) and the preparation of referrals under the *Environment Protection and Biodiversity Conservation Act (1999)* (EPBC Act). Rachel has worked extensively with government agencies in the Project management of environmental assessments of public infrastructure Projects including upgrades of major highways and intersections for Roads and Maritime and upgrades of water supply systems and sewage treatment works for Hunter Water.
Chris Thomson	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 with 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.

Expert review of the plan

An expert review of the plan was undertaken by Dr Peggy Eby. Dr Eby is recognised as one of Australia's leading flying-fox ecologists having completed her PhD on the interaction between Grey-headed Flying-foxes, seasonal movements in relation to dietary requirements and their role in seed dispersal. She prepared the Draft National Recovery Plan for the Greg-Headed Flying-fox and has published numerous scientific articles on various aspects of flying-fox ecology.

Recommendations provided by Dr Eby have been incorporated into the final management plan.

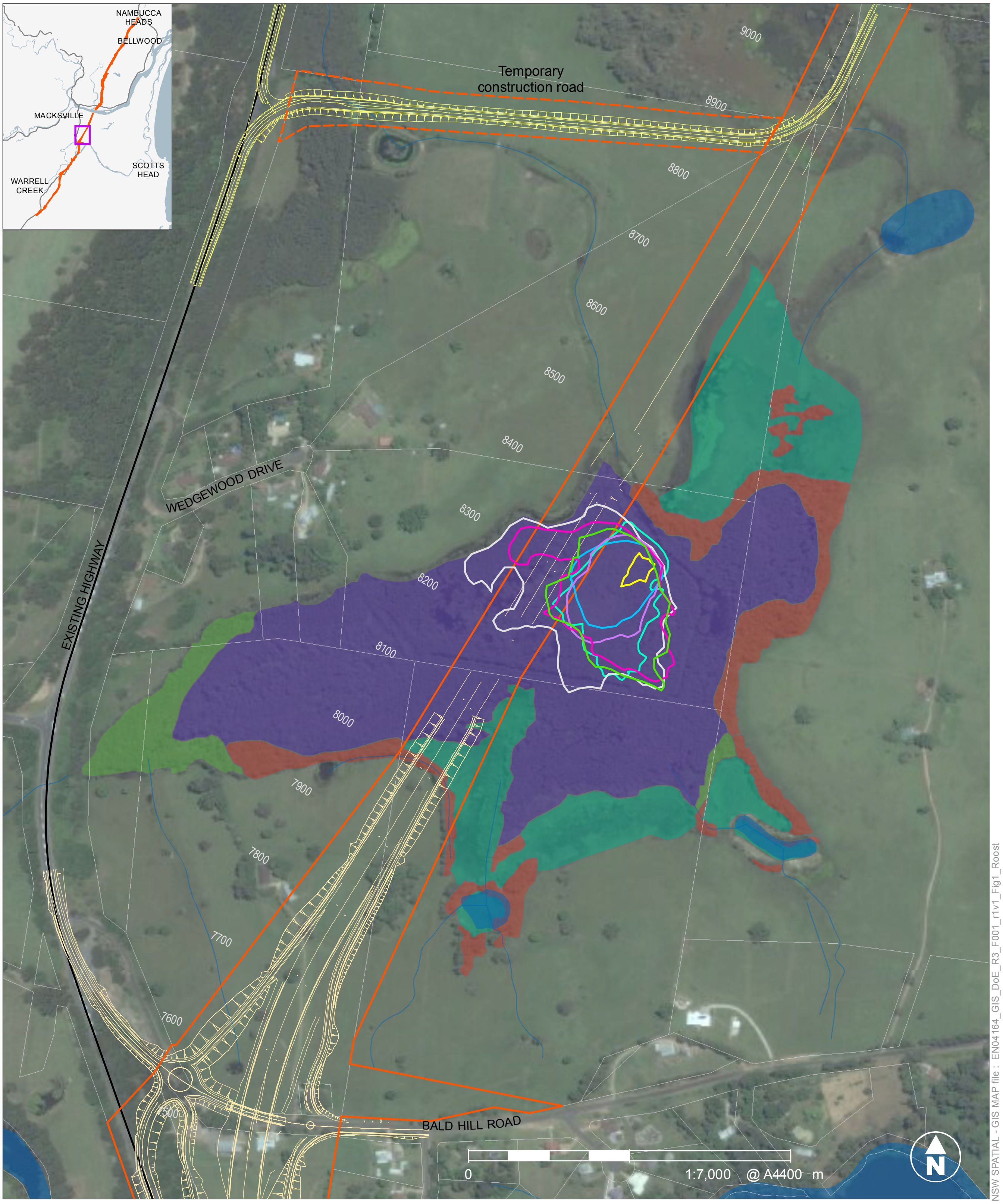
Figure 1-1 Overview of locality



Road boundary
Existing highway
Railway
Waterway

DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010

Figure 1-2 Location of the Flying-fox camp



Road boundary
Road design
Temporary construction road boundary
Temporary construction road design
Existing highway
Railway
Waterway

April 2013 Flying-fox camp footprint
September 2013 Flying-fox camp footprint
November 2013 Flying-fox camp footprint
January 2014 Flying-fox camp footprint
February 2014 Flying-fox camp footprint
March 2014 Flying-fox camp footprint
April 2014 Flying-fox camp footprint

Vegetation type

Broad-leaved Paperbark Swamp Forest
Freshwater Wetland
Swamp Mahogany / Broad-leaved Paperbark Swamp Forest
Swamp Oak Swamp Forest

DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, Streetworks 2001, SKM 2010, OEH 2013

2. Flying-fox populations

2.1 General knowledge

2.1.1 Flying-fox populations within the region

Three species of flying foxes occupy the mid north coast region of NSW: the Grey-headed Flying-fox (GHFF) (*Pteropus poliocephalus*), the Black Flying-fox (BFF) (*Pteropus alecto*) and the Little Red Flying-fox (LRFF) (*Pteropus scapulatus*). All three species are migratory. Individuals move long distances in response to variations in the abundance of food, primarily nectar secretion from eucalypts (*Eucalyptus, Corymbia, Angophora*) but also fleshy fruits (Eby 1991 and 1996, Hall and Richards 2000; Roberts *et al.* 2012). Eucalypt flowering is notably erratic. Most species do not flower every year in a local area and flowering intensity is highly variable (Eby and Law 2008). Therefore, the size of local flying-fox populations varies substantially both from season to season and from year to year.

The GHFF is the most common in the region and is the predominant species in the Macksville flying-fox camp. The BFF occurs in lower numbers than the GHFF and has been recorded in the Macksville flying-fox camp. LRFFs occupy the mid north coast irregularly, but are occasionally present in large numbers. Small numbers were present in the Macksville flying-fox camp in autumn of 2014.

2.1.2 Roosting habitat

The Grey-headed Flying-fox roosts in camps, usually in dense riparian habitats, during the day and disperses at dusk in search of preferred food sources comprised mainly of eucalypt blossom and rainforest fruits. Camps provide resting habitat within foraging distance of food sources, sites of significant behaviours such as mating, birth and lactation and night refuge for flightless young.

Habitat associated with camps have been characterised by the following (Roberts 2005):

- Vegetation with closed canopy (on the mid north coast, camps typically occur in rainforest or swamp forest dominated by *Melaleuca quinquenervia*).
- Continuous canopy area >1 hectare.
- Canopy height >8 metres.
- Close proximity to waterways (<500 metres), commonly rivers or creeks.
- Level topography, <5 degree incline.
- Positioned within nightly commuting distance of sufficient food resources to support the population of a communal roost.

While these characteristics can be used to describe roosting habitat, they are insufficient to predict the specific locations of camps, suggesting additional habitat characteristics that are important to flying-foxes are yet to be identified.

Twenty camp sites were recorded within a 50 kilometre radius of the Macksville camp, including the site itself (Eby 2012). Thirteen of the 20 camp sites meet at least one of the criteria for Roosting Habitat Critical to Survival of Grey-headed Flying-foxes as defined in the DECC (2009) (Eby 2012), refer to **Figure 2-1**.

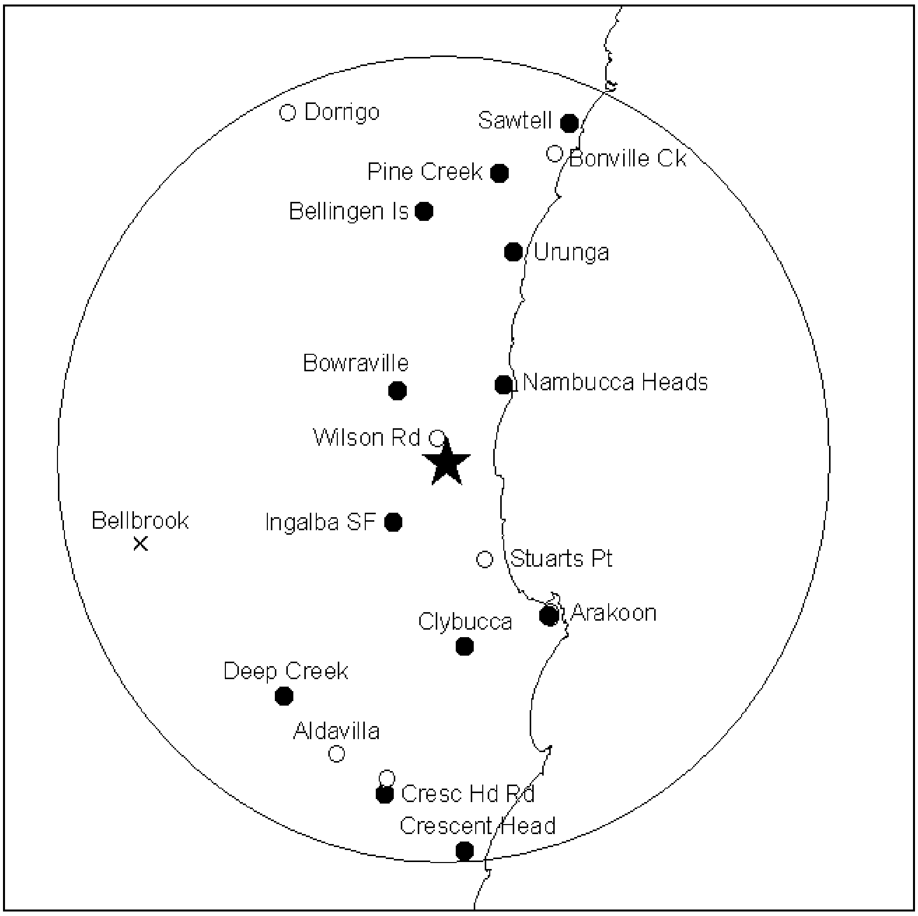


Figure 2-1 : The distribution of flying fox camp sites located within 50 kilometres of the Macksville camp (black star) as defined by Eby (2012)

Legend:

- **Black circles - camps that meet criteria for habitat critical to the survival of Grey-headed flying foxes (DECC, 2009).**
- **Open circles - camps that were not assessed due to insufficient information.**
- **Black cross – The approximate location of the Bellbrook camp (Eby, 2012).**

2.1.3 Foraging habitat

Flying-foxes are canopy-feeding frugivores and nectarivores, which use diverse vegetation types including rainforest, open forests, closed and open woodlands, Melaleuca swamps and Banksia woodlands. The Grey-headed Flying-fox is highly mobile and commutes to foraging areas, which are typically located within 15 kilometres of day roosts. Flights of more than 50 kilometres from their roost to feeding areas may also occur.

GHFFs are likely to forage on flowering eucalypts and fruit trees throughout the locality of the Macksville flying-fox camp, refer to **Figure 2-2**. The following vegetation types within the locality are known to provide suitable foraging habitat for the species (Eby, 2012):

- Blackbutt Open Forest.
- Mixed Floodplain Forest.
- White Mahogany/Grey Gum/Ironbark Moist Open Forest.
- Flooded Gum Moist Open Forest.
- Swamp Mahogany/Paperbark Swamp Forest
- Lowland Rainforest.

Highly productive plants in the blossom diet of flying-foxes are dominant in five of the habitat types listed above. These species include *Corymbia intermedia, Eucalyptus pilularis, E. robusta, E. siderophloia* and *Melaleuca quinquenervia*. A diverse range of fruit-producing diet species dominate the sixth type, Lowland rainforest, with *Eucalyptus grandis* and *Lophostemon confertus* emergents (Eby, 2012). Potential foraging habitat has been mapped by Eby (2012), refer to **Figure 2-2**. **Table 2-1** summarises the number and area of vegetation within 50 kilometres of the Project which meet the criteria for foraging habitat critical to flying-foxes (DECC, 2009).

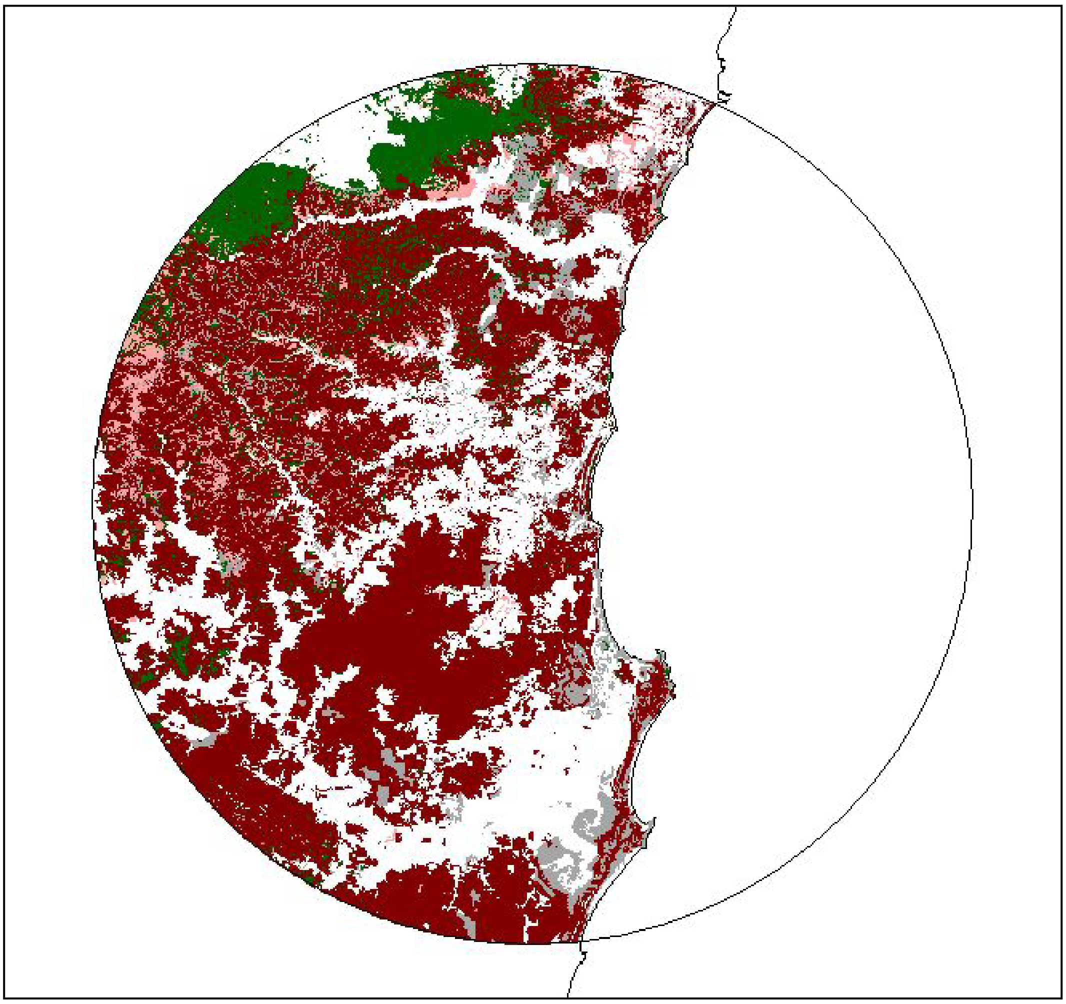


Figure 2-2 The distribution of native vegetation within 50 kilometres of the Macksville flying fox camp (black star). Deep red polygons indicate vegetation containing blossom diet species and identified as critical foraging habitat. Green polygons indicate rainforest vegetation identified as critical foraging habitat. Light red polygons indicate foraging habitat with low levels of productivity and not included in assessments (ranks 3 & 4, Eby and Law 2008). Grey polygons indicate native vegetation that does not contain flying fox diet species. White areas are cleared land or water bodies.

Table 2-1 Summary of the number and area of vegetation types in the study area that meet criteria for foraging habitat critical to flying foxes, from Eby (2012).

DECC 2009 critical foraging habitat criteria	Vegetation types (n)	Area (ha)
Criterion 1. productive during resource bottlenecks	45	249,300
Criterion 2. supports large populations	24	179,400
Criterion 3. productive during key reproductive periods	77	327,800
Criterion 4. supports commercial fruit industries	45	224,100
Total	77	327,800

2.1.4 Regional presence

Numerous previous records of flying-foxes on the NSW Wildlife Atlas database exist from within the locality of the study area, including 90 records within five kilometres of the Project footprint and 326 records from within 10 kilometres of the Project (Office of Environment and Heritage (OEH), 2013).

There are a number of known camps for the Grey-headed Flying-fox in the region of the Project as described in **Section 2.1**.

2.2 Flying-fox population, camp and habitat within the Project footprint

2.2.1 Data collection - Macksville flying-fox camp

Data describing the Macksville flying-fox camp and its inhabitants has been acquired from a range of sources. In 2012 a history of use of the site was compiled from pre-existing information as part of an initial assessment that aimed to document the characteristics of the camp consistent with requirements of the *NSW Flying fox Camp Management Policy* (DECC 2009); and assess the potential likely impact of construction and operation of the adjoining Nambucca Heads to Urunga upgrade on the camp (Eby 2012). This information was supplemented by field work conducted in the following year and from satellite telemetry records of animals captured at the Royal Botanic Gardens Sydney in June 2012 (John Martin, Royal Botanic Garden and Domain Trust, Sydney). A systematic program of monthly monitoring was introduced in winter 2013 which focused on the seasonality of occupation of the camp site, the species and number of flying-foxes present, the camp footprint and likely importance as a maternity site. The frequency of monitoring was increased to fortnightly monitoring in January 2014 (SKM data; GeoLINK 2013a-g and 2014a-t, refer **Section 6**). A table of results to date is presented in **Appendix B** and summarised below.

Population size

The size of the Macksville colony has fluctuated from 0 to around 40,000 – 50,000 animals over the monitoring period, for further details, refer to **Appendix B**. Population size has varied between years with relatively high numbers recorded in summer 2012, autumn 2013, early spring 2013 and autumn 2014; and relatively low numbers recorded in late spring / summer 2013. The camp was empty in winter 2013 and 2014. This variation is in keeping with fluctuations recorded at other sites.

Species present

Grey-headed Flying-foxes, Black Flying-foxes and Little Red Flying-foxes have been recorded at the site. Grey-headed Flying-foxes predominate and make up 80-95% of the population.

Age and persistence of the camp

The Macksville flying-fox camp was established in late spring 2011. It is too early in its history to predict its long-term status (Eby, 2012). The formation of new flying-fox camps is generally associated with either a period of food scarcity when flying foxes disperse into small aggregations close to feeding areas (Eby *et al.* 2012), or abandonment of a near-by site (Hall 2002, Roberts *et al.* 2011). There is no evidence that food for flying foxes in south-east Australia was scarce at the time the Macksville camp was formed in late spring / summer 2011. However, the timing was associated with a notable shift in occupation of the camp at Bowraville (Eby, 2012).

It is likely that the Macksville camp formed in response to the abandonment of the Bowraville camp in 2011. Indications include the timing of abandonment of Bowraville relative to the establishment of Macksville, the proximity of the two sites, seasonal trends in population size and spatial associations in foraging areas accessed from the two camps. Flying-foxes returned to the Bowraville camp in October 2013 after an unprecedented absence of two years (GeoLINK 2013d). It is not possible to predict whether animals will continue to use the site.

Timing of when the camp is occupied

Combined survey and telemetry records confirmed occupation of the Macksville camp in December 2011; January, March and June 2012; each month from October 2012 to May 2013; and irregularly from September to April 2014. The bats were absent at the time of June, July and August 2013 surveys and the May through to September 2014 surveys, indicating seasonal use of the site (GeoLINK 2013a – 2013g and GeoLINK 2014a – 2014t).

Populations in excess of 10,000 including reproductive adults were recorded in the birth period (2011 and 2013), during lactation (2012 and 2014) and at the time of conception (2013 and 2014). Dependent young were recorded at the site in each year of monitoring. Thus the population is considered to be an ‘important population’ as defined under the EPBC Act as it is likely to be a key source population for breeding and dispersal. Numbers varied between October 2013 to mid-April 2014 and the site was occupied irregularly in these months, this is in keeping with expected inter-annual variations. For further details of the timing and numbers of when the camp is occupied refer to **Appendix B**.

Proximity of the camp to the Project

The proposed road corridor traverses the western edge of the perimeter of the Macksville flying-fox camp (refer to **Figure 1-2**). There is potential for the camp footprint to occupy much of this area during peak periods.

Condition of the vegetation where the flying-fox is currently roosting within the Project boundary

A habitat assessment was completed as part of a survey completed on 23 – 24 July 2013. Vegetation was assessed as predominantly in good condition, although localised areas around the edges of the remnant were in low or moderate condition due to edge effects, historic clearing and/ or livestock disturbances. Stands of mostly treeless Freshwater Wetland vegetation communities occur to the north-east and south-east of the forested areas. These wetland areas are listed under the TSC Act as the Endangered Ecological Community (EEC) - Freshwater wetlands on coastal floodplains of the NSW North Coast, Sydney Basin and South East Corner bioregions.

GeoLINK noted that there was a substantial *Salvina molesta* infestation that covered approximately 40 per cent of the water in the Swamp Sclerophyll Forest. This species is listed as a noxious species and weed of national significance and it was noted that care should be taken by all personnel visiting the site to avoid spread of this highly invasive species.

3. Key threats and potential impacts of the Project

3.1 Key threats to the species

3.1.1 Loss of habitat including loss of potential roosting sites and foraging opportunities

Flying-foxes require a continuous sequence of productive foraging habitats, the migration corridors or stopover habitats that link them, and suitable roosting habitat within nightly commuting distance of foraging areas (Fleming and Eby 2003). The clearing of vegetation results in the loss of foraging habitat, roosting sites and migration corridors and this is recognised as a threatening process to the Grey-headed Flying-fox (DECC, 2009).

The loss of roosting habitat is recognised as a threatening process to the Grey-headed Flying-fox (DECC, 2009). The degradation of vegetation in small remnants threatens longevity and may also reduce the suitability of sites as camps.

The loss of foraging habitat is recognised as a primary threat to Grey-headed Flying-foxes (DECC, 2009). Flying-foxes feed primarily on blossoms and fruit and supplement this diet with leaves. The majority of animals feed on nectar and pollen from Eucalypts, Melaleucas and Banksias. Loss of winter and spring forage is of particular concern as food bottlenecks occur in these seasons. Food shortages during late gestation, birth and early lactation can result in rapid weight loss in adults, poor reproductive success and high rates of mortality (Roberts, 2006, DECC, 2009).

Within 50 kilometres of the Project there are approximately 327,800 hectares of critical foraging habitat available, refer to **Figure 2-2** and **Table 2-1**.

3.1.2 Fragmentation of habitat and impacts to connectivity

Camps are used as day refuges by animals that forage in surrounding areas over several weeks, and as short-term stopover sites by migrating animals (DECC, 2009). Flying-foxes are proficient at foraging in fragmented landscapes. They are however reliant on corridors and landscape linkages to gain access to food. Their mobility enables them to move freely across fragmented, degraded and urban landscapes. Flying-foxes have been recorded flying large distances from their roost to different feeding areas (Roberts *et. al*, 2012). A reduction in roosting and foraging habitat reduces connectivity across the landscape.

3.1.3 Disturbance of roosting sites

Roosting flying-foxes are readily disturbed by various stimuli such as loud noise, smoke, dust and alterations to roosting vegetation (Roberts et al. 2011). Prolonged or intensive disturbances cause the animals to take flight for lengthy periods during the day, to repeatedly move between roost trees and may eventually cause animals to abandon camp sites. Disturbances to colonies potentially have adverse effects on the life cycle of flying-foxes, particularly if the disturbance occurs when females are heavily pregnant or have dependant young. Disturbance is particularly detrimental during the last weeks of pregnancy when females can spontaneously abort (Garnett et al. 1998, Luly et al, 2010). Additionally, disturbance of a maternity roost during the breeding season can result in the death of dependent young as females can be forced to fly off leaving dependent young behind (Garnett et al. 1998, Roberts, 2006).

Disturbance of colonies located in proximity to food resources during periods of food shortages (ie winter) can also have an adverse impact on the life cycle of flying-foxes. Disturbance has the potential to cause flying-foxes to become fatigued as they are forced to fly around, especially if there is limited alternative roosting habitat close by (Roberts, 2006). This issue is exacerbated when there are pregnant females or lactating females with dependent young present in the camp. The potential impacts may be amplified due to cumulative effects of ongoing dispersal activities at other flying-fox camps in NSW and Queensland (Roberts *et al.* 2011).

3.1.4 Noise, vibration and light impacts

Noise and vibration from machinery and associated activities can disturb flying-foxes in a camp (SEQ Catchments, 2012). Abandonment of a camp could lead to a significant impact to roosting populations during critical periods in their reproductive cycle i.e. when there are pregnant females or lactating females with dependent young present in the camp.

3.1.5 Impacts to groundwater/ponded surface water within flying-fox habitat

Research indicates that flying-foxes in coastal lowlands of SEQ and NSW choose to roost in vegetation that contains a closed canopy, a complex vegetation structure and is located within 500 metres of a waterway. The mid-storey vegetation within a camp site is considered critical for maintaining a cool, humid and sheltered environment to alleviate stress during drought and extreme temperatures and a dense understorey is believed to contribute to the provision of a desirable microclimate (SEQ Catchments, 2012).

Modification to groundwater and surface water hydrological regimes has the potential to:

1) Cause a change in vegetation structure with implications for a particular camp's viability as a flying-fox roosting site (a common method used to disperse flying-fox camps is camp modification, which includes modifying the vegetation structure of a camp (Roberts, 2006)).

2) Substantially alter the microclimate of the roost, particularly levels of humidity which can be important in defining roost locations (Snoyman and Brown 2010).

3.1.6 Electrocution on power lines, entanglement in netting and on barbed wire fencing

Flying-foxes are prone to accidental injury and death from various obstacles. They are prone to electrocution on power lines (Tidemann 1999, K. Parry-Jones, University of Sydney unpublished data); they can become entangled in netting that is intended to protect backyard fruit trees; and they can become entangled on barbed-wire fencing, particularly in rural areas (Halpin et al. 1999, van der Ree 1999, DECC, 2009). Such traumas can cause injuries resulting in death and can also cause pregnant females to spontaneously abort (Halpin et al. 1999). Trauma caused to lactating females can result in the death of dependent young left at the camp at night while females forage.

3.2 Potential impacts from the Project

This section identifies potential impacts from the Project. Measures to avoid, minimise and/or mitigate these potential impacts are addressed in **Sections 4, 5 and 6**. A monitoring program is discussed in **Section 7**.

3.2.1 Direct impacts of clearing work

The perimeter of the flying-fox camp overlaps the Project footprint and zone identified for vegetation clearing at its western edge. If flying-foxes were present at the time there would be potential for animals roosting in the camp to be injured or killed during clearing works through disturbance during the daytime, disorientation and/or increased susceptibility to predators.

The level of disturbance in and immediately adjacent to the camp area would likely displace the flying-foxes from their current roosting site, which may lead to stress and reduced fecundity for this population.

3.2.2 Loss of habitat including loss of potential roosting sites and foraging opportunities

The assessment of the area of habitat affected by direct clearing and damage to vegetation during construction of the Warrell Creek to Nambucca Heads Pacific Highway upgrade was based on the following:

- Concept design with 15 metre buffer.
- Construction/ operational water quality basins with 10 metre buffer.

- Adjustments to access roads within Nambucca State Forest with 10 metre buffer.
- Utility adjustments with clearing requirements of utility authorities.
- Three metre clearing width for boundary fencing - excluding within Nambucca State Forest and swamp forest where flying fox camp is located.

The area identified for clearing includes a 10 per cent contingency which allows provision for clearing construction phase water quality basins, accesses to ancillary facilities, stockpile sites and design refinements.

Clearing required for construction would remove 3.1 hectares of Swamp Mahogany /Paperbark Swamp Forest at the roost location. The total clearing of this community is 5.3 hectares, with the additional area located in another part of the corridor away from the camp site. The clearing will bisect the 23.5 ha remnant of Swamp Sclerophyll forest which contains the Macksville flying-fox camp. The current camp footprint lies partly within the road corridor hence there would be a direct impact associated with the removal of critical flying-fox roosting habitat. The entire area of Swamp Sclerophyll Forest (23.5 hectares) could potentially be used for roosting during peak periods. There would also be indirect impacts to the remaining patch of Swamp Sclerophyll Forest. As such there would be impacts (direct and indirect) to a total of 23.5 hectares of critical roosting habitat as defined in the Recovery Plan (DECC, 2009).

Five vegetation types which provide critical foraging habitat for the Grey-headed Flying-fox occur within the construction footprint of the Project (Eby, 2012) and highly productive plants in the blossom diet of Flying-foxes dominant in these habitat types include *Corymbia intermedia*, *Eucalyptus pilularis*, *E. robusta*, *E. siderophloia* and *Melaleuca quinquenervia*. The loss of foraging habitat for these key vegetation types equates to 106.6 hectares and consists of:

- Blackbutt Open Forest – 75.2 ha.
- Mixed Floodplain Forest – 4.0 ha.
- White Mahogany/Grey Gum/Ironbark Moist Open Forest – 7.3 ha.
- Flooded Gum Moist Open Forest – 14.8 ha.
- Swamp Mahogany /Paperbark Swamp Forest – 5.3 ha.

The area of each vegetation type that would be cleared represents <1 per cent of the total extent of the type within a 50 kilometre radius of the Macksville camp (Eby, 2012). It is considered that the presence of foraging habitat within the region would maintain connectivity and food resources for flying-foxes. The most substantial impact would be from the loss of a relatively small area of Swamp Forest - Swamp Mahogany / Paperbark (Map Unit 6). Approximately 5.3 hectares of this unit would be lost from the study area from the Project. This vegetation unit is of particular importance to flying-foxes as it contains two key diet species and hence foraging habitat, *Eucalyptus robusta* and *Melaleuca quinquenervia*, which are productive during winter when feeding options are highly restricted and food scarcities are common (DECC 2009, Eby et al., 2012).

3.2.3 Fragmentation of habitat and impacts to connectivity

Impacts to flying-foxes from habitat fragmentation would occur at two scales: the scale of the remnant containing the flying-fox camp and the scale of the Project area. The linear area to be cleared bisects the remnant in an area used by roosting animals. The fragmentation of the roosting habitat may cause the animals to abandon the camp site.

Removal of vegetation beyond the remnant will result in fragmentation of foraging habitat. However, flying-fox are highly mobile species and are proficient at moving across fragmented landscapes. As noted above, foraging habitat is widely available within a 50 kilometre radius of the Macksville camp.

3.2.4 Disturbance of roosting sites

Clearing of the line of vegetation through the remnant Swamp Forest would substantially alter the vegetation and microclimate of the current camp area. The remnant will be bisected and new edges exposed to sun, wind and dry (rather than inundated) substrates will be introduced as will the potential for degradation of the vegetation along the edges.

