APPENDIX B2

Flora and Fauna Management Sub Plan

Nambucca Heads to Urunga

JULY 2014

Contents

Tables

Appendices

Document control

File name	NH2U_FFMP_Rev5
Report name	NH2U Flora and Fauna Management Plan
Revision number	5

Plan approved by:

[signed]	*[signed]*	*[signed]*
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Lend Lease Project Director	Lend Lease EM	Roads and Maritime Senior Project Manager

Revision history

Revision	Date	Description	Approval
1		Issued for stakeholder review	
2		Amendments to accommodate authority and stakeholder comments	
3	Mar 2013	WC2U Plan updated to be specific to NH2U	
3.1	Mar 2013	Issued to Roads and Maritime / PV / ER	
3.2	Apr 2013	Issued to ERG for review	
3.3	May 2013	Updated to include ERG comments	
4	Aug 2013	Updated to address DP&I comments	
5	July 2014	Minor update to change RMS to Roads and Maritime, and Abigroup to Lend Lease, plus other minor changes approved by the ER	

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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*
NH2U	Nambucca Heads to Urunga *(Stage 1 of WC2U Project)*
NPW Act	*National Parks and Wildlife Act 1974*
NW Act	*Noxious Weeds Act 1993*
OEH	Office of Environment and Heritage
SEPP	State Environmental Planning Policy
SoC	Revised Statement of Commitments included in the Submissions Report
SWTC	Scope of Works and Technical Criteria (Roads and Maritime)
TSC Act	*Threatened Species and Conservation Act 1995*
WC2U	Warrell Creek to Urunga
WP	Working Paper (part of the Environmental Assessment)

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 from Nambucca Heads to Urunga (NH2U). The NH2U Project is Stage 1 of the Warrell Creek to Urunga (WC2U) Project, approved by the Minister for Planning and Infrastructure in 2011.

The NH2U section of the WC2U Project involves the construction of approximately 21.6km of new highway from south of Nambucca Heads Interchange to the existing Waterfall Way Interchange at Raleigh, north of Urunga. The NH2U Project is being constructed by Lend Lease.

This FFMP has been prepared to address the requirements of the Minister's Conditions of Approval (CoA), the Roads and Maritime 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 Lend Lease's environmental management framework for the Project, as described in Section 4.1 of the CEMP. In accordance with CoA B31(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 Lend Lease's 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 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 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.*
- *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) (EPBC Act).
- State Environmental Planning Policy (SEPP) No. 44 – Koala Habitat Protection.

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:

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

- 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*.
- NSW Fisheries. 1999. DPI Policy and Guidelines: Aquatic Habitat Management and Fish Conservation.
- 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.	Roads and Maritime correspondence dated 25 May 2011 Roads and Maritime 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.	(The southern most chainage of the NH2U Project is equivalent to ch19395. Options immediately north to these chainages have been investigated in consultation with DPI (Fisheries) and EPA. Options that produced improvements to biodiversity impacts have been discussed and revised fauna connectivity structures will be forwarded to DP&I for approved under MCoA B1 as discussed in meeting held with Roads and Maritime, Lend Lease and DP&I on 24 July 2013
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.	FFMP Table 5-1
CoA B4	The Proponent shall in consultation with EPA, ensure that the design of the project as far as	FFMP Table 5-1

CoA No.	Condition Requirements	Document Reference
	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.	
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* (NSl4/ Fisheries). As far as feasible and reasonable, culvert replacements as part of the project shall incorporate naturalised 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.	FFMP Table 5-1
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 EPA 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	Appendix B - Threatened Flora Management Plan

CoA No.	Condition Requirements	Document Reference
	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*.	
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 (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	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
	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 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	Appendix C - Ecological Monitoring Program

CoA No.	Condition Requirements	Document Reference
	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 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 EPA 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;	Appendix C - Ecological Monitoring Program Appendix G – Pre-clearing Permit Appendix D - Giant Barred Frog Management Strategy FFMP Table 5-1

CoA No.	Condition Requirements	Document Reference
	ii. updated sensitive area / vegetation maps based on B31(b)(i) above and previous survey work;	Appendix A6 of the CEMP FFMP Table 5-1
	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, including short and long term management measures;	Appendix F - Microchiropteran Bat Management Strategy
	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;	FFMP Table 5-1 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;	FFMP Table 5-1 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	FFMP Table 5-1 Appendix J – Unexpected Threatened Flora Species/EEC's procedure Appendix I – Fauna Handling and Rescue Procedure
	viii. mechanism for the monitoring, review and amendment of this plan;	FFMP Section 7

CoA No.	Condition Requirements	Document Reference
CoA 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.	FFMP Table 5-1

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
		Erection of exclusion fencing to prevent any further encroachment into Newry State Forest to the east of the construction footprint.	Pre-construction		Table 5-1
		Threatened species directly impacted by the Proposal will be translocated to a suitable location outside the impact	Pre-construction		Table 5-1 Appendix B

Outcome	Ref #	Commitment	Timing	Reference Document	FFMP Reference
		zone.			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 boundary as soon as possible during construction.	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	Pre-	Table 10-12 of the EA.	Table 5-1

Outcome	Ref #	Commitment	Timing	Reference Document	FFMP Reference
		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.	construction and construction		
	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
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	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 (Roads and Maritime)
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	Section 10.4.3 of the EA	Table 5-1

Outcome	Ref #	Commitment	Timing	Reference Document	FFMP Reference
			construction		

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 also 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 EEC's 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 NH2U 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	*Amorphospermum whitei*	-	Vulnerable	Identified
Maundia	*Maundia triglochinoides*	-	Vulnerable	Potential (not identified in NH2U)
Wooll's Tylophora	*Tylophora woollsi*	Endangered	Endangered	Identified
Koala Bells	*Artanema fimbriatum*	-	-	Identified
Ford's Goodenia	*Goodenia fordiana*	-	-	Identified
Floyd's Grass	*Alexfloydia repens*	-	Endangered	Potential (not identified in NH2U)
Bellingen Ironbark	*Eucalyptus ancophila*	-	-	Identified

Common name	Scientific name	EPBC Act	TSC Act	Occurrence
Great Climbing Orchid	*Psuedovanilla foliata*	-	-	Identified
Spider Orchid	*Dendrobium melaleucaphilum*	-	Endangered	Identified
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 in Table 4-2 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
Black-necked Stork	*Ehippiorhynchus asiaticus*	-	Endangered
Spotted-tailed Quoll	*Dasyurus maculatus*	Vulnerable	Vulnerable
Brush-tailed Phascogale	*Phascogale tapotafa*	-	Vulnerable
Yellow-bellied Glider	*Petaurus australis*	-	Vulnerable
Koala	*Phascolarctos cinereus*	Vulnerable	Vulnerable
Glossy Black-Cockatoo	*Calyptorhynchus lathami*	-	Vulnerable
Square-tailed Kite	*Lophiotinia isura*	-	Vulnerable
Emu	*Dromaius noveahollandia*	-	Endangered population
Black Bittern	*Ixobrychus flavicollis*	-	Vulnerable
Green and Golden Bell Frog	*Litoria aurea*	Endangered	Endangered
Green-thighed Frog	*Litoria brevipalmata*	-	Vulnerable
Giant Barred Frog	*Mixophyes iteratus*	Endangered	Endangered
Swift Parrot	*Lathamus discolour*	Endangered	Endangered
Regent Honeyeater	*Xanthomyza phrygia*	Endangered	Endangered
Little Bentwing-bat	*Miniopterus australis*	-	Vulnerable
Eastern Bentwing-bat	*Miniopterus schreibersii*	-	Vulnerable
Common Blossom bat	*Syconycteris australis*	-	Vulnerable
Greater Broad-nosed Bat	*Scoteanax rueppellii*	-	Vulnerable
Eastern Freetail-bat	*Mormopterus norfolkensis*	-	Vulnerable
Eastern False Pipistrelle	*Falsistrellus tasmaniensis*	-	Vulnerable
Grey-headed Flying-fox	*Pteropus poliocephalus*	Vulnerable	Vulnerable
Yellow-bellied Sheathtail bat	*Saccolaimus flaviventris*	-	Vulnerable

4.1.5 Aquatic fauna

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

Table 4-4 Aquatic fauna

Habitat	Species
Freshwater Boggy Creek, Cow Creek and Oyster Creek.	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 Deep Creek, Kalang River	The most widely distributed species at all sites was the Grass Shrimp (*Macrobrachium intermedium)*. The Estuary 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 in the NH2U section of the WC2U Project referred to above is provided in Table 4-5.

Table 4-5 Fisheries habitat classifications

Waterway	Classification #	Description
McGraths Creek	Class 3 – Minimal Fish Habitat	Named or unnamed waterway with intermittent flow and potential refuge, breeding or feeding areas for some aquatic fauna (e.g. fish, yabbies). Semi-permanent pools form within the waterway or adjacent wetlands after a rain event. Otherwise, any minor waterway that interconnects with wetlands or recognised aquatic habitats.
Boggy 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.
Cow Creek	Class 2 – Moderate Fish Habitat	
Oyster Creek	Class 2 – Moderate Fish Habitat	
Deep Creek	Class 1 – Major Fish Habitat	Major permanently or intermittently flowing waterway (e.g. river or major creek), habitat of a threatened fish species.
Kalang 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).
- 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.

4.3.1 Pre-construction surveys

In accordance with the relevant Roads and Maritime management strategies included as Appendices A-F in this FFMP, pre-construction surveys were undertaken by the Project Ecologist 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 included existing bridges and culverts for the presence of micro-bat roosting prior to the planned disturbance of such structures and targeted surveys for threatened fauna species within and in the vicinity of the project corridor undertaken during suitable conditions.

Sensitive area plans, vegetation maps and Table 5.1 of this FFMP will be updated if required by the above completed surveys.

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, Lend Lease EMS Procedures (700 Series) and other Roads and Maritime 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, prepared and co-ordinated by Roads and Maritime.

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 10.5.1 CoA B31(b)(v) G36 Sections 6.9 and 6.10
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 Section 6.9
FF3	In the event that threatened species or endangered ecological communities are unexpectedly identified during construction the Unexpected Threatened Flora Species /EECs Procedure (Appendix J of this FFMP) 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 B31(b)(i)(v)
FF5	The Ecological Monitoring Program (Appendix C of this FFMP) will be implemented prior and throughout construction, including pre-clearing and clearing procedures, fauna underpass structures and exclusion fencing, nest box installation, landscape rehabilitation, protection of in-situ threatened flora populations, establishment of translocation areas		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, 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 Roads and	Roads and Maritime *Biodiversity Guidelines* *Roads and Maritime Practice Note: Clearing and Fauna Management –*	Pre-construction Construction	Project / Site Engineers Forman / Leading Hands Environmental Manager	SoC F2 and F3 CoA B31(b)(5) G36 Section 6.9 G40 Section 2.4.1 SWTC App 4.30

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	Maritime *Biodiversity Guidelines*.	*Pacific Highway Projects (May 2012)*			
FF7	Pre-clearing checklists are to be undertaken in accordance with Appendix G of this FFMP		Construction	Project Ecologist Environmental Manager	Appendix G of this FFMP
FF8	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, frogs and bridge and culvert structures.	*Roads and Maritime Practice Note: Clearing and Fauna Management – Pacific Highway Projects (May 2012)*	Pre-construction Construction	Project Ecologist	EA 10.5.1, WP1-6.2.1 SWTC App. 5 – 5.2 Appendices D,E,F,G,I of this FFMP
FF9	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 (Appendix I of this FFMP).		Construction	Project Ecologist Environmental Manager Environmental Officer	Good practice
FF10	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 10.5.1, WP1-6.2.1 CoA B31(b)(5)
FF11	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 10.5.1, 10.5.5, WP1-6.2.1 CoA B31(b)(5)
FF12	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.	*Roads and Maritime Environmental Direction No.25 – Management of Tannins from Vegetation Mulch*	Construction	Project / Site Engineers Forman / Leading Hands Environmental Manager	EA WP1-6.2.1 G36 Section 6.9

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
FF13	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 10.5.1, WP1-6.2.1 G38 Section 3.1.1
FF14	Weeds will be managed in accordance with the Weed Management Plan (Appendix K of this FFMP), including the requirement for public notification of pesticide use if required.		Construction	Project / Site Engineers Forman / Leading Hands Environmental Manager	EA 10.5.1, 10.5.4, WP1-6.2.1 G36 Section 6.9 CoA B31(b)(v) G36 Appendix H
FF15	Clearing will be undertaken consistent with the process described in Guide 4 of the Roads and Maritime *Biodiversity Guidelines* (including the use of a rotating harvester head to fell habitat trees).	Roads and Maritime *Biodiversity Guidelines*. *Roads and Maritime Practice Note: Clearing and Fauna Management – Pacific Highway Projects (May 2012)*	Pre-Construction Construction	Project / Site Engineers Forman / Leading Hands Environmental Manager Project Ecologist	EA CoA B31(b)(v) G40 Section 2.4.3
FF16	Prior to clearing any vegetation within the site at the locations of the Widened Medians the Project Ecologist will undertake an ecological 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, Roads and Maritime Representative and EPA.		Pre-construction	Environmental Manager Project Ecologist	Roads and Maritime SWTC App 4 – 4.7
FF17	Where possible erosion and sediment controls will be positioned outside (and upslope of) EEC areas.		Construction	Forman / Leading Hands Design Manager Environmental Manager	SWTC App 36

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
FF18	Revegetation will use non-invasive, non-weed species that are unlikely to impact on EECs.		Construction	Forman / Leading Hands Environmental Manager	SWTC App 36
FF19	The use of fertilizers (used during hydromulching and revegetation operations) will be avoided in or upslope of EECs wherever possible.		Construction	Forman / Leading Hands Environmental Officers	SWTC App 36
THREATENED FLORA					
FF20	Threatened flora within and immediately adjacent to the limits of clearing will be located and tagged prior to commencement of construction, by a qualified ecologist. Where already tagged by post-approval targeted surveys (refer App. B) tagging will be retained and individuals noted in Sensitive Area Plans.		Pre-construction	Project Ecologist Environmental Manager	EA 10.5.1, WP1-6.2.3 Appendix B of this FFMP
FF21	The measures identified in the Threatened Flora Management Plan (Appendix B of this FFMP) will be implemented, including translocation procedures and monitoring during construction and procedures for the management of roadside threatened flora during construction.		Pre-construction Construction	Environmental Manager Project Ecologist	CoA B7 Appendix B of this FFMP
FF22	Temporary fencing will be installed around the perimeter of each retained in situ threatened species location (clear of its canopy line) before the start of vegetation clearing. A sign identifying the site as an Environmental Protection Area will also be attached to the fence.		Construction	Forman / Leading Hands Environmental Manager	SWTC App 36
FF23	For all works within 100m of known threatened species, the work method statement will include relevant protection measures		Construction	Environmental Manager	SWTC App 36
THREATENED FAUNA					
FF24	The measures identified in the Giant Barred Frog Management Strategy (Appendix D of this FFMP) will be implemented if individuals are identified during construction.		As specified	Environmental Manager Project Ecologist	CoA B31(b)(iii) SWTC App 14 Appendix D of this FFMP

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
FF25	The measures identified in the Green-thighed Frog Management Strategy (Appendix E of this FFMP) will be implemented during construction.		As specified	Environmental Manager Project Ecologist	CoA B31(b)(vi) SWTC App 14 Appendix E of this FFMP
FF26	All potential habitats of these frogs will be incorporated on to the sensitive area plans.		Pre-construction	Environmental Manager	SWTC App 36
FF27	If threatened frogs are found during construction, minimise clearing and limit disturbance near potential frog habitat, particularly during breeding seasons for the target species.		Construction	Forman / Leading Hands Environmental Manager	SWTC App 36
FF28	Opportunities to hand clear near any potential frog habitat and leave grass cover, roots, etc. will be investigated during construction.		Construction	Forman / Leading Hands Environmental Manager	SWTC App 36
FF29	Where possible, install the frog ponds early in the construction phase along with permanent frog fencing.		Construction	Forman / Leading Hands Environmental Manager	SWTC App 36
FF30	The measures identified in the Microchiropteran Bat Management Strategy (Appendix F of this FFMP) will be implemented including the installation of bat boxes, additional field survey, staged roost exclusion, preservation of existing roots, seasonal exclusion of works, protection of existing habitat, unexpected finds process and monitoring.		As specified	Environmental Manager Project Ecologist	CoA B31(b)(iv) SWTC App 14 Appendix F of this FFMP
FF31	The Nest Box Plan of Management (Appendix A of this FFMP) will be implemented, requiring nest boxes of varying styles and designs to suit a range of fauna be installed and monitored. The Nest Box Plan of Management details design, location, installation methods and timing, monitoring and reporting requirements.		Pre-construction Construction	Environmental Manager Project Ecologist	EA 10.5.1, WP1-6.2.1 CoA B6 SWTC App 4 – 4.9, App 14 Appendix A of this FFMP
FF32	VMSs/signs will be considered warning motorists of koalas and asking them to take caution.		Construction	Forman / Leading Hands Environmental	SWTC App 36

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
				Manager	
FF33	Fauna crossings will be installed as early as possible		Construction	Forman / Leading Hands Environmental Manager	Good practice
WILDLIFE PROTECTION					
FF34	Following the completion of clearing operations and any bridge and culvert structures removal, a report will be provided to Roads and Maritime, to be prepared in consultation with the project ecologist, detailing information including fauna sightings, relocation and rescue.		Construction	Project Ecologist Environment Manager	SWTC App. 5 – 5.2 Appendices D,E,F,G,I of this FFMP
FF35	Fauna fencing, including floppy top, frog fencing and temporary Koala fencing, is to comply with the requirements of the SWTC App. 5.4 and App. 14.5, with design undertaken in consultation and agreement with the EPA as relevant.		Pre-Construction Construction	Environment Manager Design Manager	SWTC App. 5 – 5.4 SWTC App 14 – 14.5
FF36	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 installed prior to the erection on any solid safety barriers for Project Works in areas of fauna habitat, 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, 10.5.1, WP1-6.2.3 SoC F11 SWTC App 5 SWTC App 9.4(e)
FF37	Within 3 months prior to opening any section of the Project Works to traffic, all fauna exclusion fencing along the section of Works which is to be opened to traffic will be installed and inspected for gaps, adequate pinning down of mesh, overhanging or nearby vegetation.		Construction	Environment Manager Project Ecologist	SWTC App. 5 – 5.4 SWTC App 9 – 9.4.2
FAUNA HABITATS AND CONNECTIVITY					
FF38	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	Roads and Maritime *Biodiversity Guidelines*.	Construction	Forman / Leading Hands Environmental	EA 10.5.1 SoC F7

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	existing vegetation and would not occur in good condition remnant vegetation. This measure will be implemented consistent with Guide 5 of the Roads and Maritime *Biodiversity Guidelines*.			Manager	
FF39	Fauna connectivity measures will be finalised during detailed design in consultation with EPA and DPI through a process of workshops and on-site ground verification.		Construction	Design Manager Environmental Manager	CoA B1, B2, B3, B4 and B5
FF40	Where detailed design refinements are made, prior to the commencement of construction of the relevant crossings, Lend Lease 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	Design Manager Environmental Manager	CoA B3
AQUATIC HABITATS					
FF41	If feasible and reasonable, construction activities over Deep Creek and the Kalang River should be minimised during the Bass and Perch spawning season between June and August		Construction	Project / Site Engineers Environmental Manager	SWTC App 36
FF42	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 10.5.8, WP1-6.2.12
FF43	Large woody debris within watercourses would be retained where possible, or where possible relocated in stream nearby. Any removal or relocation of LWD within watercourses will be undertaken in consultation with NSW DPI.		Construction	Project / Site Engineers Forman / Leading Hands Environmental Manager	EA 10.5.8, WP1-6.2.12
FF44	Where waterway working platforms constructed from rock are used they must be installed in accordance with SWTC App 4.8, including limiting to 3m depth (Mean low water		Construction	Environmental Manager Forman / Leading	Roads and Maritime SWTC App 4 – 4.8 G36 Section 6.5.4

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	springs level) and WMSs developed in consultation with EPA and DPI Fisheries.			Hands Project / Site Engineers	
FF45	A full time erosion and sediment control team dedicated to each waterway working platform will be provided during placement of the waterway working platforms, maintenance of the waterway working platforms and removal of the waterway working platforms.		Construction	Environmental Manager Forman / Leading Hands	Roads and Maritime SWTC App 4 – 4.8
FF46	Waterway working platforms will as a minimum: a. be constructed from materials which do not contain any fine materials; b. be designed to allow for effective and regular clean up of sediment; c. be designed to prevent small rock or fine capping materials from being washed out of the platform; d. be wrapped in geotextile materials; e. remain in the waterway for the minimum time possible; f. include large rock armouring on all the external faces; g. be protected by anti-pollution booms and silt curtains; h. include appropriate water flow to safely convey water and reduce impacts in high flow events; and i. include appropriate fish passage treatments.		Construction	Environmental Manager Design Manager Forman / Leading Hands Project / Site Engineers	Roads and Maritime SWTC App 4 – 4.8
FF47	The channel profile of waterways where waterway working platforms are used will be restored as close as practicable to original after the platform is removed.		Construction	Project / Site Engineers Environmental Manager	Good practice
FF48	Where farm dams are decommissioned, any endemic native fish species will be relocated by a suitably qualified aquatic ecologist with a permit from NSW DPI Fisheries.		Construction	Ecologist Environmental Manager	Good practice
PESTS AND DISEASES					
FF49	Washing procedures will be implemented to ensure that insect pests and their eggs/larvae are not present on		Construction	Project / Site Engineers	EA 10.5.4, WP1-6.2.8

ID	Measure / Requirement	Resources needed	When to implement	Responsibility	Reference
	equipment.			Forman / Leading Hands Environmental Manager	
FF50	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 Roads and Maritime Biodiversity Guidelines)	Roads and Maritime *Biodiversity Guidelines*.	Construction	Project Engineers Forman / Leading Hands Environment Manager	EA 10.5.4, WP1-6.2.8
FF51	An aquatic survey of all farm dams to be decommissioned, and drainage lines, will be undertaken to identify any native fish, pest or exotic fish and aquatic weeds that may be present. The survey should also identify appropriate release points for native fish species		Construction	Ecologist Environmental Manager	Good practice

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

General 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.
- Results of post clearing fauna observations (refer Table 5-1 of this FFMP).
- Threatened Flora Management Plan.
- Giant Barred Frog and Green-thighed Frog Management Strategies.

- Nest Box Plan of Management.
- Microchiropteran Bat Management Strategy

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.

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

Appendix B

Threatened Flora Management Plan

Appendix C
Ecological Monitoring Program

Appendix D
Giant Barred Frog Management Strategy

Appendix E
Green-thighed Frog Management Strategy

Appendix F

Microchiropteran Bat Management Strategy

Appendix G
Pre-clearing permit

Appendix H
Working Around Trees Guideline

Appendix I
Fauna Handling and Rescue Procedure

Appendix J

Unexpected Threatened Flora Species / EECs Procedure

Appendix K
Weed Management Plan

WARRELL CREEK TO URUNGA:

NEST BOX PLAN OF MANAGEMENT

FEBRUARY 2013



PREPARED FOR THE ROADS AND MARITIME SERVICES BY:

LEWIS ECOLOGICAL SURVEYS

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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.

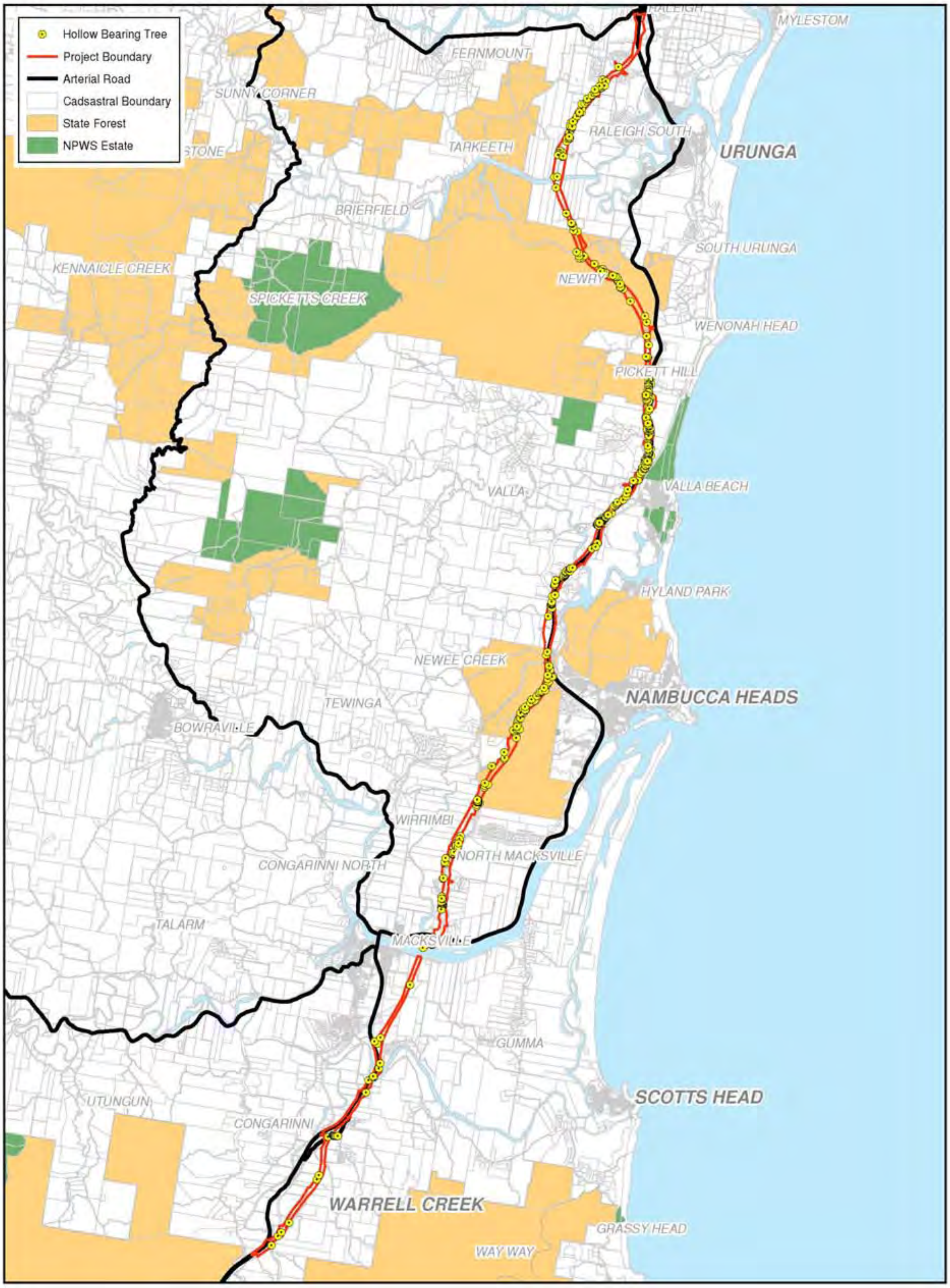

Figure 1 : LOCATION OF HOLLOW BEARING TREES

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
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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*).

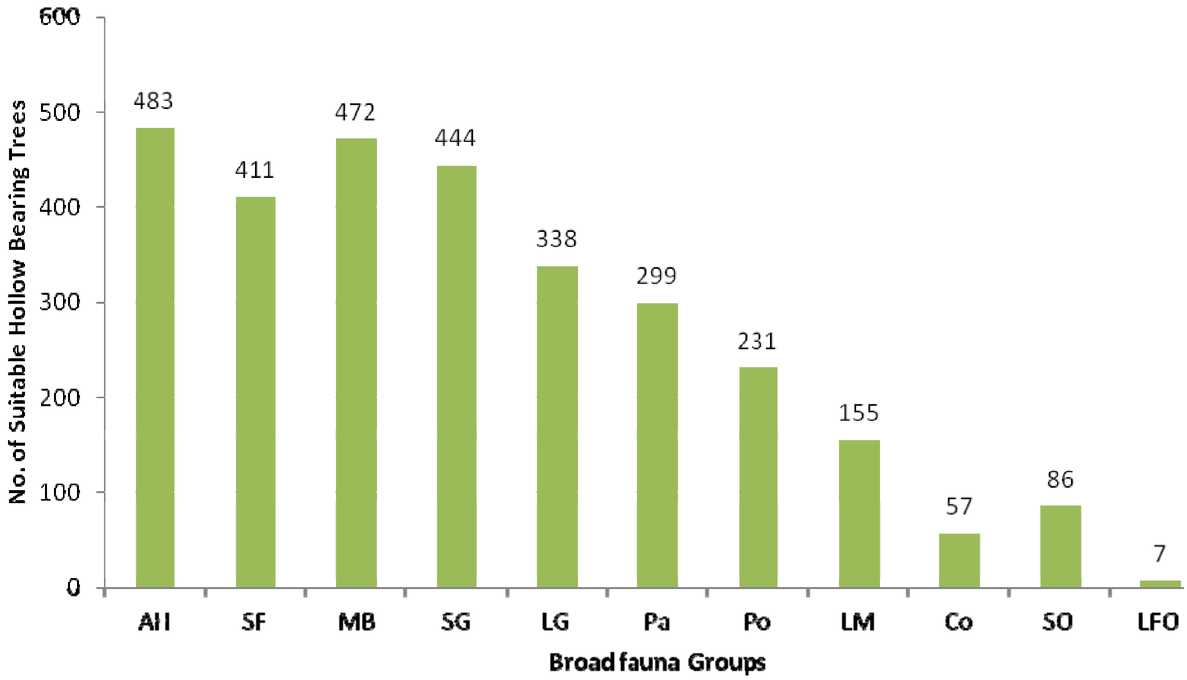

Figure 3-2. Suitability of the identified tree hollows to broad fauna groups from the 519 HBT's identified within the road corridor.

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: S	M	L	Total	Nest Boxes Required	Nest Box Zone (Figure 3-1)
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 = $\dfrac{\text{Number of identified HBT's within the clearing footprint of a specified zone}}{\text{Area (ha) of vegetated land identified for removal}}$ = Density HBT/ha

B = $\dfrac{\text{Total number of tree hollows identified}}{\text{Total number of HBT's within the zone}}$ = 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.

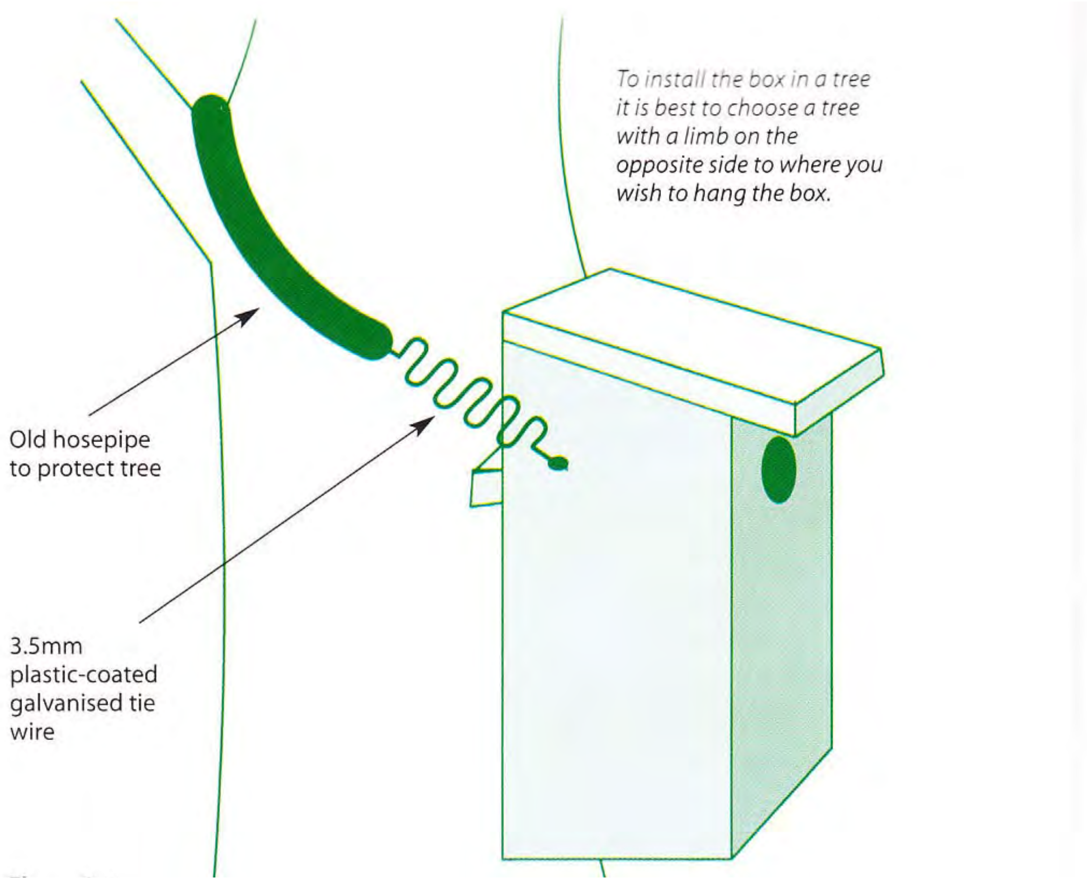

Figure 5-1. Diagrammatic sketch of the Habisure system. Courtesy of Alan and Stacey Franks (Hollow Log Homes ©)

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

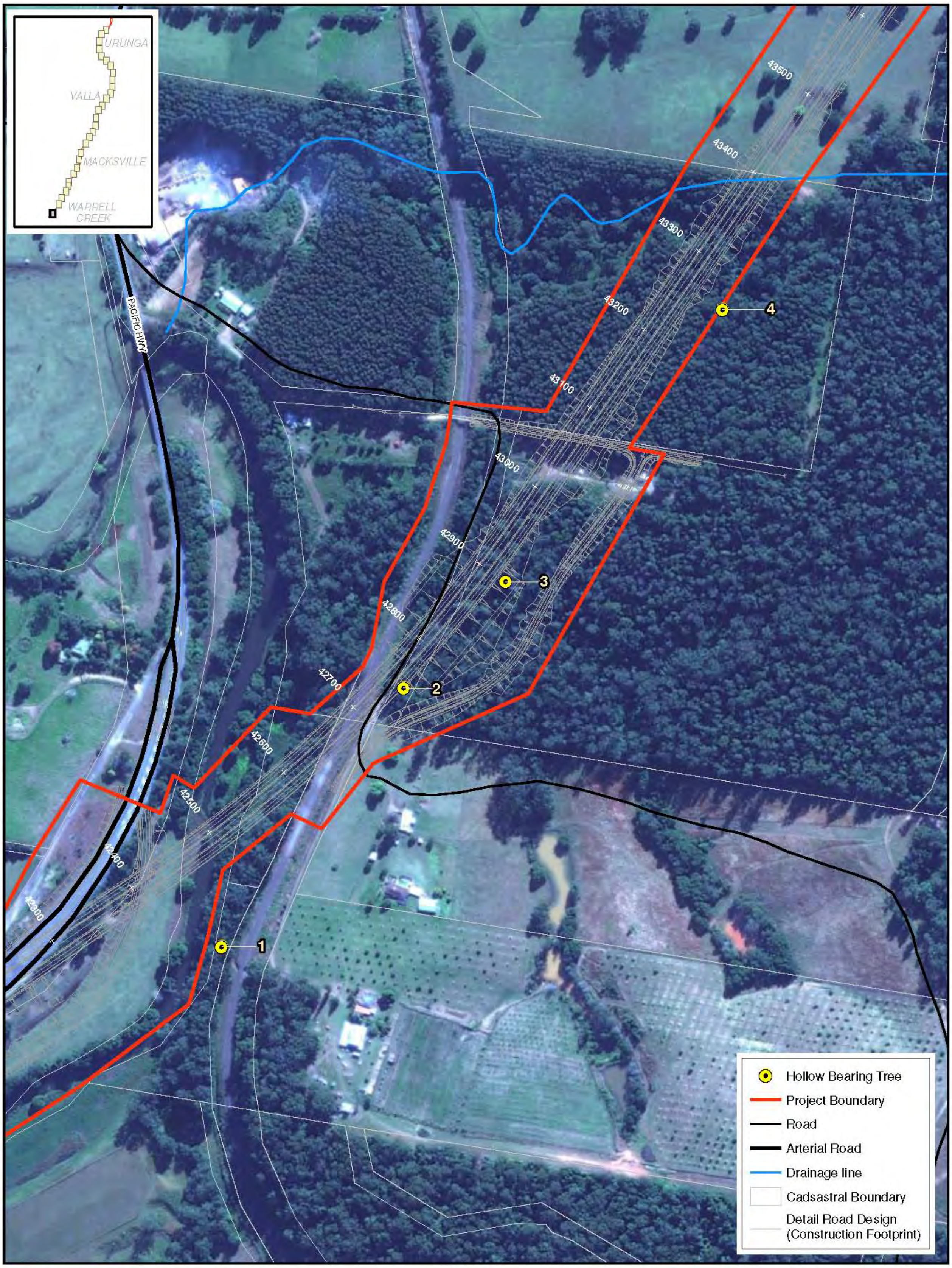

Figure 2 : HOLLOW BEARING TREES

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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Lewis Ecological Surveys

File: Figure_2-30_RTA_Grafton_HBT_Survey_121102
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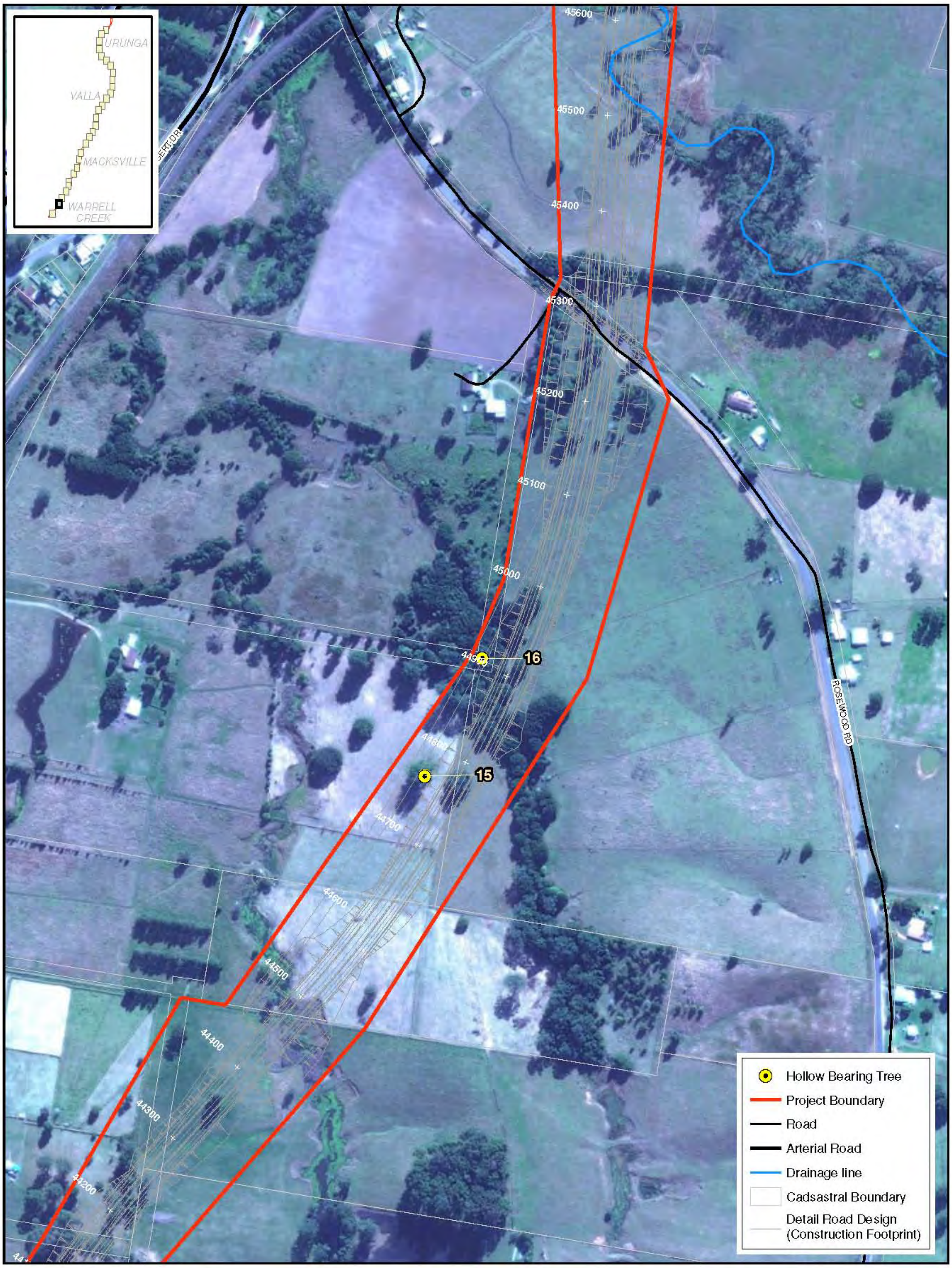

Figure 3 : HOLLOW BEARING TREES

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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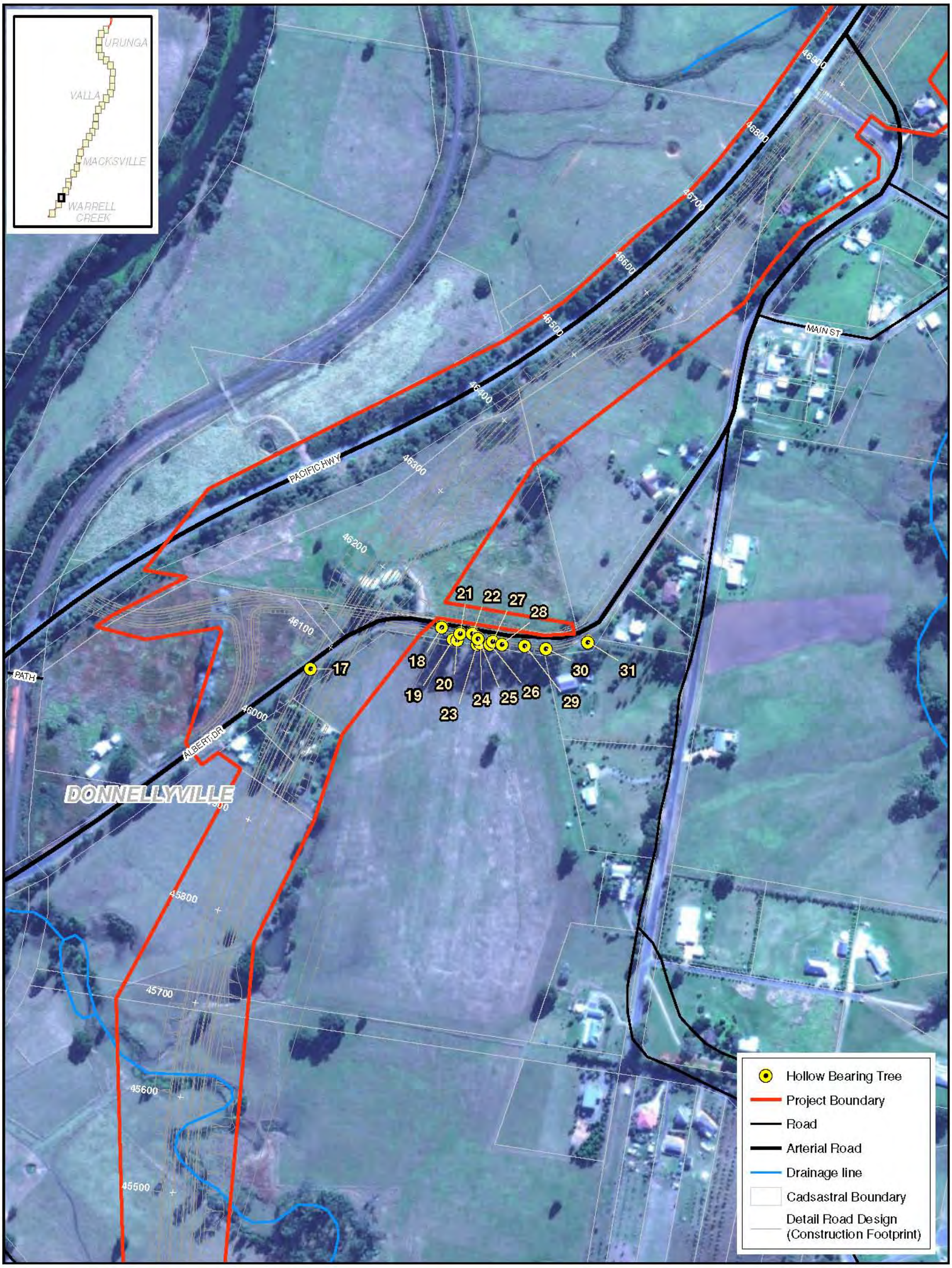

Figure 4 : HOLLOW BEARING TREES

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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0 50 100 150 200 250
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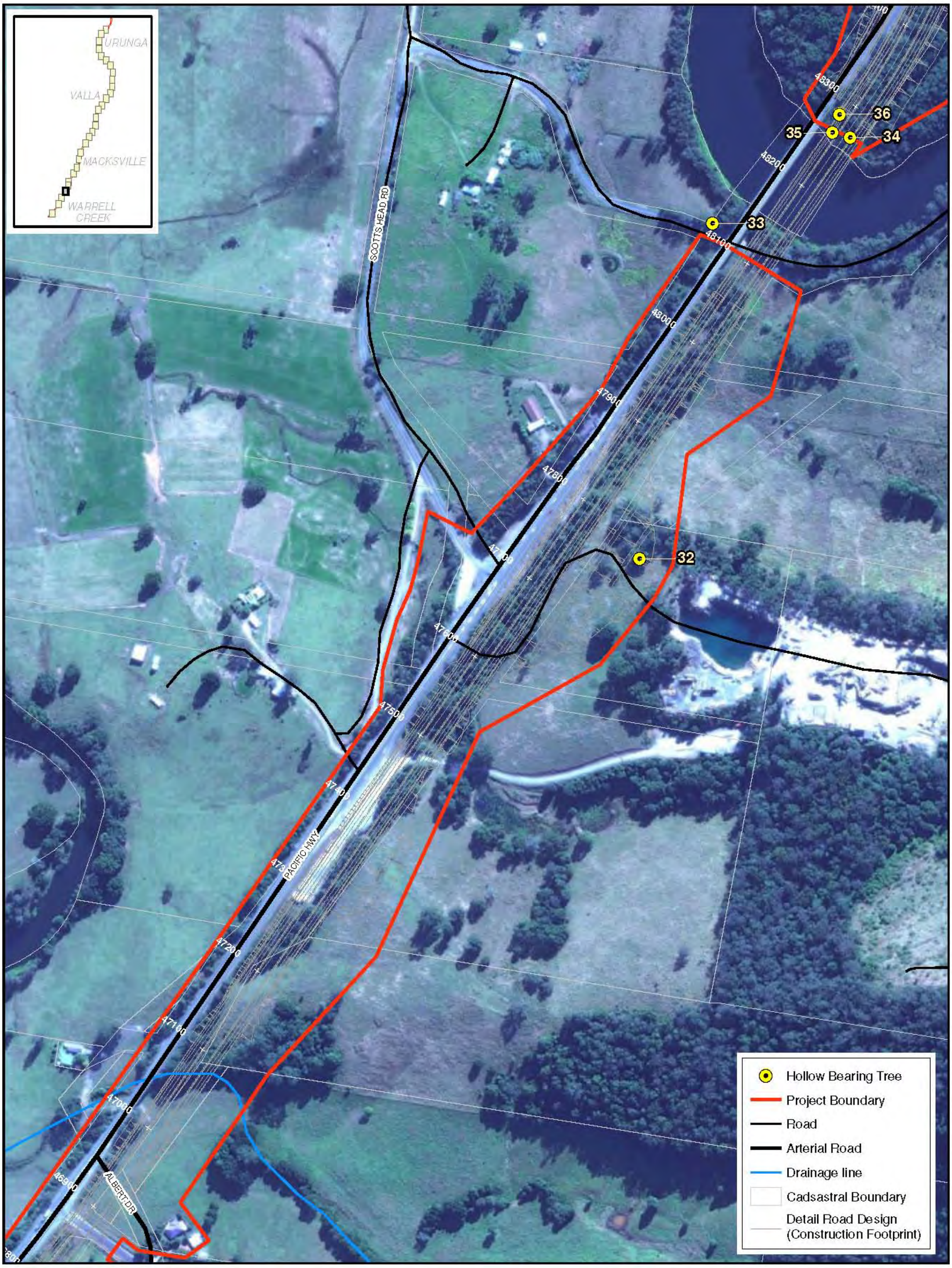

Figure 5 : HOLLOW BEARING TREES

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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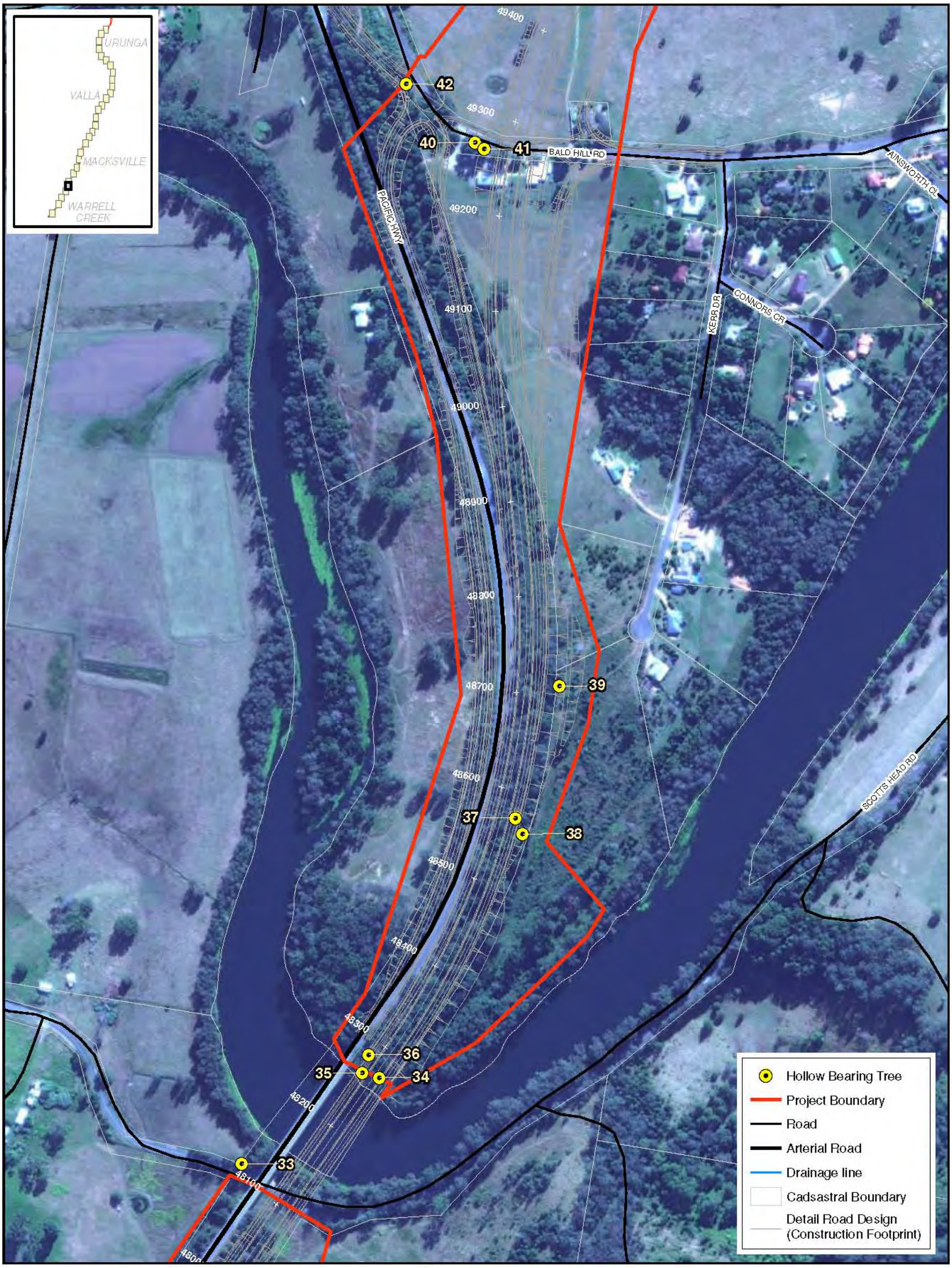

Figure 6 : HOLLOW BEARING TREES

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
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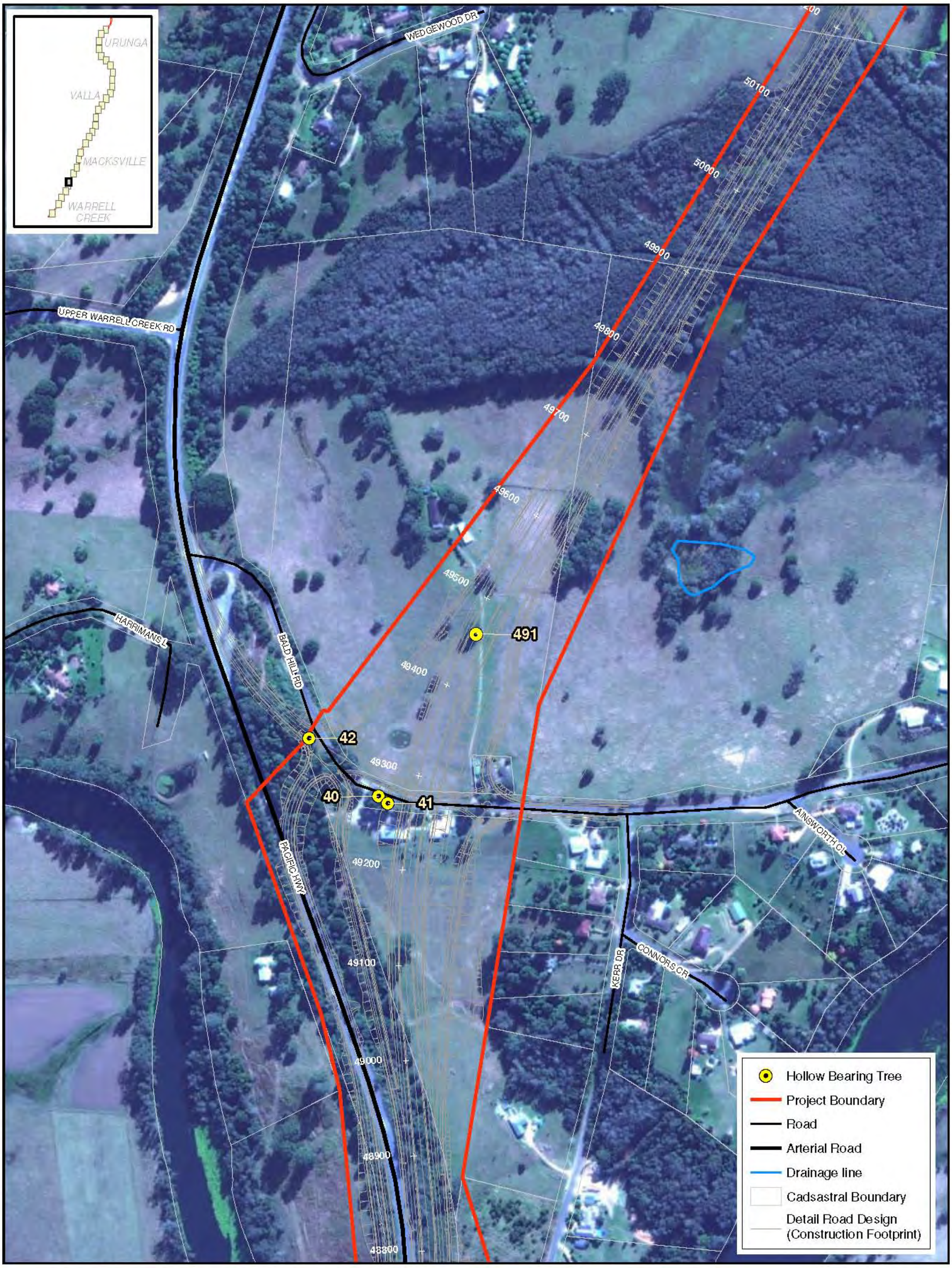

Figure 7 : HOLLOW BEARING TREES

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
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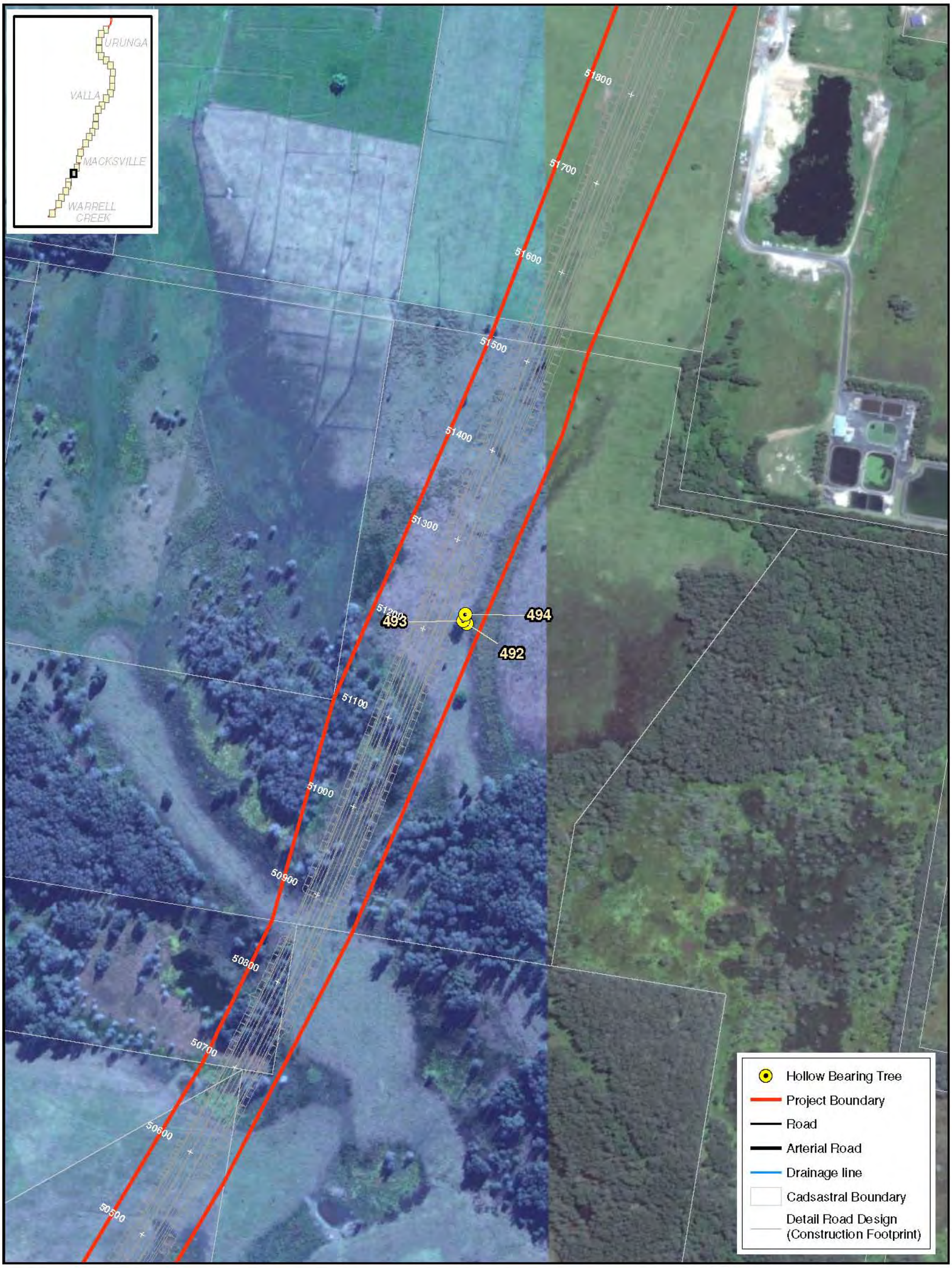

Figure 8 : HOLLOW BEARING TREES

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
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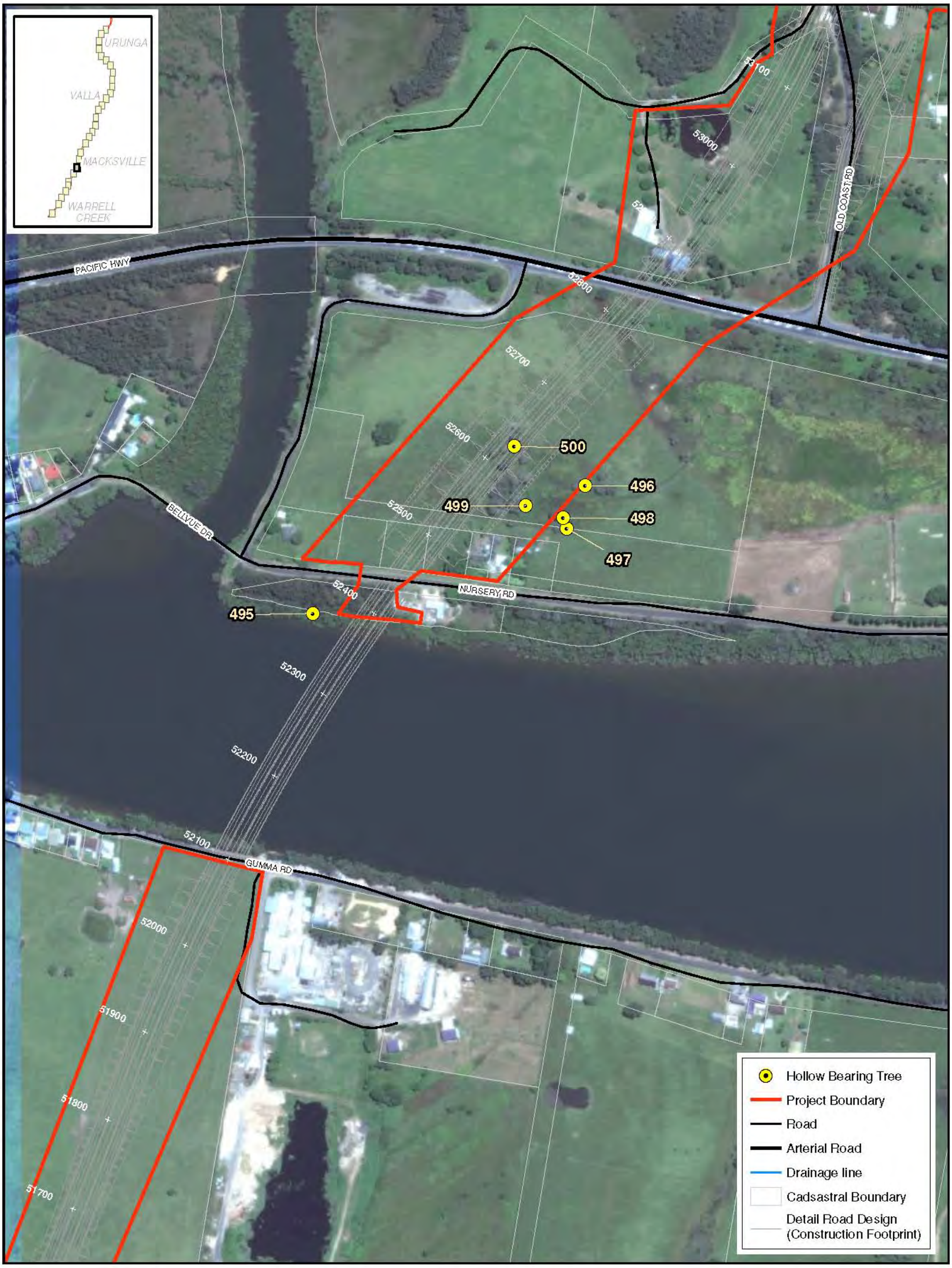

Figure 9 : HOLLOW BEARING TREES

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
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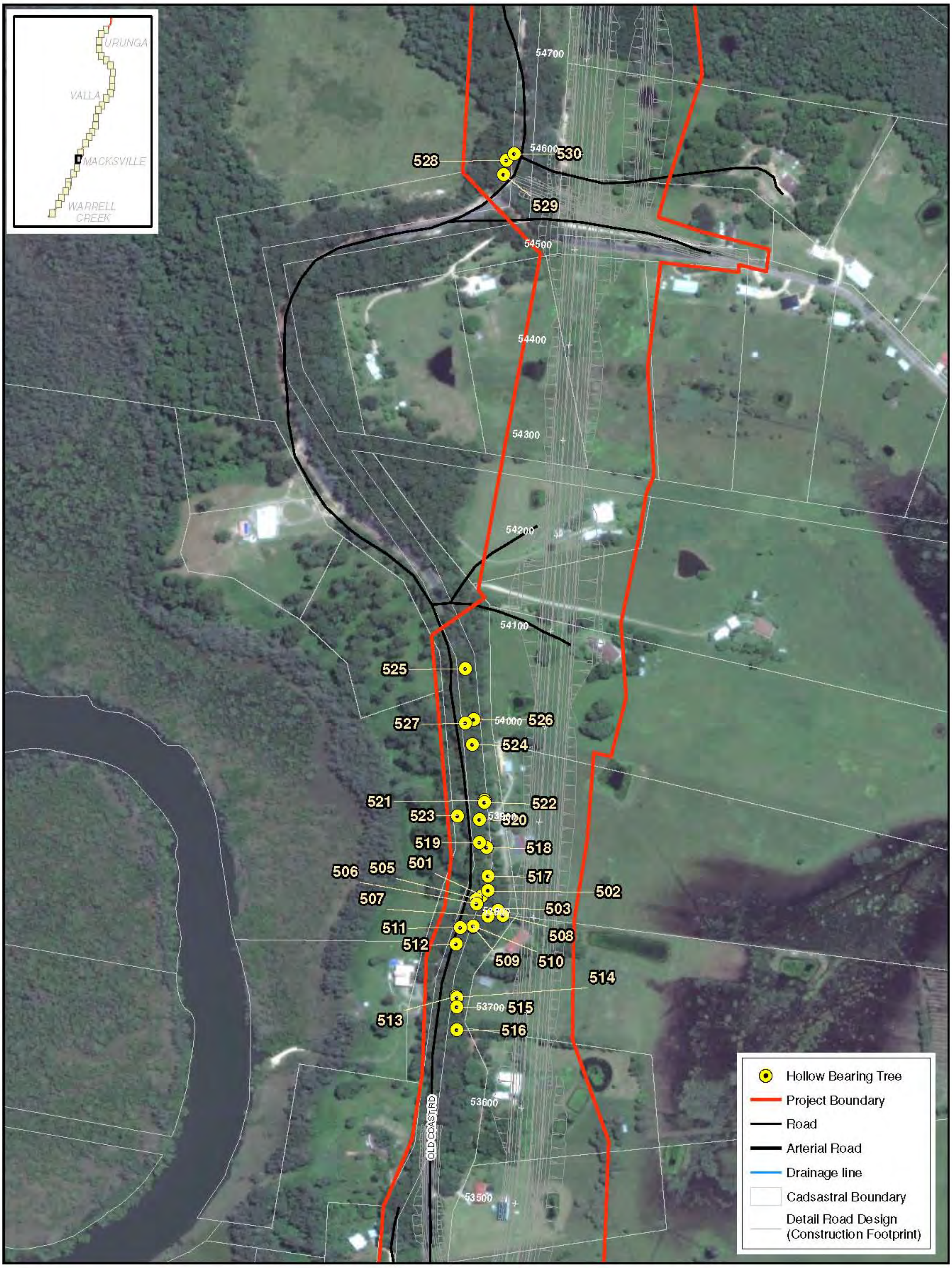

