Warrell Creek to Nambucca Heads Pacific Highway Upgrade

Commonwealth Approval EPBC 2013/7101 Annual Compliance Report February 2017 – February 2018

Roads and Maritime Services | May 2018

NSW GOVERNMENT

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Terms and Abbreviations

BOS	Biodiversity Offset Strategy
CEMP	Construction Environmental Management Plan
Clear Milkvine	Marsdenia longiloba
Cryptic Forest Twiner	Tylophora Woollsii
DoEE	Federal Department of Environment and Energy
DPE	State Department of Planning and Environment
EPBC Act	Environment Protection and Biodiversity Conservation Act 1999
FFMP	Flora and Fauna Management Plan
GBF	Giant Barred Frog
GBFMP	Giant Barred Frog Management Plan
Geolink	Geolink – Project Ecologist for WC2NH Project
GHFF	Grey-headed Flying-fox
Pacifico	Acciona Ferrovial Joint Venture (the Roads and Maritime's road construction contractor for the project).
STQ	Spotted-Tail Quoll
TFMP	Threatened Flora Management Plan
WC2NH	Warrell Creek to Nambucca Heads Pacific Highway Upgrade Project

Contents

1. Introduction

1.1. Purpose of this document

The purpose of this document is to facilitate demonstration by Roads and Maritime Services (Roads and Maritime) of satisfactory compliance with the Commonwealth approval conditions for the Warrell Creek to Nambucca Heads Pacific Highway Upgrade project (the Project) with particular reference to Condition 19 and 20. This report covers the third reporting period from February 2017 to February 2018.

For each condition, one or more actions are identified which, once implemented, will achieve satisfactory compliance with the condition. Where appropriate, the timing for completion of individual actions is identified.

For each action, the minimum relevant documentation to support demonstration of compliance is identified. This documentation would inform any future compliance audit.

Where an approval condition makes reference to information being provided to the Commonwealth Minister for the Environment, the associated action(s) assumes that this information will be provided, in the first instance, to the Commonwealth Department of the Environment.

1.2. Key dates

The timing for compliance with certain approval conditions is linked to specific dates as follows:

- Commonwealth approval: 11 Dec 2014
- Start of construction: 9 Feb 2015
- Scheduled completion of construction: 15 June 2018 (weather permitting)
- Expiry of Commonwealth approval 31 Dec 2064

1.3. Responsibility for compliance

Responsibility for compliance with all approval conditions sits with Roads & Maritime.

1.4. NSW planning approval

Condition 3 and 4 (of the Commonwealth approval) provides for the use of plans, strategies or reports required under the NSW approval to satisfy the requirements of the Commonwealth approval, subject to provision of a separate document demonstrating how the document addresses the relevant Commonwealth approval requirements.

Specialists in the fields of flora and fauna have been engaged by Roads & Maritime and the construction contractor to undertake various ecology-related management activities with regard to complying with the NSW planning approval and the CEMP.

This document contains actions relevant to compliance with the NSW planning approval that are also considered to satisfy compliance with Commonwealth approval requirements.

1.5. Definitions for action status conditions

TBA	To Be Arranged - Further works required prior to starting action.
In progress	Action initiated but not yet complete.
Ongoing	Action in place but ongoing works required to ensure compliance.
Complete	Action completed.

1.6. Non Compliances with EPBC Conditions

No non-compliances against the approval conditions were identified during the third reporting period (February 2017 – February 2018).

2. Compliance Tracking Tables

The following sections provide a compliance status for the reporting period for the 26 conditions of approval. Note: where relevant, the conditions have been amended to reflect the current approval variation.

2.1. Condition 1

The approval holder must not clear more than:

a) 17.80 hectares (ha) of **Slender Marsdenia/Clear Milkvine and Woolls Tylophora/Cryptic Forest Twiner habitat**;

b) 106.6 ha of **Koala habitat**, including 86.50 ha critical to the survival;

c) 106.6 ha of **Grey-headed Flying-fox habitat**, comprised of 103.50 ha of foraging habitat critical to survival and 3.10 ha of roosting habitat critical to survival;

d) 114.1 ha of **Spotted-tail Quoll habitat**;

e) 0.70 ha of **Giant Barred Frog habitat**;

f) 3.40 ha of Australian Painted Snipe (*Rostratula australis*) wetland habitat;

g) 5.3 ha of habitat for the Regent Honeyeater (*Anthochaera phrygia*) and Swift Parrot (*Lathamus discolour*) wintering habitat, comprising dry schlerophyll forests containing Swamp Mahogany; and

h) 26.1 ha of Milky Silkpod (*Parsonsia dorrigoensis*) habitat, comprising Mixed Floodplain Forest, Flooded Gum Open Forest and White Mahogany/Grey Gum/Ironbark Open Forest.

	Action	Timing	Status	Compliance evidence
1.1	Progressive review of area cleared	Regularly during construction	Compliant Ongoing	Record of clearing numbers provided in monthly report from Contractor to RMS. Refer to Table 1.1 below for clearing quantities for the reporting period.
1.2	Report on clearing progress	Monthly	Ongoing	Information provided by contractor to RMS in monthly report
1.3	Confirm clearing limitation targets have been met	Post-construction	TBA	As built survey of actual clearing area. Not able to action until after completion of clearing. Memo/short report

Table 1.1: Clearing Quantities for the reporting period.

February 2018 Completed Clearing Quantities (Aerial Survey)			
Habitat Type	**Clearing Quantity (ha)**	**Limit (ha) as per Condition 1 Approval**	**Current Difference showing remaining habitat (ha) under Condition 1 Approval**
Slender Marsdenia/Clear milkvine and Woolls Tylophora/Cryptic Forest Twiner habitat	15.67	17.80	2.13
Koala	78.17	106.60	28.43
Koala (Critical Habitat)	59.13	86.50	27.37
Grey-headed Flying-fox	80.32	106.60	26.28
Grey-headed Flying-fox (foraging habitat critical to survival)	78.17	103.50	25.33
Grey-headed Flying-fox (roosting habitat critical to survival)	2.15	3.10	0.95
Giant Barred Frog	0.63	0.7	0.07
Spotted –tail Quoll habitat	84.27	114.10	29.83
Australian Painted Snipe (Rostratula australis)	2.49	3.4	0.91
Regent Honeyeater (Anthochaera phrygia) and Swift Parrot (Lathamus discolour)	4.03	5.30	1.27
Parsonsia dorrigoensis (Milky Silkpod)	22.75	26.1	3.35

NOTE: The above clearing data represents clearing undertaken up to February 2018. Clearing quantities for all habitat types are below the limits as specified in condition one.

It is anticipated that minor ongoing clearing associated with property adjustments and design refinements will be undertaken until the completion of the project.

2.2. Condition 2

Within 30 days of the **complete on of construction**, the **approval holder** must:

a) notify the **Minister** in writing of the **completion of construction**; and

b) provide a report (supported by maps) that clearly shows the location of all **threatened species**, including the number of individuals of threatened flora and their **habitat cleared** as a result of **action**, which demonstrates compliance with Condition 1.

	Action	Timing	Status	Compliance evidence
2.1	Prepare works as executed Environmental and Clearing Plans to show extent of clearing.	June 2018	TBA	Report & supporting mapping
2.2	Calculate final clearing quantity and include in summary table.	June 2018	TBA	Report & supporting mapping
2.3	Provide written notification (letter) of completion of construction and report to Dept. of the Environment	June 2018	TBA	Notification letter Completed document transmittal form or equivalent

2.3. Condition 3

The **approval holder** must undertake the **action** and implement all mitigation measures in accordance with the **Koala Management Plan**, **Grey-headed Flying-Fox Management Plan**, **Spotted-tail Quoll Management Plan** and **Giant Barred Frog Management Plan**. These **Plans** must be implemented.

	Action	Timing	Status	Compliance evidence
3.1	Implement the Koala Management Plan	Pre-construction, Construction and Operation	Compliant Ongoing	Sensitive Area Plans Ecological Monitoring Report Roadkill Quarterly Reports Completed Pre-clearing Checklists Fauna Relocation Register Habitat Tree Hollow Register Environmental Work Method Statements (EWMS) for Activities Project Induction Biodiversity Offset Strategy Urban Design and Landscape Plan Fauna Connectivity Report See summary below

3.2	Implement the Grey-Headed Flying Fox Management Plan	Pre-construction, Construction and Operation	Compliant Ongoing	Sensitive Area Plans Ecological Monitoring Report Roadkill Quarterly Reports Completed Pre-clearing Checklists Fauna Relocation Register Habitat Tree Hollow Register Environmental Work Method Statements (EWMS) for Activities Project Induction Biodiversity Offset Strategy Urban Design and Landscape Plan Fauna Connectivity Report See summary below
3.3	Implement the Spotted-tail Quoll Management Plan	Pre-construction, Construction and Operation	Compliant Ongoing	Sensitive Area Plans Ecological Monitoring Report Roadkill Quarterly Reports Completed Pre-clearing Checklists Fauna Relocation Register Habitat Tree Hollow Register Environmental Work Method Statements (EWMS) for Activities Project Induction Biodiversity Offset Strategy Urban Design and Landscape Plan Fauna Connectivity Report See summary below

3.4	Implement the Giant Barred Frog Management Plan	Pre-construction, Construction and Operation	Compliant Ongoing	Sensitive Area Plans Ecological Monitoring Report Roadkill Quarterly Reports Completed Pre-clearing Checklists Fauna Relocation Register Habitat Tree Hollow Register Environmental Work Method Statements (EWMS) for Activities Project Induction Biodiversity Offset Strategy Urban Design and Landscape Plan Fauna Connectivity Report See summary below

Compliance Tracker

Table 3.1: Compliance with the Koala Management Plan

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
Design Phase/Pre-construction	Minimise areas of Koala habitat to be cleared where feasible and reasonable during the detailed design phase.	The Project design has minimised clearing quantities as much as possible by ensuring the construction corridor is as narrow as possible. Ancillary sites have been located in areas where clearing is minimal.	Design Drawings
Pre-construction	All ancillary sites to be located outside of mapped Koala habitat.	Ancillary sites have been located in areas of minimal clearing and have minimised clearing of Koala habitat trees.	Sensitive Area Plans Ancillary Facility Register
Pre-Construction	Prior to any clearing taking place, the Project Ecologist will undertake	Prior to construction commencing, only minor clearing (<150mm DBH) was undertaken. The Project	Early Works Permits

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
	an inspection of vegetation, to be cleared, to determine if work activities do not constitute "Construction" as defined in the planning approval under the NSW EP&A Act and are excluded from the Referral under the Federal EPBC Act.	Ecologist inspected all areas of clearing to ensure no Koala habitat was removed during Pre-construction activities.	
Pre-Construction/ Construction	The limits of clearing are to be clearly marked on all relevant work plans and protective fencing erected to mark these limits (i.e. 'no-go' areas).	The clearing limits have been included on the Sensitive Area Plans and marked in the field using yellow flagging.	Sensitive Area Plans Early Works Permits Pre-clearing and Ground Disturbance Permits
Detailed Design/Pre-construction	Areas for Koala habitat restoration/connectivity are to be identified and included in the detailed design.	Habitat connectivity planting has been included in the Urban Design and Landscape Plan	Urban Design and Landscape Plan
Pre-construction/ Construction	Preparation of an EWMS would be undertaken for all work/construction activities and would include where necessary measures to minimise risk to Koalas.	An EWMS has been prepared for all work activities which includes measures to protect flora and fauna in accordance with the Flora and Fauna Management Plan (FFMP)	EWMS
	Induction of all personnel involved with pre-construction/construction activities would be undertaken to advise on Koala management requirements	Project Induction includes information about identification of Koala's on site.	Project Induction

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
	For any areas of vegetation to be cleared during the pre-construction stage of the Project, a suitably qualified ecologist will undertake a search for native fauna (including Koalas) in the vicinity of clearing immediately prior to clearing commencing. During the construction stage, pre-clearing surveys will be undertaken within 48 hours of any clearing commencing (These are to include spotlighting surveys within suitable habitat on the night prior to clearing operations commencing in a given area.) In the event that a Koala is identified within 50 metres of a works area, works will be rescheduled until the construction stage of the Project. During the construction phase clearing works, the suitably qualified expert or an experienced wildlife handler under the supervision of the suitably qualified expert will be available to retrieve and provide appropriate care of any displaced matters of NES and release the fauna into adjacent habitats safe from construction work. Immediately prior to (within 2 hours) of clearing commencing in a given area, an additional ecologist inspection is to be undertaken to confirm that clearing areas remain free of fauna (including Koalas). Where Koalas are identified no works would be undertaken within 50 metres of the animal and the measures within the Fauna Management Protocol for	The Project Ecologist undertakes inspections of all areas to be cleared and signs off on the Pre-clearing Inspection Checklist prior to commencement. No Koala's have been identified on site during clearing operations.	Pre-clearing and Ground Disturbance Permit

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
	Koalas (refer to Table 4.1 of Koala Management Plan) would be implemented. Should relocation of Koalas be required, a Koala Relocation Strategy included in Appendix C of the Koala Management Plan would be implemented.		
Pre-construction and Construction	Koala Management Protocol to be implemented requiring all personnel to report Koalas (including road kill). An assessment of future road kill risks including adaptive management actions is to be provided by the Project Ecologist where: - A Koala is detected within/near the site, or - Koala road kill is detected. Prior to the construction of fauna passage locations and installation of fauna fence, where continuous lines of jersey barriers are to be installed, gaps	No Koala roadkill has been identified on the Project during Pre-construction and Construction Phase of the Project. No concrete barriers have been placed through Koala habitat areas.	Roadkill records and quarterly report.

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
	are to be provided to allow escape of any animals off the highway. Where gaps cannot be provided, a suitable material will be placed over the barrier to allow Koalas to climb over the barrier.		
Pre-construction/ Construction/ Operation	Appropriate habitat offsets to be identified by including targeted Koala surveys (GeoLINK 2014) using recognised survey approaches to confirm usage of potential offset properties.	Offset properties set up Koala's identified on Norton Property. Refer to CoA 14 for further details	Monitoring Records
Construction	Progressive rehabilitation of identified areas (refer to Appendix B of the Koala Management Strategy) during the construction stage using collected topsoil and seed at specific sites and to develop different successional stages of rehabilitation. Key rehabilitation measures would include: - Progressive revegetation/rehabilitation during the construction phase using collected topsoil and seed at specific sites and to develop different successional stages of rehabilitation. - Planting of locally occurring species, including plants representative of groundcover, understorey and canopy strata. - Planting of preferred food trees for native fauna, including appropriate eucalypt species for the Koala. - Plantings are to be undertaken around fauna crossing structures to optimise utilisation of these structures. - Monitoring and maintenance of plantings. - Managing and controlling	Progressive rehabilitation of the site has commenced. The worksite will be rehabilitated in accordance with the Urban Design and Landscape Plan. Landscape rehabilitation is monitored monthly with a quarterly report developed during the third year of construction. Weed management is undertaken in accordance with the Weed and Pathogen Management Plan (WPMP).	Urban Design and Landscape Plan Site Inspection Records RMS Specification G36 Weed Management Records

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
	weeds.		
Pre-Construction Detailed Design/ Construction	EPA will be consulted during the detailed design phase on fauna crossing structure specific requirements for fauna furniture and treatments in and around fauna crossing structures. This will include, but not necessarily be limited to requirements for refuge poles and/or horizontal rails, pathways and appropriate plantings and/or \sizing /placement of scour rock & treatment of the substrate e.g. soil and/or mulch over the concrete floor and apron. Advice will be provided by the project ecologist on fauna furniture to be installed within fauna crossing structures.	The EPA/Fisheries have been consulted with and have provided input into the detailed design of the fauna crossing structures including the fauna furniture design. The Fauna Connectivity Report prepared by RMS includes detailed information of the consultation process undertaken with the EPA and Fisheries in relation to the fauna crossing structures. The Project has made prototype panels to demonstrate different types of stone pitching that was to be placed in the low flow channel of Butchers Creek. The prototype panels were shown to the EPA and Fisheries to determine the preferred option for frog and fish passage in this waterway. The fauna furniture design has been demonstrated on site using a prototype and shown to the EPA. The EPA are satisfied with the general arrangement. The fauna drop down design has been demonstrated on site using a prototype and shown to the EPA. The EPA are satisfied with the general arrangement.	Detailed Design Drawings ERG Minutes Fauna Connectivity Report

Table 3.2: Compliance with Grey Headed Flying Fox Management Plan

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
Pre-construction	Identify exclusion zones and install exclusion fencing or marking. Exclusion fencing or marking is intended to exclude construction activities from occurring in flying-fox habitat.	Orange flagging and no-go zone signage placed prior to the commencement of construction activities. Flagging was removed when confirmation received that the flying foxes were not utilising the roost on site.	Inspection records Sensitive Area Plans
Detailed Design/ Pre-construction	Minimise through detailed design the incidence of clearing vegetation containing Swamp Mahogany, Melaleuca quinquenervia, Banksia integrifolia and Eucalyptus tereticornis that contribute to foraging habitat during known food bottle necks (i.e. winter period).	The width of the road corridor through the flying fox roost area has been minimised. The total quantity of clearing foraging habitat for GHFF has been minimised.	Sensitive Area Plans Detailed Design Drawings
Pre-construction/ Construction	Construction related infrastructure to be planned and sited within cleared or disturbed areas of the ancillary site. Particularly away from water sources and flying-fox movements areas.	Ancillary sites have been located away from the GHFF roost area and potential habitat.	Consistency review documents for Ancillary site facilities. Ancillary Facility Register
Construction	Pre-clearing and clearing surveys of all vegetation within the clearing footprint conducted as per protocol. Implement contingency plan for moving flying-fox out of the clearing corridor during vegetation clearing/construction, refer to Appendix C of the GHFF Management Plan.	Pre-clearing and ground disturbance permits have been signed off by the Project Ecologist prior to commencing clearing activities. Project Ecologist present during clearing operations in GHFF habitat. No GHFF have been moved from the Project site for clearing operations	Pre-clearing and ground disturbance checklists.
Detailed Design	To minimise the risk of flying-fox vehicle strike during take-off from roosting/foraging, road corridor revegetation and ornamental planting is not to include plants that flower prolifically and produce nectar	The Urban Design and Landscape Plan has considered revegetation that is suitable for the GHFF. Tree species have been located away from the sides of the roadway. Fauna	Urban Design and Landscape Plan Road Furniture

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
	food sources likely to attract flying-foxes.	exclusion fencing has been designed for this area.	Design Package (RF01)
Construction	Exclusion zones fenced off and/or clearly marked. Fencing and marking monitored with breaches repaired.	The clearing limits have been clearly marked with yellow flagging and no-go zone signage. Rural fencing has been installed to prevent access beyond the Project Boundary into the exclusion zone.	Inspection records
Construction	Installation of temporary exclusion fencing around ancillary facilities.	No Ancillary Site Facilities have been placed in the vicinity of GHFF habitat.	Sensitive Area Plans
Construction	Impacts to the flying-fox camp from construction noise, vibration and light would be managed through maintaining exclusion zone buffers and fencing. Only low noise / low disturbance construction activities to occur within the exclusion zone buffer during mid-September to the following April. Inclusion of cross drainage and the provision of a permeable, free draining rock platform in the vicinity of the camp. Implement contingency plan for moving flying-fox out of the clearing corridor and 100 metre buffer during vegetation clearing/ construction, refer to Appendix C of the GHFF Management Plan.	No GHFF have been detected using the camp since prior to the commencement of construction. The GHFF colony has been detected using an alternative roost location and have not returned to the roost adjacent to the worksite. During the last reporting period, the GHFF Management Plan has been updated to permit the project to undertake activities such as haulage through the site buffer zone if the GHFF population returns to the roost site. This update was approved in January 2017.	GHFF Monitoring Reports
Construction	Implement water quality procedures from the CEMP.	Regular inspections of the erosion and sediment controls in the area is ongoing throughout construction. Water quality monitoring is currently ongoing.	Inspection records Water Quality Monitoring Records

Table 3.3: Compliance with Spotted-tail Quoll Management Plan

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
Detailed Design and Construction	Minimise areas of vegetation (STQ habitat) to be cleared where feasible and reasonable during the detailed design and construction phase. Design changes (e.g. additional ancillary facilities, batch plants etc. to avoid clearing of vegetation (STQ habitat)).	The Project design has minimised clearing quantities as much as possible by ensuring the construction corridor is as narrow as possible. Ancillary sites have been located in areas where clearing is minimal and avoids STQ habitat.	Detailed Design Ancillary Facility Register
Pre-construction	All ancillary sites to be located outside of STQ habitat.	Ancillary sites have been located in areas where clearing is minimal and avoids STQ habitat.	Ancillary Site Facility Consistency Reviews Ancillary Facility Register
Pre-construction	Prior to any clearing taking place, the Project Ecologist will undertake an inspection of vegetation to be cleared to determine if work activities do not constitute “Construction” as defined in the planning approval under the NSW EP&A Act and are excluded from the Referral under the Federal EPBC Act.	Prior to construction commencing, only minor clearing (<150mm DBH) was undertaken. The Project Ecologist inspected all areas of clearing to ensure no STQ habitat was removed during Pre-construction activities.	Early Works Permits
Construction	The limits of clearing are to be clearly marked on all relevant work plans and protective fencing erected to mark these limits (i.e. no-go areas). Fauna habitat resources for the STQ to be marked by the ecologist and retained within areas adjacent to the clearing footprint and within the Project boundary where appropriate.	The clearing limits have been included on the Sensitive Area Plans and marked in the field using yellow flagging. Habitat resources are marked by the Project Ecologist where appropriate	Sensitive Area Plans Pre-clearing and Ground Disturbance Permit
Detailed Design	Areas for STQ habitat restoration/connectivity are to be identified and included in the detailed design.	Habitat connectivity planting has been included in the Urban Design and Landscape Plan	Urban Design and Landscape Plan

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
Construction	Preparation of an EWMS would be undertaken for all work activities and would include where necessary measures to minimise risk to the STQ.	An EWMS has been prepared for all work activities which includes measures to protect flora and fauna in accordance with the Flora and Fauna Management Plan (FFMP).	EWMS
	Induction of all personnel involved with activities would be undertaken to advise of STQ management requirements.	Project Induction includes information about identification of STQ on site.	Project Induction
	For any area of vegetation to be cleared during the pre-construction stage of the project, a suitably qualified ecologist will undertake a search for native fauna (including STQ) in the vicinity of clearing immediately prior to clearing commencing. During construction a suitably qualified ecologist will undertake pre-clearing surveys for threatened fauna species (including STQs) prior to (within 48 hours) any clearing commencing. For the STQ, these would focus on dens, large hollow-bearing trees, scats and any other potential habitat features such as rock formations. Immediately prior to (within 2 hours) of clearing commencing within a given clearing area an additional ecologist inspection is to be undertaken to confirm that clearing areas remain free of fauna (including STQs). In the event that a STQ is identified, no works would be undertaken within 200 metres of the animal and the measures within the Fauna Management Protocol for STQs (refer to Table 4.1) would be implemented. For any STQ detected on/near the site the protocol shown in Table 4.1 is to be implemented.	The Project Ecologist undertakes inspections of all areas to be cleared and signs off on the Pre-clearing Inspection Checklist prior to commencement. No STQ have been identified on site during clearing operations.	Pre-clearing and ground disturbance Permit

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
Construction	STQ Management Protocol (Table 4-1) to be implemented requiring all personnel to report STQs (including road kill). Assessment of future road kill risk including adaptive management actions to be provided by Project Ecologist where STQ road kill is detected.	No STQ roadkill has been identified on the Project.	Roadkill records and quarterly reports
Construction	Progressive rehabilitation of identified areas refer to Appendix C) during the construction stage using collected topsoil and seed at specific sites and to develop different successional stages of rehabilitation. Key rehabilitation measures would include: - Progressive revegetation/rehabilitation during the construction phase using collected topsoil and seed at specific sites and to develop different successional stages of rehabilitation. -Planting of locally occurring species, including plants representative of groundcover, understorey and canopy strata. - Plantings are to be undertaken around fauna crossing structures to optimise utilisation of these structures. - Monitoring and maintenance of plantings. Managing and controlling weeds.	Progressive rehabilitation of the site has commenced. The site will be rehabilitated in accordance with the Urban Design and Landscape Plan which includes habitat connectivity planting around the fauna passage structures.	Inspection records Urban Design and Landscape Plan
Detailed Design and Construction	EPA will be consulted during the detailed design phase on fauna crossing structure specific requirements for fauna furniture and treatments in and around fauna crossing structures. This will include, but not necessarily be limited to requirements for refuge poles and/or horizontal rails, pathways and appropriate plantings and/or sizing	The EPA/Fisheries has been consulted with and have provided input into the detailed design of the fauna crossing structures including the fauna furniture design. The fauna furniture design has been demonstrated on site using a prototype and shown to the EPA. The EPA	Detailed design drawings

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
	/placement of scour rock & treatment of the substrate e.g. soil and/or mulch over the concrete floor and apron. Advice will be provided by the project ecologist on fauna furniture to be installed within fauna crossing structures.	are satisfied with the general arrangement. The fauna drop down design has been demonstrated on site using a prototype and shown to the EPA. The EPA are satisfied with the general arrangement.	