Recent satellite telemetry work has clearly demonstrated that the animals roosting at the Macksville camp are part of the migratory population and move between various camps distributed over large distances from Macksville (J. Martin, RBGT Sydney, unpublished data). These animals are potentially exposed to dispersal actions that occur beyond the Macksville area, many of which are intentional. The long-term impact on the population is unknown and will depend on the ability of the flying-foxes to find a suitable alternate camp site. Twenty camp sites were recorded within a 50 kilometre radius of the Macksville camp, including the site itself (Eby 2012). Thirteen of the 20 camp sites meet at least one of the criteria for Roosting Habitat Critical to Survival of Grey-headed Flying-foxes as defined in the DECC (2009) (Eby 2012), refer to **Figure 2-1**.

3.2.5 Noise, vibration, dust and light impacts

The present roost site lies partly within the road corridor hence there will be a direct disturbance to the flying-fox roost site by construction activities. This is unavoidable due to the alignment of the State approved critical infrastructure project. The main construction impact from noise, vibration, dust and light would be associated with vehicles and machinery such as excavators, dozers, trucks, graders pile drivers and other machinery, rock fall etc during filling operations and ancillary noise associated with vegetation clearance. The area affected by disturbance from noise, vibration and dust would be defined as the area of habitat required to be removed for the construction of the Project plus a zone of 100 metres into the edge of the vegetation along the new edges. Some out of hours construction work would be required for health/safety, programming and engineering reasons which would require lighting. This would be discussed further with regulatory authorities and the adjacent community.

Opening of the section of the Project, in the vicinity of the flying-fox colony to highway traffic when the population of the roost is at or near its greatest may result in the abandonment of the roost, at least temporarily. The flying-fox camp may potentially be abandoned due to disturbance from noise, vibration, dust and light during construction. The most common method for intentionally dispersing flying-foxes from a roost is repeated exposure to loud noise (Roberts et al. 2011). The likely impact of noise during construction is, therefore, a particularly important consideration. The potential impact of vibration is not known. Richards (2004) reported that during the construction of the Southeast Freeway, the long term maternity colony at Slacks Creek in Brisbane vacated the site and did not return for 20 years. No mitigation measures were in place to reduce the impact of construction on the colony. Due to the timing of the desertion, it was concluded that the construction work caused the camp dispersal.

Eby (2013) summarised the conditions and outcomes of five construction projects of comparable magnitude to the WC2U Project and one smaller project, conducted in close proximity to flying-fox roosts (refer to **Table 3-1**). All construction works occurred whilst a flying-fox colony was in occupancy at the adjacent roost sites. Four of the roost sites were abandoned during construction and not re-established; and one roost site was abandoned but re-established 20 years later. It should be noted that whilst substantial construction activities were occurring around 240 metres from the Kurnell roost, the timing of roost abandonment at that site was additionally associated with drawdown of surface waters during severe drought conditions. As such it is not conclusive that the abandonment of the Kurnell roost could be attributed to adjacent construction activities.

In addition, the temporary roost that formed near the township of Tarcutta, NSW was established during a uniquely long and widespread food shortage for flying-foxes in south east Australia. The animals departed the site at a time when other temporary camps in the regional area also emptied. This also coincided with pile driving during construction of a bridge 250 metres from the roost. It is therefore not clear whether departure from the site was associated with the pile driving.

Table 3-1 A summary of the conditions and outcomes of five construction projects of comparable magnitude to the WC2U Project and one smaller project, conducted in close proximity to flying-fox roosts. This information is provided to assist in predicting the potential for flying-foxes to abandon the Macksville roost as an outcome of construction.

ROOST	PROJECT	WORKS NEAR ROOST SITE*	ROOST OCCUPANCY	APPROXIMATE DISTANCE ROOST TO WORKS	OUTCOME	NEW ROOST SITE & DIST
Kempsey Crescent Head Road	Pacific Highway Kempsey bypass	Crushing and screening facility, bridge piling	Annual - seasonal / long history of use	Around 200 metres from crushing plant and 500 metres from bridge piling activities	Roost present for the first two years of construction with ancillary facilities in operation as well as bridge piling activities. Roost abandoned after 2 years of construction commencing and has not re-established	Rudders Park, 2 km
Moorland	Pacific Highway Moorland to Herons Creek upgrade	Widen to 4 lane dual carriageway	Irregular / long history of use	Abuts: some roost site vegetation removed	Roost abandoned, not re-established	Lansdowne State Forest, 7 km
Kurnell**	Sydney Desalination Plant	Construction of extensive plant; 5 km pipeline; tunnelling; trenching	Annual – seasonal / long history of use	240 metres nearest above ground works, 450 metres nearest below ground works	Roost abandoned during construction, not re-established	Kareela, 10 km
Slacks Creek	Southeast Freeway (Qld)	Construct dual carriageway, interchange, bridge	Continuous / long history of use	175 metres to highway; 200 metres to the bridge	Roost abandoned during construction re-established after 20 years	Unknown
Tarcutta***	Hume Highway Tarcutta bypass	Construct 4 lane dual carriageway; bridge	Temporary (food shortage)	230 metres to highway; 250 metres to the bridge	Roost abandoned during construction, not re-established**	None, temporary site
Campbelltown	Access road	Construct 2 lane road; bridge piling	Annual – seasonal / new roost	80 metres to the road; 300 metres to the bridge	Roost remained through construction	Not applicable

* All construction works occurred whilst a flying-fox colony was in occupancy at the adjacent roost sites.

** Whilst substantial construction activities were occurring around 240 metres from the Kurnell roost, the timing of roost abandonment at that site was additionally associated with drawdown of surface waters during severe drought conditions. As such it is not conclusive that the abandonment of the Kurnell roost could be attributed to adjacent construction activities.

*** A temporary roost formed near the township of Tarcutta, NSW during a uniquely long and widespread food shortage for flying-foxes in south east Australia. The animals departed the site at a time when other temporary camps in the regional area also emptied. This also coincided with pile driving during construction of a bridge 250m from the roost. It is not clear whether departure from the site was associated with the pile driving.

Sources of information: http://www.rta.nsw.gov.au/roadProjects/index.html; A. Wyatt (OEH); C. Slade (Forests NSW); Eby (2009); Hall (2002); K. Whiting (EMM); A. Taylor (Campbelltown CC)

The roost associated with the smaller Campbelltown project was occupied throughout the construction period, despite works occurring 80 metres away. New roost sites were formed within 10 kilometres of three of the five abandoned sites.

3.2.6 Electrocution on power lines, entanglement in netting and on barbed wire fencing

No impact from electrocution would be anticipated. At its nearest point, the existing 11kV power line along the northern side of Bald Hill Road occurs approximately 600 metres south of the flying-fox camp. This power line would be relocated underground as part of the Project, thereby eliminating this potential risk to flying-foxes.

No impact from barbed wire fencing would be anticipated. Fauna exclusion fencing would be erected within the zone of cleared land five metres outside the footprint of the proposed activity. This fence would be connected to boundary fencing outside the forest to avoid the need to clear for and erect fencing, including barbed wire fencing, along the corridor boundary through the forest.

No netting would be installed as part of the Project.

3.2.7 Negative public attitude, conflict with humans and health risks

Conflict between humans and flying-foxes is an ongoing and increasing issue, particularly affecting camps located near developed areas. Conflict and negative perceptions of flying-foxes can affect the species directly through harassment and deliberate destruction (DECC, 2009). Should flying-foxes abandon the camp at Macksville, they would be likely to establish a new roost site in the local area rather than join an existing site (Roberts et al. 2011). Vegetation that meets known descriptive characteristics as roosting habitat is widely available. However, as critical roost selection criteria are not defined, it would not be possible to predict or control the location of a new site. A new camp could prove a source of conflict for people living in the surrounding area.

Flying-foxes can carry diseases of significance to humans. These diseases include Australian Bat Lyssavirus (ABL) and Hendra virus. ABL can only be contracted from being bitten or scratched by an animal infected with ABL. Hendra virus can only be contracted by contact with an infected horse. The colony would be tested for the presence of Hendra virus when the site is occupied by a sufficient population of flying-foxes. An ecologist, experienced with flying-foxes, would supervise vegetation clearing and habitat removal activities in the vicinity of the camp. A fauna handling protocol is discussed in **Section 5.3.7**.

3.2.8 Noise, vibration and light impacts

Operational impacts associated with noise and light will include general traffic noise and lighting from vehicles. Roadside lighting would be limited to lighting required for the interchange at Bald Hill Road south of the camp. Disturbance due to noise, vibration and light will be continual once the highway is operational. Noise, vibration and light impacts from vehicles will be greatest during peak traffic times. Due to the disturbance from noise, vibration and light being a permanent impact this impact will extend through all seasons.

Disturbance due to noise, vibration and light is expected to penetrate approximately 100 metres into the vegetation on either side of the highway.

3.2.9 Proximity of the camp from the disturbance

The present camp footprint lies partly within the road corridor. There will be a direct disturbance to the flying-fox camp site by the operation of the highway. This is unavoidable due to the alignment of the State approved critical infrastructure Project.

3.2.10 Mortality due to vehicle strike during take-off from roosting/foraging sites

Richards (2004) reported that flying-foxes are likely to die or be injured from collision with vehicles when exiting roosts near construction zones.

Flying-fox camp abandonment, at least temporarily, is expected to occur due to disturbance during construction (noise, dust) and during operation (noise, landscape alteration). In the event flying-foxes continue to forage in the surrounding swamp forest, there may be collisions between flying-foxes and vehicles due to the proximity of the camp to highway traffic. Collisions would be particularly likely at times when the flying-foxes are experiencing a shortage of food, are weaker and as such, are flying lower (Eby, 2013). Collisions can occur at a range of distances from roosts.

If females remain at the camp there is a likelihood of reduced ability to manoeuvre around traffic when carrying heavy, dependent young. Additionally, inexperienced young may also suffer vehicle strike due to an inability to avoid vehicles when learning to fly (Richards, 2004). In a banding study conducted between 1988 and 1999, Tidemann (1999) identified that 3 per cent of Grey-headed Flying-foxes died as a result of collision with motor vehicles.

3.2.11 Impacts to groundwater/ponded surface water within flying-fox habitat

During the April 2013 survey, the camp was located in the areas of deepest inundation in the swamp (water depths of 1-1.5 metres). There is a potential that changes to the groundwater/ponded surface water regime would occur as a result of local drawdown. Impacts on the dynamics of the ground and ponded surface water in the Project area could indirectly impact the flying-fox colony and result in the abandonment of the camp. Eby (2013) states that changes to the groundwater regime have the potential to substantially alter the microclimate of a camp site, particularly levels of humidity which can be important in defining roost locations (Snoyman and Brown 2010).

The Project would require cuttings through Bald Hill Road (to the south of the wetland) to be excavated to an approximate relative level of 10 metres Australian Height Datum (AHD) (some 15 to 17 metres depth). Groundwater levels in the areas of the cuttings are likely to be three to eight metres below the surface and thus groundwater seepages are anticipated into the cuttings, leading to a local drawdown in the groundwater level either side of the cutting beneath the Bald Hill Road ridgeline. An assessment by Coffey Geotechnics (2013) found, that on the basis of the supplied information, the drawdown of the groundwater level beneath the ridgeline is unlikely to have an environmental impact on surface ecosystems or existing groundwater usage on the ridgeline. Furthermore it is considered by Coffey to be highly unlikely that the Project would result in long term draw down of the groundwater table in the wetland area and the Nambucca River floodplain. Any surface water flows in the cutting/s would be captured and transported to the wetland area through drainage measures (with possible treatment if required).

Accordingly, the Project would not reduce the supply of groundwater that may currently flow towards to the wetland area and would be unlikely to result in long term draw down of the groundwater table in the section of Swamp Sclerophyll Forest where the flying-fox colony has a roosting camp. Further information regarding the hydrologic regime and management measures is provided in Section 16 of Volume 1 of the WC2U EA (RTA, 2010a).

However, modifications to the hydrological regime have the potential to impact on microclimates within vegetation communities by creating greater fluctuation in temperature and humidity (Catterall, Lynch and Jansen, 2007). Runoff from the highway has the potential to contain pollutants and fine sediment which can also modify vegetation communities by causing infilling of channels and alterations to water chemistry. This can also exacerbate the growth of aquatic weeds. This degradation of habitat can further reduce the amount of roosting and/or foraging resources available to flying-foxes.

The Project includes transverse drainage culverts to maintain the hydrological regime (and hence the microclimates within vegetation communities) during the operational phase. The Project also includes a range of water quality management measures, including sediment basins and drainage swales, to manage runoff from the highway and minimise the risk of pollutants and fine sediment entering the waterways.

4. Pre-construction management measures

4.1 Potential pre-construction impacts

Location of infrastructure within ancillary facility sites may impact on flying-fox habitat, movements, foraging and behaviour.

4.2 Main goals for management

The main goals for management are as follows:

- No damage to flying-fox habitat outside road corridor.
- No damage to flying-fox habitat outside designated ancillary facility areas.
- No mortality of flying-foxes due to the ancillary facilities.

4.3 Detailed design considerations

The alignment of the Project within the State approved corridor in the vicinity of the colony has been refined to maximise the separation from the camp. The refined alignment would involve locating the northbound carriageway as close as practical to the western boundary of the approved corridor and reducing the width of the median between the two carriageways from 12 metres to 5 metres.

A number of additional factors would be addressed in the detailed design phase to minimise the impacts of the Project. The factors to be considered which would be particularly relevant for the minimisation of impacts to the Macksville camp include:

- Avoiding and minimising vegetation removal.
- Consideration of the placement of ancillary facilities. These are required to be placed outside the 500 metres buffer distance from the camp.
- Consideration of potential long term changes to the hydrological regime within the Swamp Sclerophyll Forest.
- Consideration of the timing and staging of works.

4.4 Mitigation measures

4.4.1 Timing of activities

Clearing within the section of Swamp Sclerophyll forest south of Macksville in which the flying-fox colony became established in October 2011 would be undertaken when the camp is empty or at its lowest occupancy. Clearing would commence at the outer edges of the Swamp Sclerophyll forest and work in towards to the centre of the swamp along the clearing corridor alignment, in order to encourage any roosting flying-foxes to temporarily move out of the swamp forest during clearing activities. Monitoring of the colony to assist with management of impacts during construction and operation of the Project impacts undertaken to date indicates this is between 1 May and mid-September (refer **Appendix B**). These periods would be further informed by future survey information.

4.4.2 Identify habitat exclusion zones and construction buffers

The boundaries of habitat exclusion zones as documented in the approved CEMP and construction buffer zones required for measures to mitigate impacts during construction (see **Section 4.3**), would be identified pre-construction and marked or fenced.

An exclusion zone is a designated 'no-go' area that is clearly identified and appropriately marked or fenced to prevent damage to native vegetation and fauna habitat. This would be documented in the Flora and Fauna Management Plan (FFMP) and based on the recorded footprint of the flying-fox camp. A buffer zone refers to the area of separation between the flying fox camp and construction activities and /or ancillary facilities. The extent of buffer zones around the flying-fox camp would be measured from the combined mapped extent of the 2013-2014 surveys. The location of the buffer zones may be modified based on monitoring results of the camp.

A buffer zone of 300 metres would be imposed between the perimeter of the camp and major construction activities (e.g. clearing, earthworks, bridgeworks and pavement construction) undertaken between mid-September and the end of April the following year when the population of the camp is likely to be at or near its maximum. The existing highway, the temporary construction connection between the existing highway and the alignment and the Bald Hill Road interchange / cutting would be excluded from the 300 metres construction buffer zone. Fortnightly monitoring of the camp will be undertaken between 1 August and the end of April the following year. Clearing of vegetation within the buffer zone would halt if there are heavily pregnant GHFF or female GHFF with dependant young present. Construction activities within 300 metres of the perimeter of the camp may be undertaken before 1 May or after 15 September each year if monitoring demonstrates that no GHFF are present.

Subject to the above, activities within the 300 metre buffer zone between mid-September and the end of April the following year would be restricted to low noise/ low disturbance construction activities required for monitoring, maintenance and incident response purposes. Observational monitoring would be undertaken to ensure that the activities undertaken are causing minimal disturbance to any flying-foxes in the camp.

A timeline showing the implementation of the 300 metre construction buffer relative to the anticipated vacancy and occupancy of the Macksville flying-fox camp is included; refer to **Figure 4-1**.

Due to the nature of the activities undertaken at ancillary sites and the duration of their operation, ancillary sites have the potential to generate greater levels of disturbance than road construction activities. Accordingly, a buffer of 500 metres would be imposed between the perimeter of the camp and any ancillary sites throughout the period of construction of the Project.

4.4.3 Procedures for human interaction with flying-foxes and management of occupational health and safety risks

The best prevention of an interaction between a human and a flying-fox is to avoid contact with flying-foxes. If an injured or trapped flying-fox is identified, the Wildlife Information and Rescue Service (WIRES) will be telephoned for assistance.

If an individual is bitten or scratched, the health and safety procedure is to thoroughly wash the wound, apply an antiseptic solution such as povidone-iodine and contact a local doctor immediately. If the individual is at risk, a doctor may provide a post-exposure Rabies vaccine. Note that even if an individual has been vaccinated beforehand, they will need to be revaccinated (Office of Environment and Heritage (OEH), 2013). This information would be incorporated into the CEMP, induction and toolbox talks.

4.5 Pre-construction monitoring

4.5.1 Baseline monitoring

Baseline monitoring at the Macksville camp would continue to be undertaken through pre-construction to confirm flying-fox presence and determine population size, species abundance and diversity, demographics and camp footprint. Methods, timing, frequency and duration are outlined in **Section 6**. This data would inform mitigation measures and monitoring activities during construction and operation (refer to **Section 4.3**).

The pre-construction monitoring program would be important for developing a baseline of population condition prior to road construction. This would provide a point of comparison to assess the impacts of the road on the population of flying-foxes and monitor the effectiveness of mitigation measures.

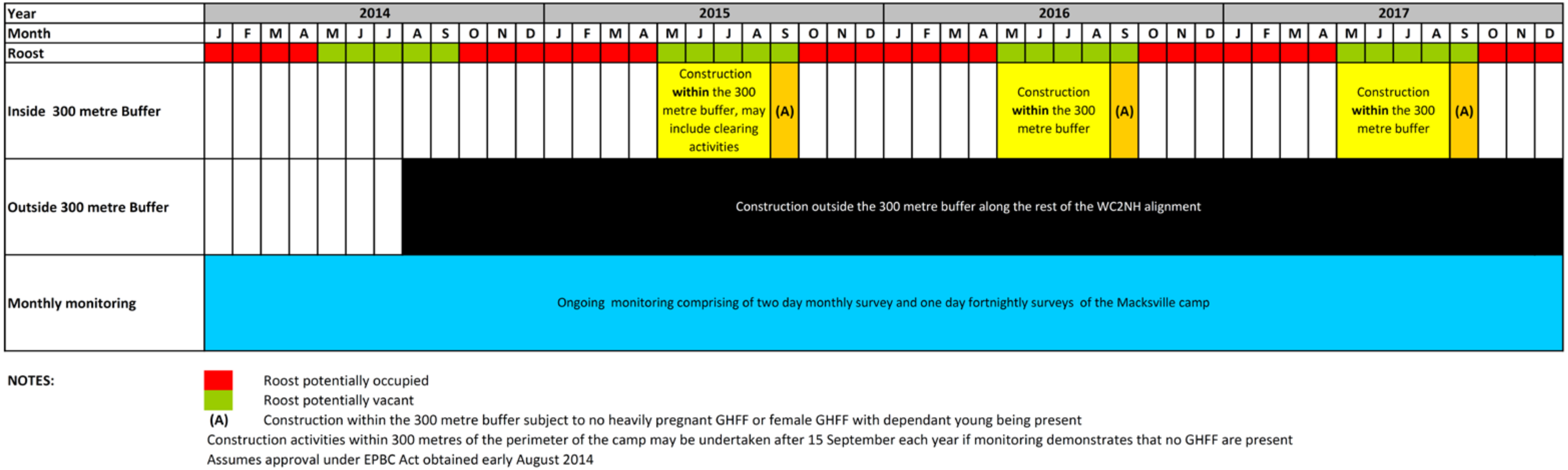


Figure 4-1 Summary timeline figure displaying construction buffer timing in relation to the occupancy of the Macksville roost

Note: Subject to (A) above and noise levels being less than the Operational Noise levels at this location once the Project opens to traffic (Leq 15hr = 56.5 dB(A) as predicted 100 m from the centre of carriageway), activities within the 300 metre buffer zone between 15 September and the end of April the following year would be restricted to haulage of materials (no construction works including no loading and unloading) and low noise / low disturbance construction activities required for monitoring, maintenance and incident response purposes if monitoring demonstrates that GHFF are present. (refer to Section 5.3.3).

4.5.2 Radio-tracking/satellite tracking

Practical/ cost effective radio-tracking/satellite tracking flying-foxes roosting in the Macksville camp prior to the start of construction may provide an opportunity to obtain data on the distribution and migratory patterns of flying-foxes in the area and the potential impacts of disturbance of the colony. The potential opportunities, benefits and impacts of radio-tracking/satellite tracking of flying-foxes roosting in the Macksville camp have been further investigated by Roads and Maritime. Advice from Dr Peggy Eby indicates that radio-tracking/satellite tracking flying-foxes would be of marginal value for the following reasons:

1) As per **Section 4.4.1**, it is highly likely that all tagged animals would depart the Macksville camp prior to disturbance commencing at the site.
2) The highly variable nature of flying-fox movements would make it difficult to interpret the impact of the disturbance on subsequent migration and feeding patterns.

Based on this advice there is no intent to pursue radio-tracking/satellite tracking of the Macksville camp flying-foxes during pre-construction monitoring.

4.6 Performance thresholds and corrective actions

Table 4-1 presents the main goals of management for pre-construction activities as described in **Section 4.2** and includes a summary of the relevant mitigation measures for flying-foxes that are to be completed prior to the commencement of construction. The table also describes how the identified mitigation measures are to be monitored, the timing and frequency of monitoring, who is responsible for implementing the measures, the performance thresholds that each goal is measured against and the corrective actions if deviation from the performance criteria occurs. A full description of the pre-construction management mitigation measures is included in **Section 4.4**.

Table 4-1 Summary of pre-construction management goals, mitigation measures, performance thresholds and corrective actions.

Main goal	Mitigation / control measure	Monitoring / timing frequency	Responsibility	Performance threshold	Corrective actions if deviation from performance criteria
• No damage to flying-fox habitat outside the road corridor or within identified exclusion areas.	• Identify exclusion zones and install exclusion fencing or marking. Exclusion fencing or marking is intended to exclude construction activities from occurring in flying-fox habitat. • Minimise through detailed design the incidence of clearing vegetation containing Swamp Mahogany, *Melaleuca quinquenervia*, *Banksia integrifolia* and *Eucalyptus tereticornis* that contribute to foraging habitat during known food bottle necks (i.e. winter period).	• Identify clearing limits prior to construction to mark and flag exclusion zones. • Follow-up inspection after surveying the Project area to ensure correct areas has been marked out prior to construction.	• Design and Construction (D&C) contractor. • D&C contractor.	• Exclusions zones identified and approved as part of the CEMP prior to construction being undertaken.	• Construction within or adjacent to areas of flying-fox habitat delayed and clearing works would not commence until exclusion zones have been approved as part of the CEMP.
• No damage to flying-fox habitat outside designated ancillary facilities. • No mortality of flying-foxes due to the ancillary facilities and pre-clearing activities.	• Minimise through detailed design the incidence of clearing vegetation containing Swamp Mahogany, *Melaleuca quinquenervia*, *Banksia integrifolia* and *Eucalyptus tereticornis* that contribute to foraging habitat during known food bottle necks (i.e. winter period). • Construction related infrastructure to be planned	• Detailed plans to be prepared showing the proposed location of construction related infrastructure and approved prior to the commencement of construction.	• D&C contractor	• Exclusions zones identified and approved as part of the CEMP prior to construction and clearing works being undertaken.	• Construction within or adjacent to areas of flying-fox habitat delayed until ancillary facility locations have been approved.

Main goal	Mitigation / control measure	Monitoring / timing frequency	Responsibility	Performance threshold	Corrective actions if deviation from performance criteria
	and sited within cleared or disturbed areas of the ancillary site. Particularly away from water sources and flying-fox movements areas.				

5. Construction management measures

5.1 Summary of potential impacts

- Direct impacts of clearing work.
- Loss of habitat including loss of potential roosting sites and foraging opportunities.
- Fragmentation of habitat and impacts to connectivity.
- Disturbance of roosting site.
- Noise, vibration, dust and light impacts.
- Impacts to groundwater/ponded surface water within flying-fox habitat.

5.2 Main goals for management

- No injury or mortality to flying-foxes as a result of vegetation clearance or construction of the Project.
- Minimise removal of roosting and foraging habitat outside the boundaries of the Project or within identified exclusion zones.
- Minimise removal of threatened flying-fox habitat outside designated ancillary facility areas.
- Minimise disturbance to the flying-fox camp from vegetation removal, surface water drawdown, noise, vibration and lighting.
- Impacts to flying-foxes during clearing managed in accordance to fauna handling protocol.
- No contamination or isolation of water supplies.

5.3 Mitigation measures

A program of measures to mitigate impacts of construction of the Project on flying-foxes would be implemented. The main strategy would be to avoid exposing animals to potentially harmful work whenever practicable through careful timing and definition of permissible activities within buffer zones around the perimeter of the camp.

5.3.1 Timing of activities

Survey work undertaken at the flying- fox camp has indicated that the camp would be empty or at its lowest occupancy between May and mid-September. Accordingly, it is proposed that construction activities along the approved alignment within the vicinity of the flying fox camp would be restricted if and when GHFF are present between 15 September and 1 May the following year. The period would be further informed by future survey information.

As discussed in **Section 3.2** above, opening of the section of the Project in the vicinity of the flying-fox colony to highway traffic when the population of the roost is at or near its greatest may result in the abandonment of the roost, at least temporarily. To minimise the risk of abandonment of the roost, Roads and Maritime has investigated opportunities to open the section of the Project in the vicinity of the camp to highway traffic when the roost is either empty or at its lowest. Subject to favourable weather during the construction period, opening of the section of the Project in the vicinity of the camp to highway traffic may be able to be achieved in the winter period prior to mid-September 2018. Extended working hours, potentially including all night work, would increase the likelihood of opening this section of the Project at this time. The potential extension of working hours to enable the section of the Project to be opened to traffic in the winter period prior to mid-September 2018 would be discussed further with regulatory authorities and the adjacent community.

5.3.2 Construction work method statements

Specific environmental work method statements (EWMS) would be prepared for specific works to ensure sound environmental practices have been implemented and to minimise the risk of environmental incidents or system failures, in accordance with the CEMP and to address flying fox issues. These would be prepared for works in the vicinity of the flying fox roost and for clearing of flying-fox habitat along the Project in consultation with relevant agencies, Roads and Maritime and the relevant Project environmental manager prior to the commencement of identified activities.

General responsibilities for environmental management are outlined in the approved construction environmental management plan (CEMP).

Roads and Maritime finalised this Flying-fox Management Plan in consultation with the Commonwealth DoE, NSW DP&I and EPA in December 2014 for the second stage of the WC2U project (WC2NH). DoEEacceptance of the plan and staging priorities was received in January 2015. Roads and Maritime, the construction contractor and the contractor's ecologist engaged for the WC2NH Project, the section relevant to the Macksville Flying-fox camp, are responsible to oversee the implementation of the plan.

5.3.3 Buffers zones and permissible construction activities

A buffer zone refers to the area of separation between the flying fox camp and construction activities. The extent of buffer zones around the flying-fox camp will be measured from the combined mapped extent of the 2013-2014 surveys. The location of the buffer zones may be modified based on monitoring results of the camp.

Based on the fact that the existing Pacific Highway, which is the main source of noise in the subject area, is located within approximately 330 metres of the mapped edge of the flying-fox camp survey in 2012, it is proposed that a buffer of 300 metres is appropriate between the perimeter of the camp and major construction activities (eg clearing, earthworks, bridgeworks and pavement construction) undertaken between mid-September and the end of April the following year when the population of the camp is likely to be at or near its maximum. The existing highway, the temporary construction connection between the existing highway and the alignment and the Bald Hill Road interchange / cutting would be excluded from the 300 metre construction buffer zone.

The systematic program of monthly monitoring introduced in winter 2013 (as discussed in Section 2.2) will continue through to 12 months after the opening of the Project to traffic. Fortnightly monitoring of the flying-fox camp will be undertaken from 1 August 2014 until clearing is complete. When construction is being undertaken within the buffer zone, daily walk through inspections will be undertaken prior to works commencing.

Subject to the following, construction activities within the 300 metre construction buffer zone will be restricted to the period 1 May to 15 September each year. Clearing of vegetation within the buffer zone will halt if heavily pregnant GHFF or female GHFF with dependant young are present as verified by the project ecologist. Construction activities within the buffer zone may be undertaken before 1 May or after 15 September each year if monitoring demonstrates that no GHFF are present.

The likely impacts associated with these activities would be reviewed with input and advice from Dr Eby or another suitably qualified and experienced GhFF expert. Observational monitoring of the camp for a-typical behavioural responses would be undertaken during the execution of these activities to assess any impacts on the flying-foxes. Noise monitoring of the haulage operations will be undertaken to substantiate that the activity is of no greater impact than predicted to occur post opening at dawn and dusk if GhFF are present. If noise levels exceed post opening levels haulage activities will cease.

It is recognised that activities occurring at ancillary sites would operate through the year. Accordingly a buffer of 500 metres would be imposed between the camp and any ancillary sites. A summary of the construction buffer zones and permissible activities allowed during construction are summarised in **Table 5-1**.

The flying fox camp would be monitored prior to and throughout construction. The population size, roosting location and demographics of the colony would be assessed as would key behaviours (e.g. reproductive behaviours). The methods employed would be consistent with those established in the pre-construction monitoring program. The methods would enable repeat measures to be compared statistically and would allow comparisons to be drawn with other camps (control sites). The frequency of monitoring sessions would vary according to the phase of the annual cycle of flying-foxes. Details of the monitoring program are provided in **Section 6** and a decision flow chart that is to be followed regarding permissible construction activities within the 300 metre buffer zone based on the results of monitoring of the Macksville flying-fox camp is summarised in **Figure 5-1**.

For the purposes of this plan, low noise / low disturbance construction activities required for monitoring, maintenance and incident response purposes include the following:

- monthly GhFF population and presence monitoring,
- daily pre construction GhFF presence inspections,
- noise monitoring during haulage operations,
- monthly and post rainfall surface and ground water sample collection,
- inspection and repair of erosion and sediment controls, and
- environmental incident response and management.