Figure 10 : HOLLOW BEARING TREES

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
Drainage: Geoscience Australia 2009
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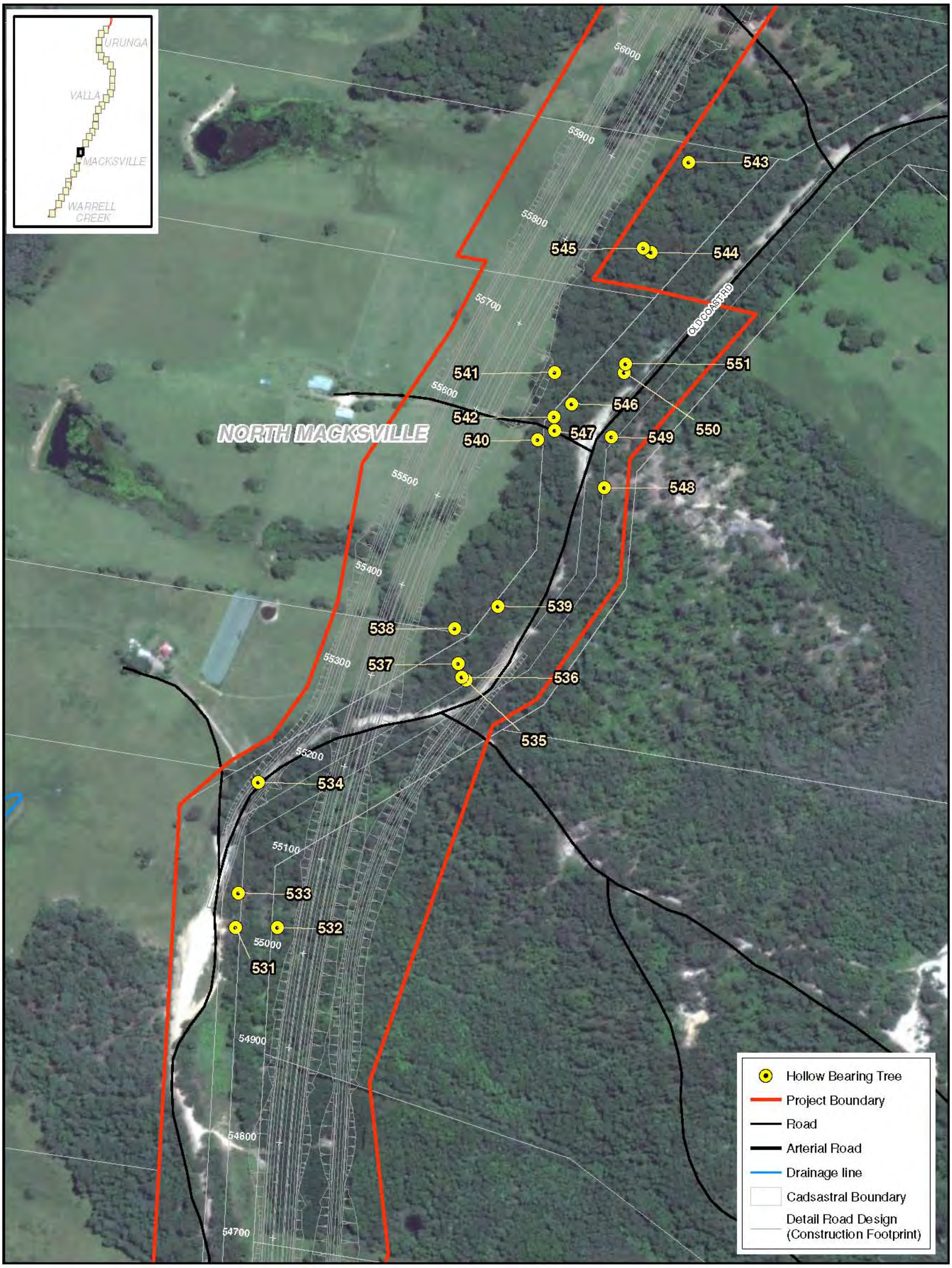

Figure 11 : HOLLOW BEARING TREES

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

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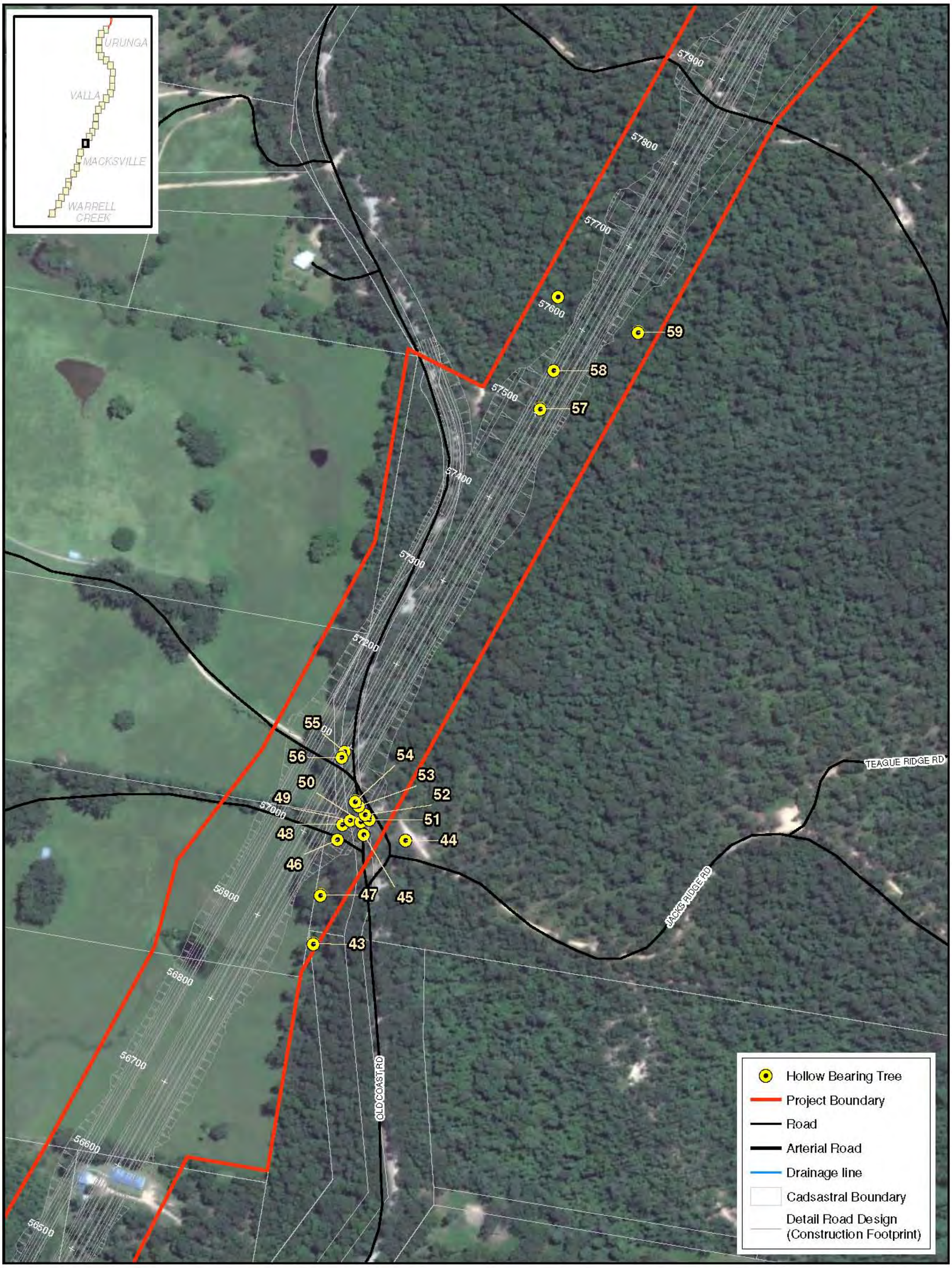

Figure 12 : HOLLOW BEARING TREES

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
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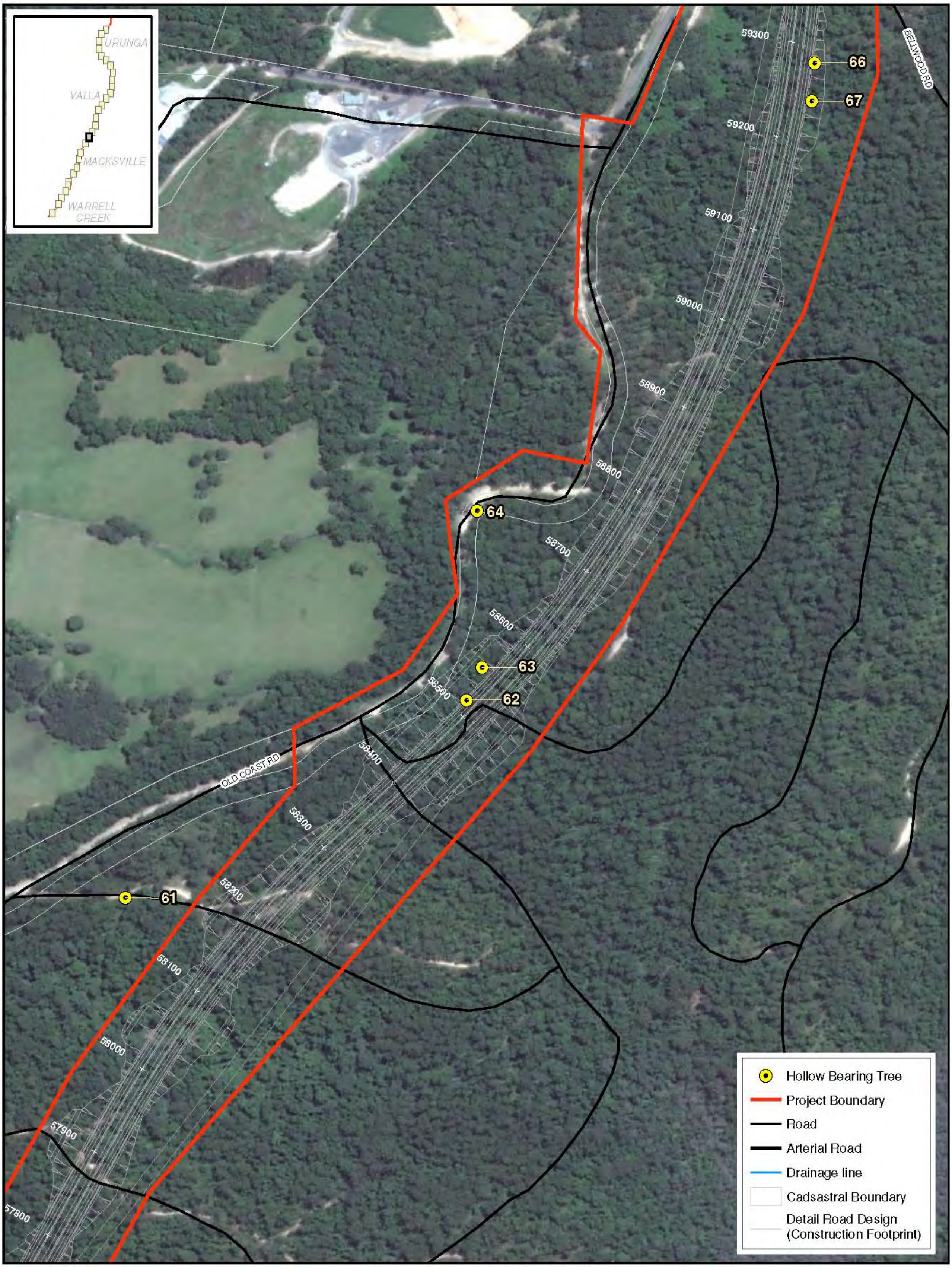

Figure 13 : **HOLLOW BEARING TREES**

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

Highway Design (footprint): RTA 2011
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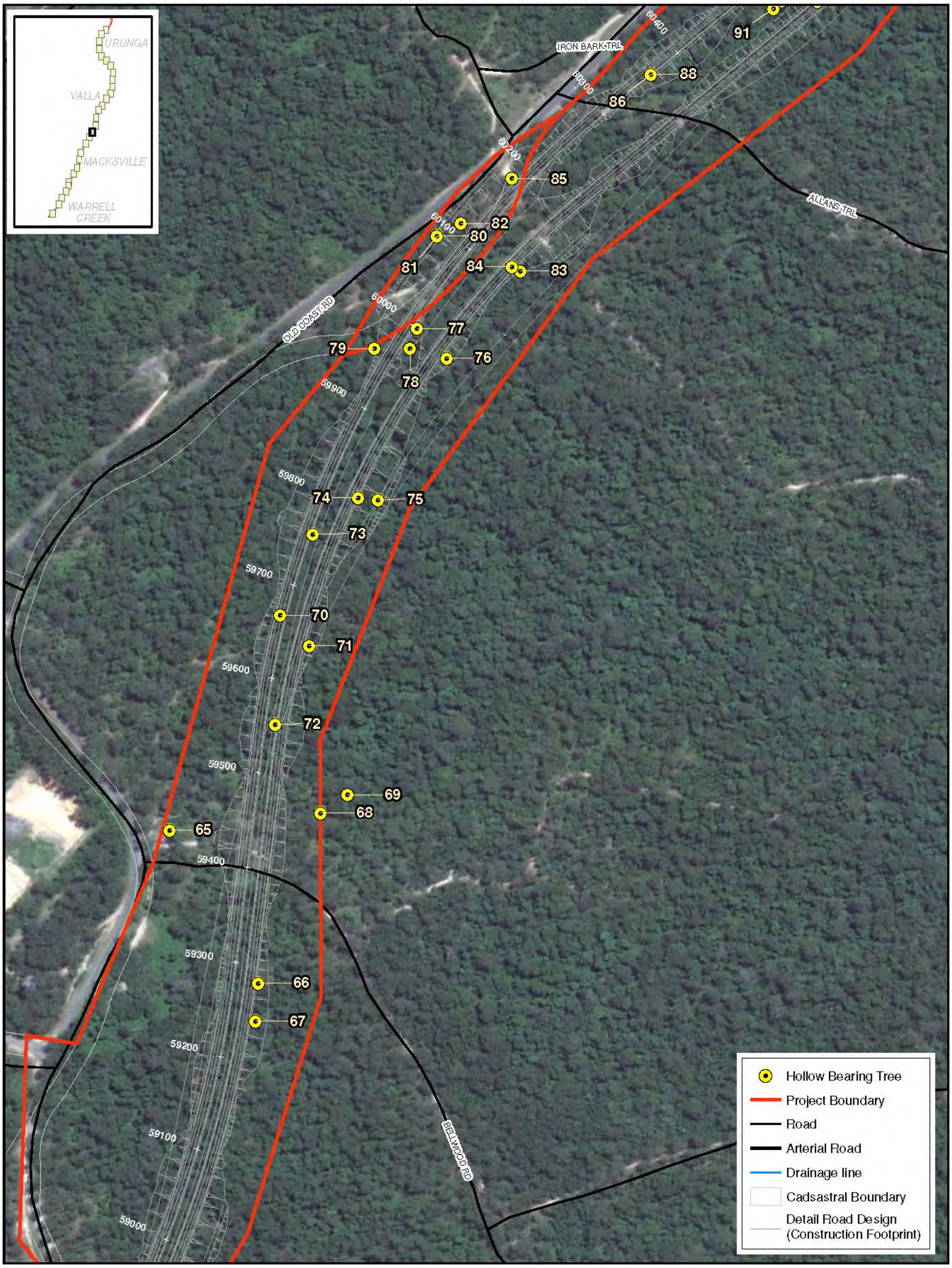

Figure 14 : HOLLOW BEARING TREES

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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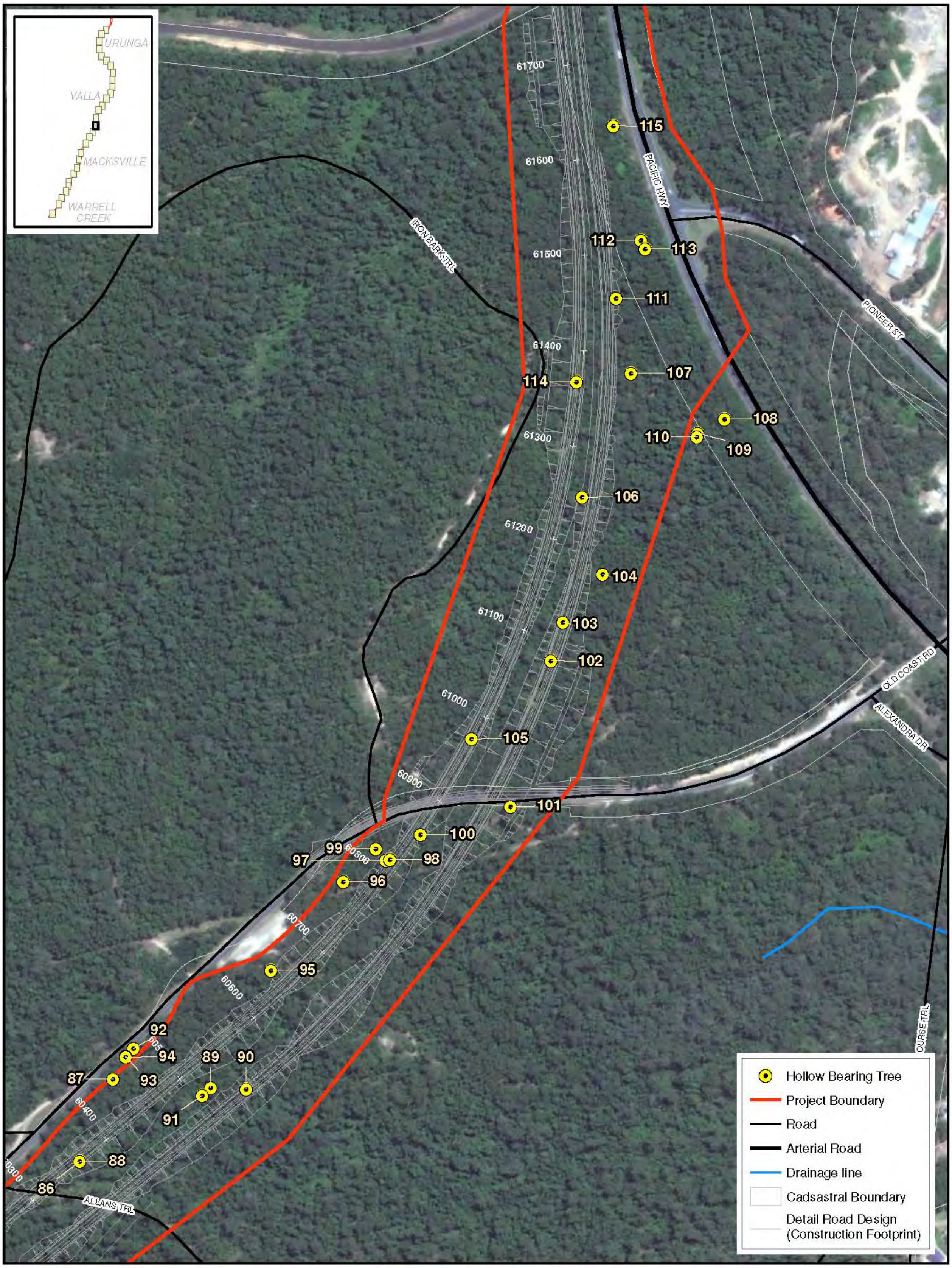

Figure 15 : **HOLLOW BEARING TREES**

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

Highway Design (footprint): RTA 2011
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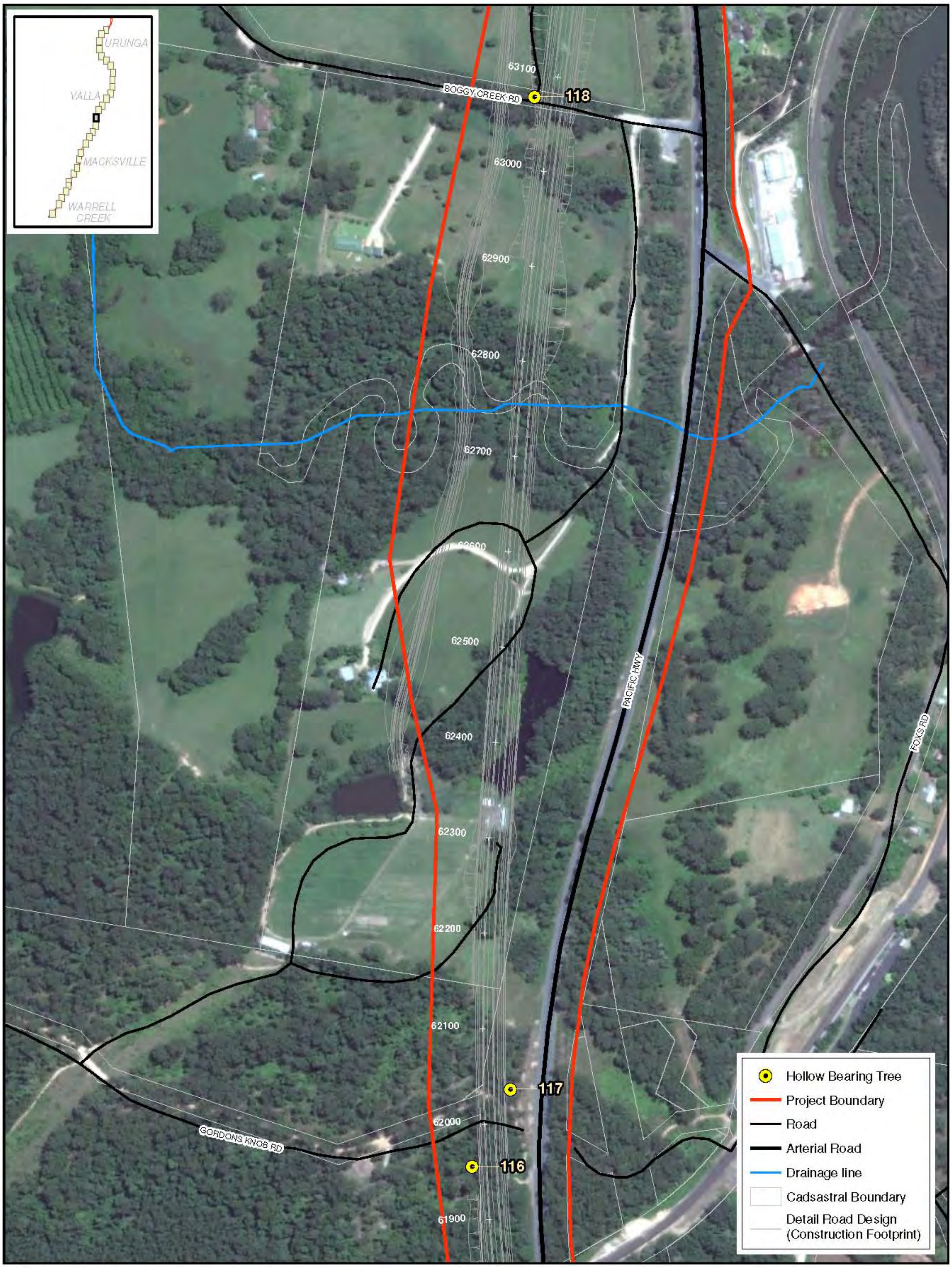

Figure 16 : HOLLOW BEARING TREES

Source:
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HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009

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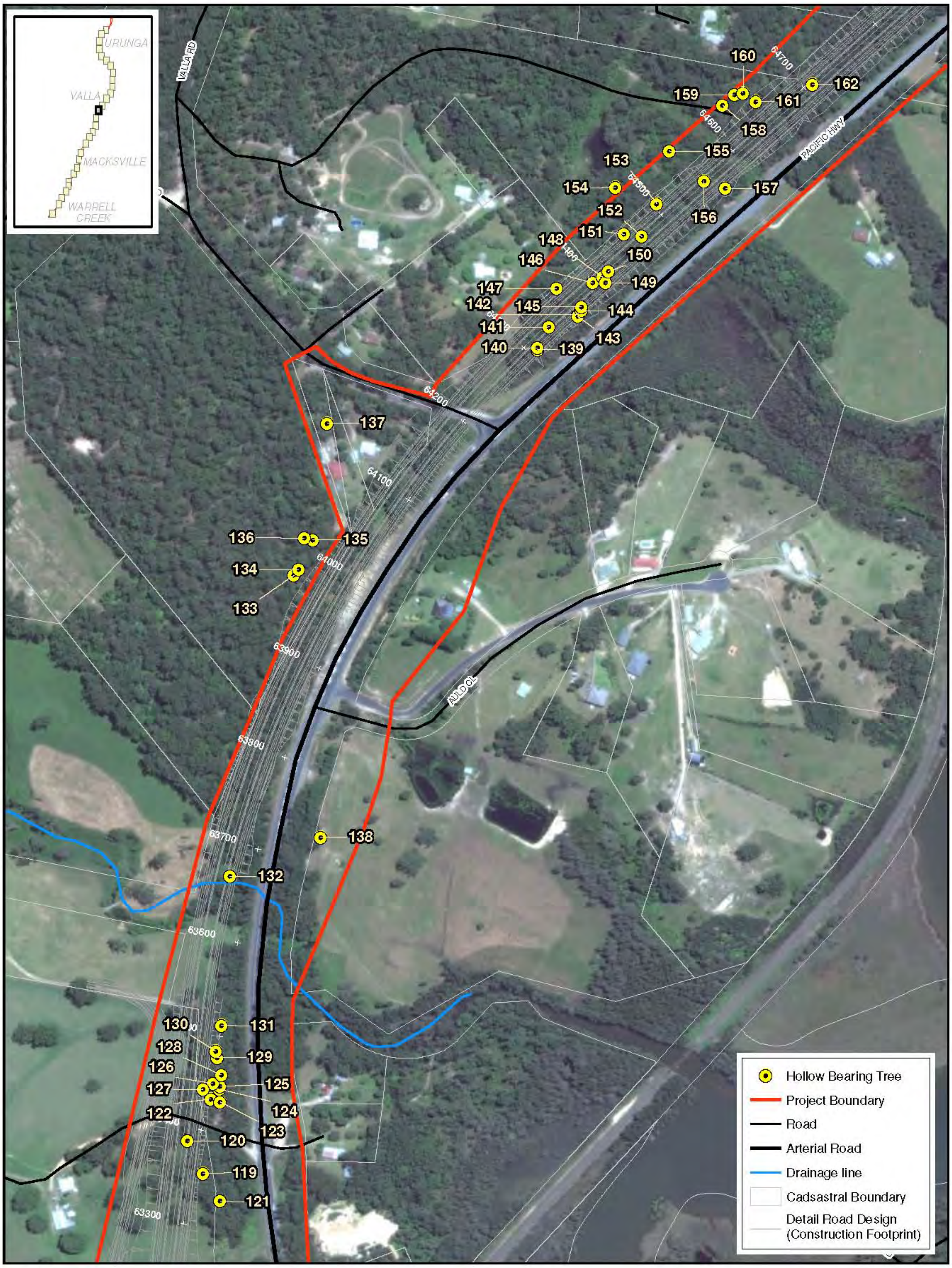

Figure 17 : HOLLOW BEARING TREES

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

Highway Design (footprint): RTA 2011
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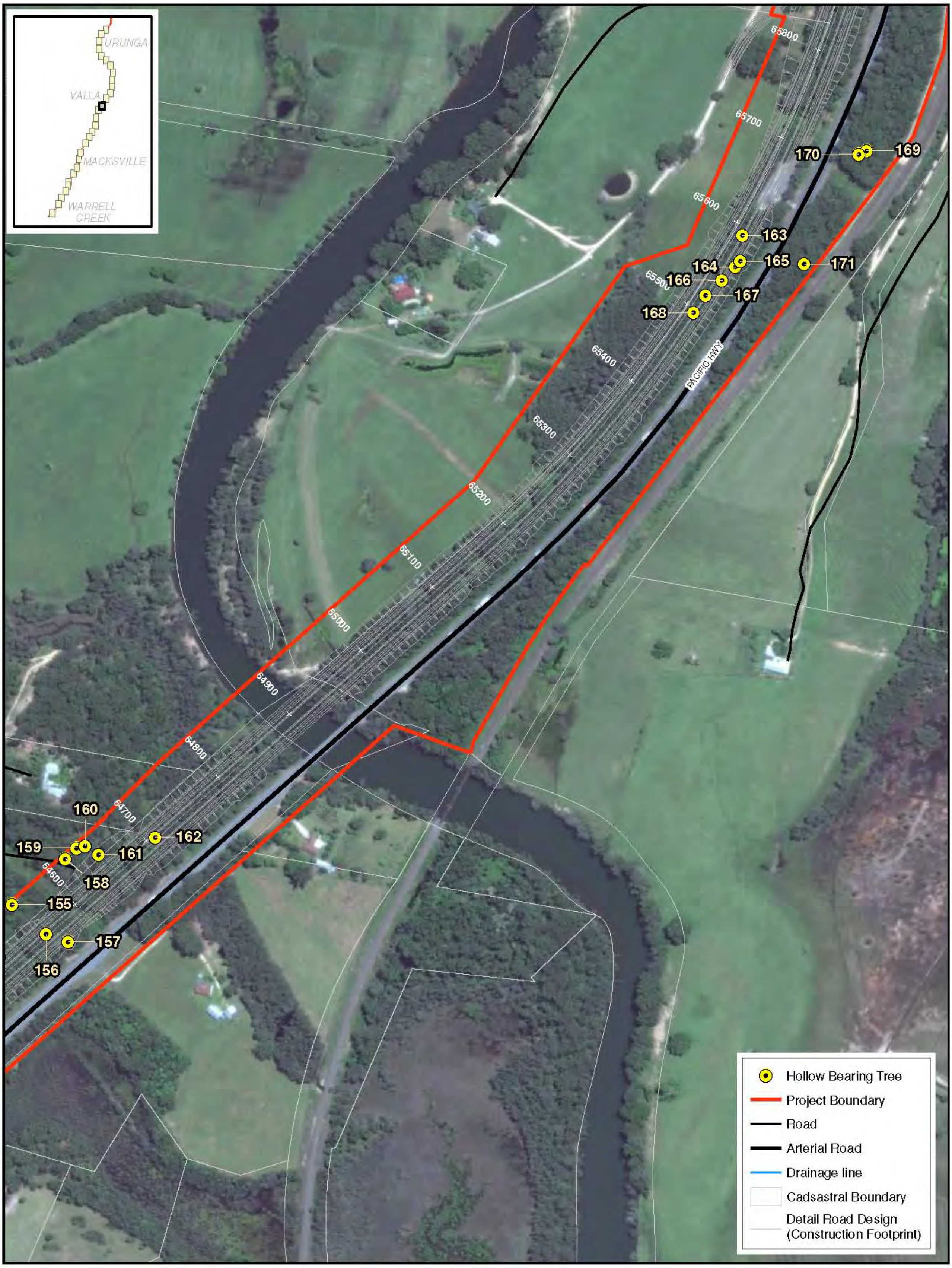

Figure 18 : HOLLOW BEARING TREES

Source:
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HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009

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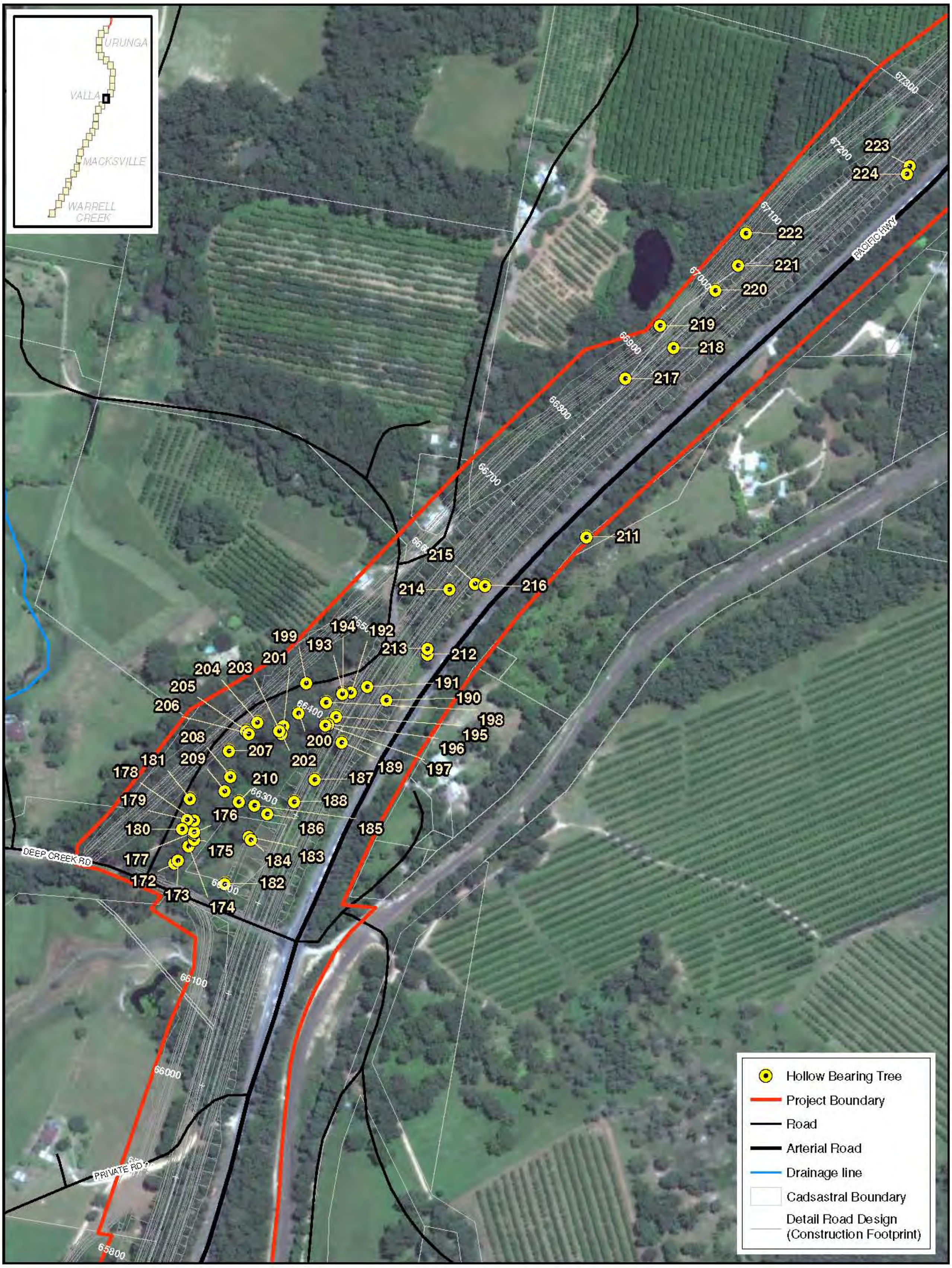

Figure 19 : HOLLOW BEARING TREES

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

Highway Design (footprint): RTA 2011
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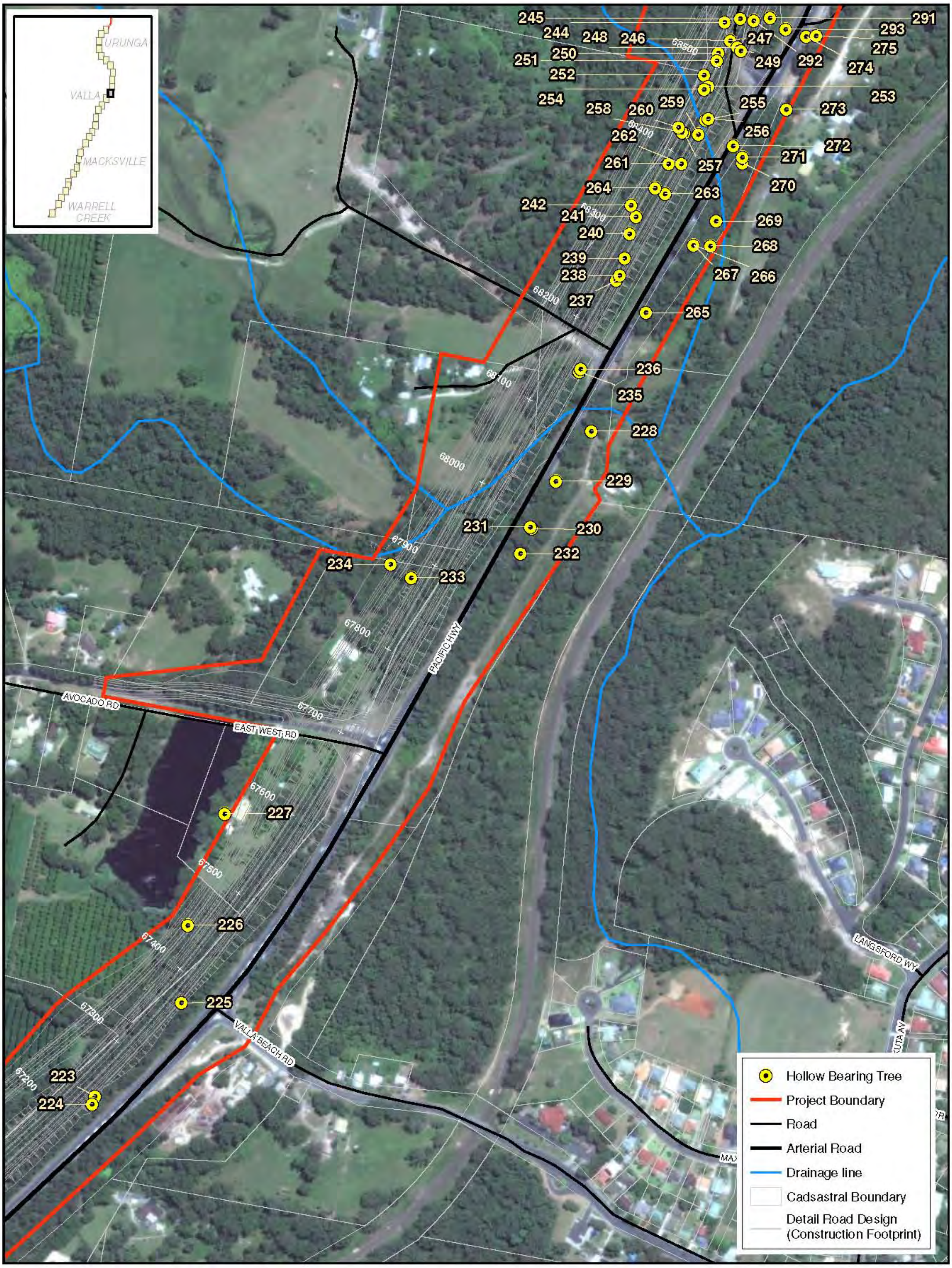

Figure 20 : HOLLOW BEARING TREES

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
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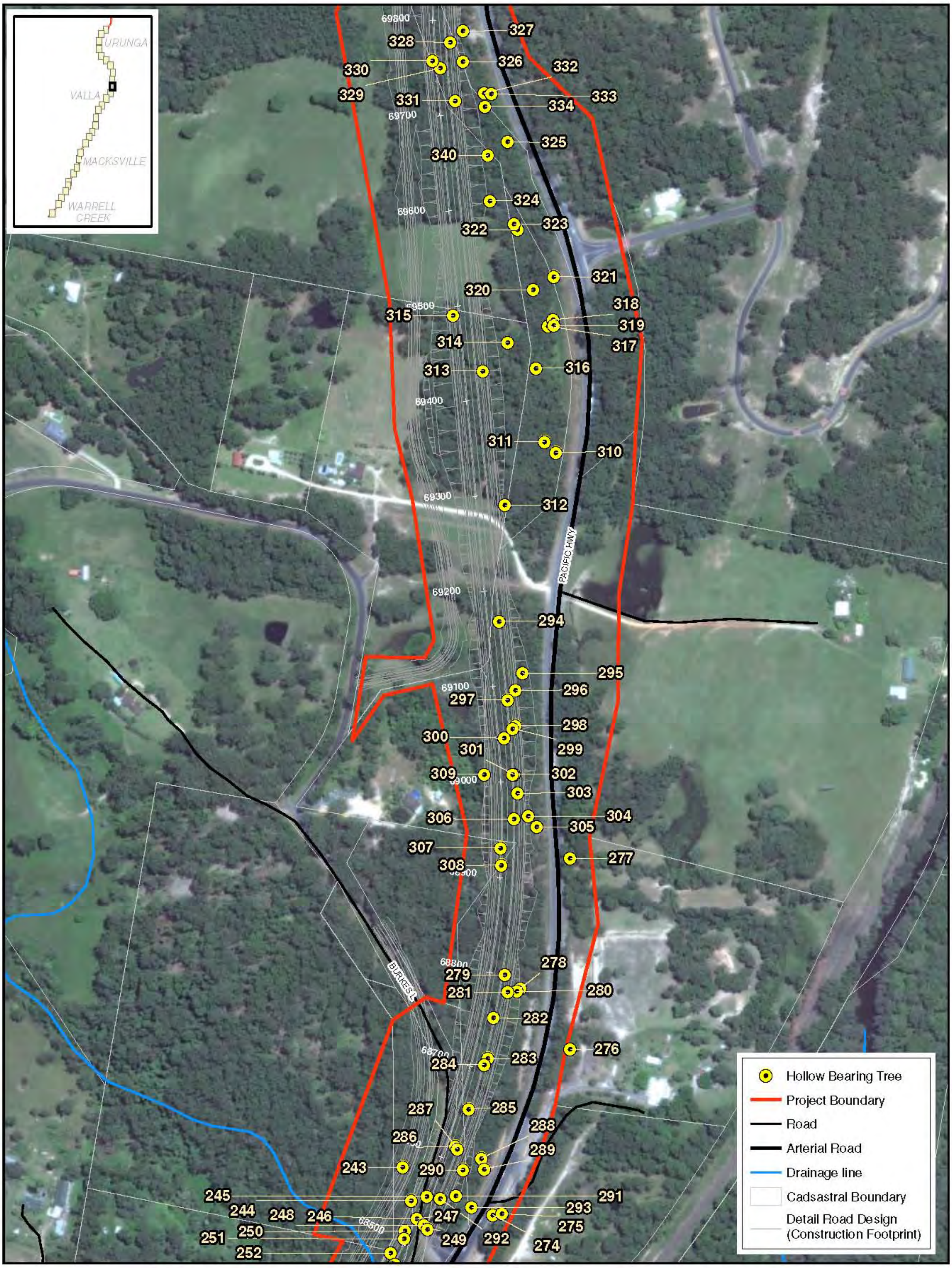

Figure 21 :

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
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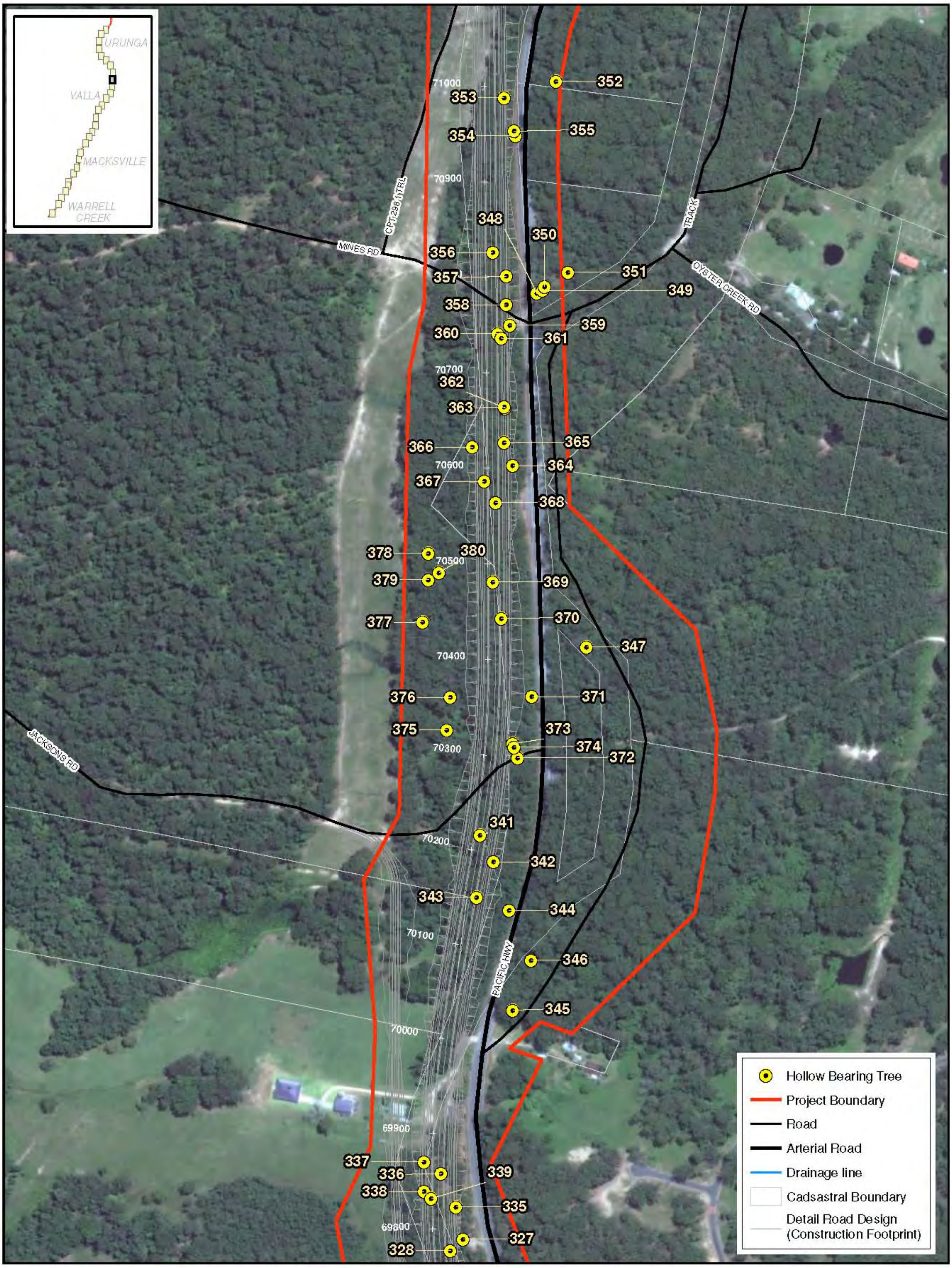

Figure 22 : **HOLLOW BEARING TREES**

Source:
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Roads: Geoscience Australia 2009

Highway Design (footprint): RTA 2011
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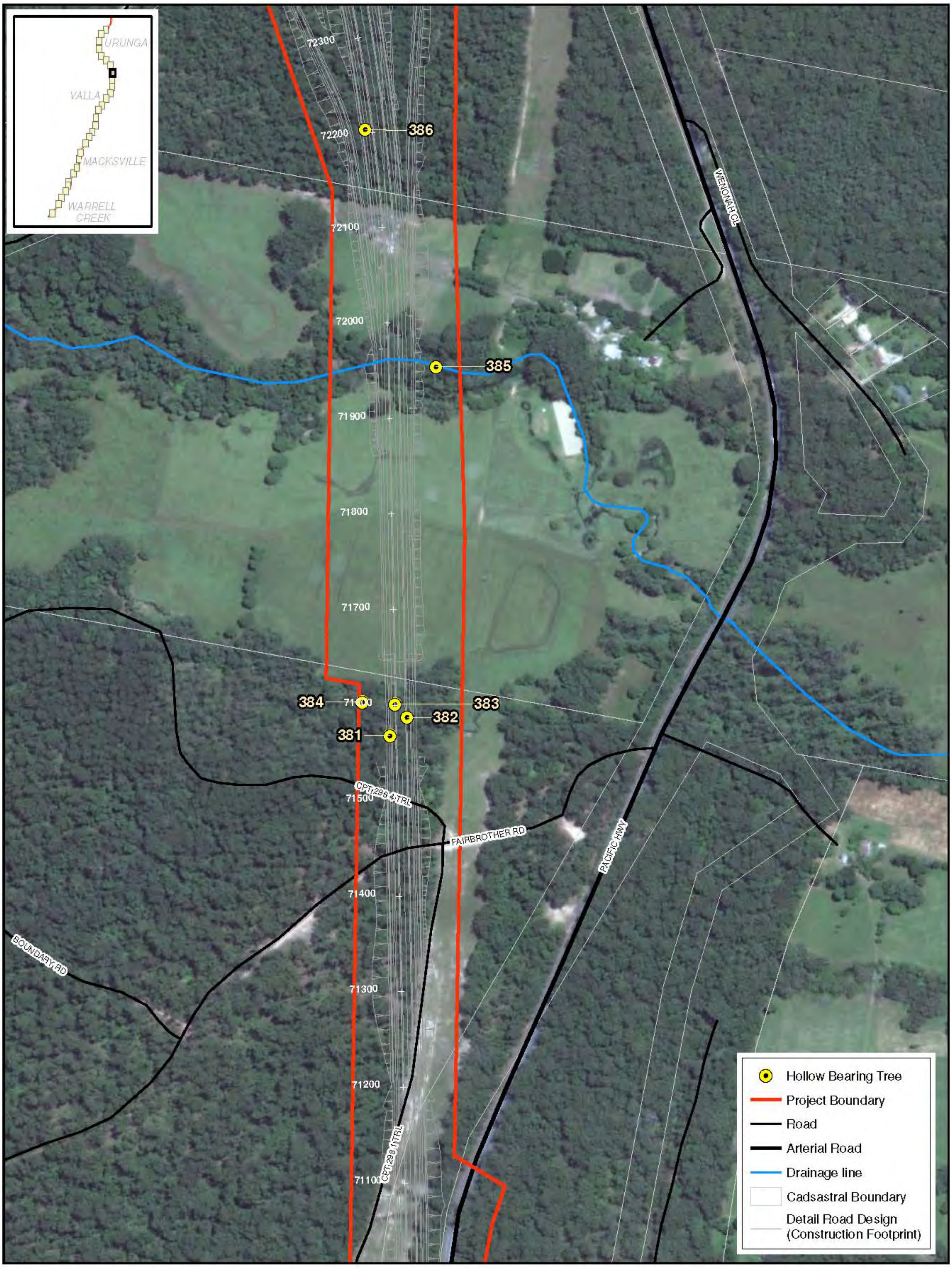

Figure 23 : HOLLOW BEARING TREES

Source:
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HBT Survey: Lewis Ecological Surveys April 2012
Roads: Geoscience Australia 2009

Highway Design (footprint): RTA 2011
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0 50 100 150 200 250
Meters
A4 Scale 1:5,000

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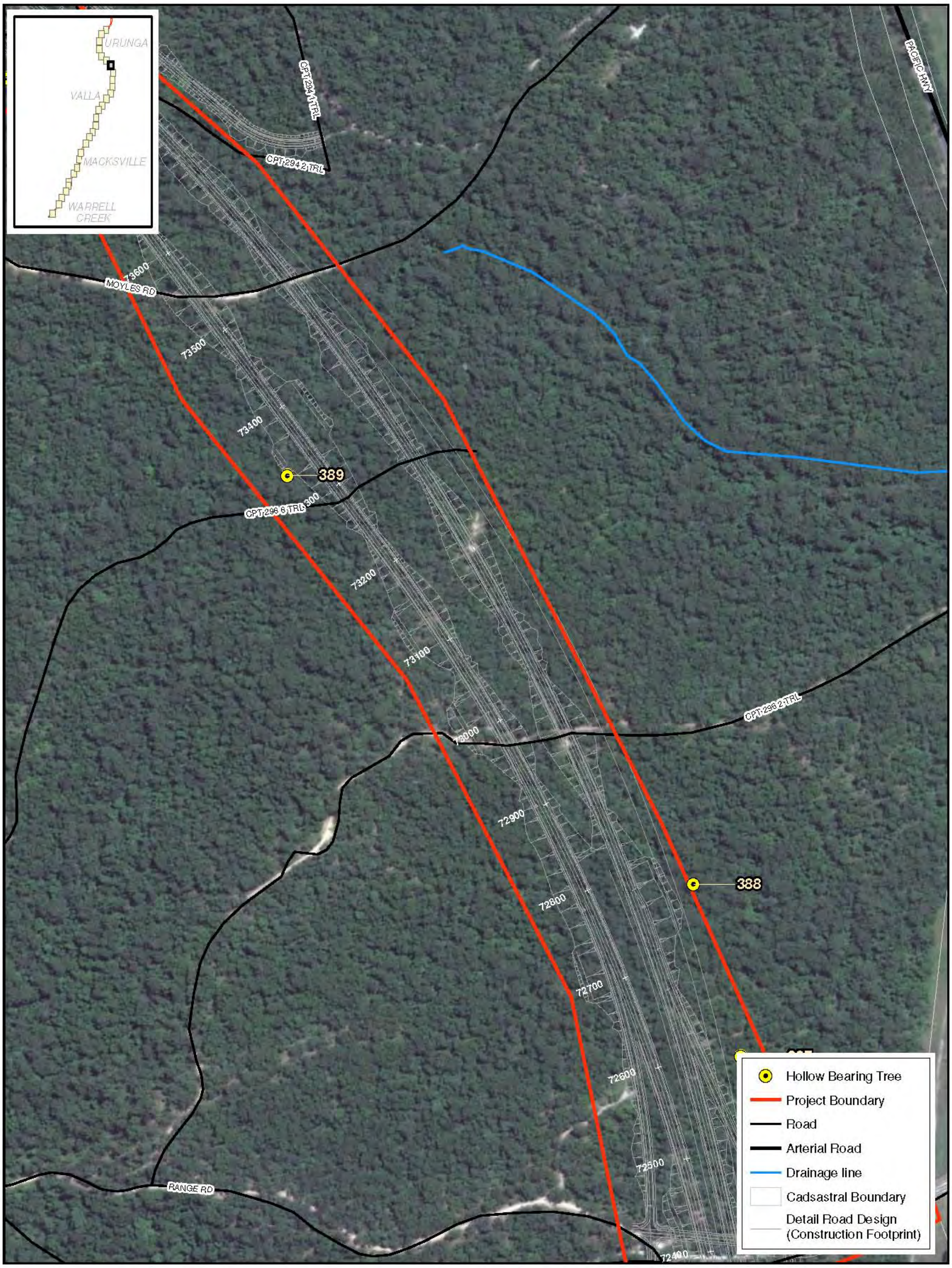

Figure 24 : **HOLLOW BEARING TREES**

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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0 50 100 150 200 250
Meters

A4 Scale 1:5,000

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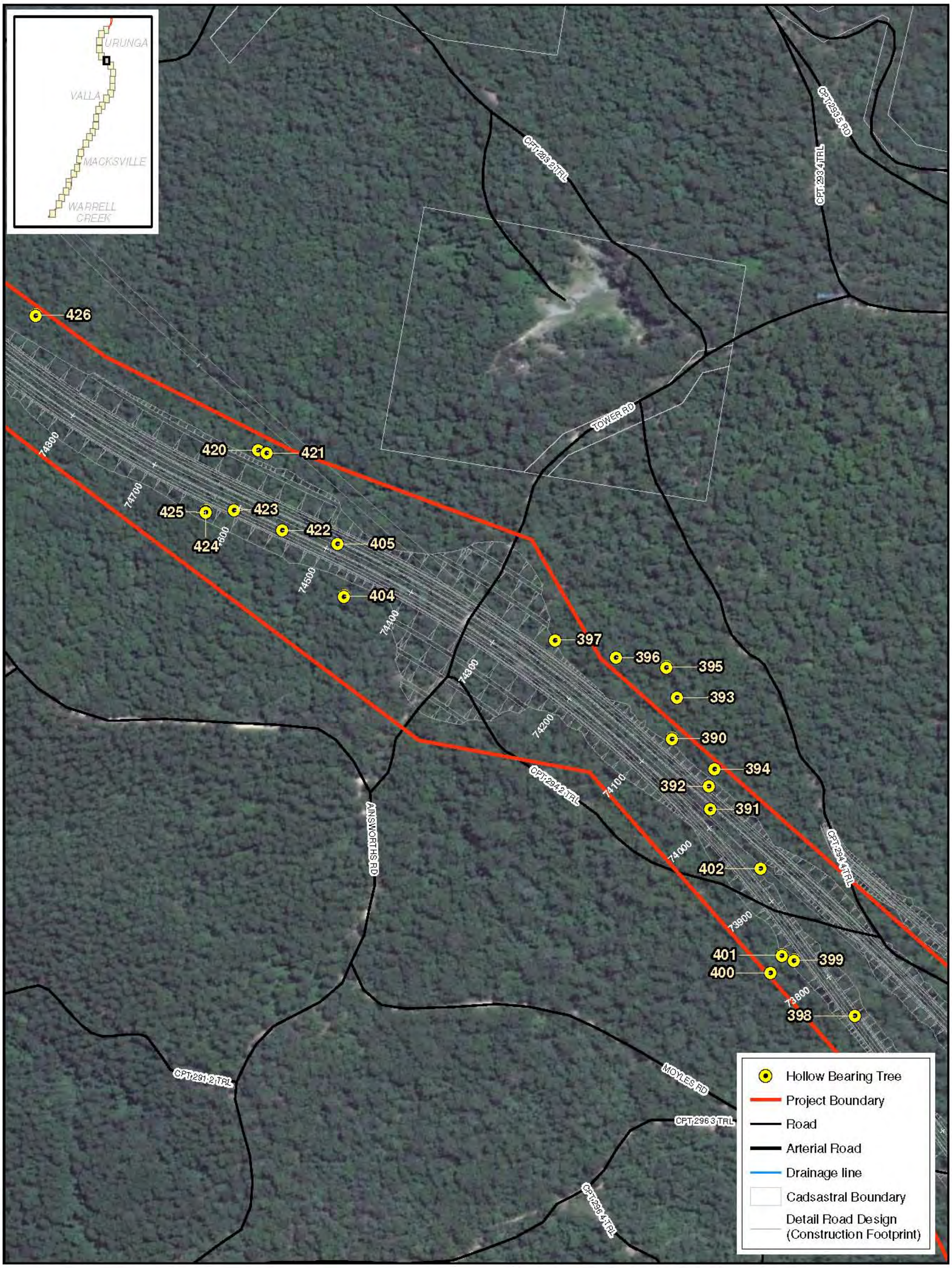

Figure 25 : HOLLOW BEARING TREES

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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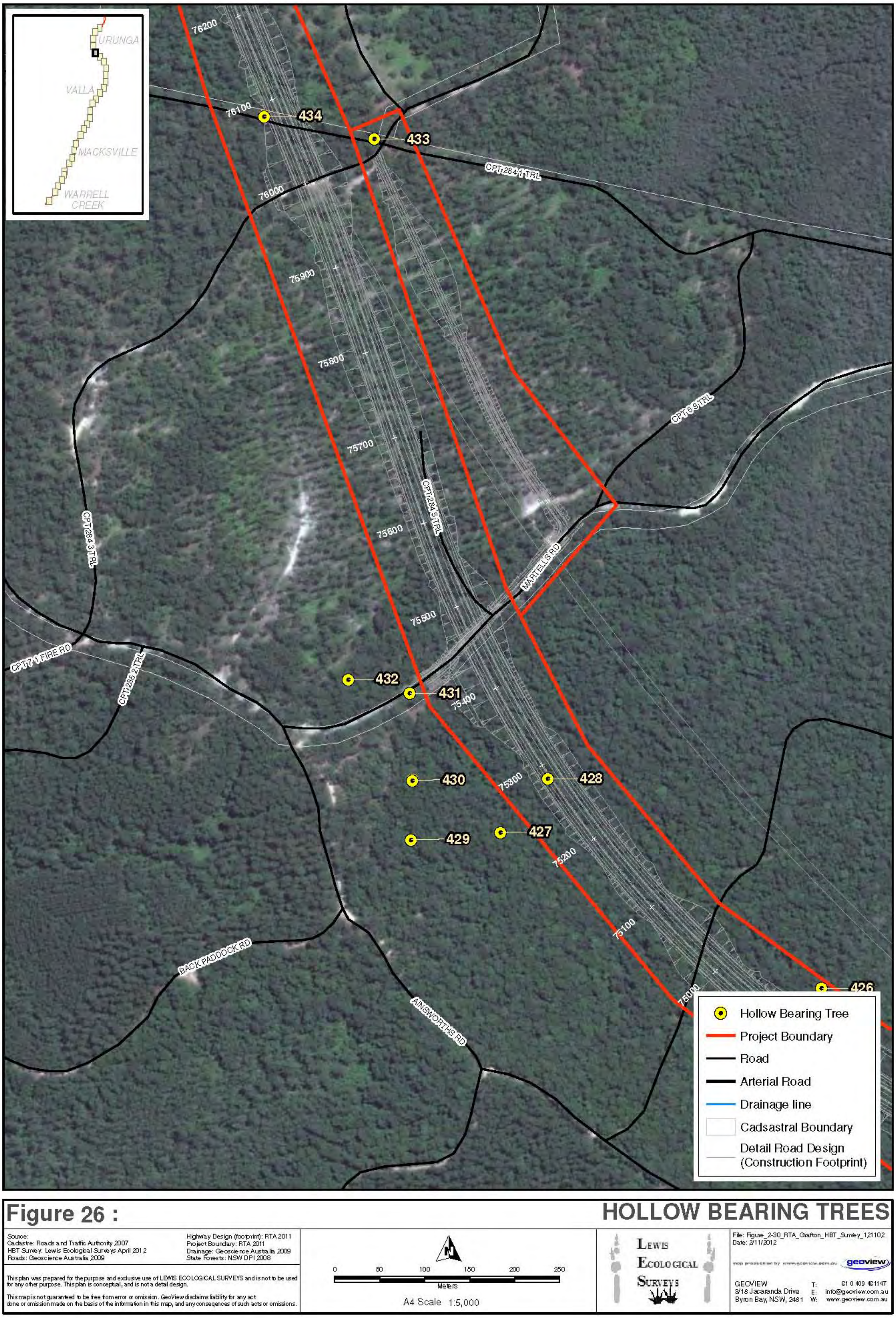

Figure 26 : HOLLOW BEARING TREES

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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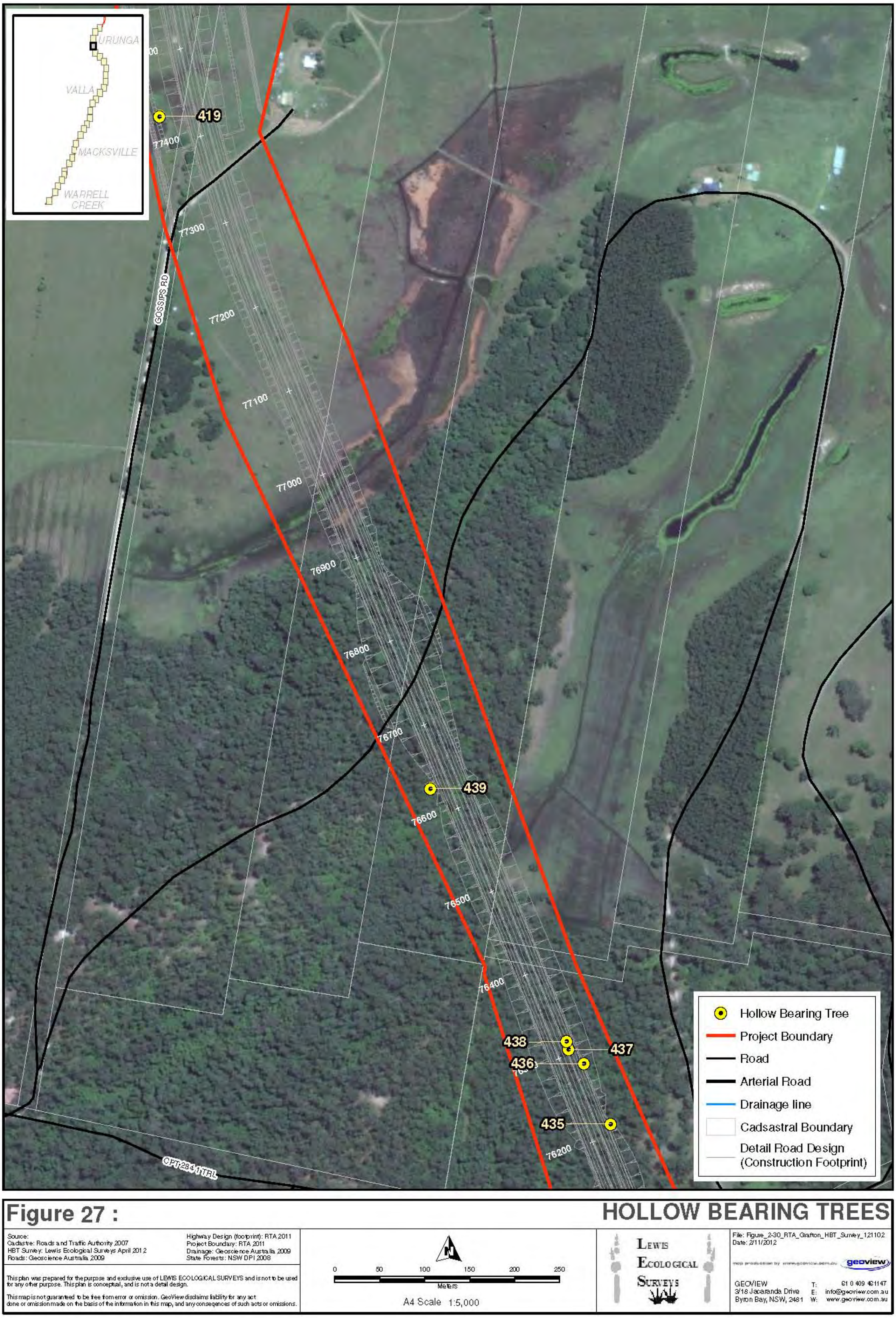