Table 3.4 Compliance with the Giant Barred Frog Management Plan

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
Pre-construction	No areas of Giant Barred Frog habitat to be cleared during preconstruction	No areas of GBF were cleared during pre-construction	Early Works Permits
Pre-construction/ Construction	All ancillary sites to be located outside of mapped Giant Barred Frog habitat.	Ancillary sites are located outside of the mapped GBF habitat.	Sensitive Area Plans Ancillary Facility Register
Pre-construction/ Construction	Perform field surveys at nominated biodiversity offset sites	Offset properties have been surveyed and area of potential habitat assessed	Shown on draft offset management plans
Construction	Any design changes required during the construction stage would minimise clearing of Giant Barred Frog habitat where feasible and reasonable	The clearing of GBF habitat has been minimised where possible. Only necessary infrastructure has been placed in the GBF habitat area.	Sensitive Area Plans
Construction	Preparation of an EWMS would be undertaken for all construction activities to clearly communicate relevant measures within this plan to work crews Ongoing induction of all personnel involved with construction activities would be undertaken to advise of Giant Barred Frog management	An EWMS has been prepared for all work activities which includes measures to protect flora and fauna in accordance with the Flora and Fauna Management Plan (FFMP). Project Induction includes information about identification of GBF on site. Temporary frog fencing has	EWMS Project Induction Pre-clearing and Ground Disturbance Permit Site Inspection Record

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
	requirements Early Works – Establishing Site Controls (Temporary Frog Fencing) (4.4.2) Pre-clearing Survey for Giant Barred Frogs (4.4.3) Clearing Supervision in Giant Barred Frog areas Dewatering Procedures in Giant Barred Frog areas (4.5.5) Permanent Frog Fencing (4.5.6) Unexpected Finds Procedure (4.5.7) (4.5.4) All mitigation measures applied during construction as per Table 5-1	been installed prior to the commencement of clearing. The Project Ecologist undertakes inspections of all areas to be cleared and signs off on the Pre-clearing Inspection Checklist prior to commencement. The Project Ecologist has supervised the clearing operations in the GBF habitat. Surveys are undertaken with input sought from the Project Ecologist when the frog fencing is reinstated after a flood event.	Urban Design and Landscape Plan
Construction	Giant Barred Frog road kill to be reported to the Project Ecologist during daily/weekly monitoring An assessment of future road kill risks including adaptive management actions is to be provided by the Project Ecologist where: - A Giant Barred Frog is detected within/ near the site; or - Giant Barred Frog road kill is detected	No GBF roadkill has been identified on the Project.	Roadkill records and quarterly report.
Construction	Progressive rehabilitation of identified areas (refer to Appendix C of the GBF Management Plan) Key rehabilitation measures will include planting of the northern bank of Upper Warrell Creek on either side of the bridge Progressive revegetation/ rehabilitation during construction	Progressive rehabilitation of the site has commenced. The site will be rehabilitated in accordance with the Urban Design and Landscape Plan which considers GBF habitat in the rehabilitation of Upper Warrell Creek.	Urban Design and Landscape Plan

Timing	Mitigation Measure	Implementation Comment	Compliance Evidence
	Use of locally endemic native species representative of those currently growing along Upper Warrell Creek Monitoring and maintenance of plantings Managing and controlling weeds		

The Ecological Monitoring Annual Report 2017-2018 provided in Attachment 1 contains the results of the monitoring required for the Management Plans during the reporting period.

2.4. Condition 4

To mitigate impacts to **threatened species**, the **approval holder** must submit the Flora and Fauna Management Sub Plan and Construction Environment Management Plan to the **Department** for approval prior to **commencement**. The Plans must include the additional mitigation measures not included in the **management plans** and as described in the **Biodiversity Offset Strategy**. The approved **plans** must be implemented.

	Action	Timing	Status	Compliance evidence
4.1	Submit Flora and Fauna Management Plan and Construction Environment Management Plan to the Department	Prior to commencement	Compliant Complete	The CEMP and FFMP were submitted to DoE on the 17 & 22 December 2014.
4.2	Plans must include the additional mitigation measures not included in the management plans as described in the Biodiversity Offset Strategy.	Prior to commencement	Compliant Complete	The plans were accepted by DoE on the 9 January 2015.
4.3	Implement the FFMP and CEMP	Construction	Compliant Ongoing	Compliance with the FFMP and CEMP is continuously monitored on site. The Project has an independent Environmental Representative to monitor compliance with these documents. See summary below.

Compliance with the CEMP and FFMP is reviewed regularly by Roads and Maritime, the independent Environmental Representative (ER) and Pacifico. There were no non-compliances relating to the FFMP reported in the 6-monthly compliance report provided to the state DPE. The Project is continuing to implement the CEMP.

2.5. Condition 5

In the event of any inconsistency, ambiguity or discrepancy between the **management plans** and the Flora and Fauna Management Plan or the Construction Environmental Management Plan, the **management plans** have precedence.

	Action	Timing	Status	Compliance evidence
5.1	Identify discrepancies in the CEMP/FFMP and Management Plans	Construction	Compliant Ongoing	No discrepancies noted

2.6. Condition 6

Prior to commencement, the approval holder must amend the monitoring program proposed in the Threatened Flora Management Plan to:

a) include detailed monitoring methodology designed to monitor the success of the management and mitigation measures proposed for pre-construction, construction and operations; and
b) ensure all performance thresholds, corrective actions and monitoring/timing frequency are specific, measurable, auditable, enforceable and time-bound to monitor the success of the management and mitigation measures proposed.

Action	Timing	Status	Compliance evidence
6.1 Update the TFMP to include detailed monitoring methodology designed to monitor the success of the management and mitigation measures	Prior to commencement	Compliant Complete	The TFMP has been approved by DoE on the 9 January 2015
6.2 Update the TFMP to ensure all performance thresholds, corrective actions and monitoring/timing frequency are specific, measurable auditable, enforceable and time-bound	Prior to commencement	Compliant Complete	The TFMP has been approved by DoE on the 9 January 2015.

2.7. Condition 7

The **approval** holder must not **commence** the **action** until the **Threatened Flora Management Plan** has been approved by the **Minister.** The approved **Threatened Flora Management Plan** must be implemented.

	Action	Timing	Status	Compliance evidence
7.1	The action must not commence until the TFMP is approved by the Minister	Prior to commencement	Compliant Complete	The TFMP was approved by DoE on the 9 January 2015.
7.2	Implement the TFMP	Construction	Compliant Ongoing	Translocation Annual Report Ecological Monitoring Report Summary Below

The overall survival rate of Slender Marsdenia after translocation was 74.4% (175 individuals translocated) and was slightly down from the 82% survival rate recorded in 2016-2017 (173 individuals translocated). This survival rate is higher than achieved for Slender Marsdenia after three years on the Nambucca Heads to Urunga Project (67.9%)

Assessment of the translocation outcomes (after three years) against the performance criteria in Appendix 11 of the WC2U Threatened Flora Management Plan (Ver. 4 24/12/2014) found that all performance criteria had been met.

There have been no impacts to retained in-situ EPBC threatened flora.

No non-compliances with the TFMP have occurred during the reporting period. Further details on the monitoring undertaken are provided in the Annual Ecological Monitoring Report in Attachment 1.

2.8. Condition 8

The **approval holder** must monitor all mitigation measures until they are demonstrated to be successful, and with written agreement from the **Department**.

	Action	Timing	Status	Compliance evidence
8.1	Monitor implementation of the mitigation measures	Construction and Operation	Compliant Ongoing	Ecological Monitoring Annual Report This Report
8.2	Obtain written agreement from the Department that all mitigation measures have been demonstrated as successful	Completion of construction and operation	Compliant TBA	Written agreement with the Department

2.9. Condition 9

If **MNES** not previously identified and reported to the **Department**, are found in the **action** area, the **approval holder** must notify the **Department** in writing within five business days of finding the **MNES**, and within a further 30 business days, the **approval holder** must outline in writing how **impacts** to these **MNES** will be avoided, mitigated and/or **offset**.

	Action	Timing	Status	Compliance evidence
9.1	Notify the Department in writing within five business days of finding MNES	Pre-Construction, Construction, Operation	Ongoing	No additional EPBC listed species have been identified during the reporting period.
9.2	Outline in writing within 30 business days how the impacts to MNES will be avoided, mitigated and/or offset	Pre-Construction, Construction, Operation	Ongoing	No additional EPBC listed species have been identified during the reporting period.

2.10. Condition 10

Prior to **commencement**, all **management plans** must be made publicly available on the **approval holder's website**, for 10 years following **commencement**. The monitoring results must also be made available on request for the duration of the **approval**.

	Action	Timing	Status	Compliance evidence
10.1	Upload Management Plans on to the public website	Construction	Compliant Complete	All management plans uploaded to the RMS website.
10.2	Monitoring results must be made available on request for the duration of the approval	Construction	Compliant Ongoing	Monitoring results are available on request.

2.11. Condition 11

The **approval** holder must make all monitoring results required by the **management plans** publicly available on the **approval holder's website** within two months of the monitoring event, for 10 years following **commencement**. The monitoring results must also be made available on request for the duration of the **approval.**

	Action	Timing	Status	Compliance evidence
11.1	All monitoring results to be uploaded to the Project website	Construction	Compliant Ongoing	please refer to Condition 25

2.12. Condition 12

To compensate for the loss of threatened species habitat, within 12 months of the approval of the action, the approval holder must submit to the Minister for approval a Biodiversity Offset Package. The Package must:

a) provide known **habitat** and compensate for the residual significant **impacts** on the **threatened species** and their **habitat** in Condition 1a) to e);
b) demonstrate consistency with and meets the requirements of the **EPBC Act Environmental Offsets Policy**;
a) detail the **offset attributes** (including maps in electronic Geographic Information System (GIS) format with accompanying **shapefiles**), site descriptions environmental values relevant to **threatened species** being **offset**, connectivity with other **habitat** and biodiversity corridors;
b) include detailed surveys and quantitative and qualitative descriptions of any proposed **offset areas** which clearly identify **baseline** conditions. This must include:
    i. a **baseline** description (prior to any management activities) of the current **quality** of the **habitat** for each relevant **threatened species** in each **offset area**, including the location of survey points (GPS reference);
    ii. the quantity (in hectares) of suitable **habitat** present within the **offsets areas** for the **threatened species** the **quality** of the **habitat** for the relevant **threatened species** found within the **offset areas**;
    iii. vegetation condition mapping; and
    iv. photo reference points.
c) be prepared by a **suitably qualified ecologist**;
d) include conservation and management measures for long-term protection and adaptive management of the **offsets** to improve **habitat** for **threatened species** within the **offset areas** from **baseline** conditions, including but not limited to:
    i. a map showing **offset areas** to be managed;
    ii. conservation management actions for each **offset area** and the details of methods to be used;
    iii. **offset** management must be consistent with **threat abatement plans** for **threatened species**;
    iv. the timing of management activity for each **offset area** and anticipated timeframes for achieving performance objectives;
    v. clear performance measures and performance indicators for each **offset area** including contingency actions, criteria for triggering contingency actions and a commitment to the implementation of these actions in the event that performance objectives are not met that will enable maintenance and enhancement of **habitat** within the **offset area**, as well as contribute to the better protection of individuals and/or populations of **threatened species** and their **habitat**;
        i. a monitoring program to assess the effectiveness of the management actions measured against the **baseline** condition. This must include, but not be limited to, control sites and periodic ecological surveys to be undertaken by a **suitably qualified ecologist**;
        ii. a risk assessment and a description of the contingency measures that would be implemented to mitigate these risks;

iii. details of the various parties responsible for the management, monitoring and implementing the management activities, including their experience and qualifications and employment or engagement status; and

iv. details of qualifications and experience of persons responsible for undertaking monitoring, review, and implementation of the Biodiversity Offset Package, including the role of the **independent expert** in preparing, reviewing, and implementing the Biodiversity Offset Package; and

a description of protection and funding arrangements or agreements including work programs and responsible entities

Action	Timing	Status	Compliance evidence
12.1 Submit a BOP to Minister of DoE for approval	Within 12 months of the approved action	Compliant	The action was approved on 11 December 2014. The Biodiversity Offset Package was submitted for approval on 11 December 2015.

2.13. Condition 13

The **approval holder** must implement the approved Biodiversity Offset Package within 24 months of the date of this **approval**.

	Action	Timing	Status	Compliance evidence
13.1	Implement the actions approved under the BOP	Within 24 months off approval	Compliant –	The BOP was approved by DoE on 5/7/2017 and is currently being implemented. BioBanking applications for two sites were submitted to OEH by 25 February 2018.

A revised draft was submitted to DoE for approval in November 2016. The revised Plan was approved by DoE on 5 July 2017.

2.14. Condition 14

If an **offset** site proposed as a part of the Offset Package is already required to be protected as a result of a separate **EPBC Act** approval, only the management actions which can be demonstrated to be additional to those required for the separate approval, can be considered as an **offset** for this project. The legal protection of the site and management action required for separate approvals cannot be considered a part of the **offsets**, in accordance with the **Environmental Offsets Policy**.

	Action	Timing	Status	Compliance evidence
14.1	Allocate offsets under the BOP from one section of a designated property. No cross over of allocation to occur.	Pre During and post construction	Compliant	There is no overlap between the WC2NH offset areas and any other project's offset areas.

To comply with the EPBC Act offset policy, RMS has allocated separate areas of the Norton property (503 ha in total) to each project as follows:

NH2U: 281 ha (includes 5 ha domestic exclusion area)

WC2NH: 185 ha

OH2K: 37 ha

A map showing the area dedicated to each property was included in the revised draft of WC2NH OMP (submitted for approval November 2016) and the NGOMP for NH2U. This will give DoE confidence that no doubling or cross over of allocations between the approved projects has or will occur.

To-date in assessing the OH2K OMP and earlier drafts of the NGOMP and WC2NH OMP, DoE have not raised any concerns with this approach.

2.15. Condition 15

The **approval holder** must, within 12 months of the **approval** of the Biodiversity Offset Package, register a legally binding conservation mechanism to provide long-term protection to the **offsets** approved by the **Minister** in the Biodiversity Offset Package, which prohibits any activities that are not conservation activities from being undertaken in the **offsets.**

Action	Timing	Status	Compliance evidence
15.1 Register within 12 months of the approval of the Biodiversity Offset Package, a legally binding conservation mechanism to provide long-term protection to the offsets approved by the Minister in the Biodiversity Offset Package, which prohibits any activities that are not conservation activities from being undertaken in the offsets	12 months from BOP approval date	Ongoing	The BOP was approved by DoE on 5/7/2017 and is currently being implemented.

The WC2NH Biodiversity Offset Package was approved by DoE in July 2017. RMS is progressing with securing the offset properties as follows:

Offset property (tenure)	Offset mechanism	Status
Norton (RMS)	Bio Banking Agreement (provides a legally binding conservation mechanism under the Threatened Species Conservation Act)	BioBanking applications have been made, but it is likely that the agreements wont' be executed by 5 July 2018.
Boambee (Forestry Corporation NSW)	Newly declared Flora Reserve which provides a legally binding conservation mechanism under the Forestry Act.	Forestry Corporation NSW has supplied their compensation terms for this site which were approved by RMS in April 2018. FCNSW will now undertake the formal gazettal process to create the Flora Reserve but it will be unlikely to be gazetted by 5 July 2018. We anticipate FCNSW finalising the gazettal process by the end of 2019 to declare the new Flora Reserve.
Swain (private)	Bio Banking Agreement.	Three BioBanking applications, covering the entire site, were submitted to OEH on behalf of the landowners in February 2018. RMS anticipates having the Biodiversity Stewardship Agreements finalised by the end of 2018, with the titles of the properties amended by the second quarter of 2019. This is dependent on OEH finalising the agreement by late 2018.

RMS has sought a variation to this condition, providing detail on the progress with implementing the package and requesting a further 24 months to finalise the protection mechanisms on the 3 offset sites.

2.16. Condition 16

If within 6 years, after impacts to Grey-headed Flying-fox habitat, the results of the monitoring required in the Grey-headed Flying-fox Management Plan, show that the Macksville Grey-headed Flying-fox Camp is abandoned by the Grey-headed Flying-fox, between September and May for two consecutive years, the approval holder must then offset the entire 23.50 ha roosting habitat critical to survival within 24 months, rather than 3.10 ha required by Condition 1.

Note: The provision of the additional offset, if required, would be additional to the requirements of Condition 13-16.

Action	Timing	Status	Compliance evidence
16.1 Monitoring GHFF camp. From monitoring results, determine if camp unoccupied continually for 2 consecutive years within a 6 year monitoring period. If unoccupied provide for the full 23.50 Ha offset area else provide for the 3.1 Ha.	Completion by 1 May 2021	Ongoing	Monitoring of the Macksville Grey-headed Flying-fox Camp was found it to be abandoned by the Grey-headed Flying-fox, between September and May for two consecutive years on 31 May 2017. Roads and Maritime is in the process of investigating suitable offset habitat.

2.17. Condition 17

Within 14 days after the **commencement** of the **action**, the person taking the **action** must advise the **Department** in writing of the actual date of **commencement**.

	Action	Timing	Status	Compliance evidence
17.1	Advice in writing to be provided to DoE 14 days prior to the commencement of the action.	14 days prior to the commencement of the action	Complete	A letter was provided to DoE by RMS on the 17 February 2015. The Commencement date for the action was the 9/2/15.

2.18. Condition 18

The **approval holder** must notify the **Department** in writing of potential non-compliance with any condition of this **approval** as soon as practical and within no later than two business days of becoming aware of the non-compliance. The notice provided to the **Department** under this condition must specify:

a) the condition which the **approval holder** has potentially breached;

b) the nature of the non-compliance; and

c) when and how the **approval holder** became aware of the non-compliance.

Further to providing any such notice, the **approval holder** must provide the following information within 10 business days of becoming aware of a potential non-compliance:

a) how the non-compliance will affect the anticipated impacts of the **approved action**, in particular how the non-compliance will affect the impacts on the **MNES**;

b) the measures the **approval holder** will take to address the impacts of the non-compliance on the **MNES** and rectify the non-compliance; and

c) the time by when the **approval holder** will rectify the non-compliance.

	Action	Timing	Status	Compliance evidence
18.1	Details of any non-compliance to be reported to DoE within 2 business days of being made aware of the non-compliance	Construction	Compliant Ongoing	No non-compliances were reported to the Department during the reporting period.

2.19. Condition 19

Within three months of every 12 month anniversary of the **commencement** of the **action**, the **approval holder** must publish a report on its **website** addressing compliance with each of the conditions of this **approval**, including implementation of any **management plan, package** as specified in the conditions. **Documentary** evidence providing proof of the date of publication must be included in the published **compliance report**. The **compliance report** must remain on the **website**, for 10 years following **commencement**. The monitoring results must also be made available on request for the duration of the **approval**. Reports of any non-compliance must also be included in the annual **compliance report.**

	Action	Timing	Status	Compliance evidence
24.1	Prepare compliance report and upload to project website	By 9 May 2016	Compliant	Report uploaded to project website. Advice provided to Dept. on date of publication.
24.2	Prepare compliance report and upload to project website	By 9 May 2017	Compliant	Report uploaded to project website. Advice provided to Dept. on date of publication.
24.3	Prepare compliance report and upload to project website	By 9 May 2018	TBA	Report uploaded to project website. Advice provided to Dept. on date of publication.
24.4	Prepare compliance report and upload to project website	By 9 May 2019	TBA	Report uploaded to project website. Advice provided to Dept. on date of publication.

2.20. Condition 20

The **approval holder** must maintain accurate **compliance records** substantiating all activities associated with or relevant to the conditions of **approval**, including measures taken to implement the **management plans, package** required by this **approval**, and make them available upon request to the **Department**. Such **compliance records** may be subject to audit by the **Department** or an independent auditor in accordance with section 458 of the **EPBC Act**, or used to verify compliance with the conditions of **approval**. Summaries of audits will be posted on the **Department's website**. The results of audits may also be publicised through the general media.