Table 5-1 Summary of mitigation measures during construction

Construction works would be managed to accommodate the following mitigation measures: ▪ A buffer of 300 metres would be imposed around the perimeter of the camp. The extent of buffer zones around the flying-fox camp would be measured from the combined mapped extent of the 2013-2014 surveys. The location of the buffer zones may be modified based on monitoring results of the camp. ▪ Construction activities within the 300 metre buffer zone would halt if monitoring demonstrates that heavily pregnant GHFF or female GHFF with dependant young were present. ▪ Construction activities within the buffer zone would be undertaken between 1 May and 15 September and if flying-fox are present in the clearing corridor the contingency strategy would be implemented. ▪ Construction activities within the buffer zone may be undertaken after 15 September each year if monitoring demonstrates that no GHFF are present. ▪ Subject to the above, and noise levels being less than the Operational Noise levels (at this location once the Project opens to traffic (Leq 15hr = 56.5 dB(A) as predicted 100 m from the centre of carriageway), activities within the 300 metre buffer zone between mid-September and the end of April the following year would be restricted to haulage of materials (no construction works including loading or unloading) and low noise/ low disturbance construction activities required for monitoring, maintenance and incident response purposes if monitoring demonstrates that GHFF are present. Observational monitoring on a daily basis along with noise monitoring during haulage operations in the morning and afternoon will be undertaken to ensure that the haulage of materials and low level noise/disturbance activities are in fact meeting those criteria. ▪ A buffer of 500 metres would be imposed around the perimeter of the camp for ancillary facilities. Ancillary sites would be excluded from this area throughout the period of construction of the Project. ▪ To minimise the extent of clearing of the Swamp Sclerophyll Forest within which the flying-fox colony is located, clearing of the forest would be limited to five metres outside the footprint of the proposed activity. ▪ The impact of construction activities on the flying fox colony would be monitored during construction. Fortnightly monitoring of the camp to be undertaken from 1 August 2014 clearing is complete Once clearing is complete monitoring is to be monthly in association with daily pre-dawn walk through inspections prior to works commencing. ▪ Clearing of vegetation would halt if there are heavily pregnant GHFF or female GHFF with dependant young present noting that an ecologist, experienced with flying-foxes would be on site during removal of vegetation in the vicinity of the flying-fox camp. ▪ Other construction activities would halt if there are heavily pregnant GHFF or female GHFF with dependant young present after 31 August. ▪ Construction activities within the buffer zone may be undertaken prior to 1 May or after 15 September each year if monitoring demonstrates that no GHFF are present. ▪ Measures would be implemented to ensure that the proposed activity does not result in long term changes to the natural surface water levels in the vicinity of the camp. Monitoring would be carried out to identify any changes to water levels using appropriate expertise where practicable. ▪ A temporary construction access road may be constructed from the existing highway to the proposed activity to the north of the flying fox camp to reduce potential impacts on the colony by providing access to the critical works on the Nambucca River floodplain and bridge over the Nambucca River. At its closest, the temporary construction access would be about 500 metres from the perimeter of the camp. The existing highway, the temporary construction connection between the existing highway and the alignment and the Bald Hill Road interchange / cutting would be excluded from the 300 metre construction buffer zone. ▪ The alignment of the Project within the State approved corridor in the vicinity of the colony would be refined to maximise separation from the camp. ▪ Measures may be implemented to facilitate opening of the section of the Project in the vicinity of the flying-fox camp-site to highway traffic when the population is at or near its minimum.

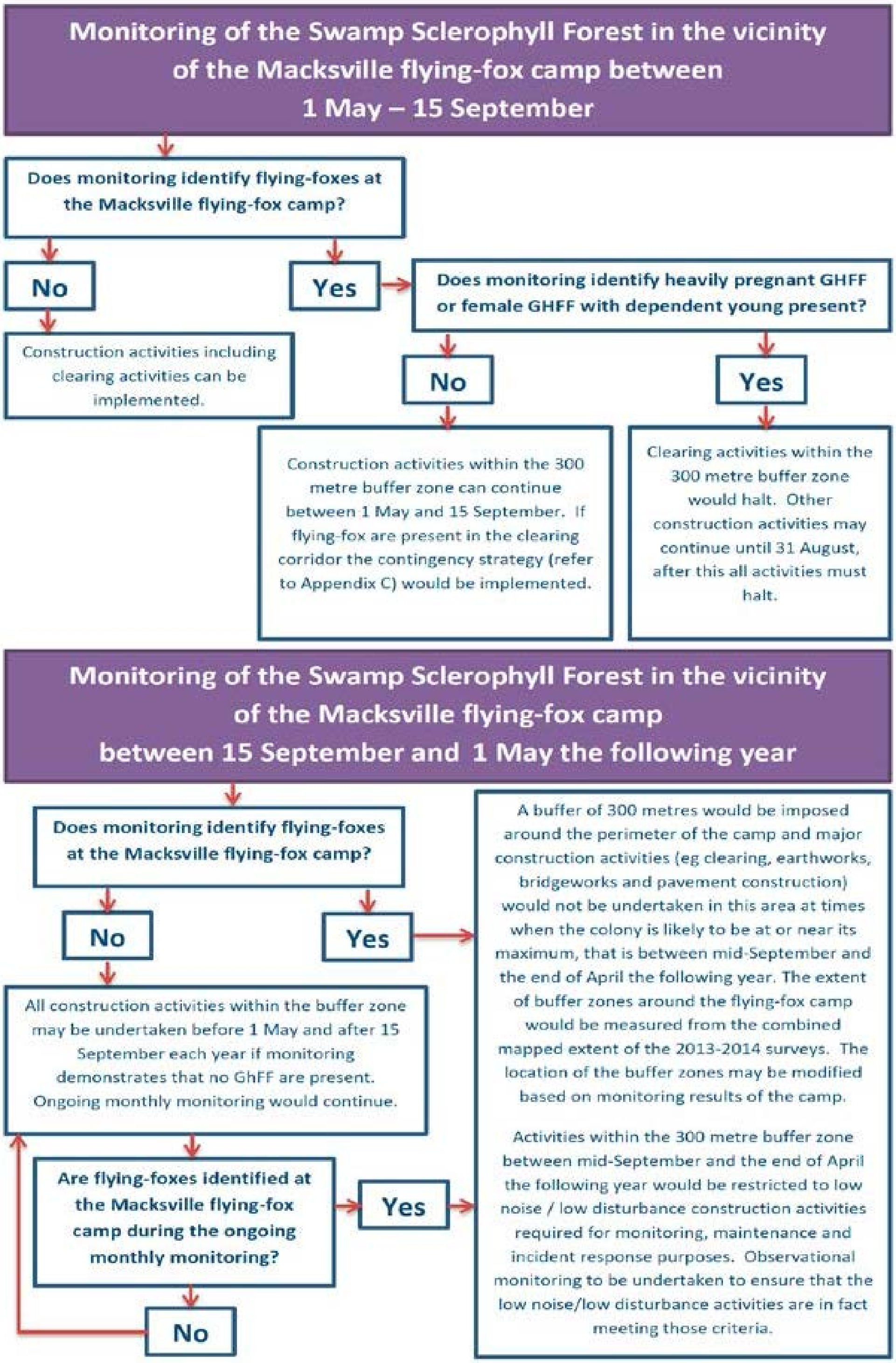


Figure 5-1 Flow chart that is to be followed regarding permissible construction activities within the 300 metre buffer zone based on the results of monitoring of the Macksville flying-fox camp

Note: Subject to the above and noise levels being less than the Operational Noise levels at this location once the Project opens to traffic (Leq 15hr = 56.5 dB(A) as predicted 100 m from the centre of carriageway), activities within the 300 metre buffer zone between 15 September and the end of April the following year would be restricted to haulage of materials (no construction works including no loading and unloading) and low noise / low disturbance construction activities required for monitoring, maintenance and incident response purposes if monitoring demonstrates that GHFF are present.

5.3.4 Construction induction and training

All contractors and other staff that would be working in the area of the flying-fox camp south of Macksville would be given tool box talks and training as part of the WC2NH Project specific induction regarding the Grey-headed Flying-fox and management of impacts to the species. This training would identify the two species of flying-fox recorded at the Macksville camp with particular emphasis on the threatened Grey-headed Flying-fox, their habitats, distribution and key threats, and all personnel would be trained to identify the species. The importance of following the clearing protocols would be made clear for all personnel that require access to the site.

5.3.5 Pre-clearing and clearing procedures

Pre-clearing and clearing procedures would be outlined in the approved Flora and Fauna Management Plan (FFMP), and would be undertaken in accordance with *Biodiversity Guidelines: Protecting and managing biodiversity on RTA Projects* (RTA 2011). In summary, prior to the commencement of clearing operations, the Project ecologist would identify all areas that contain vegetation and habitat to be retained, including exclusion zones. Targeted surveys for flying-foxes would also be undertaken.

If a flying-fox is identified within the construction clearing zone, all clearing works will cease within 100 metres of the observed individual, or the edge of the group if a number of individuals are identified. Clearing will not commence in the area where the flying-foxes were identified until clearance is given by the Project ecologist. This is to enable the animal to move off its own volition or to be relocated in accordance with the *NSW Code of Practice for Injured, Sick and Orphaned Flying-foxes* (OEH 2012).

The ecologist would manage any injured or displaced flying-foxes with assistance from a wildlife carer or vet for rehabilitating injured wildlife. The ecologist or wildlife carer would relocate and release displaced flying-foxes upon confirmation of the animal's health.

5.3.6 Contingency strategy for moving flying-foxes out of the highway corridor during clearing operations between the period 1 May – 15 September.

Should a flying-fox (or group of flying-foxes) be identified within the construction clearing zone and within 100 metres of clearing activities during the pre-clearing ecology surveys outlined above, the contractor may need to move the flying-foxes out of the construction clearing zone using the contingency strategy included in **Appendix C**.

The contingency strategy for moving the flying-fox has been prepared as a precautionary measure should flying-foxes remain in the camp during the 1 May to 15 September period when clearing work is proposed to be undertaken within the 300 metre construction buffer. Concurrence from EPA and DoEEwould be obtained prior to implementation of the contingency strategy included in **Appendix C**.

The contingency strategy aims to move flying-foxes from vegetation proposed to be removed during clearing activities and 100 metres beyond this in order to prevent stress, injuries or mortality to the animals. The aim of the contingency strategy is to herd the animals through the contiguous tract of Swamp Sclerophyll Forest until they reach vegetation not proposed to be removed during the clearing activities. This strategy is a temporary contingency to minimise impacts on flying-foxes should animals be roosting in vegetation proposed to be removed and is not a long term dispersal/relocation strategy. No disturbances to the flying-foxes would occur during high wind, heavy rain or other adverse environmental conditions. Pre-clearance ecology surveys would occur daily prior to any clearing works commencing.

The contingency strategy for moving the flying-foxes out of vegetation proposed to be removed during clearing activities would be undertaken as a series of separate steps. Each individual step would only be implemented if the previous step was not successful in moving all flying-foxes out of vegetation proposed to be removed. Refer to Appendix C for further detail. The 100m offset from the construction corridor is also adopted for noise monitoring during haulage operations if GhFF are present.

5.3.7 Fauna handling protocol

An ecologist would be present on site during all vegetation clearing activities in the vicinity of the Macksville camp to monitor the behaviour of any flying-foxes that may be present. Licensed wildlife carers would be identified prior to commencement of works to ensure that personnel are available on-site as required. Any injured, sick or orphaned flying-foxes will be cared for by a licensed wildlife carer. A daily fauna incident log will be maintained during clearing activities.

5.3.8 Management of construction noise, vibration and light impacts

Impacts to the flying-fox camp from construction noise, vibration and light would be managed through maintaining a works buffer of 300 metres between the perimeter of the camp and major construction activities (e.g. clearing, earthworks, bridgeworks and pavement construction) if GhFF are present between mid-September and the end of April the following year when the population of the camp is likely to be at or near its maximum. The existing highway, the temporary construction connection between the existing highway and the alignment (if required) and the Bald Hill Road interchange / cutting would be excluded from the 300 metre construction buffer zone. Fortnightly monitoring of the camp would be undertaken from 1 August 2014 to clearing is complete. Clearing of vegetation within the buffer zone would halt if there are heavily pregnant GHFF or female GHFF with dependant young present. Other construction activities would halt if there are heavily pregnant GHFF or female GHFF with dependant young present after 31 August. Construction activities within the buffer zone may be undertaken prior to 1 May or after 15 September each year if monitoring demonstrates that no GHFF are present.

Subject to the above and noise levels being less than the Operational Noise levels at this location once the Project opens to traffic (Leq 15hr = 56.5 dB(A) as predicted 100 m from the centre of carriageway), within the 300 metre buffer zone between 15 September and the end of April the following year would be restricted to haulage of materials (no construction works including no loading and unloading) and low noise / low disturbance construction activities required for monitoring, maintenance and incident response purposes if monitoring demonstrates that GHFF are present. Observational monitoring of the camp for a-typical behavioural responses would be undertaken during the execution of these activities on a daily basis to assess any impacts on the flying-foxes. Construction activities within 300 metre of the perimeter of the camp may be undertaken after 15 September each year if monitoring demonstrates that no GHFF are present.

A buffer of 500 metres would also be imposed between the camp and any ancillary sites throughout the period of construction of the Project.

5.3.9 Management of construction impacts to groundwater/ponded surface water levels

It is acknowledged that the dynamics of the ground and ponded surface water in the area could indirectly impact on the camp and result in the potential abandonment of the camp. Management of this potential impact would include cross drainage and the provision of a permeable, free draining rock platform to ensure that the proposed activity does not result in long term changes to the natural surface water levels in the vicinity of the camp. It is noted that drought and rainfall may alter water levels and Roads and Maritime would have no influence on changes on these variables, nor any freehold works outside the corridor.

Short term modifications to the level of the ponded surface water in the area may be required during the 1 May to 15 September period during which construction activities along the approved alignment within the vicinity of the flying fox camp would be undertaken. Any short term modifications to the level of the ponded surface water in the area would be undertaken to facilitate construction of this section of the Project within the available 1 May to 15 September period. Any short term modifications to the level of the ponded surface water in the area would be implemented for the minimum time required to facilitate construction of this section of the Project.

Monitoring within, upstream of and downstream of the construction corridor would be carried out to identify any changes to water levels.

5.3.10 Management of construction impacts to water quality

The Project has the potential to change the ground water and surface water hydrological functioning of the surrounding habitat due to dewatering of the swamp during construction, increased runoff containing pollutants and fine sediment and weed invasion. These changes may have impacts on the suitability of the habitat as a foraging site and the suitability of remaining vegetation as roosting habitat for flying-foxes.

Rainfall in the area would be monitored in association with drainage performance to identify if the hydrology and water quality has been adversely impacted by the Project. Procedures, including erosion and sediment control measures included in the approved CEMP, would be implemented to maintain water quality during construction. These measures would be important in maintaining the current condition of flying-fox habitat retained within and adjacent to the Project and include:

- Controlled access to watercourses by construction workers and vehicles.
- Storage of chemicals, fuel and lubricants in suitably located and bunded areas to minimise the impact of any spillage or contamination on the Construction Site and adjoining areas. No location of these storage areas within 50 metres of any aquatic habitat, flood prone areas, or on slopes steeper than 1:10.
- No refuelling or maintenance of plant and equipment, mixing cutting oil with bitumen, or carrying out any other activity which may result in spillage of a chemical, fuel or lubricant at any location which drains directly to a waterway or environmentally sensitive areas, without the appropriate temporary bunding being provided. No unattended refuelling operations.
- Specific measures for construction and operational phase water quality management, including pollution and discharge controls, construction and operational phase water quality basins and swales.

5.3.11 Management of construction vehicles

All construction vehicles would be required to comply with the speed limits set out in the CEMP and to remain out of exclusion areas. Low noise reversing beepers (quakers) on vehicles will be used on vehicles.

5.3.12 Strategies for minimising flying-fox vehicle strike during take-off from roosting/foraging

Construction within 300 metres of the flying-fox roost will be restricted to the period 1 May to 15 September when the camp is vacated or at its lowest occupancy. These periods would be further informed by future survey information. Construction activities within 300 metres of the perimeter of the camp may be undertaken after 15 September each year if monitoring demonstrates that no GHFF are present.

To minimise the risk of flying-fox vehicle strike during take-off from roosting/foraging, road corridor revegetation and ornamental planting is not to include plants that flower prolifically and produce nectar food sources likely to attract flying-foxes.

5.3.13 Procedures for human interaction with flying foxes and management of occupational health and safety risks

A procedure for the management of human interaction with flying-foxes would be included in a communication and media strategy which would be prepared prior to the commencement of construction. The strategy would include, but not be limited to:

- A mechanism for people to make reports of new GHFF camps or increases in numbers.
- A series of press releases, targeted communications and/or media releases for potentially impacted communities, particularly for residents/receivers adjacent to existing camp sites.
- A mechanism for dispute resolution.

The strategy will be included in the Community Communication Strategy required under MCoA B28 which would be prepared by Roads and Maritime in consultation with EPA.

5.3.14 Procedures for managing the loss of roosting and foraging habitat

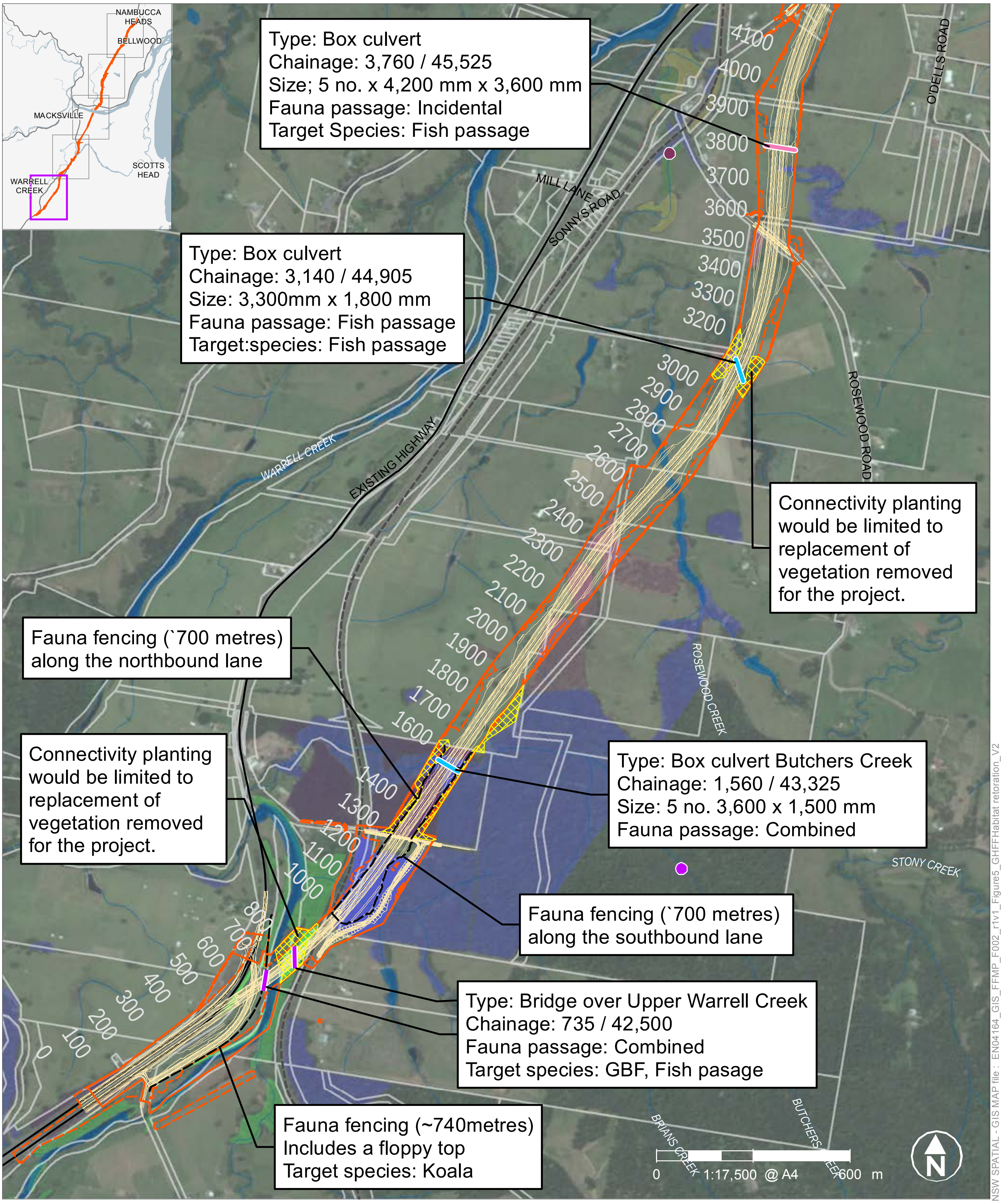
Habitat restoration would occur in areas of flying-fox habitat identified along the edges of the highway alignment that have been directly or indirectly impacted as part of the Project and would include temporary ancillary facilities, access tracks, watercourse crossings, etc (refer to the maps series included as **Figure 5-2**). These areas would be actively rehabilitated, regenerated and/ or revegetated to promote biodiversity outcomes and visual integration. Key rehabilitation measures would include:

- Progressive revegetation/rehabilitation during the construction phase using collected topsoil and seed at specific sites and to develop different successional stages of rehabilitation.
- Planting and seeding of preferred food trees for the GHFF which includes winter-flowering trees to supplement seasonal foraging habitat (refer to **Appendix D**).
- Monitoring revegetation/rehabilitation areas to ensure the establishment/restoration of seedlings and plants.
- Management and control of noxious and environmental weeds.

These measures would be implemented as part of the CEMP for the Project.

Roads and Maritime is developing a biodiversity offset package in accordance with the EPBC Act offsets policy for the residual impacts to the GHFF habitat. For the GHFF, the proposed offsets allow for impacts on both foraging and roosting habitat. As a precautionary approach, the proposed offsets assume that all of the 23.5 hectare patch of Swamp Sclerophyll Forest within which the camp site is located could be used for roosting during peak periods and that the Project could have direct or indirect impacts on entire patch of forest.

As part of the offset package, Roads and Maritime would also provide funding to enable the implementation of the *Bowraville flying-fox camp Plan of Management* adopted by Nambucca Heads Shire Council following consultation with the affected community. Roads and Maritime funding would be up to the lesser of $100,000 or 50 per cent of the cost of implementing the Management Plan.



Legend

- Proposed areas of connectivity and habitat restoration
- Road boundary
- Road design
- Service Road - Old Coast Road
- Clearing boundary
- State Forest boundary
- Lot (survey)
- Combined culvert with fauna underpass
- Dedicated fauna underpass
- Fauna fence
- Bridge with fauna passage
- Incidental fauna passage

Vegetation map units (WC2U EA, RTA

- Map Unit 1: Open Forest - Blackbutt
- Map Unit 2: Mixed Floodplain Forest (Subtropical Coastal Floodplain Forest (EEC – TSC Act)
- Map Unit 3: Moist Open Forest - White Mahogany/Grey Gum/Ironbark
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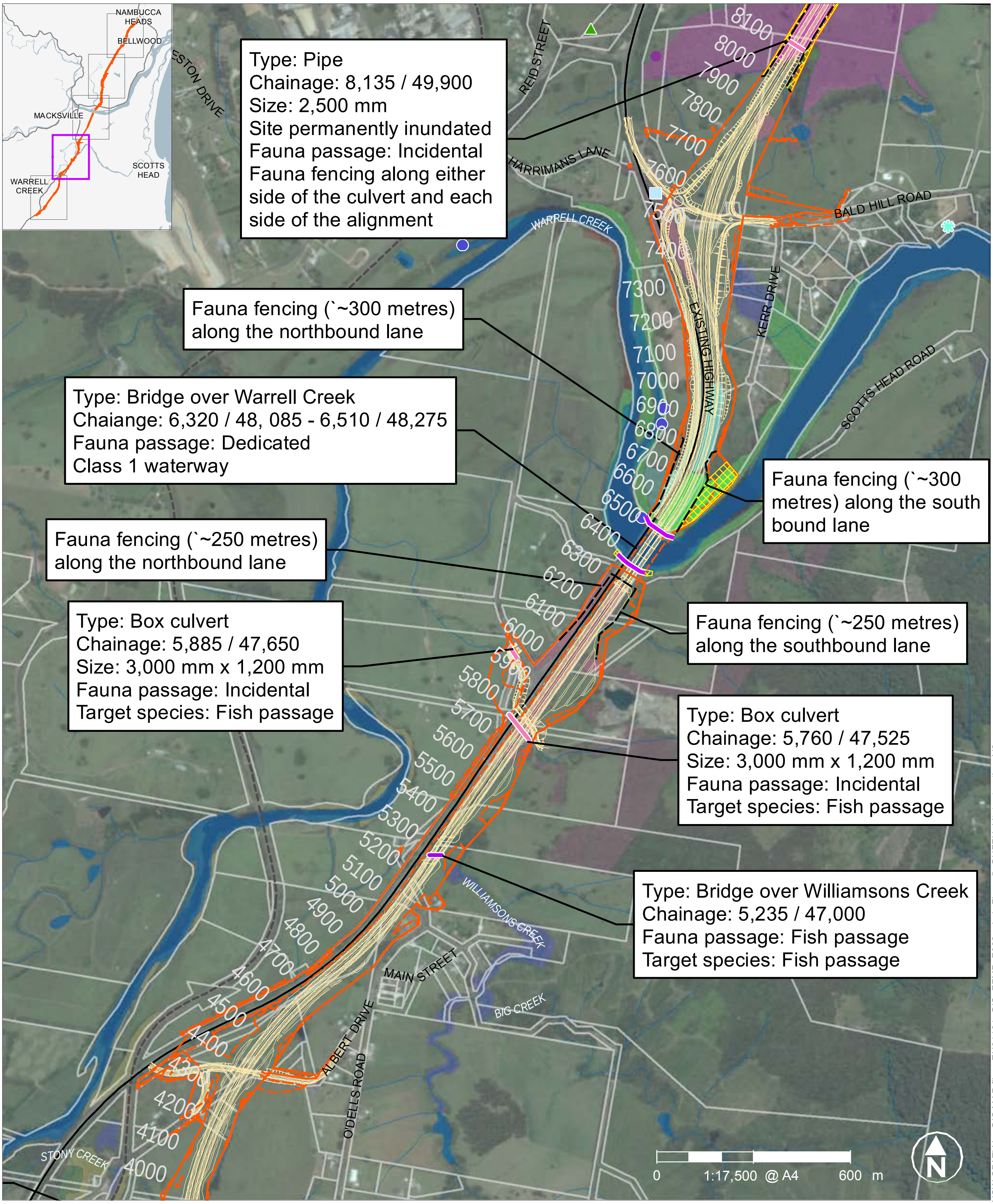
- Map Unit 10: Coastal Saltmarsh (VEC – EPBC Act and TSC Act)
- Map Unit 11: Open Forest - Scribbly Gum
- Map Unit 12: Hardwood plantation
- Map Unit 13: Softwood plantation

NOTES
- The chainages in this figure reflect the WC2U EA chainages. To convert these to the referral chainages add 41765.
- The locations of the fauna crossings and fauna fences are indicative only.

DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information

NSW GOVERNMENT | Transport Roads & Maritime Services
SKM

Figure 5-2 | Fauna connectivity and habitat restoration



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Legend

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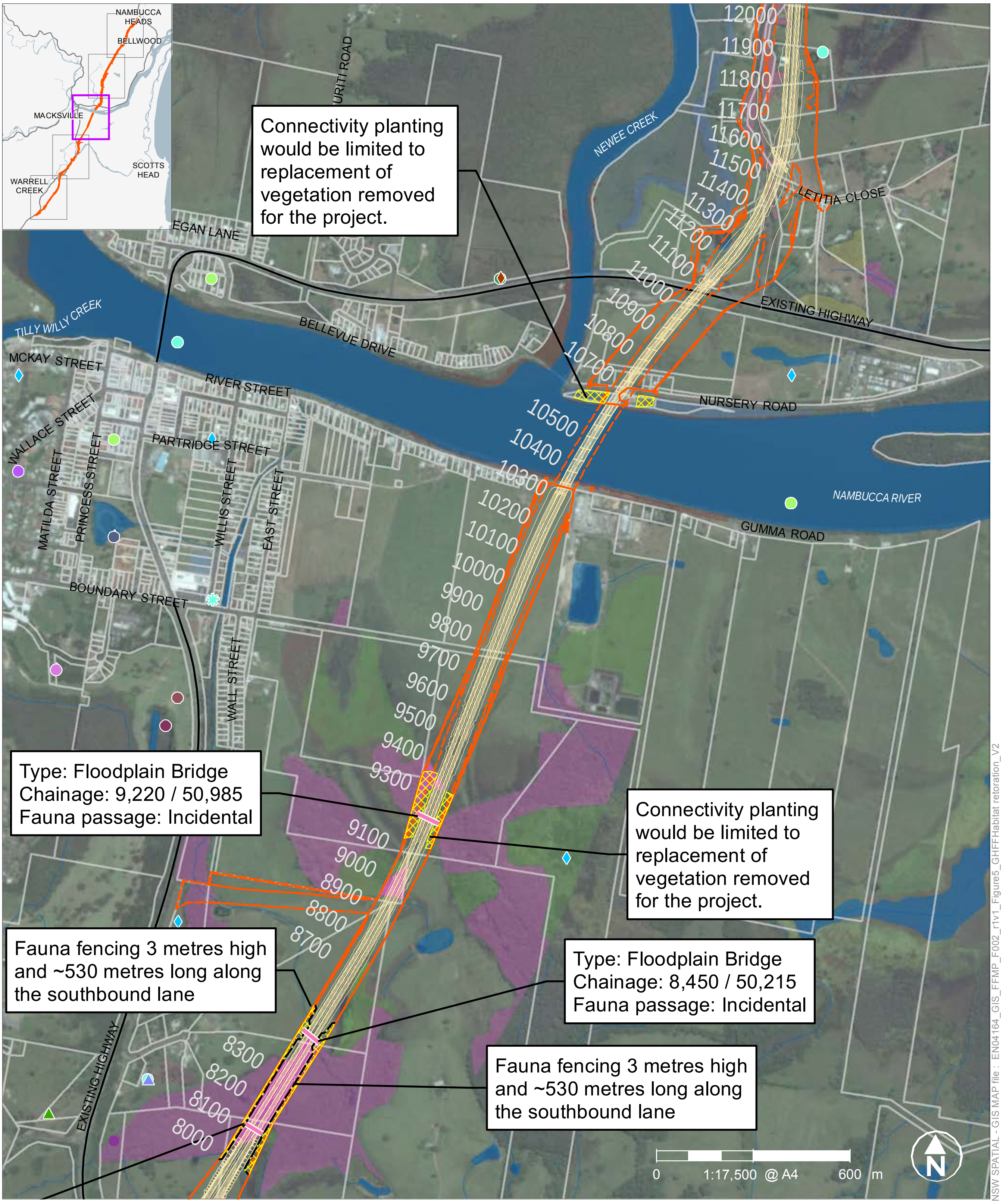
SKM