Figure 27 : HOLLOW BEARING TREES

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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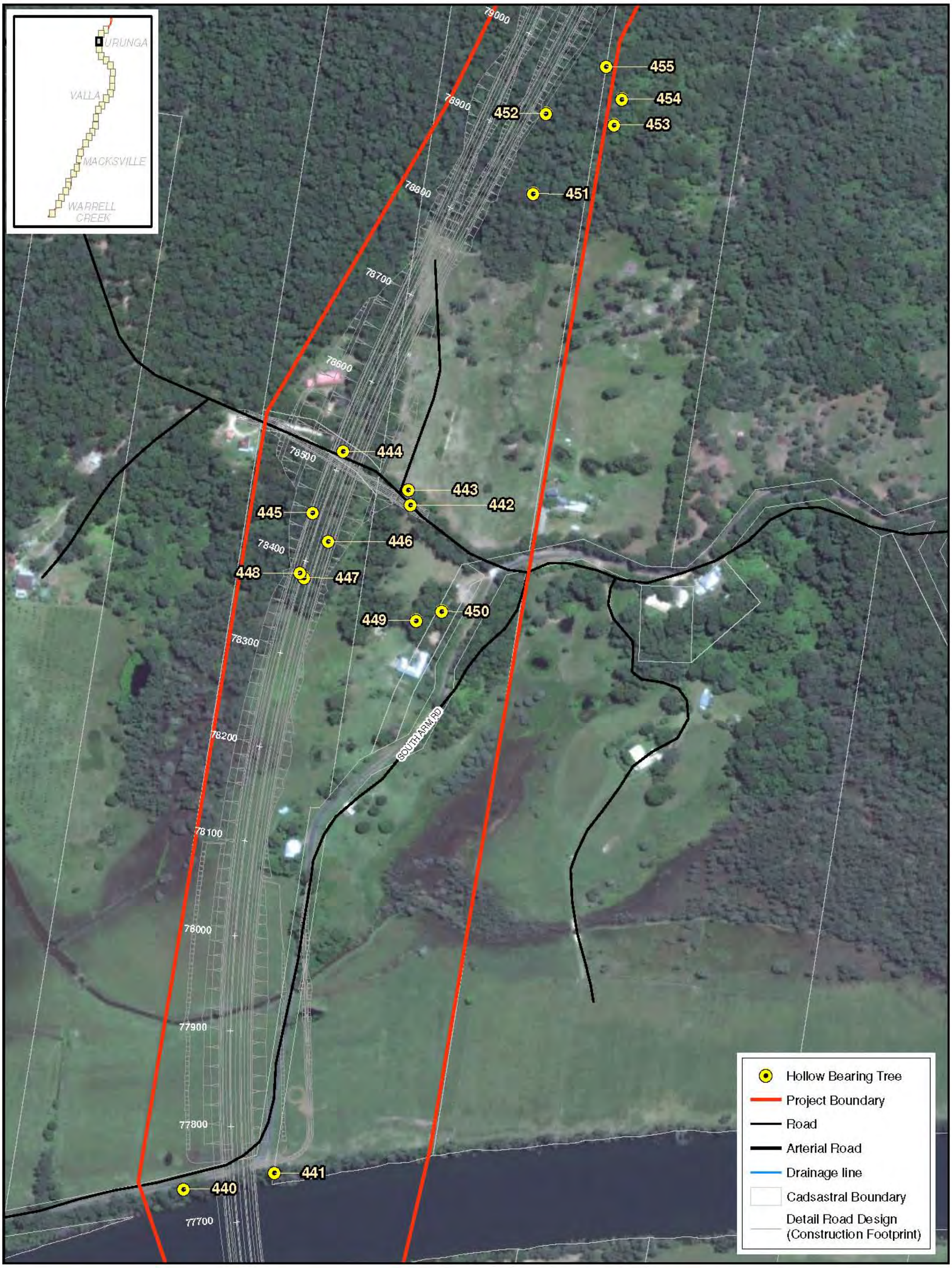

Figure 28 : HOLLOW BEARING TREES

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
A4 Scale 1:5,000

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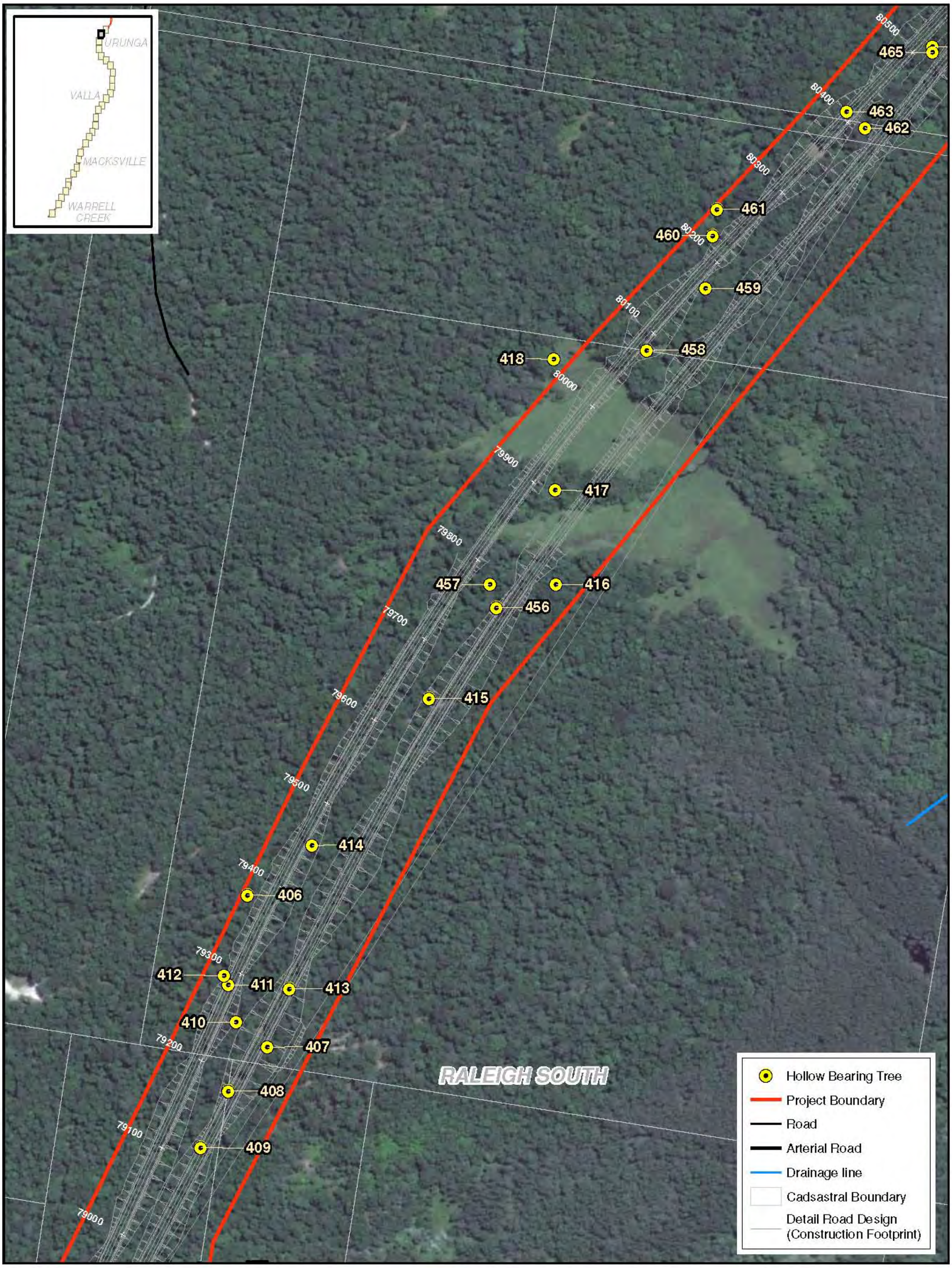

Figure 29 : **HOLLOW BEARING TREES**

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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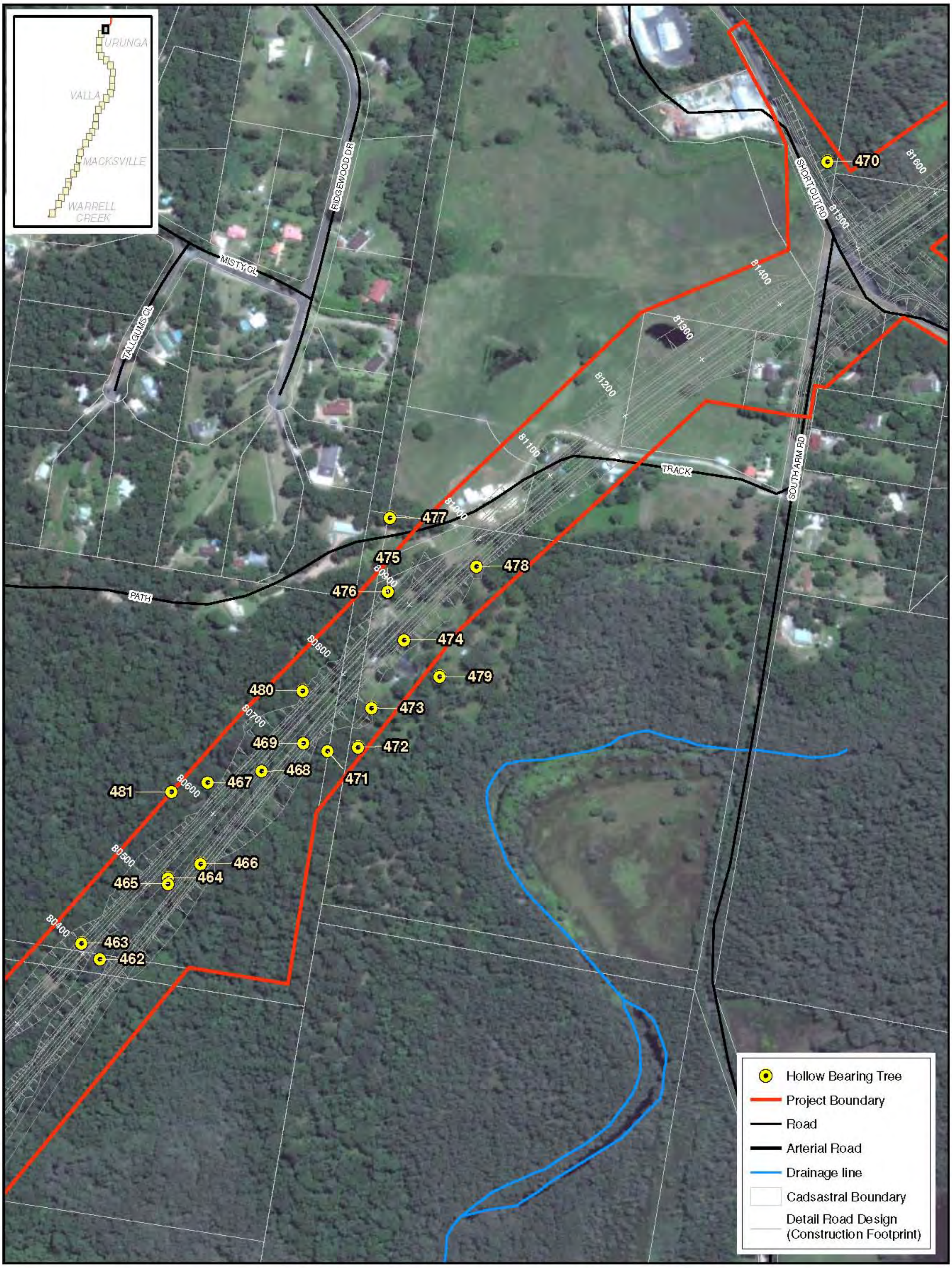

Figure 30 : HOLLOW BEARING TREES

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
A4 Scale 1:5,000

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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 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
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	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													
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

Warrell Creek to Urunga Upgrade

Threatened Flora Management Plan

Prepared for:

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6/03/2013

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

EXECUTIVE SUMMARY

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, as shown in the table below.

	Directly Impacted		**Indirectly Impacted**		**Road Reserve - in-situ**	
Threatened Species	points	no.	points	no.	Points	no.
Slender Marsdenia (E) (*Marsdenia longiloba*)	50	161	10	22	9	20
Rusty Plum (V) (*Niemeyera whitei*)	13	13 + sdls	4	4	2	2
Maundia (V) (*Maundia triglochinoides*)	~400+ m^2		~120 m^2		~60 m^2	
Floyds Grass (E) (*Alexfloydia repens*)	-		~6 m^2		-	
Wooll's Tylophora (E) (*Tylophora woollsii*)	5	9	-	-	3	6
Spider Orchid (E) (*Dendrobium melaleucaphilum*)	10	~30	16	35	70	200
ROTAP						
Ford's Goodenia (*Goodenia fordiana*)	9	9m^2	1	1m^2	-	-
Bellingen Ironbark (*Eucalyptus ancophila*)	2	15	2	4	-	-
Potential Threatened Species Listing						
Koala Bells (*Artanema fimbriatum*)	7	65	2	55	-	-

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.

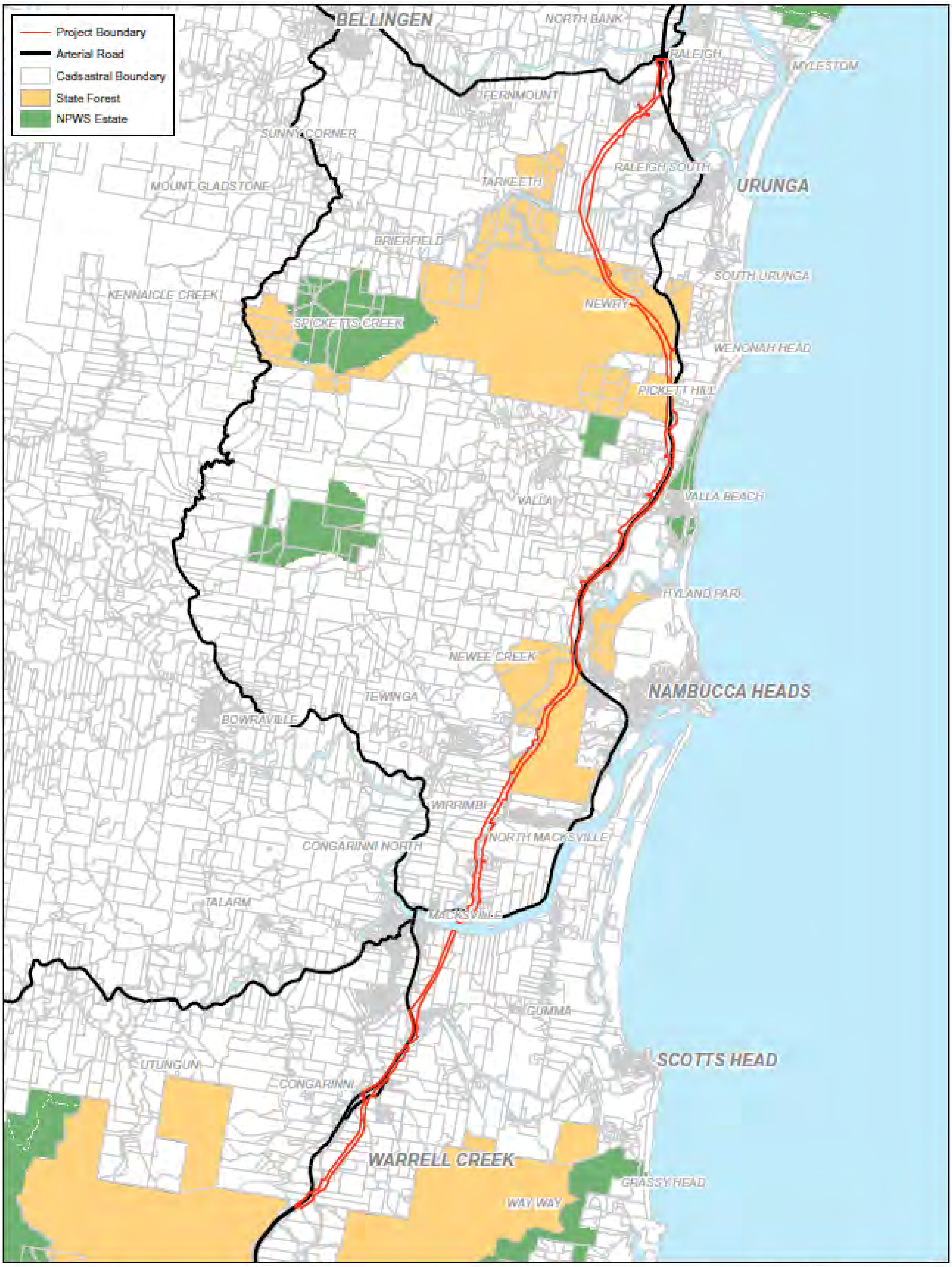

Figure 1:

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

Source:
Cadastre: Roads and Traffic Authority 2009
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, Rainforest 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
Lowland Rainforest (EEC)	0.58
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

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 - a broad vegetation type with a closed canopy and dominated by mesophytic tree genera.

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.

Regionally significant species - a species which is rare, disjunct or at the distributional limits of its range (after Sheringham and Westway 1995).

Nationally rare or ROTAP species - a species listed in the publication 'Rare or Threatened Australian Plants' (Briggs and Leigh 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 the 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 Crouches 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 Cockburns 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	Moist open forest/rainforest transition in hilly terrain.
Niemeyera whitei Rusty Plum	V - nl	Wet sclerophyll forest and rainforest.
		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 -	E - nl	Wet sclerophyll forest edges; Wildlife

Newry Golden Wattle		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*, where there were no discrete individuals, GPS points were recorded to indicate the extent or limits of each patch occurrence.

A recording form was set up on the Nautiz and the species, identification number, plant height and other relevant details entered for each recorded 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 m^2 (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 mapped by EcoPro (2010) was surveyed for the Eastern Underground Orchid for this report in November 2011. To identify other areas where the orchid may occur, habitat information recorded with specimens of *Rhizanthella slateri* held at the Royal Botanic Gardens Herbarium in Sydney (10 collections) and the National Herbarium in Canberra (5 collections) was requested from the two herbaria. The collated habitat information indicated that *Rhizanthella slateri* occurs in wet and dry sclerophyll forest on siliceous soils formed on high quartz geology, particularly sandstone and rhyolite. These rock types are not present in the study, although chert, a siliceous metamorphic rock, probably occurs at least sparsely.

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 either Permian metamorphics (Nambucca Beds) on hilly terrain, or floodplain alluvium in valleys. It was decided to search for *R. slateri* at sites where vegetation indicators of more siliceous soil were observed during the survey, such as forest with a sclerophyllous, heathy understorey. At sites judged to be potential habitat for *R. slateri*, 10 m x 10 m plots were established, leaf litter and mulch partially removed so the ground surface could be examined for *R. slateri* flowers or seeding heads.

3.3.7 Spatial Impact Analysis

The recorded flora points were overlaid on the highway design to determine if they were directly impacted, indirectly impacted or outside the area of direct and indirect impact. Definitions of these impact zones are provided below.

Directly impacted:- Directly impacted individuals are located on the construction footprint or areas that require clearing.

Indirectly impacted:- Indirectly impacted individuals are located within 10 m of the construction footprint. In this zone it is assumed that the existing habitat will potentially be subject to disturbance during construction and minor localized changes in ecological conditions. The outer boundary of the indirect impact zone varies according to the level of disturbance at specific points. Note that individuals located on the project boundary that require fencing were also considered as directly impacted.

While the indirect areas are considered to be within 10 metres of the construction footprint, it is not anticipated that this 10 metre zone will be completely disturbed during the construction process. Wherever possible, the clearing limits would be contained to the minimum amount necessary to allow construction activities to be undertaken. Some areas along the alignment such as around bridge abutments and sediment basins are likely to utilize most of the 10 metre area. Notwithstanding the direct and indirect impacts, it should be noted that RMS has realigned various sections of the proposed alignment to minimise impacts on areas of known threatened species.

In-Situ within road reserve:- These individuals are located within the future road reserve however are outside the construction footprint, and not considered to be “Indirectly impacted” as detailed above.

Outside project corridor:- These individuals are located outside the approved project corridor and are not considered to be directly or indirectly impact by the proposed construction works.

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 3. Threatened and rare flora records were classed as either: (i) directly impacted (i.e. within the construction footprint), (ii) indirectly impacted (within 10m of the construction footprint) or (iii) in-situ within the road reserve (outside the indirect impact zone). 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 3: Impact analysis summary giving the number/area of each recorded species directly impacted, indirectly impacted and not impacted (to remain in-situ) within the road reserve; 'points' are the number of gps points where the species was recorded; 'no.' gives the total number of individuals at gps points. Mat-forming species were recorded as an area in square metres. (note - a few recorded points were outside the project boundary)

	Directly Impacted		**Indirectly Impacted**		**Road Reserve - in-situ**	
Threatened Species	points	no.	points	no.	Points	no.
Slender Marsdenia (E) (*Marsdenia longiloba*)	50	161	10	22	9	20
Rusty Plum (V) (*Niemeyera whitei*)	13	13 + sdls	4	4	2	2
Maundia (V) (*Maundia triglochinoides*)	~400+ m^2		~120 m^2		~60 m^2	
Floyds Grass (E) (*Alexfloydia repens*)	-		~6 m^2		-	
Wooll's Tylophora (E) (*Tylophora woollsii*)	5	9	-	-	3	6
Spider Orchid (E) (*Dendrobium melaleucaphilum*)	10	~30	16	35	70	200
ROTAP						
Ford's Goodenia (*Goodenia fordiana*)	9	9m^2	1	1m^2	-	-
Bellingen Ironbark (*Eucalyptus ancophila*)	2	15	2	4	-	-
Potential Threatened Species Listing						
Koala Bells (*Artanema fimbriatum*)	7	65	2	55	-	-

3.4.2 Slender Marsdenia (*Marsdenia longiloba*)

Locations

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 69 GPS points were recorded, representing 203 stem-individuals and at least 22 different sub-populations ('sub-populations' defined as geographically separate records at least 100m apart). The great majority of recorded points were within the zone of direct and indirect impact.

Directly impacted

- A total of 50 gps points representing 161 individuals ('stem-individuals) are directly impacted. These represent at least 23 different sub-populations.

Indirectly impacted

- A total of 10 gps points representing 22 individuals are indirectly impacted.

In-situ within road reserve

- Nine points representing 20 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

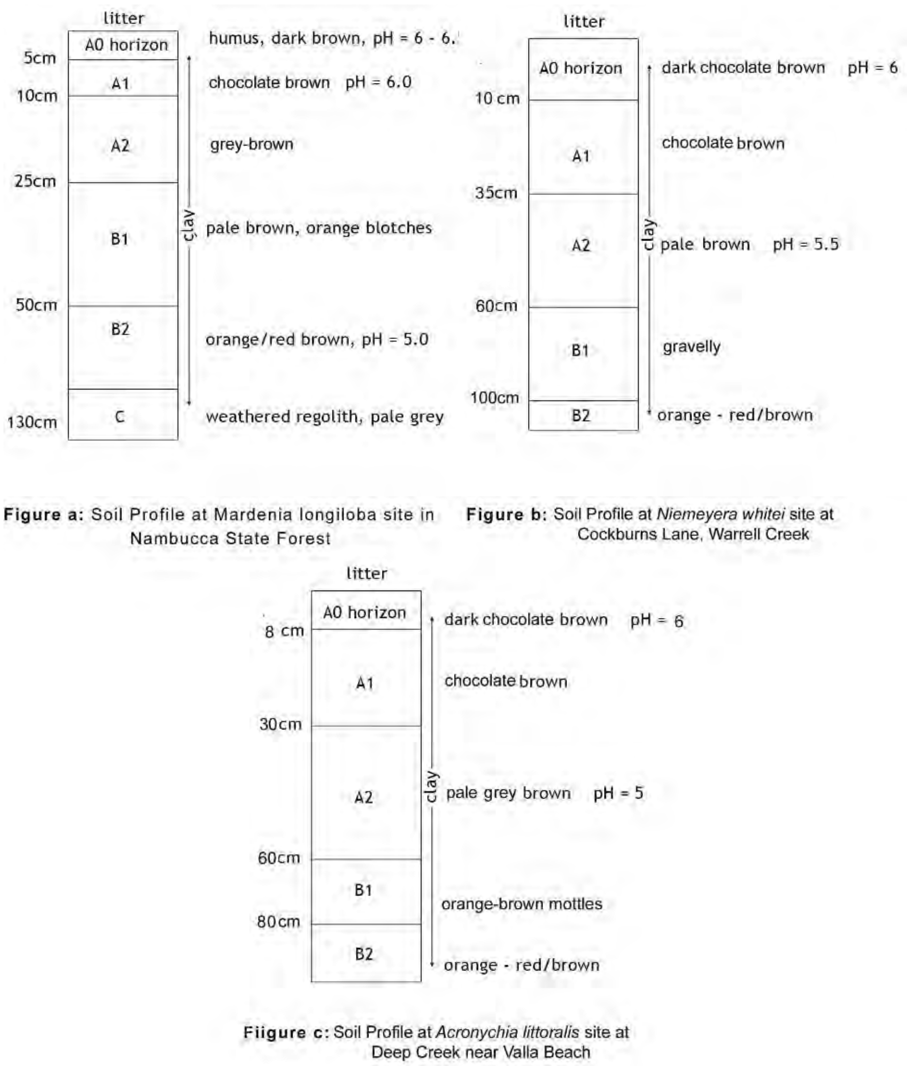

Figure 2: Representative soil profiles at threatened species sites on the WC2U corridor.

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 near the Nambucca Heads turn-off and Cockburns Lane south of Warrell Creek. A single small tree was recorded at Boggy Creek. A population of 17 trees and saplings, as well as seedlings was recorded at Cockburns Lane in a 150 meter long section of the road alignment. The trees were up to 10 metres in height and 30 cm in diameter.

Directly impacted

- Twelve trees at Cockburns Lane (Warrell Creek), north of the railway line near the Nambucca Heads turn-off and the single tree at Boggy Creek are directly impacted.

Indirectly impacted

- Three trees at Cockburns Lane (Warrell Creek) and one tree north of the railway line Nambucca Heads are indirectly impacted.

In-situ within road reserve

- Two trees at Cockburns Lane, Warrell Creek south would remain in-situ.

Habitat

At Boggy Creek, the single Rusty Plum occurs in lowland rainforest on the creek bank, surrounded by Flooded Gum wet sclerophyll forest. The tree north of the railway line is in wet sclerophyll forest on a south-facing hillslope. The population at Cockburns Lane is in similar wet sclerophyll/rainforest habitat on a south-facing hillslope and gully drainage line. The soil at this site is a red clay podzol formed on hornfels, a dark crystalline rock derived from the Nambucca Beds by secondary metamorphism produced by the Mt Yarrahappini intrusion (RTA 2010).

Plate 4: Rusty Plum sapling at Cockburns Lane, south of Warrell Creek. NW-50a

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 features. 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 purplish petioles and purplish tinge to the 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.

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 is an emergent, aquatic herb with upright, sword-shaped leaves that project 0.5 m to 1 m above water when mature. Maundia was recorded at Crouches Creek near Warrell Creek, and in a freshwater area south of Macksville. The Crouches Creek population occurs for 150 metres along the the creek, including beneath the footprint of new bridge. There is a break in the population under the existing highway bridge, which appears to be associated with a riffle section in the creek rather than possible shading by the bridge.

The second population was recorded at sites on the southern and northern sides of a large freshwater swamp approximately 2 km southeast of Macksville and 1 km south of new Nambucca River Bridge site. The whole of swamp could not be surveyed as some of the property owners were not allowing access, but it is likely that other patches of Maundia occur between the stands recorded on the southern and northern sides of the swamp (see Appendix 1, Figure 11). On the southern side of the swamp the population extended well outside the project boundary in November 2011.

<u>Directly impacted</u>

- Approximately 400 square meters of dense Maundia is directly impacted in the freshwater swamp south of the Nambucca River. (Note – additional plants may be directly impacted in the unsurveyed section between Maundia points 82 and 98 – see Appendix 1.)

<u>Indirectly impacted</u>

- The Crouches Creek population is indirectly impacted either side of the bridge footprint.
- An additional area of Maundia occurs in the indirect impact zone south of the Nambucca River.

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

- Part of the Crouches Creek population would remain in-situ within the road reserve on either side of the existing and new bridges.
- The edge of the second population is probably within the road reserve.

Habitat

The Crouches Creek site is located at the edge of the coastal floodplain where the creek consists 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 showed that Maundia is submerged during floods under fast flowing water. When inspected in October 2012, Maundia had died back over winter and was just starting to produce new green shoots projecting above the water. The plants may have died back due to frost, as other Maundia plants on the creek edge protected by trees had not died back. The second population on the Nambucca River floodplain occurs in treeless freshwater wetland and swamp sclerophyll forest.

The absence of Maundia underneath the existing highway bridge at Crouches Creek was initially thought to be due to shading from the bridge. However, further study showed that Maundia occurs under the shade of tree canopies as well as in full sun, usually in Broad-leaved Paperbark (*Melaleuca quinquenervia*) swamp forest. Absence of the species beneath the existing bridge may be due to faster flow conditions in the riffle section underneath the bridge, rather than lower sunlight exposure. As the new bridge is wider, shading may be greater, but some direct sunlight would reach stream vegetation in the morning and afternoon due to the N-S bridge orientation.

Plate 6: Leaves and flower spike of *Maudia triglochinoides* at Crouches Creek, November 2011.

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

Plate 8: Crouches 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: Crouches 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 just 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

- Not directly impacted.

Indirectly impacted

- The occurrence on the eastern side of road corridor on the project boundary is indirectly impacted.

In-situ within road reserve

- Nil (present outside the road reserve).

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 mutually exclusive patches in essentially the same habitat indicating they are competitors. *Ottochloa gracillima* may have replaced Floyds Grass on the edge of Warrell Creek between the western and eastern project boundary because of past disturbance.

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 two locations – (i) approximately 4km north of the Kalang River, where only one mature plant was found, and (ii) in Newry State Forest, where a substantial population was found in swamp forest next to the *Rhizanthella slateri* potential habitat area. The latter population was recorded in detail by EcoPro (2010). It 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. Impact analysis of the flora points recorded by EcoPro (2010) showed that the current design impacts directly on ten Spider Orchid points, each point representing one or more Spider Orchids plants on one *Melaleuca styphelioides* host tree.

<u>Directly impacted</u>

- Ten 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 gully wet sclerophyll forest and rainforest 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 and rainforest on the WC2U road corridor.

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

Locations

Only a selection of locations of this nationally rare species were recorded, as the species appeared to be relatively common within the study area where its preferred habitat is wet gullies and lower slopes. Four locations with a total of 19 trees were directly or indirectly impacted (Table 3).

One very large old-growth specimen of *E. ancophila* was recorded north of the Kalang River, which unfortunately is on the clearing footprint.

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.

Directly impacted

- Seven locations are directly impacted.

Indirectly impacted

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

In-situ within road reserve

- None.

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

Note 2 - *Artanema fimbriatum* was recorded in close proximity to the project boundary at Raleigh (Refer Appendix 1 Figure 2).

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 recommened 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 work 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).

Ground orchids can be overlooked in summer flora surveys as most are present above-ground only in autumn and winter (a few extending into spring) and they must be in flower for identification. Threatened ground orchid species potentially present in the WC2U road corridor that may have been overlooked due the timing of the survey include *Diuris sp. aff chrysantha* (Byron Bay Diuris), also recorded for Coffs Harbour, 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: A narrow band of rainforest on a gulley south of Warrell Creek, backed by tall Flooded Gum wet sclerophyll forest, 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 at different times. The first site (TA1) was planted with 27 vines in February 2007 and the second site with 64 vines one year later (Feb 2008).

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

In TA2, the 64 vines were planted to compare performance on the two soil types present at this site – a grey clay loam with quartz gravel in the northern half and brown clay loam in the southern half of site. A similar pattern of stem dieback and decline to TA1 was recorded, on both soil types. The decline was even more rapid, survival rate falling to 22% after only one year. After 4 years (2011) the survival rate of stem individuals was 26%, about the same as TA1.

However, stem-less plants were excavated in winter 2009 and the rhizome system was found to be alive and healthy, 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.

Monitoring of naturally growing local Slender Marsdenia populations in the road reserve showed no evidence of seasonal dormancy, rather new shoots could be found sporadically at any time of year, even in spring when the soil was relatively dry. In the transplants there was no obvious relationship between shoot dieback and planting depth, or site variables such as aspect or soil type. Instead, the stem dieback response appeared to be induced somehow by the planting treatment. Slow release fertilizer and hay mulch were used at TA1 and at TA2 extra effort was made to optimise the growth of Slender Marsdenia in light of its poor performance in TAI which had been planted a year earlier. Larger holes were dug and filled with humus enriched topsoil gathered from the adjacent forest. Slow release fertiliser was added to the soil, as in TA1. However, the additional site preparation appeared to increase the rate of shoot decline after introduction.

The following hypothesis has been proposed to explain the decline of Slender Marsdenia after planting out. Slender Marsdenia is a small vine which is able to compete and co-exist with much larger shrubs and trees by exploiting nutrients released in the topsoil by decomposition of organic matter. It can do this efficiently when nutrients are produced steadily at low concentration, as in humus enriched topsoil. When artificial fertiliser is added to the soil, it stimulates the roots of surrounding shrubs and trees to grown into the root space of Slender Marsdenia. A high intensity of interspecific root competition suppresses and eventually kills Slender Marsdenia by preventing significant stem growth and replenishment of rhizome storage. Slender Marsdenia may be unable to compete and absorb sufficient nutrient under conditions of high interspecific root density.

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. Not least was an 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 examine if trees could be transplanted successfully with less pruning. The stem-branch system was reduced by about one half instead of two thirds or more, as usually carried out. The result was greater transplant death which appeared to be caused by increased physiological stress and transplanting shock, given vascular system demand and impaired root system function.
- 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 may 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.

Translocation Benefits

The following conservation, scientific and educational benefits would flow 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 at two locations within the project boundary. The first location at Crouches Creek is located partly under the footprint of the new highway bridge in the creek and along its edge. As the bridge can be constructed without directly impacting on the water course, Maundia at this site will be protected and managed in-situ. A second population is located in freshwater swamp and adjoining swamp sclerophyll forest southeast of Macksville. Approximately 400 m² is currently known to be directly impacted. The total area may be greater, as ~1km section of swamp between Maundia points 82 and 92 has not been surveyed as the landowners have not permitted access (compulsory acquisition in progress).

During the 2011 survey, a large area of Maundia dominated freshwater swamp was observed directly east of the road alignment at Maundia point 82, which covered at least 1 hectare (see Appendix 1, Figure 11). Other stands of Maudia were recorded in swamp sclerophyll forest outside the road alignment on the northwest side (see Figure 11).

Recent surveys, particularly in the Lower Macleay district directly south of the Nambucca, have found Maundia to be more common than previously thought. Maundia was found to be relatively common and widespread on the Collombatti Creek floodplain and along creeks leading back into State Forest during a targeted survey conducted in 2012 for the F2E project (Benwell 2012). Maundia appears to be quite secure on the NSW Mid North Coast which is at the centre of its geographical distribution.

The prospects for successfully translocating Maundia are largely unknown and a matter of speculation. It is certainly 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. Information from one of the two people involved indicated that Maundia seed were difficult to germinate and plants failed to establish when planted out at the translocation site (Benwell 2012). Translocation of this species by transplanting carried out in a swamp environment would not be a straightforward exercise. Finding a suitable translocation site and managing it over the long-term is also likely to be problematic.

In light of the relatively secure status of *Maudia triglochinoides* on the NSW Mid North Coast and the potential difficulties inherent in translocation of this species, it is proposed to focus management on amelioration of impacts to Maudia growing in-situ in swamp habitat adjoining the new highway, a significant task in itself. During detailed design, emphasis would be placed on minimising impacts to in-situ individuals. Management measures are detailed in Section 4.5.4.

3.5.6 Floyds Grass (*Alexfloydia repens*)

Technical feasibility

At present there is no proposal to translocate this species for the WC2U project as the single recorded occurrence at Warrell Creek is on the project boundary and it should be possible to preserve and manage this species in-situ. Translocation would be carried out in the event that the detailed design found this was not possible.

Floyds Grass was successfully translocated for the Bonville Deviation project. Salvage translocation took place to a recipient site in Bongil Bongil National Park adjoinoing the road corridor.

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

3.5.7 Spider Orchid (*Dendrobium melaleucaphilum*)

Technical feasibility

There appear to have been no previous attempts to translocate this species, although epiphytic orchids are often taken from the wild and established in cultivation. Tranplanting of epiphytic orchid plants would be subject to the same requirement as any other species, such as a receival site with matching habitat, carefully conducted transplanting and follow-up plant care. 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 four threatened species and two rare species directly impacted by the WC2U project is feasible and justified in terms of technical practicality, conservation benefit and improvements to conservation science and translocation techniques. These species are Slender Marsdenia, Woolls' Tylophora, Rusty Plum and Spider Orchid (threatened), and Goodenia fordiana and Koala Bells (rare).

Three of the four 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 <u>threatened species or their habitat identified in the Environmental Assessment to be impacted by the project</u> 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

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

- Wet sclerophyll gully on Nambucca Beds geology

- Floodplain rainforest/Swamp Oak/Swamp Sclerophyll remnant mosaic

- Permanent freshwater stream or swamp

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 on Nambucca Beds geology
Rusty Plum (*Niemeyera whitei*)	Wet sclerophyll gully on Nambucca Beds geology
Wooll's Tylophora (*Tylophora woollsii*)	Wet sclerophyll gully on Nambucca Beds geology
Spider Orchid (*Dendrobium melaleucaphilum*)	Floodplain swamp sclerophyll forest with *Melaleuca styphelioides*
Floyds Grass (*Alexfloydia repens*)	Floodplain riparian Swamp Oak forest
Maundia (*Maundia triglochinoides*)	Permanent freshwater stream or swamp

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, accoriding to the vegetation mapping in the EA, and multiple this 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.
(Note – there is currently no proposal to translocate Floyds Grass which is indirectly impacted by the WC2U upgrade, however, the species has been included in the Translocation Plan in the event the detailed design considers that translocation is necessary.)

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.

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 rainforest habitat and establishing functional rainforest 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 Cockburns 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 Cockburns 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 rainforest 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

*Habita*t: *Dendrobium melaleucaphilum* is an epiphytic orchid, which grows in swamp 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 and rainforest 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 Crouches 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 supporting rainforest
	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 for threatened and rare species impacted where the road corridor crosses State Forest, as long the sites selected do 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 four threatened species and two rare species (Table 6) with the aim of establishing populations that are self-sustaining over the long-term. This will require propagation and introduction of additional individuals to establish minimum viable population (MVP) sizes and adequate levels of genetic diversity. Also integral to the translocation project would be restoration of good quality habitat to the receival sites, 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 six species to be translocated, one is a tree, two are small vines, one an epiphytic orchid and two 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). The tree species (Rusty Plum) would 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.

Translocation work with 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 salvage transplanting. The benefits of transplanting established individuals of threatened species have been 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 there 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.)

Species	Transplanted*# Individuals	MVP Number	Type of propagation	Seeding time
Threatened Species				
Slender Marsdenia (Marsdenia longiloba)	161	300	rhizome cuttings	Winter
Rusty Plum (Niemeyera whitei)	17	150	seed	November
Floyds Grass (Alexfloydia repens)	$0m^2$	$0m^2$		
Wooll's Tylophora (Tylophora woollsii)	9	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

* additional individuals recorded during the service utilities survey (Ecos Environmental 2012) have been included in the translocation.
# 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*)
Given the detailed data recorded on the local distribution of Slender Marsdenia within the WC2U road corridor and the number of individuals impacted by the project, it is recommended that population genetic research form part of an offset package for Slender Marsdenia. The proposed genetic research would be carried out as part of the offset package and in conjunction with the translocation plan for this species. The aim of genetic research would be to identify patterns of genetic variation within and between sub-populations of Slender Marsdenia and to use this information to better understand the 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 rarely if ever forms 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 WC2U 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.

Research would be directed at answering the following questions: -

- Given that Slender Marsdenia rarely if ever produces seed (apparently), how much genetic variation exists in this species within and between sub-populations?

- 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 the species disperse to two adjacent gullies when seed production is so rare?

- What do patterns of genetic variation tell us about the frequency of pollination and direction of pollen flow in Slender Marsdenia across the landscape?

- What does the spatial distribution of genetic variability 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?

Pot cultivation of Slender Marsdenia transplanted from the wild would also be undertaken with the aim of making plants flower and set seed under enhanced growth conditions (as observed during the Bonville translocation project). Breeding system processes could then be examined in flowers, and seed viability checked and related back to the results of genetic analysis.

Carrying on from the research conducted for the Bonville translocation project, the translocation would also be designed to examine the survival response of translocated plants to different methods of site preparation 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*)

A total of 161 individuals ('stem-individuals) of Slender Marsdenia recorded at 50 gps points are directly impacted by the WC2U upgrade (Table 13). The points represent about 20 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. Occurrences are mapped in Appendices 1 and 3, and tabulated in Appendix 2.

Currently it is proposed to translocate Slender Marsdenia only on the northern half of the WC2U upgrade using a new approach (ie direct transplanting and no fertiliser addition) predicted to improve establishment success. If there is no marked improvement in translocation success from this method no further translocation of Slender Marsdenia would be attempted for the southern half of the project. (Note – the WC2U project is to be constructed in two stages, the southern half probably two years later).

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.'

ID	Species	Easting	Northing	No.	Size
ml-1	Marsdenia longiloba	497485.537248	6610602.704080	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
ml-14	Marsdenia longiloba	500386.537955	6620686.516890	2	Small
ml-14a	Marsdenia longiloba	500409.842004	6620668.210490	2	Small
ml-14b	Marsdenia longiloba	500435.641790	6620740.522920	1	Small
ml-15	Marsdenia longiloba	500426.432922	6618920.638680	1	3.5m
ml-16	Marsdenia longiloba	500442.890991	6618806.680550	1	0.4m
ml-17	Marsdenia longiloba	497791.779559	6625851.107730	1	Small
ml-18	Marsdenia longiloba	497816.564585	6625875.307700	1	0.1m
ml-19	Marsdenia longiloba	497826.637279	6625891.378130	4	0.2m
ml-2	Marsdenia longiloba	497468.445578	6610614.520770	1	Small
ml-20	Marsdenia longiloba	497827.754605	6625902.460010	1	0.2m
ml-21	Marsdenia longiloba	497835.590897	6625905.231990	5	0.2m
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-28	Marsdenia longiloba	498002.652999	6626288.504580	1	Small
ml-3	Marsdenia longiloba	497477.228559	6610618.955580	15	Small
ml-33	Marsdenia longiloba	498121.454487	6626489.842450	1	0.3m
ml-34	Marsdenia longiloba	498198.977611	6626789.798790	1	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-44	Marsdenia longiloba	495748.069111	6607748.011070	2	0.3m
ml-45	Marsdenia longiloba	497602.692015	6613080.268090	1	Small
ml-46	Marsdenia longiloba	497598.702108	6613063.459720	40	to 5m
ml-48	Marsdenia longiloba	497602.055454	6613069.370790	10	to 1.5m
ml-49	Marsdenia longiloba	497496.039690	6612142.718430	1	0.15m
ml-5	Marsdenia longiloba	496683.949976	6609585.722830	1	Small
ml-62	Marsdenia longiloba	489566.954445	6594529.180790	10	0.1m
ml-7	Marsdenia longiloba	496637.195041	6609472.118760	6	0.6m
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-90	Marsdenia longiloba	494181	6604547	2	2.5m
ml-91	Marsdenia longiloba	494198	6604550	1	0.8m
ml-92	Marsdenia longiloba	494347	6604098	1	1.1m
ml-93	Marsdenia longiloba	494336	6604191	1	1.8m
uml-5	Marsdenia longiloba	497779.939952	6625872.714539	1	1.5m
uml-6	Marsdenia longiloba	497772.427480	6625850.919071	1	1m

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 dislodge during transplanting (they break up easily) to be used to

- 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 two locations on the WC2U corridor - Boggy Creek near Valla and Cockburns Lane south of Warrell Creek. A single small tree at Boggy Creek and 13 trees and saplings at Cockburns 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 Appendices 1 and 3, 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-50a	Niemeyera whitei	489567.922961	6594517.176060	1	2m
nw-50b	Niemeyera whitei	489598.600127	6594456.623420	1	8m
nw-53	Niemeyera whitei	489592.527720	6594469.546710	2	0.5m
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-60	Niemeyera whitei	489577.387074	6594460.296860	1	0.5m
nw-61	Niemeyera whitei	489581.165661	6594510.354950	1	6m
nw-64	Niemeyera whitei	489636.959937	6594531.465170	1	8m
nw-70	Niemeyera whitei	489548.594230	6594550.773100	1	2m
nw-50	Niemeyera whitei	497460.267315	6612110.387950	1	2.5m
unw-9	Niemeyera whitei	497406.818180	6611193.165316	1	7m

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 was recorded at two locations:- Crouches Creek near Warrell Creek and the Nambucca River floodplain southeast of Macksville. No translocation of Maundia is proposed for the WC2U project. Both populations would be managed with the aim of minimising impacts to in-situ populations adjoining the road corridor.

Table 16a: GPS points marking the extent of the Maundia stand at Crouches Creek.

ID	Species	Easting	Northing	No.
mt-74	Maundia triglochinoides	491716.604039	6598059.237540	Mat
mt-75	Maundia triglochinoides	491659.329340	6598066.765920	Mat
mt-76	Maundia triglochinoides	491604.147159	6598050.284420	Mat
mt-77	Maundia triglochinoides	491524.399223	6598033.044450	Mat

Table 16b: GPS points marking the approximate extent of the Maundia population on the Nambucca floodplain to be transplanted.

ID	Species	Easting	Northing	No.
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.

In addition, 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 'potential impact' (ie adjoining construction) reference plots to be monitored for a minimum of five years.

4.5.5 Floyds Grass (*Alexfloydia repens*)

Floyds Grass was recorded at one location on the northern bank of Warrell Creek on the eastern and western sides of the project boundary (see Appendix 1). No plants are directly impacted by the current design, although the patch on the eastern side of the project boundary would be indirectly impacted.

At this stage Floyds Grass will probably not require translocation as it occurs on the project boundary outside the construction zone, however, it is possible that the detailed road design will find it is impractical to preserve this patch in-situ. Indirect impacts arising from the close proximity of the construction zone (e.g. run-off, weed invasion, soil eutrophication) may also be a problem, in which case the spedcies would be be translocated to adjoining land fronting onto Warrell Creek owned my RMS.

Table 17: GPS points marking the extent of the Floyds Grass stand at Crouches Creek on the eastern project boundary, which is indirectly impacted.

ID	Species	Easting	Northing	No.
ar-78	Alexfloydia repens	492334.706995	6599021.622260	mat
ar-79	Alexfloydia repens	492344.763916	6599013.133180	mat

If necessary, 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 within the project boundary - 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 flora points indirectly impacted, containing 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 large area of potential habitat for this species is present on the WC2U corridor, but appreciable populations occur at only one location in Newry State Forest, indicating how severely depleted this species has become. Population enhancement would undertaken as part of the translocation process to increase populations and compensate for loss of potential habitat due to highway construction.

Table 18: *Dendrobium melaleucaphilum* proposed for translocation recorded during the current survey.

ID	Species	Easting	Northing	No.	Size
dm-34a	*Dendrobium melaleucaphilum*	498827.816416	6627524.966920	1	mature
	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	

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) and translocation of directly impacted individuals and indirectly impacted individuals as determined by the Project Ecologist.

- The individuals to be translocated will be directly transplanted to young *Melaleuca styphelioides* trees (the favoured host) in adjoining swamp forest. The plants will be transplanted with roots in bark and fixed to the host tree with coarse, mesh netting.

- Follow-up watering of plants will be necessary to assist establishment just as for species transplanted to soil.

- Seed collected will be collected from salvaged individual if available, or from other plants in the local area, and propagated to produce individuals for population enhancement.

- Once propagated plants are grown to a suitable size and thoroughly hardened-off, the plants will be introduced to a field site(s) containing suitable habitat.

- Plants will be inoculated with fungal mycorrhize using bark and soil organic matter collected from a local *Dendrobium melaleucaphilum* site, at least 6 months before introduction.

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 on the maps 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 area and slashed to control tall grass and weeds that 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.

4.7.7 Monitoring Program

Objective

The objective of monitoring would be to record the results of the translocation project, including information that can be used to evaluate its success and identify causes of survival or mortality. Monitoring of the translocations would be conducted during construction and after construction for a minimum of 5 years, a total of approximately 8 years.

ID code, tagging and mapping

After transplanting, individuals would be tagged with the ID code allocated during the targeted survey. This would be written on flagging tape and attached to the plant at the receival site. A map of the receival site/translocation area will be prepared showing the position of all translocated individuals and their identification number. The map would be used to assist in relocating individuals during monitoring. It would also enable individuals to be re-located if tags are dislodged or interfered with. MVP individuals would also be tagged, numbered and recorded when introduced to the receival site.

Monitoring data

The following data would 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
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 (including presence / absence of Myrtle Rust)
Recruitment – evidence of recruitment
Evidence of any other damage or disturbance
Site conditions

Plant community canopy height and cover
Weed abundance and composition
Climatic events (eg. drought, unusually cold winter temperatures etc)
Maintenance carried out – when and what kind of maintenance carried out at the site since the last monitoring
Any other ecological impacts

Monitoring frequency

Monitoring of the translocations would be conducted as follows: every 3 months for the first year; every 6 months in the second year and once a year thereafter. Monitoring would be conducted during construction and after construction for a minimum of 5 years, a total of approximately 8 years.

Translocation monitoring report

An annual translocation monitoring report would be prepared at the end of each year of the five year monitoring program (starting from the completion of translocation). The report would include the following information: -

- Background and description of the translocation project;
- A description of translocation methods;
- A description of monitoring methods;
- An analysis of monitoring data on a species by species basis;
- An assessment of causes of plant mortality;
- An accurate 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 Translocation Plan at the start of the project;
- An evaluation of the methods and cost-effectiveness of the translocation project; and
- Work plan for monitoring, maintenance and management of the translocation site; over the next twelve months.

4.7.8 Evaluation

Evaluation is the process of examining and analysing the progress and outcomes of the translocation project, including information gathered during the monitoring program, 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).

The following performance criteria derived from ANPC 2004 and adapted by EEPL are proposed as a basis for evaluating the success of this translocation project: -

Short Term Criteria (to 5 years)

The Translocation of each species:

- at least 60% of the transplants and enhancement introductions are surviving after the first year and 50% after five years;

- flowering and seed production occurs in transplanted individuals (where mature individuals are transplanted);
- several individuals from the local population are established; and
- the translocated populations display similar growth and vigour to naturally occurring populations.

Habitat and threat management:
- good quality habitat estored in and surrounding the receival site;
- maintenance carried out each year as described in the Translocation Plan; and
- threatening processes including weed invasion controlled or eradicated.

Propagation of population enhancement individuals:
- propagation carried out from the local population;
- plants labelled with provenance number in the nursery and throughout the propagation and introduction process;
- the required number of plants propagated; and
- techniques for successful propagation of each species are demonstrated.

Long Term Criteria (decades)

- population enhancement individuals survive to reproductive maturity;
- new seedlings or vegetative offspring are established;
- the number of individuals in the population is sustained or increased by natural recruitment;
- adequate levels of genetic fitness are maintained through generations;
- reproduction, including the production of flowers and fruit, and seed viability is consistent with levels in naturally occurring plants;
- natural habitat conditions are restored or maintained at the receival site.

These criteria are consistent with DECC (2007 p.22) which recommends evaluation of success in terms of the following criteria:-

“For plant translocations, in accordance with the ANPC Guidelines for the Translocation of Threatened Plants in Australia (2004). the criteria for success of translocations used in all planning and management documents should be:

- an adequate number of transplants have survived to enable foundation of a viable population, with representatives from the range of genetic individuals planted;
- translocated individuals are reproducing, including the production of flowers and fruit at levels consistent with naturally occurring plants, and seed viability is consistent with that in naturally occurring plants;
- new seedlings are established;
- the number of individuals within the population is being sustained or increased by natural recruitment;
- adequate levels of biodiversity, particularly genetic variation are maintained through generations.”

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 4 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 during the targeted flora survey within 10m of the construction footprint (indirect impact zone) that would require protective measures during clearing. 'Distance' is the distance of the plant to the edge of clearing. (Note - the number of indirectly impacted plants may change on the detailed design.)

ID	Species	Easting	Northing	No.	Ht	Distance
ar-78	Alexfloydia repens	492334.706995	6599021.622260	mat		3.34116
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
ml-68	Marsdenia longiloba	489663.695772	6594588.748820	1	1.5m	5.03628
ml-71	Marsdenia longiloba	489557.487157	6594589.199920	1	2m	6.49403
mt-75	Maundia triglochinoides	491659.329340	6598066.765920	mat		0.36295

nw-65	Niemeyera whitei	489638.063190	6594544.949530	1	5m	4.14811
nw-66	Niemeyera whitei	489647.610383	6594566.753670	1	4m	7.21401
nw-73	Niemeyera whitei	489672.663574	6594549.969920	1	5m	4.42401

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 rainforest 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 would be applied to roadside threatened species locations. Where threatened plant species are present on the edge of construction, the Landscaping/ Revegetation Plan would revegetate batters and bare areas with ecologically compatible, native species to weed growth, restore natural vegetation and provide edge protection for threatened species.

The Landscaping Plan/Vegetation Management Plan/CEMP for the WC2U project would contain specific revegetation measure for each roadside threatened flora location to ensure these sites are adequately buffered with fast growing native species and weeds do not become dominant. The Plans would contain an implementation schedule with actions and targets for each threatened species location, rather than treating threatened species sites as part of the general highway landscaping/ revegetation.

Generally weed invasion would be minimised by the following measures:-

- Weeds often invade roadside vegetation in salvaged topsoil used to top-dress batters and bare areas. The WC2U 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 would be used to top-dress batters and bare areas.

- Soil free of weed seed would be particularly useful in areas to be planted with ground covers or other low landscape plantings that tend to be overrun with weeds in a short time, even with the use of mulches.

- Rapid revegetation of bare areas with hardy native species to produce a dense ground cover that excludes weeds; either dense shrubbery and/or ground layer plants such as native grasses and Lomandra.

- A plant ecologist would be requested to identify areas of forest within the clearing footprint suitable for salvage of weed free topsoil for use in revegetation and landscapring, and to advise on appropriate methods of storage and use.

5.3 Monitoring of In-situ Roadside Specimens

Monitoring would be carried out to determine the effectiveness of protective measures and provide feedback to management on any need for corrective measures if required.

The following data are to be recorded for each in-situ specimen: -
Identification
Genus
Species and subspecies
Identifier – unique plant number
Location –location; easting, northing & description

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 (including presence / absence of Myrtle Rust)
Recruitment
Evidence of any other damage or disturbance

Site conditions
Plant community canopy height and cover
Weed abundance and composition
Climatic events (eg. drought, unusually cold winter temperatures etc)
Maintenance carried out – when and what kind of maintenance carried out at the site since the last monitoring
Any other ecological impacts

Recommended timing for monitoring is as follows: initially after installing protective barriers, 6-monthly intervals for two years and once a year thereafter. In addition, regular inspections would be carried out during clearing and formation of the road (without recording monitoring data).

A summary of the roadside threatened plant monitoring would be prepared and included in the annual translocation monitoring report. This report will summarise the monitoring data (described above), assess the effectiveness of protective measures and recommend further actions if required.

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 rainforest habitat and establishing functional rainforest 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).

Note - the road design shown on these plans is from the (modified) Concept Design. There may be further changes to the design when the detailed design is prepared by the contractor (see Section 6).