	Action	Timing	Status	Compliance evidence
20.1	Maintain compliance records for the management plans	Construction, operation	Ongoing	Compliance records are maintained on the relevant RMS document management systems, available on the Project Website or internally via Teambinder.
20.2	Maintain compliance records for the Biodiversity Offset Strategy	Construction, operation	Ongoing	Works on implementing the BOS yet to commence however offset properties secured

2.21. Condition 21

Upon the direction of the **Minister**, the **approval holder** must ensure that an independent audit of compliance with the conditions of **approval** is conducted and a report submitted to the **Minister**. The audit must not commence unless and until the **Minister** has approved the independent auditor and audit criteria. The audit report must address the criteria to the satisfaction of the **Minister.**

	Action	Timing	Status	Compliance evidence
21.1	Prepare independent audit of compliance with the conditions of approval if directed by the Minister to do so.	When Directed	TBA	An independent audit of the conditions of approval has not been required during the reporting period.

2.22. Condition 22

If the **approval holder** wishes to carry out any activity otherwise than in accordance with a **management plans, strategy, package** as specified in the conditions, the **approval holder** must submit to the **Department** for the **Minister's** written approval a revised version of that **management plan, package**. The varied activity must not commence until the **Minister** has approved the varied **management plan, package** in writing. The **Minister** will not approve a varied **management plan, package** unless the revised **management plan, package** would result in an equivalent or improved environmental outcome over time. If the **Minister** approves the revised **management plan, package** that **management plan, package** must be implemented in place of the **management plan, package** originally approved.

	Action	Timing	Status	Compliance evidence
22.1	Provide updated management plan or package for approval	Construction, operation	Compliant Ongoing	STQ Management Plan and Koala Management Plan varied on 22 January 2015. STQ Management Plan and Koala Management Plan varied on 3 October 2016. During this reporting period the GHFF Management Plan, STQ Management Plan and Koala Management Plan were updated to change the road kill monitoring program prior to the partial opening of Stage 2A. The updated plans were approved by DoE on the 12th of January 2018.

2.23. Condition 23

If the **Minister** believes that it is necessary or convenient for the better protection of **MNES** to do so, the **Minister** may request that the **approval holder** make specified revisions to a **management plan, package** required by the conditions and submit the revised **management plan, package** for the **Minister's** written approval. The **approval holder** must comply with any such request. The revised **management plan, package** must be implemented. Until the **Minister** has approved a revised **management plan, package**, the **approval holder** must continue to implement the previously approved **management plan, package**, as specified in the conditions.

	Action	Timing	Status	Compliance evidence
23.1	Update the Management Plan or Package in response to a direction from the Minister and provide for approval.	As directed	TBA	No updates to the management plans or package have been required.

2.24. Condition 24

If, at any time after five years from the date of this **approval**, the **approval holder** has not **commenced** the **action**, then the **approval holder** must not **commence** the **action** without the written agreement of the **Minister.**

	Action	Timing	Status	Compliance evidence
24.1	Notify the Minister of the commencement of the action	Prior to Commencement	Compliant Complete	RMS notified the Minister of the commencement of the action on the 17 February 2015.

2.25. Condition 25

Unless otherwise agreed to in writing by the **Minister**, the **approval holder** must publish the **management plans, package**, monitoring data in these conditions of **approval** on its **website**. Each **management plans, package**, monitoring data must be published on the **website** within one month of being approved (unless otherwise specified in these conditions) or within one month of data collection.

	Action	Timing	Status	Compliance evidence
25.1	Publish management plans on the Project Website	Within one month of being approved	Compliant Complete	Management Plans uploaded onto the project website
25.2	Publish the Biodiversity Offset Package on the Project Website	Within one month of being approved	Compliant Complete	The Biodiversity Offset Package has been published on the project website
25.3	Publish monitoring data onto the website	Within one month of undertaking the monitoring	Compliant Ongoing	Monitoring data has been published on the project website in accordance with the timeframes.

2.26. Condition 26

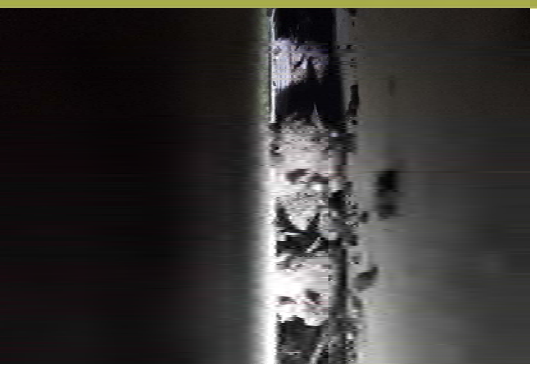
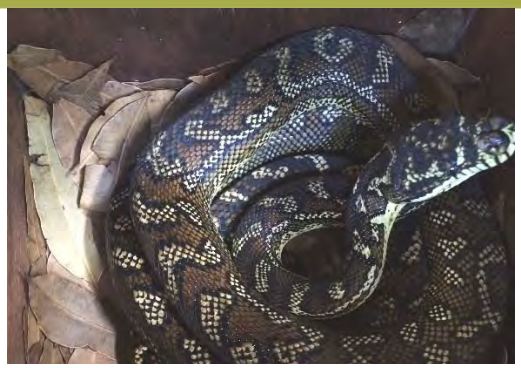
The **approval holder** must notify the **Department** within 5 business days of publishing the **management plan, package**, monitoring data on their website and the **management plan, package**, monitoring data must remain on the website for the life of this **approval**.

	Action	Timing	Status	Compliance evidence
26.1	Management plans uploaded on RMS website	With 5 days	Compliant	The CEMP TFMP and FFMP were uploaded on the project web site on 17 February 2015. Plan revisions have been uploaded onto the project website with notification provided to DoE within 5 business days of publication.
26.2	Monitoring data	Within 2 months of receipt	Compliant	RMS provides email notification to the Department's 'Post Approval" and 'EPBC Monitoring' mailboxes within 5 days of publishing relevant information onto the project website

Attachment 1 Ecological Monitoring Report 2017-2018

Ecological Monitoring Annual Report (2017/2018)

Warrell Creek to Nambucca Heads Pacific Highway Upgrade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Prepared for: Roads and Maritime Services

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2378-1430	First issue	16/03/2017	JOL
2378-1435	Second issue	23/03/2018	JOL
2378-1436	Third issue	13/04/2018	JOL

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1. Introduction

1.1 Introduction

The Pacific Highway Upgrade Program is a joint commitment by the Australian and New South Wales governments to improve the standard and safety of the Pacific Highway between Hexham and the Queensland border. The NSW Minister for Planning approved the Warrell Creek to Urunga (WC2U) Pacific Highway Upgrade Project (the project) under Part 3A (now repealed) of the *Environmental Planning and Assessment Act 1979* (EP&A Act) on 19 July 2011, subject to the Minister's Conditions of Approval (MCoA) being met.

The WC2U Project comprises approximately 42 kilometres of dual carriageway road that would bypass the towns of Warrell Creek, Macksville, Nambucca Heads and Urunga on the Mid North Coast of NSW. The project has been divided into two stages with Stage 1 consisting of approximately 22.5 kilometres from Nambucca Heads to Urunga (NH2U) and Stage 2 consisting of the remaining 19.6 kilometres of dual carriageway between Warrell Creek and Nambucca Heads (WC2NH). This report relates to Stage 2 (WC2NH) as 'the project'.

As part of WC2NH an ecological monitoring program has been prepared to satisfy the Minister's Condition of Approval B10, which requires preconstruction, construction and post construction phase monitoring (Benchmark 2014). The monitoring program incorporates all threatened species monitoring developed as part of individual species management plans (refer to the Construction Environmental Management Plan (CEMP)). This annual report (the third completed to date) provides the results of the ecological monitoring program undertaken in 2017/2018 in relation to the following:

- Pre-clearing and clearing procedures
- Flying-fox population monitoring
- Threatened Microbats
- Nest box monitoring
- Koala population
- Road kill monitoring
- In-situ threatened flora
- Threatened flora translocation monitoring
- Landscape rehabilitation monitoring
- Giant Barred Frog population monitoring
- Weed and Pathogen monitoring.

The following sections provide a summary of ecological monitoring tasks undertaken in the third year of construction.

Note: The project construction year anniversary is 9 February so the annual monitoring period encompasses all site assessments between 9 February 2017 and 8 February 2018. Further details of ecological monitoring are provided in separate monitoring reports appended to this report.

Additional ecological monitoring was undertaken by GeoLINK for the WC2NH project but outside of the Annual Ecological Monitoring period, and included:

- Grey Headed Flying Fox (GHFF) Habitat monitoring; and
- Stage 2A Road Kill Monitoring.

These monitoring reports will be issued during April 2018.

The WC2NH Project completion is scheduled for mid-June 2018. From this time the project will enter the operational phase of monitoring and will be undertaken by the appointed ecological consultant with RMS as the contract manager.

2. Pre-clearing and Clearing Procedures

The Conditions of Approval and species management plans which form part of the *Flora and Fauna Management Sub-Plan* for the project requires a number of pre-clearing surveys to be undertaken. A summary of pre-clearing surveys undertaken on the project is provided in the sections below.

A habitat tree register and register of fauna capture/ relocations is provided in **Appendix A**. A more detailed description of pre-clearing survey results will be provided as part of the post-clearing report upon completion of clearing activities. Mainline clearing is now complete, however minor clearing is on-going as part of subsequent approvals or later staged works.

2.1 Pre-clearing Surveys

2.1.1 Green-thighed Frog

No clearing was undertaken within mapped Green-thighed Frog (GTF) habitat during the reporting period, therefore the requirement for targeted GTF pre-clearing surveys was not triggered.

2.1.2 Giant Barred Frog

Targeted Giant Barred Frog (GBF) Surveys within the work zone and adjacent GBF habitat areas were undertaken where adjustments to the frog exclusion fence has been required, particularly post rainfall events where the frog fencing was breached or intentionally moved to allow high flows to move through the Upper Warrell Creek system. Diurnal surveys were undertaken within the work zone to capture and relocate any GBF potentially located on the work side of the fence. No GBF were located on the work side of the fence during these surveys.

In addition to the above, active searches of all areas of GBF habitat were undertaken either the night prior to or immediately prior (less than two hours) to the commencement of works where any GBF habitat was impacted. No GBF were detected during such surveys.

2.1.3 Koala and Spotted-tailed Quoll

Pre-clearing surveys for Koalas were undertaken, involving spotlighting within areas of suitable habitat, on the night prior to clearing any areas of Koala habitat on the project. Diurnal visual searches were also conducted in areas of suitable habitat immediately prior to commencement of clearing operations to detect any Koalas that may have entered the area overnight. No Koalas or evidence of recent presence were detected during clearing operations in Year 3.

Pre-clearing surveys for the Spotted-tailed Quoll (STQ) were conducted immediately prior to commencement of clearing and included searches of potential denning habitat, including large hollow logs and rock piles. No STQ or evidence of recent presence was detected during clearing operations in Year 3.

2.1.4 Searches for Fauna Immediately Prior to Clearing

A final pre-clearing visual search was undertaken by an ecologist immediately prior (i.e. less than two hours) to commencement of clearing operations to ensure that areas to be cleared are as free of fauna as possible. This survey was often successful in flushing mobile fauna from the works area including birds, macropods and reptiles before the commencement of clearing. Fauna encountered during these surveys are listed within **Appendix A**.

2.2 Clearing Supervision

Following the completion of the pre-clearing surveys described in **Section 2.1**, tree removal was undertaken in a staged manner, with non-habitat trees being removed first, then potential habitat trees being removed with a swivel head harvester at least 24-48 hours later to enable resident hollow-dependent fauna time to evacuate the tree prior to felling. Year 3 clearing methodology predominantly used Arborists to clear vegetation. No actual hollow bearing trees were removed during the Year 3 monitoring period. A suitably qualified, licensed and experienced ecologist and/or a suitably licensed and experienced wildlife carer from GeoLINK was present to observe the removal of each potential habitat tree.

A habitat tree register and register of fauna capture/ relocations is provided in **Appendix A**.

Ecologist clearing supervision was also undertaken for mapped GBF habitat. No GBF were observed during clearing supervision or relocation of frog exclusion fencing undertaken in such areas.

3. Flying-fox Population Monitoring

3.1 Introduction

Population monitoring at the Macksville Grey-headed Flying-fox camp (north of Bald Hill Road) has been undertaken on at least a monthly basis since July 2013 to confirm flying-fox presence and determine patterns of occupation, species composition, demographic composition, key behaviours, and habitat characteristics. The sampling methodology and timing has been undertaken in accordance with the approved *Flying-fox Management Plan* (Gorecki *et al*. 2017).

Population monitoring commenced in the winter of 2013 to provide a baseline of population condition prior to road construction, which will provide a point of comparison to assess the impacts of the road on the population of flying-foxes and monitor the effectiveness of mitigation measures (Gorecki *et al*. 2016). Population monitoring will continue to be undertaken monthly throughout the pre-construction phase, construction phase and first year of the operational phase of the project. The monitoring program would be reviewed regularly and refined if considered appropriate.

A report documenting the results of the January 2018 monitoring event for Year 3 is provided in **Appendix B**.

3.2 Summary of Results

No occurrences of flying-foxes roosting at the site were recorded during monthly monitoring between February 2017 and January 2018. The results of the flying-fox monitoring to date indicate that, excluding a brief stopover at the site in mid-January 2015, flying-foxes have been absent from the site since mid-April 2014. The nearby Macksville Cemetery flying-fox camp (first recorded in March 2015) appears to be the replacement camp for the site.

Population trends at the site and monitored regional camps are shown in **Figure 3.1**, for the Year 3 monitoring period. Major trends include:

- No flying foxes were recorded at the site, Bowraville or Wheatley Street (Bellingen) camps.
- The Gordon Park and Bellingen Island camps were the only camps occupied year-round.
- Flying-fox numbers at the Macksville Cemetery camp were greatest from late-spring to autumn, with a peak in summer/ early autumn. Flying-foxes were absent or present only in low numbers in winter and early spring.

Grey-headed Flying-foxes dominated the species composition at occupied camps, comprising between 70 per cent and 95 per cent of all individuals present during most periods, though recordings down to 50 per cent of individuals present were recorded at some camps. Black-flying foxes comprised the main other species present, although Little Red Flying-foxes were recorded at Macksville Cemetery camp in April 2017.

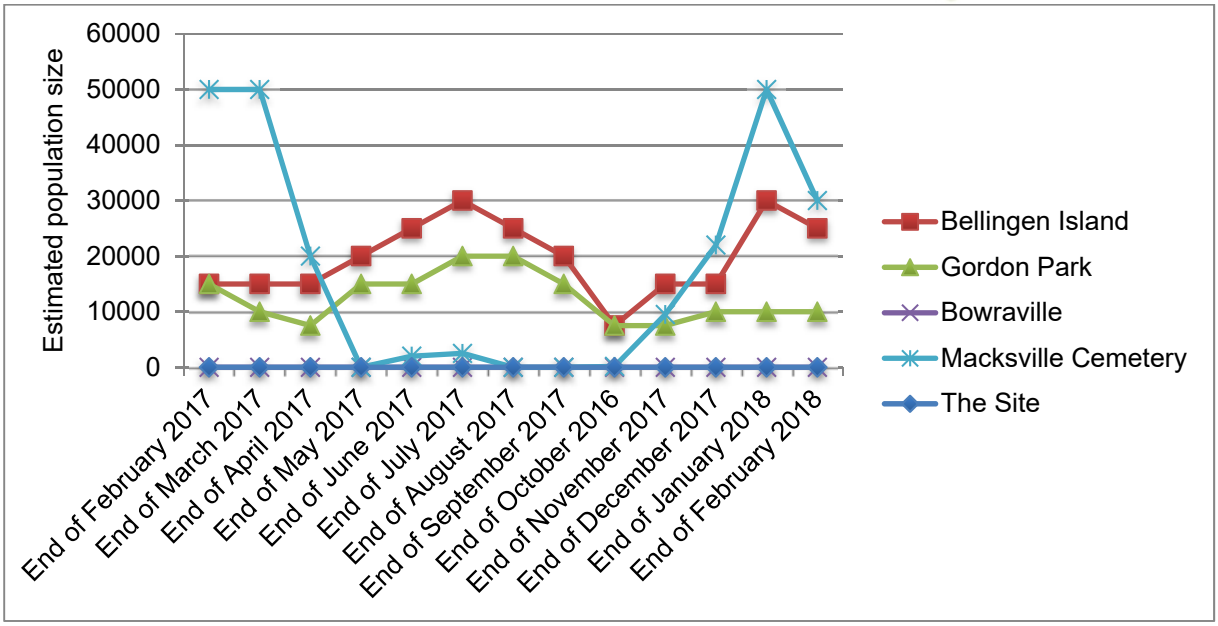

Figure 3.1 Population trends at the site and regional camps over past 12 months

4. Threatened Microbats

The following sections provide a summary of monitoring activities completed for threatened microbats. Microbat monitoring reports covering the third year of construction are provided in **Appendix C**.

4.1.1 Microbat Habitat (Flyway) Monitoring

Microbat habitat (flyway) monitoring was undertaken between 15 February 2017 and 15 January 2018 as per the requirements of the Ecological Monitoring Program.

To monitor potential impacts to microbat flyways, the following riparian zones were nominated as monitoring sites:

- Crouches Creek;
- Rosewood Creek;
- Butchers Creek;
- Un-named tributary near Cockburns Lane (Cockburns Creek); and
- Upper Warrell Creek (UWC).

Two photo points, one on either side of the nominated creek, have been established. Photographs were taken looking towards the highway construction zone and towards the intact riparian zone adjacent. The condition of the flyway habitat was recorded, noting changes to the quality of the flyway or any visible obstructions.

The riparian zones associated with flyway monitoring locations have been altered or intercepted by the highway upgrade construction. The two bridges and two box cell culverts offer unobstructed flyways connecting adjacent riparian vegetation. The Cockburn Creek flyway is the most restricted due to the placement of fill and less favourable crossing opportunities, due to limited underpass options through the narrow pipe culvert. However, aerial passage is still viable above the highway alignment. Currently no vegetation or weed overgrowth has been noted as an obstruction to microbat flyways in association with the monitoring sites, however over time maturing landscape vegetation may need monitoring for obstruction of flyways as this vegetation matures.

Over time, microbat flyway monitoring to date has indicated that the flyways are largely unobstructed by vegetation overgrowth or weeds. While riparian vegetation is intercepted by construction, flyway opportunities are provided via under passage or viable aerial passage above the highway, hence satisfying the objectives of the *Microchiropteran Bat Management Strategy* (Lewis, 2014).

4.1.2 Microbat Roost Box Monitoring

Microbat roost boxes were installed by RMS prior to construction commencing. Roost boxes were inspected quarterly to determine species presence/ absence and estimate numbers and breeding activity. Bat box inspections commenced six months after installation and will continue seasonally until the construction phase is complete. Seasonal monitoring will finish after two years of operation.

The monitoring results have indicated a moderate uptake/ usage rate in the third year of construction with between seven and 22 microbats were recorded in 2017 compared to 10 and 19 microbats during the 2016 monitoring period.

Up to six roost boxes were occupied by microbats in 2017 compared to five boxes in 2016.

The total diversity of bat species observed using roost boxes has increased from at least two species in 2016 to at least four species recorded in 2017.

4.1.3 Microbat Persistence and Behaviour Monitoring

Microbat persistence and behaviour monitoring was not undertaken during the reporting period as per the requirements of the Ecological Monitoring Program, as these requirements have now been met. Monitoring was required to be undertaken seasonally throughout Years 1 and 2 of the construction phase and this has been completed.

To date, monitoring has indicated the ongoing use of the roost site despite construction activities occurring in proximity. During daytime ecologist site inspections to monitor microbat disturbance, no microbats have been observed leaving the roost as a result of activities related to the highway upgrade.

4.1.4 Microbat Overwintering Habitat Surveys

A total of 37 structures representing potential microbat roost sites were inspected in June 2017. For the current reporting period, structures which were previously identified as potential microbat habitat within the *Microchiropteran Bat Management Strategy* (Lewis, 2014) were inspected. Additionally, structures constructed as part of the WC2NH highway upgrade, such as culverts at Butchers and Stoney Creek, fauna underpasses (concrete box culverts) through the northern zone and newly constructed overpass bridge structures were also inspected.

Microbat occupation was recorded at seven culverts and one bridge with a total count of approximately 467 individuals. The Deadman's Gully culvert (ID599205) recorded approximately 400 *Miniopterus* sp. and a number of roost sites with numbers of microbats ranging from one to 26 microbats. Of the seven culverts inspected four newly constructed culverts recorded occupation by microbats. These were the Widened Median 4 fauna underpass, Rosewood Tributary, Butchers Creek and the box culvert near the Sheather Property. These large box culverts are either still partially under construction (mainly finishing works at the entry/ exit points or the installation of fauna furniture) or have works within 100 metres from the structure at the time of occupation by microbats. Monitoring of these structures has been undertaken during construction by the contractor's environmental team and Project Ecologist.

5. Nest Box Monitoring

5.1 Introduction

GeoLINK was engaged to undertake the installation and seasonal monitoring of 143 nest boxes in accordance with the *WC2NH Nest Box Management Plan*. The installation of 60 per cent of nest boxes was required prior to vegetation clearing operations commencing, with the aim to provide temporary refuge for hollow dependent fauna displaced during clearing operations. The remaining 40 per cent of nest boxes were installed post mainline clearing. All nest boxes were installed between November 2014 and December 2016.

The Ecological Monitoring Program requires monitoring to be undertaken during summer and winter of Years 2, 3 and 4 of construction and during summer and winter of and Years 2 and 4 of operation. Maintenance of nest boxes will be undertaken in line with the monitoring regime. Summer 2018 monitoring is likely to be the last monitoring event to be undertaken during the construction phase as the project is scheduled for completion mid-June 2018.

A report documenting the results of the third and fourth monitoring events for Year 3 (winter 2017 and summer 2018) is provided in **Appendix D**.

5.2 Summary of Results

Nest box monitoring was undertaken for winter 2017 and summer 2018. The results indicate that occupation rates of the nest boxes increased from summer 2017 (16.5 per cent occupied) when compared to winter 2017 where 26.5 per cent of boxes were recorded as occupied, although summer 2018 observed a decrease in comparison to winter 2017 with 18 per cent of boxes recorded as occupied. Signs of box use by fauna (evidenced by the presence of nesting material, chewings, scats or eggs etc) indicates an increase for each monitoring event since the commencement of monitoring in summer 2017. Summer 2018 recorded an increase in evidence of use by 6.5 per cent when compared to winter 2017 which recorded 68.5 per cent, summer 2018 recorded 75 per cent evidence of use by fauna.