Figure 5-3 | Fauna connectivity and habitat restoration



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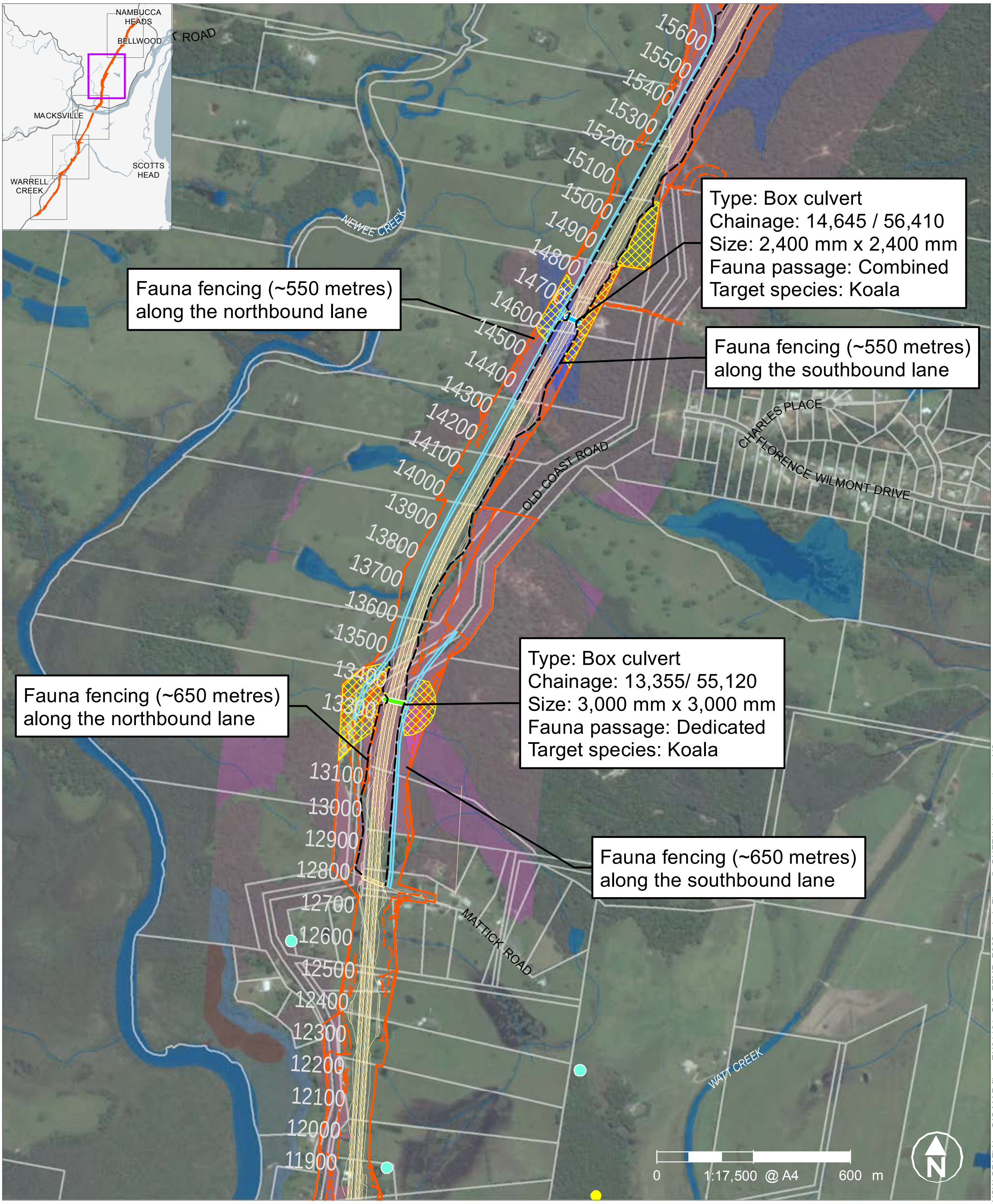
NSW GOVERNMENT Transport Roads & Maritime Services SKM

Figure 5-4 | Fauna connectivity and habitat restoration



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Legend

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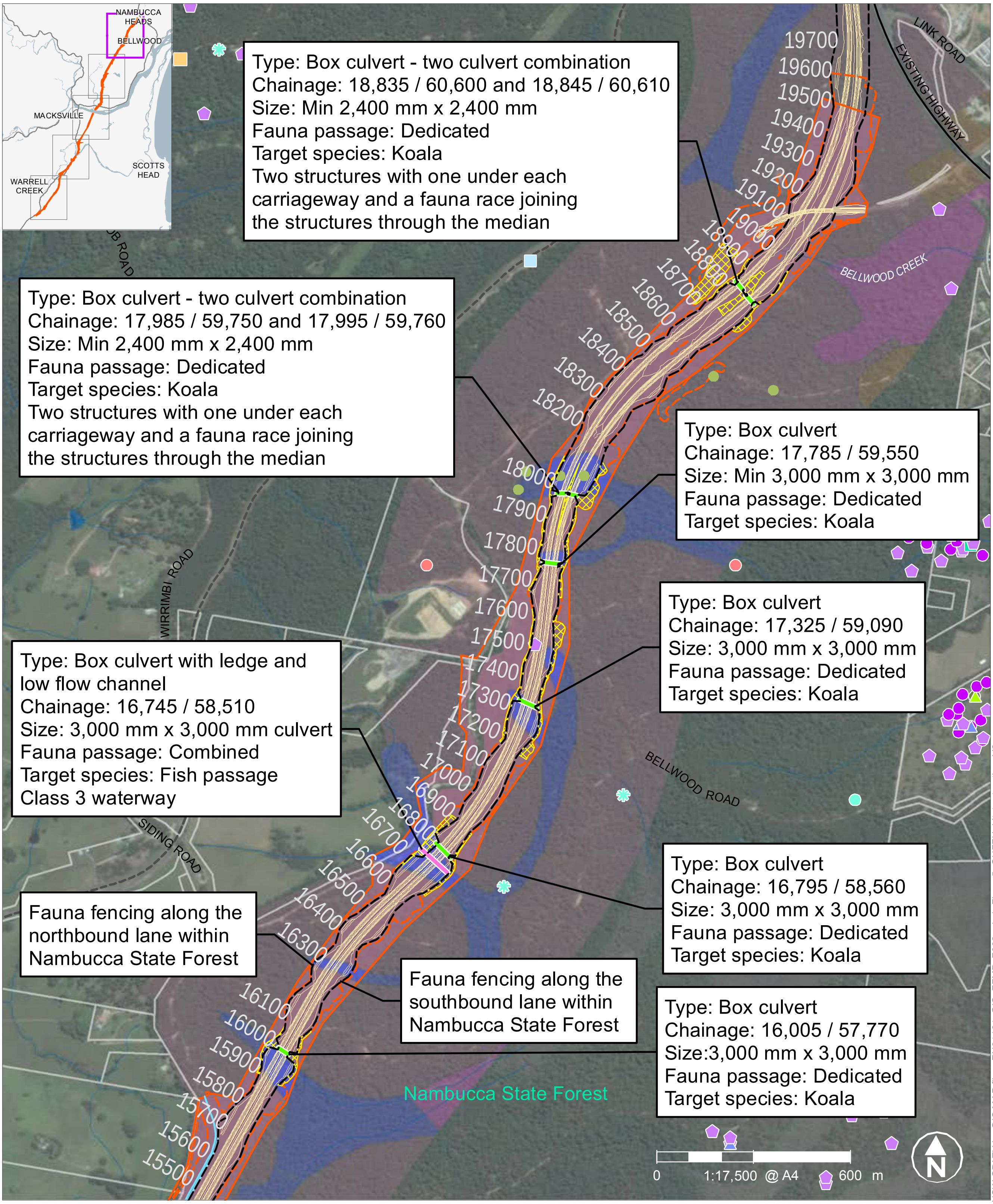
NSW GOVERNMENT Transport Roads & Maritime Services SKM

Figure 5-5 | Fauna connectivity and habitat restoration



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- Map Unit 4: Moist Open Forest - Flooded Gum
- Map Unit 5: Lowland Rainforest (EEC – EPBC Act and the TSC Act)
- Map Unit 6: Swamp Forest - Swamp Mahogany/Paperbark (Swamp Sclerophyll Forest (EEC – TSC Act)
- Map Unit 7: Swamp Forest - Swamp Oak (Swamp Oak Floodplain Forest (EEC – TSC Act)
- Map Unit 8: Freshwater Wetlands (TEC – TSC Act)
- Map Unit 9: Mangrove Forest
- Map Unit 10: Coastal Saltmarsh (VEC – EPBC Act and TSC Act)
- Map Unit 11: Open Forest - Scribbly Gum
- Map Unit 12: Hardwood plantation
- Map Unit 13: Softwood plantation

NOTES

- The chainages in this figure reflect the WC2U EA chainages. To convert these to the referral chainages add 41765.
- The locations of the fauna crossings and fauna fences are indicative only.

DATA SOURCES
ESRI basemaps 2013, Roads and Maritime Services 2010, 2013, LPMA 2010, SKM 2010, OEH 2013
This mapping is current as at December 2013 and could be refined with updated survey information

NSW GOVERNMENT Transport Roads & Maritime Services SKM

5.4 Performance thresholds and corrective actions

Table 5-1 presents the main goals of management for construction activities as described in **Section 5.2** and includes a summary of the relevant mitigation measures for flying-foxes that are to be completed during construction. The table also describes how the identified mitigation measures are to be monitored, the timing and frequency of monitoring, who is responsible for implementing the measures, the performance thresholds that each goal is measured against and the corrective actions if deviation from the performance criteria occurs. A full description of the construction management mitigation measures is included in **Section 5.3**.

Table 5-2 Summary of construction management goals, mitigation measures, performance thresholds and corrective actions

Main goals	Mitigation / control measure	Monitoring/timing frequency	Responsibility	Performance thresholds	Corrective actions if deviation from performance criteria
• No injuries or mortality of flying-foxes as a result of vegetation clearance or construction of the Project.	• Pre-clearing and clearing surveys of all vegetation within the clearing footprint conducted as per protocol. • Implement contingency plan for moving flying-fox out of the clearing corridor during vegetation clearing/construction, refer to **Appendix C**. • To minimise the risk of flying-fox vehicle strike during take-off from roosting/foraging, road corridor revegetation and ornamental planting is not to include plants that flower prolifically and produce nectar food sources likely to attract flying-foxes.	• Ecologist on site during all vegetation removal. • Ecologist, experienced with flying-foxes, on site during removal of vegetation in the vicinity of the flying-fox camp. • Daily fauna incident log to be maintained. • Identify if flying-foxes are killed by vehicle strike within the Project boundaries during Roads and Maritime Services routine road inspections.	• D& C contractor • D&C contractor • D&C contractor • Roads and Maritime	• A single flying-fox injured or killed during vegetation clearance. • Zero rate of flying-fox vehicle strikes.	• Stop clearing works within or adjacent to areas of flying-fox habitat immediately. • Delay vegetation clearing until survey by a qualified ecologist has been undertaken to identify where flying-fox are located. • Implement contingency plan for moving flying-fox out of the clearing corridor during vegetation clearing / construction, refer to **Appendix C**. • Review road corridor revegetation adjoining the locations of recorded flying-fox road kills.
• Minimise removal of roosting and foraging habitat outside the boundaries of the Project or within identified exclusion zones.	• Exclusion zones fenced off and/or clearly marked. • Fencing and marking monitored with breaches repaired.	• Audit fencing and marking integrity prior to commencement of and monthly during construction.	• D&C contractor • D&C contractor	• Breach in exclusion zone/fencing by construction vehicle or unauthorised construction activities.	• Stop construction in the area of the breach until exclusion fencing and/or marking has been repaired. Investigate why breach occurred and implement corrective

Main goals	Mitigation / control measure	Monitoring/timing frequency	Responsibility	Performance thresholds	Corrective actions if deviation from performance criteria
					actions as required to prevent reoccurrence. • Supplementary revegetation of disturbed habitat and monitor recovery for period of 12 months.
• Minimise removal to threatened flying-fox habitat outside designated ancillary facility areas.	• Installation of temporary exclusion fencing around ancillary facilities.	• Audit fencing integrity prior to commencement of construction. • Monthly monitoring of exclusion fences and protection zones as part of the FFMP.	• D&C contractor • D&C contractor	• Breach in exclusion zone/fencing by construction vehicle or unauthorised construction activities.	• Stop construction in the area of the breach until exclusion fencing has been repaired. Investigate why breach occurred and implement corrective actions as required to prevent reoccurrence. • Supplementary revegetation of disturbed habitat and monitor recovery for period of 12 months.
• Minimise disturbance to the flying-fox camp from vegetation removal, surface water drawdown, noise, vibration and lighting.	• Pre-clearing and clearing surveys of all vegetation within the clearing footprint conducted as per protocol. • Impacts to the flying-fox camp from construction noise, vibration and light would be managed through maintaining exclusion zone buffers	• Ecologist on site during all vegetation removal. • Ecologist, experienced with flying-foxes, on site during removal of vegetation in the vicinity of the flying-fox camp. • Daily fauna incident log to be maintained. • Regular fortnightly	• D&C contractor • D&C contractor • D&C contractor • D&C contractor	• Breach in exclusion zone/fencing by construction vehicle or unauthorised construction activities. • During flying-fox monitoring (including that undertaken during clearing activities) more than 1 dead Grey-headed Flying-fox/foetus or more	• Stop clearing works within or adjacent to areas of flying-fox habitat immediately. • Immediately stop the low noise or low disturbance construction activities (incl. haulage of materials) and organise a qualified ecologist to evaluate the flying-foxes

Main goals	Mitigation / control measure	Monitoring/timing frequency	Responsibility	Performance thresholds	Corrective actions if deviation from performance criteria
	and fencing. • Only low noise / low disturbance construction activities to occur within the exclusion zone buffer during mid-September to the following April. • Inclusion of cross drainage and the provision of a permeable, free draining rock platform in the vicinity of the camp. • Implement contingency plan for moving flying-fox out of the clearing corridor and 100 metre buffer during vegetation clearing/ construction, refer to **Appendix C**.	monitoring of the flying-fox camp to start on 1 August and extend until monitoring confirms the camp has been vacated. • Monitoring within, upstream of and downstream of the construction corridor would be carried out to identify any changes to water levels.		than 1 injured Grey-headed Flying-fox is found. • Greater than 10 % change from the baseline in surface water levels in the section of swamp sclerophyll forest where the flying-fox camp is located during construction activities. • Presence of heavily pregnant females or dependent young after 1 August.	condition prior to works restarting. Ecologist to monitor flying-fox behaviour when works restart. • Immediately stop works to the swamp and organise a qualified geotechnical company to evaluate impacts to the surface water levels prior to works restarting. • Clearing of vegetation to halt if there are heavily pregnant GHFF or female GHFF with dependant young present noting that an ecologist, experienced with flying-foxes would be on site during removal of vegetation in the vicinity of the flying-fox camp. • Other construction activities to halt if there are heavily pregnant GHFF or female GHFF with dependant young present after 31 August..
• Impacts to flying-foxes	• Implement exclusion zone	• Audit fencing and marking	• D&C contractor	• Breach in exclusion zone	• Stop construction in area

Main goals	Mitigation / control measure	Monitoring/timing frequency	Responsibility	Performance thresholds	Corrective actions if deviation from performance criteria
during clearing managed in accordance to fauna handling protocol.	and fencing strategy. • Pre-clearing and clearing surveys conducted as per protocol outlined. • Implementation of flying-fox handling procedure.	integrity prior to commencement of construction. • Monthly monitoring of exclusion fence and protection zones. • Monthly fauna incident log to be maintained.	• D&C contractor • D&C contractor	by construction vehicle of personnel. • Flying-fox injured or killed during vegetation clearance.	and review the fencing, pre-clearing and clearing survey and flying-fox handling requirements.
• No contamination or isolation of water supplies.	• Implement water quality procedures from the CEMP.	• Monthly and event based monitoring of water quality controls • Weekly and event based inspection of erosion controls.	• D&C contractor	• A notable change in water quality as per CEMP requirements.	• Review CEMP water management procedures as necessary.
• Construction activities post clearing	• Monitor within the 300 m buffer extents only the cleared project boundary • If presence of flying-foxes identified limit construction activities to low noise activities include haulage only	• Daily pre-dawn inspections for the presence of Flying–foxes • Monthly monitoring and population studies	• D&C Contractor	• No Flying-fox present construction activity continues. • If flying-foxes present initiate haulage and low noise activities only. Commence noise monitoring	• undertake noise monitoring to verify that haulage activities generate noise less than that predicted for operation noise levels measurable noise level being 56.5 dB(A) LAeq. Over 1 hr period • If noise level greater than that predicted for operation stage, haulage activities to cease or be modified to generate noise less than that predicted for operational

Main goals	Mitigation / control measure	Monitoring/timing frequency	Responsibility	Performance thresholds	Corrective actions if deviation from performance criteria
					noise levels.

6. Operational management measures

6.1 Summary of potential impacts during operation

- Noise, vibration and light impacts.
- Mortality due to vehicle strikes during take-off from roosting/foraging sites.
- Impacts to groundwater/ponded surface water levels within flying-fox habitat.

6.1.1 Negative public attitude, conflict with humans and health risks

It is likely that a proportion of flying-foxes that currently use the Macksville camp will relocate to one of the 20 camps present within a 50 kilometre radius of the Macksville camp (refer **Figure 2-1**). It is also possible that one or more new camp sites will establish (Roberts *et. al.,* 2011). The location of a new camp cannot be predicted and there is potential for new sites of conflict to be created. The increase in numbers at some of the camps located near developed areas has the potential to create conflict with humans.

6.2 Main goals for management

- No reduction of the quality of flying-fox habitats adjacent to the Project corridor due to the operation of the Project and to minimise the impact of edge effects.
- No reported mortality and/or injury from vehicle collisions.
- No contamination or isolation of water supplies.

6.3 Mitigation measures

6.3.1 Maintenance of habitat restoration and weeds

Inspection, monitoring and maintenance of revegetated areas of GHFF habitat within the Project would occur periodically during operation of the Project. These activities would be undertaken in all areas disturbed by the Project, including the disturbed section of Swamp Sclerophyll Forest south of Macksville occupied by the flying-fox camp. Details of maintenance activities including weed management would be incorporated into Roads and Maritime's existing environmental management systems in accordance with MCoA D1 under the NSW EP&A Act.

6.3.2 Management of operational noise, vibration and light impacts

Operational impacts associated with noise, vibration and light will include general traffic noise and lighting from vehicles. A low noise pavement will be provided from the bridge over Warrell Creek to the north of Macksville to manage road traffic noise levels for noise sensitive receivers in the township of Macksville and adjacent areas. The Macksville camp is located adjacent to this section of low noise pavement. Consequently, this section of low noise pavement will reduce road traffic noise levels in the vicinity of the camp.

Roadside lighting would be limited to lighting required for the interchange at Bald Hill Road south of the camp.

6.3.3 Management of operational impacts to groundwater/ponded surface water quality

Potential operational impacts to groundwater/ponded surface water are increased runoff containing pollutants and fine sediment and weed invasion. These potential changes may have impacts on the suitability of the habitat as a foraging site for flying-foxes.

Operational erosion and sedimentation control measures such as water quality basins and drainage swales would be utilised on the Project to minimise these impacts and maintain water quality during operation of the Project.

These measures would be important in maintaining the current condition of flying-fox habitat retained within and adjacent to the Project.

6.3.4 Management of operational impacts to groundwater/ponded surface water levels

It is acknowledged that the dynamics of the ground and ponded surface water in the area could indirectly impact on the camp and result in the potential abandonment of the camp. Management of this potential impact would include cross drainage and the provision of a permeable, free draining rock platform to ensure that the proposed activity does not result in long term changes to the natural surface water levels in the vicinity of the camp. It is noted that drought and rainfall may alter water levels and Roads and Maritime would have no influence on changes on these variables, nor any freehold works outside the corridor.

6.3.5 Strategies for minimising flying-fox vehicle strike during take-off from roosting/foraging

To minimise the risk of flying-fox vehicle strike during take-off from roosting/foraging, road corridor revegetation and ornamental planting is not to include plants that flower prolifically and produce nectar food sources likely to attract flying-foxes. Fauna fencing would also be provided along the boundaries of the patch of Swamp Sclerophyll Forest where the Macksville camp is located and includes around 530 metres of fencing along the northbound and southbound carriageways. Fencing would be three metres high in this area to prevent animals striking trucks on the highway when exiting or entering the Macksville camp.

6.3.6 Establishment of new flying-fox camps

There is potential for new flying-fox camps to become established in response to the reduction of roosting habitat at the Macksville camp due to the Project and disturbance of the camp due to the proximity of the new highway alignment. Subject to there being a demonstrable linkage between:

- The Project and the reduction in occupancy of the Macksville camp.
- The reduction in occupancy of the Macksville camp and the establishment of new GHFF camps.

Roads and Maritime would develop and implement a strategy for the management of new GHFF camps that may become established within 5 kilometres of the Macksville camp site. The strategy would be developed in consultation with EPA, DoE, the relevant local council and affected landholders. The strategy would include camps which become established within 12 months of the permanent opening of the full length of the Project to traffic. Roads and Maritime would provide the resources and funding required to implement the agreed reasonable and feasible mitigation measures identified in the strategy.

6.3.7 Strategies for monitoring any flying-fox dispersal (radio-tracking/satellite tracking)

The potential opportunities, benefits and impacts of radio-tracking/satellite tracking of flying-foxes roosting in the Macksville camp have been further investigated by Roads and Maritime Services. Advice from Dr Peggy Eby indicates that radio-tracking/satellite tracking flying-foxes would be of marginal value due to the following:

1) As outlined in **Section 4.4.1**, it is highly likely that all tagged animals would depart the Macksville camp prior to disturbance commencing at the site.

2) The highly variable nature of flying-fox movements would make it difficult to interpret the impact of the disturbance on subsequent migration and feeding patterns.

Based on this advice, opportunities for radio-tracking/satellite tracking of the Macksville camp flying-foxes during operation of the Project will not be pursued.

6.3.8 Management of negative public attitude, conflict with humans and health risks

A procedure for the management of negative public attitudes that may arise from conflict between local residents and flying-foxes would be included in a communications and media strategy. The strategy which would be prepared prior to the commencement of construction would include but not be limited to:

- A mechanism for people to make reports of new GHFF camps or increases in numbers.
- A series of press releases, targeted communication/media for potentially impacted community, particularly for residents/receivers adjacent to existing camp sites.
- A mechanism for dispute resolution.

The strategy will be included in the Community Communication Strategy required under MCoA B28 which would be prepared by Roads and Maritime in consultation with EPA.

6.4 Performance thresholds and corrective actions

Table 6-1 presents the main goals of management for operation activities as described in **Section 6.2** and includes a summary of the relevant mitigation measures for flying-foxes that are to be completed during operation of the Project. The table describes how the identified mitigation measures are to be monitored, the timing and frequency of monitoring, who is responsible for implementing the measures, the performance thresholds that each goal is measured against and the corrective actions if deviation from the performance criteria occurs. A full description of the operation management mitigation measures is included in **Section 6.3**.

Table 6-1 Summary of operation management goals, mitigation measures, performance thresholds and corrective actions

Main goal	Mitigation / control measure	Monitoring/timing frequency	Responsibility	Performance thresholds	Corrective actions if deviation from performance criteria
• No reduction of the quality of flying-fox habitats adjacent to the Project corridor due to the operation of the Project and to minimise the impact of edge effects.	• Continuation of the systematic program of monthly monitoring introduced in winter 2013 (as discussed in **Section 2.2**). • Revegetation and maintenance activities as documented in **Section 5.3.14**.	• Continuation of the systematic program of monthly monitoring introduced in winter 2013 (as discussed in **Section 2.2**) for 12 months after the opening of the Project to traffic. • Quarterly monitoring of the quality of the habitat adjacent to the Project for up to one year after the opening of the Project to traffic unless otherwise agreed with P&I, EPA and DOE.	• Roads and Maritime • Roads and Maritime	• Deterioration in the quality of adjacent habitat vegetation as a result of the Project (as determined by qualified ecologist).	• Implementation of corrective actions agreed with EPA and DoE.
• No contamination or isolation of water supplies.	• Maintenance of operational phase water quality measures.	• Monitoring of water quality as per the Project Surface Water Quality Management Procedure, including in the flying fox swamp area.	• Roads and Maritime	• No notable change in water quality due to the Project taking into account the Surface Water Quality Management Procedure and other factors such as adjacent land use, drought and rainfall.	• Review maintenance arrangements for water quality management measures as necessary.

Main goal	Mitigation / control measure	Monitoring/timing frequency	Responsibility	Performance thresholds	Corrective actions if deviation from performance criteria
• No reported mortality and/or injury from vehicle collisions.	• Maintenance of roadside foraging habitat to discourage roadside foraging. • Construction of fauna fencing along the boundaries of the patch of Swamp Sclerophyll Forest where the Macksville camp is located. Fencing would be three metres high in this area to prevent animals striking trucks on the highway when exiting or entering the Macksville camp.	• Regular maintenance of roadside foraging habitat to discourage roadside foraging. • Regular maintenance of fauna fencing. • Investigation in response to observations and reports of flying-fox kills (refer further to **Chapter 7**).	• Roads and Maritime. • Roads and Maritime. • Roads and Maritime.	• Zero flying-fox mortality within 300 metres of the camp footprint.	• Re-evaluate strategies if flying-foxes continue to collide with vehicles.
• No reported disturbance or mortality from noise generated during operation of the project	• Regular maintenance of road pavements to assure in good condition • Noise dampening technology for trucks to be widely promoted to the industry	• Monthly presence population monitoring to include noise monitoring and description of noise environment in report• • Operational noise monitoring to include trigger limits of 56.5dB(A) LAeq 1hr as measured100 m from the camp from 15September to the end of April the following year	• Roads and Maritime.	• No appreciable impact on flying fox camp from operational noise	• Explore alternative pavement treatments if noise generated during operation has been definitively ascertained to have an adverse impact

Note: Disturbance of the camp is further defined at Sec 3.1.3 of this plan.

7. Monitoring program

A systematic field program for monthly monitoring the Macksville flying-fox camp was initiated in the winter of 2013. The frequency of monitoring was increased to fortnightly monitoring in January 2014 (SKM data; GeoLINK 2013a-g and 2014a-t, refer **Section 6** and **Appendix B**). The objectives are to increase and improve the information available on the biology and ecology of the colony; to provide information pertinent to developing and refining options for mitigating the impacts of construction and operation of the Project; and to provide baseline data for assessing the impact of the Project. The monthly field monitoring program would continue through to 12 months after the opening of the Project to traffic. The fortnightly field monitoring program would continue through construction of the Project during the period when the flying-foxes are anticipated to be in the camp. The fortnightly field monitoring would commence on 1 August (before the flying-foxes are expected to be in camp) and extend until monitoring confirms the camp has been vacated. The monitoring program would be reviewed regularly and refined if considered appropriate.

7.1 Main goals of monitoring program

The main goals of the monitoring program are to assess the impacts of pre-construction, construction and operation activities from the Project on the Macksville flying-fox camp and provide data for any required refinements to mitigation measures.

7.2 Pre-construction monitoring

7.2.1 Aims of pre-construction monitoring

- To collect data on parameters suitable for assessing potential impacts of construction and operation of the Project on the Macksville flying-fox camp, particularly trends in:
  - Patterns of occupation (population size and the location of roosting animals).
  - Demographic composition (sex and age class).
  - Species composition (population size and roosting location).
  - Key behaviours (reproductive and territorial behaviours).
  - Habitat characteristics (tree species and height, depth of ground water).
- To use systematic, repeatable methods suitable for statistical analysis.
- To collect data from a control site to assist with interpreting results from the Macksville camp.
- Where possible, to employ sampling methods consistent with those used to monitor other flying-fox camps in order to create opportunities for comparisons to be drawn with other sites.
- To build a set of baseline data for use in assessing impact and developing and refining mitigation measures.

A system of monthly monitoring would be needed to provide adequate information given the rapid changes in these parameters which occur due to the irregular nature of the primary driver of roost occupation, eucalypt flowering.

7.2.2 Methods of pre-construction monitoring

Patterns of occupation

The boundary of the area occupied by flying-foxes would be mapped using point readings from hand-held GPS taken at regular intervals.

The size of the population would be estimated by ground assessment, where the numbers of individuals in each tree are estimated by direct observation; or by exit count, where observers estimate the numbers of animals exiting the roost at dusk. A categorical estimate of population size would be made at the time of most surveys with a more accurate assessment made at the time of predicted maximum population (January 2014).

At all but the January 2014 assessment, population size would be recorded in one of the following five categories:

- Nil
- <1,000
- 1,000 – <5,000
- 5,000 - <10,000
- 10,000 - <20,000
- >20,000

In January, population size would be estimated using exit counts conducted on two consecutive nights. Observers would be positioned to observe the exit paths being used at the time.

Species composition

Camps in the study area are primarily occupied by Grey-headed Flying-foxes. Small numbers of Black flying-foxes may also be present. The number of Black flying-foxes present in the Macksville roost would be estimated by ground assessment and their location mapped by GPS reading and the percentage of each species in the population would be estimated. This method would also be used to estimate numbers of Little Red Flying-foxes.

Demographic composition

Randomly located target trees would be identified for assessing population demographics. In each target tree the sex, age class and reproductive status of individuals roosting adjacent to each other would be recorded until at least 10 adult females were sampled.

Key behaviours

Repeat cross-sectional samples of key reproductive (mating, maternal etc) and territorial behaviours taken at target trees, standardised for sampling effort (time).

Habitat characteristics

The height and species of random samples of roost trees and trees located outside the roosting area would be recorded. Changes to the depth of ground water within the roosting area would also be monitored.

Control site

The monthly field survey protocol above would be repeated at a control site to assist with interpreting results collected at the Macksville flying-fox camp. Data collected at a nearby control site would assist in differentiating between environmental conditions that affect flying-fox populations throughout a broad area and site-specific effects. For example, reproductive output in flying-foxes is affected by short-term food shortages which uniformly influence closely-positioned roosts. It is important to be able to interpret levels of reproductive output at the Macksville camp in this broader context. The flying-fox camp at Bellingen Island has been identified as an appropriate control site. The camp site has been monitored on a monthly basis since October 2013.

Reporting

A report of results would be provided to Roads and Maritime on the completion of each field monitoring session.

7.3 Monitoring during construction

7.3.1 Aims of construction monitoring

- To assess the impacts of construction on the Macksville flying-fox camp.
- To refine mitigation measures, particularly the timing of changed activities and the boundary of buffer zone.

7.3.2 Monitoring 16 September to 30 April

Activities within the 300 metre buffer zone around the camp perimeter would be restricted to monitoring, maintenance and incidence response.

Monthly monitoring

The program of monthly field monitoring described in **Section 7.2** would continue through construction of the Project. Methods would be as per **Section 7.2**, and would include ongoing monthly field monitoring of the Bellingen Island control site and observational comments from the regional flying-fox camps at Gordon Park and Bowraville

As flying-foxes would be likely to change their roosting location within the 23.5 hectare remnant during construction, an exit flight would be observed on the evening prior to each monitoring session to confirm the presence of the colony.

Refinements to the monitoring program would include monitoring at any new or substantially increased camps within 5 kilometres of the Macksville camp site to determine impacts of the Project on behavioural patterns and the effectiveness of mitigation measures. The monitoring program would be refined in consultation with EPA and would include monitoring of breeding activities, pregnant females and dependant young.

Fortnightly monitoring

A program of fortnightly monitoring to supplement the monthly assessments would continue during pre-construction. The monitoring program would be reviewed regularly and refined if considered appropriate. A subset of methods employed in the monthly field monitoring would be used for the fortnightly monitoring. The boundary of the area occupied would be mapped, population size would be estimated, species composition would be assessed and general observations would be made of demographic composition and behaviours. Once the flying-foxes have returned to the camp monthly monitoring only will continue.

Additional measures

The monitoring program would be reviewed regularly and refined if considered appropriate.

7.3.3 Monitoring 1 May to 15 September

Survey work undertaken at the flying- fox camp has indicated that the camp would be empty or at its lowest occupancy between May and mid-September. Major construction activities within the 300 metres buffer zone around the camp (eg clearing, earthworks, bridgeworks and pavement construction) would be undertaken at this time. The location of the buffer zones may be modified based on monitoring results of the camp. The existing highway, the temporary construction connection between the existing highway and the alignment (if required) and the Bald Hill Road interchange / cutting would be excluded from the 300 metre construction buffer zone.