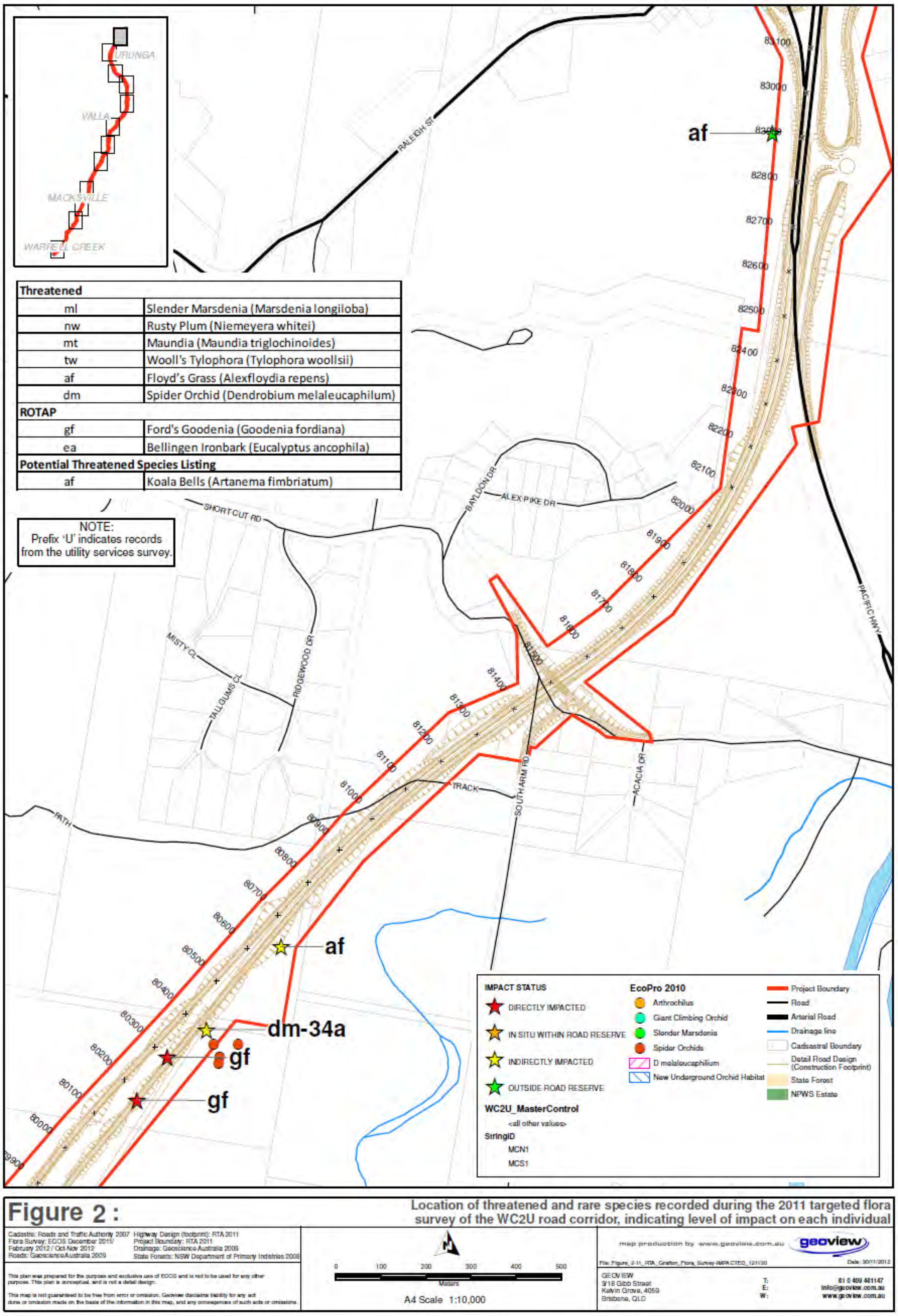

Figure 2 : Location of threatened and rare species recorded during the 2011 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

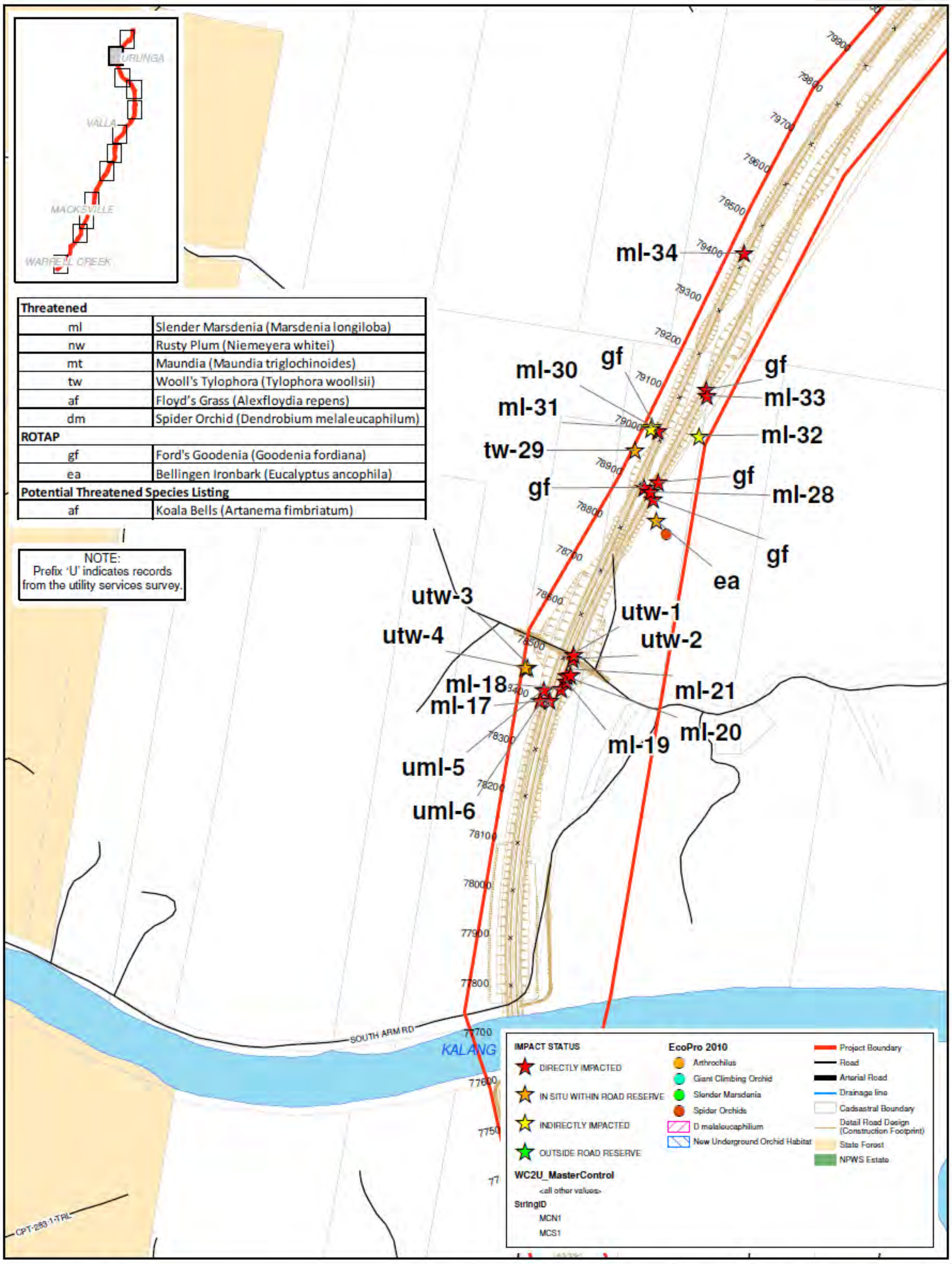

Figure 3 : Location of threatened and rare species recorded during the 2011 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

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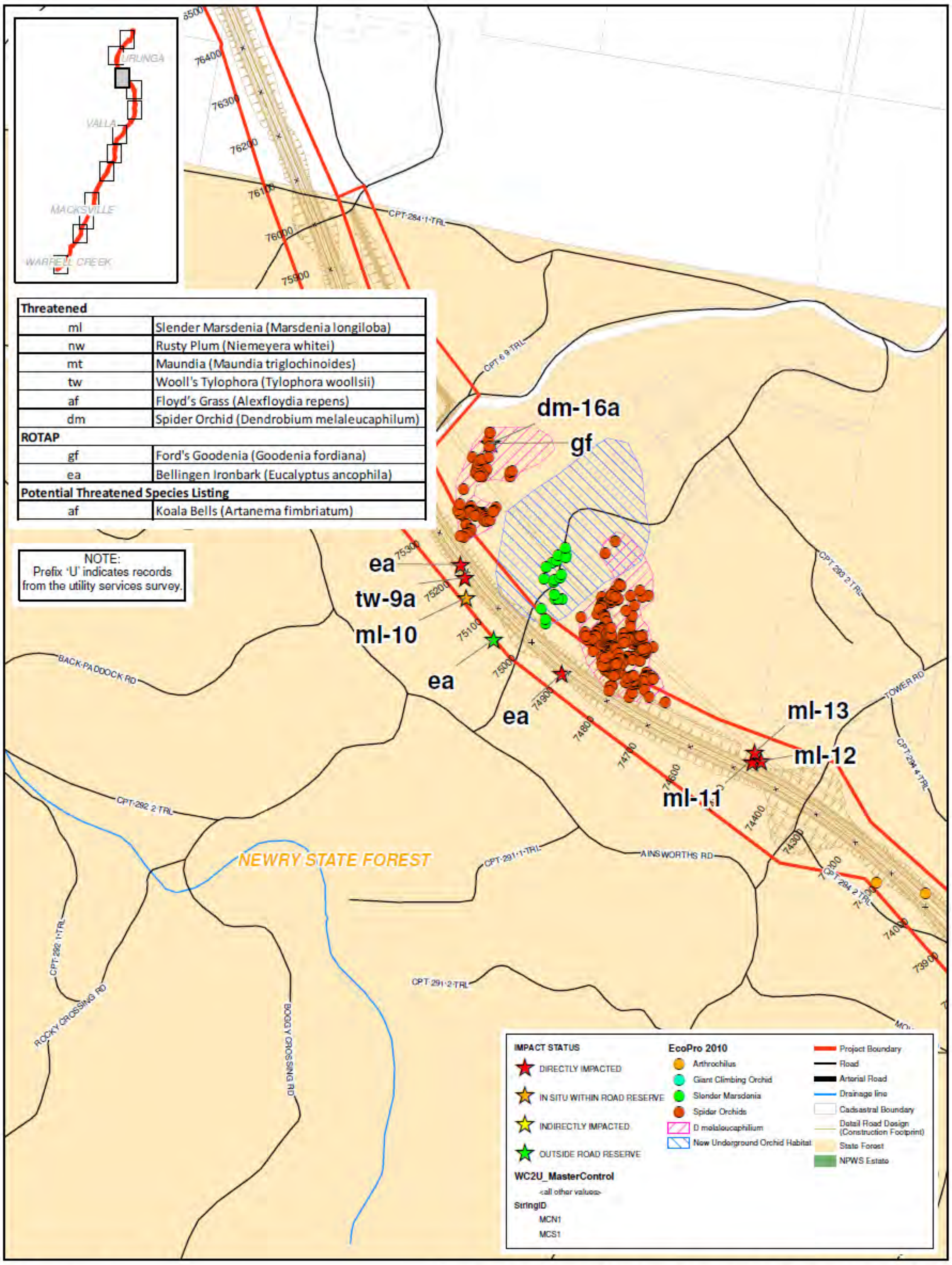

Figure 4 : Location of threatened and rare species recorded during the 2011 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

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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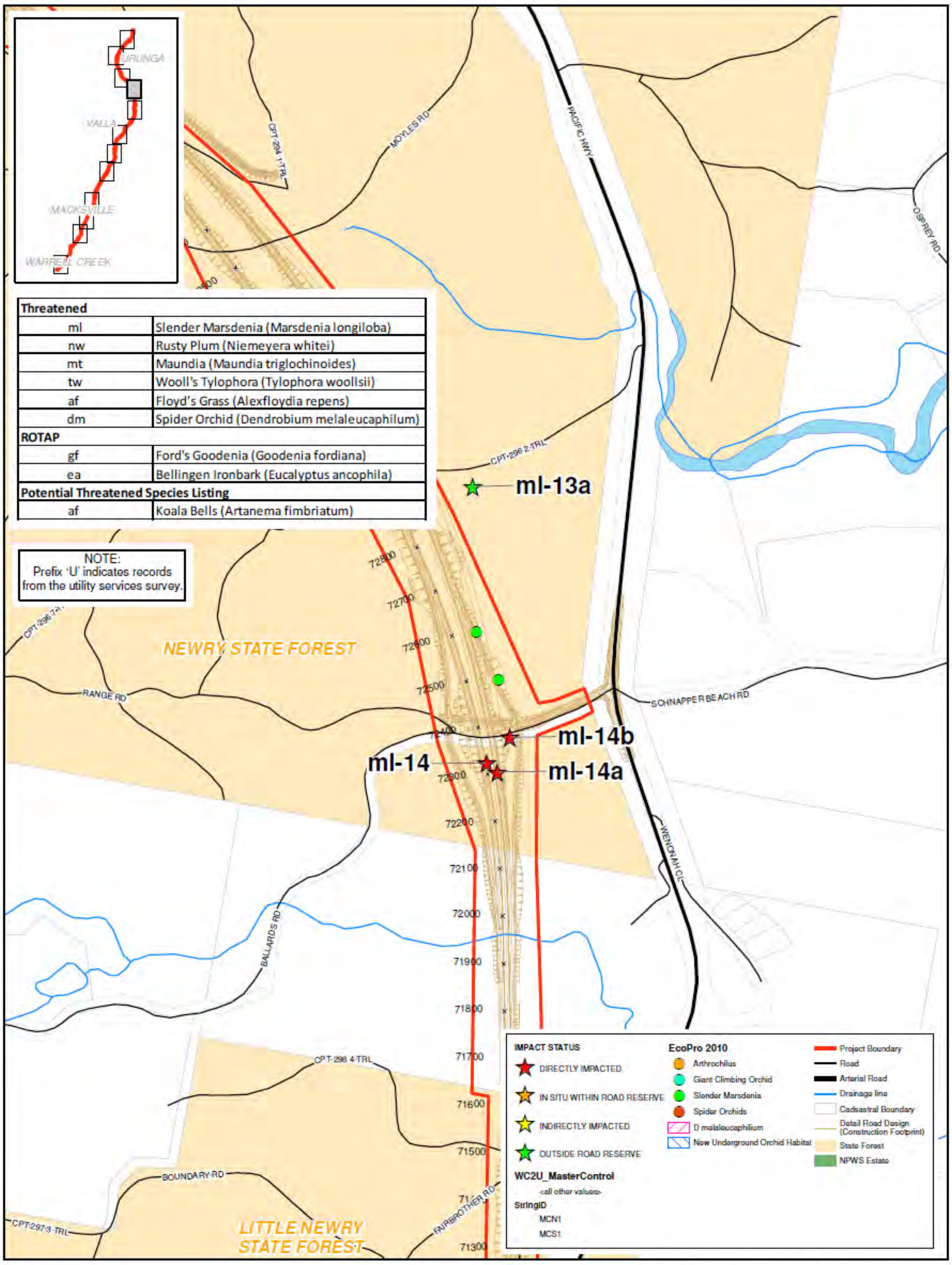

Figure 5 : Location of threatened and rare species recorded during the 2011 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

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 Industries 2008

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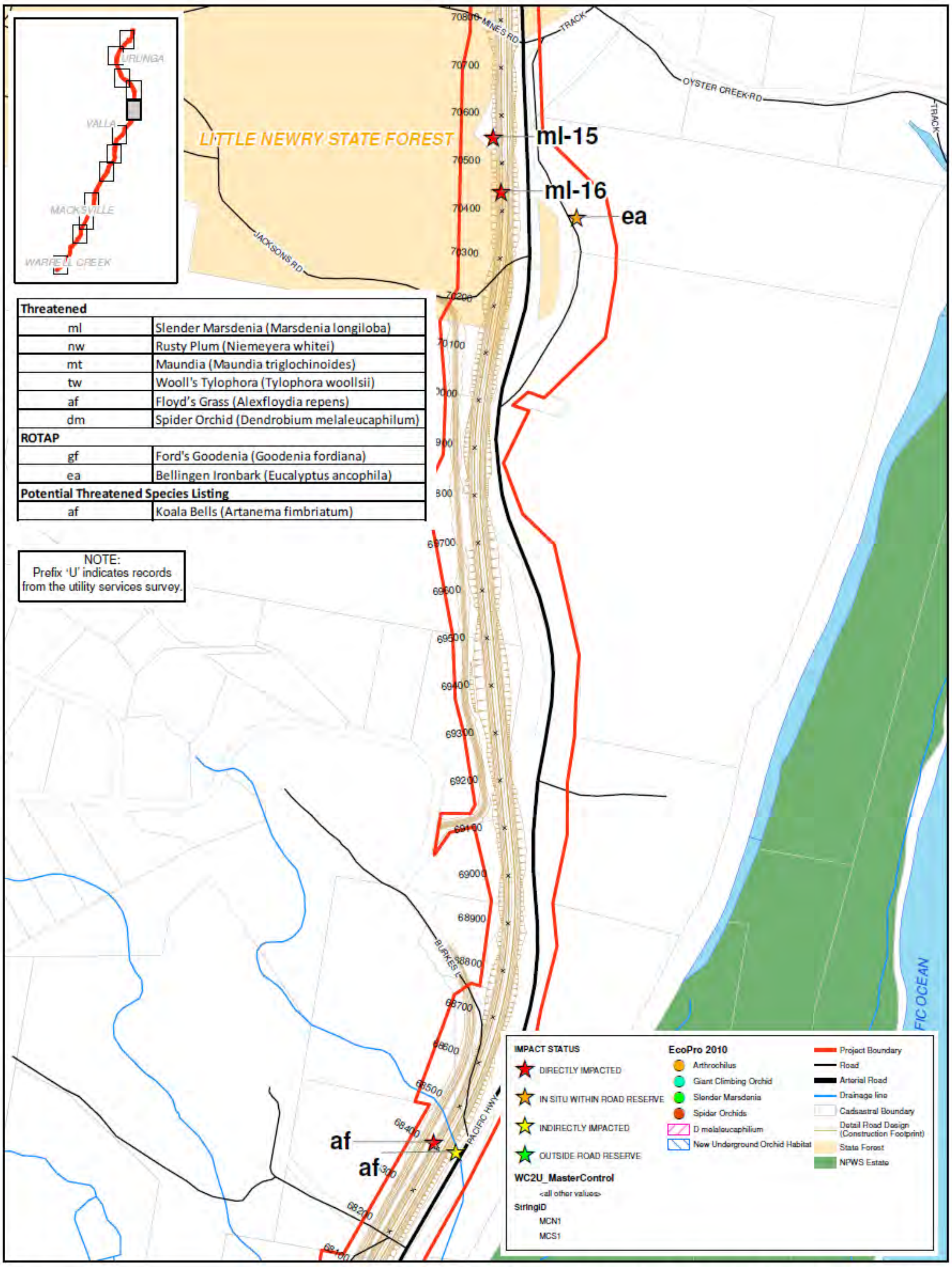

Figure 6 : Location of threatened and rare species recorded during the 2011 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

Cadastre: Roads and Traffic Authority 2007 Highway Design (footprint): RTA 2011
Flora Survey: ECOS December 2011/ February 2012 / Oct-Nov 2012 Project Boundary: RTA 2011
Roads: GeoscienceAustralia 2009 Drainage: Geoscience Australia 2009
State Forests: NSW Department of Primary Industries 2008

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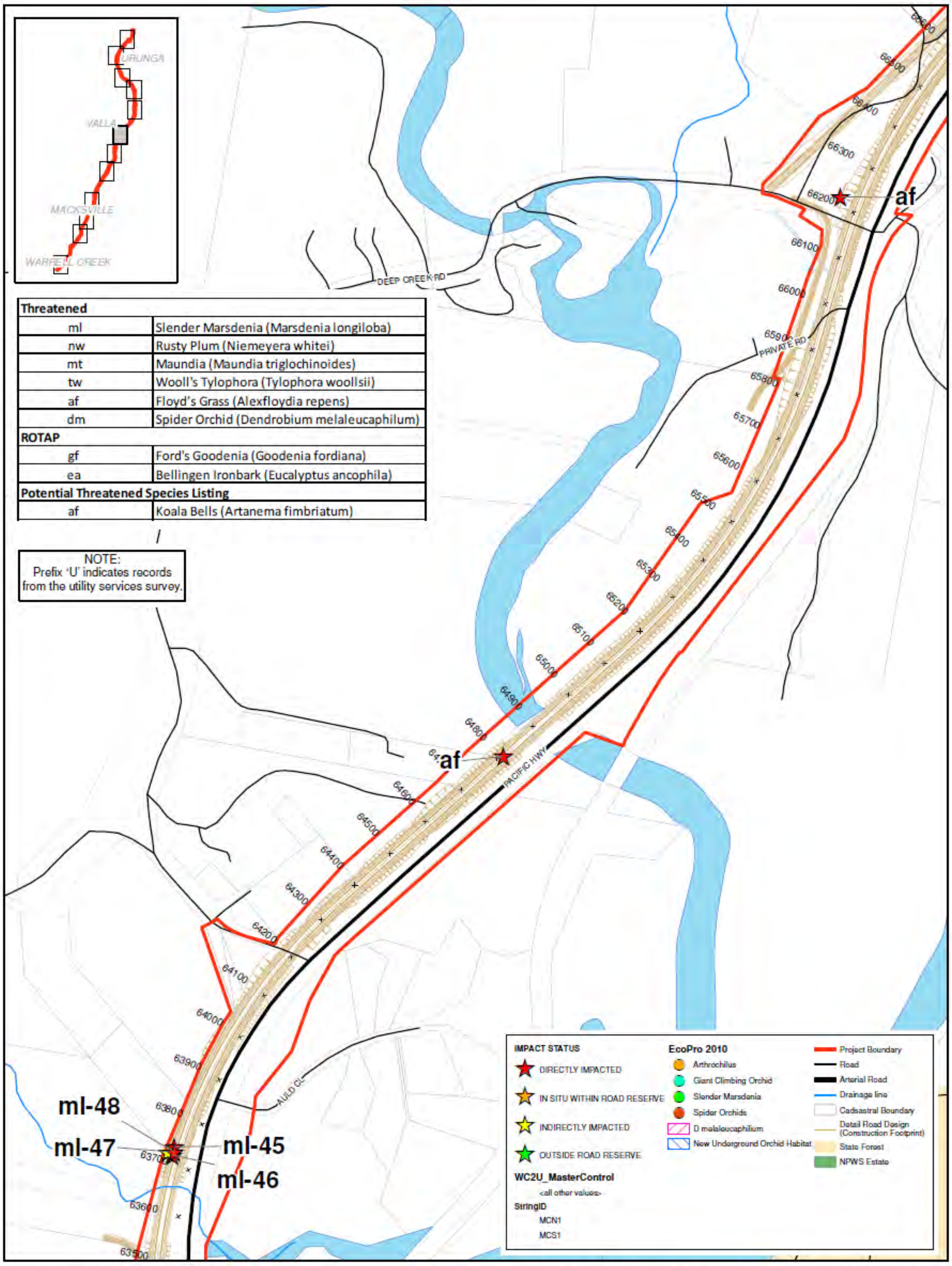

Figure 7 : Location of threatened and rare species recorded during the 2011 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

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 Indstries 2008

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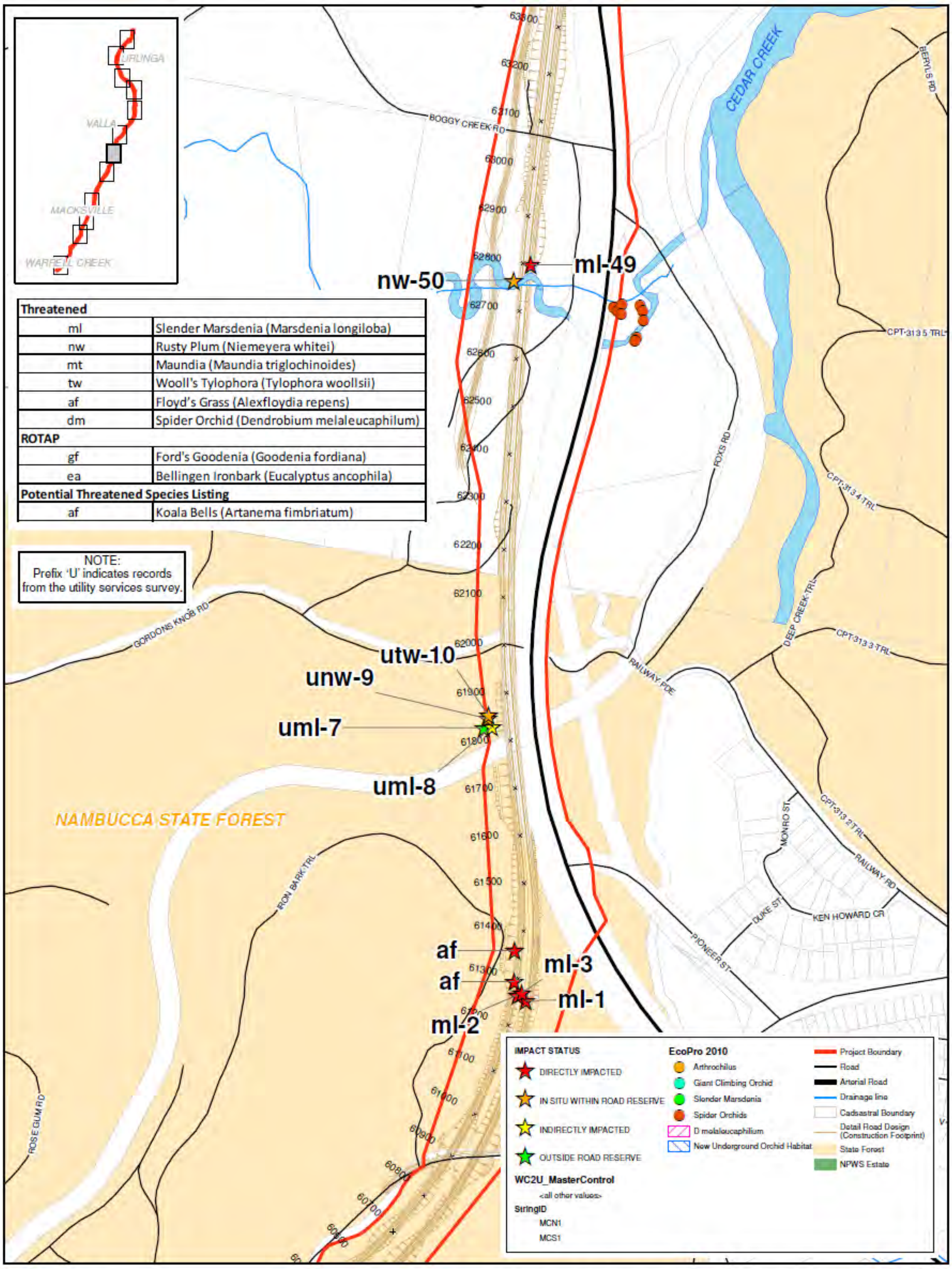

Figure 8 : Location of threatened and rare species recorded during the 2011 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

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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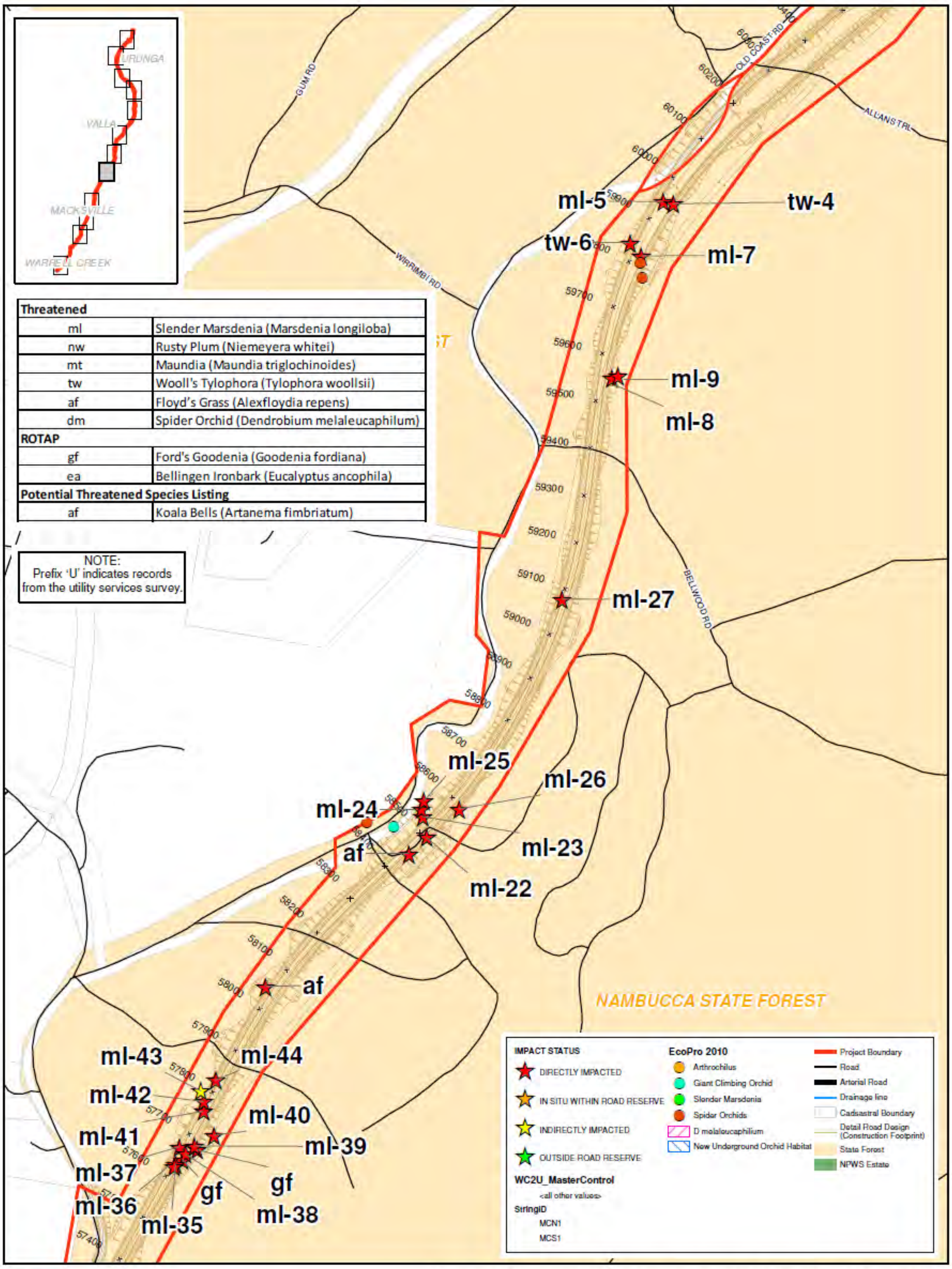

Figure 9 : Location of threatened and rare species recorded during the 2011 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

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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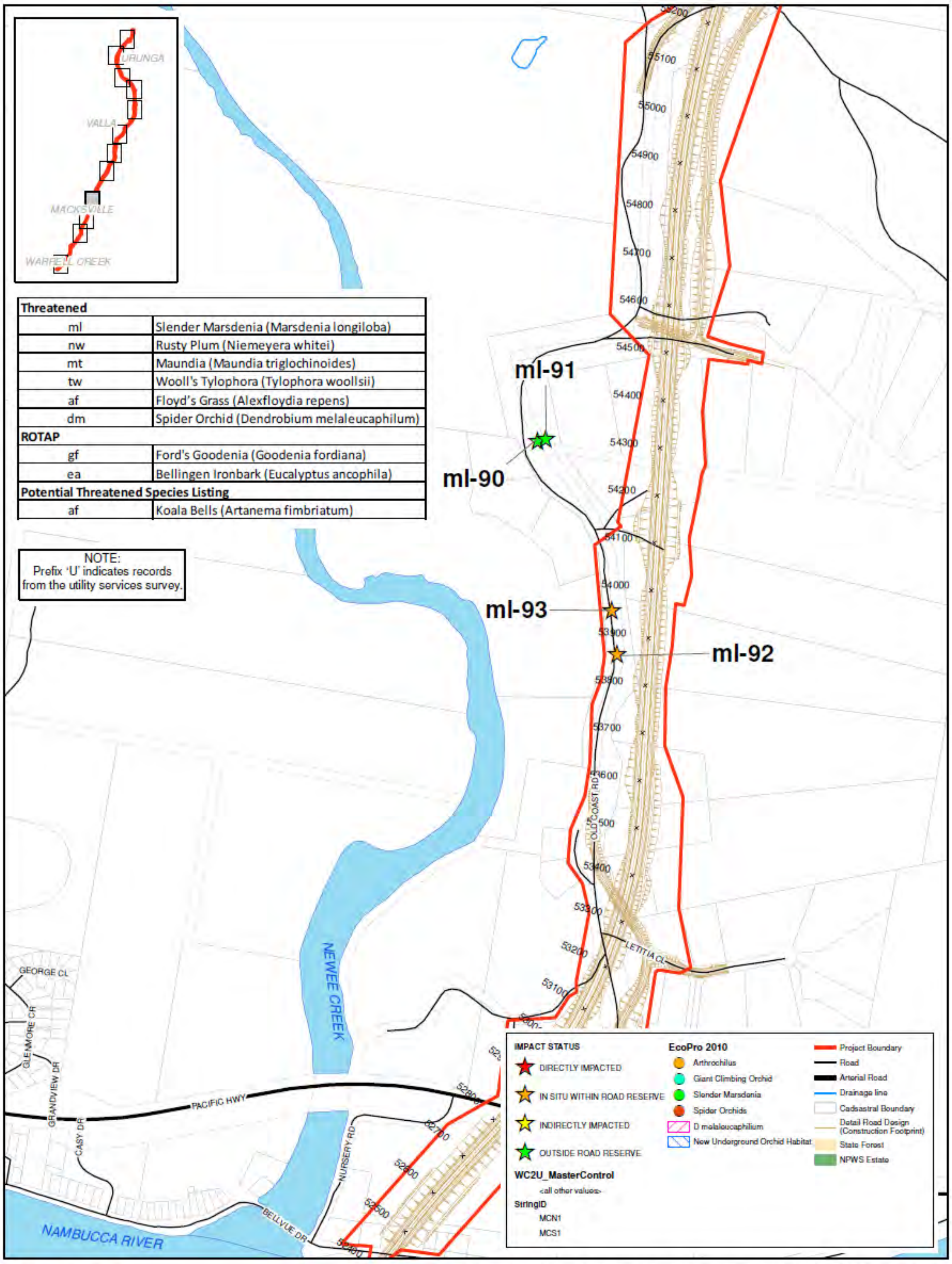

Figure 10: Location of threatened and rare species recorded during the 2011 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

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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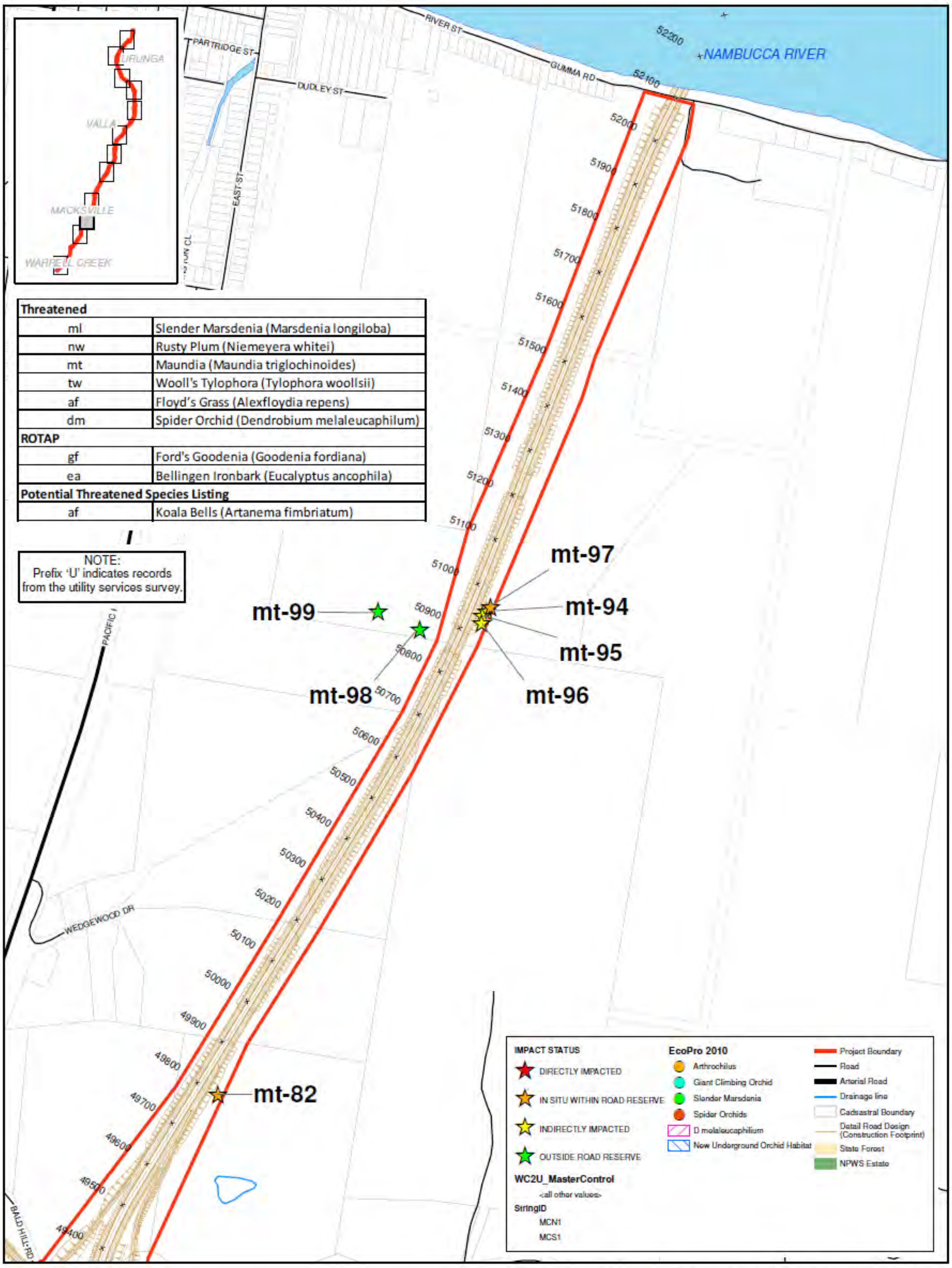

Figure 11: Location of threatened and rare species recorded during the 2011 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

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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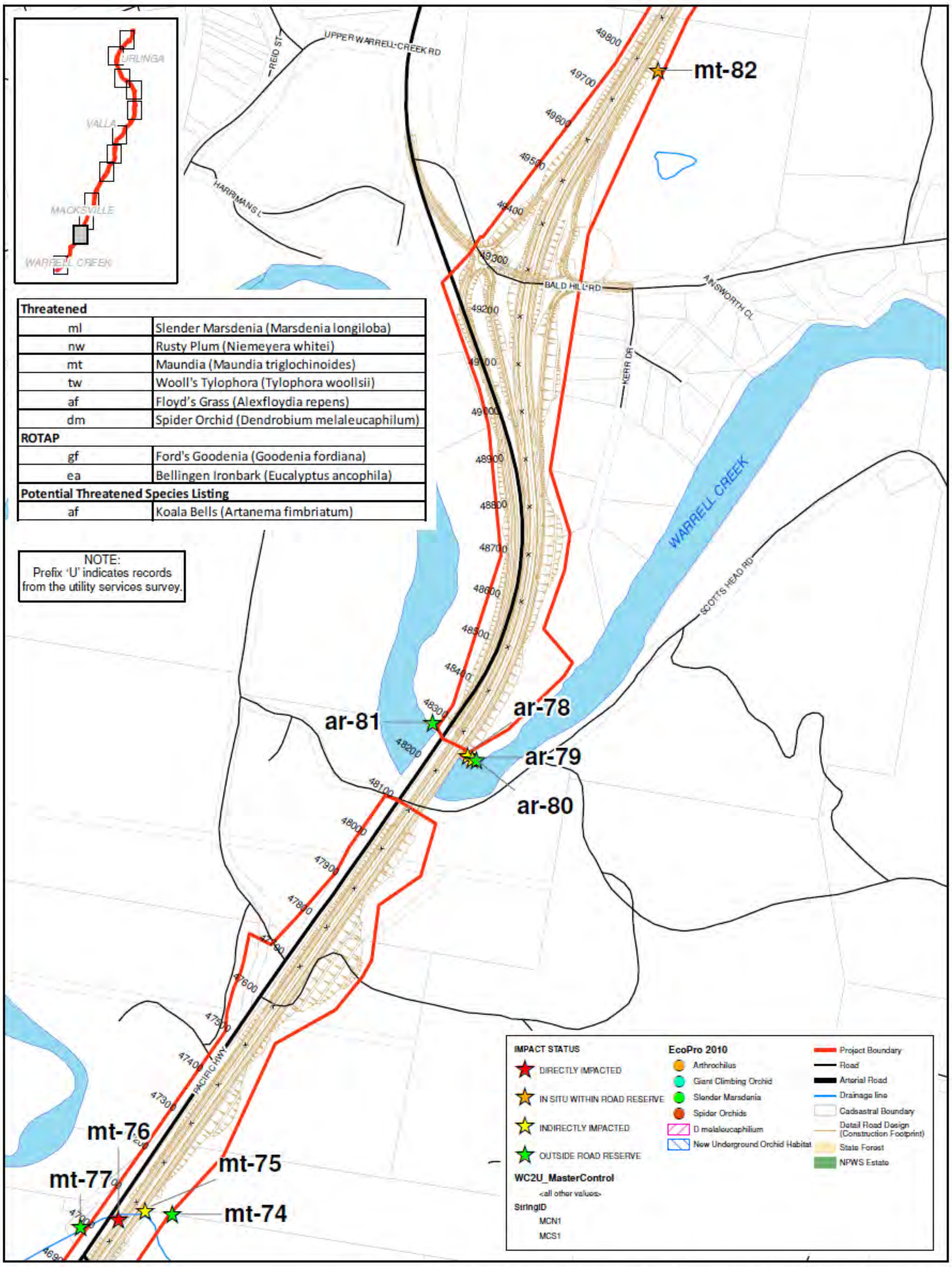

Figure 12: Location of threatened and rare species recorded during the 2011 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

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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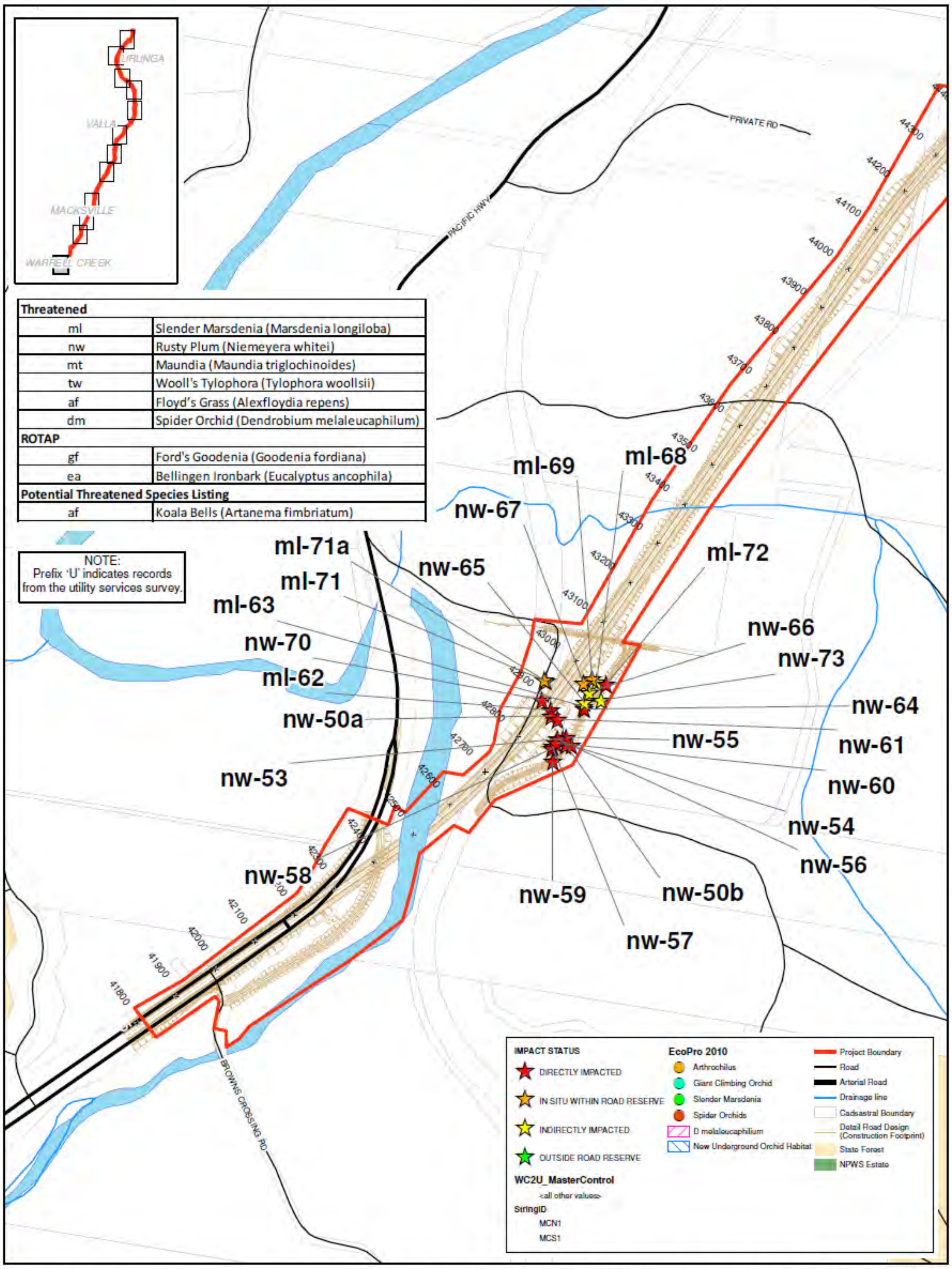

Figure 13: Location of threatened and rare species recorded during the 2011 targeted flora survey of the WC2U road corridor, indicating level of impact on each individual

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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APPENDIX 2: LOCATIONAL COORDINATES OF THREATENED FLORA AND RESULTS OF IMPACT ANALYSIS indicating whether 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. 'Distance' gives the distance of indirectly impacted individuals to the construction footprint or edge of the direct impact zone. The results below are separated into two tables - one for the targeted survey conducted for this management plan and the second for the EcoPro (2010) targeted orchid survey.

ID	SPECIES	EASTING	NORTHING	NUMBERS	HEIGHT	IMPACTED	DISTANCE
ar-78	Alexfloydia repens	492334.706995	6599021.622260	mat		INDIRECTLY IMPACTED	3.34116
ar-79	Alexfloydia repens	492344.763916	6599013.133180	mat		INDIRECTLY IMPACTED	9.18854
ar-80	Alexfloydia repens	492353.539390	6599011.846530	mat		OUTSIDE ROAD RESERVE	
ar-81	Alexfloydia repens	492261.429754	6599090.278560	mat		OUTSIDE ROAD RESERVE	
af	Artanema fimbriatum	497462.035272	6610707.607140	30		DIRECTLY IMPACTED	
af	Artanema fimbriatum	497461.092414	6610642.223760	1		DIRECTLY IMPACTED	
af	Artanema fimbriatum	495851.457703	6607944.201690	1		DIRECTLY IMPACTED	
af	Artanema fimbriatum	496151.378340	6608221.361400	12		DIRECTLY IMPACTED	
af	Artanema fimbriatum	498993.037493	6627709.492660	50		INDIRECTLY IMPACTED	2.18388
af	Artanema fimbriatum	500084.954156	6629520.828840	5		OUTSIDE ROAD RESERVE	
af	Artanema fimbriatum	498290.907731	6613899.162890	10		DIRECTLY IMPACTED	
af	Artanema fimbriatum	498996.450225	6615072.078720	6		DIRECTLY IMPACTED	
af	Artanema fimbriatum	500301.385190	6616814.366140	5		DIRECTLY IMPACTED	
af	Artanema fimbriatum	500347.886710	6616794.232820	5		INDIRECTLY IMPACTED	3.60148
dm-16a	Dendrobium melaleucaphilum	498649.693941	6623095.420120	1		OUTSIDE ROAD RESERVE	
dm-34a	Dendrobium melaleucaphilum	498827.816416	6627524.966920	1		INDIRECTLY IMPACTED	4.15633
ea	Eucalyptus ancophila	498584.490443	6622840.717360	5	25m	DIRECTLY IMPACTED	
ea	Eucalyptus ancophila	498796.690430	6622611.905850	10	30m	DIRECTLY IMPACTED	
ea	Eucalyptus ancophila	500600.800758	6618752.556970	3	30m	IN SITU ROAD RESERVE	

ea	Eucalyptus ancophila	498014.979409	6626228.850630	1	45m	IN SITU 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	498740.165666	6627464.008120	mat		DIRECTLY IMPACTED	
gf	Goodenia fordiana	495678.042363	6607581.015290	mat		DIRECTLY IMPACTED	
gf	Goodenia fordiana	495708.849288	6607601.898610	mat		DIRECTLY IMPACTED	
gf	Goodenia fordiana	498672.994767	6627368.143990	mat		DIRECTLY IMPACTED	
ml-1	Marsdenia longiloba	497485.537248	6610602.704080	1	small	DIRECTLY IMPACTED	
ml-10	Marsdenia longiloba	498596.651119	6622771.273610	3	0.2m	IN SITU 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-13a	Marsdenia longiloba	500357.942502	6621267.385270	1	small	OUTSIDE ROAD RESERVE	
ml-14	Marsdenia longiloba	500386.537955	6620686.516890	2	small	DIRECTLY IMPACTED	
ml-14a	Marsdenia longiloba	500409.842004	6620668.210490	2	small	DIRECTLY IMPACTED	
ml-14b	Marsdenia longiloba	500435.641790	6620740.522920	1	small	DIRECTLY IMPACTED	
ml-15	Marsdenia longiloba	500426.432922	6618920.638680	1	3.5m	DIRECTLY IMPACTED	
ml-16	Marsdenia longiloba	500442.890991	6618806.680550	1	0.4m	DIRECTLY IMPACTED	
ml-17	Marsdenia longiloba	497791.779559	6625851.107730	1	small	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-2	Marsdenia longiloba	497468.445578	6610614.520770	1	small	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-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-28	Marsdenia longiloba	498002.652999	6626288.504580	1	small	DIRECTLY IMPACTED	
ml-3	Marsdenia longiloba	497477.228559	6610618.955580	15	small	DIRECTLY IMPACTED	
ml-30	Marsdenia longiloba	498005.986444	6626426.102340	2	0.3m	INDIRECTLY IMPACTED	9.37399
ml-31	Marsdenia longiloba	498004.547702	6626422.038800	1	1.3m	INDIRECTLY IMPACTED	9.95268
ml-32	Marsdenia longiloba	498104.834883	6626406.357810	1	0.4m	INDIRECTLY IMPACTED	6.37603
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	
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	0.1m	INDIRECTLY IMPACTED	4.21898
ml-44	Marsdenia longiloba	495748.069111	6607748.011070	2	0.3m	DIRECTLY IMPACTED	
ml-45	Marsdenia longiloba	497602.692015	6613080.268090	1	small	DIRECTLY IMPACTED	

ml-46	Marsdenia longiloba	497598.702108	6613063.459720	40	to 5m	DIRECTLY IMPACTED	
ml-47	Marsdenia longiloba	497588.956090	6613070.291360	10	to 1m	INDIRECTLY IMPACTED	3.09248
ml-48	Marsdenia longiloba	497602.055454	6613069.370790	10	to 1.5m	DIRECTLY IMPACTED	
ml-49	Marsdenia longiloba	497496.039690	6612142.718430	1	0.15m	DIRECTLY IMPACTED	
ml-5	Marsdenia longiloba	496683.949976	6609585.722830	1	small	DIRECTLY IMPACTED	
ml-62	Marsdenia longiloba	489566.954445	6594529.180790	10	0.1m	DIRECTLY IMPACTED	
ml-63	Marsdenia longiloba	489635.678810	6594537.005010	1	0.1m	INDIRECTLY IMPACTED	2.37169
ml-68	Marsdenia longiloba	489663.695772	6594588.748820	1	1.5m	INDIRECTLY IMPACTED	5.03628
ml-69	Marsdenia longiloba	489653.642640	6594595.388410	1	1m	IN SITU ROAD RESERVE	
ml-7	Marsdenia longiloba	496637.195041	6609472.118760	6	0.6m	DIRECTLY IMPACTED	
ml-71	Marsdenia longiloba	489557.487157	6594589.199920	1	2m	INDIRECTLY IMPACTED	6.49403
ml-71a	Marsdenia longiloba	489553.726825	6594591.727680	3	2m	IN SITU ROAD RESERVE	
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		OUTSIDE ROAD RESERVE	
mt-75	Maundia triglochinoides	491659.329340	6598066.765920	mat		INDIRECTLY IMPACTED	0.36295
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		IN SITU ROAD RESERVE	
nw-50	Niemeyera whitei	497460.267315	6612110.387950	1	2.5m	IN SITU ROAD RESERVE	
nw-50a	Niemeyera whitei	489567.922961	6594517.176060	1	2m	DIRECTLY IMPACTED	
unw-9	Niemeyera whitei	497406.818180	6611193.165316	1	7m	DIRECTLY IMPACTED	
nw-50b	Niemeyera whitei	489598.600127	6594456.623420	1	8m	DIRECTLY IMPACTED	
nw-53	Niemeyera whitei	489592.527720	6594469.546710	2	0.5m	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-60	Niemeyera whitei	489577.387074	6594460.296860	1	0.5m	DIRECTLY IMPACTED	
nw-61	Niemeyera whitei	489581.165661	6594510.354950	1	6m	DIRECTLY IMPACTED	
nw-64	Niemeyera whitei	489636.959937	6594531.465170	1	8m	DIRECTLY IMPACTED	
nw-65	Niemeyera whitei	489638.063190	6594544.949530	1	5m	INDIRECTLY IMPACTED	4.14811
nw-66	Niemeyera whitei	489647.610383	6594566.753670	1	4m	INDIRECTLY IMPACTED	7.21401
nw-67	Niemeyera whitei	489635.791819	6594585.027810	1	3m	IN SITU ROAD RESERVE	
nw-70	Niemeyera whitei	489548.594230	6594550.773100	1	2m	DIRECTLY IMPACTED	
nw-73	Niemeyera whitei	489672.663574	6594549.969920	1	5m	INDIRECTLY IMPACTED	4.42401
tw-29	Tylophora woollsii	497970.168547	6626375.858880	1	0.3m	IN SITU ROAD RESERVE	
tw-4	Tylophora woollsii	496704.871330	6609581.111790	1	small	DIRECTLY IMPACTED	
tw-6	Tylophora woollsii	496614.669628	6609500.001180	1	0.4m	DIRECTLY IMPACTED	
tw-9a	Tylophora woollsii	498593.927600	6622812.829640	1	0.5m	DIRECTLY IMPACTED	
ml-90	Marsdenia longiloba	494181	6604547	2	2.5m	OUTSIDE ROAD RESERVE	242.31
ml-91	Marsdenia longiloba	494198	6604550	1	0.8m	OUTSIDE ROAD RESERVE	222.23
utw-1	Tylophora woollsii	497840.222513	6625937.923801	1	1.4	DIRECTLY IMPACTED	
utw-2	Tylophora woollsii	497841.820182	6625946.420056	5	0.5	DIRECTLY IMPACTED	
ml-92	Marsdenia longiloba	494347	6604098	1	1.1m	IN SITU ROAD RESERVE	49.21
ml-93	Marsdenia longiloba	494336	6604191	1	1.8m	IN SITU ROAD RESERVE	61.08
mt-94	Maundia triglochinoides	493295	6601470	mat		INDIRECTLY IMPACTED	8.56
mt-95	Maundia triglochinoides	493286	6601461	mat		INDIRECTLY IMPACTED	3.62
uml-5	Marsdenia longiloba	497779.939952	6625872.714539	1	1.5m	DIRECTLY IMPACTED	

uml-6	Marsdenia longiloba	497772.427480	6625850.919071	1	1m	DIRECTLY IMPACTED	
mt-96	Maundia triglochinoides	493285	6601445	mat		INDIRECTLY IMPACTED	9.19
mt-97	Maundia triglochinoides	493304	6601479	mat		IN SITU ROAD RESERVE	13.45
mt-98	Maundia triglochinoides	493156	6601432	mat		OUTSIDE ROAD RESERVE	63.90
mt-99	Maundia triglochinoides	493069	6601470	mat		OUTSIDE ROAD RESERVE	158.90

Table 2: Impact Analysis of threatened flora data recorded by EcoPro (2010) overlaid on the most recent highway 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
Spider Orchids	498951.169835	6622683.403040	OUTSIDE ROAD RESERVE
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
Spider Orchids	498957.494397	6622688.941912	OUTSIDE ROAD RESERVE
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
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Spider Orchids	498893.597350	6622762.846869	OUTSIDE ROAD RESERVE
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Spider Orchids	498891.981164	6622642.721320	OUTSIDE ROAD RESERVE

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APPENDIX 3: PLANS SHOWING THE DISTRIBUTION OF THREATENED AND RARE SPECIES on the whole WC2U road corridor

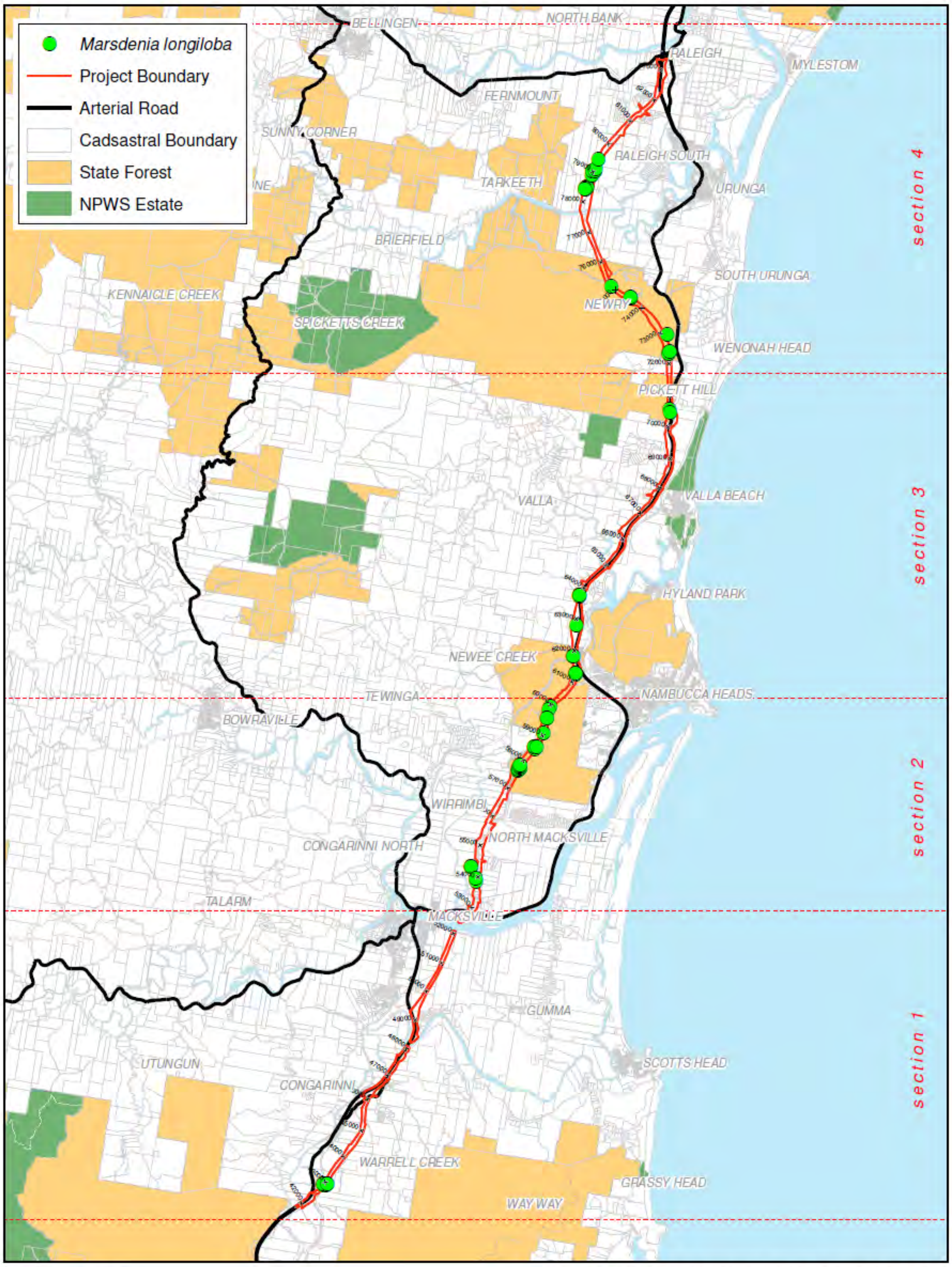

Figure 12: Distribution of Slender Marsdenia (Marsdenia longiloba) on the WC2U road corridor recorded during the 2011 targeted flora survey.

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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0 2 4 6 8
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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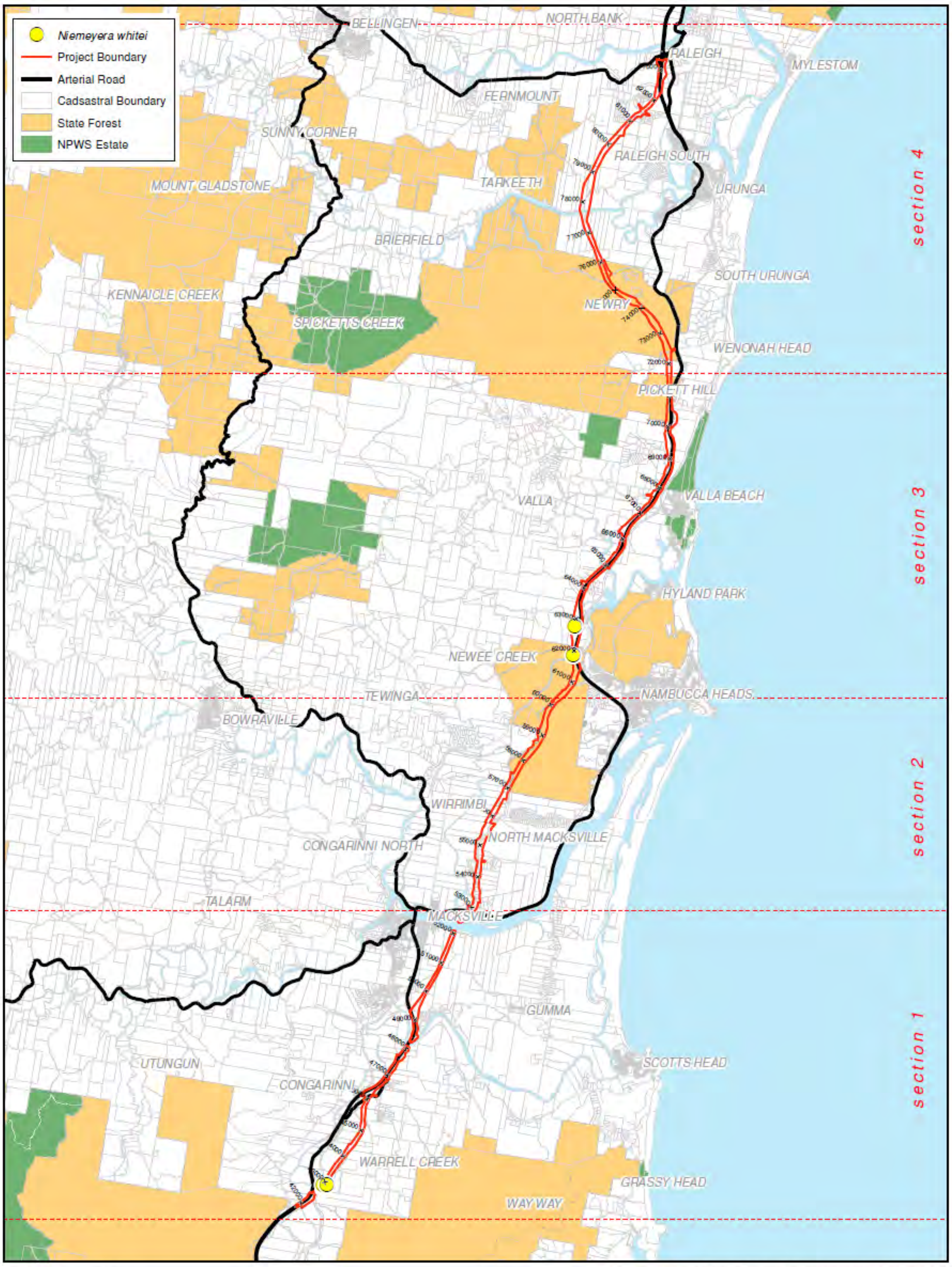

Figure 13: Distribution of Rusty Plum (Niemeyera whitei) on the WC2U road corridor recorded during the 2011 targeted flora survey.

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

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File: Figure_13_RTA_Grafton_Flora_Survey_Species_Distribution
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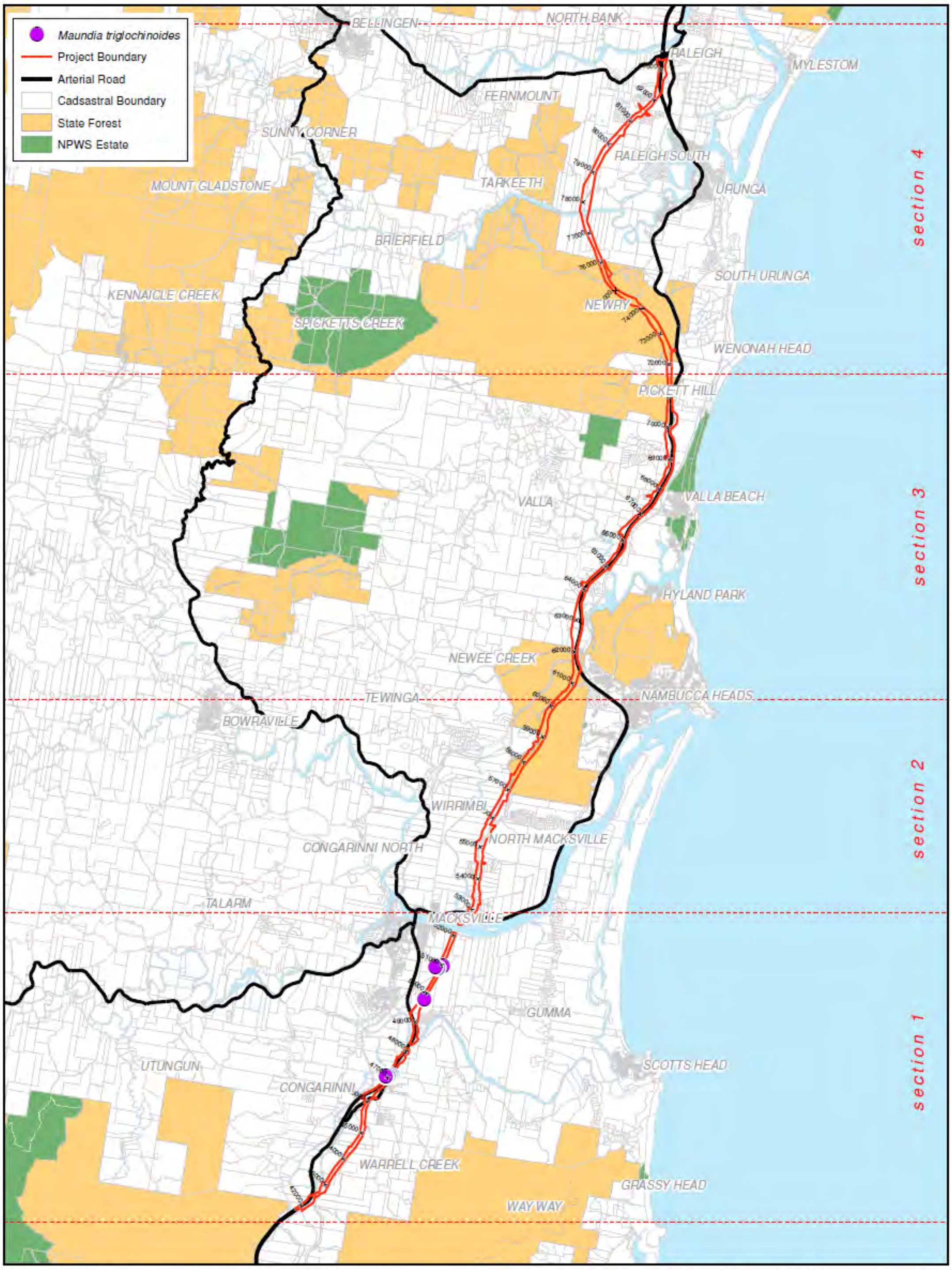

Figure 15: Distribution of Maundia (Maundia triglochinoides) on the WC2U road corridor recorded during the 2011 targeted flora survey.

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
A4 Scale 1:150,000

map production by www.geoview.com.au geoview
File: Figure_15_RTA_Grafton_Flora_Survey_Species_Distribution
Date: 25-01-2012

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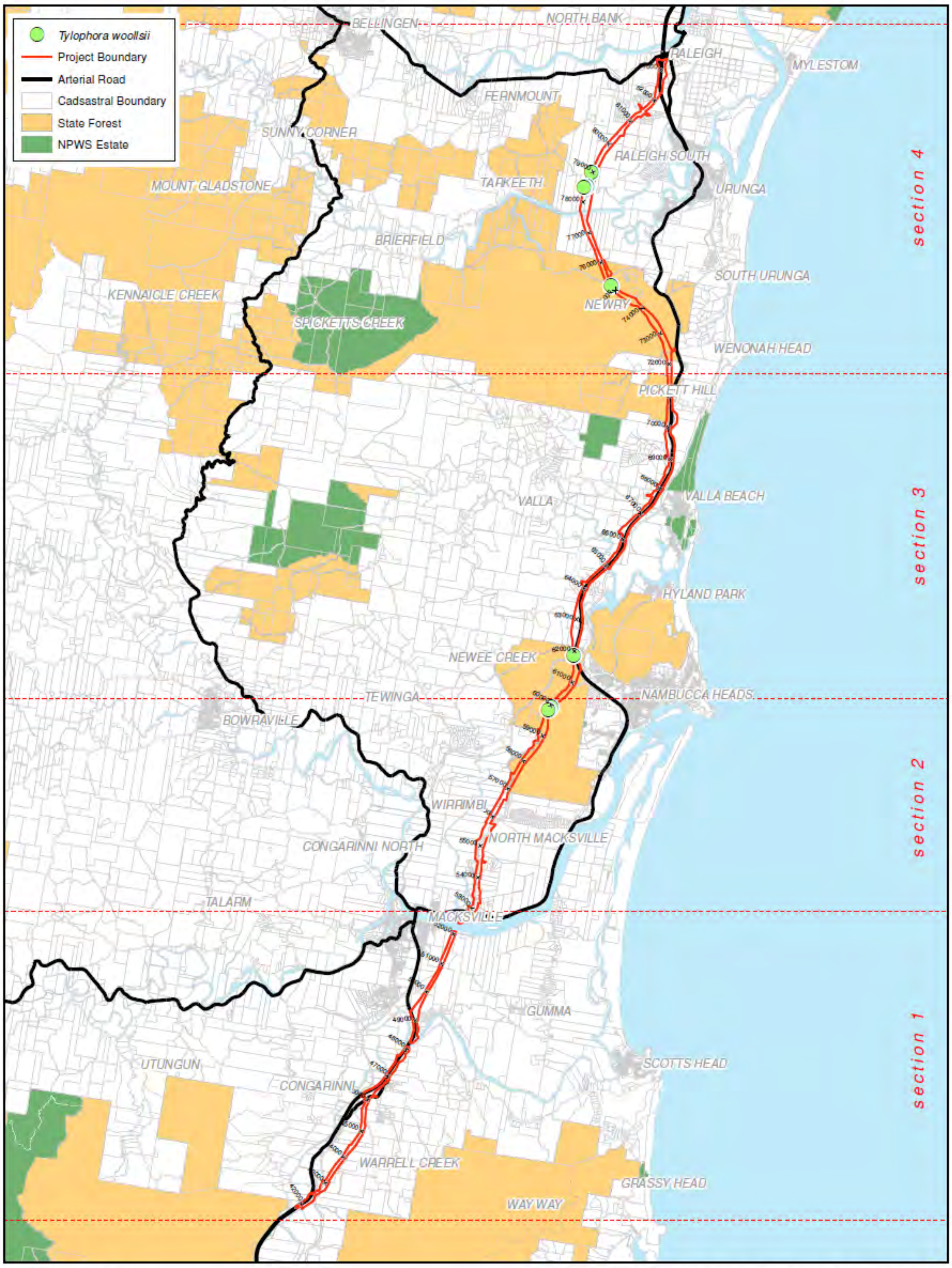

Figure 16: Distribution of Wooll's Tylophora (Tylophora woollsii) on the WC2U road corridor recorded during the 2011 targeted flora survey.