For both Year 3 monitoring events, the Sugar Glider was the most commonly recorded species and no threatened species were recorded. Five nest boxes contained active Native Stingless Bee (NSB) hives during summer 2018, an increase from three boxes occupied by NSB during winter 2017. It should also be noted that the number of European bee hives recorded has increased, with four hives recorded during winter 2017 and eight hives recorded during summer 2018 monitoring. Species diversity recorded within the boxes has decreased during Year 3 from winter (nine species) to summer (seven species). Fourteen native and one introduced fauna species have been recorded using the nest boxes to date.

6. Koala Population Monitoring

6.1 Introduction

Monitoring has been undertaken in accordance with the approved *Koala Management Plan* for the WC2NH section of the Pacific Highway Upgrade.

Koala population surveys consist of two separate monitoring events within the spring period. Both diurnal and nocturnal surveys along 25 transects, 500 metres long and spaced 150 metres apart. The transects run perpendicular to the highway alignment within the Nambucca State Forest and in the vicinity of the Old Coast Road area between chainage 15600 and 19500. Additional spotlighting was undertaken on tracks and easements across this area at a rate of two kilometres/ hour targeting each side of the highway. Survey techniques such as visual observations, spotlighting, call play back and active searches for scats at the base of primary Koala food trees were employed during field surveys.

Baseline population monitoring recorded low numbers of Koalas (one animal per monitoring event) during nocturnal spotlighting surveys during autumn and spring of 2014. Both animals were male.

Year 1 population monitoring also resulted in low numbers of Koala. A Koala believed to be same individual was recorded across multiple days first during diurnal survey then on three separate occasions during nocturnal spotlighting north west of the Bowraville turnoff. The sex of the animal was not determined.

A report documenting the results of the spring 2017 (Year 3) Koala population monitoring event is provided in **Appendix E**.

6.2 Summary of Results

The summary of findings from field surveys and spotlighting undertaken during September 2017 is as follows:

- No Koalas were observed during nocturnal or diurnal the transect surveys during the 2017 spring monitoring event.
- Koala scats were found at the base of two Tallowwood (*Eucalyptus microcorys*) at the eastern end of transects E18 and E19.

Three Koalas were identified during spotlighting surveys on tracks/ easements on three separate locations and days as follows:

- One Koala approached on ground in response to call playback then climbed a Blackbutt (*E. pilularis*).
- One Koala called in response to call playback.
- One Koala was detected from eye shine resting in a Tallowwood. This individual was not responsive to call playback.
- No additional Koala evidence (scratches or scats) was observed during spotlighting surveys on tracks/ easements during the 2017 spring monitoring event.

These results indicate an increase in the number of Koalas recorded (three) when compared to the Spring 2015 results or Year 1 construction where one individual was recorded. The results of the Construction Stage (Years 1 and 3) monitoring and baseline monitoring events support the results of previous Koala surveys and confirm that the Nambucca State Forest/ Old Coast Road area appears subject to low level usage by Koalas.

The results of monitoring undertaken to date (inclusive of baseline monitoring) indicate that Koalas are using both the dry upper slopes and ridges associated with the northern portion of Nambucca State Forest and the moist gullies that occur predominantly in the southern portion of the study site.

Ongoing monitoring is required to identify any changes in resident Koala activity (abundance, home range and movements) in response to construction of WC2NH and the effectiveness of Koala habitat connectivity mitigation measures (i.e. fauna underpasses and exclusion fencing).

7. Road Kill Monitoring

7.1 Introduction

Daily roadkill monitoring has been undertaken during the third year of construction in accordance with the requirements of the roadkill monitoring strategy prepared for the project.

Reports documenting the results of the third year of monitoring are provided in **Appendix E**.

7.2 Summary of Results

Twenty-nine fauna road mortalities have been recorded during the third year of monitoring. Fauna road kills have increased in the third year compared to Year 2 of monitoring which recorded 21 fauna road mortalities, Year 1 recorded 15 fauna road mortalities. Both native and introduced species have been recorded within the roadkill data. No Environmental Protection and Biodiversity Conservation Act (1999) (EPBC) or Biodiversity Conservation Act (2017) (BC) listed threatened fauna or listed migratory species were recorded as roadkill during the Year 3 monitoring period.

8. In-situ Threatened Flora Monitoring

8.1 Introduction

In accordance with the project *Threatened Flora Management Plan* (2016 V5) (TFMP), monitoring of threatened flora species retained in-situ as part of the WC2NH project has been undertaken by GeoLINK. All in-situ threatened flora were located and tagged prior to clearing activities commencing, with no-go fencing and signage installed as required and the location of threatened plants shown on project *Sensitive Area Plans* (SAPs). Each retain threatened flora species was assessed based on plant health, the presence of flowers or fruit, new growth or recruitment of young plants or weed infestations present within the vicinity. Monitoring of the health of in-situ threatened flora was undertaken prior to clearing commencing then six monthly (spring and autumn) during Years 1 and 2 of construction and once during spring of Year 3.

In accordance with the project TFMP, monitoring of potential changes in the habitat of Slender Marsdenia and Woolls' Tylophora habitat was conducted. Monitoring was undertaken in habitat adjacent to the construction footprint. Permanent plots were established in the indirect impact zones at 10 representative points in Slender Marsdenia and Woolls' Tylophora habitat as mapped by Dr Andrew Benwell in spring 2010. Each plot is 10 metres wide and 20 metres long, with the long axis parallel to the edge of clearing. Each plot was assessed based on native vegetation structure, level of weed incursion and microclimate class.

The In-situ Threatened Flora and Slender Marsdenia and Woolls' Tylophora Habitat monitoring report for spring 2017 is provided in **Appendix G**.

8.2 Summary of Results

8.2.1 In-situ threatened flora

Based on the monitoring results, the majority of in-situ threatened flora appear to be persisting with good condition scores for health overall. A number of sites and species including Slender Marsdenia and Maundia have recorded new growth and new recruits while other sites of the same species have undergone what appears to be seasonal or natural die-off. For example, Maundia in Crouches Creek was recorded to have been successfully translocated into the newly constructed creek realignment during spring 2016 monitoring, however was not visibly present at the site during Spring 2017 monitoring. Slender Marsdenia has recorded plant die-back at a number of locations and also recruitment of new plants at the same sites over time.

Monitoring of the Spider Orchid has recorded a new recruit during spring 2016 which has persisted, with new growth also recorded during spring 2017. This additional plant has now been added to the monitoring regime for future data collection during the project operational phase of monitoring.

Tall Knotweed at the northern end of the Nambucca floodplain was not recorded at all during spring 2017 monitoring. This result is not unusual for this species, which is known for fluctuations in presence at the subject monitoring site and also reference sites within the Maclean area (northern NSW).

Rusty Plum around the Cockburns Lane area appear to be in good health with all plants recording new growth and condition class scores of three or above during spring 2017. Two mature plants not previously monitored and added to the monitoring regime also appear in good health.

Although the survival rates of in-situ threatened flora do not meet the performance indicator minimum requirements, no die-back or direct construction related impacts have been recorded as having contributed to the monitoring results to date. Corrective actions are discussed within the TFMP if the performance measures are not met; however, none of the corrective actions have been triggered based on the most recent monitoring results with regard to weed control, plant theft or protection from edge effects (although this measure was prescribed during spring 2016 by GeoLINK).

Overall, the protective measures implemented for the project to safeguard retained threatened flora have been effective with no plant mortality directly associated with impacts from construction activities. All exclusion fencing and No-Go signage was observed to be in place around in-situ threatened flora at the time of monitoring.

8.2.2 Slender Marsdenia and Woolls Tylophora Habitat Monitoring

To date there are no substantial changes in Woolls' Tylophora and Slender Marsdenia habitat occurring adjacent to the clearing boundary as recorded from the monitoring plots. An increased percentage cover of native vegetation in the groundcover and mid-storey strata has been recorded, with no significant increase in percentage cover of existing weed species. The minor changes in vegetation strata to date have not affected any microclimate class scores for any of the quadrats monitored.

This report presents a complete set of results for the construction phase monitoring including pre-construction baseline monitoring and Years 1 - 3 of the construction phase, refer to **Appendix G**.

9. Threatened Flora Translocation Areas

9.1 Introduction

The overall aim of the translocation project is to establish viable populations of the impacted threatened flora species in habitat adjacent to the highway corridor. To achieve this aim, the translocation program has three components:

- Salvage transplanting of impacted individuals from the construction footprint.
- Population enhancement by introduction of additional plants propagated from locally collected seed, to increase the initial population size and promote establishment of a viable long-term population.
- Restoration of good quality habitat in the receiver sites where required.

Monitoring of translocation areas was undertaken in accordance with the requirements of the *Threatened Flora Management Plan* in order to evaluate the success of translocations undertaken for threatened flora. A report detailing the third year of translocation area monitoring is provided in **Appendix H**.

9.2 Summary of Results

The report documents the results of translocations of threatened plant species conducted for the Warrell Creek to Nambucca Heads (WC2NH) upgrade of the Pacific Highway after approximately three years (Feb 2015 to November 2017). Methods used during implementation are also described. The translocation project was implemented by Ecos Environmental for Pacifico (Acciona - Ferrovial joint venture) based on the Warrell Creek to Urunga *Threatened Flora Management Plan* (ECOS Environmental Ver. 4 (24 December 2014) and Ver. 5 (1 July 2016)). Five threatened species were translocated from the highway corridor to adjoining bushland: *Marsdenia longiloba* (Slender Marsdenia), *Tylophora woollsii* (Woolls' Tylophora), *Dendrobium melaleucaphilum* (Spider Orchid), *Niemeyera whitei* (Rusty Plum) and Floyds Grass (*Alexfloydia repens*). One nationally rare species, *Artanema fimbriata* (Koala Bells) was also translocated.

The translocation project aimed to establish populations of the impacted species in habitat adjacent to the highway corridor. To achieve this aim, the translocation program involved the following actions:

- salvage transplanting of impacted individuals from the construction footprint;
- enhancement of the size of the translocation population where possible by propagation and introduction, or direct seeding;
- restoration of good quality habitat to the receival sites.

Potential receival sites were assessed according to physical, biotic and logistical criteria set out in the *Threatened Flora Management Plan*. Nine receival sites spread out along the 19.6 kilometre road corridor were selected that provided habitat assessed as suitable for each species, whilst minimising the distance plants were moved from the donor sites. Eight receival sites were located in the Road Reserve of the new highway and one on adjoining RMS property. Receival sites in the Road Reserve

were selected with a buffer of forest ~20 metres wide to the edge of the cleared highway alignment and with State Forest on the other side to provide microclimatic protection.

Salvage of impacted plants was carried out by direct transplanting. Approximately three years after translocation, the survival rate of all species was >70 per cent with the exception of Koala Bells. The overall survival rate of Slender Marsdenia, the main species requiring translocation was 74.4 per cent (175 individuals translocated). This survival rate is in line with NH2U (67.9 per cent - 2013-2016) and much higher than Bonville (45 per cent and 25 per cent, two sites, 2007-2010). Plants were transplanted directly to the new sites, watered-in and given follow-up watering, otherwise they received no further treatment. Fertilisers were not applied. Results supported the hypothesis that low survival for Bonville was due to the adverse effect of fertiliser addition and soil improvement. This effect appeared to be field interactions, as in pot cultivation, Slender Marsdenia grew strongly in response to fertiliser addition.

Spider Orchid flowered in spring each year, including Year 1 only six months after transplanting, but no seed pods were formed during the three years. Koala Bells started to flower a month after transplanting and set seed. Most plants died at the end of Year 1 and 2 due to its inherently short life cycle and a few persisted to Year 3. A different approach was used to prepare the receival site for Floyds Grass which was heavily infested with Broad-leaved Paspalum and other weeds. Ground layer vegetation and the top 10 centimetres of soil containing most of the soil seedbank was stripped off with an excavator, which created largely weed free soil conditions for Floyds Grass to establish in. Nearly all Floyds Grass clumps survived after three years (94 per cent) and continue to grow.

Assessment of the translocation outcomes after three years according to the performance criteria in Appendix 11 of the WC2U *Threatened Flora Management Plan* (Ver. 4 24 December 2014) found that all performance criteria had been met (Corrective action not required for Koala Bells as the species has a naturally short life cycle; plants survived and grew to maturity, seeding the habitat).

10. Landscape Rehabilitation Monitoring

10.1 Introduction

The landscape rehabilitation monitoring methodology was developed based on the requirements of the *Urban Design Landscape Plan* (UDLP) in accordance with the requirements of the project Ecological Monitoring Program. The monitoring methodology was utilised for this assessment and was the same as for the baseline assessment completed in spring 2016 and the first Year 2 (summer 2017) monitoring event undertaken by GeoLINK. Since autumn 2017, Pacifico have been responsible for the Landscape Rehabilitation Monitoring and have conducted their assessments as per the attached seasonal monitoring reports provided in **Appendix I**. These reports represent the Year 3 seasonal monitoring events. Landscape monitoring will be undertaken seasonally until construction completion, the forecast completion date is mid-June 2018.

10.2 Summary of Results

Based on the monitoring results, most landscaping sites appear to be establishing well and indicate a high degree of native establishment and persistence, although dominance by Pigeon Grass (*Setaria sphacelata*) appears throughout the southern zones (sites 1 - 5). This high percentage of Pigeon Grass has been described within the seasonal monitoring site summaries as meeting the landscape objectives of the UDLP (refer to **Section 5.6.2** of the UDLP) as the batters assimilate with the surrounding grazing landscape dominated by pasture grasses. Continued monitoring of native shrub and plant growth is required to ensure target growth of native plants are still being met where Pigeon Grass is dominant.

The bushland reconstruction sites throughout the northern zone (sites 6 - 9) appear to be establishing well with healthy growth of plants, increasing percentage of cover and low occurrence of weed species. Overall, these sites are assimilating with the surrounding landscape and meeting the objectives of the UDLP.

The landscape plantings around the creek riparian and culvert inlet/ outlets recorded variable rates of compliance with the UDLP. Stony Creek native species are establishing well and are successfully stabilising the creek banks. Williamsons Creek has recorded poor compliance and replanting of this area was undertaken during spring 2017. Replanting and installation methodology changes have been proposed for spring 2018 and ongoing monitoring of this site is required to ensure compliance is met. Butchers Creek has also recorded poor native regeneration compliance regarding soft scour treatments, however it should be noted that this site was originally constructed as a hard scour treatment. Numerous soft treatment methodologies are being trailed at this location to improve biodiversity outcomes. Hydroseeded sediment pockets will require ongoing monitoring to determine the success of this application at Butchers Creek.

Unseasonably low rainfall was recorded during the winter monitoring period which contributed to some lower than expected native plant growth.

11. Giant Barred Frog Population

11.1 Introduction

A population of Giant Barred Frogs (GBF) (*Mixophyes iteratus*) inhabit the Upper Warrell Creek (UWC) system which intercepts the WC2NH route alignment. As such, this population of GBF and construction works are required to be managed in accordance with the *WC2NH Giant Barred Frog Management Strategy* (Lewis Ecological, 2014).

GeoLINK have been engaged by Pacifico to undertake seasonal monitoring of two GBF management zones within the project alignment. UWC has a resident population of GBF which has been previously studied by Lewis Ecological (2013/2014) to establish a population baseline. A total of 47 GBF were recorded, including records of juveniles and sub-adults (and recaptures). Since the unexpected find of GBF tadpoles within Butchers Creek, a new GBF management area was established with eight survey zones created for monitoring. No GBF have been recorded within the Butchers Creek survey zones during seasonal population monitoring for Years 1 or 3 of construction.

Transects were established on each side of the project footprint along Upper Warrell Creek (UWC) for 500 metres either side of the alignment and Butchers Creek, 200 metres either side of the alignment. Habitat, abiotic, water quality and tadpole trapping data were collected during the day. GBF population data was collected during nocturnal surveys to record weight, snout to vent length, sex and GPS location of capture, all frogs were microchipped and swabbed for Chytrid fungus. Visual encounters via spotlighting and call playback were employed to detect frogs within the study area. At UWC and Butchers Creek 20 by 50 metre monitoring zones were surveyed on both sides of the creek (20 zones at UWC; eight zones at Butchers Creek). Monitoring methods were in accordance with the WC2NH *GBF Management Strategy* (Lewis Ecological, 2014).

A report documenting the results of Year 3 of construction phase GBF population monitoring is provided in **Appendix J**.

11.2 Summary of Results

Population monitoring undertaken in 2015/2016 (Year 1) returned fewer records of GBF across the three monitoring periods of autumn, spring and summer, with a total of 16 frogs captured at UWC. No sub-adults or juveniles were recorded during this survey period. Population monitoring undertaken in 2017/2018 (Year 3) returned again fewer records of GBF across the three monitoring periods of autumn, spring and summer, with a total of 14 frogs captured at UWC. Only one sub-adult was recorded during the Year 3 during monitoring. No juveniles were recorded during any survey periods. No GBF tagged in the baseline population monitoring of 2013/2014 have been recaptured during seasonal monitoring for Years 1 or 3 of construction.

It can be reasonably expected that a reduced number of GBF have been recorded during construction phase monitoring as a result of an area of high GBF activity (and breeding habitat) has now been fully or partially impacted by construction works. During baseline population monitoring these areas recorded the highest number of frog captures with 21 records in Zones 8 and 9 and six in Zone 10 (i.e. a total of 27 GBF). Prior to construction works, pre-clearing surveys resulted in the capture and relocation of three GBF to outside of the works footprint; no other GBF were accounted for. Despite meeting the mitigation measure requirements via pre-clearing surveys, spotter/ catcher presence

during clearing works and installation of exclusion fencing, it appears GBF within the construction zone have been affected and this population has declined.

Other factors which may explain the considerable reduction in GBF records and no further recaptures since baseline population monitoring may include:

- Non-favourable survey conditions due to lower than usual rainfall, particularly in the lead up to spring 2017 monitoring.
- Lower than average monthly rainfall records and smaller than usual flood events.
- The apparent lack of successful breeding events during the years between monitoring (and therefore no recruitment of juveniles).
- GBF previously captured or recorded in baseline studies have moved out of the survey area seeking better dispersal or breeding opportunities.

Section 7.0 of the *Giant Barred Frog Management Strategy* (GBFMS) states that the objectives of the GBF monitoring program are as follows:

- *To demonstrate through the life of the Project that mitigation has maintained or improved population sizes and habitat of the Giant Barred Frog. The use of preconstruction, during construction and post construction monitoring to measure both frog distribution, abundance and habitat quality with defined thresholds will used to measure the overall performance of the mitigation; and*
- *To ensure that mitigation measures are effective in maintaining Giant Barred Frog connectivity near the Project.*

Based on the results to date, the UWC GBF population has not been maintained or improved, but has declined. However, the reduction in GBF population is not attributable to non-compliance with mitigation measures, as all construction mitigation measures as recommended within the GBFMS have been implemented. While this is the last monitoring event to be conducted during the construction phase, operational phase monitoring will now commence and continue over a six-year period with three monitoring events during Years 1, 3 and 5 of operational phase. Continued monitoring during the operational phase will provide further information on the GBF population post-revegetation of the habitat and operational phase of the project. This will provide information on the longer-term trends of the GBF population at UWC.

A summary of the Key Performance Indicators (KPIs) which informs the GBF monitoring during the construction phase of the project indicates all monitoring complies with KPIs (or objectives) where relevant. Despite this, the objective of maintaining or improving the GBF population at UWC has not been achieved.

Future GBF monitoring as part of the operational phase of works will continue to provide data which will provide further insight into the GBF population trajectory at UWC. Implementation of targeted restoration works as per the Urban Design and Landscaping Plan for the WC2NH Project at UWC will also assist in embellishing GBF habitat where construction works have occurred.

12. Weed and Pathogen Monitoring

12.1 Introduction

A *Weed and Pathogen Management Plan* (WPMP) has been prepared as part of the Warrell Creek to Nambucca Heads (WC2NH) *Construction Environment Management Plan* (CEMP). The WPMP requires that weed monitoring is undertaken to identify occurrences of noxious/ environmental weeds and signs of plant pathogens. The weed monitoring program comprises the following:

1. *"Fixed photograph points are to be established at 15 locations within the project site to monitor the change in weed levels and detect any signs of plant pathogens. Photo points are to be placed in areas of native vegetation outside the clearing limits (but inside the project boundary) and should be spread across different vegetation types, EECs and threatened flora/ fauna habitats associated with the site. The locations of the photo points are to be determined by the project ecologist during the first weed monitoring session. A star picket and metal tag (with identification code) would be used to mark all locations with a photograph to be taken during monitoring sessions always facing in the same direction.*
2. *Surveys of the entire project site will be undertaken routinely by the project ecologist to identify noxious/ environmental weed infestations. Substantial weed infestations are to be mapped and provided to the AFJV Environmental team in a brief report. AFJV will also monitor weed infestations on the construction site through the Weekly Environmental Checklist process.*
3. *Searches for signs of dieback (indicative of Phytophthora cinnamoni) and Myrtle Rust will be undertaken in areas of native vegetation retained within the project site. Any such signs are to be investigated further with testing to be undertaken if required".*

When the WC2NH Project was awarded, the *Noxious Weeds Act 1993* (NW Act) legislated the control of noxious weed species within NSW. The NW Act has since been repealed and replaced with the *Biosecurity Act 2015*. As the project approved CEMP and the *Weed and Pathogen Management Plan* (GeoLINK, 2014) were approved referencing the NW Act, the recommendations in this report will be in accordance with the approved CEMP which references the NW Act.

A report documenting the results of Year 3 Weed and Pathogen monitoring is provided in **Appendix K.**

12.2 Summary of Results

The presence of weed infestations is lowest within the northern half of the project, north of the Pacific Highway and Old Coast Road intersection, with very few areas of weed encroachment recorded.

Areas of concern which currently or have the potential to develop weed infestation are creeks and drainage lines, particularly in the southern section of the project such as Rosewood Creek, Butchers Creek and Upper Warrell Creek (UWC). Weed control and proposed landscape plantings within the UWC riparian zone is of key importance due to the presence of the threatened Giant Barred Frog (GBF). Typical GBF habitat comprises mostly open ground with a deep layer of leaf litter beneath with a vegetated forest canopy. Dense pasture grass infestations may limit the dispersal of GBF within habitat areas and limit available breeding habitat for the species, which typically occupies habitat within 20 metres of the water's edge of freshwater streams and occasionally dams. It is recommended to plan for the future control of weeds around the riparian zone of UWC to protect GBF

habitat. In accordance with the *GBF Management Strategy* (Lewis, 2014) the proposed landscape planting will maintain or enhance connectivity of GBF habitat post-construction and into the operational phase of the highway (Stage 2B). Stage 2B is forecast to open to traffic in June of 2018.