Monitoring presence / absence

During vegetation clearing activities in the remnant patch of swamp forest that contains the Macksville flying-fox camp, observation of a dusk exit flight and a dawn entry flight would be used to monitor presence / absence of flying-foxes. Construction would halt if there are heavily pregnant GHFF or female GHFF with dependant young present after 31 August each year.

Monitoring during vegetation clearing

Pre-clearing and clearing procedures would be outlined in the Flora and Fauna Management Plan (FFMP), and would be undertaken in accordance with *Biodiversity Guidelines: Protecting and Managing Biodiversity on RTA Projects* (RTA 2011). In summary, prior to the commencement of clearing operations, the Project ecologist would identify all areas that contain vegetation and habitat to be retained, including exclusion zones. Targeted surveys for flying-foxes would also be undertaken by an ecologist experienced with flying-foxes. An ecologist would be present during clearing activities in the vicinity of the roost. If, between 1 May and 15 September flying-fox are present in the clearing corridor the contingency strategy would be implemented, refer to **Appendix C**.

Vehicle strike monitoring

Incidental observations of flying-fox mortalities would be collected by the construction team during the construction phase. The GPS location of each specimen would be recorded and assessed in relation to its proximity to nearest vegetation.

7.4 Monitoring during operation

7.4.1 Monthly monitoring

A monthly field monitoring program would continue through to 12 months after the opening of the Project to traffic using methods set out in **Section 7.2**.

Flying-foxes would be likely to change their roosting location within the 23.5 hectare remnant. An exit flight would be observed on the evening prior to each monitoring session to confirm the presence of the colony.

7.4.2 Road mortality/vehicle strike monitoring

Road kill / vehicle strike monitoring will occur during operation of the Project. No pre-construction baseline monitoring will be implemented as the existing highway is currently a two lane highway that is located over 500 metres from the Macksville flying-fox camp. Once the Project is constructed it will be a four lane highway that will be running immediately adjacent and through the Macksville roost. As such any baseline data collected will not be comparable to data available during construction and operation of the Project.

Road kill monitoring program, would commence weekly for 12 weeks commencing the week of opening each stage to traffic. Surveys would be targeted 500 metres either side of the Macksville flying-fox camp (chainage 8,000 / 49,765). Excluding the season/s covered by the initial 12 week monitoring period (refer above), subsequent surveys will be conducted weekly during October (spring), January (summer), April (autumn) & July (winter) for up to five consecutive years post opening to traffic, or until mitigation measures have been demonstrated to be effective.

For each road kill observed, the following attributes will be recorded-

- Geographic Coordinates of any road kill.
- Whether fauna fencing was installed at/near the location.
- .
- Species of road kill. Where there is any doubt to the identification of the carcass, photographs shall be forwarded to a qualified ecologist for identification / confirmation of the species.

If the animal is identified as an EPBC Act threatened species, the following information will also be recorded-

- Sex and age class (juvenile or adult) where possible and safety limitations permit.
- Presence of pouch young (for marsupials) where possible and safety limitations permit.
- Presence of flightless young (for flying-foxes or other bats).
- Distance to a fauna connectivity structure.
- Distance to drop down structure.
- If fauna fencing was installed, is there any damage to the fence in the vicinity.
- Weather conditions at the time of the monitoring (from the Bureau of Meteorology) – including temperature, rainfall in the last 24 hours, moon phase.
- If the animal is identified as a flying-fox:
  - Distance to nearest camp,
  - Distance to nearest canopy vegetation,
  - Presence of flowering food trees in neighbouring median or roadside vegetation; plants identified to species and referenced with diet list.
- .

Basic reports of the data collected will be provided after each survey season. This will include graphs of the data and any previously collected data to provide simple visual comparisons of road kill. This will also include overall road kill counts as well as separate graphs for the target species (if deaths have occurred).

The annual report will be provided to DoEEand EPA within one month of completion of the fourth monitoring season. From then on it will be provided within one month of the same monitoring season in subsequent years until monitoring is completed.

Analysis of the data itself will be included in an annual monitoring report. This report will include a statistical analysis of all of the data collected to that time including graphical representations of the road kill that is recorded.

Where any annual report identifies a significant difference between the road kill numbers of the different treatments (transect types), DoEEand EPA shall be notified, and a meeting will be set to discuss such differences with the relevant agencies, Roads and Maritime the reporting ecologist.

Such a meeting would occur within one month of completion of the annual report, which should ensure sufficient time to consider/review the response to any recorded significant differences from the Project. Refer to **Appendix F** for the Warrell Creek to Nambucca Heads Upgrade Road Kill Monitoring Program.

7.4.3 Water quality

Water quality in adjacent drainage areas would be monitored as per the CEMP / water quality management plan.

7.5 Evaluation, Project review and reporting

Monthly reports would be prepared outlining the results of monitoring undertaken pertaining to the Project.

7.5.1 Responsibility

Suitably qualified specialists engaged by Roads and Maritime would be responsible for the evaluation of the monitoring information and reporting to Roads and Maritime.

7.5.2 Timing

A brief report of results would be provided to Roads and Maritime on the completion of each monthly or fortnightly field monitoring session.

An annual report would be prepared during construction and operation for distribution by Roads and Maritime to other relevant government agencies (P&I, EPA and DoE) in regards to monitoring of flying-foxes and outlining actions undertaking under the management plan.

7.6 Performance thresholds and corrective actions

Table 7-1 presents the performance thresholds for the monitoring program and the corrective actions if deviation from the performance criteria occurs. A full description of the mitigation measures to be implemented during the monitoring program is included in **Sections 7.1 to 7.4**.

Table 7-1 Summary of monitoring program performance thresholds and corrective actions

Main goal	Mitigation / control measure	Monitoring/timing frequency	Responsibility	Performance thresholds	Corrective actions if deviation from performance criteria
• To assess the impacts of pre-construction, construction and operation activities from the Project on the Macksville flying-fox camp and provide data for any required refinements to mitigation measures.	• Continuation of the systematic program of monthly flying-fox monitoring introduced in Winter 2013 (as discussed in **Section 2.2**) during the pre-construction and construction stages of the Project. • During the pre-construction stage of the Project continuation of the fortnightly monitoring program introduced in January 2014. • During construction of the Project fortnightly monitoring would start 1 August and extend until clearing is complete. • Initiation of a quarterly monitoring program of the quality of the habitat adjacent to the Project for the first year after the opening of the Project to traffic unless otherwise agreed with P&I, EPA and DOE. • Implementation of a road kill monitoring program upon opening of each stage of the Project to traffic using the methodology outlined in **Section 7.4.2** and **Appendix F**). • Monitoring beyond the two year survey period to be undertaken	• Continuation of the systematic program of monthly monitoring introduced in Winter 2013 (as discussed in Section 2.2) for 12 months after the opening of the Project to traffic. • Continuation of the fortnightly monitoring program introduced in January 2014 during the pre-construction stage of the Project. • During construction of the Project fortnightly monitoring would start 1 August and extend until clearing is complete. • Quarterly monitoring of the quality of the habitat adjacent to the Project for up to one year after the opening of the Project to traffic unless otherwise agreed with P&I, EPA and DOE. • Road kill monitoring would commence upon opening of each stage of the Project to traffic. Excluding the season/s covered by the initial 12 week monitoring period, subsequent surveys will be conducted weekly during October (spring), January (summer), April (autumn) & July (winter) for up to five consecutive	• Roads and Maritime. • Roads and Maritime. • Roads and Maritime. • Roads and Maritime. • Roads and Maritime.	• Significant reduction in reproductive output (measured as mean percentage of females with young in target trees) relative to control site. • Zero flying-fox mortality within 300 metres of the camp footprint. • Should the annual road kill monitoring reports identify a significant difference between the road kill numbers of the different treatments (fenced or unfenced sections).	• Based on a comparison with control sites, investigate possible causes of reduced reproduction, including impacts from the Project and the potential for natural variation in consultation with EPA. • Should investigations indicate that the Project is likely to be a cause of reduced reproduction, review opportunities to undertake onsite corrective actions in consultation with EPA. • Re-evaluate strategies if flying-foxes continue to collide with vehicles. • Where any annual report identifies a significant difference between the road kill numbers of the different treatments (fenced or unfenced sections), DoEEand EPA shall be notified, and a meeting will be set to discuss such differences with the relevant agencies, Roads and Maritime & the reporting ecologist. • Such a meeting would occur within one month of completion

Main goal	Mitigation / control measure	Monitoring/timing frequency	Responsibility	Performance thresholds	Corrective actions if deviation from performance criteria
	as part of the Roads and Maritime Asset Division regular inspection program assessing the operation of the highway.	years post opening to traffic, or until mitigation measures have been demonstrated to be effective.			of the annual report, which should ensure sufficient time to consider/review the response to any recorded significant differences from the Project. Refer further to **Appendix F**.
• To assess the clearing activities from the Project on the Macksville flying-fox camp and assess the implementation of the contingency strategy for moving flying-foxes out of the highway corridor during clearing activities between the period 1 May – 15 September	• During removal of vegetation in the vicinity of the flying-fox camp an ecologist, experienced with flying-foxes would be on site and implement the pre-clearing and clearing procedures outlined in Sections 4 and 5 of this Management Plan and if monitoring identifies flying-fox are present the contingency strategy included as **Appendix C** would be implemented.	• During all times that clearing activities occur within the Swamp Sclerophyll Forest where the Macksville Flying-fox camp is located.	• D&C contractor	• More than 1 dead/foetus or more than 1 injured Grey-headed Flying-fox is found which, in the opinion of the ecologist experienced with flying-foxes, are likely to have been killed or injured by the disturbance activities.	• All physical disturbance activities to the Swamp Sclerophyll Forest will cease immediately. • Disturbance activities will be reviewed by the ecologist experienced with flying-foxes and, where considered appropriate, scaled back. • The flying-foxes would be monitored continuously during the clearing activities to ascertain whether or not the change in the disturbance regime has been successful. If mortality/injury of the animals remains above the performance thresholds then all physical disturbance activities will cease immediately, and further advice sought from OEH and flying-fox experts

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Appendix A. Summary table and implementation schedule of the management plan

Table A-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.

The program schedule would be updated following a review of the approval and Project timelines.

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

No.	Task	Responsibility	Pre-construction	Construction	Operational				
					Year 1	Year 2	Year 3	Year 4	Year 5
1. Pre-construction management									
1.1	Monthly surveys to establish baseline data about the location and condition of flying-fox habitat and populations.	Ecologist	X						
1.2	Identify exclusion zones and temporary fencing and/or marking to protect habitats in the pre-construction phase.	D&C Contractor	X						
1.3	Location of ancillary facilities outside 500m buffer zone Note: The location of the buffer zones may be modified based on monitoring results of the camp.	D&C Contractor							
2. Construction management									
2.1	Construction work method statements	D&C Contractor		X					
2.2	Construction induction and training	Roads and Maritime / D&C Contractor		X					
2.3	Pre-clearing and clearing surveys	Ecologist		X					
2.4	Fauna handling protocol	D&C Contractor		X					
2.5	Temporary exclusion zones	D&C Contractor		X					
2.6	Habitat revegetation	D&C Contractor		X					
2.7	Water quality and hydrology	D&C Contractor		X					

No.	Task	Responsibility	Pre-construction	Construction	Operational				
					Year 1	Year 2	Year 3	Year 4	Year 5
3. Operational management									
3.1	Maintenance of roadside vegetation	D&C Contractor (years 1, 2 & 3), Roads and Maritime (subsequent years)			X	X	X	X	X
3.2	Water monitoring	Roads and Maritime			X	X	X	X	X
4. Monitoring program									
4.1	Monthly flying-fox monitoring	Ecologist	X	X	X				
4.2	Fortnightly flying-fox monitoring Note: during the construction of the Project, the program of fortnightly monitoring will be undertaken between 1 August and the end of April the following year. Clearing of vegetation within the buffer zone would halt if there are heavily pregnant GHFF or female GHFF with dependant young present. Construction activities within 300 metres of the perimeter of the camp may be undertaken before 1 May or after 15 September each year if monitoring demonstrates that no GHFF are present..	Ecologist	X	X					
4.3	Quarterly flying-fox monitoring (unless otherwise agreed with P&I, EPA and DOE).	Ecologist				X	X	X	X
4.4	Road mortality monitoring	Roads and Maritime		X	X	X	X	X	X
4.5	Evaluation and reporting	Ecologist	X	X	X	X	X	X	X

Appendix B. Summary of monitoring results - Macksville flying-fox colony

Date	Source of data	Population estimate	Species composition	Dependent young	Comment	Population estimate control sites
Nov - Dec 2011	Neighbours in Eby (2012)	Present, no estimate	No data	Yes	Presence of young determined by vocalisation	No data
Jan 2012	Neighbours in Eby (2012)	>10,000	No data	Yes		No data
Feb-Apr 2012	Neighbours, Nambucca Council in Eby (2012)	Present, no estimate	GHFF March 2012, balance Unknown	Unknown		No data
May	Eby (2012)	0				No data
June	Eby (2012)	2,000 - 5,000	GHFF (>80%); BFF	Not applicable		No data
Oct 2012 – May 2013	Royal Botanic Garden Trust (J. Martin unpublished data)	Present, no estimate	GHFF confirmed, (BFF unknown)	Unknown but presumed	Both male & female satellite-collared GHFF recorded at the site	No data
Apr 2013	SKM	10,000 - >20,000	GHFF; BFF	Yes		No data
Jul 2013	GeoLINK (2013 a)	0				No data
Aug 2013	GeoLINK (2013 b)	0				No data
Sep 2013	GeoLINK (2013 c)	>10,000	GHFF (95%), BFF (5%)	Not applicable	Survey conducted prior to birth period	Not surveyed
Oct 2013	GeoLINK (2013 d)	0 - 40	Unknown	Unknown	Evidence of use as stopover site	Nambucca >10,000 Bowraville 3,000 Bellingen >10,000
Nov 2013	GeoLINK (2013 e)	1,200	GHFF (80%) BFF (20%)	Yes		Nambucca >10,000 Bowraville 4,000 Bellingen >10,000
4 Dec 2013	GeoLINK (2013 f)	0 - 20	Unknown	Unknown	Evidence of use as stopover site	Nambucca >10,000 Bowraville >10,000 Bellingen >10,000
18 Dec 2013	GeoLINK (2013 g)	2,500	GHFF (90%) BFF (10%)	Yes		Not surveyed
9 Jan 2014	GeoLINK (2014a)	0 - 25	Unknown	Unknown	Evidence of use as stopover site	Not surveyed

Date	Source of data	Population estimate	Species composition	Dependent young	Comment	Population estimate control sites
27 January 2014	GeoLINK (2014b)	5,000 – 8,000	GHFF (90%) BFF (10%)	Yes	Due to the dispersed nature flying fox at the site at present, males were generally not in 'bachelor trees' and instead were widely spread and occupied individual mating territories. When females were present they occurred in isolated clumps within areas more broadly occupied by males	Gordon Park: >10,000 Bowraville: >10,000 Bellingen: >20,000
13 February 2014	GeoLINK (2014c)	Around 30,000	Unknown	Yes	The roost footprint at the site was also mapped as being relatively large, occupying 3.60 ha. The relatively large numbers of flying-fox currently occupying the site is likely to be in response to recent heavy flowering of Pink Bloodwood (*Corymbia intermedia*) in the region, and to a lesser degree flowering of Broad-leaved Paperbark (*Melaleuca quinquenervia*), which is just beginning.	Not surveyed
27 February 2014	GeoLINK (2014d)	Around 34,000	GHFF (95%) BFF (5%)	Female GHFF with young (partly dependent; i.e. beginning to show some independent behaviour). However, the majority of females did not have young	The roost footprint was smaller than that recorded in the last survey but more densely occupied. Little Red Flying-fox (LRFF) also present for the first time at Nambucca camp (not at other camps) and mating behaviours were evident. Numbers of flying-fox at Bowraville and Bellingen were reduced as was the roost footprints, and this reduction in numbers was particularly evident at the Bowraville camp. Nambucca camp population was still at same levels as previously recorded.	Gordon Park: >10,000. Bowraville: 5,000-10,000. Bellingen Island: >20,000 (however, a reduction in numbers compared with recent months).
12 March 2014	GeoLINK (2014e)	Between 40,000 to 50,000	GHFF (95%) BFF (5%	Observations indicate that last season's young flying fox are now independent of their mothers.	GHFF mating behaviours were observed. Key GHFF diet species (Eby and Law 2008) which are currently flowering in the region include Broad-leaved Paperbark (*Melaleuca quinquenervia*) and Coastal Blackbutt (*Eucalyptus pilularis*) (foothills and ranges). Pink Bloodwood (*Corymbia intermedia*) has now completed its recent heavy flowering	Not surveyed
25 March 2014	GeoLINK (2014f)	Around 22,000	GHFF (75% - 90%) BFF and LRFF (between 25- 10%)	Female GHFF with young (partially dependent) were observed roosting at the site and other regional camps visited. However, at the site the vast majority of females did not have young.	The proportion of female GHFF at the site is substantially less than that recorded at Bellingen Island. This has been a consistent pattern over the 2013-2014 summer/ autumn period. Little Red Flying-fox were recorded at the site for the first time since the current round of monitoring began in July 2013. It is possible that these Little Red Flying-fox may have been present at the site since the population began to increase in February and remained undetected (due to their aggregating in discrete dense clusters). Mating behaviours were evident.	Gordon Park: >10,000. Bowraville: 5,000-10,000. Bellingen Island: >20,000.
10 April 2014	GeoLINK (2014g)	Around 25,000	GHFF (>90%) BFF (5%) and LRFF (5%)	A kinship between some female GHFF and young was still apparent.	Flying-fox numbers and the roost footprint were similar to that recorded during the last monitoring event in late March. Mating behaviours were observed at the site and the regional	Not surveyed

Date	Source of data	Population estimate	Species composition	Dependent young	Comment	Population estimate control sites
					camps. Numbers of flying-fox and the roost footprint at the site, Nambucca and Bellingen was similar to that recorded during the last monitoring event.	
28-29 April 2014	GeoLINK (2014h)	0	No flying-fox of any species were recorded at the site. Therefore, no detailed species composition data was collected for the site.	Not applicable for the Macksville site.	A small number (<300) of flying-foxes were observed flying-over the site, but are likely to have originated in other regional camps (e.g. Gordon Park) and are passing by the site and/ or foraging in flowering Swamp Mahogany present at the site. No flying-fox were recorded in the site traverse. Numbers of flying-fox and regional camps appear to be decreasing since a summer population peak (except for at Gordon Park). GHFF dominated flying-fox numbers at occupied camps, with Black Flying-fox making up a relatively small proportion. Little Red Flying-fox have left the Gordon Park site. A small proportion (10-30%) of females had (semi) dependent young at the Bellingen Island comparison camp which has decreased from the proportion recorded in the previous monitoring event (no data collected at the site as no flying-fox were present). Mating behaviours were observed at occupied regional camps.	Gordon Park: 10,000 – 20,000. Bowraville: 0. Bellingen Island: 10,000.
14 May 2014	GeoLINK (2014i)	0	No flying-fox of any species were recorded at the site. Therefore, no detailed species composition data was collected for the site.	Not applicable for the Macksville site.	A small number (<100) of flying-foxes were observed flying-over the site, but are likely to have originated in other regional camps (e.g. Gordon Park) and are passing by the site and/ or foraging in flowering Swamp Mahogany present at the site. No flying-fox were recorded in the site traverse. Flying-fox numbers at regional camps have decreased since a summer population peak (except for at Gordon Park). GHFF dominated flying-fox numbers at occupied camps, with Black Flying-fox making up a relatively small proportion (<10% at the Gordon Park camp). The key GHFF nectar source trees Swamp Mahogany and Broad-leaved Paperbark are flowering locally.	Gordon Park: 10,000 – 20,000. Bowraville: 0. Bellingen Island: <1,000.
28-29 May	GeoLINK (2014j)	0	No flying-fox of any species were recorded at the site. Therefore, no detailed species composition data was collected for the site.	Not applicable for the Macksville site.	No flying-foxes were counted exiting the site during this month's exit count. Also no flying-fox were recorded to be roosting at the site in the site traverse. A small numbers (<10) of flying-foxes were observed flying-over the site, but are likely to have originated in other regional camps (e.g. Gordon Park) and are passing by the site and/ or foraging in flowering Swamp Mahogany present at the site. Flying-fox numbers at regional camps have decreased since a	Gordon Park: 10,000 – 20,000. Bowraville: 0 Bellingen Island: 0 (note: GHFF continue to roost at an alternative site in Bellingen near the

Date	Source of data	Population estimate	Species composition	Dependent young	Comment	Population estimate control sites
					summer population peak (except for at Gordon Park). GHFF were observed to be roosting at an alternative site in Bellingen near the showground behind Wheatley Street and currently number in the thousands. GHFF dominated flying-fox numbers at occupied camps, with Black Flying-fox only making up a 10% of all individuals at the Gordon Park camp. Both male and female GHFF present. No dependent young were observed. The key GHFF nectar source trees Swamp Mahogany and Broad-leaved Paperbark are flowering locally, and along with flowering Coast Banksia are likely to be influencing which camps are currently occupied, and in what numbers, within the locality.	showground behind Wheatley Street and currently number in the thousands).
10 – 11 June 2014	GeoLINK (2014k)	0	No flying-fox of any species were recorded at the site. Therefore, no detailed species composition data was collected for the site.	Not applicable for the Macksville site.	A small number (<100) of flying-foxes were observed flying-over the site, but are likely to have originated in other regional camps (e.g. Gordon Park) and are passing by the site and/ or foraging in flowering Swamp Mahogany present at the site. No flying-fox were recorded in the site traverse. Flying-fox numbers at regional camps have generally decreased since a summer population peak (except for at Gordon Park). GHFF dominated flying-fox numbers at occupied camps, with Black Flying-fox only making up a 10% of all individuals at the Gordon Park camp. The key GHFF nectar source trees Swamp Mahogany and Broad-leaved Paperbark are flowering locally, and along with flowering Coast Banksia are likely to be influencing which camps are currently occupied, and in what numbers, within the locality.	Gordon Park: 10,000 – 20,000. Bowraville: 0 Bellingen Island: 0 (note: GHFF continue to roost at an alternative site in Bellingen near the showground behind Wheatley Street and currently number in the thousands).
30 June 2014	GeoLINK (2014l)	0	No flying-fox of any species were recorded at the site in the exit count or the site traverse. Therefore, no detailed species composition data was collected for the site	Not applicable for the Macksville site.	Flying-fox numbers at the site and regional camps have generally decreased since a summer population peak, including an absence of flying-foxes at Bowraville and Bellingen Island (however, as has been recorded in previous monitoring events, GHFF continue to roost at a nearby alternative site in Bellingen behind Wheatley Street and currently number in the thousands). The exception to the general decrease in flying-fox numbers at the visited regional camps is Gordon Park (Nambucca Heads) where flying-fox numbers are still relatively high – estimated to be 10,000 – 20,000 individuals. GHFF dominated flying-fox numbers at occupied camps, with Black Flying-fox only making up a 10% of all individuals at the Gordon Park camp and 5% of all individuals at the Wheatley Street camp (Bellingen).	Gordon Park: 10,000 – 20,000. Bowraville: 0 Bellingen Island: 0 (note: GHFF continue to roost at an alternative site in Bellingen near the showground behind Wheatley Street and currently number in the thousands).

Date	Source of data	Population estimate	Species composition	Dependent young	Comment	Population estimate control sites
					Heavy flowering of Swamp Mahogany (a key GHFF nectar source tree) within the broader locality has now finished. Flowering in a number of other key GHFF nectar source species (Coastal Blackbutt, Forest Red Gum and Broad-leaved Paperbark) also typically occurs at this time of the year (although no substantial flowering in the region of any of these species was observed in the current monitoring event).	
12-17 July 2014	GeoLINK (2014m)	0	No flying-fox of any species were recorded at the site in the exit count or the site traverse.	Not applicable for the Macksville site.	Flying-fox remain absent at Bowraville and Bellingen Island (however, as has been recorded in previous monitoring events, GHFF continue to roost at a nearby alternative site in Bellingen behind Wheatley Street and currently number in the thousands. However, numbers appear to have decreased recently). At Gordon Park (Nambucca Heads) flying-fox numbers are still relatively high – estimated to be 10,000 – 20,000 individuals. GHFF dominated flying-fox numbers at occupied camps, with Black Flying-fox only making up a 10% of all individuals at the Gordon Park camp and none of the individuals at the Wheatley Street camp (Bellingen). Heavy flowering of Swamp Mahogany (a key GHFF nectar source tree) within the broader locality has now finished. Flowering in a number of key GHFF nectar source species (Swamp Mahogany, Coastal Blackbutt, Forest Red Gum and Broad-leaved Paperbark) typically occurs at this time of the year (although no substantial flowering in the region of any of these species was observed in the current monitoring event). Flying-fox were observed to be regularly foraging in Coast Banksia (non key GHFF nectar source) at Nambucca Heads during the monitoring event.	Gordon Park: 10,000 – 20,000. Bowraville: 0 Bellingen Island: 0 (note: GHFF continue to roost at an alternative site in Bellingen near the showground behind Wheatley Street and currently number in the thousands).
30-31 July 2014	GeoLINK (2014n)	0	No flying-fox of any species were recorded at the site in the exit count or the site traverse.	Not applicable for the Macksville site.	As has been recorded since May, the number of flying-foxes at regional camps remains generally low, including an absence of flying-foxes at Bowraville and Bellingen Island (however, as has been recorded in previous monitoring events, GHFF continue to roost at a nearby alternative site in Bellingen behind Wheatley Street and currently number approximately 1,000). The exception to the general low number of flying-foxes recorded at the visited regional camps is Gordon Park (Nambucca Heads) where flying-fox numbers are still relatively high – estimated to be 10,000 – 20,000 individuals. GHFF dominated flying-fox numbers at occupied camps, with Black Flying-fox only making up approximately 10% of all individuals at the Gordon Park camp and 5% of all individuals at	Gordon Park: 10,000 – 20,000. Bowraville: 0 Bellingen Island: 0 (note: GHFF continue to roost at an alternative site in Bellingen near the showground behind Wheatley Street and currently number approximately 1,000).

Date	Source of data	Population estimate	Species composition	Dependent young	Comment	Population estimate control sites
					the Wheatley Street camp. Both female and male GHFF are present at the Wheatley Street camp and females outnumber males. No mating behaviour was recorded and no young flying-foxes are present. Flowering in a number of other key GHFF nectar source species (Coastal Blackbutt, Forest Red Gum and Broad-leaved Paperbark) also typically occurs at this time of the year although no substantial flowering of any of these species was observed in the region during the current monitoring event.	
15-16 August 2014	GeoLINK (2014o)	0	No flying-fox of any species were recorded at the site in the exit count or the site traverse.	Not applicable for the Macksville site.	As has been recorded since May, the number of flying-foxes at regional camps remains generally low, including an absence of flying-foxes at Bowraville and <1,000 at Bellingen Island (re-occupied after intermittent absence over the last couple of months). Flying-foxes were absent from the nearby Wheatley Street camp in Bellingen. The exception to the general low number of flying-foxes recorded at the visited regional camps is Gordon Park (Nambucca Heads) where flying-fox numbers are still relatively high – estimated to be >10,000 individuals. GHFF dominated flying-fox numbers at occupied camps. Black Flying-fox constituted approximately 10% of all individuals at the Gordon Park camp. Flowering in a number of other key GHFF nectar source species (Coastal Blackbutt, Forest Red Gum and Grey Ironbark) typically occurs at this time of the year although no substantial flowering of any of these species was observed in the region during the current monitoring event.	Gordon Park: >10,000. Bowraville: 0 Bellingen Island: < 1,000 (note: flying-foxes were absent from the nearby Wheatley Street camp).
2-3 September 2014	GeoLINK (2014p)	0	No flying-fox of any species were recorded at the site in the exit count or the site traverse.	Not applicable for the Macksville site.	As has been recorded since May, the number of flying-foxes at regional camps remains generally low, including an absence of flying-foxes at Bowraville. Bellingen Island was occupied with a relatively low number of flying-foxes (estimated to be 3,000-5,000 individuals) and the Wheatley Street 'over-flow' camp nearby was unoccupied. Flying-fox numbers at Gordon Park (Nambucca Heads) were still comparatively high but less than has been recorded over recent months (estimated to be around 10,000 individuals). GHFF dominated flying-fox numbers at occupied camps, with Black Flying-fox only making up approximately 10% of all individuals at the Gordon Park and Bellingen Island camps. Both female and male GHFF are present at the Bellingen Island camp and females outnumber males. No young flying-foxes are	Gordon Park (around 10,000) Bowraville: 0 Bellingen Island: (around 3,000 – 5,000)

Date	Source of data	Population estimate	Species composition	Dependent young	Comment	Population estimate control sites
					present. Flowering in a number of key GHFF nectar source species (Coastal Blackbutt, Forest Red Gum and Grey Ironbark) typically occurs at this time of the year in the region, although only minor flowering of Forest Red Gum was observed in the region during the current monitoring event.	
15-17 September 2014	GeoLINK (2014q)	0	No flying-fox of any species were recorded at the site in the exit count or the site traverse.	Not applicable for the Macksville site.	As has been recorded since May, the number of flying-foxes at regional camps remains generally low, including an absence of flying-foxes at Bowraville. Bellingen Island was occupied with a relatively low number of flying-foxes (estimated to be 3,000-5,000) and the Wheatley Street 'over-flow' camp nearby was unoccupied. Flying-fox numbers at Gordon Park (Nambucca Heads) were still comparatively high (around 10,000 to 15,000 individuals). GHFF dominated flying-fox numbers at occupied camps, with Black Flying-fox only making up approximately 10% of all individuals at the Gordon Park and Bellingen Island camps. Flowering in a number of key GHFF nectar source species (Coastal Blackbutt, Forest Red Gum and Grey Ironbark) typically occurs at this time of the year in the region, although only minor flowering of Forest Red Gum and light flowering of Grey Ironbark was observed in the region during the current monitoring event.	Gordon Park (between 10,000 to 15,000) Bowraville: 0 Bellingen Island: (around 3,000 – 5,000)
30 September – 1 October 2014	GeoLINK (2014r)	0	No flying-fox of any species were recorded at the site in the exit count or the site traverse.	Not applicable for the Macksville site.	As has been recorded since May, the number of flying-foxes at regional camps remains generally low, including an absence of flying-foxes at Bowraville. Bellingen Island was occupied with a relatively low number of flying-foxes (estimated to be 5,000) and the Wheatley Street 'over-flow' camp nearby was unoccupied. Flying-fox numbers at Gordon Park (Nambucca Heads) were still comparatively high (around 10,000 individuals) but have decreased since the last monitoring event. GHFF dominated flying-fox numbers at occupied camps, with Black Flying-fox only making up approximately 10% of all individuals at the Gordon Park and Bellingen Island camps. Flowering in a number of key GHFF nectar source species (Forest Red Gum and Grey Ironbark) typically occurs at this time of the year in the region, although only minor flowering of Forest Red Gum and light flowering of Grey Ironbark was observed in the region during the current monitoring event. No young observed yet. Female GHFF outnumbered males at most demographic point count sites.	Gordon Park (around 10,000) Bowraville: 0 Bellingen Island: (around 5,000)

Date	Source of data	Population estimate	Species composition	Dependent young	Comment	Population estimate control sites
14 October 2014	GeoLINK (2014s)	0	No flying-fox of any species were recorded at the site in the exit count or the site traverse.	Not applicable for the Macksville site.	Flying-fox were absent from Bowraville. Bellingen Island was occupied with a relatively low number of flying-foxes (estimated to be approximately 5,000) and the Wheatley Street 'over-flow' camp nearby was unoccupied. Flying-fox numbers at Gordon Park (Nambucca Heads) were still comparatively high (around 10,000 individuals). GHFF dominated flying-fox numbers at occupied camps, with Black Flying-fox only making up <10% of all individuals at the Gordon Park and Bellingen Island camps. Dependent young GHFF were observed at Gordon Park and Bellingen Island for the first time this breeding season. Flowering in a number of key GHFF nectar source species (Forest Red Gum, Grey Ironbark and Silky Oak) typically occurs at this time of the year in the region. Observations locally included minor flowering of Forest Red Gum, moderate flowering of Grey Ironbark, and heavy flowering of Silky Oak (likely planted: outside of natural distribution).	Gordon Park (around 10,000) Bowraville: 0 Bellingen Island: (around 5,000)
29 - 30 October 2014	GeoLINK (2014t)	0	No flying-fox of any species were recorded at the site in the exit count or the site traverse.	Not applicable for the Macksville site.	Flying-fox have returned to the Bowraville camp in low numbers (between 1,000-5,000 individuals). The number of flying-foxes at Bellingen Island has increased slightly (estimated to be approximately 7,500-10,000 individuals) and the Wheatley Street 'over-flow' camp nearby was unoccupied. Flying-fox numbers at Gordon Park (Nambucca Heads) were still comparatively high (around 10,000-15,000 individuals). GHFF dominated flying-fox numbers at occupied camps, with Black Flying-fox only making up around 5-10% of all individuals at the Gordon Park and Bellingen Island camps. Dependent young GHFF were recorded with between 40% and 90% of female GHFF at Bellingen Island (an average of 75% of females had dependent young). Dependent young were also observed at Gordon Park. Flowering in a number of key GHFF nectar source species (Forest Red Gum, Grey Ironbark and Silky Oak) typically occurs at this time of the year in the region. Observations locally included minor flowering of Grey Ironbark and heavy flowering of Silky Oak (likely planted: outside of natural distribution).	Gordon Park (around 10,000 – 15,000) Bowraville: (around 1,000 to 1,500) Bellingen Island: (around 7,500 – 10,000)

Appendix C. Contingency strategy for moving flying-foxes out of the highway corridor during clearing operations between the period 1 May – 15 September.