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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File: Figure_16_RTA_Grafton_Flora_Survey_Species_Distribution Date: 10-03-2012

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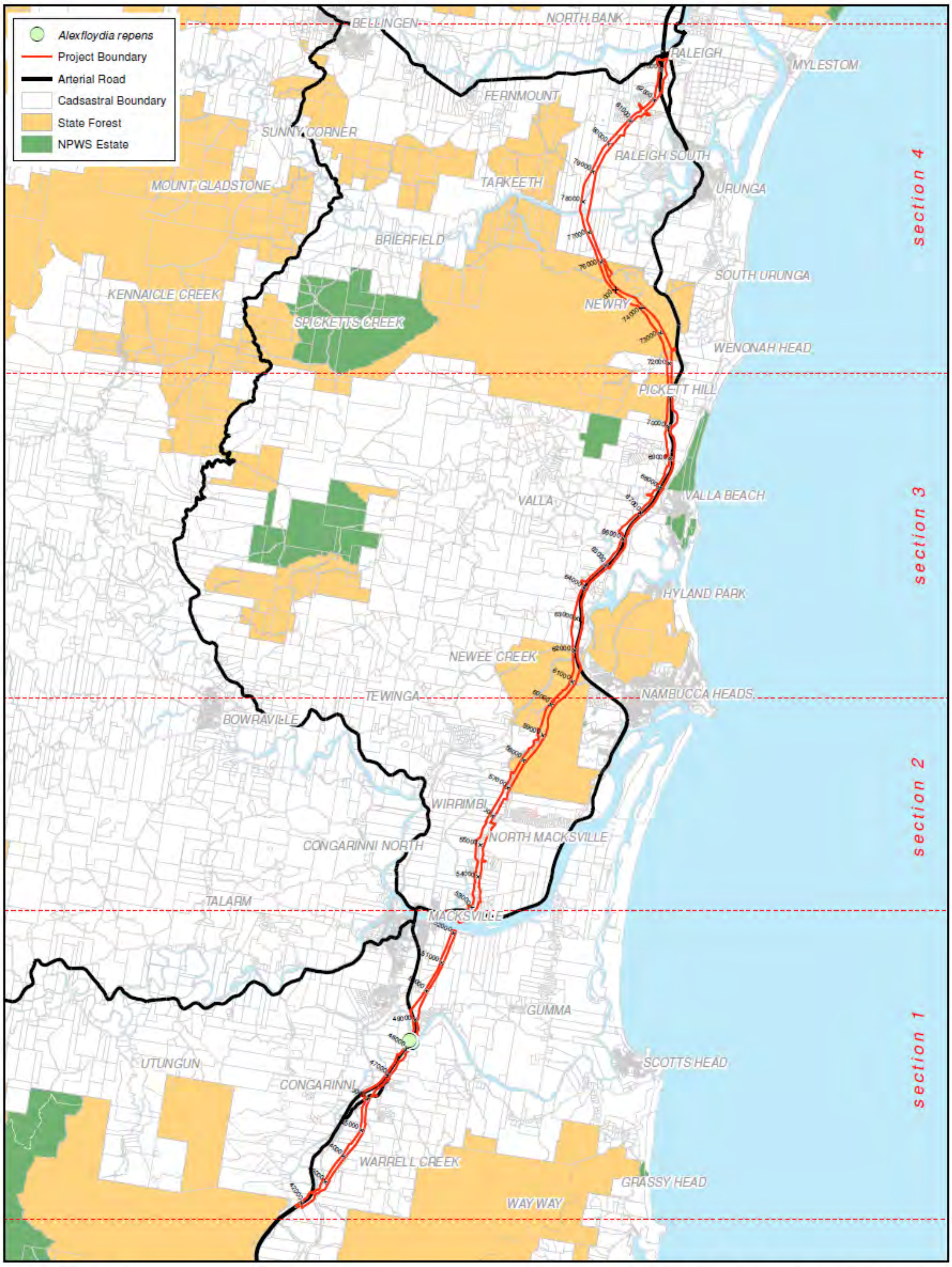

Figure 17: Distribution of Floyds Grass (Alexfloydia repens) on the WC2U road corridor recorded during the 2011 targeted flora survey.

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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File: Figure_17_RTA_Grafton_Flora_Survey_Species_Distribution
Date: 25-01-2012

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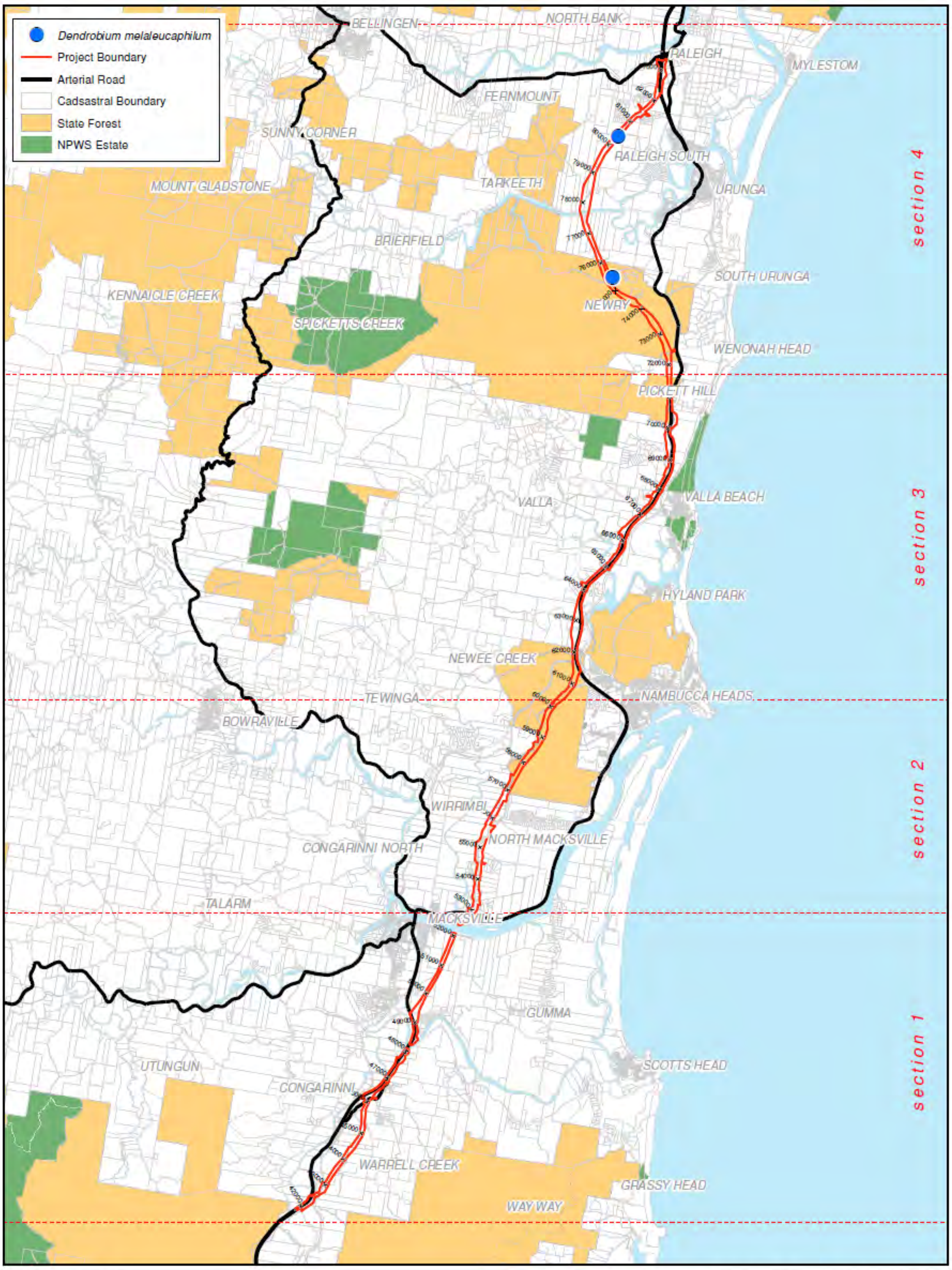

Figure 18: Distribution of Spider Orchid (Dendrobium melaleucaphilum) on the WC2U road corridor recorded during the 2011 targeted flora survey.

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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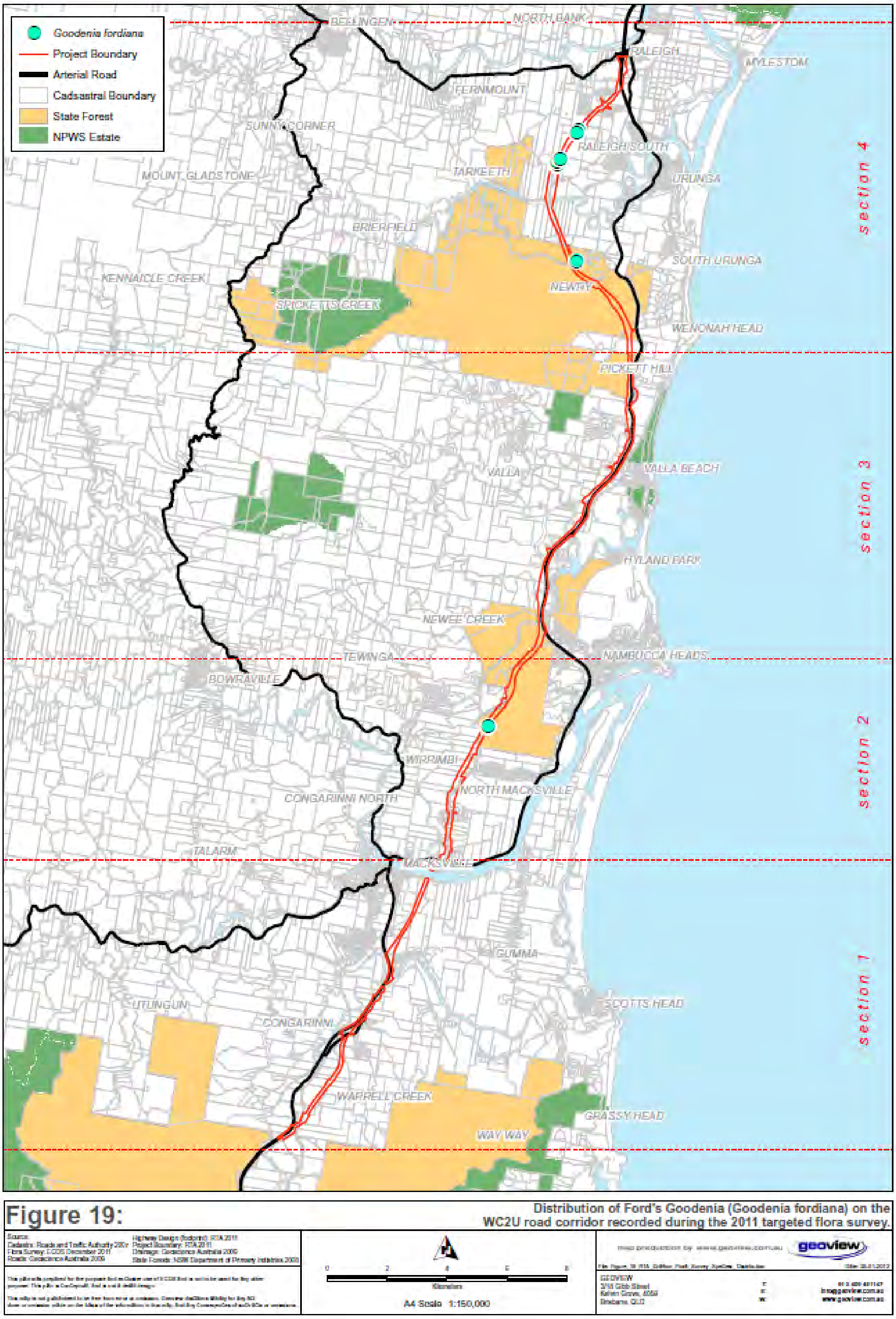

Figure 19: Distribution of Ford's Goodenia (Goodenia fordiana) on the WC2U road corridor recorded during the 2011 targeted flora survey.

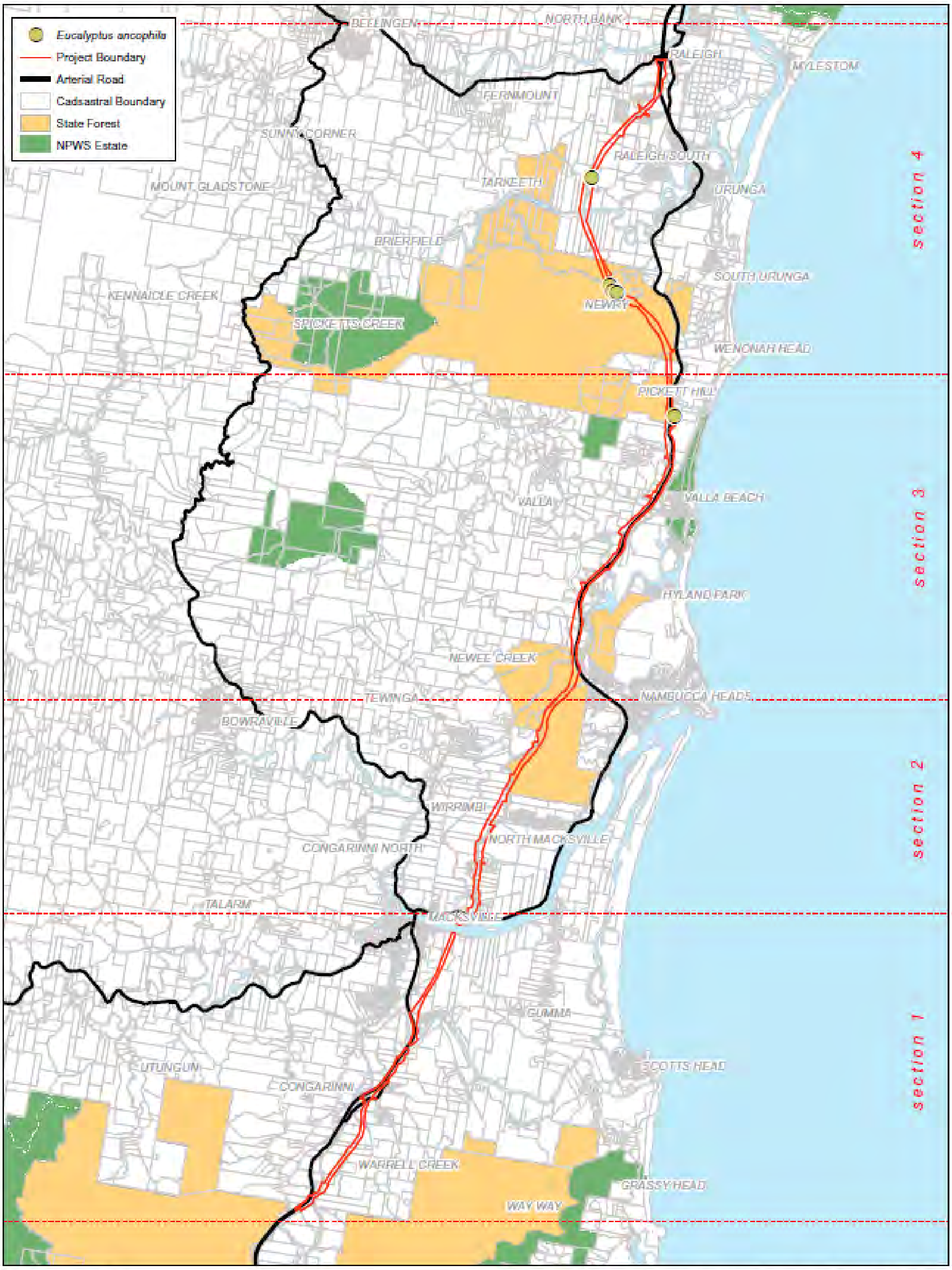

Figure 20: Distribution of Bellingen Ironbark (Eucalyptus ancophila) on the WC2U road corridor recorded during the 2011 targeted flora survey.

A4 Scale 1:150,000

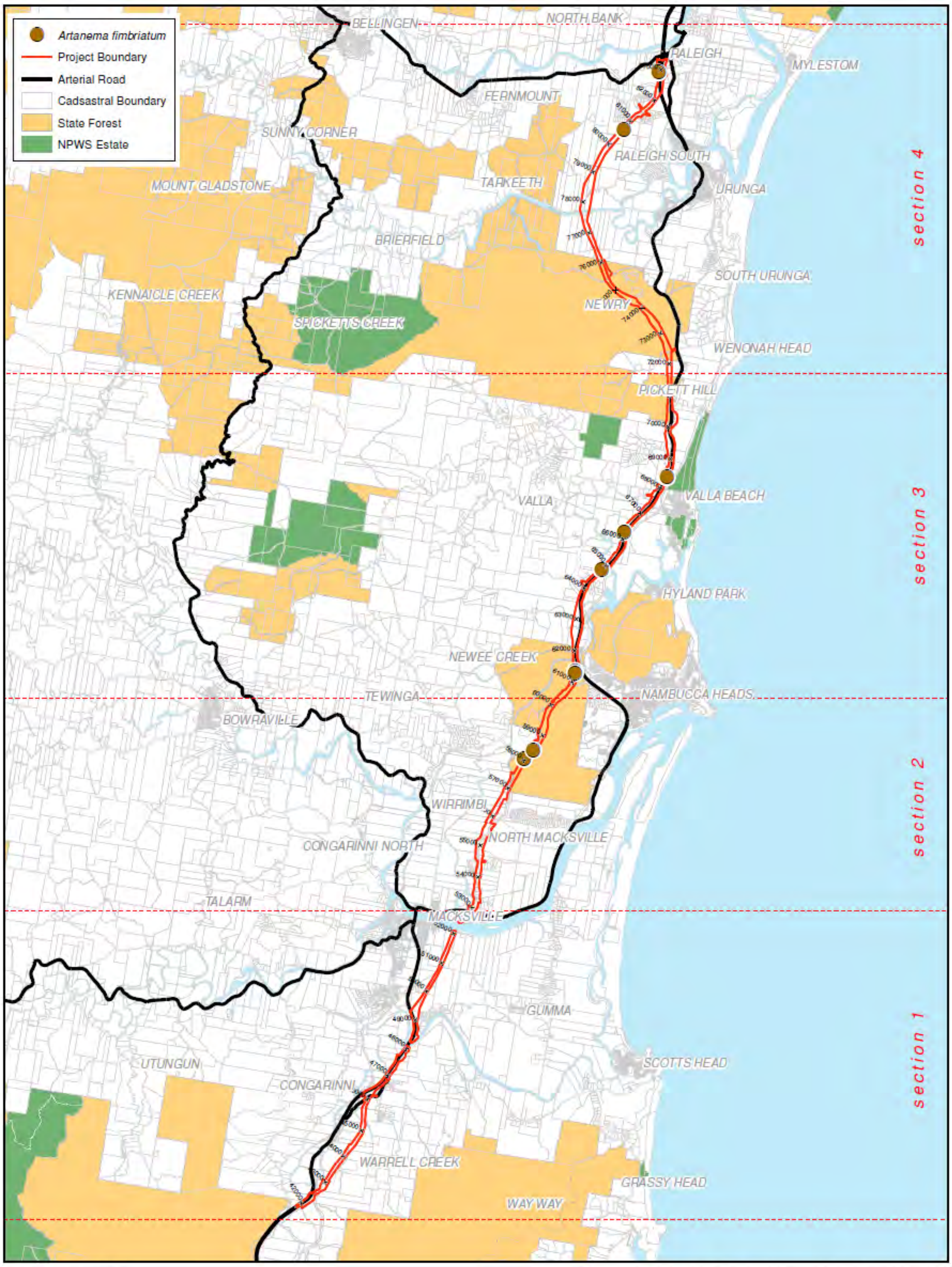

Figure 21: Distribution of Koala Bells (Artanema fimbriatum) on the WC2U road corridor recorded during the 2011 targeted flora survey.

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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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: Crouches 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.

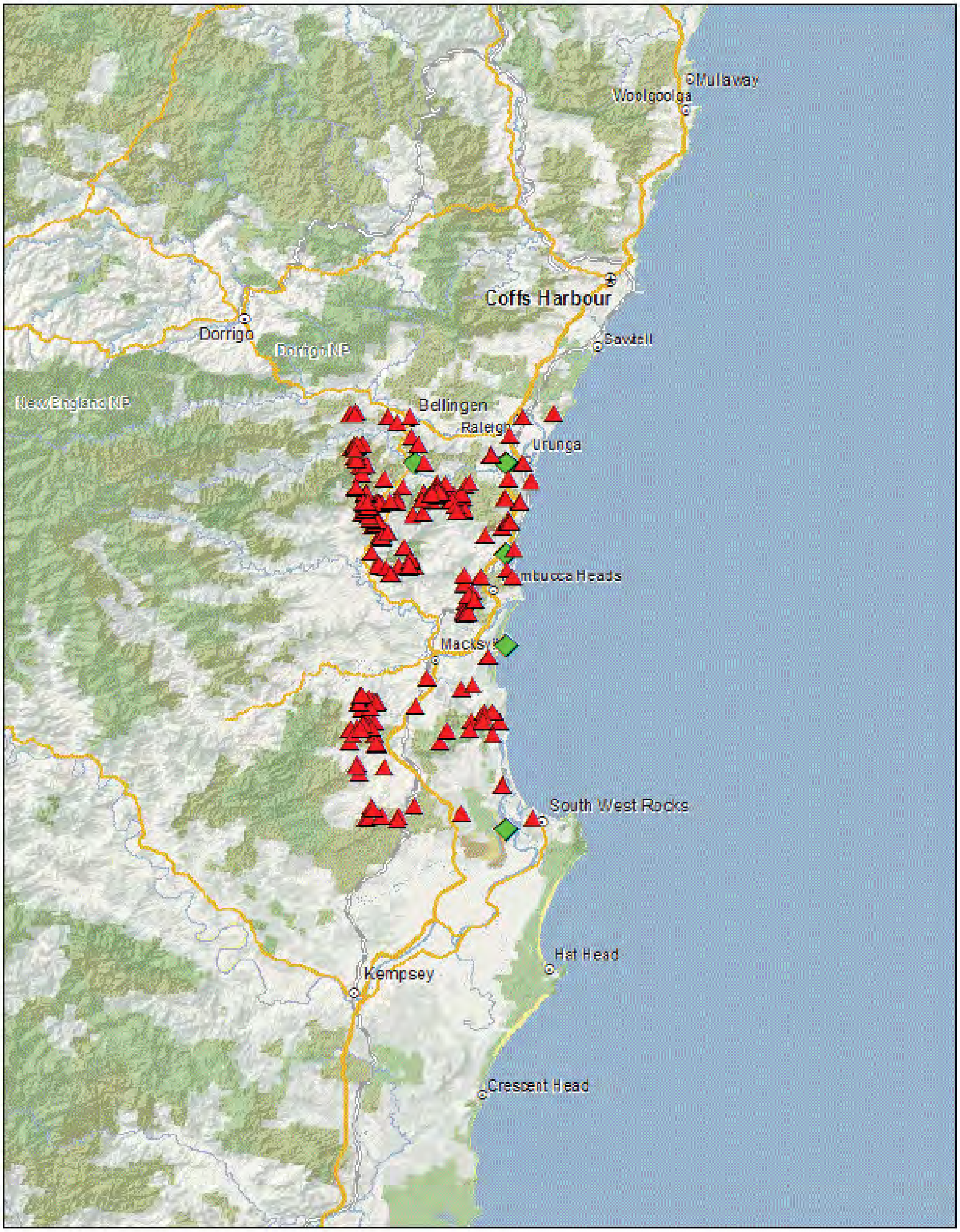
Within two years of the approval of the Biodiversity Offset Strategy, unless otherwise agreed by the Director General, the Proponent shall prepare and submit a Biodiversity Offset Package which identifies the final suite of offset measures to be implemented for the project for the approval of the Director 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.

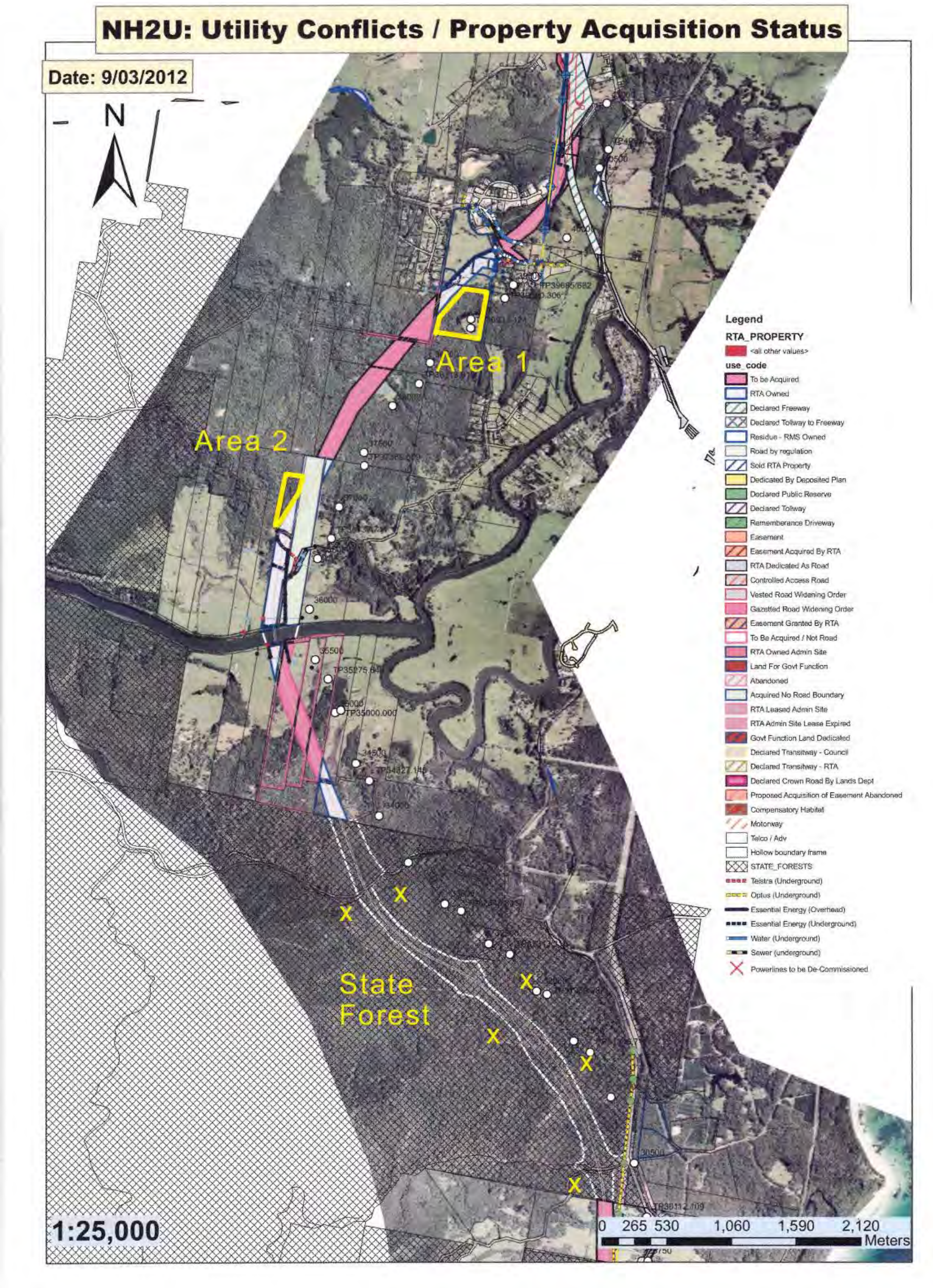
Report generated on 12/12/2011 2:17 PM

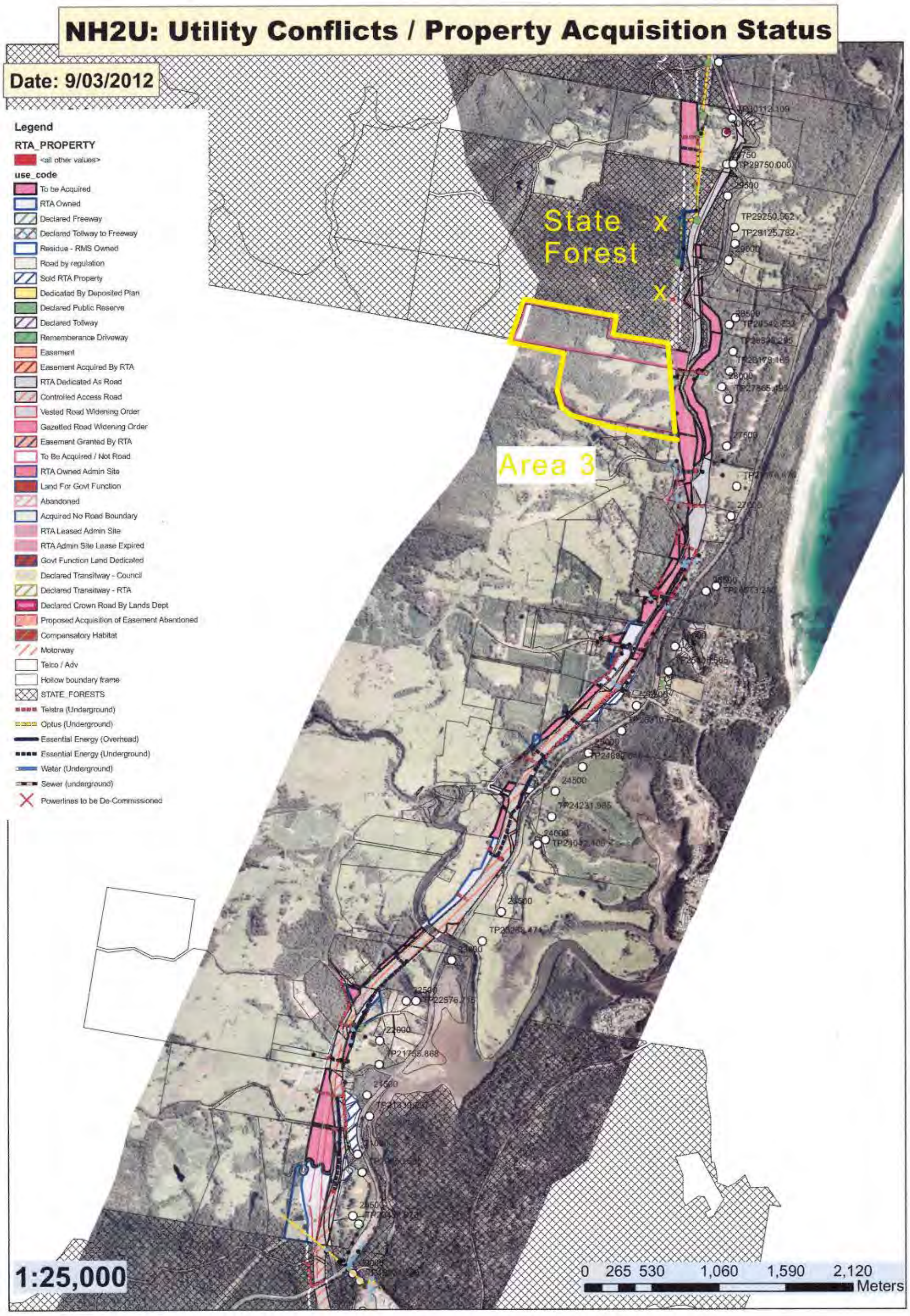
Kingdom	Class	Family	Species Code	Scientific Name	Exotic	Common Name	Legal Status	Records	Info
Flora	Flora	Apocynaceae	1233	*Marsdenia longiloba*		Slender Marsdenia	E1	58	
Flora	Flora	Apocynaceae	9505	*Parsonsia dorrigoensis*		Milky Silkpod	V	133	
Flora	Flora	Euphorbiaceae	9851	*Chamaesyce psammogeton*		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	

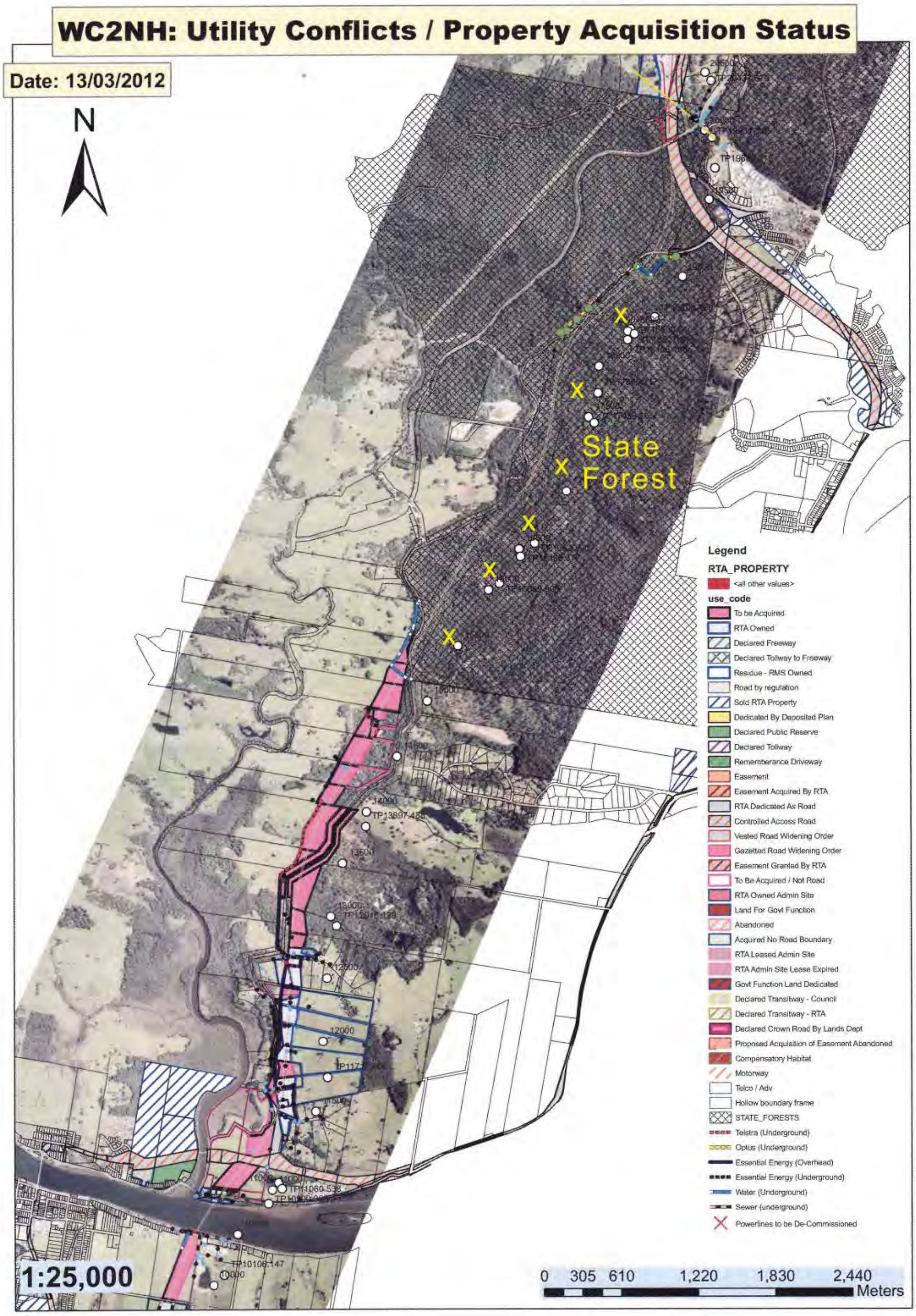
EPBC Act Protected Matters Report

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




NH2U: Utility Conflicts / Property Acquisition Status
Date: 9/03/2012
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
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
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use_code
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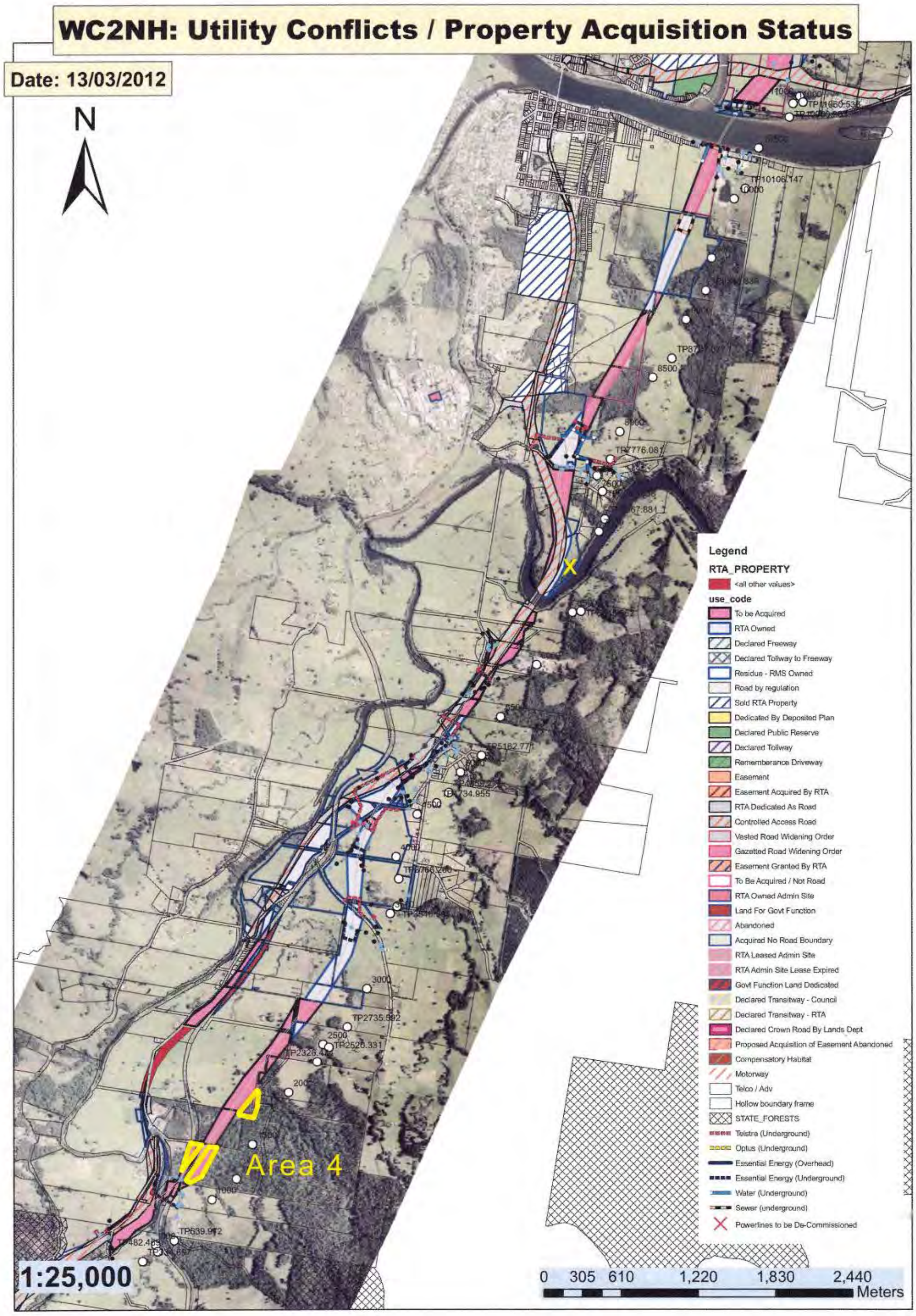
RTA Owned
Declared Freeway
Declared Tollway to Freeway
Residue - RMS Owned
Road by regulation
Sold RTA Property
Dedicated By Deposited Plan
Declared Public Reserve
Declared Tollway
Rememberance Driveway
Easement
Easement Acquired By RTA
RTA Dedicated As Road
Controlled Access Road
Vested Road Widening 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
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Area 4
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use_code
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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

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

Maudia 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. *Maudia triglochinoides* is similar in appearance to *Triglochin procerum* (now split into several species). *Maudia 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?

Maudia triglochinoides was recorded at two locations south of Macksville. One location is on Crouches Creek where it crosses the highway corridor. The second location is a freshwater swamp just south of Macksville. The Crouches Creek population follows the creek for approximately 150 metres across the road corridor and extends further upstream and downstream outside the road corridor. *Maudia 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 Crouches 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, Maudia 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 *Maudia 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?

Maudia 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 Crouches 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. In patches planted into Swamp Oak Forest after clearing the ground of exotics, runners grew up to 2.4 metres in 12 months.
- On bare ground created either artificially, or by flood-induced dieback of ground layer vegetation, it can regenerate rapidly from runners to form a dense cover.
- Established ground cover vegetation forms a barrier to 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; new bare sites may be colonised 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. It is likely that other patches of *Alexfloydia repens* are present along Warrell Creek upstream and downstream of the highway corridor.

No clearing of Alexfloydia repens is proposed as the recorded occurrence is on the project boundary rather than within the construction footprint. Construction related factors with potential to adversely effect the life cycle of *Alexfloydia repens* 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.

If practical, the road design will be modified to ensure there is no direct or indirect impact on the life cycle of the patch of *Alexfloydia repens* covering a few square metres recorded on the eastern boundary of the project where it meets Warrell Creek. Otherwise the patch will be translocated. As noted above, this species can be translocated with a high likelihood of success.

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 may indirectly impact on the habitat of *Alexfloydia repens* upstream and downstream of the Warrell Creek bridge site.

Potential adverse effects of the WC2U project on habitat include clearing encroachment, sediment run-off, micro-climate change, 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 indirectly on only a very small portion of the 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 is likely to contribute to further invasion of these species, 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 these and other weed species.

Minimisation of clearing, sedimentation/erosion control and weed control measures would reduce the impact of disturbance on the Warrell Creek population.

How is the Project likely to affect habitat connectivity?

The road corridor bisects the habitat of *Alexfloydia repens* at Warrell Creek. Although no individuals were recorded within the project boundary, suitable habitat is clearly present and removal of *Paspalum wettsteinii* and the native ground cover grass *Ottochloa gracillima* would allow the *Alexfloydia repens* to colonise the creek bank and 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, moist open forest and rainforest 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, rainforest 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, rainforest 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 and rainforest. 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 Crouches 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.)

Warrell Creek to Urunga Pacific Highway Upgrade Ecological Monitoring Program

Stage 1: Nambucca to Urunga

Prepared for:
NSW Roads and Maritime Services

June 2013

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WARRELL CREEK TO URUNGA PACIFIC HIGHWAY UPGRADE

STAGE 1 ECOLOGICAL MONITORING PROGRAM

(Nambucca Heads to Urunga Section Chainage 19500 - 41300)

June 2013

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Approved by:____________________
Project Manager

Document Control:

Date	Status	Dispatched	Clent	Client Contact
21/5/2012	Draft 1	email	RMS	Kristy Harvey
7/6/2012	Draft 2	email	RMS	Kristy Harvey
6/7/2012	Draft 3	email	RMS	Kristy Harvey
20/11/2012	Draft 4	email	RMS	Belinda Bock
5/12/2012	Final	email	RMS	Belinda Bock
19/12/2012	Final	email	RMS	Belinda Bock
12/03/2013	Final	email	RMS	Belinda Bock
14/04/2013	Final	email	RMS	Belinda Bock
25/06/2013	Final	email	RMS	Belinda Bock

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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 19500-41300); and
Stage 2 - Nambucca Heads to Warrell Creek section (chainage 19500-000).

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) was contracted by the NSW Department of Roads and Maritime Services (RMS) to prepare the EcMP for Stage 1 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 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 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;

(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.

There are 39 mitigation measures relevant to the EcMP preparation for Stage 1 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.

Table 1.1: Mitigation measures relevant to EcMP preparation for Stage 1 of the WC2U upgrade project.

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 3.3
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 3.3
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 3.4
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 3.5
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 2"d Ed 2OO4: Guidelines for the Translocation of NSW Government Department of Planning and lnfrastructure 6 Threatened Species in Australia, including details of ongoing maintenance such as responsibilities, timing and duration;	Section 2.7 and 3.8
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, materials and unauthorised personnel.	Section 2.6 and 3.7
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 3.2.2
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 2.2.1; 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

Source	Mitigation Measure	Relevant Section of EcMP
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
RSOC F1	Clearing of native vegetation (including endangered ecological communities) will be restricted to the minimum area necessary for construction.	Section 2.1 and 3.2
RSOC 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 and 3.2
RSOC 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 along the road boundary as soon as possible during construction.	Section 2.7 and 3.8
RSOC 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 3.8
RSOC 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
RSOC 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
RSOC 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 3.4
RSOC F9	Provision of fauna crossings will be as identified in the environmental assessment. All fauna crossings will be confirmed with the EPA and I&I (Fisheries) during the detailed design phase.	Section 2.2 and 3.3
RSOC 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 3.3
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 3.6
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 3.6
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 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

Source	Mitigation Measure	Relevant Section of EcMP
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 and 3.3
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 3.5
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 3.3
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
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 3.6
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 3.6
EA Ch10 – Section 10.5.3	Widening of the median at important locations.	Section 2.3 and 3.4
EA Ch10 – Section 10.5.3	Widening of the median at important locations.	Section 2.3 and 3.4
EA Ch10 – Section 10.5.3	Provision of dedicated, combined and incidental fauna underpass structures.	Section 2.2 and 3.3
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 3.3
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 3.6
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 3.6

Source	Mitigation Measure	Relevant Section of EcMP
EA Ch10 – Section 10.5.5	Roadside verges will be rehabilitated adjacent to culvert entrances and bridge pylons.	Section 2.5 and 3.6

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. Chapter one states the aim of the EcMP and identifies those responsible for its implementation. Chapter two identifies which proposed mitigation measures are to be subject to monitoring. Chapter three provides a detailed description of the monitoring methods recommended for each proposed mitigation measure. Chapter four identifies potential contingencies that may be applied if any of the mitigation measures prove to be insufficient. Chapter five specifies the reporting requirements.

2 Mitigation measures requiring monitoring

A meeting with the RMS, EPA and BEM was held at the Coffs Harbour EPA office 26 September 2012 to devise an agreed scope for the Stage 1 EcMP. It was agreed that the EcMP for Stage 1 will focus on all seven groups of mitigation measures proposed as part of the Warrell Creek to Urunga Pacific Highway Upgrade project (Stage 1):

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.

A description of each proposed mitigation measure nominated for monitoring is provided below.

2.1 Pre-clearing and clearing procedures

The Revised Statement of Commitments (RSoC) and WC2U upgrade project Environmental Assessment (EA) include several 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:

- RSoC F1 - Clearing of native vegetation, including Endangered Ecological Communities (EECs) will be restricted to the minimum area necessary for construction;

- RSoC 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;

- RSoC 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;

- RSoC 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 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; and
- 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.

Although not specified in the EA or RSoCs, 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 and threatened frog species.

Delineation of clearing boundaries

Targeted surveys will be undertaken to delineate the boundaries of vegetation (including EECs) to be retained within the project corridor. The clearing boundaries will then be subject to geodetic survey to enable accurate placement of protective fencing and inclusion on constraints mapping.

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 the known osprey nest 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. Vegetation within a 50 metre radius of any tree containing a residing koala will be retained until the koala has vacated habitat within the clearing limits.

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 2012a). 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.

Subject to the results of further surveys to be conducted at Boggy Creek and McGraths Creek, additional targeted surveys for the giant barred frog may be required at these sites up to five days prior to clearing. Refer to the giant barred frog management strategy (LES 2012b) for more detail.

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 2013). Consequently, a microbat management strategy has been prepared by LES.

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.

All captured fauna will be released into adjacent or proximate areas of suitable habitat beyond the project clearing limit.

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.*

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.

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 RSoCs and EA mitigation measures include:

- RSoC F9 - Provision of fauna crossings will be as identified in the environmental assessment. All fauna crossings will be confirmed with the EPA and I&I (Fisheries) during the detailed design phase;

- RSoC 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 25 fauna underpass structures are proposed for Stage 1 of the WC2U upgrade project (*Table 2.1*). These will consist of 16 sites with box culverts, six bridge sites, two sites with pipe culverts and one site with a bibo arch.

Table 2.1: Underpass structures proposed for Stage 1 of the WC2U upgrade project.

Chainage	Structure	Dimensions	Underpass Length (m)
19820	Box Culvert	5 x 2400 x 2100	97 + 30
20800	Bridge	n/a	96
21740	Bridge	n/a	122
23040	Bridge	n/a	n/a
24305	Box Culvert	2700 x 900	n/a
25255	Box Culvert	2700 x 2400	42 + 37
26535	Box Culvert	4 x 3600 x 1200; Plus 1 x 3600 x 2400	18 + 52
27848	Pipe Culvert	4 x 1200	n/a
28275	Pipe Culvert	2 x 1800	n/a
28565	Box Culvert	3600 x 3000	53
29650	Bridge	n/a	100
30855	Box Culvert	2100 x 900	110
31510	Bridge	n/a	n/a
31750-930	Box Culvert	2400 x 2400	50 + 50
32930	Arch	4 x 9m	62
33395	Box Culvert	3000 x 2400	n/a
33940	Box Culvert	2400 x 1200	n/a
34450	Box Culvert x 3	3600 x 2400; 3600 x 3600; 3000 x 3000	68
34780	Box Culvert	3600 x 2100	56
35095	Box Culvert	23 x 3600 x 3000	50
36905	Box Culvert	2 x 2400 x 1200	53
37950	Bridge	n/a	n/a
38330	Box Culvert	2 x 3000 x 1500	28 + 37
39990	Box Culvert	17 x 3300 x 2100	n/a
40500	Box Culvert	9 x 3000 x 2100	48 + 17

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. Where possible, the fauna underpass structures will also be designed to accommodate use by several threatened fauna species including the spotted-tailed quoll (*Dasyurus maculatus*), brush-tailed phascogale (*Phascogale tapoatafa*), giant barred frog (*Mixophyes iteratus*) and koala (*Phascolarctos cinereus*).

In addition, MCoA B2 requires the RMS to further investigate design refinements to improve fauna connectivity between chainages 19150 and 19820. If this process delivers an improved fauna connectivity structure within Stage 1 of the project, the additional structure will be included in the monitoring program.

2.3 Widened vegetated medians

MCoA B4 states "*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*". Furthermore, RSoCs and EA mitigation measures relevant to the provision of widened medians include:

- RSoC 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 medians 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 vegetated medians will consist of strips of retained tall sclerophyll forest vegetation (minimum 40 metres wide), which will extend up to 900 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.

2.4 Nest box installation

The relevant EA mitigation measure is contained in 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*.

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 2012c). A Nest Box Management Plan (NBMP) has been prepared by LES 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"*.

A total of 303 nest boxes are to be installed along the Upgrade corridor between chainage 19.600 and 39.000. Detailed descriptions of nest box locations, nest box types and target species for each area are provided in the NBMP (LES 2012c). 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.

2.5 Landscape rehabilitation

Relevant EA 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 will be developed for weed infested areas to ensure that all potential weed propagules from soil and vegetative material are appropriately disposed of;

- Chapter 10 Section 10.5.5 - Roadside verges will be rehabilitated adjacent to culvert entrances and bridge pylons.

In order to comply with MCoA B21(c) the contractor will prepare and implement an Urban Design and Landscape Plan (UDLP) for the project, which 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.) which 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 OEH 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 plant species management plan prepared by Benwell (2012), 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 OEH 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 NSW Government Department of Planning and lnfrastructure 6 Threatened Species in Australia, 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 RSoC 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 measures is also described in RSoC 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 1 of the WC2U upgrade project translocations are proposed for four threatened flora species directly impacted by the Upgrade, *Amorphospermum whitei, Marsdenia longiloba, Tylophora woollsii* and *Dendrobium melaleucaphilum* (Benwell 2012). 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 2012).

Details of the proposed translocation areas and procedures are provided in the Draft Warrell Creek to Urunga Upgrade Threatened Species Management Plan (Benwell 2012).

3 Monitoring methods

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*.

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; FU = fauna underpass and exclusion fence monitoring; VM = vegetated medians; NM = nestbox monitoring; LR = landscape rehabilitation monitoring; ITF = in-situ threatened flora population monitoring; TA = translocation area monitoring.

Mitigation Measure	Construction Phase																Operational Phase																																			
	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			
	A	W	S	S	A	W	S	S	A	W	S	S	A	W	S	S	A	W	S	S	A	W	S	S	A	W	S	S	A	W	S	S	A	W	S	S	A	W	S	S	A	W	S	S	A	W	S	S	A	W	S	S
P & C																																																				
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VM																																																				
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LR																																																				
ITF																																																				
TA																																																				

Note: Orange Shading indicates timing of monitoring only if the Giant Barred Frog is detected during future surveys. A; W; S; S - Autumn; Winter; Spring; Summer.

3.2 Pre-clearing and clearing procedures

3.2.1 Timing of monitoring

Surveys for delineating clearing limit boundaries, 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 delineation surveys (refer to *Section 2.1.1*) will be incorporated into the project constraints mapping, which will be submitted in annual reporting to the RMS and OEH.

Monitoring of other pre-clearing and clearing procedures will consist of data collection and reporting tasks that will culminate in the production of a detailed clearing report to be submitted to the RMS and OEH upon completion of the clearing phase of the project. Information contained within the clearing report will 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 (2012d) 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 modifications 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.
Frog Surveys	Sampling date; observers; location; sampling start/finish times, prevailing weather conditions; frog species and abundances observed/captured; release date, release time; GPS location of release point; habitat type at release point.
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.
Habitat Tree Removal	Date; tree number; tree species; trunk diameter; hollow type; entrance diameter and depth; chamber shape; hollow height; evidence of fauna use; captures; mortalities; injuries; age; breeding status; release point details.

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; and
- accurate quantification of tree hollow resources being removed.

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).

Monitoring methods

Monitoring of the green-thighed frog population will consist of two main components:

1. Monitoring of constructed breeding ponds; and
2. 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 a LES (2012a).

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

No Known habitat for the giant barred frog has been identified within the Nambucca Heads to Urunga section of the upgrade project. However, additional targeted surveys for the species will be undertaken at Boggy Creek (chainage 62765) and McGraths Creek (chainage 71965) in spring and summer prior to the commencement of clearing works. If the species is detected at either of these sites then monitoring of these populations will consist of:

- Frog surveys conducted during spring, summer and autumn along a one kilometre transect per site. Captured individuals will 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; and
- Tadpole surveys using bait traps (20 traps per transect) and opportunistic dip netting.

If the species is detected then a monitoring event will be undertaken at the time of detection (ie. collection of baseline data), followed by five annual monitoring events commencing with the post-construction phase of the project. Further details of monitoring methods are provided in the giant barred frog management strategy prepared by a LES (2012b).

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 (2012b).

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.

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 one year post-construction (*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 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.

3.5 Fauna underpasses and exclusion fencing

Subject to the availability of suitable control sites, monitoring of the fauna underpasses and exclusion fencing will employ a Before-After Control Versus Impact (BACI) design. The BACI design allows for monitoring to occur on treated and untreated sites both before and after the subject mitigation measures have been installed or implemented (McComb *et al*. 2010).

Of the 25 fauna underpass sites proposed for Stage 1 of the WC2U upgrade project, seven sites have been selected for monitoring (*Table 3.3*). An additional site between chainage 19500 and 19820 may be added subject to the outcome of proposed design refinements to improve fauna connectivity in this area. The selection criteria for fauna underpass monitoring include a continuous underpass length greater than 90 metres (excludes bridges and arches) and/or location of the structure within an area of suitable habitat for one or more of the target threatened species (ie. koala, brush-tailed phascogale, spotted-tailed quoll or giant barred frog). It was agreed with EPA that bridge underpasses will not require monitoring given that such structures have been demonstrated to provide effective fauna movement on other similar road projects.

Table 3.3: Proposed fauna underpass structures suitable for monitoring.

Chainage	Structure	Underpass Length (m)	SQ	BtP	K	GBF
26535	Box Culvert	18 + 52			x	
28565	Box Culvert	53	x	x	x	
30855	Box Culvert	110	x	x	x	
31750-930	Box Culvert	50 + 50	x	x	x	
32930	Arch	62	x	x	x	
33395	Box Culvert	n/a	x	x	x	
34450	Box Culvert	68	x	x	x	

3.5.1 Control Site Selection

The BACI monitoring design requires the use of control sites to enable monitoring to occur on treated and untreated sites both before and after management has occurred (McComb *et al*. 2010). However, there are several logistical challenges to be overcome in selecting suitable control sites:

- locating suitably undisturbed yet comparable habitat within 10 kilometres of the project;
- obtaining approval from landholders and maintaining approval with any subsequent changes in land ownership; and
- ensuring that management at control sites does not change significantly over the 8 to 10 year monitoring period (e.g. timber harvesting and fire regimes).

Consequently, an assessment of potential control sites will be undertaken in consultation with EPA prior to commencement of baseline monitoring. Where feasible, control sites will be incorporated into the monitoring program. Ideally, the minimum number of control sites required will be that sufficient to represent each of the threatened fauna species targeted by the underpass and exclusion fencing mitigation measures.

3.5.2 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 threatened fauna species targeted by the underpass structures (*Table 3.4*). 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, resulting in higher rates of fauna underpass usage, hence higher detection rates and sample sizes.

Table 3.4: Breeding seasons and likely dispersal periods of threatened fauna species targeted by the fauna underpass structures.

Scientific Name	Common Name	Breeding Season	Likely Dispersal Periods
Dasyurus maculatus	Spotted-tailed Quoll	Late May to early August (Belcher *et al*. 2008).	Spring and summer.
Phascogale tapoatafa	Brush-tailed Phascogale	Mid May to early July (Soderquist & Rhind 2008). Males expand home ranges during breeding season (Soderquist & Rhind 2008).	Mid-summer (Soderquist & Rhind 2008).
Phascolarctos cinereus	Koala	Spring and summer (Martin *et al*. 2008).	Spring and summer.

The monitoring will commence after the vegetation clearing phase of the project has been completed, but before the underpass structures become operational. The impacts resulting from vegetation clearing are not relevant to assessing the effectiveness of fauna underpass or exclusion fence mitigation measures. Therefore, it will be necessary to collect the baseline monitoring data after the vegetation clearing phase in order to eliminate or control this variable so that its effects cannot be confused or confounded with those of the independent variable (ie. impacts of underpasses and exclusion fencing) (Hayek 1994).

Monitoring events will be undertaken in autumn and spring each year for a minimum of one year during the construction phase and five predominantly non-consecutive years during the operational phase of the project (*Table 3.1*). The autumn monitoring events will be conducted over eight weeks each year, preferably commencing in mid-March and finishing in mid-May. The spring monitoring events will also be conducted over eight weeks each year, preferably commencing in mid-September and finishing in mid-November.

3.5.3 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:

- sand pad sampling (eight sampling nights per sand pad per monitoring event);
- hairtube sampling (minimum 20 sampling nights per hairtube per monitoring event);
- detection with automated cameras (minimum 40 sampling nights per camera per monitoring event);
- scat and track searches; and
- use of artificial groundcover (e.g. corrugated iron or plywood sheeting).

Due to the potential risk of inundation, the use of automated cameras is not recommended at combined drainage/fauna underpass structures.

Fauna underpass structures

Sand pads will be established several metres inside each underpass entrance. Each sand pad will be at least one metre wide and extend across the entire width of the underpass structure.

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.

Automated cameras will be installed near the centre of each fauna underpass structure (excluding combined structures) to detect mainly medium to large fauna species and their direction of movement. Smaller fauna species capable of moving beneath the camera detection beam will be sampled by other census techniques including hairtubes, sand pads and scat and track searches.

Each fauna underpass structure will be carefully searched for fauna scats, hair and tracks each time the sand pads are inspected.

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 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 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 and road mortality searches. Monitoring will also include an inspection of the exclusion fencing to assess fence condition, structural integrity, overhanging vegetation and vine growth.

The road mortality searches will involve careful inspections of roadside areas, not just the immediate road surface, to detect the remains of vertebrate fauna that have been struck by vehicles but have been able to move off the road surface before dying.

3.5.4 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;
- evidence of use by dispersing individuals and different age cohorts;
- use by cover-dependent species and species with low mobility; and

- low incidences of fauna road strike mortality.

3.6 Widened vegetated medians

3.6.1 Timing of monitoring

The timing of monitoring for the widened vegetated medians has been selected to coincide with the breeding seasons and likely dispersal periods of threatened glider species targeted by the mitigation measure (*Table 3.5*). As explained in *Section 3.5.2*, these periods are likely to represent peaks in glider movement, resulting in increased usage of the vegetated median.

Table 3.5: Breeding seasons and likely dispersal periods of threatened glider species targeted by the widened vegetated medians.

Scientific Name	Common Name	Breeding Season	Likely Dispersal Periods
Petaurus australis	Yellow-bellied Glider	Variable depending on habitat characteristics (Tyndale-Biscoe 2005). However, breeding in NSW generally occurs between July and September (Tyndale-Biscoe 2005).	When young are 12 to 24 months of age (Goldingay 2008).
Petaurus norfolcensis	Squirrel Glider	Young are born between April and November, with a peak during winter (Van der Ree & Suckling 2008).	When young are 12 to 18 months of age (Van der Ree & Suckling 2008).

Monitoring of the vegetated medians will commence during the second autumn of the operational phase of the Upgradeproject. Monitoring will be undertaken over six weeks each season on years 2, 3 and 5 of the operational phase (*Table 3.1*). 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.

3.6.2 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; and
- trapping.

Hairtube sampling

Hairtube sampling will be conducted for six weeks each monitoring event, with wafers and baits being replaced every two to three weeks. Hair samples will be sent to an appropriately qualified/experienced specialist for identification.

Hairtube transects, each containing 20 hairtubes (spaced 25 to 30 metres apart), will be established in retained forest habitat either side of the Upgrade corridor at each vegetated median site. One hairtube transect, containing 20 hairtubes (spaced 25 metres apart), will be established in each vegetated median.

Each hairtube will be attached to the main trunk of a mature Eucalypt at approximately six metres above the ground, and baited with a mixture of honey, oats and peanut butter. The main trunk above the hairtube will be sprayed with a mixture of honey and water upon installation to provide an additional attractant for gliders.

Spotlighting surveys

Spotlighting surveys will be conducted by two observers walking at one kilometre per hour on three occasions during each season. At each vegetated median site spotlighting transects (minimum 500 metres long), will be established in retained forest habitat either side of the Upgrade corridor and within the vegetated median (three transects in total). All fauna detected by spotlight will be identified to species, behaviour noted and located recorded using a GPS. If gliders are detected, they should be observed until their direction of movement can be ascertained.

Trapping and radio tracking

Spotlighting and hair tube sampling cannot always determine whether gliders occupying vegetated medians are residents of the median or traversing the road corridor. Consequently, upon the identification of target gliders in Year 2 of the operational phase, trapping and radio tracking will be undertaken in Year 3 to confirm glider movement across the highway via vegetated medians.

Transects of 10 large Elliot traps will be mounted on brackets approximately six metres high up the trunk of a tree and at 50 metre intervals. One transect will be located in the centre of each median for a period of four nights. Traps will be baited with a mixture of peanut butter, honey and oats. A honey solution will be sprayed up the tree trunk as an attractant. Traps will be checked early each morning and any trapped gliders will be processed and released on site at dusk.

Captured gliders will be weighed, sexed and assigned to age classes based on tooth condition, ventral fur colour and breeding status and fitted with a radio transmitter (Hyder Consulting 2012). A telemetry receiver will be used to locate the gliders, which will be radio-tracked at least one night a week for the following four weeks. The location of each radio-tracked individual will be recorded between two and four times per night and at least once each day. The GPS coordinates of each location will be recorded, along with the microhabitat being used and observed behaviour. Tagged individuals will be trapped and transmitters removed at the end of the monitoring period.

3.6.3 Potential indicators of success

Potential indicators of success for the vegetated median monitoring will include:

- evidence of regular use of median vegetation by the target glider species;
- evidence of use by dispersing individuals and different age cohorts; and
- use by glider species other than threatened species e.g. sugar glider and greater glider.

3.7 Nest box monitoring

3.7.1 Timing of monitoring

LES (2012d) has proposed that nestbox 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 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 nest boxes;
- checking each box is not holding water or leaking; and
- removing excess nesting material as this may impede access over time.

3.7.2 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.

3.8 Landscape rehabilitation

At the time of EcMP preparation no Landscape Rehabilitation Plan has been prepared for the WC2U project. Therefore, in the absence of such a plan, the objectives for monitoring landscape rehabilitation areas will be based on those applied to similar previous road projects (RTA undated), which will include:

- Plant species must be representative of each of the structural strata (tree, shrub and herb layer) of the target vegetation community;
- All of the species identified with positive or unique fidelity to the target vegetation community;
- At least 50% of the vascular plant species should be representative of the target vegetation community; with a community frequency of 25% or greater;
- Sufficient cover of native herbs established at a density which is sufficient to ensure continuous plant coverage by completion of the landscaping maintenance period;

- Weed species comprise no greater than 5% of all plant species per restored area with exception of 15% in riparian vegetation communities; and
- Weed cover is less than 5% per restored area.

The area to be rehabilitated within the WC2U upgrade project will most likely consist of several target vegetation types and implementation of several rehabilitation methods. Therefore, a minimum of one sampling site will be established within each stratification unit (ie. combination of target vegetation type and rehabilitation method). Additional sampling sites will be established in most of the stratification units to sample responses to variations in microclimate, topographic position and aspect. The intensity of sampling effort will be determined in accordance with the recommended number of sampling sites per stratification unit provided in *Table 3.6*.

Table 3.6: Recommended number of sampling sites depending on stratification unit size.

Size of Stratification Unit (ha)	Minimum Number of Sampling Sites Required
0-2	1
>2-20	3
>20-50	4
>50-100	5

A combination of transect and plot-based sampling techniques will be applied at each sampling site to enable recording of the structural and floristic data required to meet the monitoring objectives.

A 50 metre long tape transect will be established at each sampling site. Foliage projective cover will be recorded at 0.5 metre intervals to enable a quantitative measure of foliage cover of both native and introduced flora species.

A sampling plot will be established at each sampling site to record the condition and composition of vegetation. The dimensions of the sampling plot will be determined by preparing a species-area curve within each target vegetation type. All plant species within the sampling plot will be recorded, along with a visual estimate of vegetative cover for each species using the Braun-Blanquet 1-5 rating system.

A photopoint will also be established at each sampling site to record long-term gross changes in vegetation structure and composition.

Landscape rehabilitation monitoring will commence six months after the establishment of rehabilitation sites. Monitoring will then be conducted every three months for a two year period initially. The need for additional monitoring will be determined following analysis of the monitoring data.

A general traverse of all Landscape Rehabilitation Areas during the baseline sampling and at subsequent six monthly intervals (ie. every second monitoring event) will be conducted to detect and assess incidences of weed encroachment at the broader landscape level.

3.9 In-situ threatened flora populations

3.9.1 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 then 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.

3.9.2 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 2012). 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 (eg. 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.

3.9.3 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 (2012); and
- threatening processes including weed invasion controlled or eradicated.

3.10 Translocation areas

3.10.1 Timing of monitoring

Monitoring of the translocations will be conducted as follows: every three months for the first year; every six months in the second year and once a year thereafter for five years post-construction.

3.10.2 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 (eg. 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.

3.10.3 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 (2012); and
- threatening processes including weed invasion controlled or eradicated.