As works on the Philip Hughes (Nambucca River) Bridge is now complete, the area beneath the bridge will be decommissioned and all construction related materials removed. This area is now at risk of encroachment by weeds which thrive in disturbed areas. The area beneath the Nambucca River Bridge comprises the Threatened Ecological Community *Freshwater Wetlands on coastal Floodplains;* weed management within this area should be implemented to assist the regeneration of native wetland species.

Searches for signs of Phytophthora (*P.cinnamomi*) and Myrtle rust were undertaken during December 2017 in areas of native vegetation retained within the site boundary. No signs were found and no indications of plant pathogens have been identified during the project to date.

13. Conclusion

The monitoring and reporting requirements of the third year of construction have been completed in accordance with the Project Ecological Monitoring Program and the Flora and Fauna management sub-plans. **Table 13.1** summarises the ecological monitoring undertaken for the project to date and the upcoming monitoring requirements for the remaining Year 4 of the construction phase.

A summary of the Key Performance Indicators which informs the ecological monitoring program has been completed (refer to **Table 13.2**) and indicates all monitoring complies with KPIs (or relevant objectives) where relevant.

Year 4 monitoring will be undertaken during the period from February 2018 until the Project is fully open to traffic which is currently scheduled for later this year. The operational monitoring program will commence at that stage.

Table 13.1 Ecological Monitoring Timeline

Giant Barred Frog	*Microbat Roost Box*	*Microbat 22 Structures - Overwintering*	*Microbat Habitat Monitoring*	*Microbat Persistence and Behaviour Monitoring*	*Yellow-bellied Glider*	*Koala Population*	*Nest Box Monitoring*	*Landscape Rehabilitation Photo Points*	*Landscape Rehabilitation Monitoring*	*In situ Threatened Flora Population*	*Translocation Areas*	*Wetland Rehabilitation Monitoring*	*Weed Photo Points*
Year 1 - Autumn 2015	Year 1 - Summer 2015	Year 2 - Winter 2016	Apr-15	Year 1 - Summer 2015	Year 2 - Winter/ Spring 2016	Year 1 - Spring 2015	Year 2 - Winter 2016	Nov-16	Year 2 - Spring 2016	Year 1 - Autumn 2015	Year 1 - Autumn 2015	Year 1 - Autumn 2015	Apr-15
Year 1 - Spring 2015	*Year 1 - Autumn 2015	Year 3 - Winter 2017	May-15	Year 1 - Autumn 2015		Year 3 - Spring 2017	Year 2 - Summer 2016	Dec-16		Year 1 - Spring 2015	Year 1 - Spring 2015	Year 1 - Winter 2015	May-15
Year 1 - Summer 2015/16	Year 1 - Winter 2015		Jun-15	Year 1 - Winter 2015			Year 3 - Winter 2017	Jan-17		Year 2 - Autumn 2016	Year 2 - Spring 2016	Year 1 - Spring 2015	Jun-15
Year 3 - Autumn 2017	Year 1 - Spring 2015		Jul-15	Year 1 - Spring 2015			Year 3 - Summer 2017	Feb-17	Year 2 - Summer 2016	Year 2 - Spring 2016	Year 3 - Spring 2017	Year 2 - Summer 2016	Jul-15
Year 3 - Spring 2017	Year 2 - Summer 2016		Aug-15	Year 2 - Summer 2016			Year 4 - Winter 2018	Mar-17		Year 3 - Spring 2017	Year 4 - Spring 2018	Construction Phase monitoring now complete	Aug-15
Year 3 - Summer 2017/18	Year 2 - Autumn 2016		Sep-15	Year 2 - Autumn 2016			Year 4 - Summer 2018	Apr-17		Year 4 - Spring 2018			Sep-15
	Year 2 - Winter 2016		Oct-15	Year 2 - Winter 2016				May-17	Year 3 - Autumn 2017				Oct-15
	Year 2 - Spring 2016		Nov-15	Year 2 - Spring 2016				Jun-17					Nov-15
	Year 3 - Summer 2017		Dec-15	Construction Phase monitoring now complete				Jul-17					Dec-15
	Year 3 - Autumn 2017		Jan-16					Aug-17	Year 3 - Winter 2017				Jan-16
	Year 3 - Winter 2017		Feb-16					Sep-17					Feb-16
	Year 3 - Spring 2017		To be continued monthly in year 3 and 4 (recommence in Feb 2017)					Oct-17					Mar-16
	Year 4 - Summer 2018		Feb-17					Nov-17	Year 3 - Spring 2017				Apr-16
	Year 4 - Autumn 2018		Mar-17					Dec-17					May-16
	Year 4 - Winter 2018		Apr-17					Jan-18					Jun-16
	Year 4 - Spring 2018		May-17					Feb-18	Year 3 - Summer 2018				Jul-16
			Jun-17					Mar-18					Aug-16
			Jul-17					Apr-18					Sep-16
			Aug-17					May-18	Year 4 - Autumn 2018				Oct-16
			Sep-17					Jun-18					Nov-16
			Oct-17					Jul-18					Dec-16

Giant Barred Frog	*Microbat Roost Box*	*Microbat 22 Structures - Overwintering*	*Microbat Habitat Monitoring*	*Microbat Persistence and Behaviour Monitoring*	*Yellow-bellied Glider*	*Koala Population*	*Nest Box Monitoring*	*Landscape Rehabilitation Photo Points*	*Landscape Rehabilitation Monitoring*	*In situ Threatened Flora Population*	*Translocation Areas*	*Wetland Rehabilitation Monitoring*	*Weed Photo Points*
			Nov-17					Aug-18	Year 4 - Winter 2018				Now 6 monthly monitoring
			Dec-17										Year 3 - June 2017
			Jan-18										Year 3 - December 2017
			July 2017 produce a 6-monthly summary report										
			Jan 2018 produce annual monitoring report										
			Feb-18										
			Mar-18										
			Apr-18										
			May-18										
			Jun-18										
			June 2018 produce a 6-monthly summary report										

Legend:

Year 1 - Winter 2015	Non-compliance
Completed	monitoring event completed
Upcoming	next seasons required monitoring
Construction Phase monitoring now complete	No monitoring required for construction phase

Table 13.2 Summary of Key Performance Criteria for Ecological Monitoring

Relevant Management Plan	*Key Performance Indictors (KPIs)*	*KPIs met?*	*Contingency if KPI Not Met*
Grey-headed Flying-fox	**Vegetation Clearing** ▪ More than one dead/ foetus or more than one injured Grey-headed Flying-fox is found which, in the opinion of the ecologist experienced with flying-foxes, are likely to have been killed or injured by the disturbance activities. **During Construction** ▪ Significant reduction in reproductive output (measured as mean percentage of females with young in target trees) relative to control site. ▪ Zero flying-fox mortality within 300 metres of the camp footprint. ▪ Should the annual road kill monitoring reports identify a significant difference between the roadkill numbers of the different treatments (transect types).	▪ Yes – no Grey-headed Flying-fox have been injured or killed as a result of project clearing activities. ▪ Yes – no significant reduction in reproductive output has been recorded as attributable to the project construction activities. ▪ Yes – no Flying-fox mortalities have been recorded within 300 m of the camp footprint due to construction activities. The camp self-relocated from the project alignment to the Macksville cemetery prior to clearing commencing. ▪ Yes – no significant difference has been recorded between road kill numbers.	No action currently required.
Microbat Habitat (Flyway) Monitoring	No key performance indicators are specifically listed in relation to this section of the plan. However, habitat monitoring would focus on inspections of the riparian zone to assess whether flyways have been constricted as part of construction works.	▪ Yes - microbat flyway monitoring to date has indicated that the flyways are largely unobstructed by vegetation overgrowth or weeds. While riparian vegetation is intercepted by construction, flyway opportunities are provided via under passage or viable aerial passage above the highway.	No action currently required.
Microbat Overwintering	No key performance indicators are specifically listed in relation to this section of the plan.	N/A	N/A
Microbat Roost Box	Roost boxes installed are being utilised by a range of microbats.	▪ Yes – the uptake of roost boxes by microbats has increased in 2017 when compared to 2016 results. ▪ Yes – the species diversity of microbats using the boxes has increased in 2017 when compared to 2016 results. ▪ No – some roost boxes have never recorded occupancy.	No action currently required.

Relevant Management Plan	*Key Performance Indictors (KPIs)*	*KPIs met?*	*Contingency if KPI Not Met*
Nest Box	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. ▪ Reduced maintenance requirements.	▪ Yes – low to moderate diversity was recorded during Year 3 monitoring events (winter and summer) the combined number of native species recorded was nine fauna species and one native invertebrate (stingless bee). ▪ Yes – two Common Brush-tailed Possums were recorded using possum boxes ▪ Yes – Sugar Gliders used a range of box types including small glider, scansorial mammal, large glider, possum and microbat boxes. ▪ Yes – only two exotic species have been recorded using the nest boxes (Black Rat and European Bees) since the commencement of monitoring. However, eight nest boxes have recorded occupation by active bee hives during the summer 2018 monitoring event (corrective actions have been implemented). ▪ Yes – low maintenance requirements have been experienced to date. One box lid required complete replacement due to damage. Minor maintenance was required for several boxes.	Buffalo ear tags have been affixed to nest boxes which have recorded European bee hive uptake with the intention that the bees will abandon the hive and leave the nest box.
Koala Population Monitoring	▪ Koala abundance and distribution pre-construction are similar to post-construction and maintained in the vicinity of Nambucca State Forest/ Old Coast Road.	▪ Yes – spring 2017 monitoring results indicate an increase in numbers of recorded Koalas from one individual recorded during Spring 2015 to three individual Koalas recorded during spring 2017. ▪ Yes - Koala observations were made across the middle section of the survey area from transect E9 to W18 (across both sides of the highway alignment) which is consistent with both baseline and spring 2015 monitoring results.	No action currently required.

Relevant Management Plan	*Key Performance Indictors (KPIs)*	*KPIs met?*	*Contingency if KPI Not Met*
Road Kill Monitoring	Number of roadkill of EPBC listed fauna species resulting from the project.	▪ Yes - No EPBC listed fauna have been recorded as road fatalities as a result of the project.	No action currently required.
In-situ Threatened Flora: In-situ Roadside	The following performance indicators are to be used to evaluate the success of protective measures for in-situ threatened flora: a) The survival rate of in-situ threatened flora at the finish of clearing is 100%. No accidental damage occurs during clearing. b) The survival rate of in-situ threatened flora at the end of years 1-3 of the monitoring program is at least 80% and at least 70% at the end of years 4-8. c) Of plants surviving at the end of each year, at least 75% are in good condition i.e. they have healthy foliage, no sign of die-back or disease and exhibit new shoot growth (Condition Class 3 or >).	a) Yes – no in-situ threatened flora plants have died due to clearing or construction operations. Natural die back of annual species has been recorded. b) Survival rate at end of Year 3 (>80%) • Tall Knotweed – No - no 2016 plants were recorded during 2017. • Spider Orchid – Yes 100% survival • Maundia – Yes 83% survival • Rusty Plum – Yes 100% survival • Slender Marsdenia – No 60% survival Note: where the survival rate of a species is below 80% at the end of Year 3 No - construction related disturbances via encroachment into the protected area, or project related erosion or sedimentation or excessive weed encroachment have been recorded as the reason for below target rates of survival. c) Yes – no construction related impacts have been recorded as affecting the health of the retained threatened flora. For those species not experiencing natural season dieback new growth and recruitment is evident amongst the retained plants.	No corrective action is currently required.
In-situ Threatened Flora: Wools Tylophora and Slender Marsdenia Habitat	The following performance indicators are to be used to evaluate changes in habitat condition a) Plot crown-cover of exotic species is no more than 15% (overlapping and/or summed) at the end of Year 1 and no more than 25% at the end	a) Yes – no increase above 25% crown cover of exotic species has been recorded at the end of Year 3 monitoring events. b) Yes – no reduction to baseline vegetation structure has been recorded when compared to the previous year's monitoring.	No corrective action is currently required.

Relevant Management Plan	Key Performance Indictors (KPIs)	KPIs met?	Contingency if KPI Not Met
	of Years 2 to 8. b) Baseline vegetation structure (height and crown cover) remains the same or increases in height and crown cover at the end of year compared to the previous year. c) There is no increase in the microclimate exposure class (e.g. 1 to 2, or 4 to 5) compared to the previous year.	c) Yes – no increase to the microclimate exposure class has been recorded when compared to the previous year.	
Threatened Flora Translocation	The following performance indicators are to be used to evaluate the success of the threatened species translocations (salvage translocation and population enhancement): a) All directly impacted individuals of threatened species were salvaged and relocated to the receival site(s). b) At least 60% of transplant and enhancement individuals are surviving after the first year, 50% after five years and 40% after eight years. c) At the end of the monitoring program (8 years), at least 50% of surviving individuals have a Condition Class of 3 or higher.	a) Yes – all impacted individuals of threatened species have been translocated. b) Yes – survival rate greater than 60%. c) Not yet applicable until the end of the monitoring program.	No corrective action is currently required.
Landscape Rehabilitation	No performance indicators have been prescribed as part of the scope of works for landscape rehabilitation monitoring provided by Pacifico.	N/A	N/A
Giant Barred Frog	The following performance indicators are to be used to evaluate the success of the GBF population and habitat management: a) GBF habitat to be cleared to not exceed approvals. b) Final Sensitive Area Plans identify sensitive areas and 100% of clearing drawings identify clearing extents. c) Clearing limit does not exceed approved limits (State and Commonwealth). d) No GBF injuries/ mortalities of adults or tadpoles as a consequence of construction activities.	a) Yes – as evidenced in the vegetation quantity tracking register. b) Yes – as illustrated on Project Sensitive Area Plans. c) Yes – clearing limits are verified by survey and delineation checked during joint pre-clearing walkthroughs. d) Yes – Pre-clearing surveys were undertaken prior to disturbance of GBF habitat and a spotter/ catcher was present during disturbances to GBF habitat. No GBF injuries or fatalities have been	KPI reference: a to d) No action currently required. e) All Construction phase GBF population monitoring is now complete. Ongoing population monitoring will be undertaken yearly during the operational phase of

Relevant Management Plan	Key Performance Indictors (KPIs)	KPIs met?	Contingency if KPI Not Met
	e) GBF recorded along the monitoring transect. f) The detection of Chytrid fungus. g) No breaches in fauna exclusion fencing. h) No roadkill of GBF resulting from the project. i) Successful establishment of GBF habitat in the nominated areas.	recorded directly as a result of construction activities, although core habitat within zones 8-10 have been directly impacted by construction at UWC. e) Yes – 16 GBF were recorded during Year 1 of construction along the monitoring transect in accordance with baseline survey methodology. Year 3 – Autumn and spring 2017 and summer 2018 recorded 14 GBFs collectively. f) Two frogs swabbed for Chytrid for Year 1 of construction tested positive (in the low range) for Chytrid. One frog swabbed positive during Year 3 monitoring. g) Yes – unavoidable breaches to frog exclusion fencing have occurred due to periodic flooding during construction however GBF surveys have been conducted to ensure no GBF have entered the active work zone during flood evets. No GBF were detected during these surveys. h) Yes – no GBF road kill has been recorded along the existing highway or as a result of the project. Once the new highway becomes operational road kill monitoring for compliance will be undertaken. i) Rehabilitation of GBF habitat has not yet commenced due to construction phase currently active.	the project as scheduled in the *GBFMS* and *Ecological Monitoring Program*. f) No action is currently required regarding Chytrid fungus detection g) to h) No action currently required i) Discussions regarding creek bank and landscape rehabilitation within GBF habitat will occur prior to the removal of the causeway crossing.
Weed and Pathogen	No key performance indicators are specifically listed within the Weed and Pathogen Management Plan.	N/A	N/A

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Appendix A

Habitat Tree Register and Fauna Capture/ Relocation Records

Table A1 WC2NH Fauna Register February 2015 to March 2018

Common name	Scientific Name	Number of Individuals	Date	Fate	Location	Chainage	Comments	Observer
February 2015								
GBF	*Mixophyes iteratus*	2	19/02/2015	Released on non-works side of frog fence	Lower Warrell Creek	42500	Observed during GBF monitoring (night time)	DH, FM, JOL
March 2015								
Sugar Glider	*Petaurus breviceps*	4	4/03/2015	Released, Unharmed	State forest off Old Coast Road	55200	Nest box attached to tree was removed. 4 x sugar gliders occupying nest box. Nest box Relocated into bush, reattached to tree on same chainage outside clearing limits	JOL
Pink-tounged Skink	*Cyclodomorphus gerrardii*	1	16/03/2015	Released, Unharmed	Cockburns Lane	42980	Found within fallen stag, released in bush on same chainage outside clearing limits	DH, FM
Yellow-bellied Glider	*Petaurus australis*	4	16/03/2015	Died in falling stag	Cockburns Lane	42980	Discovered in fallen stag. Three dead on arrival one euthanised by Macksville vet	DH, FM
Brushtail Possum	*Trichosurus vulpecula*	5	16/03/2015	Escaped falling stag	Cockburns Lane	42980	Observed escaping fallen stag. Appeared to be unharmed	DH, FM
Ringtail Possum	*Pseudocheirus peregrinus*	2	23/03/2015	Self-relocated	NE siding Lane	58150	Observed during pre-dawn survey	DH, FM
Red-backed Toadlet	*Pseudophryne coriacea*	1	23/03/2015	Self-relocated	NE siding Lane	58150	Observed during pre-dawn survey	DH, FM
Sugar Glider	*Petaurus breviceps*	1	25/03/2015	Self-relocated	NE siding Lane	58150	Observed during pre-dawn survey	DH, FM
Carpet Python	*Morelia spilota*	1	30/03/2015	Died on site, possible machinery strike	NE siding Lane	58150	Observed during site visit	DH, FM
Fawn-footed Melomys	*Melomys cervinipes*	1	30/03/2015	Released, Unharmed	NE siding Lane	58150	Observed habitat tree removal	DH, FM
Southern Dwarf-crowned Snake	*Cacophis krefftii*	1	27/03/2015	Released outside of clearing limits	NE siding Lane	58150	Observed habitat tree removal	DH, FM
GBF	*Mixophyes iteratus*	3	11/03/2015	Released on non-works side of frog fence	Lower Warrell Creek	42500	Observed during GBF monitoring (night time)	DH, FM, JH
April 2015								

Common name	Scientific Name	Number of Individuals	Date	Fate	Location	Chainage	Comments	Observer
Sugar Glider	*Petaurus breviceps*	1	1/04/2015	Released outside of clearing limits	Above quarry on Pacific Hwy	47750	Observed in HBT held during the day then released after dark	DH, FM
Sugar Glider	*Petaurus breviceps*	3	8/04/2015	Self-relocated	Old coast Road	59300	Found in habitat tree when dropped	FM
Sugar Glider	*Petaurus breviceps*	1	8/04/2015	Wires	Old Coast Road	59300	Found in habitat tree when dropped	FM
Blind Snake	*Ramphtyphlops nigrescens*	1	9/04/2015		Bald hill Road	49300	Found in habitat tree when dropped	FM
Green Tree Snake	*Dendrelaphis punctulata*	1	15/04/2015	Relocated outside of project area	Bald hill Road	48500	Salvaged from debris after habitat tree felling	FM, GJM
Carpet Python	*Morelia spilota*	1	23/04/2015	Relocated outside of project area	Lower Warrell Creek	48100	Collected from the south side of lower Warrell Creek	DH, EW
May 2015								
White-headed Pigeon	*Columba leucomela*	1	4/05/2015	Taken to Macksville vet	North Bald Hill	49300	N/A	N/A
Carpet Python	*Morelia spilota*	1	14/05/2015	wires	Cockburns Lane	42800	N/A	N/A
Carpet Python	*Morelia spilota*	1	15/05/2015	Relocated outside of project area	Butchers Creek	43200	N/A	N/A
Pacific Black Duck	*Anas superciliosa*	15	29/05/2015	Relocated outside of project area	Dam wall	44500	Mother duck plus 14 ducklings, shooed from dam wall into neighbouring water body (outside of alignment)	N/A
Carpet Python	*Morelia spilota*	1	29/05/2015	Relocated outside of project area	South of Butchers creek	42700	N/A	N/A
June 2015								
Swamp Wallaby	*Wallabia bicolor*	1+1	5/06/2015	Mother hit by car, joey survived	Intersection of Scotts Head Road	48100	Wires carer to rehabilitate	FM, EW
Lace Monitor	*Varanus varius*	1	11/06/2015	Relocated to nearby bush land, unharmed	North of Sheathers driveway	56200	Encountered during clearing	FM
Carpet Python	*Morelia spilota*	1	11/06/2015	Relocated to nearby bush land, unharmed	North of Sheathers driveway	56200	Encountered during clearing	FM
Feathertail Glider	*Acrobates pygmaeus*	2	16/06/2015	Relocated to nearby bushland unharmed	Adjacent Jacks ridge	57000	Placed in nest box with dry leafy material	DH, FM
Little Forest Bat	*Vespadelus sp.*	4	16/06/2015	3 deceased, 1 Relocated after sun down	Adjacent Jacks ridge	57000	Encountered during clearing	DH, FM
Eastern Water Dragon	*Itellagama lesueurii*	6	16/06/2015	5 Relocated outside of project area, 1 euthanised	Culvert, near quarry access	47500	Encountered during clearing	DH, FM

Common name	Scientific Name	Number of Individuals	Date	Fate	Location	Chainage	Comments	Observer
Sugar Glider	*Petaurus breviceps*	1	18/06/2015	Relocated to nearby bush land, unharmed	Jacks Ridge	57050	Encountered during clearing	FM
Southern Dwarf-crowned Snake	*Cacophis krefftii*	1	22/06/2015	Self-relocated	South Bald Hill	48900	Encountered during clearing	DH
Carpet Python	*Morelia spilota*	1	23/06/2015	Relocated to nearby bush land, unharmed	Poplar trail, OCR	58200	Encountered during clearing	FM
Red-bellied Black Snake	*Pseudechis porphyriacus*	1	24/06/2015	Relocated to nearby bush land, unharmed	Old Mill, Sheathers	56100	Encountered during clearing	FM
Echidna	*Tachyglossus aculeatus*	1	25/06/2015	Relocated to nearby bush land, unharmed	Poplar trail, OCR	58200	Encountered during clearing	FM, JOL, JL
Kookaburra	*Dacelo novaeguineae*	1	25/06/2015	Died after being struck by stick in mulcher	Poplar trail, OCR	58200	Encountered during clearing	DH
July 2015								
Brushtail Possum	*Trichosurus vulpecula*	1	1/07/2015	Relocated outside of project boundary	Old Coast Road	N/A	possibly with young	FM
Eastern Small-eyed Snake	*Cryptophis nigrescens*	1	8/07/2015	Relocated outside of project boundary	Old Coast Road	N/A	Encountered during clearing	FM
Lace Monitor	*Varanus varius*	1	15/07/2015	Injured in clearing and grubbing, taken to Macksville vet	Old Coast Road	N/A	Successfully rehabilitated and will be release back to state forest once fauna fencing has been installed and connected.	FM
Eastern Water Dragon	*Itellagama lesueurii*	1	15/07/2015	Relocated outside of project boundary	Old Coast Road and Pacific Highway	52900	Found in rubbish pile	FM
Blind Snake	*Ramphtyphlops nigrescens*	1	15/07/2015	Relocated outside of project boundary	Old Coast Road	N/A	Encountered during clearing	FM
Echidna	*Tachyglossus aculeatus*	1	16/07/2015	Relocated outside of project boundary	Stoney creek	45600	Encountered during clearing	FM
Sugar Glider	*Petaurus breviceps*	2	17/07/2015	Found in nest box that required moving outside of clearing limits	Old Coast Road	N/A	Encountered in preparation for clearing	FM
Blue-tongue Lizard	*Tiliqua scincoides.*	1	21/07/2015	Found during top soil stripping, Relocated unharmed	North of southern compound	46100	Encountered during topsoil strip	FM