Appendix C

Contingency strategy for moving flying-foxes out of the highway corridor during clearing activities between the period 1 May – 15 September.

Background

The following contingency strategy for moving any resident flying-foxes including Grey Headed Flying Foxes (GHFF) out of the highway corridor during clearing activities between the period 1 May – 15 September has been prepared for the upgrade of the Pacific Highway between Warrell Creek and Nambucca Heads (the Project). The contingency strategy is aimed at relocating the animals out of the clearing corridor near the seasonal Macksville roost site and does not relate to the construction activities themselves.

Clearing activities for the Project would include removal of trees and vegetation, soft soil treatment and the importation of appropriate rockfill materials to allow the proposed highway corridor to be easily accessed.

At the time clearing activities are proposed to be undertaken (1 May – 15 September), it is anticipated that all young would be flying and feeding independently and that no animals would remain in the roost at night. As proposed clearing activities would move from the edges of the Swamp Sclerophyll Forest towards the roost camp, it is envisaged that the clearing activity itself would create enough disturbance to temporarily discourage any flying-foxes from roosting in the area of the clearing activities.

In accordance with Section 5.3.5 of the Flying-fox Management Plan, this contingency strategy would be implemented should a flying-fox (or group of flying-foxes) be identified within the construction clearing zone and within 100 metres of clearing activities during pre-clearing ecology surveys.

The contingency strategy aims to move flying-foxes from vegetation proposed to be removed during clearing activities in order to prevent stress, injuries or mortality to the animals. The aim of the contingency strategy is to herd the animals through the contiguous tract of Swamp Sclerophyll Forest until they reach vegetation 100 metres from the vegetation proposed to be removed during the clearing activities. This strategy is a temporary contingency to minimise impacts on flying-foxes should they be roosting in or near vegetation proposed to be removed and is not a long term dispersal/relocation strategy. No disturbances to the flying-foxes would occur during high wind, heavy rain or other adverse environmental conditions. Pre-clearance dawn ecology surveys would occur daily prior to any clearing works commencing. The cumulative disturbance of animals due to exposure to noise and light activities would be limited to no more than three hours every 24 hours.

The contingency strategy and the Flying-fox Management Plan have been developed in conjunction with the Office of Environment and Heritage (OEH) and the Department of the Environment (DoE) as part of the approval process. Concurrence with OEH and DoE will need to be obtained prior to implementation of the strategy.

The contingency strategy for moving the flying-foxes 100 metres from vegetation proposed to be removed during clearing activities would be undertaken as a series of separate steps. Each individual step would only be implemented if the previous step was not successful in moving all flying-foxes out of vegetation proposed to be removed. The contingency strategy would be implemented in accordance with the decision making flow chart, refer to **Figure 1.**

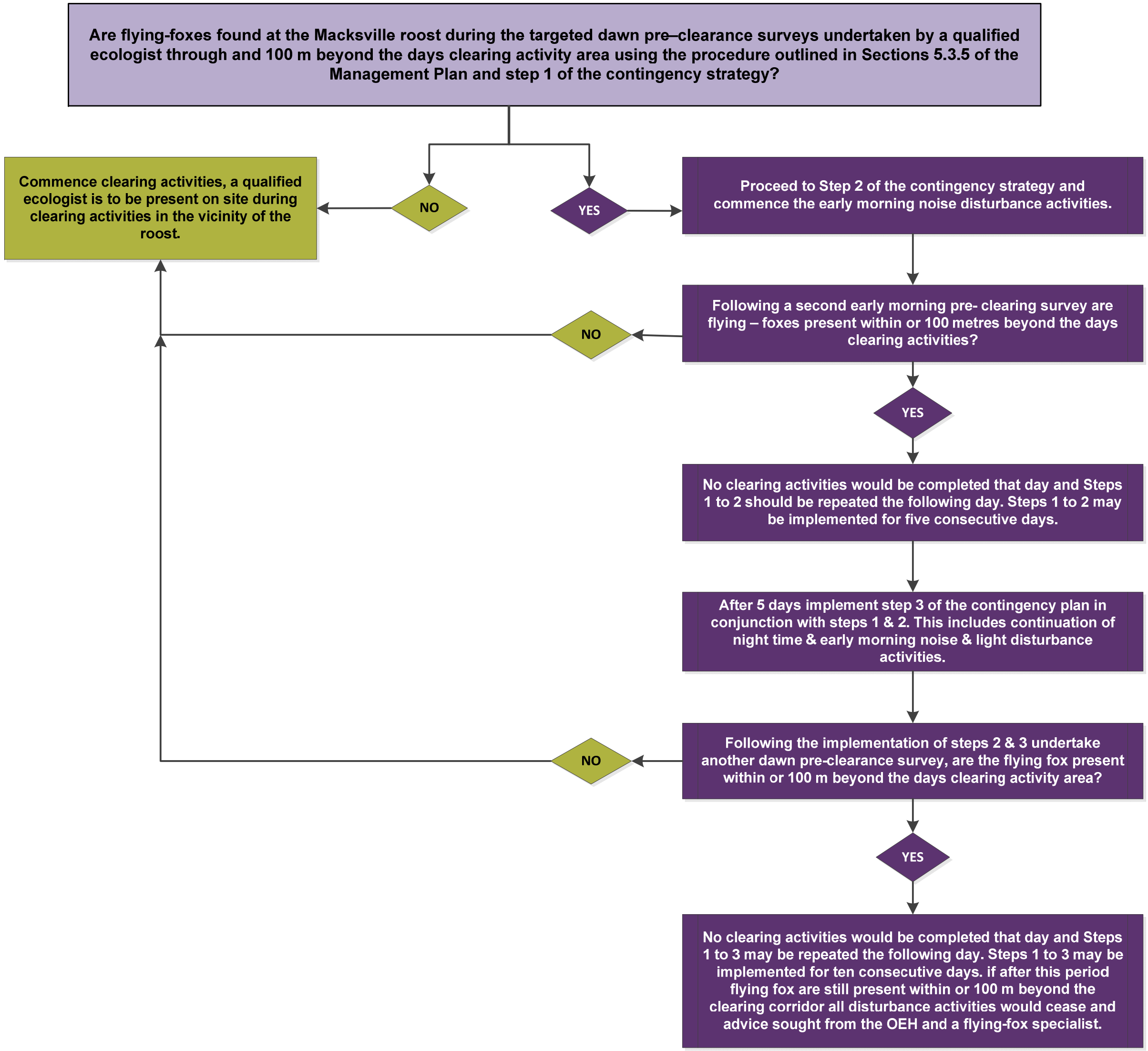


Figure 1 Decision-making flow chart for the contingency strategy

The three steps of the contingency strategy are summarised as follows:

Step 1 – Pre-clearance ecology survey

A pre-clearance ecology survey would be undertaken of the area proposed to be cleared that day. This survey would entail a dawn survey through and 100 metres beyond; the vegetation proposed to be removed during that day's clearing activities. The pre-clearance ecology survey would consist of two to three teams of ecologists working in pairs using spot lights and binoculars. An inflatable boat may be utilised to allow safe access into the Swamp Sclerophyll Forest. Flood lights could also be set up to assist with the ecology survey.

Should flying-foxes not be located within the area surveyed, a dawn survey through, and 100 metres beyond, the vegetation proposed to be removed during the day's clearing activities would be undertaken on the day of the clearing. The ecology survey would consist of two to three teams of ecologists working in pairs using spot lights and binoculars. An inflatable boat may be utilised to allow safe access into the Swamp Sclerophyll Forest. Flood lights could also be set up to assist with the ecology survey.

Should flying-foxes not be located during the dawn survey, clearing activities would be undertaken in accordance with the Flying-fox Management Plan and the project CEMP.

Should heavily pregnant females or females with dependent young be present during the pre-clearance dawn ecology surveys, noise/light disturbance or clearing activities would not be implemented and further advice would be sought from OEH and flying-fox experts.

Should flying-foxes (other than heavily pregnant females or females with dependent young) be located within the area surveyed during the dawn survey, Step 2 would commence.

Step 2 – Early morning noise disturbance to move the animals out of the area of impact

Should the dawn survey locate flying-foxes (other than heavily pregnant females or females with dependant young) within the construction clearing zone and within 100 metres of clearing activities, a combination of non-lethal noise disturbance methods would be implemented to encourage the flying-foxes to move. As per Tidemann (2003) and Roberts et al (2011), flying-foxes take flight to avoid loud, percussive noises generated close to where they are roosting and noise has successfully been used to disperse animals from long-term roosting sites. The sources of noise available for use at the Macksville camp would be constrained by the difficulties of working in the swamp and may include swishing branches, beating on drums, beating on metal objects, whistles and playing pre-recorded mixes of random sounds as developed for camp dispersals at the Royal Botanical Gardens (RBG) Melbourne and RBG Sydney through waterproof, mobile speakers. Around six to eight people would be strategically located within the vegetation to be cleared on the following day with the aim of using sound disturbance to move the flying-foxes slowly out of the day's clearing area and 100 metres beyond that. All personnel involved in the noise generation would commence making the noise at the same time.

Disturbance using noise would be escalated slowly, as per the intensity levels outlined in **Table 1** to encourage the flying-foxes to move without shocking or harming them, causing mortality of individuals or pregnant females to abort. Disturbance activity may be implemented in a continuous one and a half hour block or intermittently in the early hours either side of dawn when the flying-fox are returning to camp. The cumulative disturbance of animals due to exposure to noise disturbance activities implemented as part of step 1 and step 2 would be limited to no more than three hours every 24 hours. Nearby residents would need to be notified prior to the disturbance activity occurring via a letterbox drop, and a summary of the type of noise to be used would be included in the consultation.

Table 1 Summary of noise disturbance intensity levels and activities

Intensity	Description	Escalation trigger
Intensity level 1	Participants will use spotlights and noise generated by swishing branches to discourage any GHFF from roosting in any areas identified within the day's construction clearing zone and within 100 metres of the clearing activities. .	If 80% of GHFF recorded in the area of the highway corridor identified for clearing activities have not moved elsewhere after 30 minutes, the activity may escalate to intensity level 2.
Intensity level 2	Participants will continue to use spotlights and will also commence banging metal objects together (e.g. stakes), beat on drums underneath each roosting tree to discourage GHFF from roosting in any areas identified within the day's construction clearing zone and within 100 metres of the clearing activities.	If 80% of GHFF recorded in the area of the highway corridor identified for clearing activities have not moved elsewhere after 30 minutes, the activity may escalate to intensity level 3.
Intensity level 3	Participants will use continue to use spotlights if it is still dark and will start blowing whistles and playing loud pre-recorded natural and man-made random sounds as developed for camp dispersals at the Royal Botanical Gardens (RBG) Melbourne and RBG Sydney through waterproof, mobile speakers to discourage GHFF from roosting in the in any areas identified within day's construction clearing zone and within 100 metres of the clearing activities.	If 80% of GHFF recorded in the area of the highway corridor identified for clearing activities have not moved elsewhere after 30 minutes, then the noise disturbance must cease for the morning.

Following completion of the early morning disturbance activities another pre-clearance survey would be completed by the ecology team of the area of vegetation proposed to be cleared for the day and extending 100 metres beyond this.

Should flying-foxes not be located during the survey, clearing activities would be undertaken in accordance with the Flying-fox Management Plan and the project CEMP.

Should flying-foxes be located within the area surveyed after five days of implementing Step 2, then Step 3 would be implemented.

Step 3 – Early evening noise disturbance to move the animals out of the area of impact

Should flying-foxes remain within vegetation proposed to be removed after implementation of the disturbance methods outlined in Step 2, further noise-based disturbance activities would be implemented to encourage the flying-foxes to move out of the clearing area in the early evening. The noise disturbance activities would be implemented either as a one and a half hour continuous block or intermittently in the early evening around two hours prior to dusk and would continue for three hours after dusk.

These early evening noise disturbance activities would be held in conjunction with the early morning noise disturbance activities. The cumulative disturbance of animals due to exposure to noise disturbance activities implemented as part of step 1 and step 2 would be limited to no more than three hours every 24 hours. Nearby residents would need to be notified prior to the disturbance activity occurring via a letterbox drop, and a summary of the type of noise to be used would be included in the consultation.

As this step will be occurring at night, shining lights into the trees and onto animals may also disturb any individual flying-foxes remaining in the camp. Noise and light disturbance activities will be escalated slowly as per the intensity level descriptions included in **Table 2**.

Table 2 Summary of noise disturbance intensity levels and activities

Intensity	Description	Escalation trigger
Intensity level 1	Participants will use spotlights and noise generated by swishing branches to discourage any GHFF from roosting in any areas identified within the day's construction clearing zone and within 100 metres of the clearing activities. .	If 80% of GHFF recorded in the area of the highway corridor identified for clearing activities have not moved elsewhere after 30 minutes, the activity may escalate to intensity level 2.
Intensity level 2	Participants will continue to use spotlights and will also commence banging metal objects together (e.g. stakes), beat on drums underneath each roosting tree to discourage GHFF from roosting in any areas identified within the day's construction clearing zone and within 100 metres of the clearing activities.	If 80% of GHFF recorded in the area of the highway corridor identified for clearing activities have not moved elsewhere after 30 minutes, the activity may escalate to intensity level 3.
Intensity level 3	Participants will use continue to use spotlights if it is still dark and will start blowing whistles and playing loud pre-recorded natural and man-made random sounds as developed for camp dispersals at the Royal Botanical Gardens (RBG) Melbourne and RBG Sydney through waterproof, mobile speakers to discourage GHFF from roosting in the in any areas identified within day's construction clearing zone and within 100 metres of the clearing activities.	If 80% of GHFF recorded in the area of the highway corridor identified for clearing activities have not moved elsewhere after 30 minutes, then the noise disturbance must cease for the day.

Following completion of the early evening and morning disturbance activities another pre-clearance dawn survey would be completed by the ecology team of the area of vegetation proposed to be cleared for the day and extending 100 metres beyond this.

Should flying-foxes not be located during the survey, clearing activities would be undertaken in accordance with the Flying-fox Management Plan and the project CEMP.

Should flying-foxes be located within the area surveyed, no clearing activities would be completed that day and Steps 1 to 3 may be repeated the following day. Steps 1 to 3 may be implemented for up to ten consecutive days. Should flying-foxes remain in the clearing activity area all disturbance activities would cease and advice sought from the OEH and a flying-fox specialist.

A flowchart of how and when each of the three individual steps of the contingency strategy is to be implemented is provided in **Figure 2**. Pre-clearance ecology surveys would continue daily during the clearing activities. As the clearing activities move through the Swamp Sclerophyll Forest the sequence of steps may need to be repeated, should flying-foxes be found to be roosting within 100 metres of the vegetation proposed to be removed during the day's clearing activities.

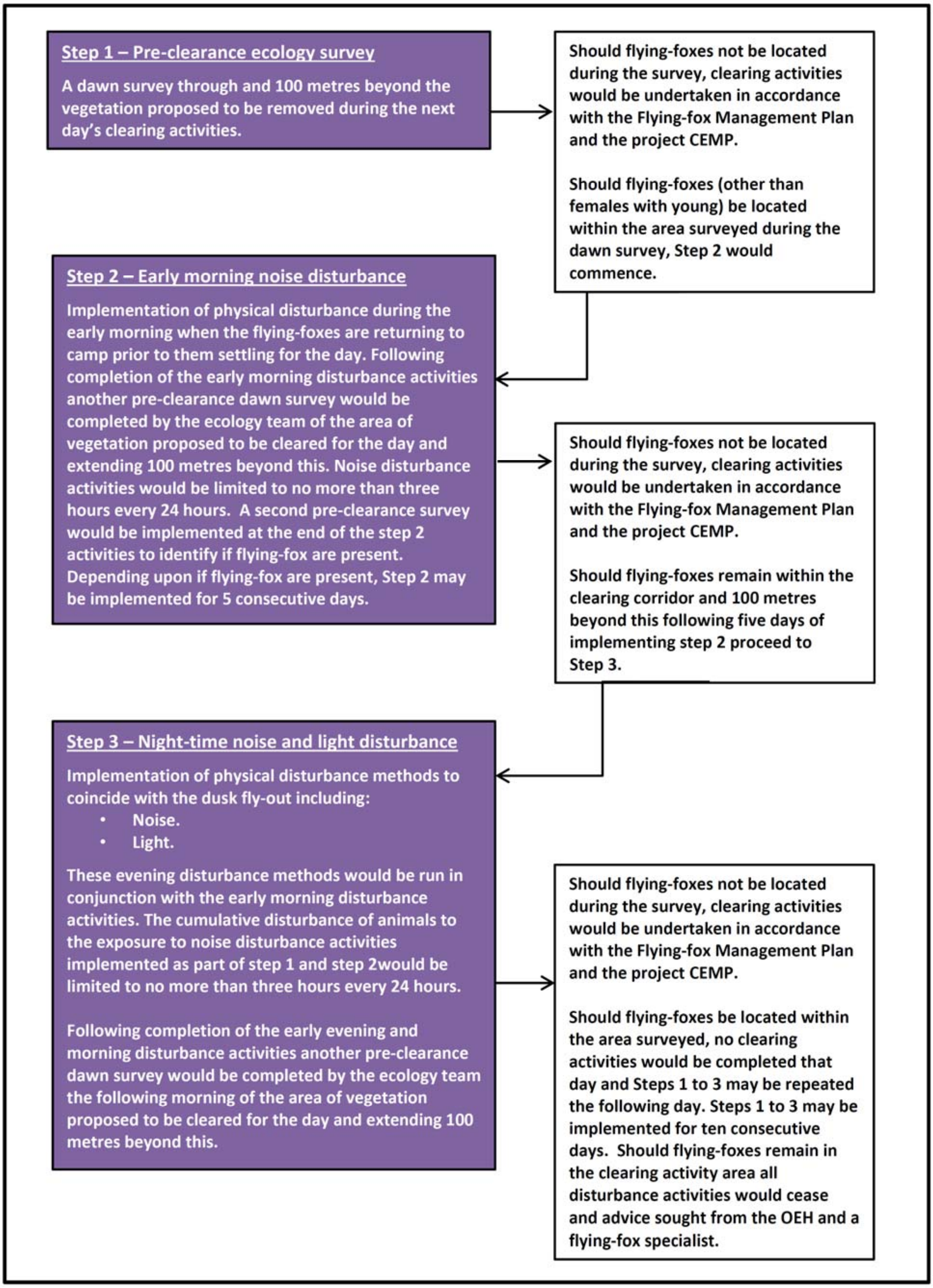


Figure 2 Flowchart of contingency strategy steps.

Monitoring performance

An ecologist experienced with flying-foxes will monitor the implementation of the strategy daily so as to determine the effectiveness of the measures against performance thresholds.

Monitoring will involve a daytime walk through the flying-fox camp and the area where clearing had occurred the previous day to search for dead or injured animals. The number of dead or injured animals is to be recorded against performance thresholds and where required corrective actions implemented. Monitoring of the flying-fox colony behaviour would also be undertaken daily in response to the clearing activities.

Performance thresholds and corrective actions

Table 1-1 presents the performance thresholds for the contingency strategy monitoring program and the corrective actions if deviation from the performance criteria occurs.

Table 1-1 Summary of monitoring program performance thresholds and corrective actions.

Performance threshold	Corrective actions
• More than 1 dead Grey-headed Flying-fox/foetus or more than 1 injured Grey-headed Flying-fox are found which, in the opinion of the ecologist experienced with flying-foxes, are likely to have been killed or injured by the disturbance activities.	• All physical disturbance activities will cease immediately. • Disturbance activities will be reviewed by the ecologist experienced with flying-foxes and, where considered appropriate, scaled back. • The flying-foxes would be monitored continuously during the clearing activities to ascertain whether or not the change in the disturbance regime has been successful. If mortality/injury of the animals remains above the performance thresholds then all physical disturbance activities will cease immediately, and further advice sought from OEH and flying-fox experts.

References

Phillips P. Hauser P. and Letnic M. 2007. Displacement of Black Flying-foxes *Pteropus alecto* from Batchelor, Northern Territory. *Australian Zoologist* 34 (2) 119-124.

Roberts B.J. Eby P. Catterall C.P. Kanowski J. and Bennett G. 2011. The outcomes and costs of relocating flying-fox camps: insights from the case of Maclean, Australia in *The Biology and Conservation of Australasian Bats*. Ed Law, B, Eby, P. Lunney, D. and Lumsden, L. Royal Zoological Society of NSW, Mosman, NSW, Australia. Pp 277-287.

Tidemann C.R. 2003. Displacement of a flying-fox camp using sound. *Ecological Management and Restoration* 4: 224-226.

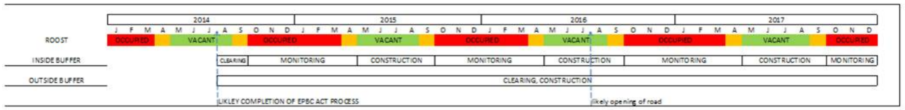
Appendix D. Grey-headed Flying-fox food plant list (blossom diet and fruit diet)

GHFF primary food tree species (blossom diet)			
Banksia integrifolia	Coastal Banksia	*Eucalyptus robusta*	Swamp Mahogany
Corymbia gummifera	Red Bloodwood	*Eucalyptus saligna*	Sydney Blue Gum
Corymbia intermedia	Pink Bloodwood	*Eucalyptus siderophloia*	Northern Grey Ironbark
Corymbia maculata	Spotted Gum	*Eucalyptus tereticornis*	Forest Red Gum
Corymbia variegata	Spotted Gum	*Grevillea robusta*	Silky Oak
Castanospermum australe	Black Bean	*Melaleuca quinquenervia*	Broad-leaved Paperbark
Eucalyptus pilularis	Blackbutt	*Syncarpia glomulifera*	Turpentine
GHFF secondary food tree species (blossom diet)			
Angophora costata	Smooth-barked Apple	*Eucalyptus grandis*	Flooded Gum
Angophora floribunda	Rough-barked Apple	*Eucalyptus propinqua*	Grey Gum
Eucalyptus acmenoides	White Mahogany	*Eucalyptus resinifera*	Red Mahogany
GHFF food tree species (fruit diet)			
Acmena smithii	Lilly Pilly	*Hedycarya angustifolia*	Native Mulberry
Alphitonia excelsa	Red Ash	*Livistona australis*	Cabbage Palm
Archontophoenix cunninghamiana	Bangalow Palm	*Maclura cochinchinensis*	Cockspur Thorn
Avicennia marina	Grey Mangrove	*Melia azedarach*	White Cedar
Cissus hypogaluca	Five-leaf Water Vine	*Melodinus australis*	Southern Melodinus
Dendrocnide excelsa	Giant Stinging Tree	*Morinda jasminoides*	Morinda
Dendrocnide photinophylla	Shining-lved Stinging Tree	*Pennantia cunninghamii*	Brown Beech
Diospyros pentamera	Myrtle Ebony	*Pittosporum undulatum*	Sweet Pittosporum
Diploglottis australis	Native Tamarind	*Planchonella australis*	Black Apple
Eucalyptus reticulatus	Blueberry Ash	*Podocarpus elatus*	Plum Pine
Ehretia acuminata	Koda	*Polyosma cunninghamii*	Featherwood
Elaeocarpus obovatus	Hard Quandong	*Rauwenhoffia leichardtii*	Zig Zag Vine
Ficus coronata	Creek Sandpaper Fig	*Rhodamnia argentea*	Malletwood
Ficus fraseri	Sandpaper Fig	*Syzygium australe*	Brush Cherry
Ficus macrophylla	Moreton Bay Fig	*Syzygium corynanthum*	Sour Cherry
Ficus obliqua	Small-leaved Fig	*Syzygium crebrinerve*	Purple Cherry
Ficus rubiginosa	Rusty Fig	*Syzygium luehmanii*	Riberry
Ficus superba	Deciduous Fig	*Syzygium. oleosum*	Blue Lilly Pilly
Ficus watkinsiana	Strangler Fig	*Schizomeria ovata*	Crabapple

Appendix E. Roads and Maritime Services response to DoE and EPA comments on the draft Flying-fox Management Plan.

DoE Requirement 3 – Flying-fox Management Plan

Roads and Maritime Services response to DoE Review

DoE R 3 Flying-fox MP – DoE review comments		
	DoE Comment	**RMS Responses**
GENERAL COMMENTS		
1	It may be useful to include a timeline /graph/map to illustrate what/which works will be carried out inside/outside the roost buffers. Basically putting the management plan into a picture/illustration. I found I lost track of what works would occur inside the buffer during occupancy vs works inside the buffer when vacant vs works outside the buffer (potentially 24hrs a day throughout the period of construction). I dummied something up which is below, just as a demonstration. 	Timeline included in Section 4.4.2 of the Flying-fox Management Plan
2	Is there a contingency if the GHFF do not return after the initial clearing of roost habitat (ie they abandon the camp)? Is it possible/likely that a decision may be made to allow construction within the 300m roost buffer during the May-September window if no bats are recorded? If so, this should be documented	Following consultation with NSW EPA, the draft FFMP has been modified to include provision for construction activities within the 300 metre construction buffer zone to be undertaken after 15 September each year if monitoring demonstrates that no GHFF are present. This provision is included in Sections 4.4.2, 5.3.3, 5.3.8, 5.3.12 of the Management Plan.
3	Section 6.3.1 Maintenance of habitat restoration and weeds. Should this also include monitoring/maintenance of weed invasion of the swamp within the roost habitat.	Added the statement “These activities would be undertaken in all areas disturbed by the Project including the disturbed section of swamp sclerophyll forest south of Macksville occupied by the flying-fox camp” to section 6.3.1.
4	The plan cross references the CEMP, FFMP and SWMP. These plans should be included in the final preliminary documentation package. The plan also includes Appendix C , which was not provided for this review.	As discussed with DotE on 28 March 2014, the Project is being delivered under a Design and Construct (D&C) contract with the CEMP, FFMP and SWMP to be prepared by the contractor. As the D&C contract is yet to be awarded, inclusion of these plans in the final preliminary documentation package would

DoE R 3 Flying-fox MP – DoE review comments		
	DoE Comment	**RMS Responses**
		cause substantial and unacceptable delays to the EPBC assessment process. Agreed with DotE on 28 March 2014 that any approval under the EPBC Act could be subject to a condition, similar to that included in the approval for the adjacent Nambucca Heads to Urunga project, requiring the CEMP, FFMP and SWMP to address the relevant matters raised in the Management Plan. Section 1.3 of the FFMP has been revised to include a commitment that these management plans would be prepared prior to the commencement of construction.
BUFFERS:		
5	The 300m buffer between construction and the GHFF camp appears arbitrary. I understand this distance is based on the distance of the camp to the current Pacific Highway, however noise/activity disturbance caused by the clearing and construction activities will be quite different to that currently experienced. Also, there is the potential for construction outside the 300m buffer to occur 24 hours a day when the camp is occupied which, with the associated lighting/noise etc, may have negative consequences for the camp.	**Basis for adoption of buffer zones** It is acknowledged that noise/activity disturbance caused by clearing and construction activities can be quite different to that currently experienced at the Macksville camp from highway traffic. Consequently, the following inputs were considered in the adoption of buffer zones around the Macksville camp: • Available data regarding flying-fox camps in the vicinity of similar construction sites; and • Site specific considerations, including constraints in the vicinity of the Macksville camp and conditions applicable at the time of establishment of the Macksville camp. *Data from similar construction sites* The scale of the 300 metre construction buffer was developed in consultation with Dr Peggy Eby and was based on the information regarding flying-fox camps in the vicinity of construction sites included within Table 3-1 of the Management Plan.