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; • 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 median vegetation by the target glider species.	• 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.
Frog Monitoring	• absence of green-thighed frogs; • ponds not holding water for a sufficient time to enable tadpoles to reach metamorphosis; • ponds holding water for too long and representing unsuitable habitat; • exotic fish fauna recorded in breeding ponds.	• conduct additional target surveys to confirm continued presence of green-thighed frogs; • modify breeding pond design to ensure appropriate water regime and vegetation structure.

Mitigation Measure	Potential Problems	Potential Contingency Measures
Translocation Areas	• unsatisfactory survival rates for transplanted individuals; • no flowering/seeding occurs in transplanted individuals; • the new or enhanced populations have different growth characteristics to the natural populations; • threatening processes including weed invasion are inadequately controlled.	• increase number of enhancement plantings; • review site characteristics at translocation sites that potentially impact on plant fertility; • extend the duration and/or frequency of monitoring to observe any impacts of different growth characteristics; • review and modify weed management measures.

5 Reporting and Review

The results of the pre-clearing and clearing procedures monitoring will be compiled, analysed and discussed in a report, which will be submitted to the project Environmental Manager upon completion of the construction phase of the Upgrade project. A copy of the report will also be submitted to the Director-General of Planning and OEH.

Monitoring results for all other mitigation measures will be compiled, analysed and discussed in annual reports, which will be submitted to the Director-General of Planning, EPA and OEH. The annual reporting will include review and updating of the EcMP to account for any changes in detailed design, inclusion of additional management plans and identification of control sites.

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PACIFIC HIGHWAY UPGRADE:

WARRELL CREEK TO URUNGA

GIANT BARRED FROG (*Mixophyes iteratus*)

MANAGEMENT STRATEGY

FEBRUARY 2013

PREPARED FOR THE ROADS AND MARITIME SERVICES BY:

LEWIS ECOLOGICAL SURVEYS

Commercial in Confidence

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 (Roads and Maritime Services and their representative: Kristy Harvey/Brett Hoffman). 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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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 tables.

Belinda Bock (Roads and Maritime Services) – Project management and logistics.

Brett Hoffman (Roads and Maritime Services) – Project manager and logistics.

Photography - Lewis Ecological Surveys © else stated

Top – The endangered Giant Barred Frog (*Mixophyes iteratus*) recorded from ch.42565 Upper Warrell Creek.

Report to be cited as: Lewis, B.D (2013). Warrell Creek to Urunga: Giant Barred Frog (*Mixophyes iteratus*) Management Strategy. Report prepared for 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)

Distribution History:

Rev.	Date	Description	Issued To	Position	Name
A	15.6.2012	Draft for comment	Roads and Maritime Services	Environmental Officer	Kristy Harvey
B	20.6.2012	Draft for comment	Roads and Maritime Services	Environmental Officer	Kristy Harvey
C	29.6.2012	Final	Roads and Maritime Services	Environmental Officer	Kristy Harvey
D	26.7.2012	Final	Roads and Maritime Services	Environmental Officer	Kristy Harvey
E*	31.10.2012	Final	Roads and Maritime Services	Environmental Officer	Belinda Bock
F	27.2.2013	Final	Roads and Maritime Services	Environmental Officer	Belinda Bock

* 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

Lewis Ecological Surveys (LES) has been contracted by Roads and Maritime Services (RMS) to prepare a management strategy for a population of Giant Barred Frog (*Mixophyes iteratus*) recorded during targeted frog surveys for the Warrell Creek to Urunga Pacific Highway Upgrade project (Lewis in prep). This species is currently listed as an endangered species pursuant to the NSW *Threatened Species Conservation* Act (1995) and Commonwealth *Environment Protection and Biodiversity Conservation* Act (1999) given that it has disappeared from much of its historic range (*see* Cogger 1995). Remnant populations of Giant Barred Frog face a number of threats including:

- Chytrid fungal disease;
- Vegetation clearance;
- Reduction in water quality, from sedimentation or pollution;
- Changes in water flow patterns, either increased or decreased flows;
- Reduction of leaf-litter and fallen log cover through burning;
- Timber harvesting and other forestry practices;
- Predation on eggs and tadpoles by introduced fish;
- Weed spraying close to streams; and (*see* Mahony 1993; Mahony *et al.* 1997; NPWS 1998; Berger et al. 1999; Hines *et al*. 1999; Lemckert 1999; Lemckert and Brassil 2000; Lewis and Rohweder 2005).

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.

During targeted surveys between December 2011 and October 2012 (i.e. summer/spring) a population of Giant Barred Frogs was recorded at Upper Warrell Creek at ch. 42565 with 1 adult female (Snout-vent 120 mm) recorded ~30 m downstream of the RMS project boundary (Figure 1-1; Lewis in prep). The individual was completely exposed above the leaf litter and sitting close to vegetative groundcover. Suitable habitat was also identified at nearby Butchers Creek (Ch. 43365) and further north within the Nambucca Heads to Urunga section of the upgrade at Boggy Creek (Ch. 62765) and McGraths Creek (Ch. 71965). The remaining creeks were considered less likely to contain Giant barred Frogs and the rivers (i.e. Kalang, Nambucca) and some creeks (i.e. Deep Creek) are saline and do not represent frog habitat.

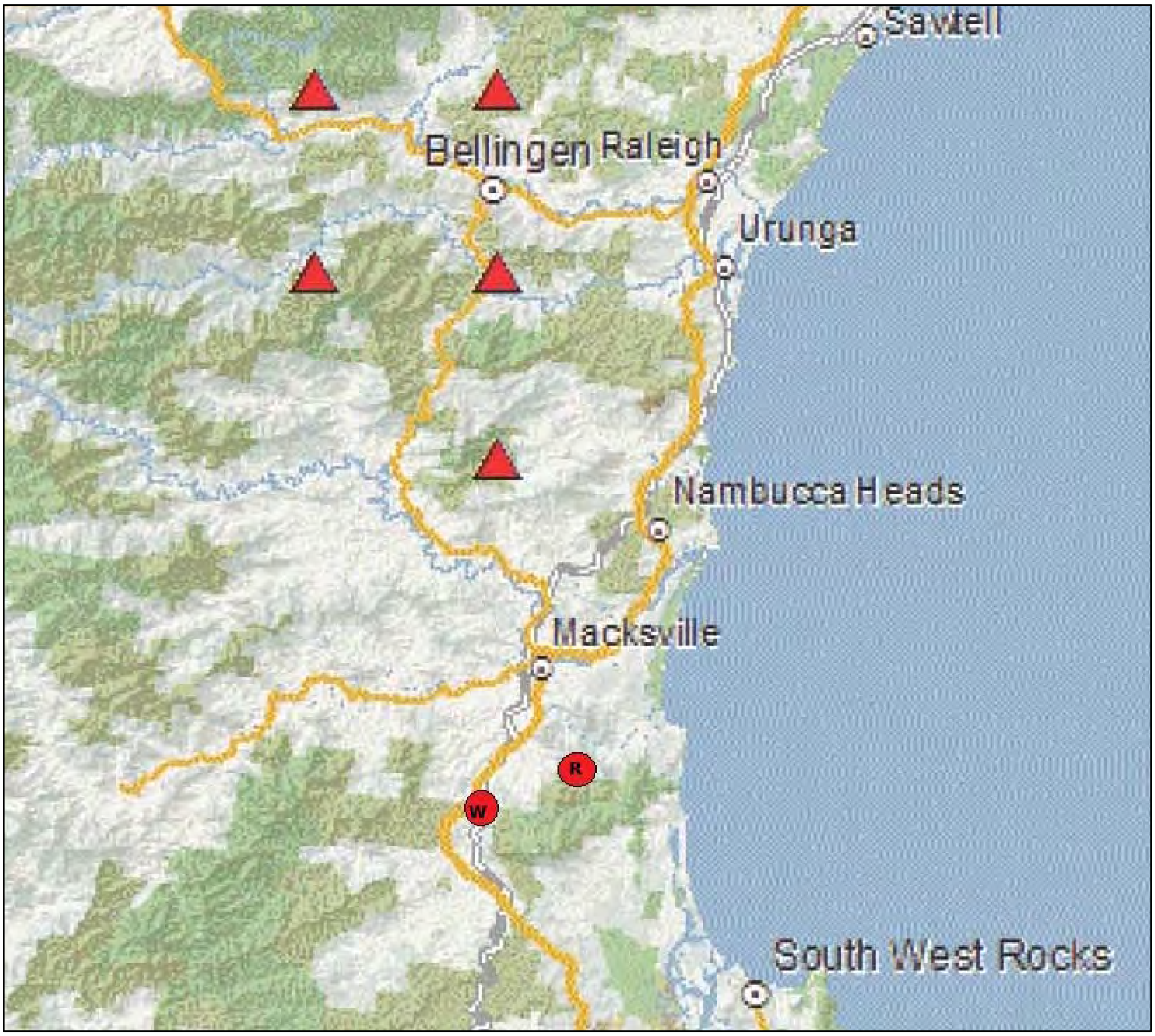

Figure 1-1. Regional historic distribution (red triangles) of Giant Barred Frog (*Mixophyes iteratus*) in the Warrell Creek to Urunga including the Warrell Creek (W) and reference site (R) record (red circles) from the field survey of Lewis (in prep). Source: Wildlife Atlas April 2012 www.bionet.nsw.gov.au/

2.0 MANAGEMENT PROCEDURE

Six management strategies have been proposed as a means to avoid, minimise and mitigate impacts to the Giant Barred Frog. They include:

1. Identification of Giant Barred Frog habitat;
2. Further surveys at Butchers Creek, Boggy Creek and McGraths Creek to finalise presence/absence (Figures 2-1; 2-2; 2-3),
3. Protection of known Giant Barred Frog habitat;
4. Pre-clearing Surveys to be implemented in three stages of:
    a. Early works when establishing site controls (i.e. clearing limits for clearing and grubbing);
    b. Pre-clearing survey within 5 days of commencing the clearing and grubbing program;
    c. Clearing supervision during the clearing and grubbing program; and
    d. De-watering procedures within areas identified as Giant Barred Frog habitat.
5. Frog fencing in areas of Giant Barred Frog habitat considered in the context of:
    a. Temporary frog fencing; and
    b. Permanent frog fencing.
6. An unexpected finds procedure to address instances where Giant Barred Frogs are detected during routine pre-clearing surveys or at other times during the project.

2.1 Identification of known and Potential Giant Barred Frog Habitat

Giant Barred Frog is known to occur at Upper Warrell Creek at ch. 42565 (Lewis in prep; Figure 2-1). Suitable or likely habitat was identified at nearby Butchers Creek (Ch. 43365) and further north within the Nambucca Heads to Urunga section of the upgrade at Boggy Creek (Ch. 62765) and McGraths Creek (Ch. 71965; Figures 2-1; 2-2; 2-3). The following section provides an opportunity for RMS to address the status of Giant Barred Frogs at those three sites identified as 'likely' habitat.

2.2 Further Surveys (Contractor)

The contractor (or RMS if contract has not been awarded) will perform further surveys at Butchers Creek, Boggy Creek and McGraths Creek (Figures 2-1; 2-2; 2-3). The survey program at each site will be as follows:

- 1 km transect with 450 m either side of the construction footprint (100 m represents construction footprint);
- The duration for this transect should be set at 2 person hours;
- Surveyed on two non-consecutive nights in spring[1] and two in summer. Combined with the earlier works performed by SKM (2010) and more recently Lewis Ecological Surveys (Lewis in prep) each of these sites will have been surveyed over a number of years and seasons.

The outcome of these surveys should provide a confidence interval capable of stating presence or absence for Giant Barred Frogs at the site. If the frogs are deemed to be absent then Giant Barred Frog management strategies will not be required at those sites. If Giant Barred Frogs are recorded then these surveys should transform immediately into a monitoring event as per Section 3.0 of this management strategy. This management strategy would then be updated accordingly.

[1] RMS to do this if the contract has not been awarded.

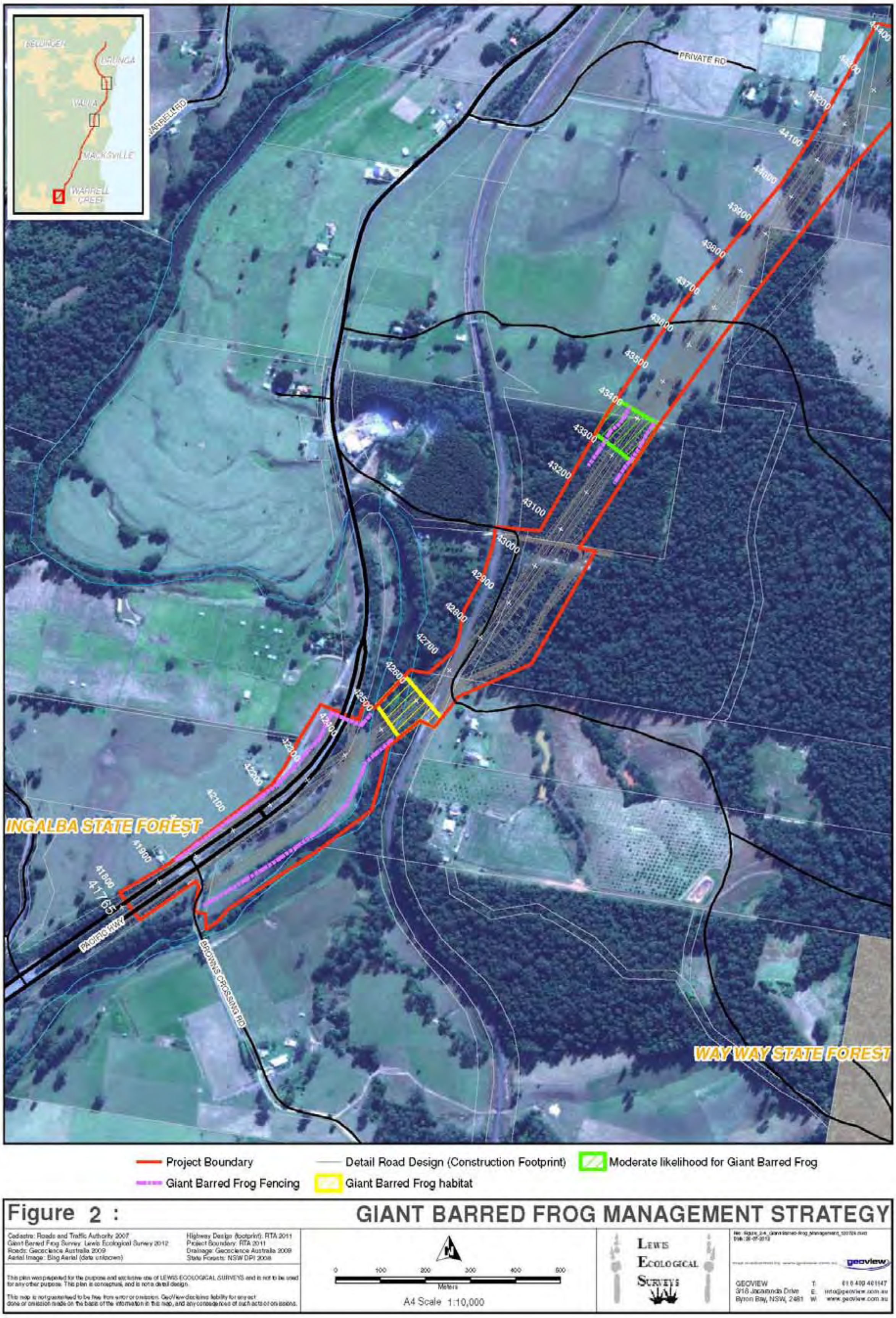

Figure 2-1. Giant Barred Frog known habitat at Warrell Creek and potential habitat at Butchers Creek.

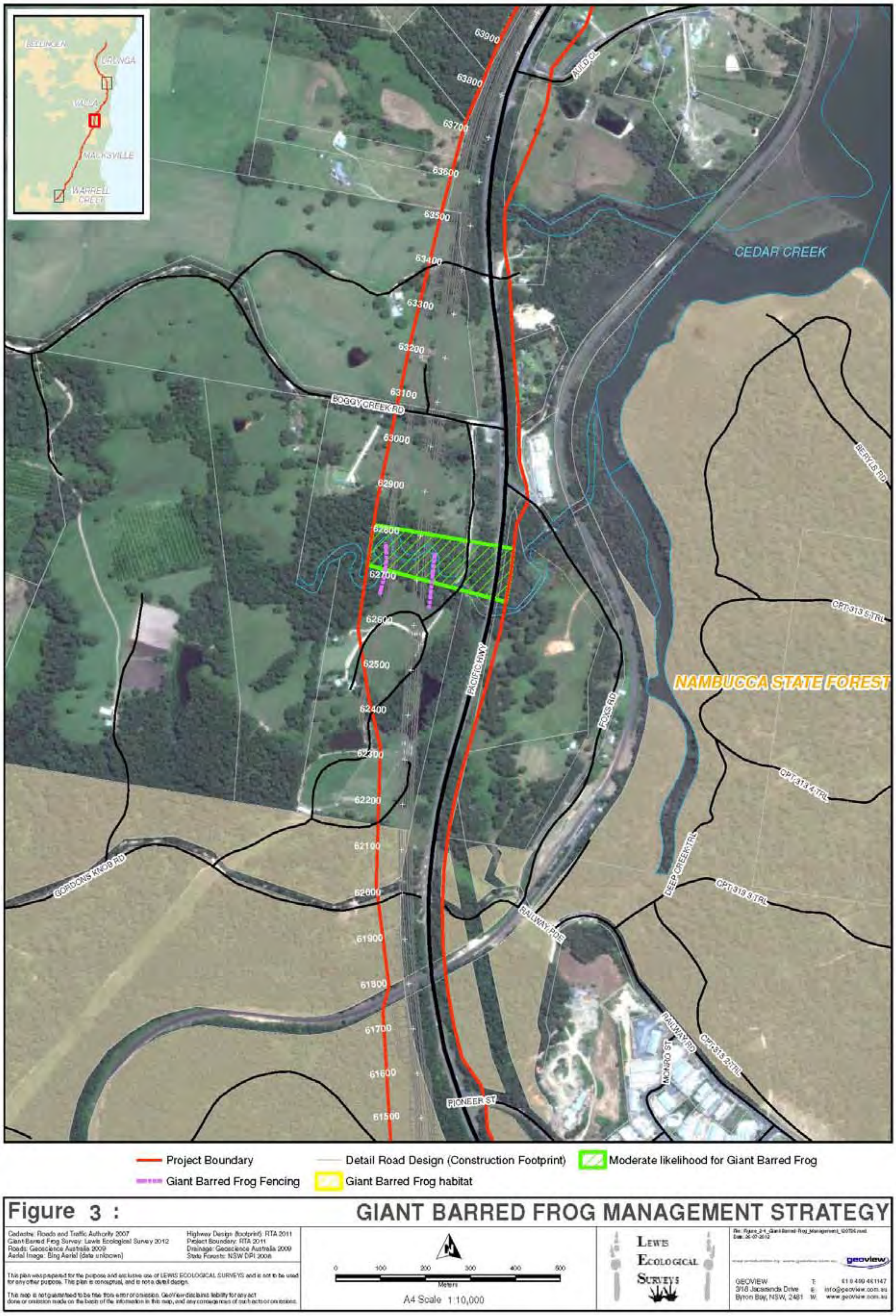

Figure 2-2. Potential Giant Barred Frog habitat at Boggy Creek.

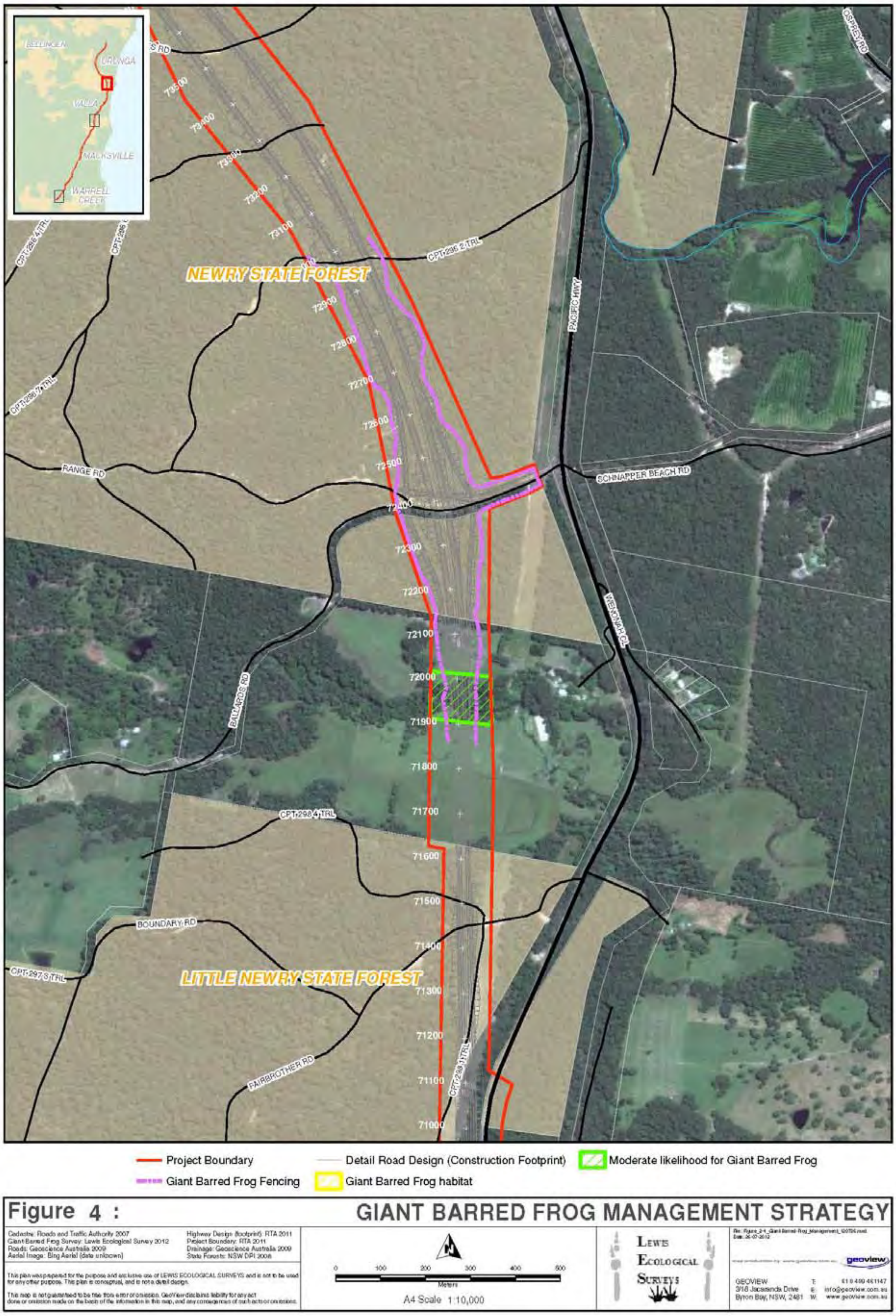

Figure 2-3. Potential Giant Barred Frog habitat at McGraths Creek.

2.3 Protection of Existing Habitat

Following the identification of Giant Barred Frog habitat (*see* Section 2.1 and 2.2 above), these areas (Upper Warrell Creek at ch. 42565, Butchers Creek at ch.43365, Boggy Creek at ch. 62765 and McGraths Creek at ch. 71965) should 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 should 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.

2.4 Pre-clearing surveys

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 the four identified sites (*see* Section 2-1) the following pre-clearing survey procedure will be performed.

2.4.1 Early Works – Establishing Site Controls (Temporary Frog Fencing)

a) The works area for the temporary fencing is inspected/searched by 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)[2]. 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 an ecologist with sufficient frog expertise. This procedure should form part of the pre clearing/ground disturbance checklist/permit.

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 within 5 days of nominated clearing start date.

[2] 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.

2.4.2 Pre-clearing Survey for Frogs

a) Within 5 days 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).

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.

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 300 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[3] 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. This protocol will be in accordance with Department of Environment and Climate Change DECC (now EPA) Hygiene protocol for the control of disease in frogs Information Circular Number 6.

2.4.3 Clearing Supervision

a) At the four identified sites 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 2.4.2 c) and 2.4.2 d).

c) The need to perform additional night time surveys will be at the discretion of the Project Ecologist. For example, only part of the site may have been cleared or more suitable weather conditions present an increased opportunity to detect frogs.

2.4.4 Dewatering Procedures in Giant Barred Frog areas

a) The dewatering process will be conducted 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.

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.

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[3] Passive Integrated Transponder (i.e. microchip as used to mark and identify domestic animals).

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 will be identified and sorted by species and/or genus and placed into separate 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.

2.5 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 the following chainages:
   i. Ch. 41965-42515 (southern/western side of Upper Warrell Creek);
   ii. Ch. 43265-43415 (Butchers Creek);
   iii. Ch. 62665-62855 (Boggy Creek); and
   iv. Ch. 71865-73015 (McGraths Creek).

Design wise, the frog fencing must 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 2-4). This design is about to be installed for the Kempsey Bypass Project and has the support of 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[4]. 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

[4] This will also be detailed in the EMS required for the project.

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.

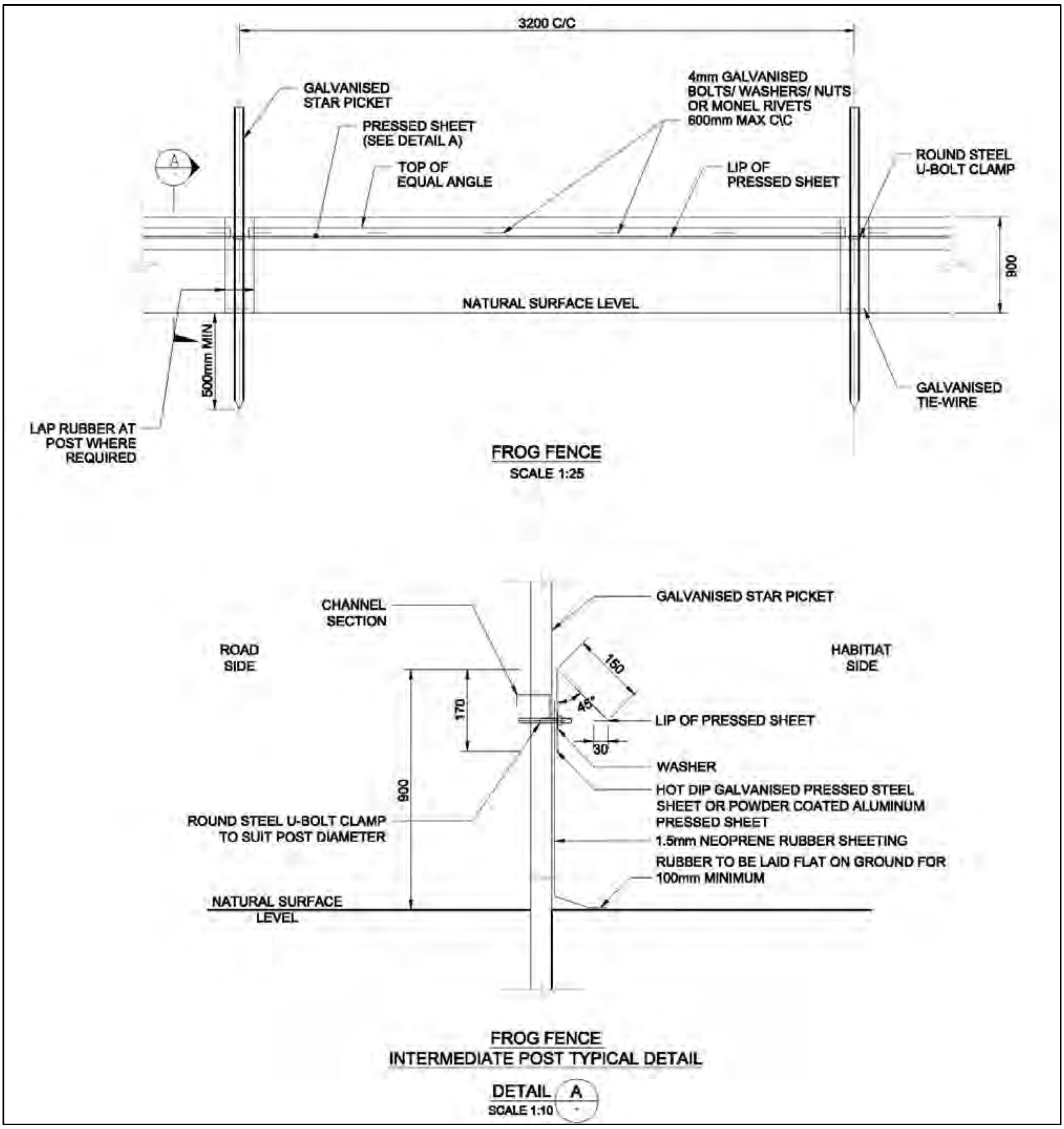

Figure 2-4. Example of a frog fence design for Warrell Creek to Urunga.

2.6 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, hundreds of metres when the clearing footprint will rarely extend beyond 120 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 specialist;
4. Implementation of the monitoring program in accordance with Section 3.2 and the performance measures outlined in Section 4.0 of this management strategy.

3.0 MONITORING OF THE MANAGEMENT STRATEGIES

There are three concerns with the Giant Barred Frog and the Pacific Highway Upgrade program between Warrell Creek and Urunga. They include:

1. Direct mortality of frogs resulting in further population declines;

2. Deterioration of habitat quality in the receiving or adjacent environment (i.e. habitat degradation);

3. Population connectivity with the construction footprint severing habitat; and

4. The potential introduction or spread of the chytrid fungus.

Whilst this management strategy demonstrates how the project will minimise these impacts there is a need to demonstrate how successful this has been during the delivery of the project. The following monitoring program provides this and outlines the performance measures associated with the program of works and corrective actions therein.

3.1 Monitoring Sites

At present the monitoring program will be limited to Upper Warrell Creek in the southern part of the project corridor. Opportunity is provided for the adoption of additional sites depending on the outcomes of Section 2.2, 2.4 and 2.6. No reference site will be incorporated into this monitoring program as a means to manage chytrid fungus.

3.2 Monitoring Survey

3.2.1 Frog Surveys

- 1 km transect with 450 m either side of the construction footprint (100 m represents construction footprint);
- The duration for this transect should be set at 2 person hours;
- Baseline data will be collected prior to construction and consist of one survey in spring, summer and autumn (i.e. three surveys). If this is not possible for the Nambucca to Urunga section of the project (i.e. last minute discovery of population) then surveys may be amalgamated into multiple surveys (3) at 6 week intervals. In either instance this approach will provide cues on habitat use within and adjacent to the road corridor leading up to construction.
- Each field survey will entail a meandering transect on both sides of the creek bank with all frogs marked via a PIT tag (i.e. micro-chipped). The objective of PIT tagging is to individually mark each frog with a unique alphanumeric identifier (i.e. code) which can be read via a bar code scanner. Juvenile/sub adult frogs (<40 mm snout vent length) 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.
- For each frog the following information will be collected:
    - Location according to demarcated survey zone;

  - o Sex (male, female, unknown);
  - o Breeding condition with:
    - ▪ males assessed on the colouration of their nuptial pads (i.e. no colour, light, moderate, dark);
    - ▪ females based on whether they are gravid or not gravid (egg bearing).
- Snout-vent length (mm);
- Weight (gms); and
- General condition of the frog (i.e. signs of chytrid).

3.2.2 Tadpole Surveys

Tadpole surveys provide an additional means to assess population structure and as to whether frogs are breeding at the site. The survey procedure will be as follows:

- The 1 km transect id divided up into 100 m zones which will equate to 4-5 zones downstream corridor, one zone within the corridor (i.e. construction site) and 4-5 zones upstream of the road corridor.
- Two bait traps (~300 mm x 200 mm) per 100 m of stream (as described above) and left operating for 3 hrs. This equates to 20 bait traps and 60 hrs of survey effort.
- Tadpole dip-netting to be undertaken opportunistically but the survey effort recorded.

3.2.3. Other Data

Abiotic variables collected during each survey will include:

- Rainfall measured in four scales:
  - o During the survey;
  - o Within past 24 hrs;
  - o Within past 7 days;
  - o With past 30 days.
- Relative humidity measured with wet/dry bulb thermometer at the start and finish of the frog survey;
- Air temperature measured with a thermometer at the start and finish of the frog survey;
- 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).

Anecdotal information including the presence of exotic fish will also be recorded.

Table 3-1. Timing of key actions, responsibilities and documentation requirements for the Giant Barred Frog monitoring.

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 Giant Barred Frog Management Strategy	√								RMS	Construction Environmental Management Plan
Construction										
Habitat Protection		√	√	√					Contractor	Ecological Monitoring Program
Additional/Further Surveys		√							Contractor or RMS if contract has not been awarded	Giant Barred Frog Management Strategy (updated) Ecological Monitoring Program
Pre-clearing Surveys		√	√						Contractor	Ecological Monitoring Program Post Clearing report Giant Barred Frog Management Strategy (updated)
Temporary Frog Fencing		√	√						Contractor	Construction Environmental Management Plan
Permanent Frog Fencing			√	√					Contractor	Ecological Monitoring Program
Unexpected Finds Procedure		√	√	√					Contractor	Giant Barred Frog Management Strategy (updated) Ecological Monitoring Program
Post Construction/Operation										
Monitoring effectiveness of mitigation				√	√	√	√	√	Contractor	Ecological Monitoring Program - Annual reporting

4.0 PERFORMANCE MEASURES

4.1 Ways to Assess Successful Performance of the Management Strategy

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 habitats 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.

4.2 Ways to Assess Unsuccessful Performance of the Management Strategy

Signs of the management strategy being unsuccessful will be based on the following six parameters:

1. Absence of Giant Barred Frog from the monitoring transect once construction has started.

Corrective Action – To employ more broad-scale surveys to determine presence of Giant Barred Frogs further upstream or downstream.

2. Giant Barred Frog injured or dying during the clearing and grubbing program.

Corrective Action –Review the clearing procedures and if necessary the performance of the Project Ecologist or frog specialist undertaken the works. Review the temporary frog fence structure and the need to implement additional controls and/or surveys.

3. Giant Barred Frog being struck by vehicles during either the construction or operational phase of the project.

Corrective Action – Review the integrity of the fence, its design, its extent for either the temporary or permanent fencing.

4. Procedures not being implemented as per the approved Giant Barred Frog management strategy unless the change or adoption of different techniques can be substantiated by a frog expert familiar with the ecology and behaviour of this species.

Corrective Action – Review the procedures that have been implemented. Seek advice from Environmental Protection Authority to demonstrate transparency.

5. The detection of chytrid fungus ‘sick and dying’ frogs.

Corrective Action – Seek advice from Environmental Protection Authority for current best practise.

5.0 REPORTING COMMITMENTS

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 the Department of Planning and Infrastructure. For Nambucca Heads to Warrell Creek, the Year 1 report will be a final assessment of Boggy Creek and McGraths Creek implementing the survey strategy outlined in section 2.2 of this document. If the contract has not been awarded by Spring then RMS will perform this task. The absence of Giant Barred Frogs at this point will represent a final close out document unless this species is discovered in accordance with routine pre-clearing surveys (section 2.4) and/or the unexpected finds procedure (section 2.6).

For the Warrell Creek to Nambucca Heads upgrade, the baseline survey report will be submitted prior to the clearing and grubbing program commencing anywhere within 500 m of either Upper Warrell Creek or Butchers Creek. This should represent a 'hold point' for this stage of the Warrell Creek to Nambucca Heads Upgrade but it should not prevent clearing and grubbing from other parts of the project corridor.

The subsequent monitoring reports will provide an assessment on the performance of the management strategies as per section 4.0 of this report.

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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

Commercial in Confidence

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 (Roads and Maritime Services and their representative: Kristy Harvey/Brett Hoffman). 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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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.

Photography - Lewis Ecological Surveys © else stated

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

TABLE OF CONTENTS

LIST OF FIGURES

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.

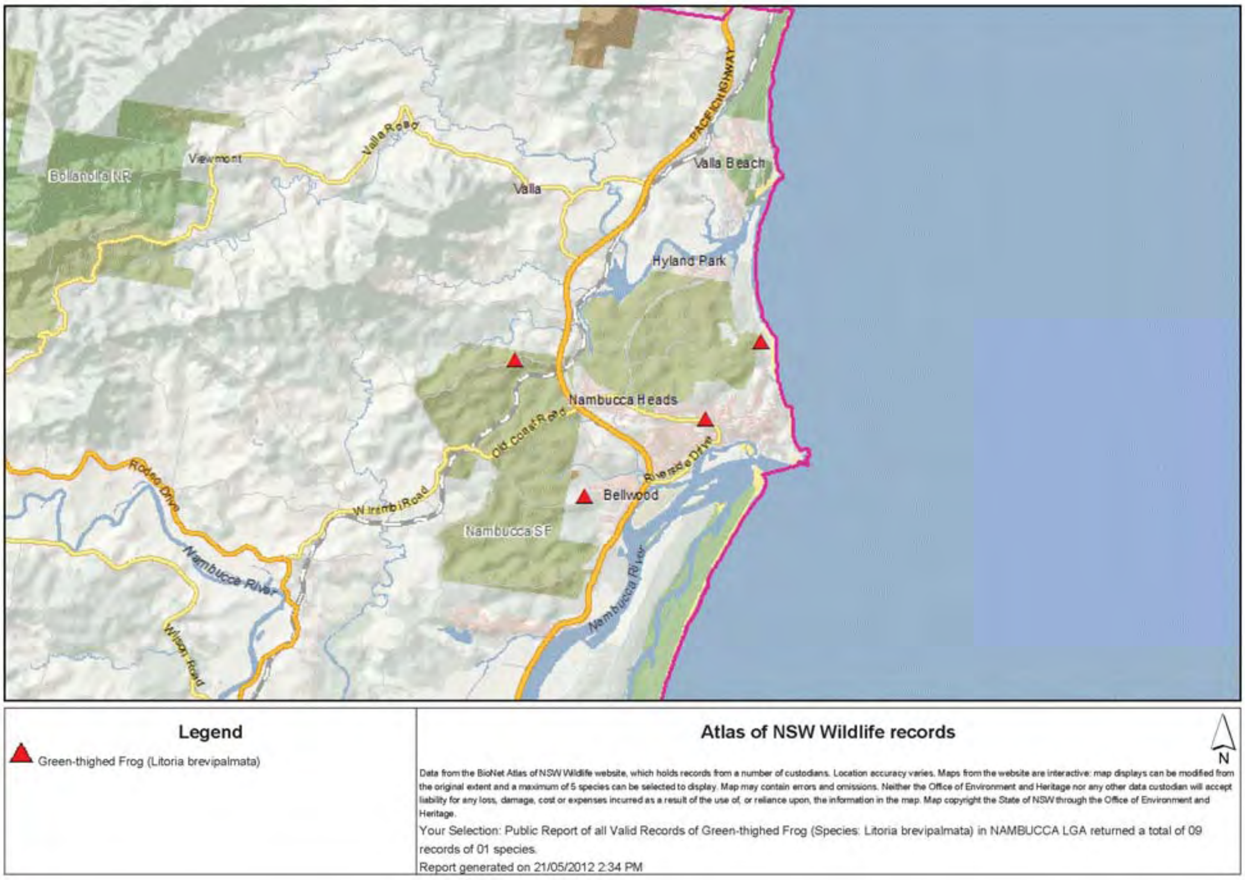

Figure 1-1. Location of documented Green-thighed Frog records.

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

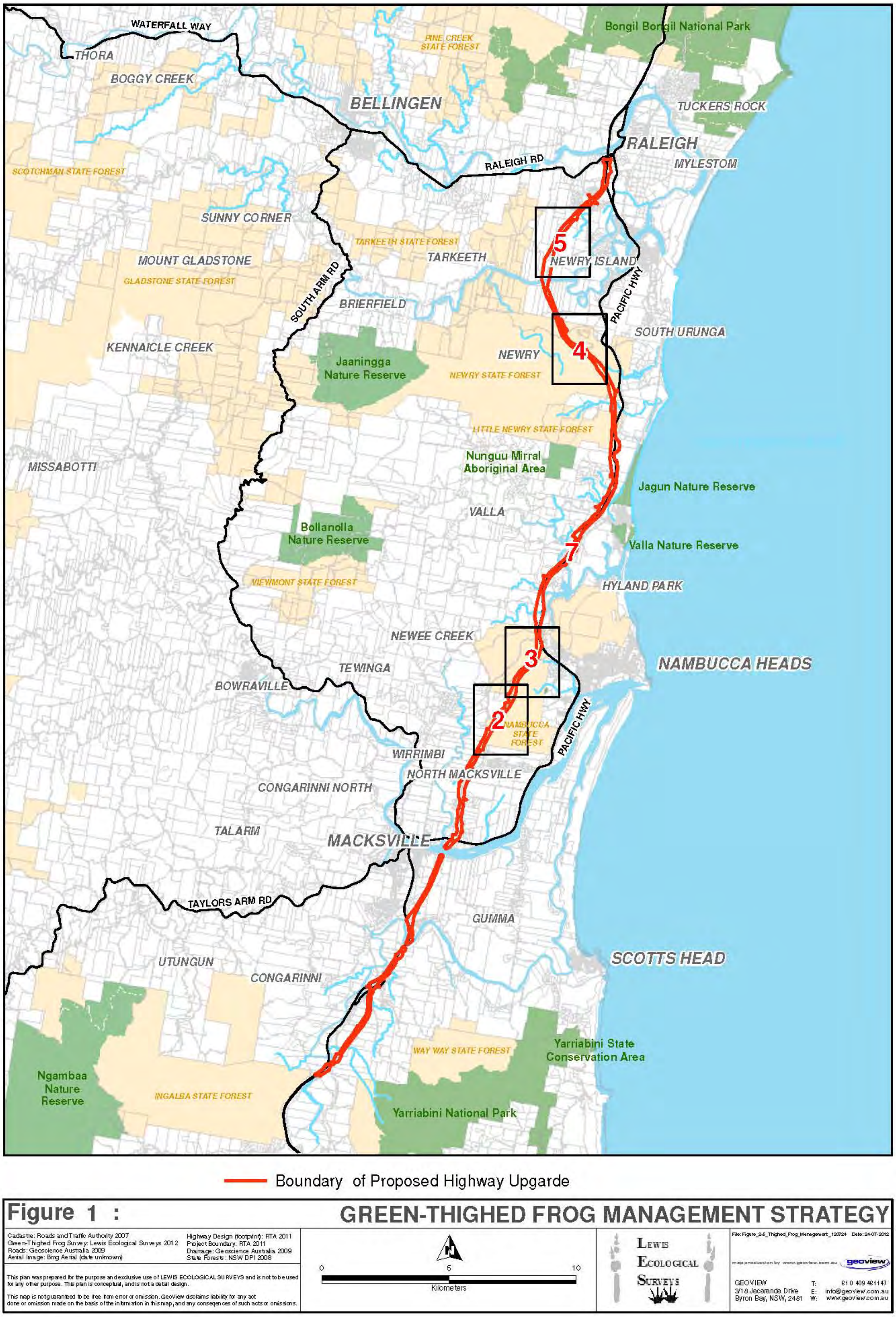

Figure 1-2. Overall of the Warrell Creek to Urunga Project.

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).

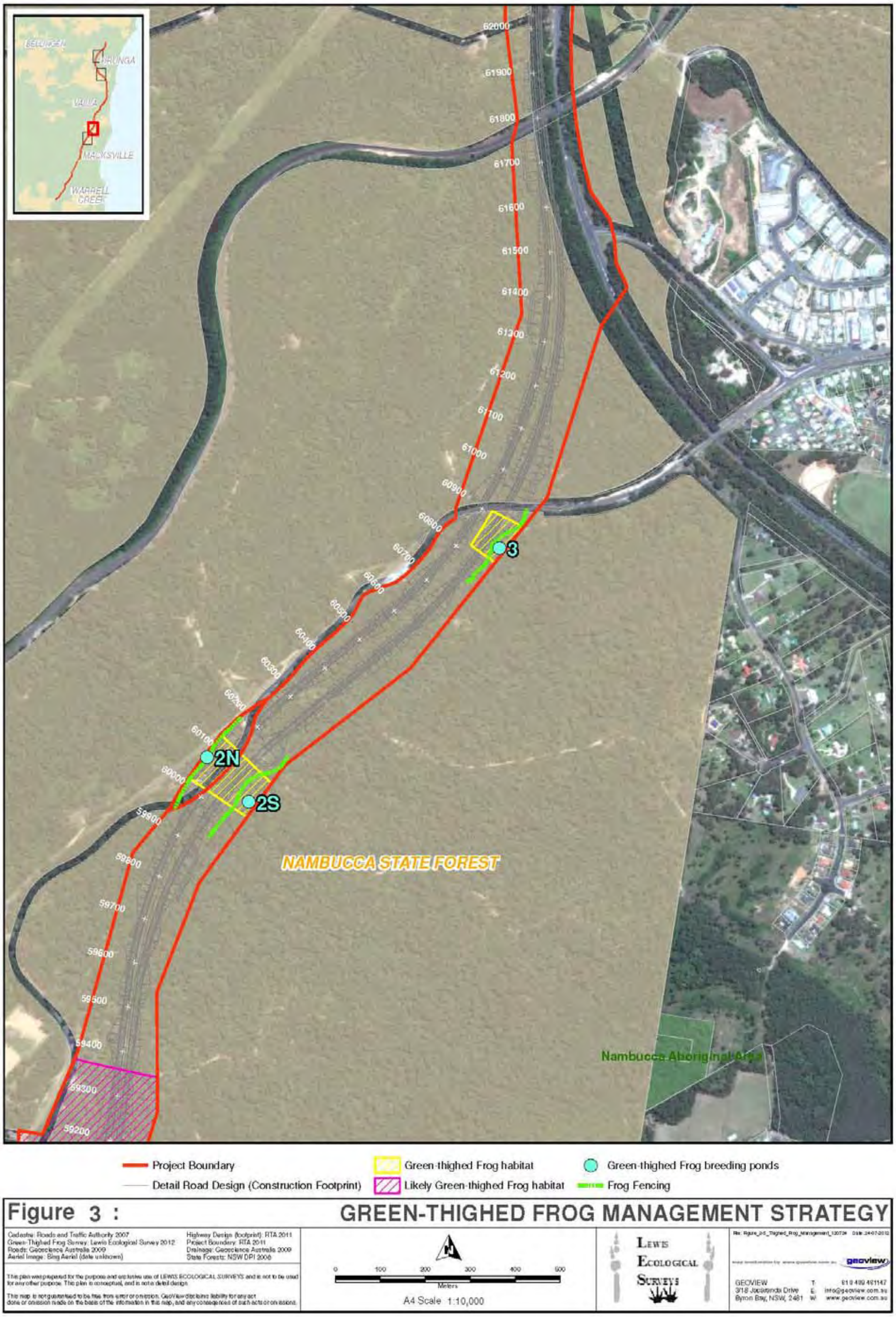

Figure 2-1. Known Green-thighed Frog locations within the RMS corridor and proposed mitigation strategies.

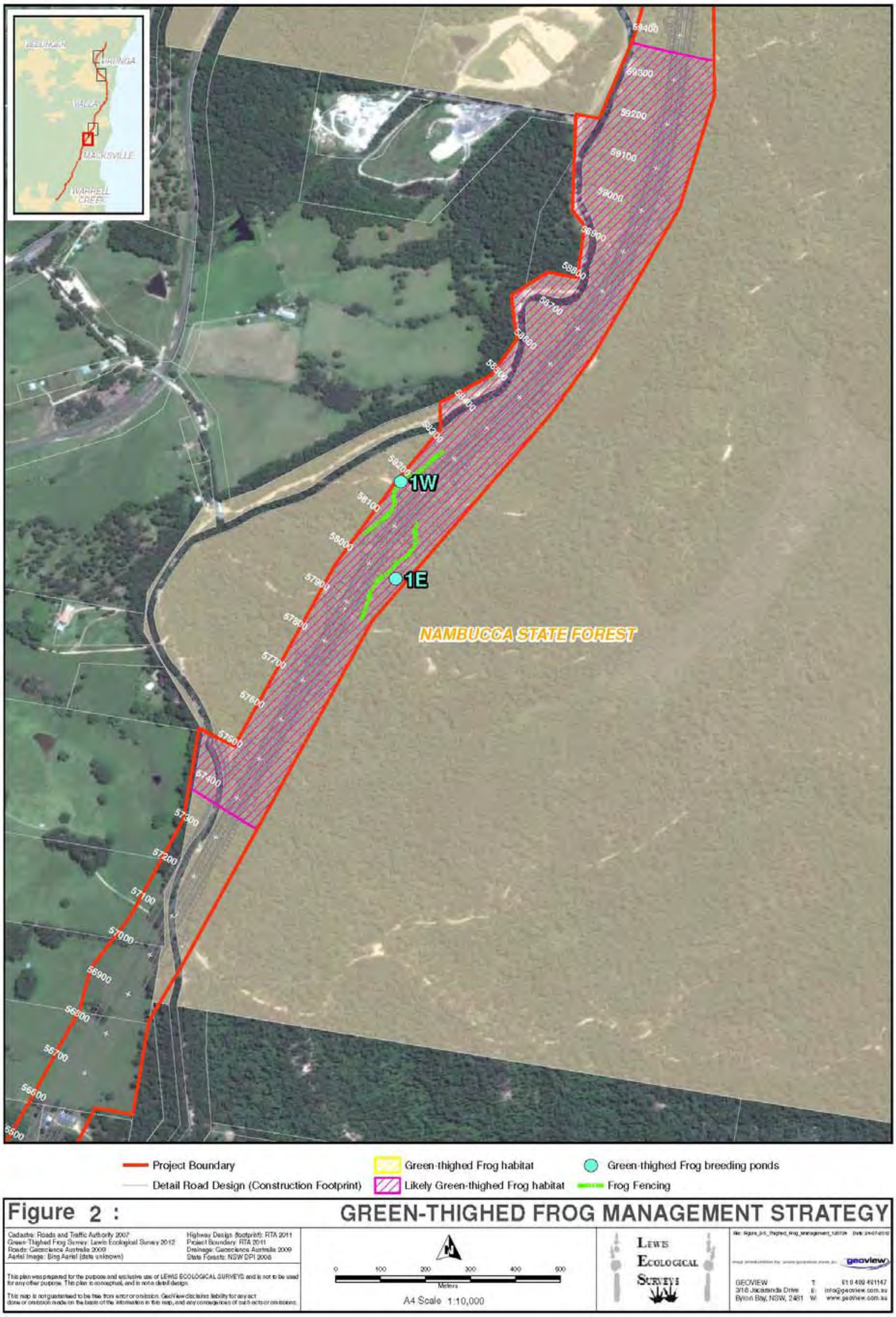

Figure 2-2. Likely Green-thighed Frog habitat within the RMS corridor and proposed mitigation strategies for the southern construction stage Warrell Creek to Nambucca Heads.

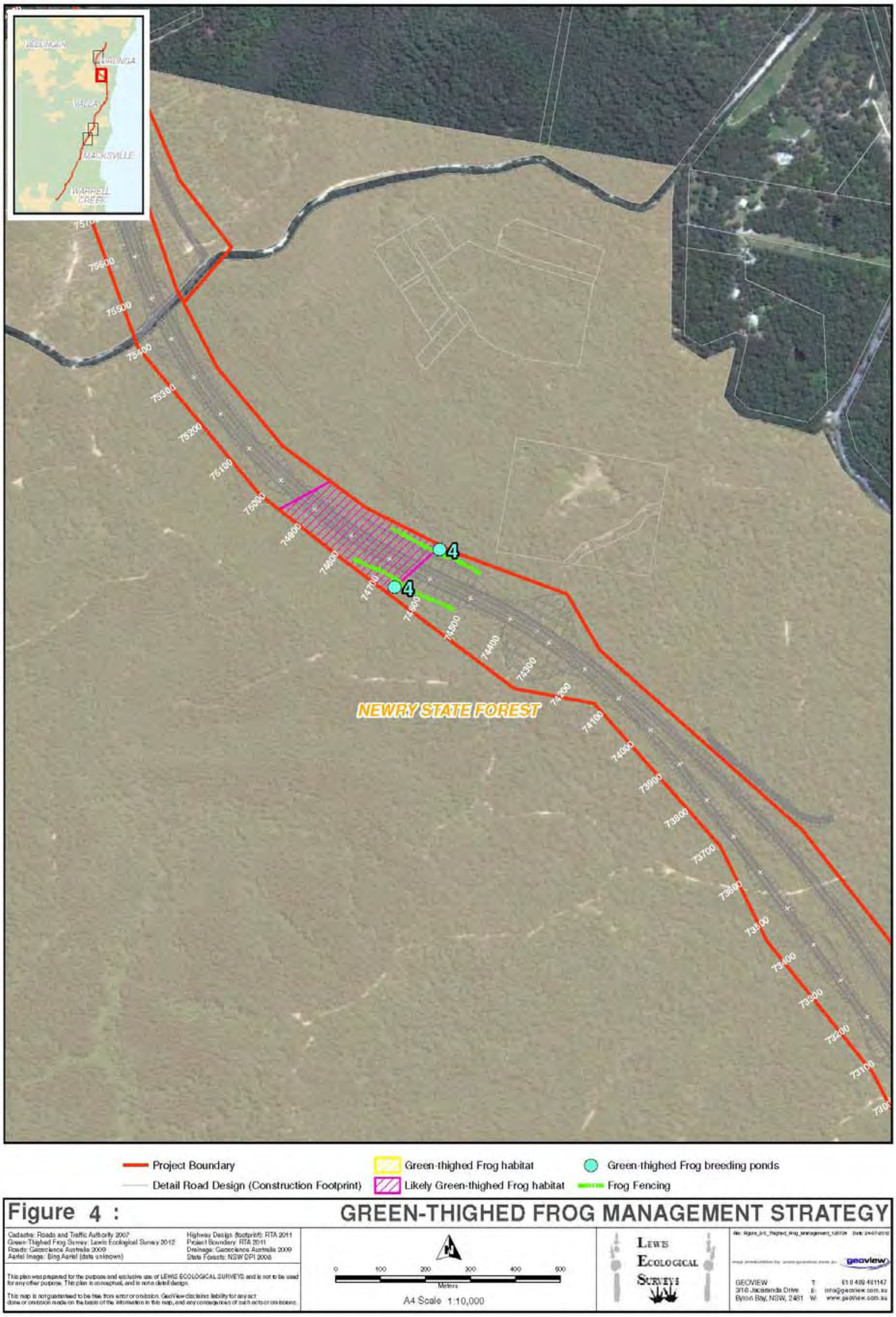

Figure 2-3. Likely Green-thighed Frog habitat within the RMS corridor and proposed mitigation strategies for the northern construction stage Nambucca Heads to Urunga.

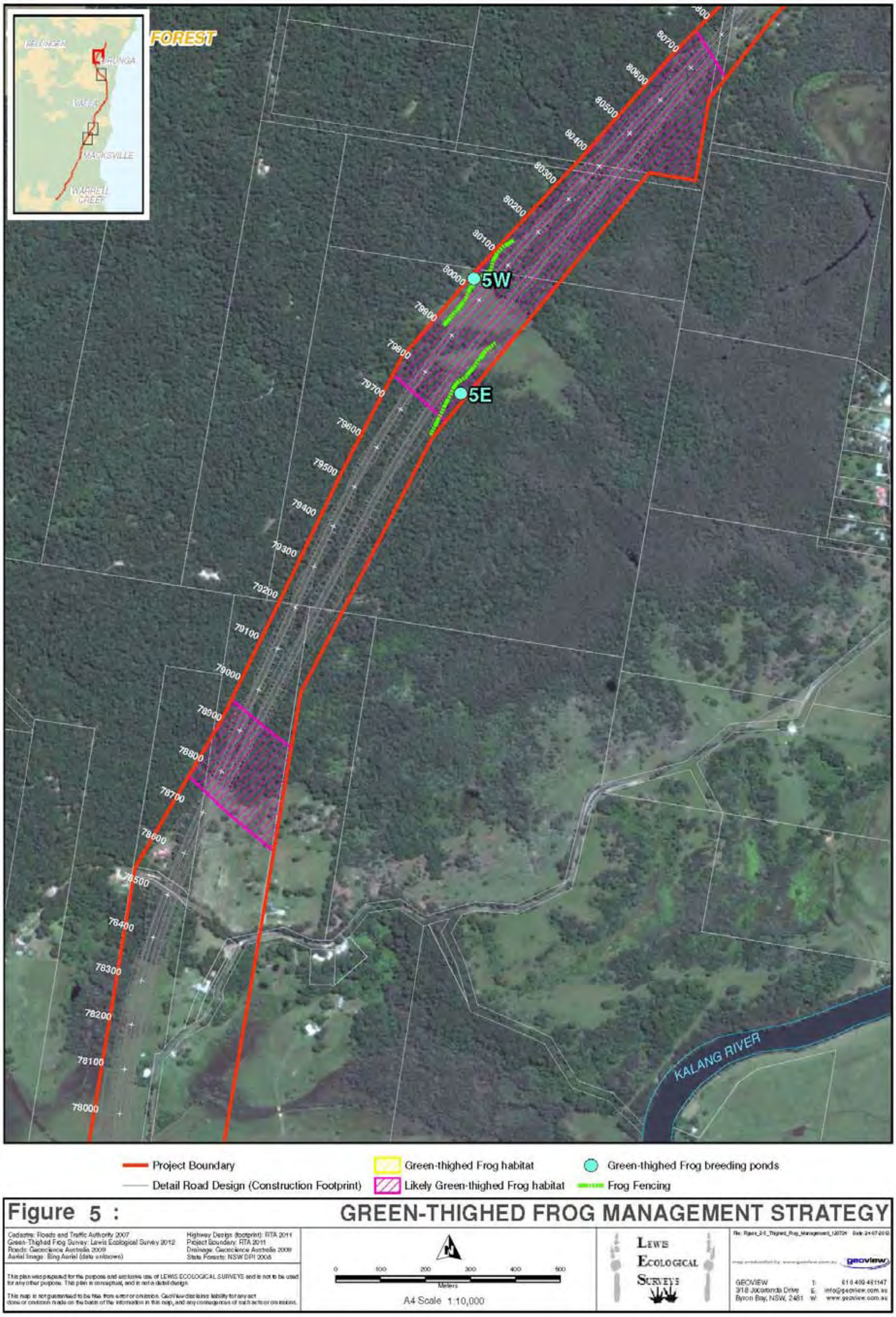

Figure 2-4. Likely Green-thighed Frog habitat within the RMS corridor and proposed mitigation strategies for the northern construction stage Nambucca Heads to Urunga.

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.

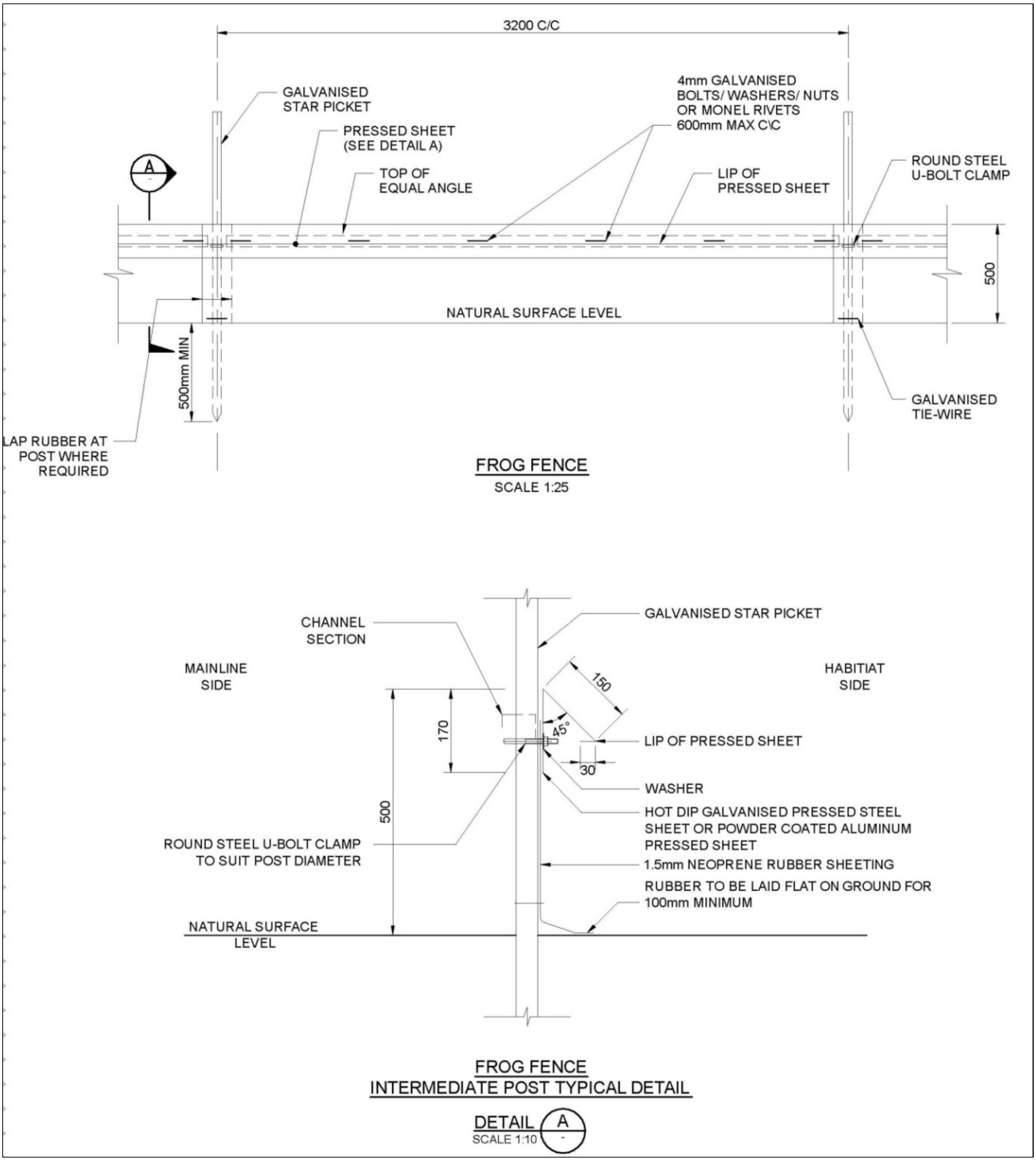

Figure 2-6. An example of frog fence design that could be used for Warrell Creek to Urunga.

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

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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).

<u>Green-thighed Frog Habitat in the study area</u>

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.

<u>Potential impacts of the Upgrade on this species</u>

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.

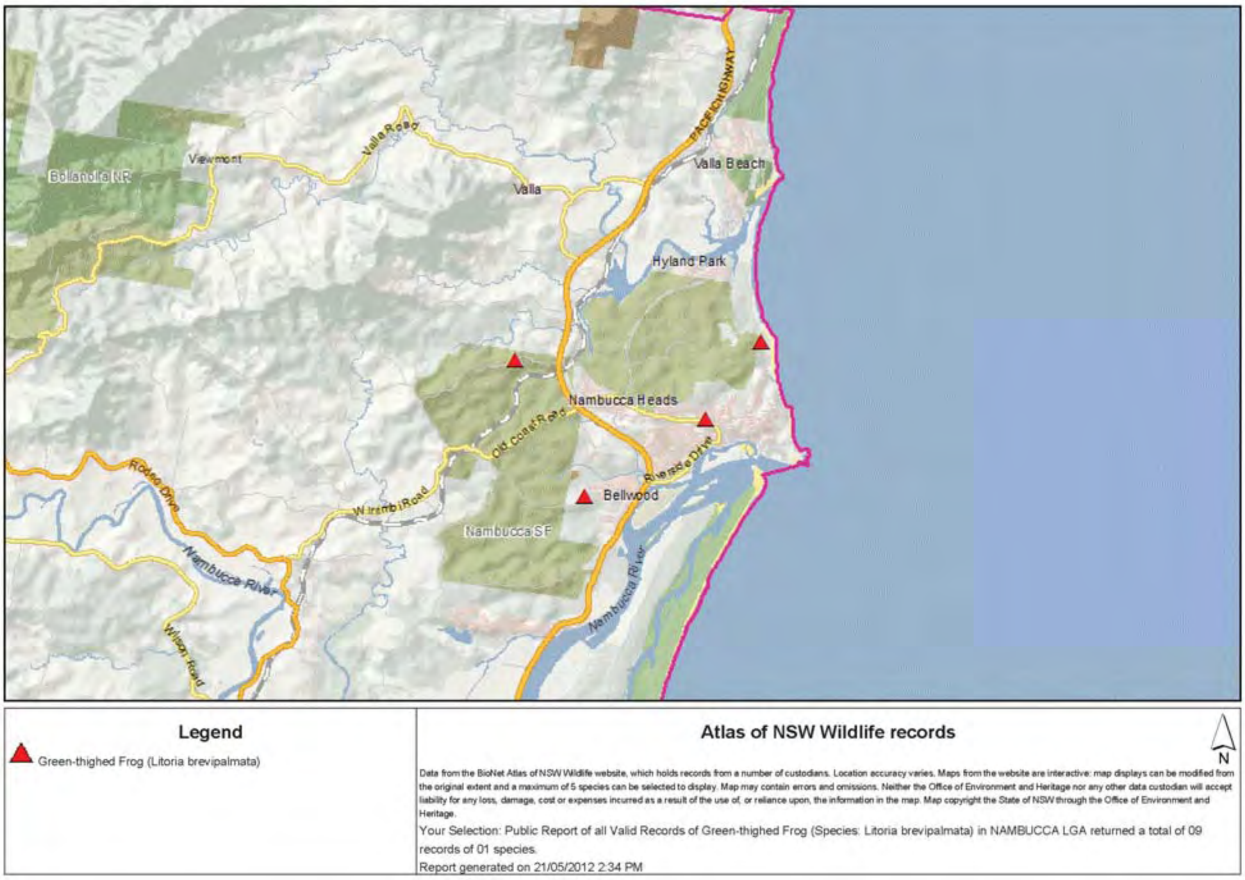

Figure A-1. Location of documented Green-thighed Frog records.