Common name	Scientific Name	Number of Individuals	Date	Fate	Location	Chainage	Comments	Observer
Swamp Wallaby	*Wallabia bicolor*	2	24/07/2015	Hit by vehicle (OCR) Mother died at scene, joey un injured being cared for by wires	Old Coast Road	N/A	Vehicle strike	FM
Feathertail Glider	*Acrobates pygmaeus*	1	27/07/2015	Found in HBT whilst clearing, Relocated to nearby bush land, unharmed	Gate 18, Old Coast Road	60900	Encountered during clearing	FM
August 2015								
No Records for August								
September 2015								
Great Barred Frog	*Mixophyes fasciolatus*	2	7/09/2015	Moved off site, found during GBF pre-clearing survey	Butchers Creek	43300	Moved off site, found during GBF pre-clearing survey	DH
Striped Rocket Frog	*Litoria nasuta*	2	9/09/2015	Moved off site, found during GBF pre-clearing survey	Butchers Creek	43300	Moved off site, found during GBF pre-clearing survey	FM
Red-backed Toadlet	*Pseudophryne coriacea*	1	9/09/2015	Moved off site, found during GBF pre-clearing survey	Butchers Creek	43300	Moved off site, found during GBF pre-clearing survey	FM
Eastern Dwarf Tree Frog	*Litoria fallax*	1	10/09/2015	Moved off site, found during GBF pre-clearing survey	Butchers Creek	43300	Moved off site, found during GBF pre-clearing survey	FM
Dwarf-crowned Snake	*Cacophis krefftii*	1	11/09/2015	Moved off site, found during GBF pre-clearing survey	Butchers Creek	43300	Moved off site, found during GBF pre-clearing survey	FM
Great Barred Frog	*Mixophyes fasciolatus*	1	17/09/2015	Moved off site, found during GBF pre-clearing survey	Butchers Creek	43300	Moved off site, found during GBF pre-clearing survey	DH
Blind Snake	*Ramphtyphlops nigrescens*	1	24/09/2015	Relocated off site unharmed	OC15	59200	Found under Geofabric in clean water drain	JOL
October 2015								
Marsh Snake	*Hemiapsis signata*	1	2/10/2015	Relocated outside of project boundary	Gate OC14 Nambucca State Forest	59000	Identified by work crew	JOL
Brown Snake	*Pseudonaja textilis*	1	6/10/2015	Relocated outside of project boundary	Albert Drive interchange	46150	Identified by work crew	JOL
Carpet Python	*Morelia spilota*	1	8/10/2015	taken to the vet for medical attention, now in care with WIRES	122 Old Coast Road house demolition, pre-demo survey was undertaken but the snake was not	54100	Identified during house demolition by work crew	JOL

Common name	Scientific Name	Number of Individuals	Date	Fate	Location	Chainage	Comments	Observer
					detected			
Eastern Rosella	*Platycercus eximius*	1	15/10/2015	taken to care for WIRES	Fill 12 south of Lower Warrell Creek	48000	N/A	JOL
November 2015								
Great Barred Frog	*Mixophyes fasciolatus*	1	19/11/2015	during frog surveys, Relocated offsite, Butchers Creek	Butchers Creek	43300	Encountered during nocturnal frog surveys	FM, JOL
Pink-tounged Skink	*Cyclodomorphus gerraroadii*	1	19/11/2015	during frog surveys, Relocated offsite, Butchers Creek	Butchers Creek	43300	Encountered during nocturnal frog surveys	FM, JOL
Brown Falcon	*Falco berigora*	1	28/11/2015	Taken to vet, found under plant in the morning, cut 10	Cut 10	47700	Identified by work crew	Enviro Crew
Koala	*Phascolarctos cinereus*	1	24/11/2015	Found during Koala surveys	Near Tip Road > 70m west of the project alignment	N/A	Encountered during koala surveys	FM, GMcL
December 2015								
Brown Snake	*Pseudonaja textilis*	1	8/12/2016	Relocated outside of project boundary	OC6 drainage excavation	55200	Identified by work crew	JOL
January 2016								
Striped Marsh Frog	*Limnodynates peronii*	1	14/01/2016	Relocated outside of Project alignment to the east	Fill 19 near South Mattick Road	54400	Identified by work crew	JOL
Red-bellied Black Snake	*Pseudechis porphyriacus*	1	20/01/2016	Euthanised at vet missing tail above the cloaca	Rosewood Creek	44900	N/A	JOL
Eastern Long-necked Turtle	*Chelodina longicollis*	1	22/01/2016	Relocated outside of Project alignment to the east	Fill 19 near South Mattick Road in sediment trap	54400	Identified by work crew	JOL
Kookaburra	*Dacelo novaeguineae*	1	27/01/2016	Hit by traffic on Old Coast Road - euthanised at vet	Old Coast Road	N/A	PV brought in to ecologists	FM
February 2016								
Grey-headed Flying-fox	*Pteropus poliocephalus*	1	16/02/2016	Found in structure pile casing, taken to vet then given to experienced WIRES carer	Nambucca River Bridge - Gumma Road	52050	Structures staff called ecologist to capture the animal	FM, JOL

Common name	Scientific Name	Number of Individuals	Date	Fate	Location	Chainage	Comments	Observer
Yellow-bellied Glider	*Petaurus australis*	3	18/02/2016	Observed on HBT at OC18 - additional monitoring and supervision of tree felling. No YBGs in the habitat tree while felling	OC18 HBT	60950	Observed on HBT at OC18 1 animal observed 2 additional animals heard calling within 100 m of the HBT. This HBT was monitored over a series of nights before felling of this tree. No YBGs in the habitat tree when felled.	JOL
Sugar Glider	*Petaurus breviceps*	2	29/02/2016	found within hollows of the OC18 HBT - safely released at night	OC18 HBT	60950	Captured during supervised felling of the HBT	DH, FM, JOL
March 2016								
Swamp Wallaby	*Wallabia bicolor*	1	2/03/2016	Found attacked by dogs - taken to vet for treatment in care with WIRES	Cut 24 OC14	58800	Attacked by 2 dogs captured by foreman and given to ecologists	JOL
Tawny Frogmouth	*Podargus strigoides*	1	7/03/2016	Collision with delivery truck on route to Pre-Cast Yard - euthanised due to missing wing	Pre-Cast Yard – North Zone	54100	Delivery driver called Enviros	JOL
Perons Tree Frog	*Litoria peronii*	1	8/03/2016	Captured during HBT felling - Relocated offsite	Stoney Creek	45500	Ecologist capture/relocate	FM
Rainbow Lorikeet	*Trichoglossus moluccanus*	1	9/03/2016	Retrieved from a hollow nest taken to wires for care	Albert Drive HBTs	42600	Taken to wires for care raised and later released in Scotts Head	JOL
Galah	*Eolophus roseicapilla*	1	9/03/2016	located in hollow nest but already deceased for a number of days	Albert Drive HBTs	42600	Deceased for a number of days likely water exposure as the hollow was inundated with water	JOL
Eastern Rosella nest	*Platycercus eximius*	2 eggs	9/03/2016	Two eggs in hollow nest - eggs destroyed	Albert Drive HBTs	42600	Two eggs in hollow nest - eggs destroyed by ecologist	JOL
Red-bellied Black Snake	*Pseudechis porphyriacus*	1	14/03/2016	escaped capture, minor laceration	Rosewood creek	44550	Injured by machinery, escaped ecologist	JOL
April 2016								
Swamp Wallaby	*Wallabia bicolor*	1	14/04/2016	Euthanised	OCR and Mattick Road	54600	Discovered early morning, possible vehicle strike	AD
May 2016								
Great Barred Frog	*Mixophyes fasciolatus*	1	9/05/2016	Relocated unharmed	Butchers Creek	43350	found during nocturnal survey	FM

Common name	Scientific Name	Number of Individuals	Date	Fate	Location	Chainage	Comments	Observer
June 2016								
Common Froglet	*Crinia signifera*	1	26-Jun	Relocated offsite safely	Butchers Creek	43350	N/A	FM
Eastern Dwarf Frog	*Littoria fallax*	1	26-Jun	Relocated offsite safely	Butchers Creek	43350	N/A	FM
Carpet Python	*Morelia spilota*	1	2-Jun	Self-relocated unharmed	Butchers Creek	43350	N/A	EW
Echidna	*Tachyglossus aculeatus*	1	10-Jun	Self-relocated unharmed	gate 5	46880	N/A	FM
July 2016								
Australian White Ibis	*Threskiornis moluccus*	1	18/07/2016	Euthanised by vet	Old Coast Road	59500	Discovered early morning by Enviro Coordinator on OCR	AD
Black Flying-fox	*Pteropus alecto*		26/07/2016	Deceased - likely vehicle strike	Gate 5 - Albert Drive	46880	Deceased - likely vehicle strike	EW
Tawny Frogmouth	*Podargus strigoides*	1	25/07/2016	Taken into care by WIRES released shortly after	Letitia drive	53300	Found at Letitia drive early morning	AD
August 2016								
Black Flying-fox	*Pteropus alecto*	1	26/08/2016	Found at gate 5 (deceased) likely vehicle strike	Albert drive North	46880	Likely vehicle strike	EW
September 2016								
Blue-tongue Lizard	*Tiliqua scincoides*	1	9/09/2016	Relocated to nearby vegetation by Pacifico south zone enviro team	Butchers Creek	43350	Encountered while working in Butchers Creek	Enviro crew
Carpet Python	*Morelia spilota*	1	13/09/2016	Sunning itself on fuel cart – self relocated once the truck was driven close to vegetation	North Zone QB area	57900	Observed on Watercart	JH
Swamp Wallaby	*Wallabia bicolor*	1	14/09/2016	Rescued from sediment basin at OC19 – released in nearby vegetation	OC19	61200	Wallaby hopped into sediment basin and became trapped in silt mud retrieved using snatch strap and tadpole dip net.	JOL
Brown Snake	*Pseudonaja textilis*	1	29/09/2016	Take to WIRES for care	Fill 6	44700	Stuck in spray seal rescued by wires and cleaned by WIRES volunteer	EW
October 2016								
Green Tree Snake	*Dendrelaphis punctulatus*	1	6/10/2016	Deceased	Fill 19	54650	N/A	AFJV

Pretty-faced Wallaby	*Macropus parryi*	1	10/10/2016	Deceased - Roadkill	Fill 24	57700	N/A	AFJV
Rabbit	*Oryctolagus cuniculus*	1	11/10/2016	Deceased - Roadkill	Fill 24	57700	N/A	AFJV
Sugar Glider	*Petaurus breviceps*	2	24/10/2016	Observed only - during NFRs pre-clearing surveys	Old Coast Road - east	53800	Observed entering a nest box at dawn (not within the clearing footprint).	JOL
Feathertail Glider	*Acrobates pygmaeus*	1	25/10/2016	Observed only - during NFRs pre-clearing surveys	Old Coast Road - east	53720	Observed in a tree not within the clearing footprint.	DJH
Ringtail Possum	*Pseudocheirus peregrinus*	1	25/10/2016	Observed only - during NFRs pre-clearing surveys	Old Coast Road - east	53780	Observed in a tree within the clearing footprint - tree not cleared until confirmed possum had self-Relocated.	DJH
Red-bellied Black Snake		1	28/10/216	Self-Relocated from machine	Location not supplied	N/A	Self-Relocated from machine	JH
Magpie chicks	*Cracticus tibicen*	2	31/10/2016	1 taken to Vet and WIRES for care 1 fatally injured during clearing	Woods Property access	53260	Occupied nest in a tall marked HBT was difficult to control the fall of this tree when felling.	JOL
November 2016								
Masked Lapwing Chick	*Vanellus miles*	1	9/11/2016	Chick without parents taken to WIRES for care	Mattick Road	54550	Steel fixers caught the chick and gave to Enviro Coordinator	JH
Green Tree Snake	*Dendrelaphis punctulatus*	1	22/11/2016	Likely roadkill	Mattick Road	54550	Collected by ecologist for ID purposes	JOL
Golden-crowned Snake	*Cacophis squamulosus*	1	31/11/2016	Relocated, unharmed	Upper Warrell Creek	42650	Captured from shallow excavation and Relocated unharmed	JOL
December 2016								
Microbat	*Miniopterus sp.*	1	12/12/2016	Observed within box culvert scupper - no action required	Nth Albert Drive - Cattle underpass	46450	Observed within box culvert scupper - no action required	JOL
January 2017								
Red-bellied Black Snake	*Pseudechis porphyriacus*	1	23/01/2017	Observation only	Upper Warrell Creek	1km south of CH48100	Observed Swimming in Upper Warrell Creek during Microbat Roost Box Monitoring event	JOL
Green Tree Snake	*Dendrelaphis punctulatus*	1	23/01/2017	Relocated unharmed	Rosewood Road Bridge abutment	45280	Captured from bag of rio bar at the bridge abutment	JOL
February 2017								
Carpet Python	*Morelia spilota*	1	13/02/2017	Captured from within tracks of excavator. Released unharmed	Brown's Crossing Road	41950	Spotter observed the snake when clearing lantana and topsoil	JOL

Common name	Scientific Name	Number of Individuals	Date	Fate	Location	Chainage	Comments	Observer
March 2017								
Striped Marsh Frog	*Limnodynastes peronii*	1	23/032017	Relocated outside of work zone	Upper Warrell Creek	42700	Found during GBF surveys	GS
April 2017								
No records April 2017								
May 2017								
Golden Crowned Snake (juvenile)	*Cacophis squamulosus*	1	03/05/2017	Captured and relocated off-site unharmed (Brown's Crossing Rd)	Upper Warrell Creek	42600	AFJV staff managed this relocation	AFJV
Pink-tounged Skink	*Cyclodomorphus gerrardii*	1	17/05/2017	Found with an injury likely due to car impact. Taken to vet for assessment.	Mattick Road overpass	54550	AFJV staff took animal to the vet	AFJV
June 2017								
No fauna records for June 2017								
July 2017								
Australian Magpie	*Cracticus tibicen*	1	05/07/2017	Euthanised by vet	North compound carpark	54100	Taken to the vet for assessment by Pacifico Environmental Coordinator. The animal was reported to have a skin infection around the head and difficulty flying the vet deemed the bird not suitable for rehabilitation and was euthanised	JH
August 2017								
No fauna records for August 2017								
September 2017								
Echidna	*Tachyglossus aculeatus*	1	05/09/2017	Captured and relocated unharmed	Fill 3 - Southern Zone		The Echidna was caught underneath the fauna fence	AD
October 2017								
No fauna records for October 2017								
November 2017								

No fauna records for October 2017								
December 2017								
No fauna records for December 2017								
January 2017								
No fauna records for January 2017								
February 2017								
No fauna records for February 2017								
March 2017								
No fauna records for March 2017								
During Years 1 and 2 fauna encountered during ecological monitoring was occasionally included within the fauna register. For the Year 3 reporting period only, fauna encountered on-site by observations, capture relocations or injured fauna was recorded.								

Table A2 WC2NH Hollow Bearing Tree Register March 2015 to March 2018

Ref	Easting	Northing	Location	Species	Surrounding Vegetation	Habitat Type	Dead or Alive	DBH (cm)	Tree Height (m)	Date Felled	Actual Functional Hollows (Predicted)	Trunk - Small (<5cm)	Trunk - Medium (5-15cm)	Trunk - Large (>15cm)	Limb - Small (<5cm)	Limb - Medium (5-15cm)	Limb - Large (>15cm)	Fissure - Small (<5cm)	Fissure - Medium (5-15cm)	Fissure - Large (>15cm)	Base - Small (<5cm)	Base - Medium (5-15cm)	Base - Large (>15cm)
G10	495998	6608055	58300-58000	Stag	Blackbutt dry open forest	Hollow-bearing tree	Dead	90	16	26/03/2015		0	1	0	2	0	0						
G11	495997	6608097	58300-58000	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	80	14	27/03/2015		0	0	0	0	0	0						
G12	495955	6608064	58300-58000	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	110	15	27/03/2015		0	0	0	3	0	0						
G13	495995	6608026	58300-58000	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	110	16	27/03/2015		0	0	0	0	0	0						
G14	495987	6608094	58300-58000	White Mahogany	Blackbutt dry open forest	Hollow-bearing tree	Alive	80	14	27/03/2015		0	0	0	2	0	0						
G15	495961	6607980	58300-58000	Tallowwood	Blackbutt dry open forest	Hollow-bearing tree	Alive	80	14	27/03/2015		0	1	4	2	3	1					1	1
G16	496044	6608102	58300-58000	Stag	Blackbutt dry open forest	Hollow-bearing tree	Dead	40	10	30/03/2015		0	0	0	0	0	0						
G17	496056	6608091	58300-58000	Stag	Blackbutt dry open forest	Hollow-bearing tree	Dead	80	14	30/03/2015		4	3	2	0	3	0						
G18	496181	6608281	58570-58700	Turpentine	Blackbutt dry open forest	Hollow-bearing tree	Alive	50	12	9/04/2015		0	2	0	4	0	0			1			
G19	492427	6599830	49100	Red Ash	Moist Open Forest- White mahogany/ Grey Gum	Bird habitat	Alive	40	15	13/04/2015		0	0	0	0	0	0						
G2	495126	6606610	57000-57500	Mahogany	Blackbutt dry open forest	Hollow-bearing tree	Alive	50	10	13/03/2015		2	0	0	0	1	0						
G20	496429	6608592	58950-59100	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	120	24	11/04/2015		0	0	0	0	0	0						
G21	496393	6608612	58950-59100	Tallowwood	Blackbutt dry open forest	Hollow-bearing tree	Alive	80	12	11/04/2015		0	0	0	0	0	0						
G22	496239	6608302	58950-59100	White Mahogany	Blackbutt dry open forest	Hollow-bearing tree	Alive	50	10	11/04/2015		0	0	2	1	3	6						
G23	492400	6600025	49300	Tallowwood	Paddock trees, farmland	Hollow-bearing tree	Alive	130	22	9/04/2015		0	0	5	4	0	0						
G24	492351	6600069	49300	Grey Gum	Paddock trees, farmland	Hollow-bearing tree	Alive	230	30	9/04/2015		0	0	1	2	0	0						
G25	492404	6599119	48280-49000	Tallowwood	Moist Open Forest- White Mahogany Grey Gum	Hollow-bearing tree	Alive	60	16	14/04/2015		0	0	0	0	0	0						
G26	492402	6599173	48280-49000	Tallowwood	Moist Open Forest- White mahogany/ Grey Gum	Hollow-bearing tree	Alive	80	18	14/04/2015		2	0	1	4	0	0						

Ref	Easting	Northing	Location	Species	Surrounding Vegetation	Habitat Type	Dead or Alive	DBH (cm)	Tree Height (m)	Date Felled	Actual Functional Hollows (Predicted)	Trunk - Small (<5cm)	Trunk - Medium (5-15cm)	Trunk - Large (>15cm)	Limb - Small (<5cm)	Limb - Medium (5-15cm)	Limb - Large (>15cm)	Fissure - Small (<5cm)	Fissure - Medium (5-15cm)	Fissure - Large (>15cm)	Base - Small (<5cm)	Base - Medium (5-15cm)	Base - Large (>15cm)
G27	497194	6610135	60900-60600	Stag	Blackbutt dry open forest	Hollow-bearing tree	Dead	72	14	17/04/2015		0	0	2	5	4	0						
G27a	497213	6610163	60900-60600	Tallowwood	Blackbutt dry open forest	Hollow-bearing tree	Alive	80	16	17/04/2015		0	0	0	0	0	0						
G28	489468	6594427	42700-42750	Blackbutt	Moist Open Forest-Flooded Gum	Hollow-bearing tree	Alive	70	15	23/04/2015		0	0	0	0	2	0						
G29	497190	6610020	60300-60600	Blackbutt	Blackbutt dry open forest	Potential hollow-bearing tree	Alive	80	16	29/04/2015		0	0	0	0	0	0						
G3	495067	6606410	56550-56350	Blackbutt	Paddock trees, farmland	Hollow-bearing tree	Alive	130	25	19/03/2015		0	0	0	0	0	0						
G30	489961	6595160	43350-45300	Stag	Moist Open Forest-Flooded Gum	Hollow-bearing tree	Dead	70	22	13/05/2015		0	3	0	4	5	0						
G31	490130	6595312	43350-45300	Turpentine	Moist Open Forest-Flooded Gum	bird habitat	Alive	12	30	13/05/2015		0	0	0	0	0	0						
G32	490152	6595348	43350-45300	Tallowwood	Moist Open Forest-Flooded Gum	Hollow-bearing tree	Alive	15	30	20/05/2015		0	0	0	2	0	0						
G33	494901	6606330	55900-56400	Bloodwood	Moist Open Forest-Flooded Gum	bird habitat	Alive	15	40	3/06/2015		0	0	0	0	0	0						
G34	494908	6606308	56100-56400	Bloodwood	Moist Open Forest-Flooded Gum	Hollow-bearing tree	Alive	65	18	10/06/2015		0	0	0	1	2	0					1	
G35	494892	6606332	56100-56400	Bloodwood	Moist Open Forest-Flooded Gum	Hollow-bearing tree	Alive	70	22	10/06/2015		0	0	0	0	2	0						
G36	495024	6606356	56100-56400	Tallowwood	Moist Open Forest-Flooded Gum	Hollow-bearing tree	Alive	45	12	11/06/2015		0	0	0	0	4	0						
G37	494945	6606330	56100-56400	Blackbutt	Moist Open Forest-Flooded Gum	Hollow-bearing tree	Alive	50	12	11/06/2015		0	0	0	0	2	0						
G38	494952	6606346	56100-56400	Bloodwood	Moist Open Forest-Flooded Gum	Hollow-bearing tree	Alive	90	18	11/06/2015		0	0	0	0	3	0						
G39	494964	6606382	56100-56400	Blackbutt	Moist Open Forest-Flooded Gum	Hollow-bearing tree	Alive	100	18	11/06/2015		0	0	0	0	2	0						
G4	495059	6606380	56550-56350	Blackbutt	Paddock trees, farmland	Hollow-bearing tree	Alive	90	18	19/03/2015		2	0	0	0	0	0						
G40	494994	6606408	56100-56400	Paperbark	Blackbutt dry open forest	Hollow-bearing tree	Alive	140	25	11/06/2015		0	0	0	0	1	0						
G41	495000	6606430	56100-56400	Bloodwood	Blackbutt dry open forest	Hollow-bearing tree	Alive	80	16	11/06/2015		0	0	3	4	1	0						1
G42	495007	6606437	56100-56400	Bloodwood	Blackbutt dry open forest	Hollow-bearing tree	Alive	60	12	11/06/2015		0	0	0	0	0	0						