DoE R 3 Flying-fox MP – DoE review comments		
	DoE Comment	**RMS Responses**
		It is relevant to note that all six camps in Table 3-1 were less than 300 metres from above ground construction activities with the furtherest camp (at Kurnell) being 240m from the closest above ground construction activities. Dr Eby (pers comm 2014/04/04) has advised that, whilst substantial construction activities were occurring around 240 metres from the Kurnell roost, the timing of roost abandonment at that site was additionally associated with drawdown of surface waters during severe drought conditions. As such it is not conclusive that the abandonment of the Kurnell roost could be attributed to adjacent construction activities. In addition, the temporary roost that formed near the township of Tarcutta, NSW was established during a uniquely long and widespread food shortage for flying-foxes in south east Australia. The animals departed the site at a time when other temporary camps in the regional area also emptied. This also coincided with pile driving during construction of a bridge 250 metres from the roost. It is therefore not clear whether departure from the site was associated with the pile driving. The roost associated with the smaller Campbelltown project was occupied throughout the construction period, despite works occurring 80 metres away. It is also relevant to note that the six construction projects listed in Table 3-1 did NOT stage their construction works to occur out of the likely occupancy season for the flying-fox. As such, the flying-fox were in residence and roosting less than 240m from construction activities during major, disruptive construction works. Dr Eby (~pers comms 04/04/2014) has noted that data obtained since 2011 indicates the Mackville camp is not a permanent camp and is instead a seasonal site that is utilised when there are suitable conditions in the area such as foraging opportunities. For the WC2NH project it is proposed to stage

DoE R 3 Flying-fox MP – DoE review comments		
	DoE Comment	**RMS Responses**
		major construction activities within 300m of the Macksville camp during the period when, based on the data obtained, the camp is likely to be empty or at its lowest occupancy. In summary, the information included in Table 3-1 is the best information currently available regarding flying-fox camps in the vicinity of similar construction sites. Table 3-1 provides a documented basis for the adoption of a construction buffer and, noting the proposed staging arrangements for construction in the vicinity of the Macksville camp, provides no data to indicate that the proposed 300 metre buffer is not appropriate. *Site specific considerations* In addition the buffer considered constraints in the vicinity of the Macksville camp, including the location of the existing of the existing Pacific Highway which is within approximately 330 metres of the edge of the roost and the location of the temporary construction buffer road that would need to be constructed to avoid impacts to the flying-fox roost. **Construction hours** Except for the exclusions specifically identified in the Conditions of Approval under the NSW EP&A Act, Roads and Maritime Services do not have approval to undertake construction works outside standard construction hours. Any requests to undertake works outside these hours would require an assessment of the potential impacts of the proposal, including potential impacts on the flying-fox camp.
6	It is also unclear as to why there is a different buffer (500m) for ancillary sites. Ancillary sites should be described and the sources of noise and the likely intensity/duration of noise at the source and at the edge of the 500 m buffer zone should be discussed.	Ancillary sites could include site compounds, temporary stockpile sites, materials management sites (including batch plants and crushing and screening sites) and other activities required to support the construction of the project. While major construction activities at any point along a linear

DoE R 3 Flying-fox MP – DoE review comments		
	DoE Comment	**RMS Responses**
		construction project are typically transient, ancillary sites are generally in operation throughout the duration of the construction of the project. Due to the nature of the activities undertaken at ancillary sites and the duration of their operation, ancillary sites have the potential to generate greater levels of disturbance than road construction activities. Accordingly a buffer of 500 metres is proposed to be provided between the perimeter of the camp and any ancillary sites. Section 4.4.2 of the FFMP has been revised to include advice that a 500 metre buffer has been adopted for ancillary sites as they have the potential to generate greater levels of disturbance than road construction activities.
7	It may be simpler/clearer to have one buffer distance (ie 500m) between the roost and any works associated with the upgrade. It would be useful to have this buffer shown in Figure 1.2	The 500m buffer between the roost and any works associated with the upgrade would include part of the existing highway to the west of the flying-fox camp and the eastern section of the temporary construction connection. Consequently, this proposed change to the buffer zone would prohibit access to the project via the temporary construction access during the proposed (mid September to end April) construction exclusion period. Subject to detailed design, the proposed change to the buffer zone may also prohibit construction of part of the intersection of the temporary construction connection and the existing highway. There is also a risk that haulage of materials for the project along the existing highway could be considered to be part of the project and therefore prohibited during the proposed construction exclusion period. A 500 metre construction buffer as proposed would have severe implications for the construction of the project. The basis for the adoption of the 300 metre construction buffer is provided in the response to (5) above.

DoE R 3 Flying-fox MP – DoE review comments		
	DoE Comment	**RMS Responses**
		The basis for the adoption of the 500 metre buffer to ancillary sites is provided in the response to (6) above. In summary, Roads and Maritime are committing to: • The implementation of buffer zones around the flying-fox camp measured from the combined mapped extent of the 2013-2014 surveys. • Modification of the location of the buffer zones based on monitoring results of the camp. • The implementation of a buffer zone of 300 metres between the perimeter of the camp and major construction activities (eg clearing, earthworks, bridgeworks and pavement construction) undertaken between mid-September and the end of April the following year, subject to: o The existing highway, the temporary construction connection between the existing highway and the alignment and the Bald Hill Road interchange / cutting being excluded from the 300m construction buffer zone; and o The extension of construction activities within the 300 metre construction buffer zone after 15 September each year if monitoring demonstrates that no GHFF are present. • The implementation of a buffer of 500 metres between the perimeter of the camp and any ancillary sites throughout the period of construction of the Project.
TIMING		
8	Previous monitoring indicates the camp is likely to be vacant from May and mid-September although, given the short history of the camp, it is difficult to know what will happen in 2014. August / September is the mid to late stages of pregnancy and commencement of birth and there may be issues with undertaking work in the August / September period if the camp becomes occupied. Is it an option to commence disturbance in mid April and stop at the end of August, which allows	Peggy Eby has advised that, should flying-foxes be in the camp when work commences, start of construction would be likely to have a greater impact on the flying-foxes than continuing the work into August / early September as the flying-foxes would be unlikely to return to the camp if the construction activity is continuous.

DoE R 3 Flying-fox MP – DoE review comments		
	DoE Comment	**RMS Responses**
	the same period of time for construction? Or keep the May window and have a contingency of continuing construction to mid-September or until a certain number of bats occupy the roost	As such Roads and Maritime Services in agreement with NSW EPA propose to undertake construction activities within 300m of the perimeter of the camp during the period 1 May to 15 September each year. Monitoring of the camp will be undertaken after 31 August each year and construction within the buffer zone would halt if there are heavily pregnant GHFF or female GHFF with dependant young present. Construction activities within 300 metres of the perimeter of the camp may be undertaken after 15 September each year if monitoring demonstrates that no GHFF are present.
9	Despite the controls, there is a residual risk of dispersal either due to construction noise or operational noise. Mention is given to this risk in part 6.1.1 (page 31), however, there is no discussion of the relevant actions to be taken if dispersal occurs and a problematic camp (i.e. urban/community conflict) is established. This is the only clear deficiency in the report. Although the risk may be considered to be fairly low, the movement of up to 30,000 individuals into a new camp could be a significant issue. There should be a basic discussion of what response would occur if a new camp was established in a nearby (i.e. 5 km) problematic location, that coincided with a decrease in individuals at the Macksville camp. Drawing a causal link between impacts on the Macksville camp and increases in numbers at established camps may be difficult without satellite data, which will not be gathered (nor considered to be essential). However, anecdotal evidence of a problematic camp established in close proximity (spatially and temporally) to the proposed action may be reasonably connected to the action. Mitigation measures for such an event should be a consideration for the proponent.	Roads and Maritime Services agrees to develop a strategy for the management of new GHFF camps that become established within 50 km of the Macksville camp site subject to there being a demonstrable linkage between: • The project and the reduction in occupancy of the Macksville camp; and • The reduction in occupancy of the Macksville camp and the establishment of new GHFF camps. The commitment would include camps which become established within 12 months after the permanent opening of the full length of the project to traffic. The strategy would be developed in consultation with EPA, DotE, Council and affected landholders. RMS also agrees to provide the resources and funding required to implement the agreed reasonable and feasible mitigation measures identified in the strategy. Details of the strategy and the resources required would be subject to the location and issues arising from the new camps and the agreed management measures. The commitment is included in Section 6.3.6 of the Flying-fox Management Plan

DoE R 3 Flying-fox MP – DoE review comments		
	DoE Comment	**RMS Responses**
EDITING		
10	Section 1.1, Page 2: ....the decision made under section 75 ~~and section 87~~ of the EPBC Act........ The decision made under section 87 of the Act refers to the assessment approach (ie preliminary documentation).	Deleted
11	. Section 1.3, Page 3: There is no Table 8.1	As this table has been deleted the following words have been added: Roads and Maritime Service and the contractor engaged to construct the project would be responsible for implementing the activities in this flying-fox management plan and would include the engagement of suitably qualified specialists to undertake and oversee surveys and monitoring activities.
12	Section 2.2, Page 9: Typo “personal” should be “personnel”	Modified
13	. Section 4.6, Page 20; Section 5.4, Page 27; Section 6.4, Page 33: Typo “responsibility” should be “responsible”	Modified in these two sections and also in Section 6.4
14	Section 5.2, Page 23: Typo “No injury or mortality ~~or injury~~ to flying foxes......”	Removed additional words
15	Section 5.3.13, Page 27: Is the reference to Section 5.3.12 correct?	Deleted this reference.
16	Section 7.5, Page 38: This table has a different format than shown in previous sections. Main goal, responsibility columns should be included	Table updated.

ENVIRONMENT PROTECTION AUTHORITY - COMMENT SHEET

Project:	Pacific Hwy Upgrade – Warrell Creek to Nambucca Heads		
Document title:	Warrell Creek to Nambucca Heads Flying-fox Management Plan		
Revision No.:	Version V05 26 February 2014 including clarifications from Director – North EPA 27 March 2014		
Reviewer name:	Craig Harré Kelly Roche	Review date:	Finalised 6 November 2014
Responses by:	Rachel Vazey (SKM) Chris Clark (Roads and Maritime Services)	Response due:	

Thank you for the opportunity to comment on the Project's Flying-fox Management Plan**.** The EPA has reviewed the plan and has outlined key areas of concern and recommendations in the table below.

Reference	EPA comment	Roads and Maritime Services Response
	The EPA acknowledges that there is a high degree of uncertainty in relation to the interactions between the proposed highway upgrade construction and operation activities and any resultant reactions by the flying-fox population within the roost location.	Noted
	Noting the above statement, the document displays some uncertainty about the likely extent of the impacts resulting from the upgrade; however it is recognised throughout the management plan that the level of disturbance may be significant enough to trigger camp abandonment. For example consider the following:	Yes it is noted that this is possible that the proposed action would likely displace the flying-foxes from their current roosting site. However monitoring has shown the site is a seasonal site only and is only used for limited times of the year. Ongoing monitoring undertaken at monthly intervals during 2013 and fortnightly intervals during 2014 has shown that the camp is typically not occupied from the end of April until September or later.
Page 2	*"The proposed action would likely displace the flying-foxes from their current roosting site".*	
Page 11	*"The level of disturbance in and immediately adjacent to the camp area would likely displace the flying-foxes from their current roosting site, which may lead to stress and reduced fecundity for this population".*	
Page 17	*"Flying-fox camp abandonment, at least temporarily, is expected to occur due to disturbance during construction (noise, dust) and during operation (noise, landscape alteration)".*	
	However, on page 9, there is some uncertainty about whether it is *"possible to predict whether animals will continue to use the site".* The EPA believes this is unlikely, at least within close proximity to the clearing footprint, particularly during clearing operations. It appears unlikely that flying-foxes will continue to utilise the site whilst construction is active.	It is also possible that animals may return to the site post construction, however this may not occur – hard to predict at this point
Table 3-1	Following these statements and the summary of outcomes of six comparable road construction projects (from Table 3-1), evidence in the table tends to indicate that road construction related activities appear to have at least an 80% likelihood of causing a flying-fox roost to be abandoned, with only one of the roosts being re-populated 20 years after dispersal. The site where roosting resumed was adjacent to a project where a single carriageway in both directions was constructed, rather than a motorway. Key differences being the width of the alignment and associated clearing, as well as the subsequent traffic volumes/usage patterns. Other differences are unknown.	All six camps in Table 3-1 were less than 300 metres from above ground construction activities with the furthest camp (at Kurnell) being 240m from the closest above ground construction activities. Dr Eby (pers comm 2014/04/04) has advised that, whilst substantial construction activities were occurring around 240 metres from the Kurnell roost, the timing of roost abandonment at that site was additionally associated with drawdown of surface waters during severe drought conditions. As such it is not conclusive that the abandonment of the Kurnell roost could be attributed to adjacent construction activities.
	To gain further insights into likely flying-fox responses, can Roads and Maritime confirm whether the projects from Table 3-1 staged their construction works out of the likely occupancy season?	The six construction projects listed in Table 3-1 did NOT stage their construction works to occur out of the likely occupancy season for the flying-fox. As such, the flying-fox were in residence and roosting less than 240m from construction activities during major, disruptive construction works.
Section 3.2 Potential Impacts from the Project	In reviewing the management plan it appears that each of the processes identified (clearing work, loss and fragmentation of habitat, disturbance of roost sites, noise, vibration, dust and light impacts etc..) predicts that the project activities are likely to individually, let alone cumulatively, result in abandonment of the roost.	Noted

Reference	EPA comment	Roads and Maritime Services Response
Page 31 Section 6.1.1	Following the points made above, the paragraph from *page 31* of the management plan identifies the very likely risk *"that a proportion of flying-foxes that currently use the Macksville camp (currently > 50,000 in number) will relocate to one of the 20 camps present within a 50 kilometre radius of the Macksville camp (refer* ***Figure 3-1****). It is also possible that one or more new camp sites will establish (Roberts et al., 2011). The location of a new camp cannot be predicted and there is potential for new sites of conflict to be created. The increase in numbers at some of the camps located near developed areas has the potential to create conflict with humans".*	Yes it is noted that this is possible that the proposed action would potentially displace the flying-foxes from their current roosting site.
	Therefore a likely outcome of the highway upgrade activities may see the flying-foxes abandon the present roost site (as stated in the management plan) and remain within the local area. Eby and Roberts (June 2013) have demonstrated in a systematic review of recent camp dispersals in Australia that in 16 of 17 cases of forced dispersals, flying-fox numbers did not diminish in the local area with 63% re-established within 600m of the original camp. It is further observed that following dispersal attempts where camps have relocated within a short distance, that there has also been formation of numerous satellite camps within the surrounding landscape. For example, following attempted dispersal in Maclean in 1999, the seasonally occupied maternity camp moved 300m into a residential area, creating extreme levels of conflict with sensitive receivers. In addition, 13 new satellite camps were observed within the lower Clarence, including a camp adjacent to residents at Iluka which also generated substantial community conflict. The secondary camp in Maclean is now continuously occupied and the Iluka camp continues to host flying-foxes on a seasonal basis, with conflicts continuing. Ongoing management of the Maclean camp to reduce conflict has been and continues to be costly, with many management actions requiring long periods of time to provide benefit.	As per item 8 of the combined DoE and OEH responses Roads and Maritime agrees to develop a strategy for the management of new GHFF camps that become established within 5 km of the Macksville camp site subject to there being a probable linkage between: • The project and the reduction in occupancy of the Macksville camp; and • The reduction in occupancy of the Macksville camp and the establishment of new GHFF camps. The commitment would include camps which become established within 12 months after the permanent opening of the full length of the project to traffic. The strategy would be developed in consultation with EPA, DoE, Council and affected landholders. Roads and Maritime also agrees to provide the resources and funding required to implement the agreed reasonable and feasible mitigation measures identified in the strategy. Details of the strategy and the resources required would be subject to the location and issues arising from the new camps and the agreed management measures. Have included the commitment in section 6.3.6 the Management Plan.
	Given this potential for flying foxes to relocate and possibly establish adjacent to sensitive receivers the EPA recommends that Roads and Maritime proactively develops a response to address these latent issues in the form of a communication and media strategy which explains the proposed management issues and approach to the community. It is recommended that Roads and Maritime specifically address the risk of flying-foxes relocating to either new or existing camps that may be located in sensitive areas. For details of previous successful communications strategies please refer to the OEH register of section 91 licences granted for dispersal of Grey-headed Flying-foxes. The EPA recommends the strategy includes but is not limited to: • A mechanism for people to make reports of new GHFF camps or increases in numbers • A series of press releases, targeted communication/media for potentially impacted community, particularly for residents/receivers adjacent to existing camp sites	As per response 6, Roads and Maritime concurs with the recommendation to prepare a communication and media strategy which includes but is not limited to: • A mechanism for people to make reports of new GHFF camps or increases in numbers. • A series of press releases, targeted communication/media for potentially impacted community, particularly for residents/receivers adjacent to existing camp sites Have included the commitment in the Management Plan in Section 5.3.13 and 6.3.8 and wording is as used above with the additional inclusion of: The strategy will be included in the Community Communication Strategy required under MCoA B28.
	In addition to these strategies it is also recommended that the following 3 management actions are undertaken: 1. Provide the EPA with details of a dispute resolution mechanism that will be in place should there be disagreement between Roads and Maritime and affected receivers over a new or substantially increased flying-fox camp within 50km of the Macksville camp.	Roads and Maritime Services concurs with the recommendation to develop a dispute resolution mechanism. The Community Communication Strategy required under MCoA B28 would include a dispute resolution mechanism in the communication and media strategy.
	2. Provide the EPA with details of the resources that would be made available to managers of new GHFF camp sites (this could be included in a GHFF regional conservation strategy as discussed below). This should also include compensation for potential loss of land use or land value.	As discussed above, Roads and Maritime Services agrees to develop a strategy for the management of new GHFF camps that become established within 5 km of the Macksville camp site subject to there being a probable linkage between: • The project and the reduction in occupancy of the Macksville camp; and • The reduction in occupancy of the Macksville camp and the establishment of new GHFF camps. The commitment would include camps which become established within 12 months after the

Reference	EPA comment	Roads and Maritime Services Response
		permanent opening of the full length of the project to traffic. The strategy would be developed in consultation with EPA, DoE, Council and affected landholders. Roads and Maritime also agrees to provide the resources and funding required to implement the agreed reasonable and feasible mitigation measures identified in the strategy. Details of the strategy and the resources required would be subject to the location and issues arising from the new camps and the agreed management measures.
Page 9	In addition to the communications strategy it is also recommended that targeted offsets are developed to compensate for this additional impact (as it was not assessed in the approved Environmental Assessment). The offset process could potentially include addressing a funding shortfall to implement the *Bowraville flying-fox camp Plan Of Management*. This recommendation is consistent with the management plan's objectives which are to "*provide measures that minimise impacts to flying-foxes".* However this recommendation should only be considered in consultation with Nambucca Heads Shire Council and the affected community. Discussion on page 9 confirms that the *"Macksville camp formed in response to the abandonment of the Bowraville camp"* and that flying-foxes returned there in some number in October 2013. Habitat augmentation of the Bowraville camp may benefit the recovery of the displaced Macksville camp, which is likely to suffer long-term impacts if an acceptable alternate camp is not available. However EPA notes that there are ongoing vandalism issues with habitat augmentation at the Bowraville camp. Given additional pressures on impacted local populations of flying-foxes Roads and Maritime may also consider a potential offset to identify and repair flying-fox habitat in the region, within a 50km radius from the Macksville camp (as depicted in **Table 3.1**). This could potentially be in the form of funding a long-term regional flying-fox conservation strategy to identify, assess, enhance and protect roost sites and the preparation of flying-fox camp management plans with associated funding for the implementation of strategies identified by those plans. In summary, the EPA recommends that Roads and Maritime develops a response to address the issues created following the likely dispersal of flying-foxes from the Macksville camp. Following the suggestions above, roads and Maritime response should include an offset proposal which identifies and prioritises offsets at a 'local' scale (within 20km following Eby and Roberts), and a more strategic scale, for example within the Nambucca Heads LGA. Additional guidance on appropriate offset development can be provided by OEH experts in flying-fox management and recovery. However as a starting point consider the actions for recovery identified in the Draft National Recovery Plan for the Grey-headed Flying-fox (Eby, July 2009).	As per response 9 on targeted offsets. Roads and Maritime Services concurs with the recommendation to provide funding to enable the implementation of the *Bowraville flying-fox camp Plan Of Management* adopted by Nambucca Heads Shire Council following consultation with the affected community. Roads and Maritime funding would be limited to the lesser of $100,000 or 50% of the cost of implementing the Management Plan. It is relevant to note that Roads and Maritime is currently developing a biodiversity offset strategy and package in consultation with EPA and DoE. The proposed offsets are being determined in accordance with the EPBC Act offsets calculator. For the GHFF, the proposed offsets allow for impacts on foraging habitat. It is considered that the biodiversity offset package being prepared in accordance with the EPBC Act offsets calculator (as outlined above) makes appropriate provision for the potential impacts of the project. The commitment is included in Section 5.3.13 of the Management Plan Noted. The author of the Draft National Recovery Plan for the Grey-headed Flying-fox (Eby, July 2009) has been consulted as part of the preparation of the Flying-fox Management Plan and the contingency strategy.
Page 10 Disturbance of roosting sites	The EPA is concerned that the proposed construction window, ending in mid-September, could extend too late and cause substantial mortalities of returning heavily pregnant mothers, or abortion of their young. It is noted in the management plan that "*disturbance is particularly detrimental during the last weeks of pregnancy when females can spontaneously abort (Garnett et al. 1998, Luly et al., 2010)".* Bearing this in mind, the EPA also notes the following from the Grey-headed Flying-fox Management Strategy for the Lower Hunter (Geolink, April 2013), *"GHFF have a low reproductive rate, with a single pup generally born in October / November (Martin & McIlwee, 2002); although births in September can occur (P. Eby unpublished data). In 2012, very young pups were observed in the first week of September (Dowling pers. com.) in the Lower Hunter".* If the camp is occupied in August, females in the third trimester of pregnancy would be expected to be using the camp, based on the typical reproductive cycle of the species. Monitoring data at the site demonstrates that >10,000 GHFF were present in September 2013 but none were present in August 2013. It is not possible to accurately predict when heavily pregnant females will arrive at the camp but it could feasibly be earlier than mid-September. The provisions in the management plan in relation to the monitoring of and management and mitigation measures specific to dependent young and pregnant females needs to be expanded upon, currently the management plan indicates monitoring for behavioural patterns, but does not provide any specific examples of mitigation or	Refer to response items 1 and 2. Peggy Eby has advised that, should flying-foxes be in the camp when work commences, start of construction would be likely to have a greater impact on the flying-foxes than continuing the work into August / early September as the flying-foxes would be unlikely to return to the camp if the construction activity is continuous. As such in a discussion held between OEH and Roads and Maritime at the end of March 2014, an agreement was made regarding the timing of the construction period, which is as follows: • Fortnightly monitoring of the camp to be undertaken after 1 August and construction to halt if there are heavily pregnant GHFF or female GHFF with dependant young present. • Clearing of vegetation would halt if there are heavily pregnant GHFF or female GHFF with dependant young present noting that an ecologist, experienced with flying-foxes would be on site during removal of vegetation in the vicinity of the flying-fox camp. • Other construction activities would halt if there are heavily pregnant GHFF or female GHFF with dependant young present after 31 August. • Construction activities within the buffer zone may be undertaken prior to 1 May or after 15

Reference	EPA comment	Roads and Maritime Services Response
	management actions in relation to breeding activity or young. Dispersal of females in the third trimester of pregnancy or with dependant young is not supported and should not be undertaken.	September each year if monitoring demonstrates that no GHFF are present. Noted. As agreed with EPA in a meeting at the end of March 2014 the following has been agreed to: • Activities within the 300 metre buffer zone between mid-September and the end of April the following year to be restricted to low noise/ low disturbance construction activities required for monitoring, maintenance and incident response purposes. Observational monitoring to be undertaken to ensure that the low level noise/disturbance activities are in fact meeting those criteria. • Construction activities within 300m of the perimeter of the camp may be undertaken before 1 May or after 15 September each year if monitoring demonstrates that no GHFF are present. • The extent of buffer zones around the flying-fox camp would be measured from the combined mapped extent of the 2013-2014 surveys. • The location of the buffer zones may be modified based on monitoring results of the camp. • A buffer zone of 300 metres would be imposed between the perimeter of the camp and major construction activities (eg clearing, earthworks, bridgeworks and pavement construction) undertaken between mid-September and the end of April the following year. The existing highway, the temporary construction connection between the existing highway and the alignment and the Bald Hill Road interchange / cutting would be excluded from the 300m construction buffer zone. • A buffer of 500 metres would be imposed between the perimeter of the camp and any ancillary sites throughout the period of construction of the Project. Information has been included in Section 4.4.2 and Section 5.3.3 and Table 5-1 of the Management Plan.
Page 12	The management plan states that *"the entire area of Swamp Sclerophyll Forest (23.5 hectares) could potentially be used for roosting during peak periods".* However following commencement of clearing it is unknown whether the flying-foxes will occupy a different part of the 23.5ha patch. If, as suggested in the management plan, flying-foxes inhabit parts of the entire 23.5ha patch, why limit the 300m construction buffer to the previously recorded camp boundaries? Following the rationale presented on page 12, the construction buffer should extend 300m from the entire 23.5 ha patch if it became occupied. This notion is supported by the following point from page 17 *"In the event flying-foxes continue to forage in the surrounding swamp forest, there may be collisions between flying-foxes and vehicles due to the proximity of the camp to highway traffic".* Further comment on extension of the buffer is made below.	As per item 2 of the DoE and OEH response table, it us noted that the 500m buffer between the roost and any works associated with the upgrade (as proposed by DoE) would include part of the existing highway to the west of the flying-fox camp and the eastern section of the temporary construction connection. Consequently, this proposed change to the buffer zone would prohibit access to the project via the temporary construction access during the proposed construction exclusion period. Subject to detailed design, the proposed change to the buffer zone may prohibit construction of part of the intersection of the temporary construction connection and the existing highway. There is also a risk that haulage of materials for the project along the existing highway could be considered to be part of the project and therefore prohibited during the proposed construction exclusion period. The MP has been updated in section 4.4.2 and 5.3.3 to include the following details: • The extent of buffer zones around the flying-fox camp would be measured from the combined mapped extent of the 2013-2014 surveys. • The location of the buffer zones may be modified based on monitoring results of the camp. • A buffer zone of 300 metres would be imposed between the perimeter of the camp and major construction activities (eg clearing, earthworks, bridgeworks and pavement construction) undertaken between mid-September and the end of April the following year. The existing highway, the temporary construction connection between the existing highway and the alignment and the Bald Hill Road interchange / cutting would be excluded from the 300m construction buffer zone. • A buffer of 500 metres would be imposed between the perimeter of the camp and any ancillary sites throughout the period of construction of the Project.
Page 18	Please read the following extract; *"Clearing within the section of Swamp Sclerophyll forest south of Macksville in which the flying-fox colony became established in October 2011 would be undertaken when the camp is empty or at its lowest occupancy".* Clarification of this section is needed for it to be understood. Therefore please confirm whether this is a commitment to clear the habitat when flying-fox numbers are *potentially* at their lowest or vacant (as indicated by current monitoring), or whether this a reference to the proposed construction window when flying-	See response above

Reference	EPA comment	Roads and Maritime Services Response
	fox numbers are *predicted* to be at their lowest i.e. May to mid-September? Further in this section it is stated that the construction period *“would be further informed by future survey information*” which tends to support the position that the construction window should be dynamic and responsive in nature.	
	Further to this point, is the above extract from the management plan a commitment to review the commencement or end of the construction window? For example, is it foreseeable that Roads and Maritime will approach the EPA with a request for an extension of the construction window if flying-fox are not present in mid-September?	Clarification included in Table 5-1 of the Management Plan that: “Construction activities within 300m of the perimeter of the camp may be undertaken before 1 May or after 15 September each year if monitoring demonstrates that no GHFF are present.”
	The management plan should flag this issue and the likely consequences of this action if this request is likely i.e. a request for an extension of the construction window beyond mid-September could result in the prevention of heavily pregnant females from roosting, even if initially in low numbers. Habitat clearing/dispersal is not supported in the event that females in the third trimester of pregnancy or with dependent young are present.	See comment immediately above.
	The following statement on page 23 also commits Roads and Maritime to reviewing the construction period as *“further informed by future survey information”.* There is further discussion on this point in EPA comments on page 26. Note the construction window mitigation measure requires greater clarity or rules describing how monitoring will influence decisions.	See comment immediately above.
	The proposal to start at the southern end of the habitat has merit if the camp is occupied and the decision to commence clearing is made. This is particularly the case if clearing commences in May 2015 as we will not likely have to be concerned with *heavily* pregnant females (they will be pregnant from May) and/or dependent young. Notwithstanding this, the EPA recommends an alternative approach which would be to commence clearing as close as possible to the camp site if at that point in time it is unoccupied. This suggested approach would take advantage of a vacant camp and hence reduce immediate impacts. This view is supported by OEH flying-fox experts and the monitoring data to date.	This suggestion is noted and will be considered during the scheduling of clearing activities. However it should be noted that the staging of construction activities is still being determined and will depend on the timing of other activities to the north and south of the swamp sclerophyll forest that need to happen before access will be provided. For example this may include the laying down of gravel etc for vehicle access and may also include works around and over existing waterways etc.
	Additionally the EPA also suggests programing clearing works from two fronts to commence following dusk ‘fly out’ to take advantage of a vacant camp. This will negate the need for invasive and stressful forced dispersal measures as outlined in Appendix C. The suggested night work could be limited to removal and laying down of individual trees with a harvester. However this work should only be undertaken when it is confirmed that there are no dependent young or females in their third trimester of pregnancy.	Noted. As above this will depend on the staging of the construction activities and what provisions need to be made to allow the machine access to the swamp.
	The EPA recommends that Roads and Maritime develops a flow chart of potential management decisions based on monitoring results and in response to the presence/absence of flying-foxes throughout different stages of their life cycle. This will provide the EPA with greater certainty on the proposed actions and potential scenarios encountered on site and provide Roads and Maritime with opportunities to react dynamically in an informed manner.	A flow chart has been created and included within the Management Plan, refer to Figure 5-1 in Chapter 5
Page 19	Following the assumption in the management plan that the entire 23.5 ha patch is suitable for roosting, why restrict the definition of the 300m buffer to the boundary area of the 2013/14 camp? This boundary is the smallest of the mapped 3 boundaries and is very likely to be abandoned, or as stated on page 38 *“Flying-foxes would be likely to change their roosting location within the 23.5ha remnant”.* Roads and Maritime should be considering the combined extent under this management plan, rather than the smallest camp footprint. Given the noticeable shifts in areas of occupancy, the EPA suggests making the buffer dynamic, with consideration of the most recent monitoring results available to Roads and Maritime.	As per item 2 of the DoE and OEH response table, Roads and Maritime have committed to the following: • The extent of buffer zones around the flying-fox camp would be measured from the combined mapped extent of the 2013-2014 surveys. For further details refer to response above
Page 24	The EPA suggests it is not reasonable to compare the traffic noise from the existing Pacific Highway to the predicted noise generated by road construction activities (although this may depend on the type of construction activities proposed at the site). The EPA seeks further evidence to support the formulation of the proposed 300m buffer. Potential disturbance from vibration associated with construction should also be considered, in particular the operation of vibrating rollers.	Refer to response item 1 in the DoE and OEH response table. Roads and Maritime have included the following commitment in Sections 4.4.2 and 5.3.3 of the MP: • Activities within the 300 metre buffer zone between mid-September and the end of April the following year to be restricted to low noise/ low disturbance construction activities required for monitoring, maintenance and incident response purposes. Observational monitoring to be undertaken to ensure that the low level noise/disturbance activities are in fact meeting those criteria. • Construction activities within 300m of the perimeter of the camp may be undertaken after 15 September each year if monitoring demonstrates that no GHFF are present.