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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PACIFIC HIGHWAY UPGRADE:

WARRELL CREEK TO URUNGA

MICROCHIROPTERAN BAT MANAGEMENT STRATEGY

APRIL 2013

PREPARED FOR ROADS AND MARITIME SERVICES BY:

LEWIS ECOLOGICAL SURVEYS

Commercial in Confidence

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 (Roads and Maritime Services and their representatives: Kristy Harvey/Brett Hoffman/Belinda Bock). 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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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

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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 (2013). 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

* 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)

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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
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'.

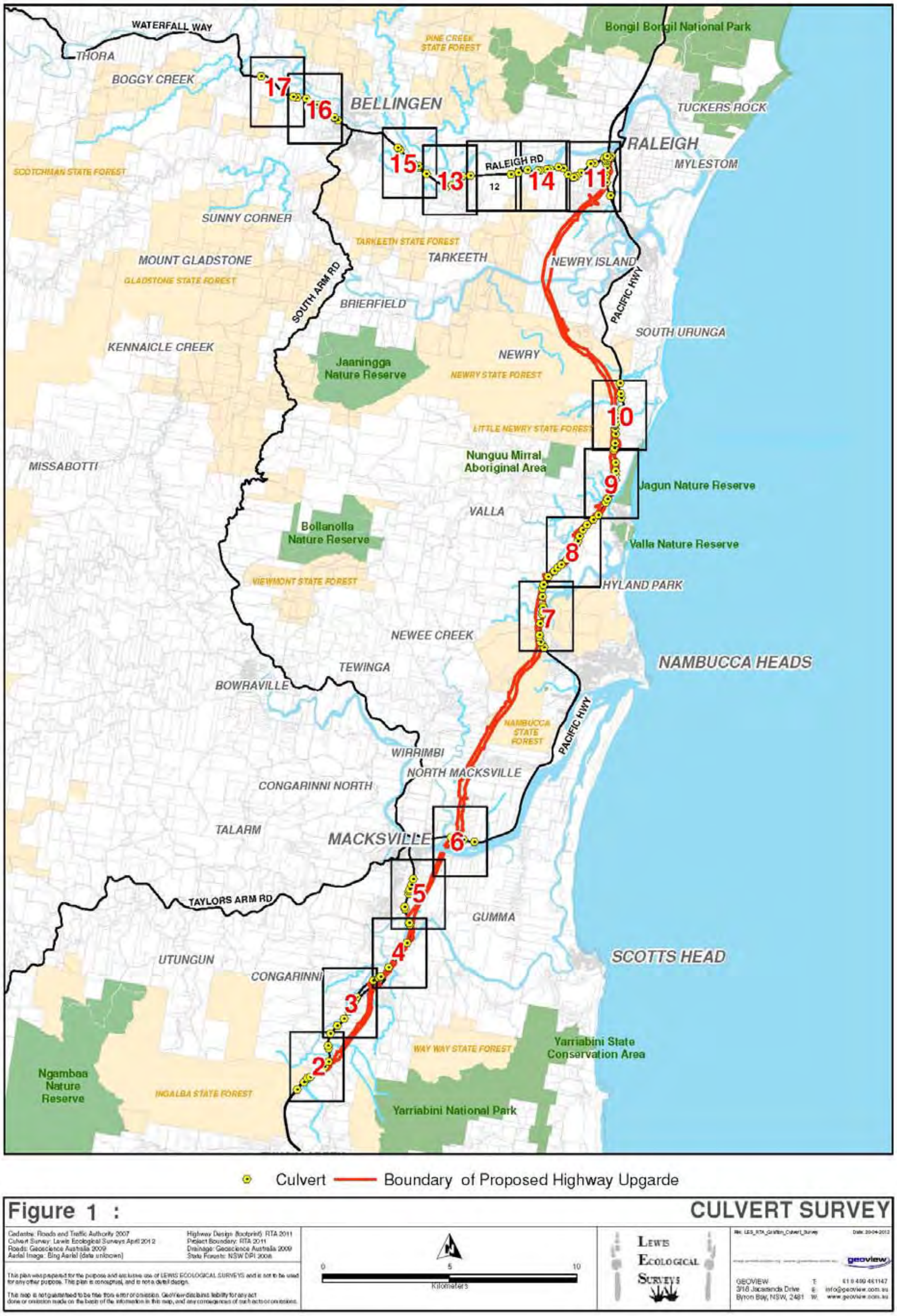


Figure 1-1. Location of culvert structures (inserts 1-11) relevant to this management strategy.

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.

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 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

[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.

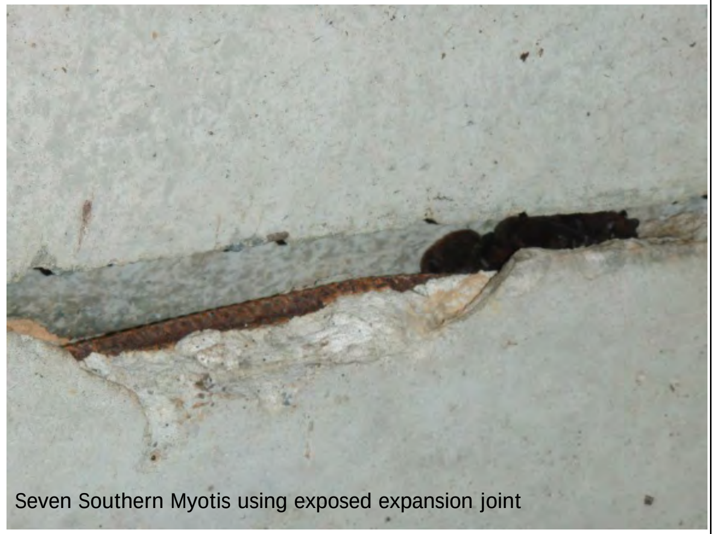
A subjective scale has been developed to qualify the likelihood of a particular bat species using each of the culvert structures (Table 4-1). In this context, biological traits (i.e. breeding/overwintering) that have been assigned as ‘moderate’ or ‘high’ have a real possibility of occurring in the particular 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
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
			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, 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 1), B, C, D, E1, E2, G1, G2
			Eastern Horseshoe Bat	Low	Low	E1, E2	B, D, 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, D, E1, E2	A (option 2), B, C, E1, E2, G1, G2
		Gould's Wattled Bat	-	Moderate	Moderate	E1, E2	B, D, E1, E2	A (option 2), B, C, E1, E2, G1, G2
			Little Bent-wing Bat	Low	Moderate	E1, E2	B, D, E1, E2	A (option 2), B, C, E1, E2, G1, G2
			Eastern Horseshoe Bat	Low	Low	E1, E2	B, D, E1, E2	A (option 2), B, C, E1, E2, G1, G2

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
Warrell Creek Bridge (1871) 	No pic	Little Bent-wing Bat	-	Low	High	E1, E2	B, D, E1, E2	B, C, E1, E2, G1, G2
		Forest Bat (*Vespadelus spp*)	-	Low	Low	E1, E2	B, D, E1, E2	B, C, E1, E2, G1, G2
			Southern Myotis	High	Moderate	E1, E2	B, D, E1, E2	A (option 2), B, C, E1, E2, G1, G2
			Gould's Wattled Bat	Moderate	Moderate	E1, E2	B, D, E1, E2	A (option 2), B, C, E1, E2, G1, G2
			Eastern Horseshoe Bat	Low	Low	E1, E2	B, D, E1, E2	B, C, E1, E2, G1, G2
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

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
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
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, D	E1, E2, B, A, C, D, G1, G2
		Southern Myotis	Low (typically have water beneath – this is a dry passage culvert)	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
599229 	No pic	Little Bent-wing Bat	Low	Moderate	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	Low	Moderate	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, D, G1, G2
599237 		Little Bent-wing Bat	Low	High	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, D, G1, G2
		Southern Myotis	Low (typically have water beneath – this is a dry passage culvert with high cattle use)	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

Structure	Roost Habitat	Species to Consider	Breeding Site	Overwintering	Works 100-200 m from roost	Works Within 100 m	Works on the structure
599238 	No pic	Little Bent-wing Bat	Low	High	E1, E2, B	E1, E2, B, D	E1, E2, B, A, C, D, G1, G2
		Southern Myotis	Low (typically have water beneath – this is largely a dry passage culvert)	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
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

Structure	Roost Habitat	Species to Consider	Breeding Site	Overwintering	Works 100-200 m from roost	Works Within 100 m	Works on the structure
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

Structure	Roost Habitat	Species to Consider	Breeding Site	Overwintering	Works 100-200 m from roost	Works Within 100 m	Works on the structure
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	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
Bridges							
Boggy Creek Bridge (6696) 		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	Very Low	Low	E1, E2, B	E1, E2, B, D	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								
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								
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								
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
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.

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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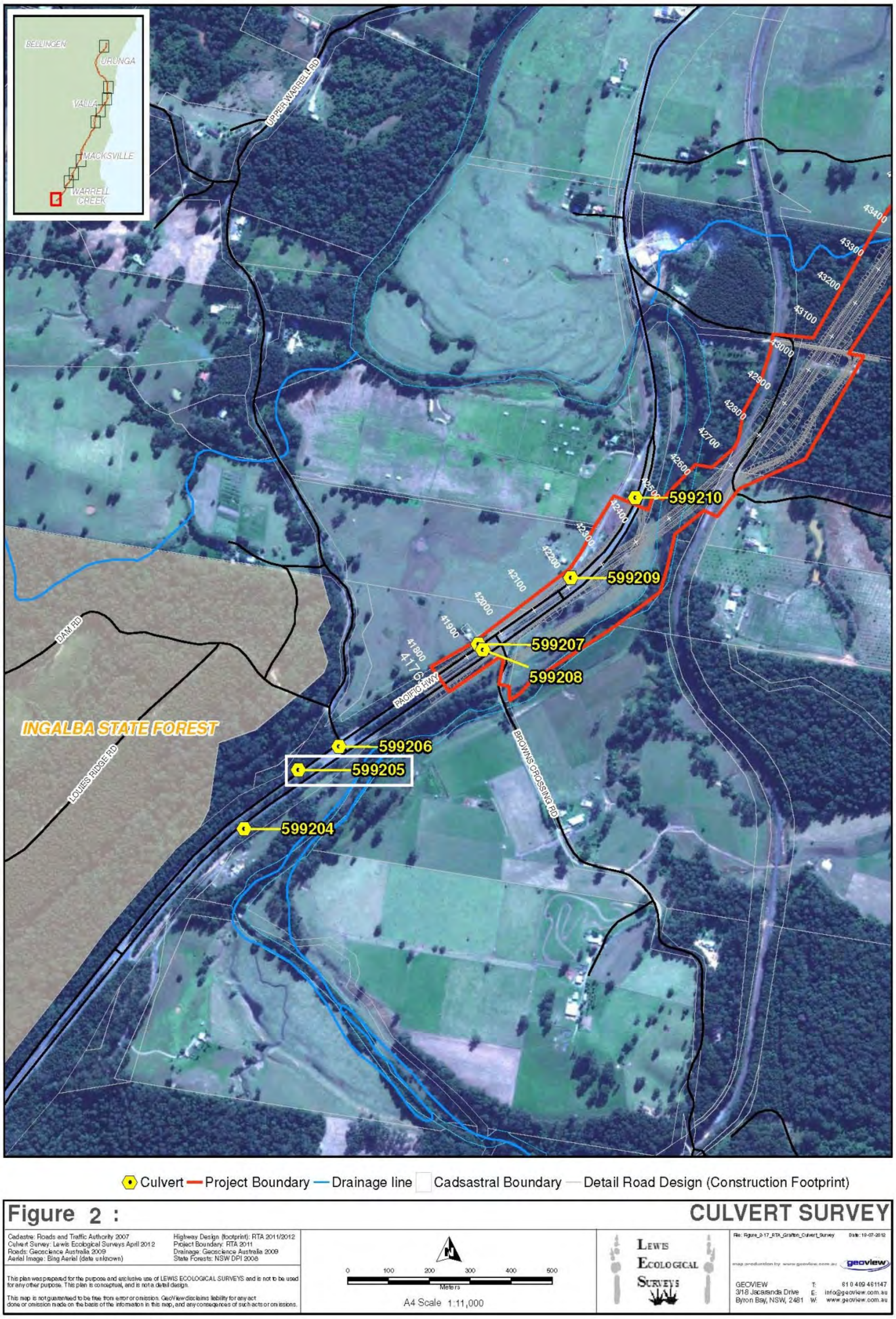
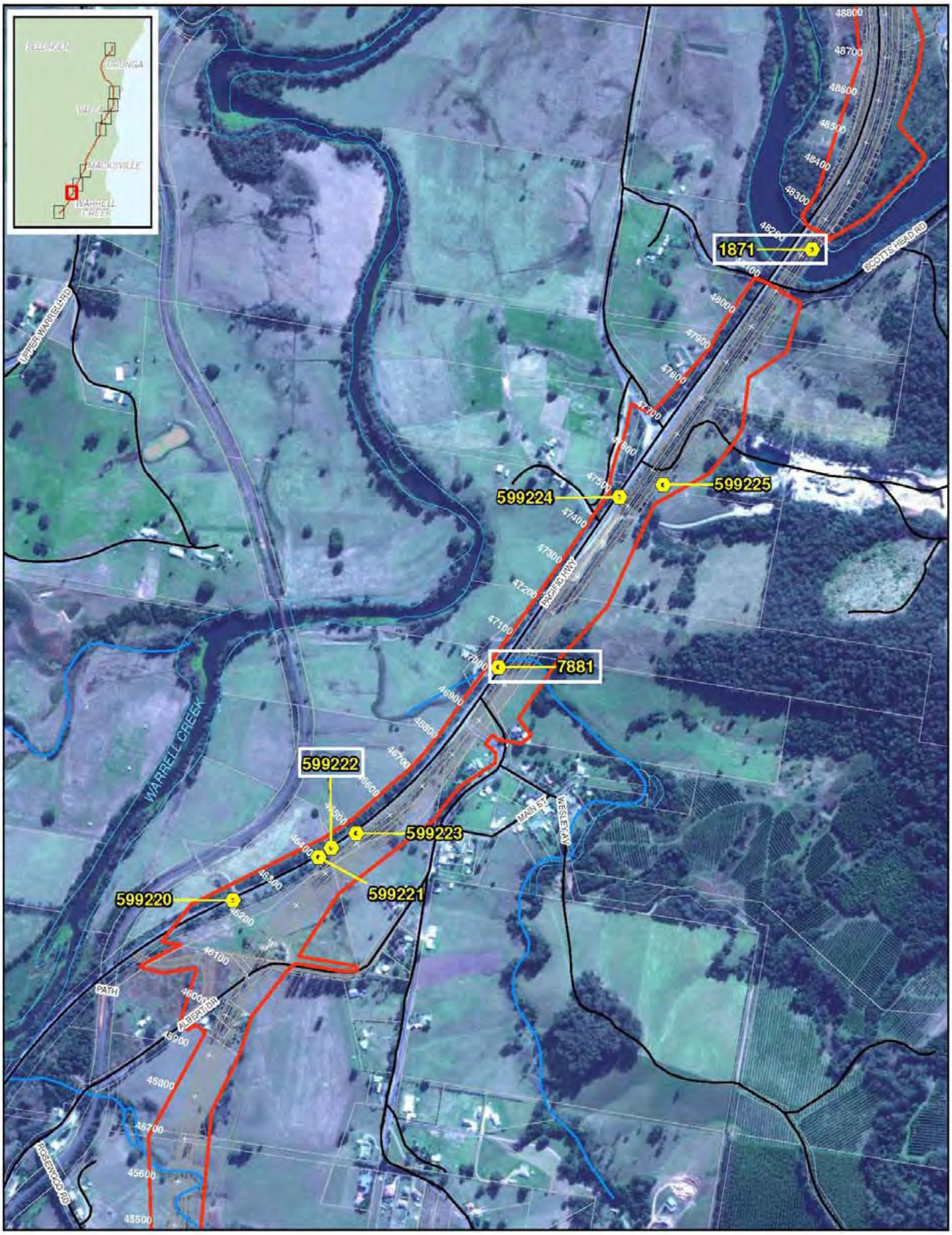
7.0 APPENDIX 1 – CULVERT AND BRIDGE LOCATIONS

Note – White boxes around culverts depicts culverts representing micro bat habitat.





Culvert — Project Boundary — Drainage line — Cadsastral Boundary — Detail Road Design (Construction Footprint)

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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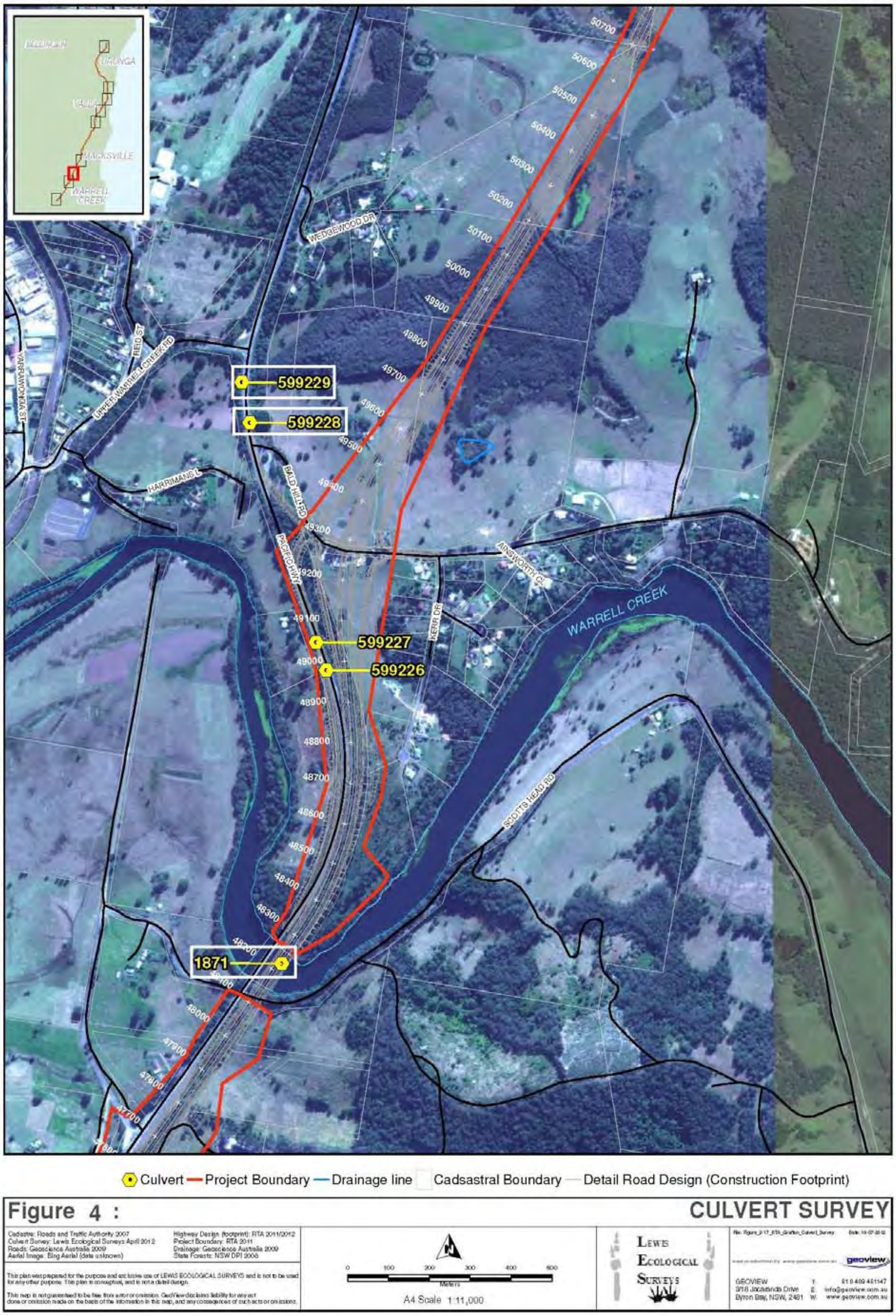
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MACKSVILLE
WARRELL CREEK
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50600
50500
50400
50300
50200
50100
50000
49900
49800
49700
49600
49500
49400
49300
49200
49100
49000
48900
48800
48700
48600
48500
48400
48300
WEDGEWOOD DR
REID ST
UPPER WARRELL CREEK RD
YARRAWONGA ST
HARRIMANS L
BALD HILL RD
PACIFIC HWY
AINSWORTH CL
KERR DR
WARRELL CREEK
SCOTTS HEAD RD
599229
599228
599227
599226
1871
Culvert
Project Boundary
Drainage line
Cadsastral Boundary
Detail Road Design (Construction Footprint)
Figure 4 :
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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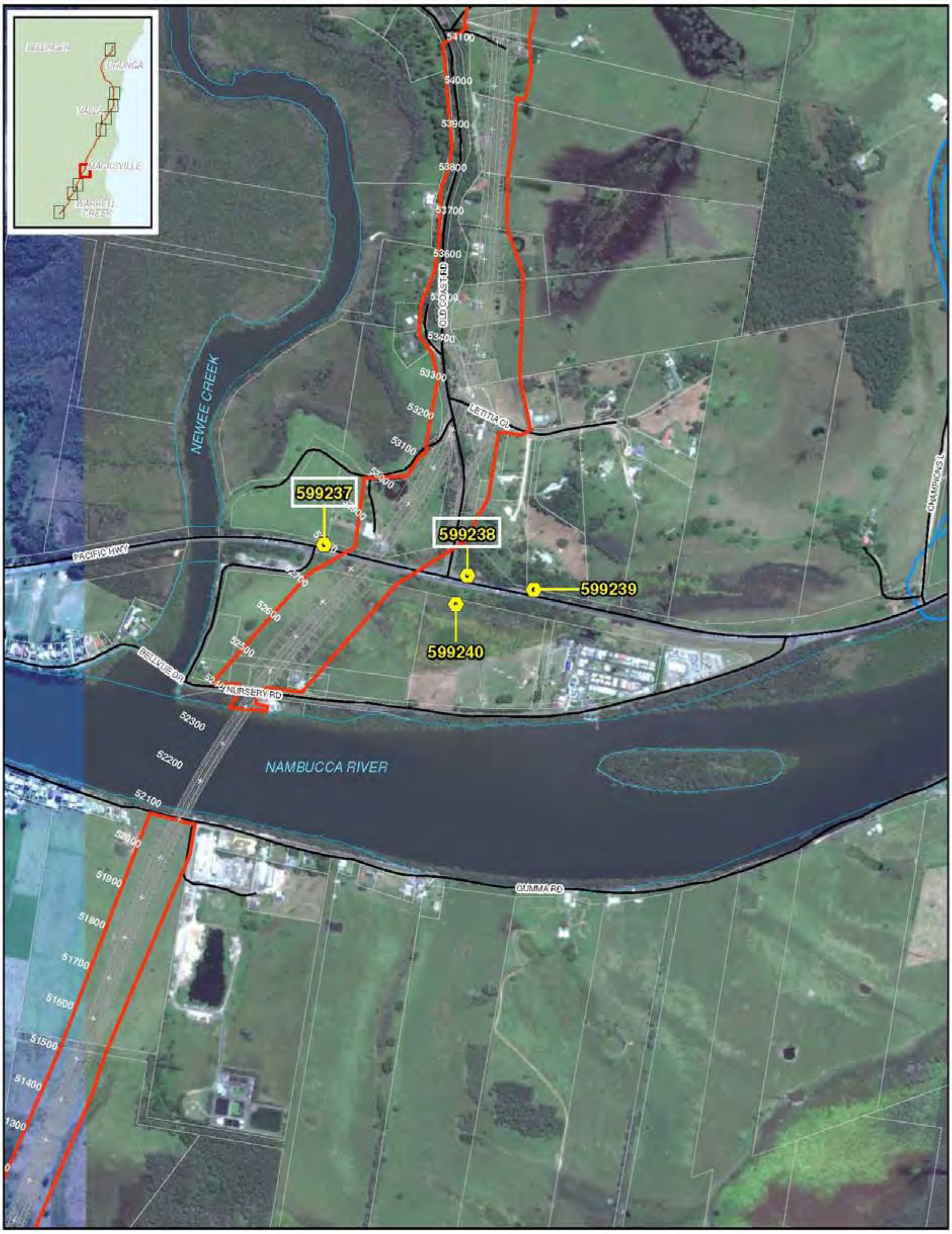

Culvert — Project Boundary — Drainage line Cadsastral Boundary — Detail Road Design (Construction Footprint)

Figure 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 2008

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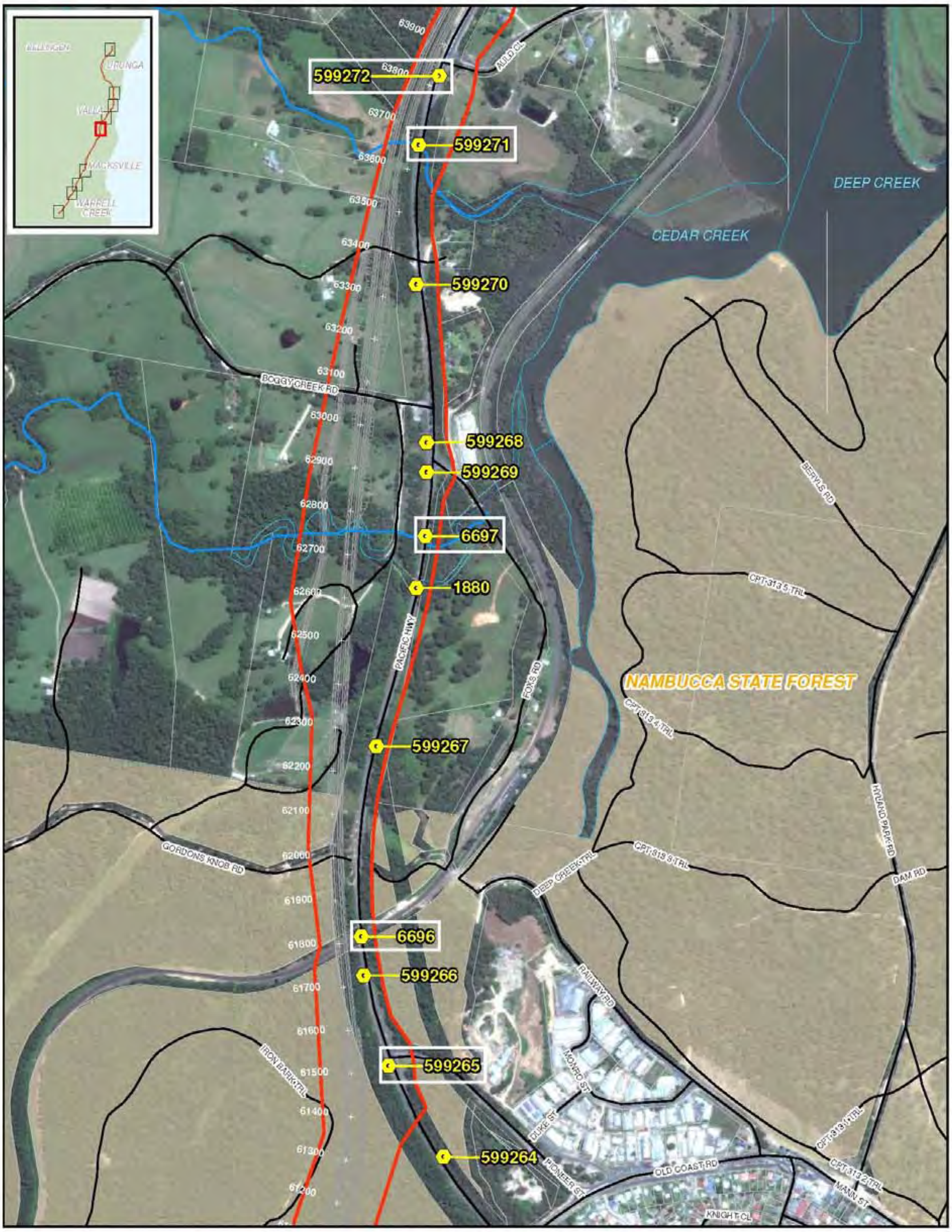

Culvert — Project Boundary — Drainage line Cadsastral Boundary — Detail Road Design (Construction Footprint)

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
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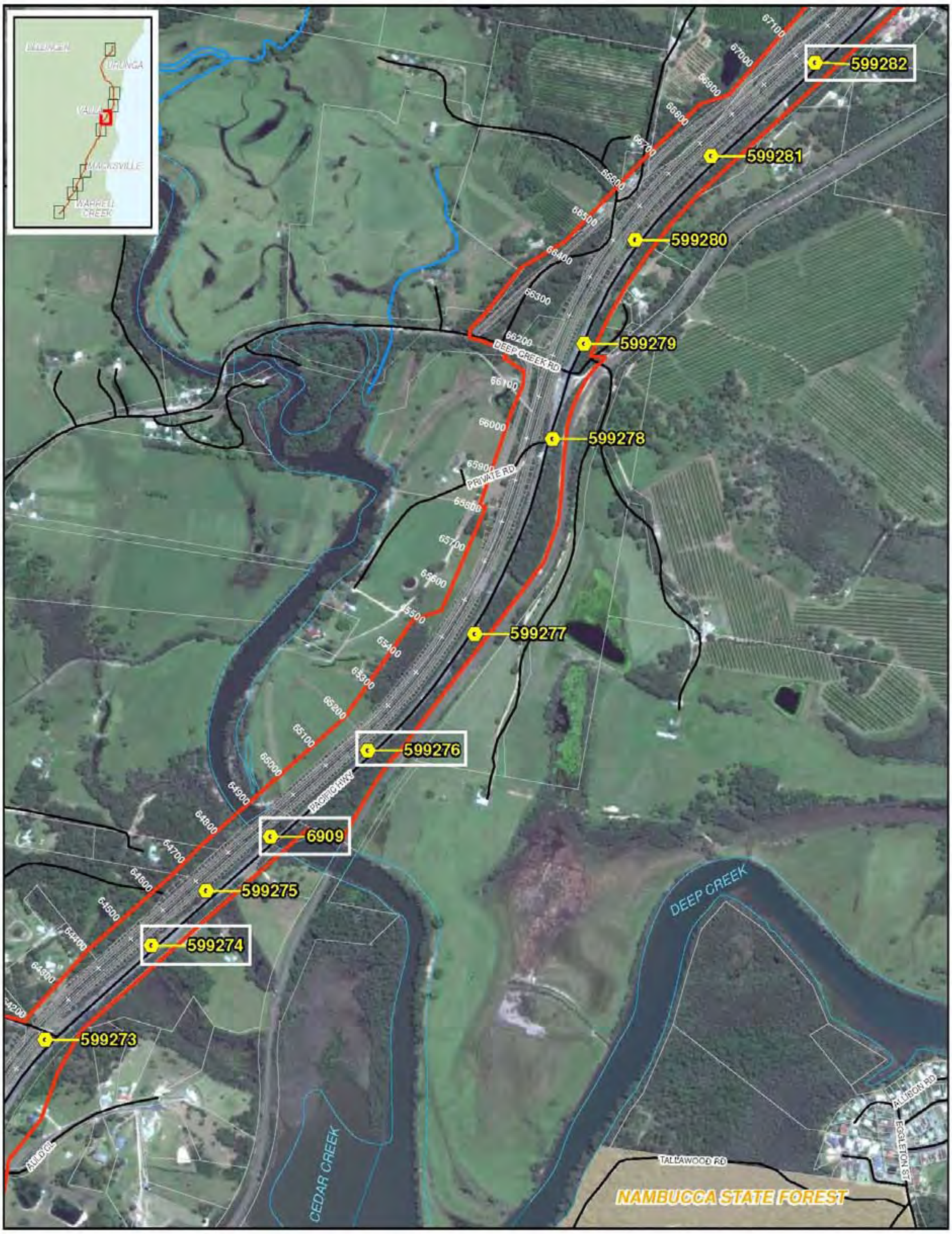

Culvert — Project Boundary — Drainage line Cadsastral Boundary — Detail Road Design (Construction Footprint)

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
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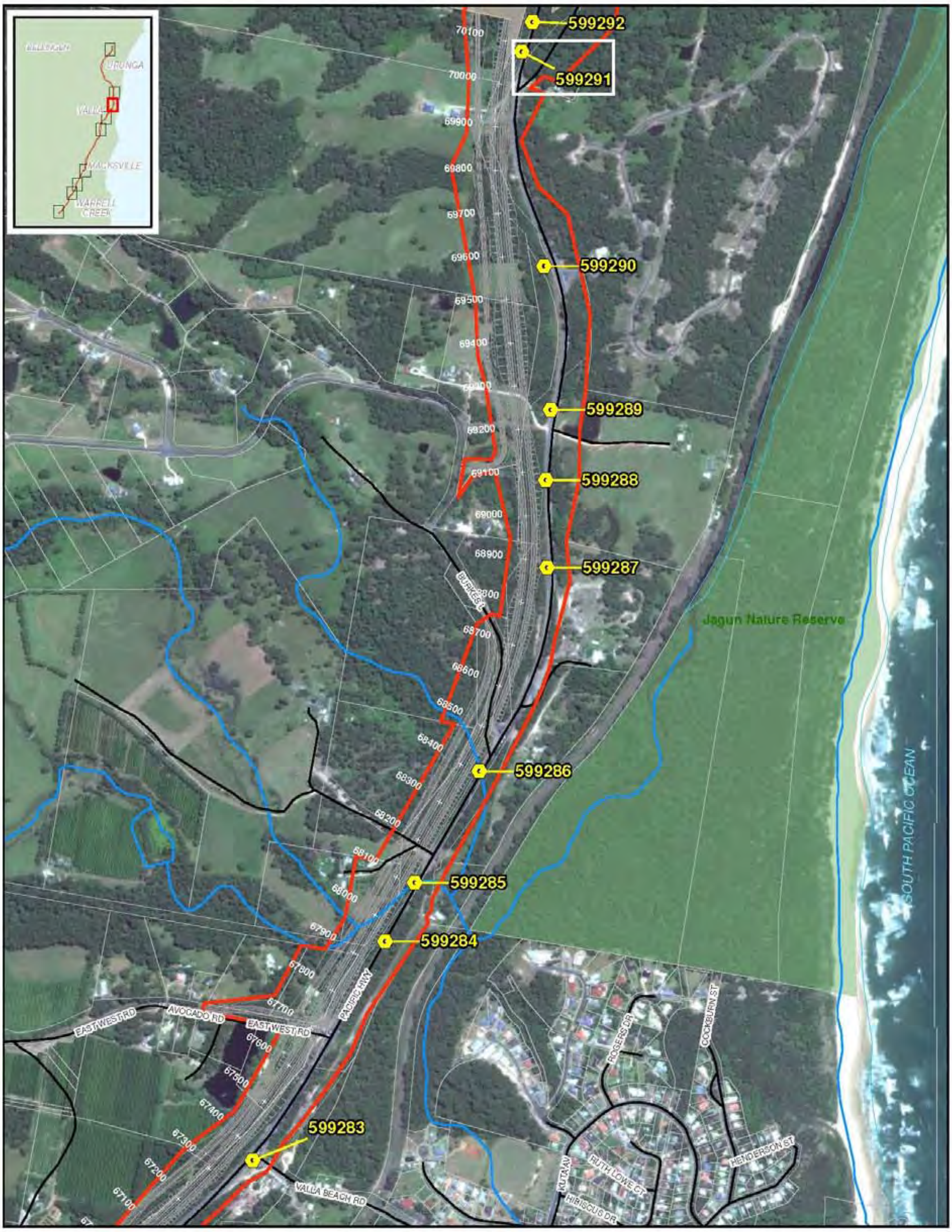

Culvert — Project Boundary — Drainage line   Cadsastral Boundary — Detail Road Design (Construction Footprint)

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
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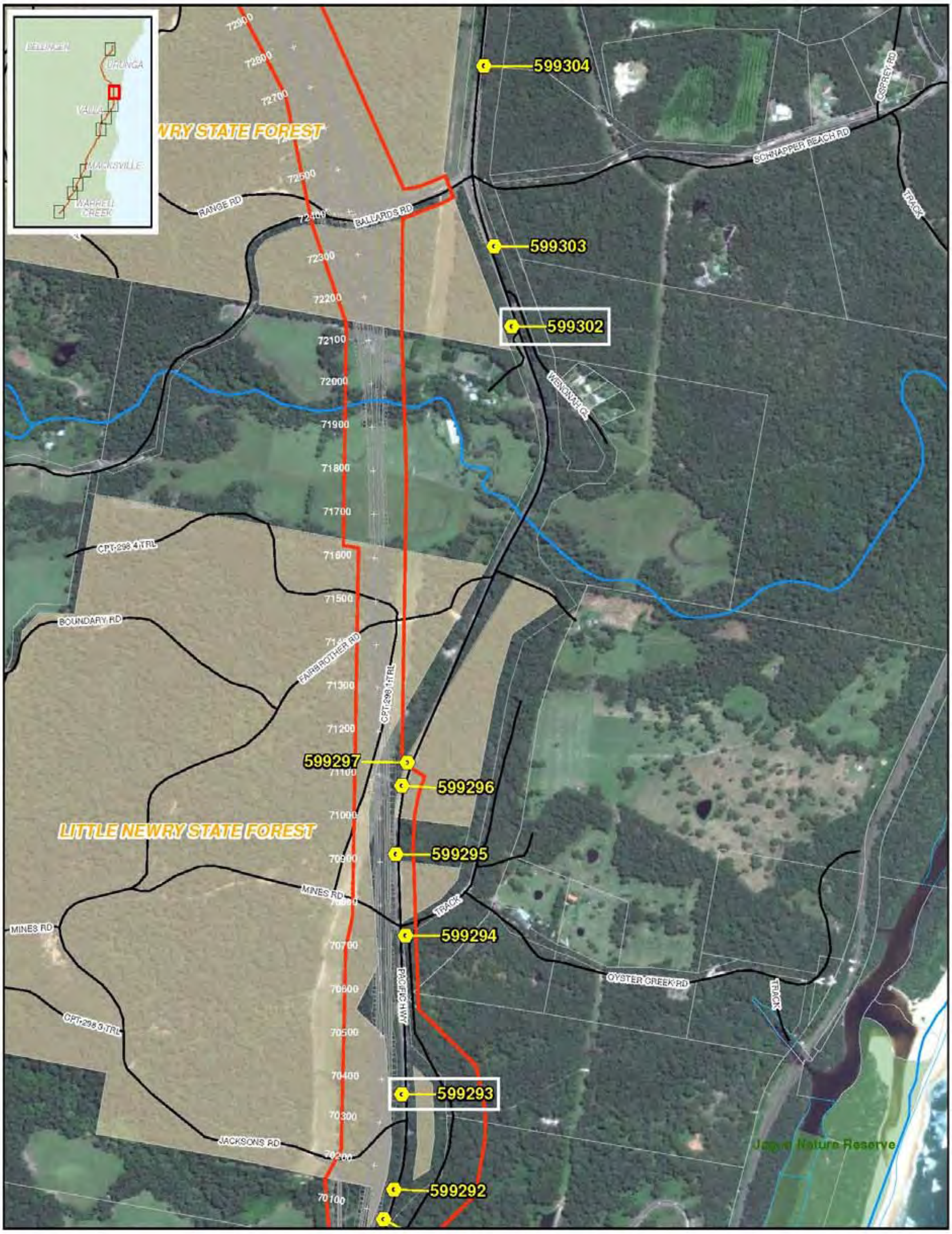

Figure 10 : CULVERT SURVEY

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
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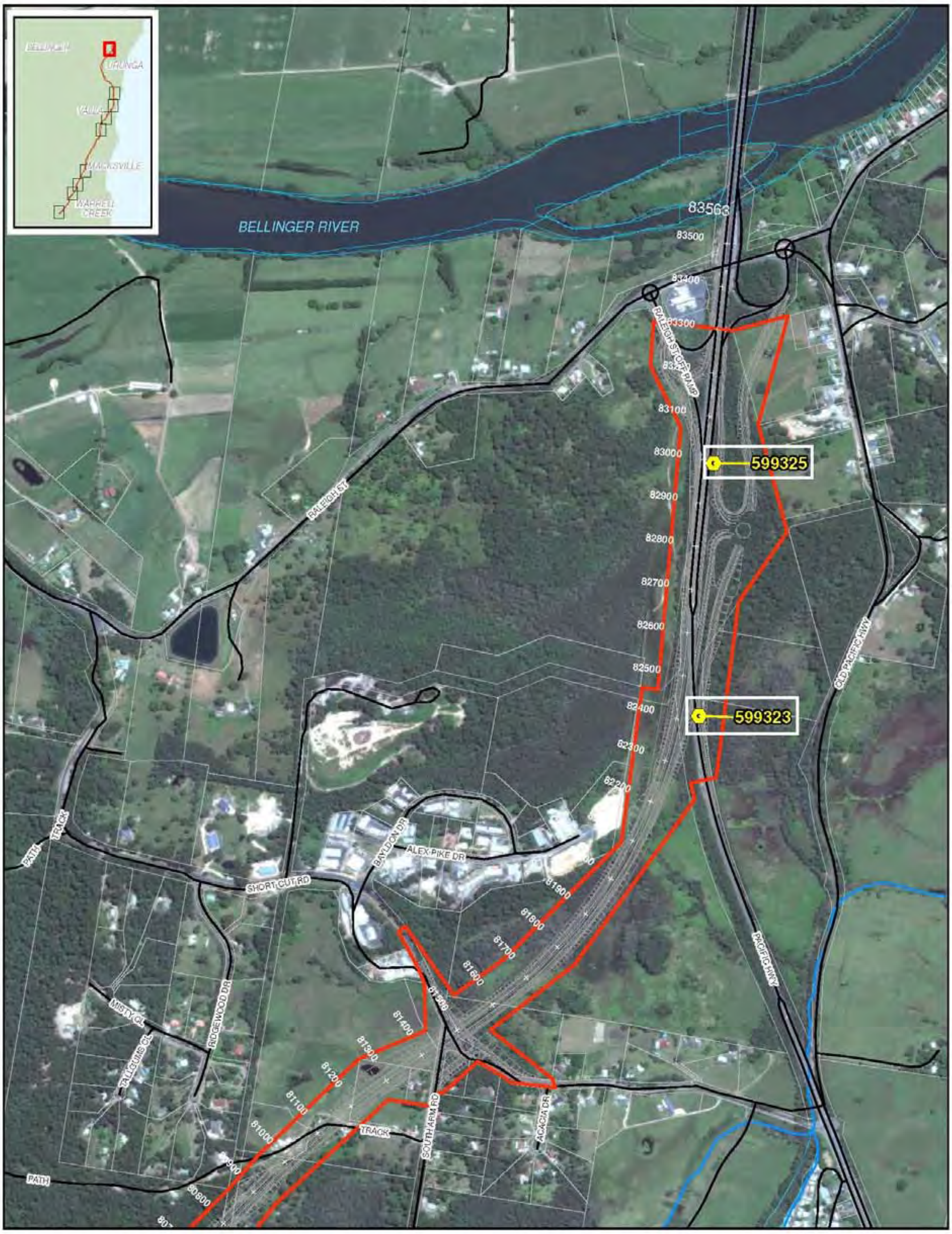

Culvert — Project Boundary — Drainage line — Cadsastral Boundary — Detail Road Design (Construction Footprint)

Figure 9 : CULVERT SURVEY

Cadastre: Roads and Traffic Authority 2007
Culvert Survey: Lewis Ecological Surveys April 2012
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Abigroup

Constructing Australia's Future

Pre-clearing permit

NOVEMBER 2013

Revision history

Revision	Date	Description	Approval
2		RMS WC2U checklist	
3	Feb 2013	NH2U Specific. Issued for internal review	
3.1	Mar 2013	Issued for RMS / PV / ER review	
3.2	Apr 2013	Issued for ERG review	
4	Nov 2013	Minor revisions approved by the ER	JB & D.Bone

Pre-clearing permit	
Project: NH2U	**Permit No.:**
Requested by:	**Date Inspected:**
Vegetation clearing start date:	**Expected completion date:**
Subcontractor:	**List of Machinery:**

Vegetation clearing Locations (Attach drawings/sketches)

Ch. From	Ch. To	Carriageway	Location	Comments

Following sections to be completed by Engineer and checked by Project Ecologist and Environmental Officer

#	Control Measure	Yes	No	Comments (Note N/A if required)
1.	Are the proposed works covered by an existing Approval? Note which document covers the works in Comments section: (eg. project approval or another approval).			
2.	Are all Sensitive Areas shown on the attached clearing plans, and been checked for accuracy/required updates? (attach both the marked up SAPs and EN1 drawings)			
3.	Has the vegetation to be cleared been clearly delineated and checked by the Project Ecologist and RMS Representative (& EPA for the widen medians)?			
4.	Have all trees / vegetation to be retained been identified by survey and exclusion areas fenced off and sign-posted? State how identified in Comments section.			
5.	Has the required threatened flora been translocated or fenced off prior to clearing?			
6.	Have all hollow bearing trees, potential hollow bearing trees, trees containing nests, bush rocks and hollow logs been clearly marked by the Project Ecologist prior to the commencement of clearing?			
8.	Have all pre-clearing assessments required by the FFMP's Ecological Monitoring Plan been undertaken by the Project Ecologist and have the checks for animals occurred at the appropriate times? (Dawn, dusk etc)? Where required, state how survey was completed, including results?			
10.	If soil disturbance is to occur, has a PESCP Plan been created and have these controls been installed?			
11.	Has weed management been undertaken, if required?			

12.	Has the Project Ecologist / relevant fauna rescue organisations been contacted and do they have adequate resources available to assist with fauna rescue? Ensure the contact details of the Project Ecologist or rescue organisations have been provided to the relevant supervisory personnel.			
13.	Has the Project Ecologist been advised of the times when they must be present for the felling of habitat trees? Note: 48-hour wait period required for felling habitat trees after the initial felling of non-habitat trees.			
15.	Are any animals present? (If *Yes*, relocation required)			
16.	Are any active nests present? (If *Yes*, relocation required)			
17.	Have the signatories to this permit walked the area concerned and confirmed the clearing boundary and sensitive areas (including heritage areas) are clearly demarcated (with appropriate durable delineation)?			

Brief description of sensitive areas / sites or threatened species within clearing zone:

ALL PARTS OF THE PERMIT MUST BE COMPLETED

Additional comments:

Inspection completed by Project Ecologist:	Signature:	Date:
Approved by EO/EM:	Signature:	Date:
Approved by Survey Manager/Surveyor:	Signature:	Date:

ENVIRO & FOREMAN SIGN-OFF: (Works Personnel to Sign-off Toolbox Form)

18.	Have relevant workers (including the clearing subcontractor) been toolboxed on the limit of clearing, sensitive area locations, no go areas, fauna descriptions and handling procedures and clearing eWMS?	☐	Enviro & Foreman Sign-off:

Lend Lease

Working around trees guideline

JULY 2014

Document control

File name	FFMP App H_Working Around Trees Guideline_Rev2
Report name	Working around trees guideline
Revision number	2

Revision history

Revision	Date	Description	Approval
0	Feb 2013	Issued for internal review	
1	Mar 2013	Issued for Roads and Maritime / PV / ER review	
1.1	Apr 2013	Issued to ERG for review	
2	July 2014	Minor update to change RMS to Roads and Maritime, and Abigroup to Lend Lease	

1 Introduction

There are no restrictions on the distribution/circulation of this guideline within Nambucca Heads to Urunga Project.

2 Purpose

Many of the works to be undertaken for the Nambucca Heads to Urunga Pacific Highway upgrade involve works within or near forests or bushland, including within endangered ecological communities. 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 Lend Lease and its subcontractors.

This guideline has been prepared to provide Lend Lease and its contractors with an easy to use guide to the minimum requirements of 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 Nambucca Heads to Urunga Project.

5 Guidelines

5.1 Tree protection

For trees identified specifically for protection, environmental and construction personnel, under supervision of an ecologist where required, are to ensure appropriate demarcation, signposting and maintenance 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 Excavations near trees

Some construction works, particularly drainage, may be designed within close proximity to vegetation planned to be retained. To ensure roots are not damaged in a way that could detrimentally affect tree health, the following points should be observed:

1. Where possible, redesign drainage to avoid impact within the drip lines of retained vegetation.
2. Excavation with machinery should occur outside the drip line of trees where possible.
3. For necessary excavation works within the drip line of trees, where the tree is planned to be retained, smaller machinery or hand excavation should be used to avoid or minimise root damage.
4. For all excavations within the drip zones of trees to be retained, proceed with caution and monitor for roots greater than 50mm in diameter. Arborist advice as to methods of cutting through even small roots should be obtained when excavating within drip zones.

   Roots greater than 50mm must not be damaged unless approved by the Environmental Officer as damage to woody roots >50mm may make trees unstable and they can fall over. Larger roots may need to be cut by an arborist.

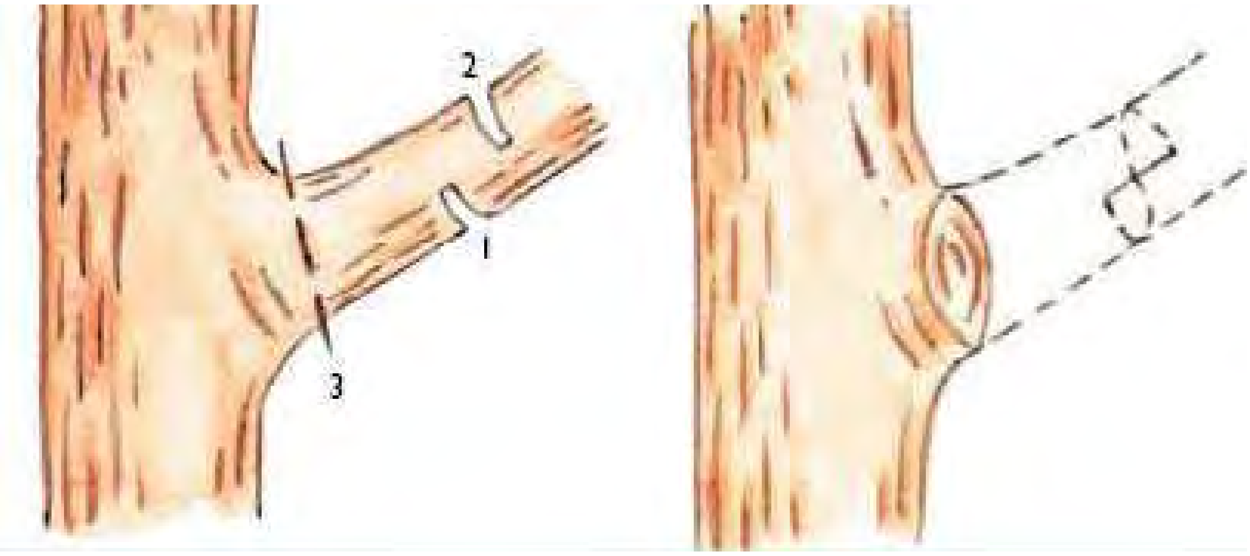
5.5 Tree trimming or removal

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 4.30.
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

Transport
Roads & Maritime
Services

Fauna handling and rescue procedure

JULY 2014

Document control

File name	FFMP App I_Fauna Handling and Rescue Procedure_Rev4
Report name	Fauna handling and rescue procedure
Revision number	4

Revision history

Revision	Date	Description	Approval
2		Roads and Maritime WC2U Procedure	
3	Feb 2013	NH2U Specific. Issued for internal review	
3.1	Mar 2013	Issued for Roads and Maritime / PV / ER Review	
3.2	Apr 2013	Review and update Project by ecologist	
4	July 2014	Minor update to change RMS to Roads and Maritime, and Abigroup to Lend Lease	

1 Introduction

There are no restrictions on the distribution/circulation of this procedure within Nambucca Heads to Urunga Project.

2 Purpose

This procedure explains the actions to be undertaken in the event fauna (including injured, shocked, dependent juvenile or other animal) are discovered that require handling or rescue during vegetation and soil clearance and ongoing construction activities.

This procedure is applicable to all native and introduced species that are found on the project site**.**

3 Induction / Training

Personnel involved in any aspect of fauna handling or rescue, or those activities where this may be required, will be trained in the requirements of this procedure. Training will include inductions, toolbox talks, pre-starts and targeted training as required.

4 Scope

This procedure is applicable to all activities that may lead to fauna handling or rescue, such as clearing operations, on the Nambucca Heads to Urunga Project.

5 Procedure

5.1 Discovery of wildlife on project site during construction activities

If wildlife is discovered on the project site during site construction activities and there is a risk these activities 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 <u>immediately notify</u> Superintendent who is then to notify the Environmental Manager or Project Ecologist, if the latter is present onsite.
2. Preferably allow fauna to leave the area without intervention.
3. If immediately available, use a licensed fauna ecologist or wildlife carer with specific animal handling experience to carry out any fauna handling.
4. If no ecologist or wildlife carer is available on site and the animal is able to be handled, 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) If time permits, call ecologist or fauna rescue for advice.
   b) Cover larger animals with a towel or blanket and place in a cardboard box and/or canvas bag.
   c) Place smaller animals in a cotton bag, tied at the top.
   d) Keep the animal in a quiet, cool, ventilated and dark location away from noisy construction activities.
   e) Aquatic fauna are to be placed in plastic aquaria or a plastic bag with sufficient amount of water. Frogs will be transported in moistened plastic bags (1 frog/bag) with a small amount of leaf litter. The translocation of frogs shall be in accordance with the Hygeine Protocol for the Control of Disease in Frogs (see below)..

   Notes on fauna handling -

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 - a form of rabies).

Note 3. Any frog handling will 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).

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.

b) Record the exact location of the animal/s and provide to the Project Ecologist or appropriate rescue agency (i.e. FAWNA / WIRES).

6. If not already done, 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	0401 195 480
FAWNA (only to be called if Project Ecologist not available)	02 6581 4141
WIRES Nambucca (only to be called if Project Ecologist not available)	02 6564 8661
RSPCA Coffs Harbour	02 6651 3311
Port Macquarie Koala Hospital	02 6584 1522
Local Vet	TBC

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 Roads and Maritime 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:

- Project Ecologist.
- EPA (131 555).
- Environmental Representative

- Others as instructed by the Roads and Maritime Representative or EPA.

The adequacy of existing safeguards will be reviewed in consultation with the above stakeholders.

8. Environmental Manager to record find in Roads and Maritime Environmental Incident Report where required following consultation with the Roads and Maritime 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.
11. Relocation of fauna adjacent to the footprint will be undertaken where possible by the Project Ecologist or wildlife rescuer and will be recorded during clearing as part of the ecologists clearing report or on the Weekly Environmental Inspection Checklist for non-clearing activities. 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:
    a) Sites identified as suitable release points by the Project Ecologist or wildlife rescuer.
    b) Release site will contain similar habitat and occur as close to the original capture location as possible.
    c) If the species is nocturnal, release will be carried out at dusk.
    d) Release would generally not be undertaken during periods of heavy rainfall.
    e) Hollow-dependent species, particularly those with dependent young, shall be released into a temporary nest box.

5.2 Project Ecologist responsibilities for fauna handling and rescue

The Project Ecologist will follow the relevant steps detailed below:

1. Surveys and rescue 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.

       Note -Habitat trees are to be felled using equipment that allows habitat trees to be carefully felled with minimal impact (e.g. claw extension).
2. 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 except for aquatic fauna; and

d) Non-native fauna 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, selected by the Project ecologist, that will not be disturbed by the project construction works.The Project Ecologist will record and provide the capture and relocation data in the post clearing report.

3. 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 suitable nest box, carry cage or canvas bag

   b) Place smaller animals in a cotton bag, tied at the top, or suitable nest box.

   c) Place frogs/tadpoles in a plastic bag with a small amount of water and leaf litter. One individual per bag.

   d) Fish and other aquatic life (i.e. turtles) place in plastic aquaria or plastic container with sufficient water.

   e) For terrestrial fauna keep the animal in a quiet, cool, well ventilated and dark place away from noisy activities.

   f) For aquatic fauna species ensure there is sufficient water and adequate aeration.

   Notes on fauna handling -

   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).

4. In the event an animal is injured the following fauna rescue services and local veterinary surgeries contact details are detailed in 5.1(6) above.

   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 will follow steps 5.1(7) to 5.1(11)

Unexpected threatened flora species / EECs Procedure

JULY 2014

Document control

File name	FFMP App J_Unexpected Threatened Flora Species_EECs Procedure_Rev3
Report name	Unexpected threatened flora species / EECs procedure
Revision number	3

Revision history

Revision	Date	Description	Approval
1		Roads and Maritime WC2U Procedure	
2	Feb 2013	NH2U Specific. Issued for internal review	
2.1	Mar 2013	Issued for Roads and Maritime / PV / ER Review	
2.2	Apr 2013	Issued for ERG review	
3	July 2014	Minor update to change RMS to Roads and Maritime, and Abigroup to Lend Lease	

1 Introduction

There are no restrictions on the distribution/circulation of this procedure within Nambucca Heads to Urunga Project.

2 Purpose

This procedure details the actions to be taken when any unexpected threatened flora species / EEC (not previously identified in the EA or Threatened Flora Management Plan) is unexpectedly encountered during excavation / construction activities. (Also see Section 6 of the Threatened Flora Management Plan – Appendix B to the FFMP).

3 Induction / Training

Personnel involved in any aspect of activities that have a risk of discovering new threatened species or EECs, such as clearing, will be trained in the requirements of this procedure. Training will include inductions, toolbox talks, pre-starts and targeted training as required.

4 Scope

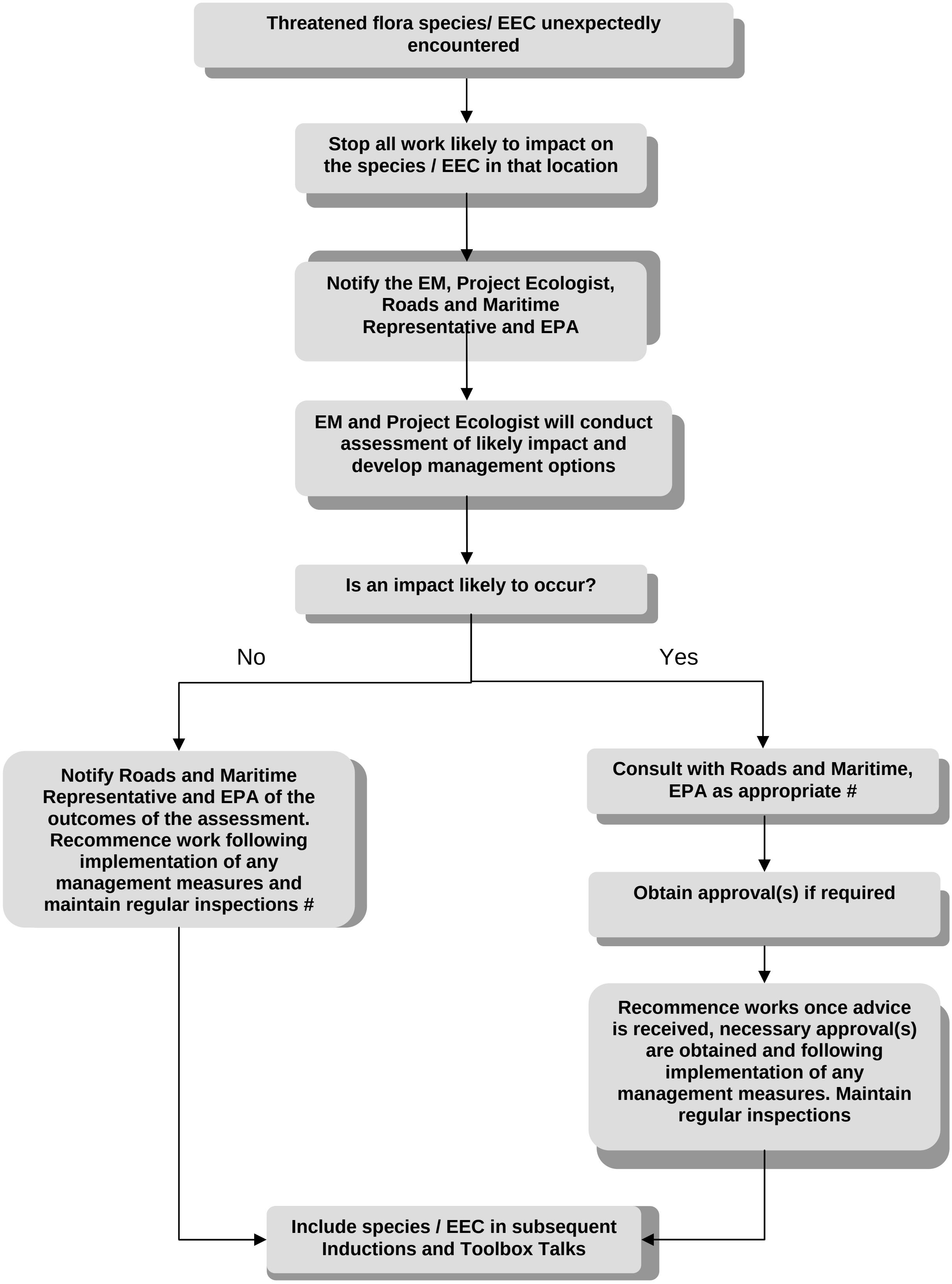
This procedure is applicable to all activities conducted by personnel that have the potential to come into contact with threatened flora species during the Nambucca Heads to Urunga project.

(Where threatened fauna is unexpectedly encountered, refer to the Fauna Handling and Rescue Procedure).

5 Procedure

1. Threatened flora species / EEC unexpectedly encountered during excavation/construction activities
If a new threatened flora species / EEC 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, Roads and Maritime 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 and appropriate management options developed in consultation with Roads and Maritime. If a significant impact is likely to occur, consultation will be undertaken with the EPA as appropriate.
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 in subsequent Project Inductions and Toolbox Talks.

Figure 1. Unexpected Threatened Flora Species / EEC 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.

Lend Lease

Weed management plan

NOVEMBER 2013

Document control

File name	FFMP App K_Weed Management Plan_Rev2
Report name	Weed management plan
Revision number	2

Revision history

Revision	Date	Description	Approval
0	Feb 2013	Issued for internal review	
1	Mar 2013	Issued for Roads and Maritime / PV / ER review	
1.1	Apr 2013	Issued for ERG review	
1.2	May 2013	Updated following ERG comments	
2	Nov 2013	Minor update to change RMS to Roads and Maritime, Abigroup to Lend Lease, consultation outcomes from Council and reference to EWMS	

1 Introduction

There are no restrictions on the distribution/circulation of this Plan within Nambucca Heads to Urunga Project.

Weed infestation and spread resulting from vegetation clearing, soil disturbance, erosion and sediment control, vehicle movement, inadequate rehabilitation/ revegetation of disturbed areas and inappropriate topsoil management has been identified as a risk associated with the Project.

This Plan provides detail for the management of both noxious and environmental weeds, with priorities for control based on these categories. Noxious weeds are species declared noxious under the NSW *Noxious Weeds Act 1993*, whilst environmental weeds are generally introduced species that threaten the integrity of natural habitats. Noxious weeds are those plants that are required by law to be controlled.

The Flora and Fauna Assessment Working Paper prepared for the project EA recorded 995 introduced flora species in the study area, nine of which were noted as declared noxious weeds in the control area of Nambucca.

The EA Flora and Fauna Assessment Working Paper notes that *"introduced flora species are generally dominant along the disturbed roadsides, cleared paddocks and areas of disturbed vegetation. A high abundance of Lantana camara is present in some areas of intact bushland, particularly along creeks and in depressions where soil moisture and fertility are higher. Introduced species were generally absent in intact areas of dry sclerophyll forest, although a low-medium abundance of Lantana camara is present in some areas particularly where there has been disturbance from logging and grazing."*

This Plan has been prepared to detail the key weed species and their distribution across the site and to outline the processes required to control and prevent the spread of weeds during the Project.

2 Purpose

This Plan has been prepared to provide Lend Lease and its contractors with an easy to use plan for the management of weeds on the project site. It will also assist to meet Project weed management objectives to control the spread of weeds; to reduce the levels of weed infestation within the construction site and adjoining areas; and to improve the quality of habitat in retained vegetation.

3 Induction / Training

All persons entering the project construction zone are responsible for ensuring their activities do not contribute to the spread of weeds both on and off the site.

All construction personnel are to be inducted on the existence of noxious weeds on site during the Project induction and as required in toolbox talks. This will include details of the controls required to implement and minimise weed spread.

4 Scope

This Plan is applicable to all activities relating to weed management on the Nambucca Heads to Urunga Project. More specific details regarding weed management, treatment and reporting are contained within the Weed Management Environmental Work Method Statement (EWMS #020).

This weed management strategy details weed management and control practices to be implemented throughout the construction phase of the project to minimise the threat to remnant vegetation within the local area. It has been developed to meet the Conditions of Approval, Statement of Commitments, licenses, permits and compliance with relevant legislation as they relate to weed management for the Project. These requirements are detailed further in the Flora and Fauna Management Plan.

Weed management and control will be conducted on all weeds identified on site with priority given to areas of re-vegetation and declared noxious weeds.

5 Weeds in the project area

The following weeds recorded within the NH2U project boundary during the targeted weed survey (ECOS Environmental February 2013) are declared noxious in the project area (http://www.dpi.nsw.gov.au/agriculture/pests-weeds/weeds/noxweed).

The abundance of weed species is indicated in column four as rare, occasional, common and very common. Rare species were recorded at only one or two sites.