Ref	Easting	Northing	Location	Species	Surrounding Vegetation	Habitat Type	Dead or Alive	DBH (cm)	Tree Height (m)	Date Felled	Actual Functional Hollows (Predicted)	Trunk - Small (<5cm)	Trunk - Medium (5-15cm)	Trunk - Large (>15cm)	Limb - Small (<5cm)	Limb - Medium (5-15cm)	Limb - Large (>15cm)	Fissure - Small (<5cm)	Fissure - Medium (5-15cm)	Fissure - Large (>15cm)	Base - Small (<5cm)	Base - Medium (5-15cm)	Base - Large (>15cm)
G43	495031	6606453	56980-57900	Paperbark	Blackbutt dry open forest	Hollow-bearing tree	Alive	45	12	16/06/2015		0	0	0	0	0	0						
G44	495058	6606488	56980-57900	Turpentine	Blackbutt dry open forest	Hollow-bearing tree	Alive	50	10	16/06/2015		2	0	0	0	0	0						
G45	495074	6606525	56980-57900	Bloodwood	Blackbutt dry open forest	Hollow-bearing tree	Alive	90	17	16/06/2015		3	0	0	3	0	0						
G46	495560	6607360	57100-57500	Stag	Blackbutt dry open forest	Hollow-bearing tree	Dead	60	15	18/06/2015		0	2	0	3	0	0						
G47	495614	6607515	57450-57800	Stag	Blackbutt dry open forest	Hollow-bearing tree	Dead	95	20	22/06/2015		0	2	0	4	0	0						
G48	496540	6608919	58700-59450	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	90	25	29/06/2015		2	1	0	3	0	0						
G49	496182	6608285	57900 - 58500	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	120	25	29/06/2015		3	0	0	0	0	0						
G5	491620	6598053	47050	Paperbark	Moist Open Forest- White mahogany /Grey Gum	Hollow-bearing tree	Alive	110	15	30/03/2015		0	0	4	0	0	0						
G50	496296	6608415	58400 - 58800	Mahogany	Blackbutt dry open forest	Hollow-bearing tree	Alive	140	25	2/07/2015		0	2	0	0	0	0						
G51	496216	6608375	58600 - 58900	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	80	16	1/07/2015		0	0	0	3	1	0						
G52	496234	6608375	58600 - 58900	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	70	22	1/07/2015		1	0	0	0	1	0						
G53	496259	6608375	58600 - 58900	Mahogany	Blackbutt dry open forest	Hollow-bearing tree	Alive	45	12	1/07/2015		1	0	0	0	1	0						1
G54	496310	6608403	58600 - 58900	Mahogany	Blackbutt dry open forest	Hollow-bearing tree	Alive	50	12	1/07/2015		1	0	0	0	0	0						
G55	496325	6608435	58600 - 58900	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	90	18	1/07/2015		1	2	0	0	0	0						
G56	496523	6609033	59000 - 59450	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	120	25	10/07/2015		1	0	0	1	0	0						
G57	496521	6609077	59000 - 59450	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	60	12	10/07/2015		1	2	0	1	0	0						
G58	496524	6609105	59000 - 59450	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	100	18	10/07/2015		2	0	0	0	0	0						
G59	497190	6610030	60400 - 60600	Stag	Blackbutt dry open forest	Hollow-bearing tree	Alive	120	22	20/07/2015		0	0	0	2	0	0						
G6	492085	6598703	47800	Stag	Moist Open Forest- White mahogany /Grey Gum	Hollow-bearing tree	Dead	50	14	7/04/2015		0	2	0	4	0	0						

Ref	Easting	Northing	Location	Species	Surrounding Vegetation	Habitat Type	Dead or Alive	DBH (cm)	Tree Height (m)	Date Felled	Actual Functional Hollows (Predicted)	Trunk - Small (<5cm)	Trunk - Medium (5-15cm)	Trunk - Large (>15cm)	Limb - Small (<5cm)	Limb - Medium (5-15cm)	Limb - Large (>15cm)	Fissure - Small (<5cm)	Fissure - Medium (5-15cm)	Fissure - Large (>15cm)	Base - Small (<5cm)	Base - Medium (5-15cm)	Base - Large (>15cm)
G60	497382	6610405	60900 - 61250	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	100	18	27/07/2015		1	0	1	1	0	0						
G61	497396	6610456	60900 - 61250	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	120	22	27/07/2015		1	0	0	0	0	0						
G62	497421	6610547	60900 - 61250	Casuarina	Blackbutt dry open forest	Hollow-bearing tree	Alive	155	18	27/07/2015		1	0	0	1	0	0						
G63	497456	6610607	60900 - 61250	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	80	22	27/07/2015		1	0	0	2	0	0						
G64	490673	6596062	Rose Wood Ck	*Ficus* sp.	Paddock	Hollow-bearing tree	Alive	20	12	3/08/2015		2	0	0	0	1	0						
G65	497388	6610414	60951 - 61280	Blackbutt	Open Forest-Blackbutt	Hollow-bearing tree	Alive	120	25	23/07/2015		0	0	0	2	2	0						
G66	497367	6610376	60950 - 61280	Blackbutt	Open Forest-Blackbutt	Hollow-bearing tree	Alive	60	12	23/07/2015		0	0	0	2	0	0						
G67	494370	6604038	53250 - 54300	Blackbutt	Moist Open Forest-White Mahogany	Hollow-bearing tree	Alive	100	18	5/08/2015		0	0	0	1	0	0						
G68	494375	6604033	53250 - 54300	Blackbutt	Moist Open Forest-White Mahogany	Hollow-bearing tree	Alive	120	22	5/08/2015		0	1	0	0	0	0						
G69	494272	6603655	53250 - 54300	Stag	Moist Open Forest-White Mahogany	Hollow-bearing tree	Dead	155	18	5/08/2015		0	0	0	1	0	0						
G7	495890	6607913	58300-58000	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	80	18	25/03/2015		0	1	0	0	0	0			1			
G70	494270	6603667	53250 - 54300	Blackbutt	Moist Open Forest-White Mahogany	Hollow-bearing tree	Alive	120	22	5/08/2015		0	1	0	0	0	0						
G71	494282	6603665	53250 - 54300	Blackbutt	Moist Open Forest-White Mahogany	Hollow-bearing tree	Alive	55	18	5/08/2015		0	1	0	1	0	0						
G72	494282	6603654	53250 - 54300	Stag	Moist Open Forest-White Mahogany	Hollow-bearing tree	Dead	135	20	5/08/2015		0	1	0	0	0	0						
G73	497119	6610042	Oc17	Blackbutt	Open Forest-Blackbutt	Potential hollow-bearing tree	Alive	120	20	7/10/2015		0	0	0	0	0	0						
G74	492086	6598490	Cut 10	*Ficus* sp.	Paddock, Quarry	Potential hollow-bearing tree	Alive	250	12	28/10/2015		0	0	0	0	0	0						
G82	497271	6610278	OC19	Blackbutt	Open Forest-Blackbutt	Potential hollow-bearing tree	Alive	105	20	18/02/2016		0	0	0	0	0	0						
G75	489570	6594557	42750-42850	Flooded Gum	Moist Open Forest-Flooded Gum	Hollow-bearing tree	Alive	65	12	12/05/2015		0	0	0	0	2	0						
G76	497275	6610275	OC19	Blackbutt	Open Forest-Blackbutt	Potential hollow-bearing tree	Alive	140	25	18/02/2016		0	0	0	0	0	0						

Ref	Easting	Northing	Location	Species	Surrounding Vegetation	Habitat Type	Dead or Alive	DBH (cm)	Tree Height (m)	Date Felled	Actual Functional Hollows (Predicted)	Trunk - Small (<5cm)	Trunk - Medium (5-15cm)	Trunk - Large (>15cm)	Limb - Small (<5cm)	Limb - Medium (5-15cm)	Limb - Large (>15cm)	Fissure - Small (<5cm)	Fissure - Medium (5-15cm)	Fissure - Large (>15cm)	Base - Small (<5cm)	Base - Medium (5-15cm)	Base - Large (>15cm)
G77	497167	6610233	OcC18	Stag	Open Forest-Blackbutt	Potential hollow-bearing tree	Dead	80	16	18/02/2016		0	0	0	0	0	0						
G78	497453	6610261	Top of OCR	Bloodwood	Open Forest-Blackbutt	Hollow-bearing tree	Alive	70	22	29/02/2016		0	2	0	1	2	2						
G79	497465	6610258	Top of OCR	Stag	Open Forest-Blackbutt	Hollow-bearing tree	Dead	45	12	29/02/2016		0	0	0	1	0	0						
G8	495919	6607947	58300-58000	Tallowwood	Blackbutt dry open forest	Potential hollow-bearing tree	Alive	50	12	25/06/2015		0	0	0	0	0	0						
G80	497520	6610273	Top of OCR	Stag	Open Forest-Blackbutt	Potential hollow-bearing tree	Dead	50	12	29/02/2016		0	0	0	2	0	0						
G81	490852	6596754	Stoney Ck	Blue Gum	Cleared creek line	Potential hollow-bearing tree	Alive	90	18	8/03/2016		0	0	0	0	0	0						
G9	495939	6607980	58300-58000	Stag	Blackbutt dry open forest	Potential hollow-bearing tree	Dead	130	18	26/03/2015		0	0	0	0	0	0						
H100	497311	6610242	North OCR	Stag	Blackbutt dry open forest	Hollow-bearing tree	Dead	80	16	28/07/2015		0	1	0	1	0	0						
H101	497405	6610271	60890	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	115	24	15/04/2015		0	0	0	3	1	0						
H102	497447	6610424	60900 - 61250	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	110	26	3/07/2015		0	0	0	2	0	0						
H103	497460	6610464	60900 - 61250	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	100	18	27/07/2015		2	1	0	1	0	0						
H104	497501	6610514	60900 - 61250	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	140	25	27/07/2015		0	2	0	0	0	0						
H105	497364	6610342	60900 - 61250	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	105	20	3/07/2015		0	2	0	0	0	0						
H16	490697	6596192	Rose Wood Ck	Flooded gum	Camphor Laurel Forest	Hollow-bearing tree	Alive	90	25	3/08/2015		2	0	0	0	2	0						
H18	491110	6597352	46200 Albert Drv	Stag	Cleared pasture land	Hollow-bearing tree	Dead	120	22	8/03/2016		0	0	0	5	3	0						
H19	491122	6597339	46200 Albert Drv	Blackbutt	Cleared pasture land	Hollow-bearing tree	Alive	120	24	8/03/2016		0	0	0	3	0	0						
H2	489482	6594420	42700-42750	Stag	Moist Open Forest-Flooded Gum	Hollow-bearing tree	Alive	130	10	23/04/2015		0	0	0	0	2	0						
H20	491126	6597338	46200 Albert Drv	Blackbutt	Cleared pasture land	Hollow-bearing tree	Alive	130	17	8/03/2016		0	1	0	2	1	0						

Ref	Easting	Northing	Location	Species	Surrounding Vegetation	Habitat Type	Dead or Alive	DBH (cm)	Tree Height (m)	Date Felled	Actual Functional Hollows (Predicted)	Trunk - Small (<5cm)	Trunk - Medium (5-15cm)	Trunk - Large (>15cm)	Limb - Small (<5cm)	Limb - Medium (5-15cm)	Limb - Large (>15cm)	Fissure - Small (<5cm)	Fissure - Medium (5-15cm)	Fissure - Large (>15cm)	Base - Small (<5cm)	Base - Medium (5-15cm)	Base - Large (>15cm)
H21	491129	6597345	46200 Albert Drv	Blackbutt	Cleared pasture land	Hollow-bearing tree	Alive	120	22	8/03/2016		0	0	0	3	2	1						
H22	491142	6597345	46200 Albert Drv	Stag	Cleared pasture land	Hollow-bearing tree	Dead	60	24	8/03/2016		0	0	0	3	2	0						
H23	491147	6597334	46200 Albert Drv	Blackbutt	Cleared pasture land	Hollow-bearing tree	Alive	170	20	8/03/2016		0	1	1	3	2	0		1				
H24	492347	6600078	49300	Blackbutt	Paddock trees, farmland	Hollow-bearing tree	Alive	70	20	9/04/2015		6	0	2	2	0	0						
H25	491148	6597340	46200 Albert Drv	Blackbutt	Cleared pasture land	Hollow-bearing tree	Alive	120	22	9/03/2016		0	0	0	5	5	2						
H26	491160	6597334	46000-46880	White Mahogany	Paddock trees, farmland	Hollow-bearing tree	Alive	70	18	24/03/2015		0	1	0	0	0	0						
H27	491163	6597337	46150	Tallowwood	Paddock trees, farmland	Hollow-bearing tree	Alive	90	22	19/03/2015		0	0	1	0	0	0						
H28	491173	6597334	46200 Albert Drv	Blackbutt	Cleared pasture land	Hollow-bearing tree	Alive	140	20	9/03/2016		0	0	2	3	0	0						
H29	491197	6597332	46200 Albert Drv	Blackbutt	Cleared pasture land	Hollow-bearing tree	Alive	100	19	9/03/2016		0	0	0	3	3	0						
H3	489589	6594531	43150-42850	Stag	Hardwood plantation	Hollow-bearing tree	Dead	230	30	16/03/2015		0	10	0	0	0	0						
H30	491219	6597329	46200 Albert Drv	Blackbutt	Cleared pasture land	Hollow-bearing tree	Alive	120	24	9/03/2016		0	0	0	2	1	0						
H32	492100	6598598	48150-47050	White Mahogany	Moist Open Forest- White mahogany /Grey Gum	Hollow-bearing tree	Alive	60	12	1/04/2015		0	0	0	2	4	0						
H33	496182	6608280	56600-57000	Bloodwood	Blackbutt dry open forest	Potential hollow-bearing tree	Alive	80	22	8/05/2015		0	0	0	0	0	0						
H34	492320	6599039	48280-47000	Tallowwood	Moist Open Forest- Flooded Gum	Hollow-bearing tree	Alive	95	16	17/04/2015		0	0	0	0	0	0						
H35	492302	6599044	48280-47000	Tallowwood	Moist Open Forest- Flooded Gum	Hollow-bearing tree	Alive	60	17	17/04/2015		0	0	0	0	0	0						
H36	492309	6599063	48280-47000	Mahogany	Moist Open Forest- Flooded Gum	Hollow-bearing tree	Alive	100	18	17/04/2015		4	2	0	5	7	0						
H37	492462	6599311	48280-49000	Grey Ironbark	Moist Open Forest- White mahogany /Grey Gum	Hollow-bearing tree	Alive	75	14	16/04/2015		0	0	2	2	0	0						
H38	492470	6599294	56980-57900	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	115	22	16/06/2015		2	0	0	0	0	0						
H39	492508	6599449	56980-57900	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	135	20	16/06/2015		4	0	1	1	0	1						

Ref	Easting	Northing	Location	Species	Surrounding Vegetation	Habitat Type	Dead or Alive	DBH (cm)	Tree Height (m)	Date Felled	Actual Functional Hollows (Predicted)	Trunk - Small (<5cm)	Trunk - Medium (5-15cm)	Trunk - Large (>15cm)	Limb - Small (<5cm)	Limb - Medium (5-15cm)	Limb - Large (>15cm)	Fissure - Small (<5cm)	Fissure - Medium (5-15cm)	Fissure - Large (>15cm)	Base - Small (<5cm)	Base - Medium (5-15cm)	Base - Large (>15cm)
H40	492419	6600018	49300	Flooded Gum	Paddock trees, farmland	Hollow-bearing tree	Alive	55	22	9/04/2015		0	0	3	3	0	0						
H41	492429	6600010	49300	Flooded Gum	Paddock trees, farmland	Hollow-bearing tree	Alive	80	18	9/04/2015		0	0	4	1	0	0						
H42	492348	6600079	56980-57900	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	150	8	16/06/2015		2	0	0	0	0	0						
H43	495410	6607047	56980-57900	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	40	14	16/06/2015		2	0	0	1	0	0						
H44	495406	6607054	56980-57900	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	200	19	16/06/2015		3	0	1	2	0	1						
H45	495410	6607049	56980-57900	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	60	17	16/06/2015		2	0	0	0	0	0						
H46	495388	6607014	56980-57900	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	110	18	16/06/2015		2	0	0	0	3	0						
H531	494424	6605254	54550-55400	Blackbutt	Moist Open Forest-Flooded Gum	Hollow-bearing tree	Alive	90	18	29/05/2015		0	5	0	0	0	0						
H533	494431	6605290	55500	Stag	Blackbutt dry open forest	Hollow-bearing tree	Dead	70	16	2/03/2015		1	0	0	3	0	0						
H55	495392	6607100	57100-57500	Blackbutt	Blackbutt dry open forest	Potential hollow-bearing tree	Alive	85	22	18/06/2015		0	0	0	0	0	0						
H56	495395	6607106	57100-57500	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	110	22	18/06/2015		0	0	1	3	1	0						
H57	495600	6607465	57100-57500	Stag	Blackbutt dry open forest	Hollow-bearing tree	Dead	110	20	18/06/2015		1	0	0	3	1	2		2				
H58	495614	6607505	57100-57500	Stag	Blackbutt dry open forest	Hollow-bearing tree	Dead	80	14	18/06/2015		1	1	0	2	0	0		3				
H62	496179	6608282	58570-58700	Brush Box	Blackbutt dry open forest	Hollow-bearing tree	Alive	40	16	9/04/2015		0	0	0	0	0	0						
H63	496195	6608316	58400 - 58800	Stag	Blackbutt dry open forest	Hollow-bearing tree	Alive	100	12	2/07/2015		0	1	0	3	0	0						
H66	496543	6608949	59300	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	120	28	8/04/2015		1	4	0	6	2	0						
H67	496540	6608909	59300	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	125	28	8/04/2015		1	0	0	1	0	0						
H73	496600	6609419	59750-60050	Red Mahogany	Moist Open Forest-Flooded Gum	Potential hollow-bearing tree	Alive	120	22	8/05/2015		0	0	0	0	0	0						
H74	496668	6609455	496668-6609455	Flooded Gum	Moist Open Forest-Flooded Gum	Hollow-bearing tree	Alive	120	26	1/05/2015		0	0	0	3	3	0						

Ref	Easting	Northing	Location	Species	Surrounding Vegetation	Habitat Type	Dead or Alive	DBH (cm)	Tree Height (m)	Date Felled	Actual Functional Hollows (Predicted)	Trunk - Small (<5cm)	Trunk - Medium (5-15cm)	Trunk - Large (>15cm)	Limb - Small (<5cm)	Limb - Medium (5-15cm)	Limb - Large (>15cm)	Fissure - Small (<5cm)	Fissure - Medium (5-15cm)	Fissure - Large (>15cm)	Base - Small (<5cm)	Base - Medium (5-15cm)	Base - Large (>15cm)
H75	496647	6609457	496646-6609457	Flooded gum	Moist Open Forest- Flooded Gum	Hollow-bearing tree	Alive	12	20	13/07/2015		3	0	0	0	0	0						
H76	496740	6609603	59650 - 60200	Blackbutt	Moist Open Forest- Flooded Gum	Potential hollow-bearing tree	Alive	85	24	15/07/2015		0	0	0	0	0	0						
H77	496709	6609634	59650 - 60200	Blackbutt	Moist Open Forest- Flooded Gum	Potential hollow-bearing tree	Alive	100	26	15/07/2015		0	0	0	0	0	0						
H79	496664	6609613	59650 - 60200	Blackbutt	Moist Open Forest- Flooded Gum	Potential hollow-bearing tree	Alive	120	28	15/07/2015		0	0	0	0	0	0						
H80	496730	6609731	60080	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	130	24	14/05/2015		0	0	3	0	2	0						
H86	496954	6609900	60300 - 60950	Stag	Blackbutt dry open forest	Hollow-bearing tree	Dead	100	26	16/07/2015		1	0	0	0	2	0						
H88	496954	6609900	48280-49000	Blackbutt	Moist Open Forest- White mahogany /Grey Gum	Hollow-bearing tree	Alive	120	26	15/04/2015		0	0	1	3	0	0						
H89	497091	6609977	60400-60500	White Mahogany	Blackbutt dry open forest	Hollow-bearing tree	Alive	40	16	27/04/2015		2	1	1	0	2	0						
H90	497128	6609976	60300 - 60950	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	120	26	16/07/2015		2	0	0	0	1	0						
H91	497082	6609969	60300 - 60950	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	120	26	16/07/2015		1	0	0	0	1	0						
H92	497002	6610015	60300 - 60950	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	105	20	16/07/2015		2	0	0	0	1	2						
H93	497002	6610010	60400 - 60600	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	140	25	20/07/2015		0	0	0	2	0	0						
H95	497154	6610100	North OCR	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	90	18	28/07/2015		0	0	1	1	0	0						
H96	497230	6610193	60750-60800	Stag	Blackbutt dry open forest	Hollow-bearing tree	Dead	120	28	9/03/2015		0	0	0	0	0	0						
H97	497274	6610215	North OCR	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	45	12	28/07/2015		0	1	0	1	0	0						
H98	497279	6610216	North OCR	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	50	12	28/07/2015		0	1	0	1	0	0						
H99	497264	6610227	North OCR	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	70	22	28/07/2015		0	1	0	1	0	0						
HB1	494348	6603808	53400 - 54100	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	100	35	24/10/2015		0	1	0	1	2	0						
HB10	494360	6604054	53400 - 54100	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	110	28	25/10/2015		0	0	0	0	1	0						1