Reference	EPA comment	Roads and Maritime Services Response
	Table 3-1 illustrates that construction activity within approximately 240m proximity to camp forced abandonment.	Noted
Page 25	The gradual encroachment of clearing has merit as a proxy to forced dispersal if flying-foxes are present, and this is the preferred method of forced dispersal if (and only if) initial clearing works are undertaken in May 2015. The EPA has recommended strict conditions that must be met prior to clearing the footprint from beyond July 2014 .i.e. no heavily pregnant females or dependent young can be present. The EPA supports cessation of clearing works if a flying-fox is present within 50m, at least during initial clearing (although bear in mind this would be unlikely if the work is undertaken in the night time and additionally when no crèched young are likely to be present). The EPA preferred method is to enable the individual to move of its own volition rather than through relocation/capture. The management plan discusses relocation methodology however it does not describe the procedures used to capture. Capture is unlikely to be a practical option as it requires use of very large mist nets across fly-out or fly-in paths and would not be effective in capturing all animals, as well as presenting welfare issues. Alternatively, is the reference to relocation only specifically regarding transportation of injured flying-foxes?	Noted, please see responses to items 1 and 2. Roads and Maritime Services has made the commitment in Table 5-1 and Sections 4.4.2, 5.3.3 and Chapter 7 of the MP that: • Fortnightly monitoring of the camp to be undertaken between 1 August and the end of April the following year. • Clearing of vegetation would halt if there are heavily pregnant GHFF or female GHFF with dependant young present noting that an ecologist, experienced with flying-foxes would be on site during removal of vegetation in the vicinity of the flying-fox camp. • Other construction activities would halt if there are heavily pregnant GHFF or female GHFF with dependant young present after 31 August. • Construction activities within the buffer zone may be undertaken prior to 1 May or after 15 September each year if monitoring demonstrates that no GHFF are present. Roads and Maritime acknowledges that OEH supports the 50 metre boundary however the management plan has been updated to use a 100 metres buffer during clearing activities following the review of the contingency strategy by Dr Peggy Eby. Roads and Maritime will investigate the possibility of undertaking works at night and seek the appropriate approval if working at night is considered to be feasible. Roads and Maritime Services are not proposing to capture animals for the Project as relocation of large numbers of animals is not feasible. As such only temporary relocation is proposed preferably within the swamp sclerophyll forest patch. It should also be noted that the site is not an established permanent roost site and appears to be a temporary roost site, refer to Eby 2012 and other monitoring reports by GeoLink 2013 – 2014 which describe the changing nature of the numbers at the site on a fortnightly basis.
Page 26 Section 5.3.6	This section of the management plan advises that Roads and Maritime is committed to the proposed construction window between May and mid-September. This section of the management plan goes further to state that if flying-foxes do not re-locate within 24 hours then strategies will be implemented to move flying-foxes. Refer comment above in relation to Appendix C. These two proposed approaches are inconsistent with a number of other sections in the management plan that discuss altering the construction window dependent on flying fox presence and monitoring results. Further in the document, on page 27, it is stated that the construction window will be *“further informed by future survey information”.* In summary it should be noted that greater clarity is required in the document on the proposed actions or likely limits to construction timing that can be driven by monitoring results and a clear decision trigger provided as to when the provisions of Appendix C will be implemented.	That is correct – there is only a limited window of time when works can occur and pre-clearing surveys will occur 24 hours before any clearing works occur. Should flying-fox be identified then the contingency strategy would be implemented. Please refer to response items 1 and 2 As stated in the management plan, the contingency strategy would be implemented should a flying-fox (or group of flying-foxes) be identified within the construction clearing zone and within100 metres of clearing activities during pre-clearing ecology surveys. Have added further information within the MP that was included within the contingency strategy to provide greater clarity on the issue, which is as follows: • Should a flying-fox (or group of flying-foxes) be identified within the construction clearing zone and within 100 metres of clearing activities during pre-clearing ecology surveys outlined above, the contractor may need to move the flying-foxes out of the construction clearing zone using the contingency strategy included in **Appendix C**. Further detail regarding the contingency strategy is included below: • The contingency strategy for moving the flying-fox has been prepared as a precautionary measure should flying-foxes remain in the camp during the 1 May to 15 September period when clearing work is proposed to be undertaken in the Project’s corridor. The contingency strategy is aimed at relocating the animals out of the clearing corridor near the seasonal

Reference	EPA comment	Roads and Maritime Services Response
		Macksville roost site and does not relate to the construction activities themselves. • Clearing activities for the Project would include removal of trees and vegetation, soft soil treatment and the importation of appropriate rockfill materials to allow the proposed highway corridor to be easily accessed. • At the time clearing activities are proposed to be undertaken (1 May – 15 September), it is anticipated that all young would be flying and feeding independently and that no animals would remain in the roost at night. As proposed clearing activities would move from the edges of the Swamp Sclerophyll Forest towards the roost camp, it is envisaged that the clearing activity itself would create enough disturbance to temporarily discourage any flying-foxes from roosting in the area of the clearing activities. • The contingency strategy aims to move flying-foxes from vegetation proposed to be removed during clearing activities in order to prevent stress, injuries or mortality to the animals. The aim of the contingency strategy is to herd the animals through the contiguous tract of Swamp Sclerophyll Forest until they reach vegetation 100 metres from the vegetation proposed to be removed during the clearing activities. This strategy is a temporary contingency to minimise impacts on flying-foxes should they be roosting in or near vegetation proposed to be removed and is not a long term dispersal/relocation strategy. No disturbances to the flying-foxes would occur during high wind, heavy rain or other adverse environmental conditions. Pre-clearance dawn ecology surveys would occur daily prior to any clearing works commencing. The cumulative disturbance of animals due to exposure to noise and light activities would be limited to no more than three hours every 24 hours. • The contingency strategy and the Flying-fox Management Plan have been developed in conjunction with the Office of Environment and Heritage (OEH) and the Department of the Environment (DoE) as part of the approval process. Concurrence with OEH and DoE will need to be obtained prior to implementation of the strategy. • The contingency strategy for moving the flying-foxes 100 metres from vegetation proposed to be removed during clearing activities would be undertaken as a series of separate steps. Each individual step would only be implemented if the previous step was not successful in moving all flying-foxes out of vegetation proposed to be removed. The contingency strategy would be implemented in accordance with the decision making flow chart, refer to Figure 1 in Appendix C.
Page 26 Section 5.3.9	Roads and Maritime has introduced the following conceptual mitigation measure; *"the potential provision of a permeable, free draining rock platform to ensure that the proposed activity does not result in long term changes to the natural surface water levels in the vicinity of the camp",* which is strongly supported by the EPA. Rather than discussing this option or deferring it to detailed design the EPA recommends a commitment is made in this plan to incorporate this design feature.	Removed the word potential from section 5.3.9, Table 5-1 and in Section 6.3.4 Wording is now as follows in Sections 5.3.9 and 6.3.4: Management of this potential impact would include cross drainage and the provision of a permeable, free draining rock platform to ensure that the proposed activity does not result in long term changes to the natural surface water levels in the vicinity of the camp. It is noted that drought and rainfall may alter water levels and Roads and Maritime would have no influence on changes on these variables, nor any freehold works outside the corridor. Wording in Table 5-1 is now: Inclusion of cross drainage and the provision of a permeable, free draining rock platform in the vicinity of the camp
Page 32 Section 6.3.6	Please clarify how the *"operation of the project will not impact on flying-foxes foraging on food resources".* It is understood that the 23.5ha habitat patch consists of foraging resources and the management plan has stated that operational impacts will likely extend 100m from the road edge i.e. into this habitat; therefore there will be operational impacts.	Operation of the project would not impact on foraging resources as these would have been impacted on during the clearing of vegetation during the construction activities. Offset for the clearing of vegetation has been considered and an offset package is being developed. Refer to response item 9 for further details
Monitoring program Page 35	It would be worthwhile capturing and evaluating data on the availability of food resources in the local area. This will assist in understanding patterns of occupancy. The monitoring component of the management plan is an essential and important component as it will provide guidance on construction activity including timing, potential dispersal methods and the effects of dispersal or camp abandonment in the wider community.	Added some additional data to section 2.1 of the report including a map showing critical foraging habitat as identified by Eby 2012. Noted

Reference	EPA comment	Roads and Maritime Services Response
	In addition to the monitoring currently proposed, the EPA also recommends the following monitoring elements are introduced, as has been required for other dispersal programs eg Sydney Botanical Gardens: • Details of a study program to band and track the movements of a representative sample of individuals from the camp using radio and satellite telemetry to measure impacts of the disturbance and to assist in management of conflict with community. The identification of individuals should be designed to determine the likelihood of increased numbers of GHFF at existing camps, or if formation of new camps is a direct result of the action. • Monitoring should be undertaken at any new or substantially increased camps to determine effects of the disturbance of GHFF welfare and breeding success following the disturbance period. NB. Conduct of monitoring programs that involve capture of flying-foxes will require an Animal Ethics Authority from Department of Primary Industries and holding of a Scientific Licence under the National Parks & Wildlife Act. There are significant timeframes associated with obtaining these authorisations.	As per section 4.5.2 of the Flying-fox Management Plan: The potential opportunities, benefits and impacts of radio-tracking/satellite tracking of flying-foxes roosting in the Macksville camp have been further investigated by Roads and Maritime Services. Advice from Dr Peggy Eby indicates that radio-tracking/satellite tracking flying-foxes would be of marginal value for the following reasons: 1) As per **Section 4.4.1**, it is highly likely that all tagged animals would depart the Macksville camp prior to disturbance commencing at the site. 2) The highly variable nature of flying-fox movements would make it difficult to interpret the impact of the disturbance on subsequent migration and feeding patterns. Based on this advice there is no intent to pursue radio-tracking/satellite tracking of the Macksville camp flying-foxes during pre-construction monitoring. It is noted that conduct of monitoring programs that involve capture of flying-foxes will require an Animal Ethics Authority from Department of Primary Industries and holding of a Scientific Licence under the National Parks & Wildlife Act. There are significant timeframes associated with obtaining these authorisations. As there is no intention to capture animals for the project this is not considered to be necessary.
Page 36	Again the document refers to a refinement of mitigation including timing of construction and buffers depending on monitoring results. It is recommended that contingencies be outlined in the flowchart referred to above, and that any proposed changes be made in consultation with the EPA.	See response items 1 and 2 and detail included above regarding construction buffers and the timing of works.
Page 38 Table 7-1	Please expand on the measures that can be introduced if investigations reveal that the project has caused a significant reduction in reproductive output? This statement is relatively open ended and addresses a very significant issue.	Impacts to reproductive output are being mitigated by the following measures as included in Section 7.6 of the Management Plan: **Main Goal:** • To assess the impacts of pre-construction, construction and operation activities from the Project on the Macksville flying-fox camp and provide data for any required refinements to mitigation measures. **Mitigation / Control frequency:** • Continuation of the systematic program of monthly flying-fox monitoring introduced in Winter 2013 (as discussed in Section 2.2) during the pre-construction and construction stages of the Project. • During the pre-construction stage of the Project continuation of the fortnightly monitoring program introduced in January 2014. • During construction of the Project fortnightly monitoring would start 1 August and extend until monitoring confirms the camp has been vacated. Initiation of a quarterly monitoring program of the quality of the habitat adjacent to the Project for the first year after the opening of the Project to traffic unless otherwise agreed with P&I, EPA and DOE. • Implementation of a road kill monitoring program during the first two years following the opening of the road (as outlined in Section 7.4.2). • Monitoring beyond the two year survey period to be undertaken as part of the Roads and Maritime Asset Division regular inspection program assessing the operation of the highway. **Monitoring / timing frequency:** • Continuation of the systematic program of monthly monitoring introduced in Winter 2013 (as discussed in Section 2.2) for 12 months after the opening of the Project to traffic. • Continuation of the fortnightly monitoring program introduced in January 2014 during the pre-construction stage of the Project. • During construction of the Project fortnightly monitoring would start 1 August and extend until monitoring confirms the camp has been vacated. • Quarterly monitoring of the quality of the habitat adjacent to the Project for up to one year after the opening of the Project to traffic unless otherwise agreed with P&I, EPA and DOE.

Reference	EPA comment	Roads and Maritime Services Response
		• Investigation in response to observations and reports of flying-fox kills as identified in the road kill monitoring program. **Responsibility:** • Roads and Maritime Services **Performance threshold:** • Significant reduction in reproductive output (measured as mean percentage of females with young in target trees) relative to control site. • Zero flying-fox mortality within 300 metres of the camp footprint. **Corrective actions if deviation from performance threshold:** • Based on a comparison with control sites, investigate possible causes of reduced reproduction, including impacts from the Project and the potential for natural variation in consultation with EPA. • Should investigations indicate that the Project is likely to be a cause of reduced reproduction, review opportunities to undertake onsite corrective actions in consultation with EPA. • Re-evaluate strategies if flying-foxes continue to collide with vehicles.
Appendix C background	*"At the time clearing activities are proposed to be undertaken (1 May – 15 September), it is anticipated that all young would be flying and feeding independently and that no animals would remain in the roost at night".* The EPA agrees with this statement, however only for the months of May through to July. From August each year there is the possibility that there will be heavily pregnant females present and as already referenced in comments above, dependent young may be present. Irrespective of the fact that females in their third trimester of pregnancy are mobile, the EPA does not support the forced dispersal of animals in this state. This advice is consistent with previous and contemporary OEH advice regarding dispersal proposals and/or approvals to modify/rehabilitate flying-fox camps. The EPA notes the decrease in GHFF distance of 100m to 50m required to trigger implementation of contingency dispersal actions. Please justify this shift and provide previous examples where the 50m buffer was successfully implemented.	It is noted that OEH does not support the forced dispersal of animals in their third trimester of pregnancy despite them still being mobile at this time. As outlined previously the following commitment has been made in the management plan in Sections 4.4.2 and 5.3.3: Clearing of vegetation would halt if there are heavily pregnant GHFF or female GHFF with dependant young present noting that an ecologist, experienced with flying-foxes would be on site during removal of vegetation in the vicinity of the flying-fox camp. Monitoring of the camp to be undertaken after 31 August and construction to halt if there are heavily pregnant GHFF or female GHFF with dependant young present. Noted As outlined above the management plan has been updated to use a 100 metre buffer during clearing activities following the review of the contingency strategy by Dr Peggy Eby.
Appendix C background	Please note the following statement from Appendix C; *"This strategy is a temporary contingency to minimise impacts on flying-foxes should they be roosting in vegetation proposed to be removed and is not a long term dispersal/relocation strategy".* The EPA understands that the proposed contingency actions do not aim to force camp abandonment or long term dispersal. However the proposed disturbance (cumulative actions from forced dispersal and construction activity) in combination with the modification to the 23.5ha remnant will likely produce the same effect. Therefore whilst Roads and Maritime may intend to only temporarily disperse flying-foxes to prevent direct injury or mortality, the net result will more likely follow the consequences of a forced camp relocation.	Noted
Appendix C Step 1	Please confirm if step 1 is also intended to provide a low level of disturbance (possibly to prepare the GHFF for future disturbance?). No additional bats will arrive in the latter part of the day. The EPA does not support habitat clearing if dependent young are present in the camp or disturbance of dependent young flying-foxes at any time. Additionally, whenever dependent young are confirmed by monitoring, the EPA does not support ongoing disturbance in any form within 300m. Therefore, if young are detected, rather than seeking further advice from OEH and flying-fox experts the EPA recommends cessation of works.	As indicated in the contingency strategy step 1 is a pre-clearance survey. The only disturbance resulting would include the use of lights – spot lights and flood lights and the presence of the ecologists walking and talking to each in the area as they move through the swamp. Other noise generating construction activities would also be potentially occur within the 300 metre construction buffer zone between the period of May 1 to September 15. Should flying-foxes be found to be present within 50 metres of the area proposed to be cleared the following day then step 2 would be implemented. Should flying-foxes not be present another pre-dawn survey would be undertaken to confirm if any animals have arrived over-night.

Reference	EPA comment	Roads and Maritime Services Response
		It is noted that the OEH does not support habitat clearing if dependent young are present in the camp or disturbance of dependent young flying-foxes at any time. However as per the meeting with OEH and Roads and Maritime Services in April 2014 Roads and Maritime have made the following commitment: • Construction activities within 300m of the perimeter of the camp to be undertaken during the period 1 May to 15 September each year. Monitoring of the camp to be undertaken and after 31 August construction to halt if there are heavily pregnant GHFF or female GHFF with dependant young present.
Appendix C Steps 2-5	The EPA supports the implementation of step 3 – *Early morning noise disturbance* if flying-foxes are present during the May –July construction window as long as dependent young and/or females in the third trimester of pregnancy are not present and as long as an approved dispersal management plan is in place that addresses arrangements for where flying-foxes may relocate, including appropriate monitoring of those locations. The EPA assumes that an ecologist will be present at all times during clearing in flying-fox habitat as they would be required to check for returning bats. Steps 2, 4 and 5 are not supported at any time. Of particular concern to OEH is the proposed use of explosive noise and smoke. OEH advises that explosive noise is likely to produce heightened levels of flying-fox stress as opposed to a controlled escalation of noise disturbance that may induce lesser stress levels. The use of smoke is more likely to provide heightened levels of ongoing flying-fox stress and is less likely to achieve dispersal. Neither of these suggested disturbance methods are currently utilised in authorised GHFF dispersals and are not considered best practice. These methods are also highly invasive to human receivers. The Sydney Botanic Gardens successfully utilised pre-recorded noise to disperse a flying-fox colony and it is recommended that Roads and Maritime engage with the team who successfully undertook this dispersal. However, it is anticipated that construction/clearing noise may negate the need for pre-recorded noise generation as this could provide sufficient noise levels to disperse animals.	Noted Roads and Maritime Services has made the commitment that: • Fortnightly monitoring of the camp to be undertaken between 1 August and the end of April the following year. • Clearing of vegetation would halt if there are heavily pregnant GHFF or female GHFF with dependant young present noting that an ecologist, experienced with flying-foxes would be on site during removal of vegetation in the vicinity of the flying-fox camp. • Other construction activities would halt if there are heavily pregnant GHFF or female GHFF with dependant young present after 31 August. • Construction activities within the buffer zone may be undertaken prior to 1 May or after 15 September each year if monitoring demonstrates that no GHFF are present. Have included the following detail in Section 7.3.3 of the MP: • An ecologist would be present during clearing activities in the vicinity of the roost. If, between 1 May and 15 September flying-fox are present in the clearing corridor the contingency strategy would be implemented, refer to **Appendix C**. In lieu of the comments received form EPA on this issue, steps 2, 4 and 5 have been removed from the contingency strategy and explosive noise and smoke activities are no longer proposed in the strategy, refer to the flow chart below of proposed activities and updated contingency strategy.

Reference	EPA comment	Roads and Maritime Services Response
		Step 1 – Pre-clearance ecology survey A dawn survey through and 100 metres beyond the vegetation proposed to be removed during the next day's clearing activities. Should flying-foxes not be located during the survey, clearing activities would be undertaken in accordance with the Flying-fox Management Plan and the project CEMP. Should flying-foxes (other than females with young) be located within the area surveyed during the dawn survey, Step 2 would commence. **Step 2 – Early morning noise disturbance** Implementation of physical disturbance during the early morning when the flying-foxes are returning to camp prior to them settling for the day. Following completion of the early morning disturbance activities another pre-clearance dawn survey would be completed by the ecology team of the area of vegetation proposed to be cleared for the day and extending 100 metres beyond this. Noise disturbance activities would be limited to no more than three hours every 24 hours. A second pre-clearance survey would be implemented at the end of the step 2 activities to identify if flying-fox are present. Depending upon if flying-fox are present, Step 2 may be implemented for 5 consecutive days. Should flying-foxes not be located during the survey, clearing activities would be undertaken in accordance with the Flying-fox Management Plan and the project CEMP. Should flying-foxes remain within the clearing corridor and 100 metres beyond this following five days of implementing step 2 proceed to Step 3. **Step 3 – Night-time noise and light disturbance** Implementation of physical disturbance methods to coincide with the dusk fly-out including: • Noise. • Light. These evening disturbance methods would be run in conjunction with the early morning disturbance activities. The cumulative disturbance of animals to the exposure to noise disturbance activities implemented as part of step 1 and step 2would be limited to no more than three hours every 24 hours. Following completion of the early evening and morning disturbance activities another pre-clearance dawn survey would be completed by the ecology team the following morning of the area of vegetation proposed to be cleared for the day and extending 100 metres beyond this. Should flying-foxes not be located during the survey, clearing activities would be undertaken in accordance with the Flying-fox Management Plan and the project CEMP. Should flying-foxes be located within the area surveyed, no clearing activities would be completed that day and Steps 1 to 3 may be repeated the following day. Steps 1 to 3 may be implemented for ten consecutive days. Should flying-foxes remain in the clearing activity area all disturbance activities would cease and advice sought from the OEH and a flying-fox specialist.

Reference	EPA comment	Roads and Maritime Services Response
General Comments	Road corridor revegetation and ornamental planting should not include plants that flower prolifically and produce nectar food sources likely to attract flying-foxes thereby increasing the risk of mortality through collision with vehicles.	OEH/EPA comments accepted and have updated Sections 5.3.12 and 6.3.5 of the management plan as follows: • To minimise the risk of flying-fox vehicle strike during take-off from roosting/foraging, road corridor revegetation and ornamental planting is not to include plants that flower prolifically and produce nectar food sources likely to attract flying-foxes.
Page 35	Can the project confirm the strategies in response to impact on heavily pregnant or dependent young GHFF if they are present before 31 August. The document appears to indicate that construction activities causing the mortality will continue.	Roads and Maritime agree to the following: • Fortnightly monitoring of the camp to be undertaken after 1 August and construction to halt if there are heavily pregnant GHFF or female GHFF with dependant young present. • Clearing of vegetation would halt if there are heavily pregnant GHFF or female GHFF with dependant young present noting that an ecologist, experienced with flying-foxes would be on site during removal of vegetation in the vicinity of the flying-fox camp. • Other construction activities would halt if there are heavily pregnant GHFF or female GHFF with dependant young present after 31 August. • Construction activities within the buffer zone may be undertaken prior to 1 May or after 15 September each year if monitoring demonstrates that no GHFF are present. The Flying-fox MP has been updated accordingly refer to Table 5-1 in the VerJ report which is also included below for information.
Page 35	The EPA understands that contingency measures have been designed to herd GHFF away from the clearing path if present during clearing; however this process itself may cause undue stress and mortality (particularly of heavily pregnant and dependent young if present).	Noted here and already in the Flying-fox MP. In response to this the contingency strategy already commits to moving flying-foxes (other than heavily pregnant females or females with dependent young) that are located within the clearing corridor between May 1 and September 15. As such no further action required.
Page 35	Consider that the proposed monthly monitoring outside of the construction window dictates that if more than five dead bats or foetuses are found then work is to stop immediately. Therefore following this logic, work should cease at any time of the year if heavily pregnant or dependent young are impacted/found deceased in adjacent habitat, not just after 31 August.	This has been updated and the performance threshold to stop work has been changed to: "During flying-fox monitoring (including that undertaken during clearing activities) more than 1 dead Grey-headed Flying-fox/foetus or more than 1 injured Grey-headed Flying-fox is found" (refer to Table 5-2 and Table 7-1 of the Flying-fox Management Plan). Further as noted above Roads and Maritime Services commits to the following: • Clearing of vegetation would halt if there are heavily pregnant GHFF or female GHFF with dependant young present noting that an ecologist, experienced with flying-foxes would be on site during removal of vegetation in the vicinity of the flying-fox camp. • Other construction activities would halt if there are heavily pregnant GHFF or female GHFF with dependant young present after 31 August. The Flying-fox MP has been updated accordingly refer to VerJ. It should also be noted that clearing is planned to commence on the 1 May and as such the flying-foxes would not be heavily pregnant or have dependant young. Other activities may occur after this period however this will only occur in the areas that have been cleared as such it is unlikely that the other construction activities will impact on heavily pregnant GHFF or female GHFF with dependant young. Further surveys completed to date have shown that the flying-foxes have not yet returned to the seasonal camp site as at 5 November 2014.

Reference	EPA comment	Roads and Maritime Services Response
Page 35	We understand that the performance thresholds in the Flying-fox Management Plan state that vegetation clearing will cease if a single GHFF is killed (assuming by any related means either directly or indirectly by clearing) and trigger dispersal action. However this appears only to apply to GHFF in the clearing path and will not stop work but rather, as a contingency measure, trigger dispersal action by the contractor. It would be appreciated this could be clarified and in any case it is suggested that the project ecologist should be involved in any decisions required in these circumstances.	In chapter 1 of the Flying-fox Management Plan there is the following commitment: • Roads and Maritime Service and the contractor engaged to construct the project would be responsible for implementing the activities in this Flying-fox Management Plan and would include the engagement of suitably qualified specialists to undertake and oversee surveys and monitoring activities. It is therefore inferred that an ecologist would be involved in all in decisions to implement the contingency strategy for moving flying-foxes or for stopping work associated with any potential flying-fox death. Table 5-2 has the following corrective actions: • Stop clearing works within or adjacent to areas of flying-fox habitat immediately. • Delay vegetation clearing until survey undertaken to identify where flying-fox are located. • Implement contingency plan for moving flying-fox out of the clearing corridor during vegetation clearing / construction, refer to Appendix C. • Review road corridor revegetation adjoining the locations of recorded flying-fox road kills. As such the first corrective action is to stop work. Following this further survey work by the ecologist would be required. Have however updated measure two above to clarify see the words included in red and underlined below: • Delay vegetation clearing until survey <u>by a qualified ecologist</u> has been undertaken to identify where flying-fox are located.

Appendix F. Warrell Creek to Nambucca Heads Upgrade Road Kill Monitoring Program.

1. WC2NH Road Kill Monitoring Program

1.1 Timing of Monitoring

Timing of road kill surveys for the WC2NH Project is described in **Table 1**.

Table 1 – Timings and locations of road kill surveys

Project Phase	Timing of survey	Location	Responsibility
During clearing operations	Daily	Portion of existing Pacific Hwy adjacent to clearing operations	Pacifico
One month following clearing operations	Daily	Portion of existing Pacific Highway adjacent to clearing operations	Pacifico
Duration of construction	Weekly	Entire length of existing Hwy in Project area	Pacifico / Roads and Maritime
Within one month of opening of the project to traffic (operational phase)	Weekly during October (spring), January (summer), April (autumn) & July (winter) for up to 5 consecutive years post construction, or until mitigation measures have been demonstrated to be effective.	1. Fenced Experimental Transects (1km) – Centre point chainages - 1600, 8000, 12800, 14400, and 17000. 2. Unfenced Control Transects (1km) – Centre point chainages - 2700, 3900, 5000, 9600 and 11300.	Roads and Maritime

1.2 Monitoring Program Objectives

The aim of the monitoring program is to effectively demonstrate that road kill rates are mitigated by the presence of fauna fencing by preventing fauna of concern from attempting to cross the WC2NH Upgrade.

1.3 Monitoring Procedure

A vehicle being driven along the entire length of the existing highway in the Project area and identifying dead wildlife (road kill) seen on the roads and within three metres of the road edge. Both driver and passenger will search the left-hand side of the road and its verge for road kill with the driver searching the road and shoulder and the passenger searching the verge. When a road kill is observed from the vehicle, a close visual inspection of the carcass will be undertaken where access is possible and where safely limitations permit. If safe access is not possible, due to local traffic conditions, binoculars will be used to try to identify and provide as detailed information as is possible on the carcass.

Where there is any doubt to the identification of the carcass, photographs will be taken and forwarded to a qualified ecologist for identification / confirmation of species.

To assist with the correct identification of road kills, the following will be undertaken-

a) The provision of a qualified ecologist (shall be a recognised expert in mammal identification in coastal northern NSW) to undertake the initial phase of operational monitoring (first season) with relevant Roads and Maritime assets team members providing some detailed training and a baseline of expert monitoring of road kills.

b) The provision of specialist training (to be undertaken by an expert as above in point a) in fauna identification for Contractors and Roads & Maritime assets team staff involved in the construction phase monitoring of road kill.

c) Where there is any doubt to the identification of the carcass, the provision of photographs of road kill to be sent to a qualified ecologist (an expert as above in point a) to confirm the identity of road kill and to maintain a permanent record of road kill for further comparisons, if needed.

1.4 Monitoring Methodology

Five sections of the WC2NH Upgrade with fencing shall be monitored as experimental “impact” sites, and five sections without fencing will be monitored as control sites.

The sections of the Upgrade to be monitored are identified as a chainage value with a central point (note - transect 500m either side of each central point) for each transect as follows:

<u>1. Fenced Experimental Transects</u> – Chainages 1600, 8000, 12800, 14400, and 17000.

<u>2. Unfenced Control Transects</u> – Chainages - 2700, 3900, 5000, 9600 and 11300.

Specific details of the monitoring methodology are:

- Each section of highway to be monitored will be one kilometre long and surveyed in both directions.

- Each section will be monitored using the method previously indicated (section 1.3) consisting of a two-person team traversing the Upgrade in a vehicle to locate and identify road kills.

- The speed of travel will be the same in all cases to avoid confounding the data collection, and should be as slow as is safely possible.

- Each section will be surveyed weekly for four weeks in Spring, Summer, Autumn and Winter (see Table 1).
- The fenced "impact" transects will be mostly centred around the end point of a fence line so that 500m is surveyed in both fenced and unfenced areas of Upgrade.
- When possible, survey of transects shall be completed within two hours of sunrise in order to maximise the potential to record road kills before either carrion eating animals or traffic render and road kill unidentifiable.
- The order of transects being surveyed should be randomised every survey period to avoid any temporal confounding of the collected data.
- If possible, each survey will be carried out on the same day to remove the influence of varying environmental conditions.
- For each road kill observed, the following attributes will be recorded-

  a. GPS and Chainage location of any road kill.

  b. Species of road kill, however, where there is any doubt to the identification of the carcass, photographs shall be forwarded to a qualified ecologist for identification / confirmation of the species.

If the animal is identified as an EPBC Act threatened species, the carcass will be photographed and the following information will also be recorded-

  c. Sex and age class (juvenile or adult) where possible and safety limitations permit.

  d. Presence of pouch young (for marsupials) where possible and safety limitations permit.

  e. Weather conditions at the time of the monitoring (from the Bureau of Meteorology) – including temperature, rainfall in the last 24 hours, wind levels (scale to be determined), moon phase.

1.5 Analysis of data

The data to be collected will be analysed using a Repeated Measures Analysis of Variance or, if the data does not comply with assumptions of normality or heteroscedacity, a suitable non-parametric test such as a Kruskal-Wallis test or Generalised Linear Modelling. The aim will be to test both whether the impact and control sites have different mean numbers of road kills and if the amount of road kill varies through time in either or both of the two types of replicate areas. Such information will indicate if the mitigation measures area working as expected to keep road kills to acceptable levels and that none of the target species are killed.

It is also required that a sensitivity analysis of the data be included as part of the annual reporting for the monitoring program.

1.6 Reporting

1.6.1 Quarterly reports

Basic reports of the data collected will be provided to Roads and Maritime after each survey season. This will include graphs of the data and any previously collected data to provide simple visual comparisons of road kill. This will also include overall road kill counts as well as separate graphs for the target species (if deaths have occurred).

1.6.2 Annual Reports

The annual report will be provided to DoE and EPA within one month of completion of the fourth monitoring season. From then on it will be provided within one month of the same monitoring season in subsequent years until monitoring is completed (Table 1).

Analysis of the data itself shall be included in an annual monitoring report. This report will include a statistical analysis of all of the data collected to that time including graphical representations of the road kill that is recorded.

Annual reports will record any potential or obvious failures in the monitoring program and provide a date by which meetings will take place to discuss any such adverse findings. This will include at least:

- Where statistically larger number numbers or road killed animals are detected on fenced sections compared to unfenced sections.
- Where any of the target threatened fauna are recorded as killed.
- Where there is a clear pattern of unexpected road kill at any point on the WC2NH Upgrade.

All analyses within annual reports will be undertaken by a suitably qualified ecologist/biometrician. This will be someone with a recognised expertise in the statistical analysis of ecological data.

1.7 Performance Measures

- Lower rates of road kill in proximity to fauna fencing (ie areas of the main carriageways within areas adjacent to installed fauna fencing) than in sections of the upgrade not near fauna fencing during monitoring events up to 5 years post construction phase, or until such time as mitigation measures have been demonstrated to be effective.
- All fauna fencing is installed at the minimum of locations as identified in the EPBC approval prior to the operational phase of the WC2NH Upgrade.

1.8 Adaptive Management

Where any annual report identifies a significant difference between the road kill numbers of the different treatments (transect types), DoE and EPA shall be notified, and a meeting will be set to discuss such differences with the relevant agencies, Roads and Maritime & the reporting ecologist.

Such a meeting would occur within one month of completion of the annual report, which should ensure sufficient time to consider/review the response to any recorded significant differences.