Noxious Weed	Class	Legal Requirements	Abundance within NH2U Project Boundary
Annual ragweed [*Ambrosia artemisiifolia*]	5	The requirements in the Noxious Weeds Act 1993 for a notifiable weed must be complied with	occasional in recently disturbed areas.
Bitou bush [*Chrysanthemoides monilifera* subspecies *rotundata*]	4	The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction	sporadic, rare, but widespread.
Blackberry [*Rubus fruticosus* aggregate species]	4	The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction and the plant must not be sold propagated or knowingly distributed	very rare
Boneseed [*Chrysanthemoides monilifera* subspecies *monilifera*]	2	The plant must be eradicated from the land and the land must be kept free of the plant	very rare
Camphor laurel [*Cinnamomum camphora*]	4	The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction and the plant must not be sold propagated or knowingly distributed	common, most trees sub-mature (2-8m)

Crofton weed [*Ageratina adenophora*]	4	The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction	common
Fireweed [*Senecio madagascariensis*]	4	The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction	occasional
Giant Parramatta grass [*Sporobolus fertilis*]	4	The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction	common; appears to grade into parramatta grass (s. parramattensis) in some areas
Groundsel bush [*Baccharis halimifolia*]	3	The plant must be fully and continuously suppressed and destroyed	occasional
Lantana [*Lantana* species]	4	The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction and the plant must not be sold propagated or knowingly distributed	very common, including 'red lantana' which is reported to be toxic to cattle.
Mistflower [*Ageratina riparia*]	4	The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction and the plant must not be sold propagated or knowingly distributed	rare

The locations of noxious and environmental weeds recorded during the weed survey are shown on the attached plans – 2 to 10. Also indicated on the plans is the general abundance of weeds, which was broken down into three categories – low, medium and high. The purpose of this mapping is to assist in identifying suitable areas for salvage of topsoil for latter use in topsoiling and landscaping. The general approach is to avoid areas with high (red) and medium (orange) weeds and target areas of low (green) weeds for topsoil salvage.

Environmental Weeds

The following environmental weeds were recorded during the weed survey of NH2U corridor. The abundance of environmental weed species is indicated in column four as rare, occasional, common, very common. Rare species were recorded at only one or two sites.

Environmental Weed	Potential Threat	Frequency within NH2U Project Boundary
Setaria/Pigeon Grass (*Setaria sphacelata*)	A tall, densely growing tussock grass. Rapidly colonises bare ground on road batters, smothers landscape plantings, topsoiled batters, invades swamp sclerophyll forest EEC	Common in cleared paddocks, may not be apparent until grazing is withdrawn.
Broad-leaved Paspalum (*Paspalum wettsteinii/mandiocanum*)	A low growing grass with broad dark green leaves. Invades the ground layer of all local native forest types, displacing native flora	Common in cleared paddocks and adjoining bushland, particularly where disturbed in the past

Umbrella Tree (*Schefflera actinophylla*)	Invades rainforest and wet sclerophyll forest	Occasional
Elephant Grass (*Pennisetum purpureum*)	Invades and dominates vegetation along creek lines in particular	Rare
Parramatta Grass (*Sporobolus parramattensis*)	Threat to agricultural grazing land as it produces poor fodder.	Occasional, grades into Giant Parramatta Grass (S. fertilis), which appears to be commoner.
Taro (*Calocasia esculenta*)	An emerging environmental weed. Spreads quickly and dominates aquatic vegetation along drainage line	Rare
Singapore Daisy (*Wedelia trilobata*)	An emerging environmental weed (herb). Spreads rapidly after reaching a critical mass, smothers ground layer vegetation.	Rare.
Winter Senna (*Senna pendula*)	A shrub in the Cassia genus with yellow flowers. Invades disturbed understorey in wet and dry sclerophyll forest	Common
Formosa Lily (*Lilium formosum*)	A herb with large white trumpet flowers, invades bare ground forming dense infestations	Common
Five-leaf Morning Glory (*Ipomoea cairica*)	A vine, invade rainforest and wet sclerophyll forest in disturbed areas.	Rare
Fishbone Fern (*Nephrolepsis cordifolia*)	An invasive fern in all types of forest, dominates and smothers ground layer vegetation.	Rare
Slash Pine (*Pinus elliottii*)	A tree invading dry sclerophyll forest along the NH2U corridor.	Occasional
Small-leaved Privet (Ligustrum sinense)	A shrub or small tree forming dense thickets along drainage lines and displacing native flora	Rare

Aquatic Noxious and Environmental Weeds

A number of exotic aquatic plant species were recorded during weed and other flora survey work, but no listed, noxious aquatic weeds were recorded, although several species have the potential to occur in the project area, as listed below. These species would be targeted in follow up aquatic plant surveys of dams and drainage lines affected by construction works. One environmental aquatic weed was recorded – Taro Colocasia esculenta.

Potential Aquatic Weed	Potential Threat	Frequency within NH2U Project Boundary
Salvinia Salvinia molesta	Completely covers dams and waterways	Not recorded but may invade water bodies
Cabomba Cabomba caroliana	Chokes dams and slow flowing creeks	Not recorded but may invade water bodies
Water Hyacinth Eichornia crassipes	Completely covers dams and waterways	Not recorded but may invade water bodies
Parrots Feathers Myriophyllum aquaticum	Chokes dams and slow flowing creeks	Not recorded but may invade water bodies
Alligator Weed Alternanthera philoxeroides	Completely covers dams and waterways	Not recorded but may invade water bodies
Taro Colocasia esculenta	Forms dense infestations along waterways displacing native species	One infestation recorded

Consultation has been undertaken with both Nambucca and Bellingen Shire Council Weed Officers regarding weed management within the project area. Both authorities biggest concern is with the introduction of new weed species to the region that are not currently present. Both councils have indicated that all weeds within the alignment should be considered to be low risk species within the region due to their current widespread distribution, with the exception of Groundsel Bush. Groundsel bush is to be treated prior to the commencement of clearing works. Nambucca Shire has also expressed a concern for Coolatai grass, not classified as a noxious weed and not yet identified in the project alignment, however a risk species for the local region.

6 Weed control classes

The study area includes Class 2, 3, 4 and 5 noxious weeds. The control requirements for each of these classes include:

Class 2: are plants that pose a potentially serious threat to primary production or the environment of a region to which the order applies and are not present in the region or are present only to a limited extent. The plant must be eradicated from the land and the land must be kept free of the plant. The weeds are also "notifiable" and a range of restrictions on their sale and movement exist.

Class 3 are plants that pose a potentially serious threat to primary production or the environment of a region to which the order applies, are not widely distributed in the area and are likely to spread in the area or to another area. The plant must be fully and continuously suppressed and destroyed.

Class 4 noxious weeds are plants that pose a potentially serious threat to primary production, the environment or human health, are widely distributed in an area to which the order applies and are likely to spread in the area or to another area. The growth of the plant must be managed in a manner that reduces its numbers spread and incidence and continuously inhibits its reproduction.

Class 5 noxious weeds are plants that are likely, by their sale or the sale of their seeds or movement within the State or an area of the State, to spread in the State or outside the State. There are no requirements to control existing plants of Class 5 weeds. However, the weeds are "notifiable" and a range of restrictions on their sale and movement exists.

7 Guidelines for weed control

There are a series of requirements to be followed to avoid the spread of weeds during construction, these are outlined below:

Guideline 1 - Ensuring only clean plant is brought to site

To control the import of weeds on the Project site from external sources, relevant engineers, site foremen and environmental staff must be diligent in ensuring that plant and equipment is free of soil / weeds prior to being brought to site.

The following process for all plant and equipment brought to site during construction will be followed.

- **Step 1** – Relevant engineers / maintenance personnel will ensure that sub-contractors and plant hire companies are notified of the requirement to ensure only clean plant and equipment are supplied or brought to site and that failure to do so may result in machinery being sent back.
- **Step 2** – Relevant engineers / maintenance personnel will ensure that all plant and equipment brought to site free of soil and weeds prior to being used on site, and this is recorded on the Plant Clean Down Checklist (Appendix D). Completed Plant Clean Down Checklist are to be returned to the Environmental Manager.
- **Step 3** – If the plant or equipment is not free of soil and weeds, the Engineer / Foreman / EM will be notified and it will either be sent back to its place of origin or cleaned on site, with special care to ensure that dirt cleaned off is captured and disposed of where it cannot be spread to surrounding areas.
- **Step 4** – The EM/EO will undertake random inspection of plant and machinery upon arrival at site to ensure that soil / weeds are not being transported onto site.

Guideline 2 - Prevention of weed spread on site

To control the potential for spread of weeds on the site the following process is to be implemented:

- **Step 1** – Placement of stockpiles, infrastructure and buildings on cleared land away from areas of native vegetation, trees or known areas of weed infestation, including aquatic weeds.
- **Step 2** – Verification of weed free status of any stockpiled soil by the EO and project weed management contractor. Soil stockpiles from different areas of the site to be stockpiled separately in accordance with the requirements of the SWTC Appendix 15 and detailed in the FFMP.
- **Step 3** – Installation and maintenance of appropriate sediment and erosion controls to prevent the free movement of weed seeds during rainfall events.
- **Step 4** – Identification of priority areas (shown as red on the attached plans) where light vehicle movement poses a high risk of spreading noxious weeds within and outside the alignment.
    - o Within these areas light vehicle access routes (i.e. cleared tracks or roads) should be delineated and vehicle movement restricted to those routes.
    - o If light vehicles traverse non designated tracks or roads then tyres, bull bars and side steps should be checked for weed seeds, or vegetative parts prior to leaving the site.
    - o Any seeds or vegetative material should be removed prior to leaving the site.

  - Where necessary, wash down facilities will be installed at high priority areas to clean machinery and vehicles affected by weeds, in particular Giant Parramatta Grass.
- **Step 5** – Inspection of boots, clothing and equipment and cleaning / washdown if necessary when moving from weed infested to weed free locations on site.
- **Step 6** – Earthworks conducted in a red (high) and orange (medium) mapped weed zone to bury topsoil containing weed seedbank underneath clean fill wherever possible (refer to EWMS #020).

Guideline 3 - Prevention of weed spread from salvaged and re-used topsoil

Salvage and re-use of topsoil from already weed infested areas is the main means by which weeds are introduced and spread along highway construction projects. Salvage of topsoil from weed-free forest areas during clearing, followed by storage and application to roadsides/batters will result in revegetation with native flora from the topsoil seedbank, rather than with weeds. This 'natural' process of revegetation will also greatly reduce the cost of landscaping and hydroseeding.

- **Step 1** – identify areas of weed-free topsoil (i.e. forest areas free of weeds) by ground survey – see attached plans (2-10).
- **Step 2** – identify topsoil storage sites at suitable intervals along the road corridor.
- **Step 3** – identify sites where topsoil is to be salvaged from; strip and transport topsoil to storage sites after vegetation clearing.
- **Step 4** – where practical, place topsoil in low (<2m) piles of any length or width.
- **Step 5** – Assay contents of soil seedbank by sample germination testing as required.
- **Step 6** - Following completion of earthworks, transport and spread topsoil; leave the bottom 10cm of stockpile if on cleared land or other land likely to contain weed seed.
- **Step 7** - Hydroseed with fast growing Jap Millet (summer) or Rye Grass (winter) to provide an initial plant cover.

(Note - native plants – grasses, herbs, shrubs and small trees - will germinate and establish significant cover in 1-2 months and largely continuous cover in 3-6 months, depending on season.)

Guideline 4 – Programmed weed control

To control Project wide weed infestations during construction the EM or EO will ensure the following procedure is implemented:

- **Step 1** – Using the information on noxious weed distribution and infestation (Appendix A) identify priority weed control areas and stockpile sites that may contain a seed bank or viable vegetative parts of noxious weeds.
- **Step 2** - The EM or EO shall discuss weed control options in priority weed control areas with the Project weed management contractor and Local Council Weed Management Officer (refer to consultation in section 5) as appropriate. This shall include discussions prior to the commencement of clearing and at various times throughout the project to account for seasonal growth and germination of seeds
- **Step 3–** The Project weed management contractor will then determine the appropriate treatment methodology and timing (in consultation with the Local Council Weed Management Officer). Recommended methods of treatment of noxious and highly invasive weeds are detailed in Appendix B.
- **Step 4**– The EM or EO and the Project weed management contractor will ensure that a record of pesticide application is kept and public notifications made in accordance

with relevant legislation and the RTA QA Specification G36H, where pesticides are to be used in areas that could be accessed by members of the public. A sample pesticide application record sheet is attached as Appendix C to this Strategy and further guidance available in RTA QA Specification G36.

- **Step 5**– The EM or EO shall ensure that a follow-up inspection is undertaken (at a date determined by the Project weed management contractor) at sites where weed control is undertaken to ensure treatment was successful. If treatment was unsuccessful the Project weed management contractor will be required to re-treat the area until it is successful.
- **Step 6** – Any weeds physically removed (particularly those bearing seeds) are to be disposed of in an appropriately licensed landfill site in accordance with the Waste and Energy Management Plan (WEMP) or buried on site following consultation with EPA and local Councils Weeds Officers.

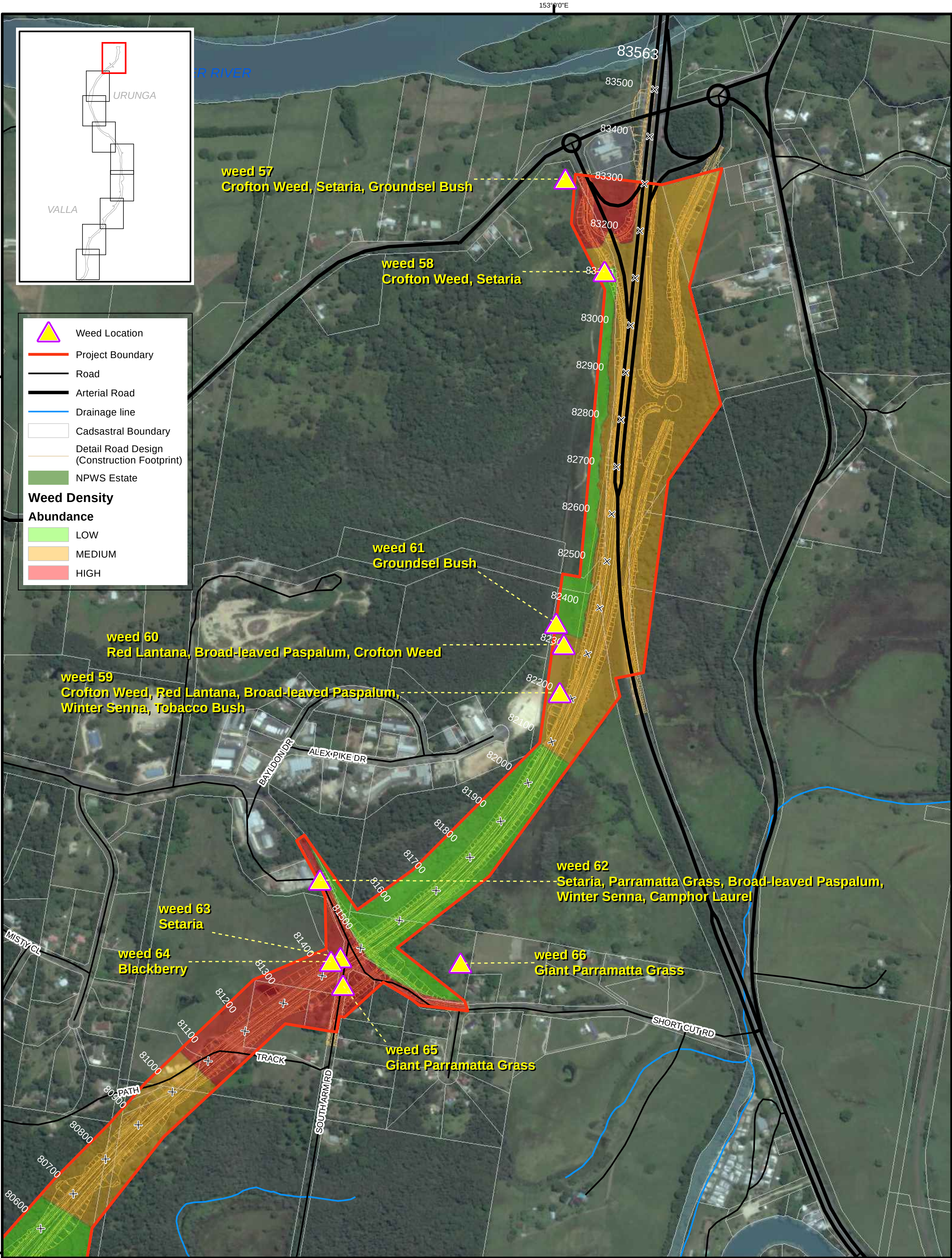
Guideline 5 – Scheduling and Reporting

Record and report on the progress of the weed control works. The reporting should include:

- **Step 1** – 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.
- **Step 2** – Submit a report to the Project Verifier, Environmental Representative and Roads and Maritime Representative outlining the results of each monitoring inspection against the weed management objectives and activities in the Weed Management Plan.
- **Step 3** – Preparation of an updated weed survey of the site and adjacent areas prior to construction commencing, to determine the presence of weed species, density and abundance. Prepare weed distribution map (see Appendix A).
- **Step 4** – Reporting of any Class 1 noxious weeds to DPI and eradication prior to impact.
- **Step 5 -** Document the weed management activities undertaken in accordance with the approved weed control schedule of works. To include, but not limited to the following information:
    - Species targeted and mapped.
    - Photographic monitoring (pre and post monitoring)
    - Areas treated (mapped)
    - Details of pesticide application (from pesticide application sheets in **Appendix C).**
- **Step 6** – Obtain appropriate sign off from the EO/EM and update weed management strategies, maps/plans and weed control schedules or programs accordingly.

Appendix A

Weed Distribution Map and Supporting Data



153°0'0"E

ECOS ENVIRONMENTAL PTY LTD

Source:	Cadastre: Roads and Traffic Authority 2007 Roads & Drainage: Geoscience Australia 2009 National Parks: NSW NPWS 2012 Highway Design (footprint): RTA 2012	Project Boundary: RTA 2012 Weed Survey: ECOS Environmental 2013 State Forests: NSW Department of Primary Industries 2008
Disclaimer:	This plan is based on or contains data provided by others. ECOS Environmental gives no warranty in relation to the data (including accuracy, reliability, completness, currency or suiability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to and use of the data. Data must not be used for direct marketing or be used in breach of privacy laws.	
File:	NH2U-002-WEED-SURVEY-140120	

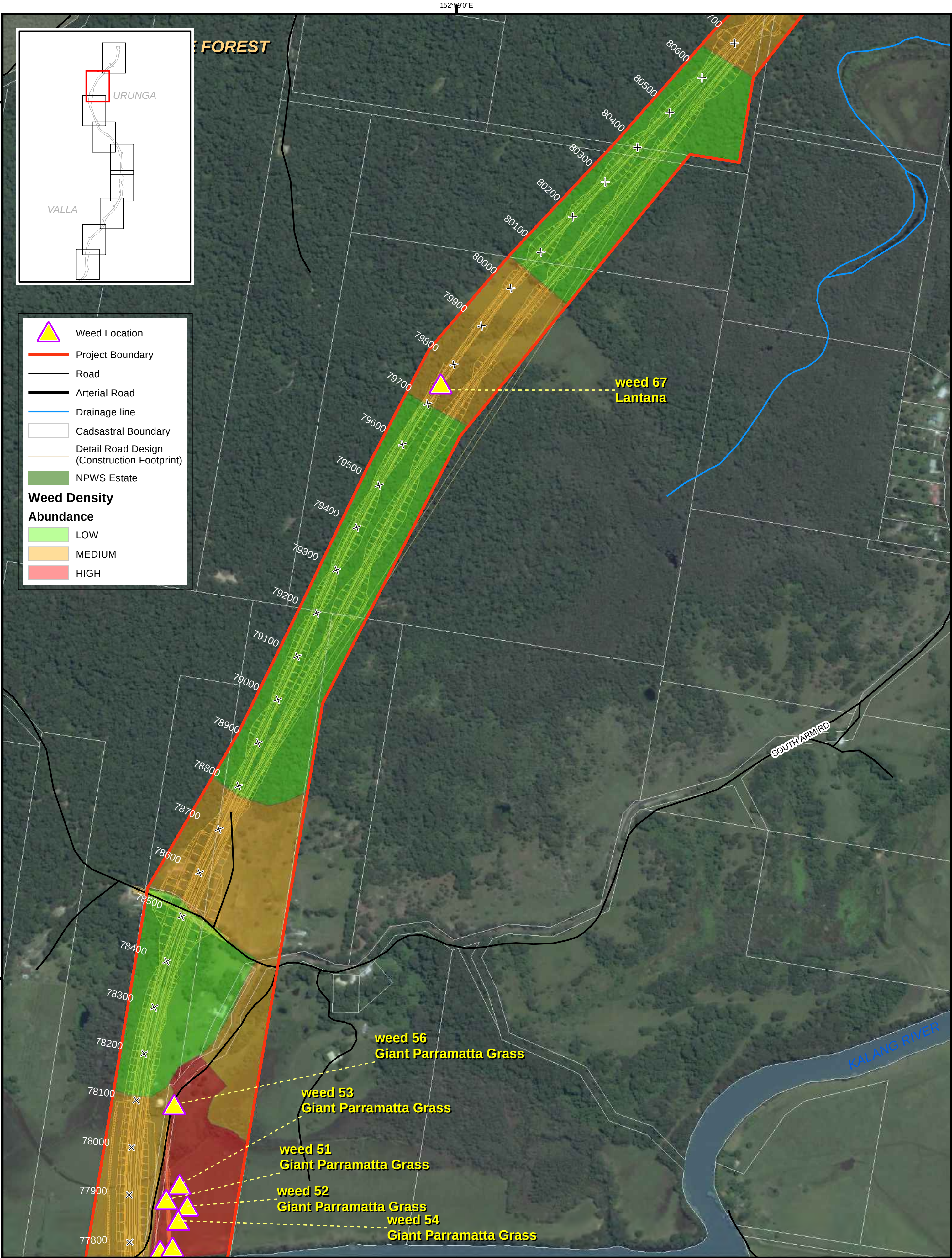
N S W E

0 50 100 150 200 250 300
Meters
A4 Scale 1:10,000

Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator

APPENDIX 2: Sheet 2

WEEDS RECORDED ON THE NAMBUCCA HEADS TO URUNGA UPGRADE DURING TARGETED SURVEYS IN FEBRUARY 2013



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ECOS ENVIRONMENTAL PTY LTD

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File:	NH2U-002-WEED-SURVEY-140120

N S W E

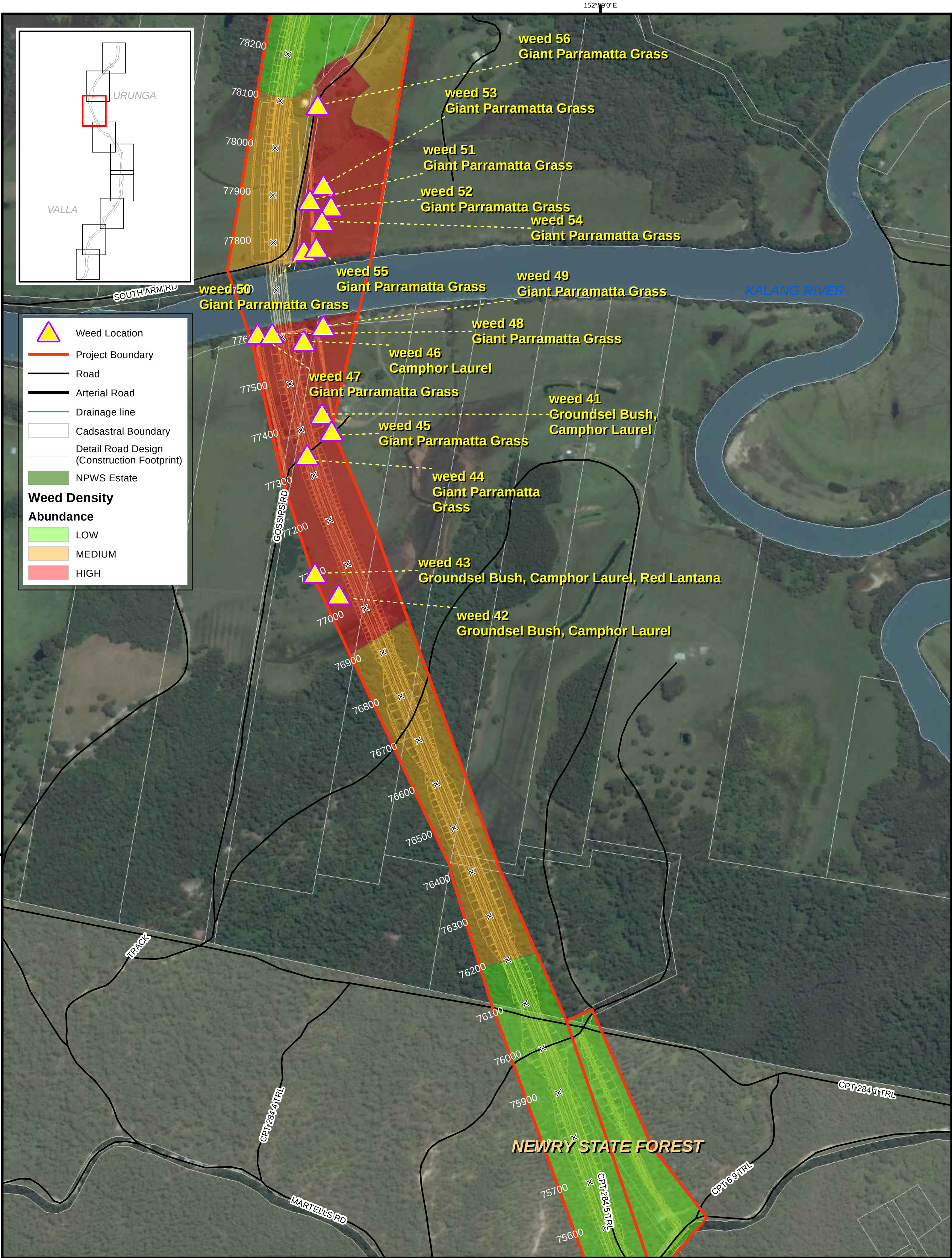
0 50 100 150 200 250 300
Meters

A4 Scale 1:10,000

Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator

APPENDIX 2: Sheet 3

WEEDS RECORDED ON THE NAMBUCCA HEADS TO URUNGA UPGRADE DURING TARGETED SURVEYS IN FEBRUARY 2013



ECOS ENVIRONMENTAL PTY LTD

Source:	Cadastre: Roads and Traffic Authority 2007 Roads & Drainage: Geoscience Australia 2009 National Parks: NSW NPWS 2012 Highway Design (footprint): RTA 2012 Project Boundary: RTA 2012 Weed Survey: ECOS Environmental 2013 State Forests: NSW Department of Primary Industries 2008
Disclaimer:	This plan is based on or contains data provided by others. ECOS Environmental gives no warranty in relation to the data (including accuracy, reliability, completness, currency or suiability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to and use of the data. Data must not be used for direct marketing or be used in breach of privacy laws.
File:	NH2U-002-WEED-SURVEY-140120

N S E W

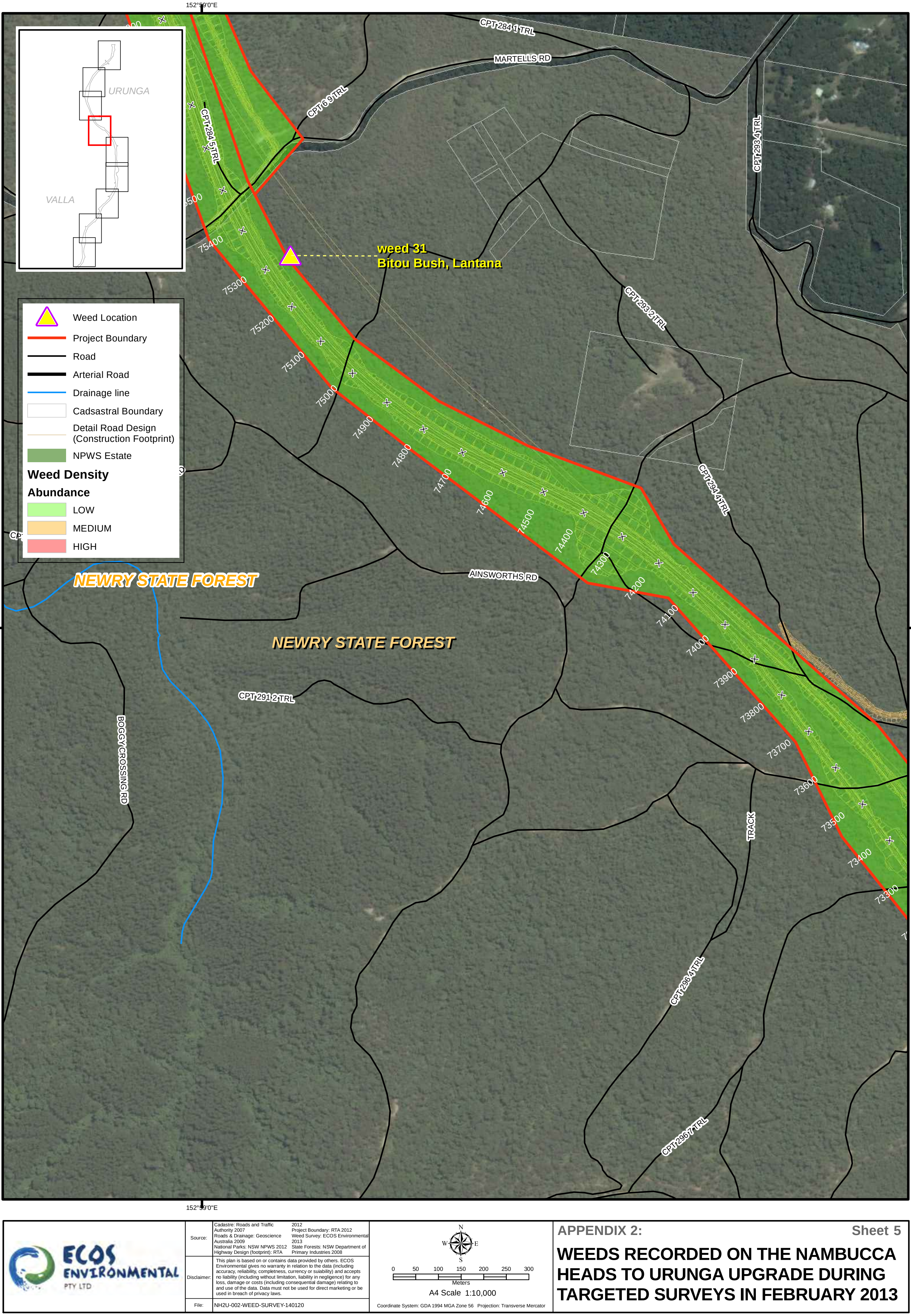
0 50 100 150 200 250 300
Meters

A4 Scale 1:10,000

Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator

APPENDIX 2: Sheet 4

WEEDS RECORDED ON THE NAMBUCCA HEADS TO URUNGA UPGRADE DURING TARGETED SURVEYS IN FEBRUARY 2013



152°59'0"E

ECOS ENVIRONMENTAL PTY LTD

Source:	Cadastre: Roads and Traffic Authority 2007 Roads & Drainage: Geoscience Australia 2009 National Parks: NSW NPWS 2012 Highway Design (footprint): RTA 2012	Project Boundary: RTA 2012 Weed Survey: ECOS Environmental 2013 State Forests: NSW Department of Primary Industries 2008
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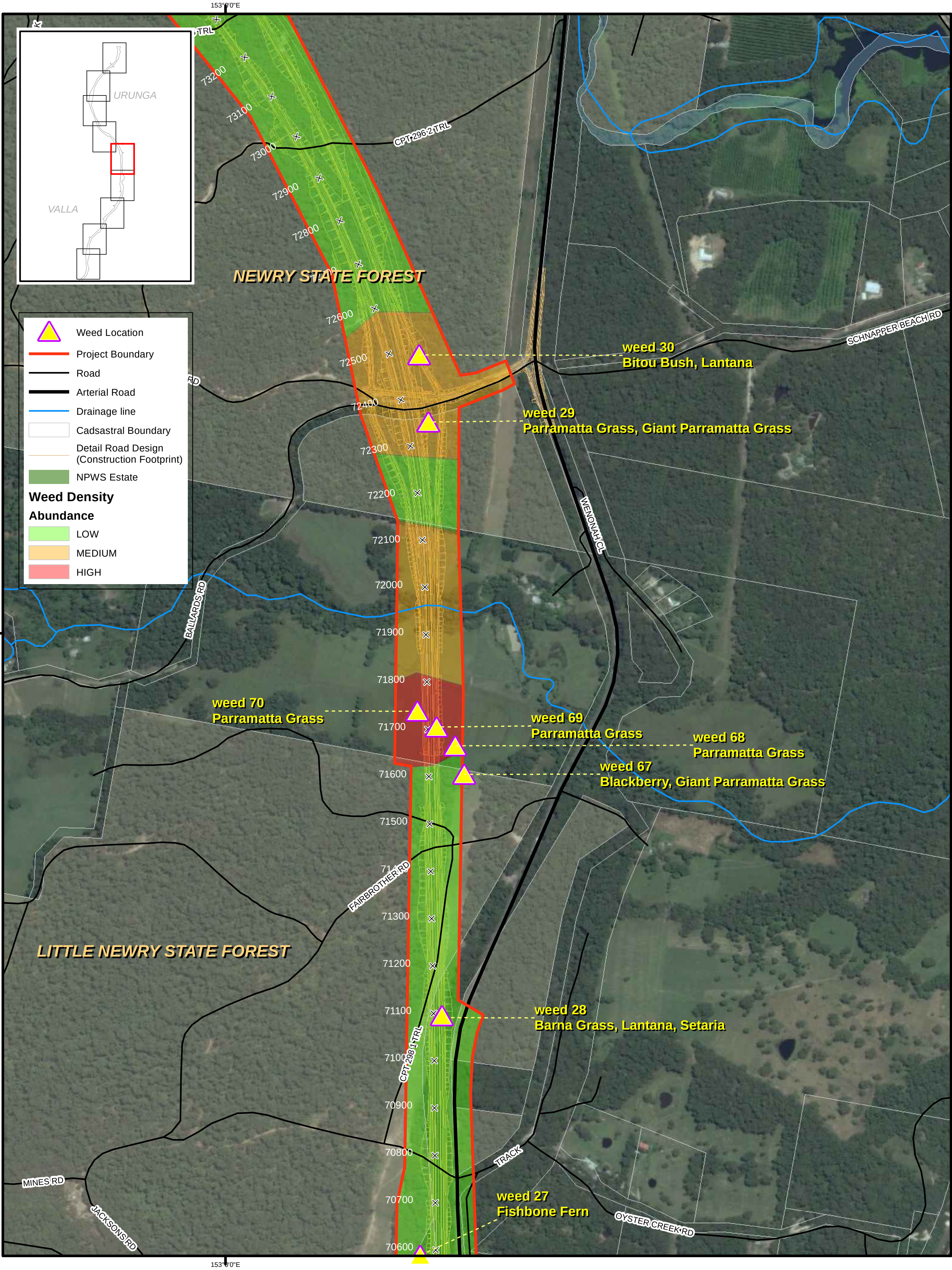
APPENDIX 2: Sheet 5

WEEDS RECORDED ON THE NAMBUCCA HEADS TO URUNGA UPGRADE DURING TARGETED SURVEYS IN FEBRUARY 2013



Source:	Cadastre: Roads and Traffic Authority 2007 Roads & Drainage: Geoscience Australia 2009 National Parks: NSW NPWS 2012 Highway Design (footprint): RTA 2012 Project Boundary: RTA 2012 Weed Survey: ECOS Environmental 2013 State Forests: NSW Department of Primary Industries 2008
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A4 Scale 1:10,000

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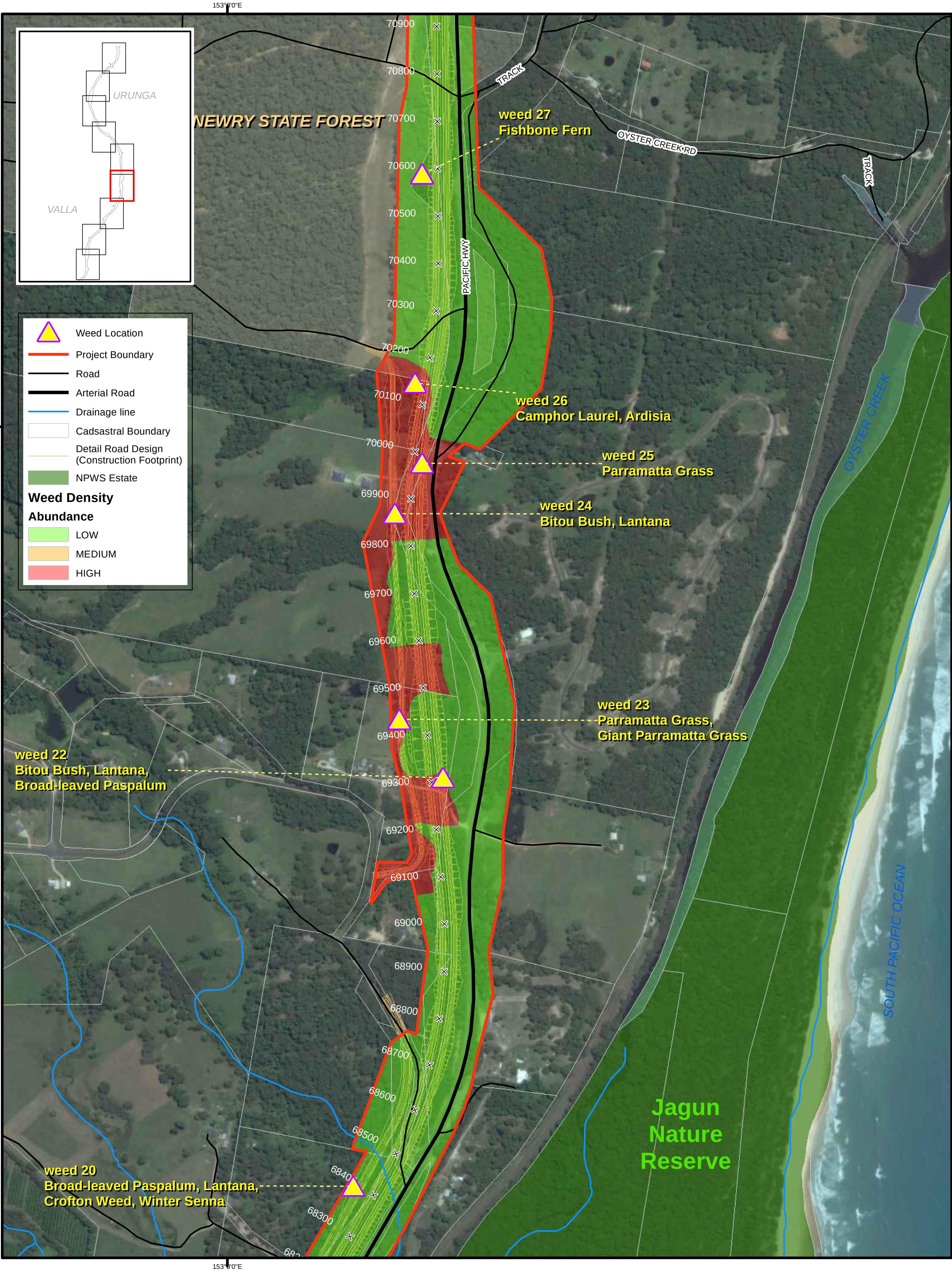
APPENDIX 2: Sheet 6

WEEDS RECORDED ON THE NAMBUCCA HEADS TO URUNGA UPGRADE DURING TARGETED SURVEYS IN FEBRUARY 2013



ECOS ENVIRONMENTAL PTY LTD

Source:	Cadastre: Roads and Traffic Authority 2007; Roads & Drainage: Geoscience Australia 2009; National Parks: NSW NPWS 2012; Highway Design (footprint): RTA 2012; Project Boundary: RTA 2012; Weed Survey: ECOS Environmental 2013; State Forests: NSW Department of Primary Industries 2008
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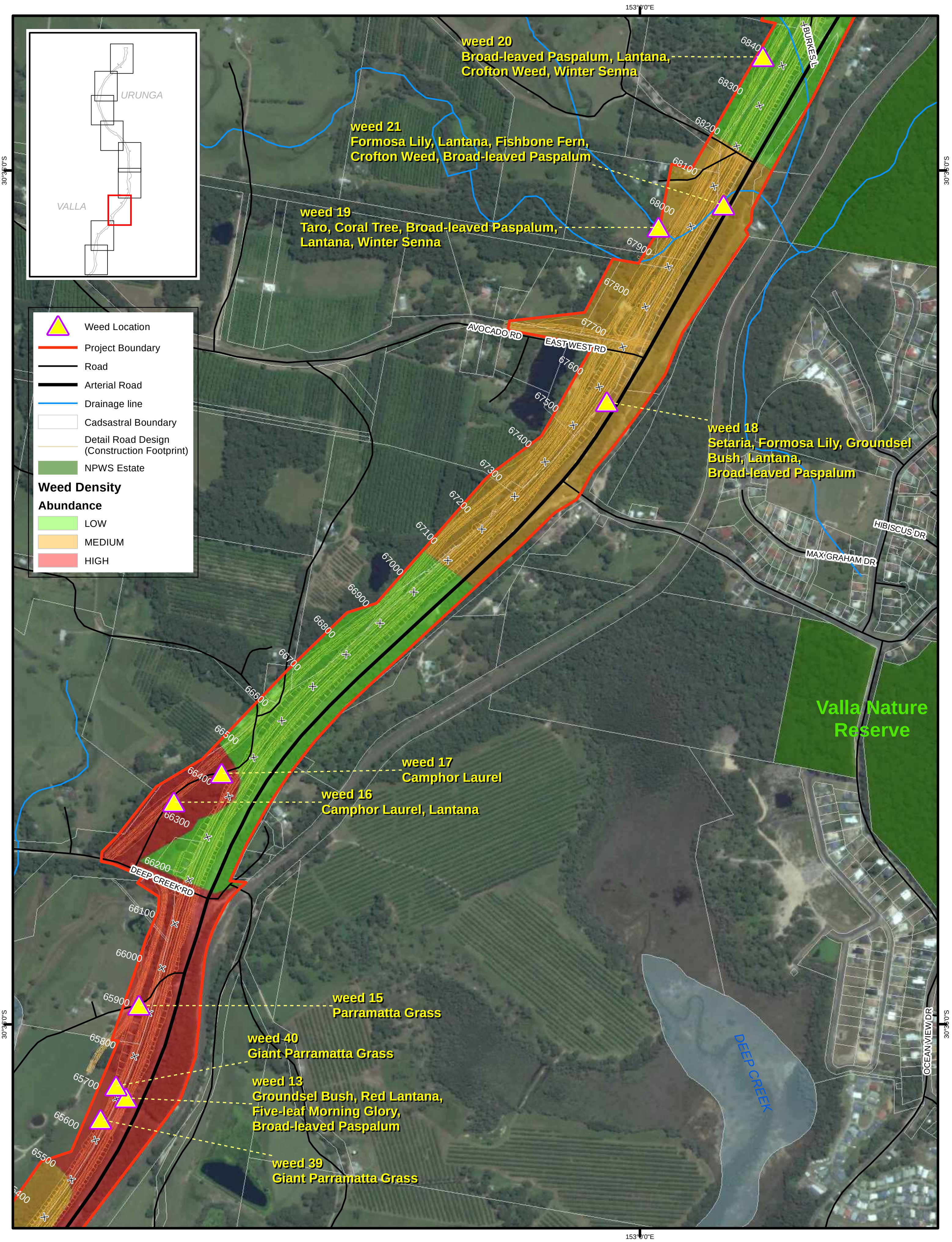
0 50 100 150 200 250 300
Meters
A4 Scale 1:10,000
Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator

APPENDIX 2: Sheet 7

WEEDS RECORDED ON THE NAMBUCCA HEADS TO URUNGA UPGRADE DURING TARGETED SURVEYS IN FEBRUARY 2013



ECOS ENVIRONMENTAL PTY LTD

Source:	Cadastre: Roads and Traffic Authority 2007 Roads & Drainage: Geoscience Australia 2009 National Parks: NSW NPWS 2012 Highway Design (footprint): RTA 2012 Project Boundary: RTA 2012 Weed Survey: ECOS Environmental 2013 State Forests: NSW Department of Primary Industries 2008
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File:	NH2U-002-WEED-SURVEY-140120

N W E S

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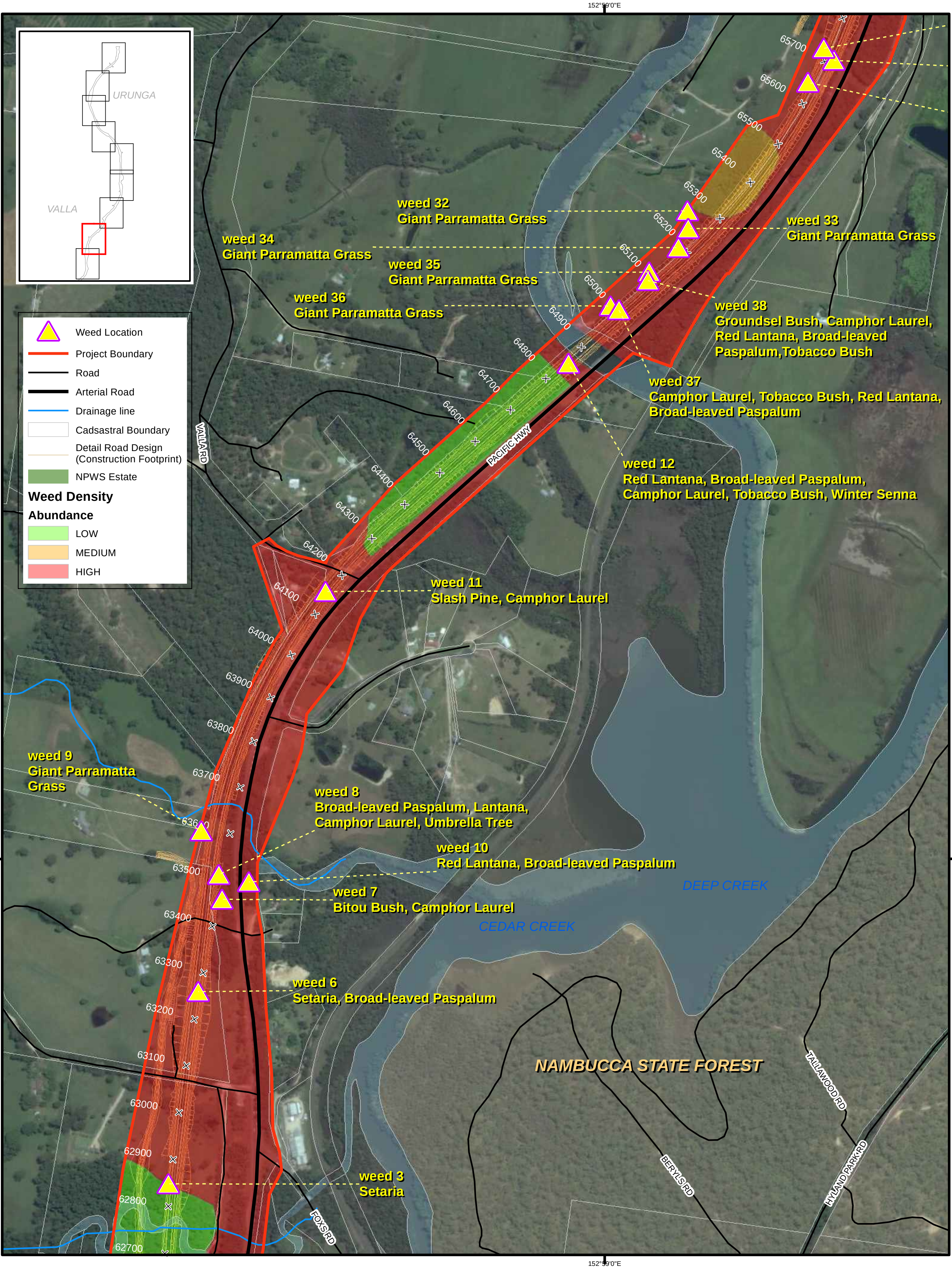
Meters

A4 Scale 1:10,000

Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator

APPENDIX 2: Sheet 8

WEEDS RECORDED ON THE NAMBUCCA HEADS TO URUNGA UPGRADE DURING TARGETED SURVEYS IN FEBRUARY 2013



ECOS ENVIRONMENTAL PTY LTD

Source:	Cadastre: Roads and Traffic Authority 2007; Roads & Drainage: Geoscience Australia 2009; National Parks: NSW NPWS 2012; Highway Design (footprint): RTA 2012; Project Boundary: RTA 2012; Weed Survey: ECOS Environmental 2013; State Forests: NSW Department of Primary Industries 2008
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N S W E

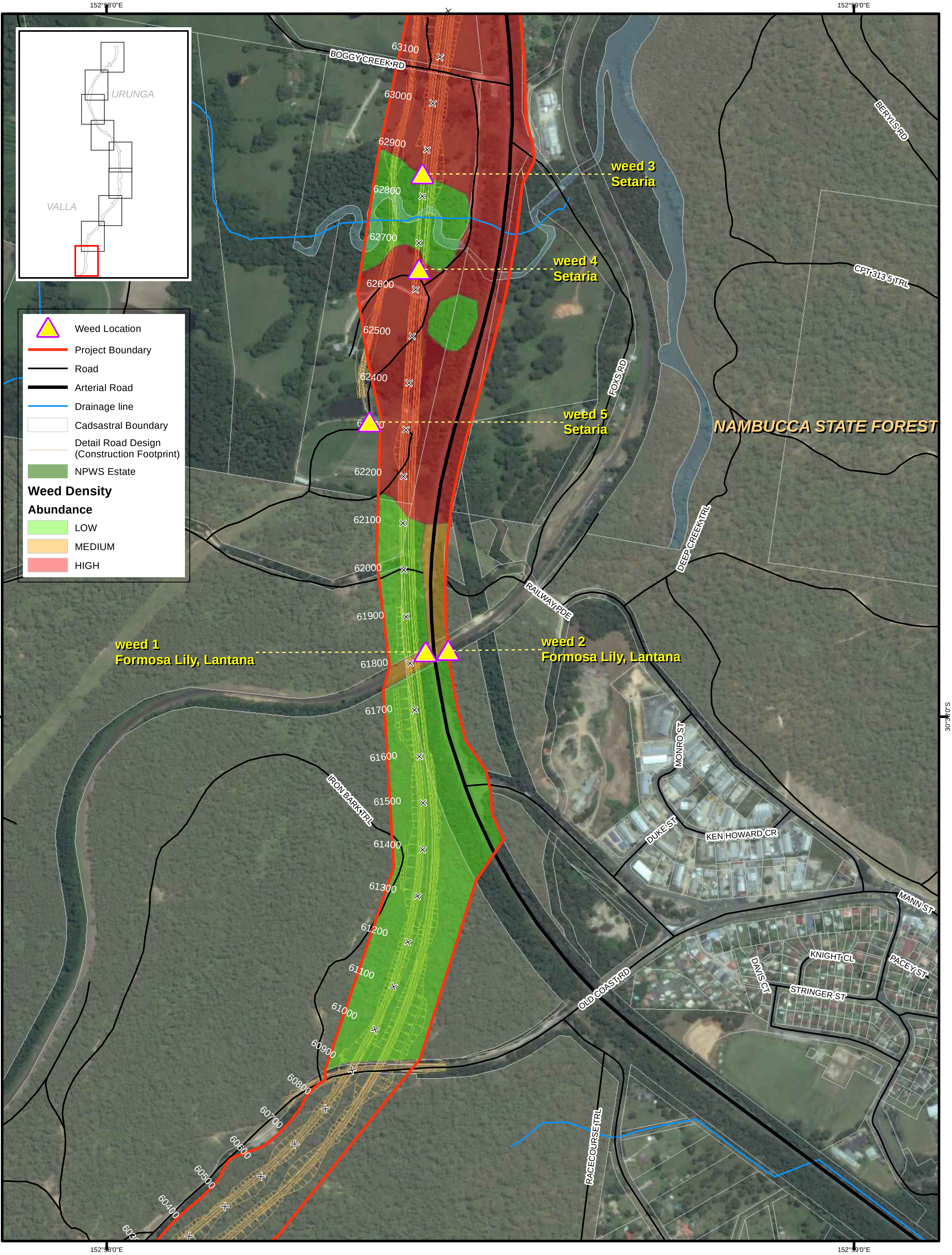
0 50 100 150 200 250 300
Meters

A4 Scale 1:10,000

Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator

APPENDIX 2: Sheet 9

WEEDS RECORDED ON THE NAMBUCCA HEADS TO URUNGA UPGRADE DURING TARGETED SURVEYS IN FEBRUARY 2013



ECOS ENVIRONMENTAL PTY LTD

Source:	Cadastre: Roads and Traffic Authority 2007 Roads & Drainage: Geoscience Australia 2009 National Parks: NSW NPWS 2012 Highway Design (footprint): RTA 2012 Project Boundary: RTA 2012 Weed Survey: ECOS Environmental 2013 State Forests: NSW Department of Primary Industries 2008
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0 50 100 150 200 250 300
Meters

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Coordinate System: GDA 1994 MGA Zone 56 Projection: Transverse Mercator

APPENDIX 2: Sheet10

WEEDS RECORDED ON THE NAMBUCCA HEADS TO URUNGA UPGRADE DURING TARGETED SURVEYS IN FEBRUARY 2013

Appendix B

Noxious Weed Identification and Control Guide

Information sourced from Weeds Australia.

Note: Recommended control method indicated by ☺ symbol

NOXIOUS WEEDS

Annual Ragweed
Ambrosia artemisiifolia

Declaration class 5

Description

Erect annual and shallow-rooted herb to 2 (rarely to 3.5) m high. Leaves grey-green, hairy.

Habitat and distribution

invades roadsides, wastelands and poor or overgrazed pastures. Spread by seed attached to animals or in mud.

Problem

The pollen from this plant is a major cause of hayfever and can aggravate asthma. Contact with the plant can also cause skin allergies.

Control

☺Chemical x Biological ☺ Mechanical/Physical

Small infestations should be controlled before flowering to prevent large infestations which can be difficult to control.

Plants may be slashed or mown prior to setting seed (i.e. at the early flowering stage or immediately prior to flowering). Checks should be carried out to ensure flowering is prevented in any regrowth that occurs. Regrowth may occur from soil seed banks and these plants should also be controlled.

It is possible to spray with selective herbicide. However these may damage legume species.

Bitou Bush
Chrysanthemoides monilifera subspecies *rotundata*

Declaration class 4

Description

Perennial sprawling shrub. Stems are woody and much branched. Leaves hairless, although young leaves have a cottony down. Flowers are 2.5 cm in diameter and bright yellow with 8-12 petals

Habitat and distribution

Originally introduced to prevent soil erosion in coastal areas, this plant is most prevalent on sand dunes and in other coastal environments. It is a weed of sub-tropical and warmer temperate coastal districts and invades sand dunes, native bushland, open woodlands and rainforest margins.

Birds and animals spread seed after eating berries.

Problem

It produces large numbers of seeds which can lay dormant for up to 5years

It grows quickly and densely, shading other plants.

It has no natural Australian predators.

Extensive taproot system enables it to survive and compete very successfully with other species.

Control

☺Chemical x Biological ☺ Mechanical/Physical

Established plants should be destroyed before they flower and produce fruit (berries).

Hand-pull seedlings and plants up to 1 m in height. Bitou bush has a shallow root system with no distinct taproot.

Bitou bush does not persist when grazed or cultivated. Slashing is not effective as regrowth occurs from the stump. The removal of adult plants stimulates seed germination and these seedlings should be removed before they produce further seeds.

Fire can destroy seedlings and many mature plants, however stimulates seed germination. Control of the resultant seedlings is necessary.

Spraying before berries turn black should render them sterile. However, to minimise seed set, plants should preferably be sprayed within six months of germination. Therefore, two spraying programs per year may be necessary to prevent seeding.

Blackberry

Rubusfruiticosusand aggregate species

Declaration status Class 4 (WONS)

Description

Erect woody shrub to 5m high with scrambling prickly stems
Flowers pink-white on the end of branches
Berries ripen from green to red to black in late summer

Habitat and distribution

Inhabit various environments in high rainfall areas – forest, riverbanks, roadsides and pastures.
Seeds are spread by birds and foxes

Problem

Highly invasive forming dense thickets.
Often provide harbours for feral animals such as rabbits

Control

☺Chemical ☺Biological × Mechanical/Physical

Spray with foliar herbicide and leave for three weeks then remove. Large plants – canes (stems) can be cut off at ground level and the cut surface painted with undiluted herbicide (Garlon or Roundup) immediately (within seconds of cutting).

Boneseed

Chrusanthemoised monilifera subspecies monilifera

Declaration class 2

Description

An upright and slightly fleshy shrub, often found growing in coastal areas with yellow 'daisy-like' flower-heads usually only having five to eight 'petals'.

Habitat and distribution

Most prevalent on sand dunes and in other coastal environments. It is widespread in the coastal and sub-coastal areas of the cooler temperate regions of Australia, and is also found in semi-arid environments. In these areas it also invades open woodlands, forests, waste areas, roadsides, waterways (i.e. riparian areas) and pastures

Problem

A vigorously growing bush able to regenerate quickly and outcompete other species after fire and establish in disturbed and undisturbed native vegetation

Control

☺Chemical ☺Biological × Mechanical/Physical

As with Bitou Bush, hand- pull seedlings and plants up to 1m. Remove any seedlings that emerge after initial removal.

Spraying should be undertaken before berries turn black. A second round of spraying should be carried out after 6months of initial spraying to prevent seeding of seed bank in soil.

Camphor laurel

Cinnamomum camphora

Declaration class 4

Description

Evergreen tree grows up to 20m. It has large spreading canopy and a short, stout bole up to 1.5m in diameter. Minute white flowers near ends of branches. Fruit small, round, green berries which turn black on ripening.

Habitat and distribution

Crofton Weed

Ageratina adenophora

Declaration status Class 4

Description

Erect perennial shrub to 2m high
Stems purplish, seed brown-black
Clusters of white tubular flowers in early spring

Habitat and distribution

Tolerates wet soils. Seeds are carried by water and by strong wind. Transported in hay, machinery, vehicles,

Especially troublesome on sloping, rocky land not readily accessible to machinery or grazing animals. Invades habitats where forests have been cleared, usually for pasture or cultivation.

Problem

Infestations along roadsides and on unused Crown Land. Concerned about competition between camphor laurel and native vegetation and the possible exclusion of regenerating native rainforests. There is a tendency for camphor laurel to form single species communities to the exclusion of ALL the species.

Control

☺Chemical   x Biological   x Mechanical/Physical

Effective control of camphor laurel can be achieved by using either the cut stump, stem injection, basal bark or foilar spray application techniques. The method used depends on the site situation, tree size, access and personal preferences.

Trees can be cut and treated or bulldozed, but this method disturbs soil and leads to rapid re-establishment of Camphor Laurel.

clothing and mud.

Problem

Will invade wetlands

Control

☺Chemical   x Biological   x Mechanical/Physical

Control small infestations before flowering to prevent large infestations which can be difficult to control. Spray with selective herbicide. Remove any regrowth manually, or by high volume application of herbicide (spot spray) where feasible.

Fireweed

Senecio madagascariensis

Declaration class 4

Description

Mostly erect annual or biennial herb to 70 cm high. Leaves variable, to 8 cm long and to1.5 cm wide.

Habitat and distribution

Coastal pastures in eastern Australia where it covers thousands of hectares. Most spread is by wind dispersed seed. Long distance dispersal also occurs by seeds on animals, in stock feed or in mud on vehicles.

Problem

Losses result from decreased pasture production and reductions in growth rates, or death, of cattle and horses caused by pyrrolizidine alkaloids occurring in the plant.

Control

☺Chemical   x Biological   ☺ Mechanical/Physical

Management options will vary depending on the situation, with different approaches, for example, for grazing enterprises, environmental areas or small area holdings:

- for environmental areas, hand-pulling individual plants and using spot spraying for herbicide

Giant Parramatta grass

Sporobolus fertilis

Declaration class 4

Description

A tussocky grass that can grow up to 2 metres in height. The seed head is up to 40cm long and resembles a rats tail. The branches at the bottom of the seed head, droop away from the central stem. The base of the stem of G.P.G is flat and coarse and shoot from the crown in a flattened shape.

Habitat and distribution

Produces a large number of seeds which spread by vehicles, machinery, livestock, floods etc.

Problem

Giant Parramatta grass can dramatically decrease producers' economic viability and lower land values

Control

☺Chemical   x Biological   ☺ Mechanical/Physical

Hand pull small plants and follow with herbicide. Clean machinery and vehicles after working in infested areas.

application may be used

It is preferable to manage a small area correctly than to poorly manage a large area.

Groundsel bush

Baccharis halimifolia

Declaration class 3

Description

A densely branched shrub, usually 1.5 to 3 m high, although sometimes grows into a small tree up to 7 m high.

Habitat and distribution

A rapid coloniser of cleared, unused land and is particularly suited to moist gullies, salt marsh areas and wetlands. It is also a major weed of coastal pine forests where there is little ground cover to compete with seedlings.

Problem

A rapid coloniser of cleared, unused and overgrazed land It can be poisonous, Groundsel bush is reputed to be poisonous to horses, and also possibly sheep. Cattle lose condition rapidly when forced to graze it; it has no value as stockfeed and heavy infestations can greatly reduce carrying capacities.

Control

☺Chemical x Biological x Mechanical/Physical

As groundsel bush is a perennial woody plant with underground growing buds, slashing or burning will rarely kill plants and such action will generally result in regrowth occurring. Therefore the regrowth should be promptly controlled using herbicide.

Many different herbicides are available for the use on Groundsel Bush plants.

Lantana

***Lantana* species**

Declaration status Class 4 (WONS)

Description

Large shrub with many branches and square stems with small prickles. Leaves are in pairs and are rough with finely toothed edges. Lantana has a strong smell when crushed. Flowers are a mixture of cream, pink or orange, numerous in small rounded heads.

Habitat and distribution

Prefers moist soils in a warm humid environment. It typically colonises along the edge of forests and cleared land.
Dispersal is via suckers from roots and spreads vegetatively.

Problem

May be allelopathic – releasing chemicals into the soil to ensure other plants colonise
Plants highly flammable and are a fire hazard in dry conditions.

Fruit eating birds and animals are the main cause of lantana spread. While, the movement of water, contaminated soil and machinery, deliberate planting and poorly disposed garden waste can help lantana spread.

Control

☺Chemical x Biological ☺ Mechanical/Physical

Variables such as seasonal conditions and lantana varieties must be considered

Hand grubbing is suitable where seedlings are identified. Spot spraying is the most suitable method for small infestations - spray entire plant with selected herbicides for plants under 2m. While herbicides applied by the basal bark technique or the cut stump technique for larger plants work best. For medium sized infestations lantana can be removed physically by stickraking, bulldozing, ploughing and grubbing. However, regrowth will occur if root stock is not removed, or from seedling germination due to soil disturbance so follow up controls will be required. Physical removal should be avoided on steep inclines or gullies.

Mistflower ***Ageratina riparia*** 	**Declaration status** Class 4 **Description** Spreading herb to 1m high. Purplish cylindrical stems. Single-veined leaves with toothed margins. Flowers winter – spring, white showy clusters. **Habitat and distribution** Favours damp areas, stream banks and clearings in rainforest and pasture. Seeds spread by wind and water. **Problem** May be poisonous to stock **Control** ☺Chemical x Biological x Mechanical/Physical Small plants can be pulled out and should be disposed of by burning or putting into black plastic bags to rot down. There are several herbicides approved for use on mistflower, which can be applied by spot spraying, via knapsack, sprinkle sprayer or hand gun.	

Appendix C

Sample Pesticides Application Sheet

Information to be recorded	***Brief description***	***Enter data here***
1. Date and time	*Start date and time* *Finish date and time*	
2. Wind speed and direction	*Record wind speed and direction (only if the pesticide is applied through the air). Wind speed must be <10km/hr. Write down any changes in weather during application.*	
3. Other weather details	*Record any weather details such as temperature, humidity and/or rainfall where the pesticide product label requires to assess these.*	
4. Who applied the pesticide	*Full operator name* *Operator contact address* *Operator contact phone*	
5. Boundaries of treated area and order of treatment	*List treated areas and order of treatment, preferably with reference to the map. List order of treatment.*	
6. Problem treated	*Identify the pest or problem treated (e.g. controlling of spot weed infestation)*	
7. Product used	*Record either full name, or a product code if a list of full product names of pesticides you use is kept at the front of your logbook.*	
8. Quantity applied and dilution	*Total amount of pesticide product mix used. Write down whether the mix was concentrated product or a diluted mixture (note the rate of dilution)*	
9. Equipment used	*Describe the equipment used (e.g. boom-spray, hand-held backpack sprayer etc)*	
10. Other Observations	*Detail any other required observations (eg. Fruiting, flowering, fauna, flora)*	

Appendix D

PLANT CLEAN DOWN CHECKLIST

Lend Lease

PLANT CLEAN DOWN CHECKLIST

Objective: All machinery, equipment or apparatus will be clean and visually free of mud, plant or weed material, oil & grease before entering site.

Action: All appliances will be cleaned of all **LOOSE SOIL** and **PLANT MATERIAL** before entering site using one (1) of the following procedures:

Physical removal, brush down, wash down or high pressure water cleaner.

Note: Appliances that are not transferring high – risk items, for example deliveries to site compounds, are exempt from clean down procedures,

Plant No: ________________________

APPLIANCE Plant	**Component To Be Checked** (includes any other part of an Appliance not mentioned)	**Authorised Signature**	**Date**
Bulldozer	Rippers, Blade, Track Frame, Belly Plate, Tracks		
Excavator	Track Frame, Underside of Slew Ring, Buckets, Tracks		
Rollers	Track Belly Plate		
Grader	Rippers, Mould Board, wheels		
Scraper	Overflow area on rear of scraper, Belly Plate, wheels		
Tractors	Underside of tractor		
Backhoe	Buckets and Backhoe attachment, Belly Plate, wheels		
Bobcat	Buckets, Belly Plate/other attachments		
Trucks	Soil build – up bins, chassis rails		
Other Appliance			
Other Appliance			

Lend Lease / Subcontractors:___________________________________

Name of person cleaning / checking equipment: _______________________

Signed: ________________ Date: __/__/__

Please return completed form to Environmental Manager