Ref	Easting	Northing	Location	Species	Surrounding Vegetation	Habitat Type	Dead or Alive	DBH (cm)	Tree Height (m)	Date Felled	Actual Functional Hollows (Predicted)	Trunk - Small (<5cm)	Trunk - Medium (5-15cm)	Trunk - Large (>15cm)	Limb - Small (<5cm)	Limb - Medium (5-15cm)	Limb - Large (>15cm)	Fissure - Small (<5cm)	Fissure - Medium (5-15cm)	Fissure - Large (>15cm)	Base - Small (<5cm)	Base - Medium (5-15cm)	Base - Large (>15cm)
HB11	494348	6604083	53400 - 54100	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	120	35	25/10/2015		0	1	0	0	0	0						
HB12	494336	6604082	53400 - 54100	Tallowwood	Blackbutt dry open forest	Hollow-bearing tree	Alive	115	30	25/10/2015		1	0	0	2	0	0						
HB13	494353	6604098	53400 - 54100	Tallowwood	Blackbutt dry open forest	Hollow-bearing tree	Alive	70	22	25/10/2015		0	0	0	2	3	0					1	
HB14	494354	6604108	53400 - 54100	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	100	30	25/10/2015		1	0	0	0	1	0						
HB15	494346	6604117	53400 - 54100	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	90	25	25/10/2015		1	0	0	0	0	0						1
HB16	494361	6604206	53400 - 54100	Grey Gum	Blackbutt dry open forest	Hollow-bearing tree	Alive	45	20	25/10/2015		0	1	0	0	0	0						
HB17	494342	6604147	53400 - 54100	Grey Gum	Blackbutt dry open forest	Hollow-bearing tree	Alive	80	25	25/10/2015		0	1	0	0	0	0						1
HB18	494344	6604151	53400 - 54100	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	100	30	25/10/2015		1	0	0	1	1	0						
HB2	494341	6603822	53400 - 54100	-	Blackbutt dry open forest	Hollow-bearing tree	Alive	80	28	24/10/2015		1	0	0	1	0	0				1		
HB3	494339	6603845	53400 - 54100	-	Blackbutt dry open forest	Hollow-bearing tree	Alive	45	22	24/10/2015		0	0	0	2	2	0						
HB4	494339	6603865	53400 - 54100	-	Blackbutt dry open forest	Hollow-bearing tree	Alive	120	35	24/10/2015		2	0	0	0	0	0		1				1
HB5	494353	6604009	53400 - 54100	-	Blackbutt dry open forest	Hollow-bearing tree	Alive	115	35	24/10/2015		0	1	0	0	2	0					1	
HB6	494342	6604025	53400 - 54100	-	Blackbutt dry open forest	Hollow-bearing tree	Alive	80	25	24/10/2015		1	0	0	2	0	0						
HB7	494345	6604032	53400 - 54100	-	Blackbutt dry open forest	Hollow-bearing tree	Alive	70	20	24/10/2015		0	0	0	0	1	0			1		1	
HB8	494356	6604032	53400 - 54100	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	110	32	24/10/2015		0	2	0	0	0	0						
HB9	494373	6604033	53400 - 54100	Stag	Blackbutt dry open forest	Hollow-bearing tree	Alive	85	28	24/10/2015		1	0	0	1	1	0						
G83	494277	6603403	53150	Tallowwood	Planted trees along property access	Hollow-bearing tree	Alive	130	25	31/11/2016		1	1										
H78	496702	6609613	60000	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	90	35	24/10/2015						1							
G84	497533	6610238	60950	Blackbutt	Blackbutt dry open forest	Hollow-bearing tree	Alive	120	35	11/11/2016				1		1							

No habitat trees were felled during the Year 3 (2017/ 2018) reporting period. This is the complete list of habitat trees removed as part of the WC2NH project to date.

Appendix B

Flying-fox Monthly Report (January 2018)

Flying-fox Monitoring January 2018

Warrell Creek to Nambucca Heads Pacific Highway Upgrade

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Lennox Head NSW 2478
T 02 6687 7666

PO Box 1446
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Prepared for: Roads and Maritime Services

UPR	*Description*	*Date Issued*	*Issued By*
2692-1077	First issue	08/02/2018	David Andrighetto

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1. Introduction

1.1 Introduction

NSW Roads and Maritime Services have been monitoring a Grey-headed Flying-fox (*Pteropus poliocephalus*) (GHFF) camp that was intermittently present within the approved alignment of the Warrell Creek to Nambucca Heads (WC2NH) Pacific Highway upgrade project near Macksville. The camp is located in a patch of swamp sclerophyll forest north of Bald Hill Road (henceforth referred to as 'the site').

GeoLINK has undertaken monitoring at the site on at least a monthly basis since July 2013. Prior to this, irregular monitoring of flying-foxes at the site has been undertaken since the initial establishment of the camp in December 2011 (Eby 2012).

This report details the January 2018 flying-fox monitoring results.

2. Flying-fox Survey

2.1 Methodology

The following GeoLINK personnel undertook fieldwork for the January 2018 flying-fox monitoring:

- Tom Pollard (ecologist).
- Dylan Hisselli (environmental scientist/ ecologist).
- Jeremy Clifford (environmental scientist).
- Kale Hardie-Porter (environmental scientist).

Fieldwork followed the methodology developed by Dr Eby for the project. Refer to Eby (2013) for full details of the methodology. A summary of the main procedures used for the monitoring is provided below.

The fieldwork was undertaken on 24 January 2018. The presence of flying-foxes at the site was assessed by undertaking a traverse of the area previously known to support flying-foxes in conjunction with a few sharp handclaps aimed at eliciting a vocal response from any flying-foxes roosting at the site.

When flying-foxes are present at the site, the following data is collected:

- The area of the roost footprint (mapped by GPS).
- Species composition.
- Demographics.
- Reproductive status.
- Behaviour.

When the site is unoccupied and flying-foxes are present at the nearby seasonally-occupied flying-fox camp within two kilometres of the site adjacent to Macksville Cemetery, the above-mentioned data is collected here instead. This data provides relevant information on the status of flying-foxes that are camped in the Macksville area.

The water level at the site was measured at GPS location 492866, 6600756 (UTM coordinates, GDA 94, Zone 56). The water level at this location is representative of the average level at the site and is tracked over time to provide information on water level fluctuations that occur at the site.

A dusk exit count survey was undertaken at both the site and the Macksville Cemetery camp to confirm the presence/ absence of flying-foxes and to provide an estimate of the current population at each camp.

Two observers were strategically located for the exit count on a northern and a southern ridge overlooking the site. Specifically, the two observers were located at the following vantage points:

- In a paddock to the north of the swamp sclerophyll forest (off Wedgewood Drive).
- On a prominent ridge to the south (at 41 Bald Hill Road).

Two observers were also located adjacent to the Macksville Cemetery camp at the following vantage points:

- At the Macksville Cemetery gate off Wallace Street (west of the camp).
- Adjacent to the Macksville Golf Course next to the Pacific Highway (east of the camp).

The exit counts extended over approximately 30 minutes from sunset until dark (approximately 7:45 pm to 8:15 pm).

Other regional flying-fox camps at Gordon Park, Nambucca Heads (approximately 12 kilometres north-east of the site), Bowraville (approximately 10.5 kilometres north-west of the site), Bellingen Wheatley Street Camp (approximately 30 kilometres north of the site) and Bellingen Island (approximately 31 kilometres north of the site) were also visited and observational comments made. Refer to **Illustration 2.1** for the location of the subject regional camps.

2.2 Results

2.2.1 Roost Footprint

No flying-foxes were recorded roosting at the site in the traverse.

Flying-foxes were observed to be roosting at the Macksville Cemetery camp. The roost extended over a comparatively large area of approximately 6.1 hectares (refer to **Illustration 2.2**).

Flying-foxes were not recorded at the Wheatley Street camp in Bellingen or at Bowraville.

Regionally, flying-foxes were observed to be roosting at Bellingen Island and Gordon Park (Nambucca Heads). The extent of the roost footprint at Bellingen Island was observed to be covering a larger area than that recorded in the previous monthly monitoring event (GeoLINK 2017), including substantial roosting in the upper canopy of the emergent fig trees within the rainforest remnant (refer to Plate 2.1). In contrast, at Gordon Park the roost extent had not changed from that recorded in the previous monitoring event.

Plate 2.1 GHFF roosting in the upper canopy of figs at Bellingen Island

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: DSA Date: 9/02/2018
Source of base data: Roads and Maritime Services

0 4 km

North

Location of Regional Flying-fox Camps

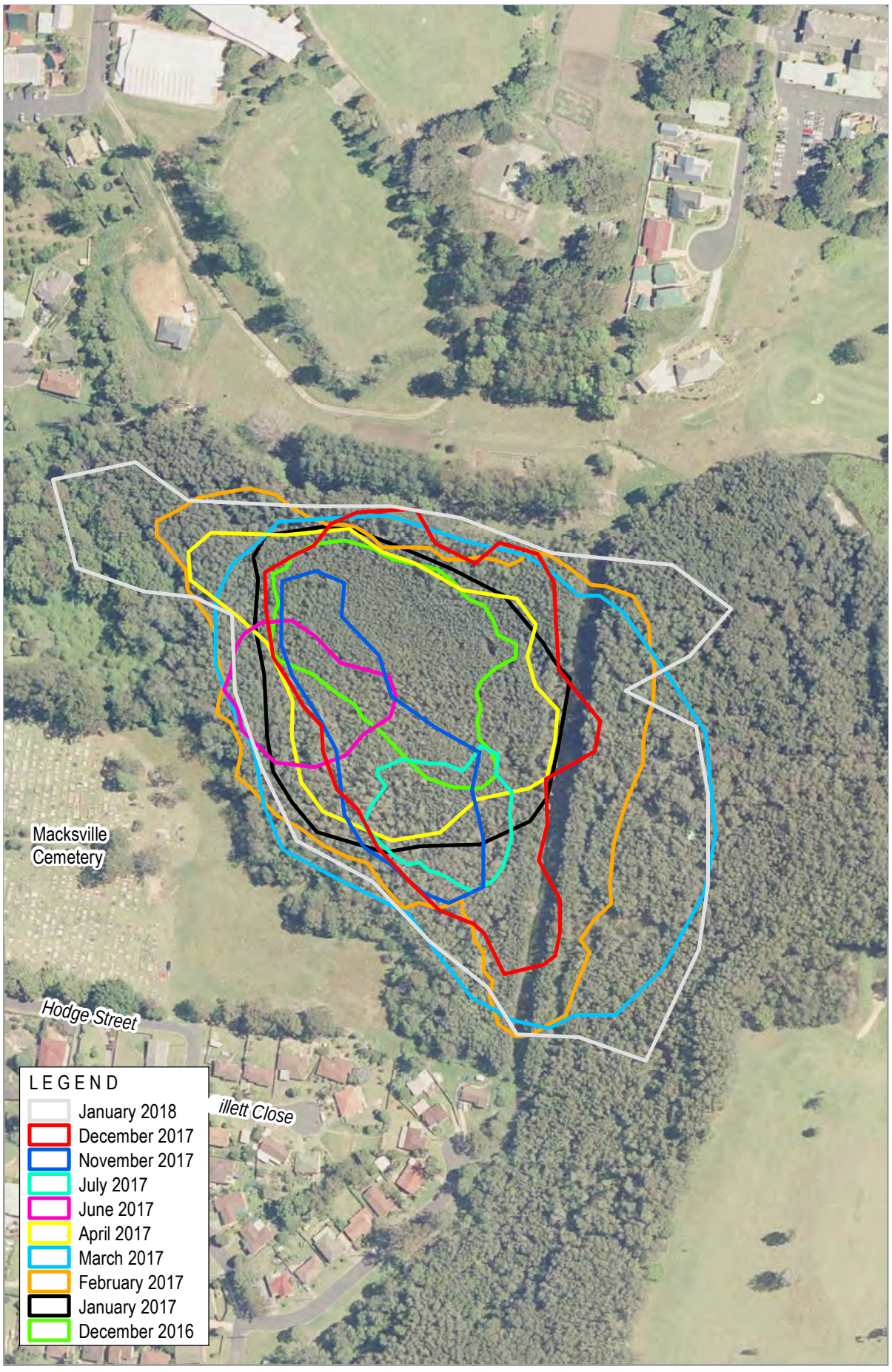
GeoLINK environmental management and design

Flying-fox Monitoring January 2018 - Warrell Creek to Nambucca Heads
Pacific Highway Upgrade
2692-1079

Illustration 2.1

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: DSA Date: 9/02/2018
Source of base data: Roads and Maritime Services



North

0 60

Macksville Cemetery Flying-fox Roost Footprint

GeoLINK environmental management and design

Flying-fox Monitoring January 2018 - Warrell Creek to Nambucca Heads
Pacific Highway Upgrade
2692-1080

Illustration 2.2

2.2.2 Population Estimates

2.2.2.1 Exit Counts

No flying-foxes were observed flying from the site during the exit count.

Approximately 50,000 individuals were recorded exiting the Macksville Cemetery camp in the exit count. The flying-foxes were exiting in two broad streams, one in a north to north-westerly direction and another in a south to south-easterly direction

2.2.2.2 Direct Counts

With the exception of the Macksville Cemetery camp, no exit counts were conducted at any of the remaining regional camps. However, rough population estimates for these camps based on extrapolation of counts in individual trees and the roost footprint are as follows:

- Gordon Park: approximately 10,000 individuals.
- Bellingen Island: approximately 30,000 individuals.
- Wheatley Street, Bellingen: no individuals recorded.
- Bowraville: no individuals recorded.

2.2.3 Detailed Data

2.2.3.1 Species Composition

The species composition and proportions observed at occupied camps were as follows:

- Macksville Cemetery: 95% GHFF and 5% Black Flying-fox.
- Bellingen Island: 95% GHFF and 5% Black Flying-fox.
- Gordon Park: 90% GHFF and 10% Black Flying-fox.

2.2.3.2 Habitat Characteristics and Demographic Composition

As flying-foxes were not recorded at the site in the current monitoring event, detailed demographic composition data was not collected. This has been the case since April 2014 (excluding a brief return in January 2015). During this period of absence the Macksville Cemetery camp has been the alternative site for collection of this data.

Both male and female GHFF were present at the Macksville Cemetery camp. The data collected indicated that the proportion of female GHFF present was high, ranging between 56% and 100% of all individuals at individual demographic point counts (83% average), (refer to **Table 2.1**). The percentage of females with dependent young GHFF at demographic point counts was moderate, ranging between 30% and 80% (55% average).

Both male and female GHFF were also present at the Bellingen Island camp. Data collected indicated that the proportion of female GHFF present was high was high, ranging between 58% and 91% of all individuals at individual demographic point counts (83% average), (refer to **Table 2.2**). The percentage of females with dependent young GHFF at demographic point counts was also generally high, ranging between 50% and 80% (70% average).

General observations of the GHFF currently roosting at the Gordon Park camp indicated that males and females were present. Dependent young were also observed with many of the females.

Table 2.1 Demographic Data of GHFF at the Macksville Cemetery Camp

Tree Code	*GPS Location (UTM coordinates GDA94, Zone 56)*	*Tree Species*	*Height (m)*	*DBH (cm)*	*Demographic Ratio (female:male)*	*Presence of Dependant Young (yes/no)*	*% Females with Dependant Young*
MC1	492036, 6601830	Broad-leaved Paperbark	15	30	10:3	Yes	60
MC2	492047, 6601840	Broad-leaved Paperbark	12	20	10:8	Yes	30
MC3	492036, 6601809	Broad-leaved Paperbark	12	30	10:2	Yes	80
MC4	492058, 6601775	Broad-leaved Paperbark	12	20	10:0	Yes	60
MC5	492080, 6601772	Broad-leaved Paperbark	15	30	10:2	Yes	50
MC6	492073, 6601735	Broad-leaved Paperbark	15	20	10:2	Yes	50
MC7	492107, 6601677	Broad-leaved Paperbark	12	20	10:0	Yes	50
MC8	492124, 6601680	Broad-leaved Paperbark	15	30	10:3	Yes	50
MC9	492117, 6601664	Broad-leaved Paperbark	12	30	10:1	Yes	60
MC10	492145, 6601645	Broad-leaved Paperbark	15	30	10:3	Yes	60

Table 2.2 Demographic Data of GHFF at the Bellingen Island Camp

Tree Code	*GPS Location (UTM coordinates GDA94, Zone 56)*	*Tree Species*	*Height (m)*	*DBH (cm)*	*Demographic Ratio (female:male)*	*Presence of Dependant Young (yes/no)*	*% Females with Dependant Young*
BI1	489984, 6631558	Creek Sandpaper Fig	12	15	10:1	Yes	70
BI2	489995, 6631544	Creek Sandpaper Fig	10	20	10:3	Yes	80
BI3	490008, 6631528	Unkown sp.	12	30	10:7	Yes	80
BI4	490047, 6631522	White Cedar	12	40	10:2	Yes	50
BI5	490058, 6631496	Giant Stinging Tree	20	100	10:1	Yes	80
BI6	490074, 6631487	White Booyong	20	40	10:3	Yes	70
BI7	490091, 6631489	Creek Sandpaper Fig	12	20	10:3	Yes	70
BI8	490101, 6631503	Giant Stinging Tree	12	20	10:1	Yes	70
BI9	490088, 6631527	Giant Stinging Tree	20	30	10:1	Yes	70
BI10	490097, 6631534	Giant Stinging Tree	15	30	10:1	Yes	60

2.2.3.3 Water Level at the Site

Water level at the site measured at the representative measurement location was approximately 55 cm in depth, which is a 10 cm increase from the level recorded last month (refer to **Figure 2.1**).

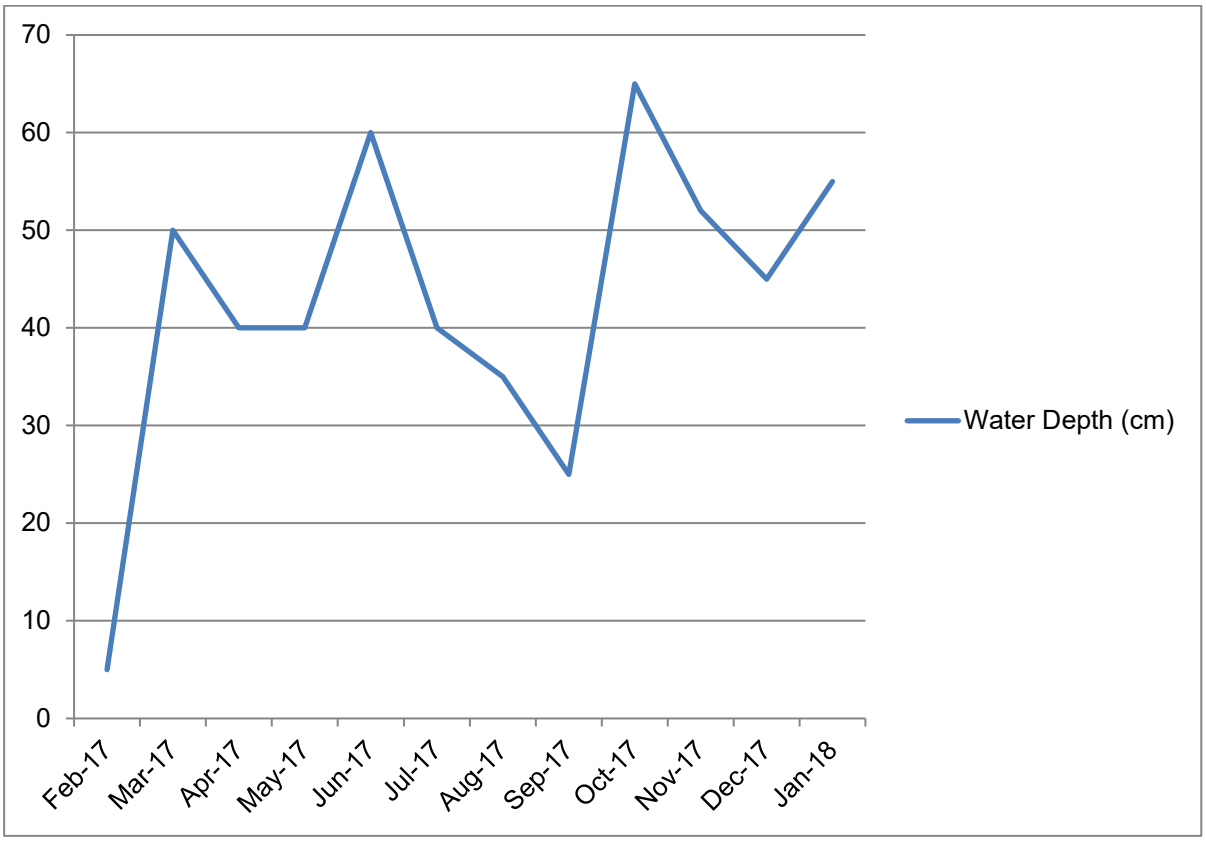


Figure 2.1 Water level measurements at the site

2.3 Discussion

2.3.1 Population Estimates

The trend in flying-fox numbers over the last 12-month period at the site and other monitored regional flying-fox camps is shown in **Figure 2.2**. No flying-foxes were recorded at the site again this month. Flying-foxes have not occupied the site (excluding a brief return in January 2015) since mid-April 2014.

The number of flying-foxes at the Macksville Cemetery camp has continued to increase from the low levels or absence that typically occurs over winter and early spring at this camp. An estimated 50,000 individuals were recorded in the current monitoring event. A similar increase in flying-fox numbers was also recorded at the Bellingen Island camp over the past month. This relatively high number of flying-foxes at both of these camps is most likely a reflection of the current availability of key food resources in the locality (refer to (**Section 2.3.3**).

In contrast, at the Gordon Park camp there has not been a recent sharp increase in flying-fox numbers. The comparatively moderate flying-fox numbers at the Gordon Park camp possibly reflects the overall poor condition of the rainforest canopy caused by a consistent flying-fox presence, resulting in an altered (and potentially less favourable) microclimate for roosting.

No flying-foxes were recorded at Bowraville in the current monitoring event. Over the past 12-month period, flying-foxes have only been present at this camp in very low numbers during late spring and early summer of 2016/17.

As can be seen in the 12-monthly population comparisons (refer to **Figure 2.2**), after reaching a low point in October the overall population levels at occupied camps are generally continuing to increase as summer progresses (with the exception of the Gordon Park camp).

2.3.2 Species Composition and Demographic Data

At occupied camps, GHFF dominated the species composition making up between 80% and 95% of all individuals, similar to the proportions recorded in the previous monthly monitoring event (GeoLINK 2017).

Female GHFF dominated the occupied camps in the current monitoring event, with demographic point counts averaging 83% at both the Bellingen Island and Macksville Cemetery camps. A similar proportion was recorded in the previous monitoring event (GeoLINK 2017).

At the Macksville Cemetery camp dependent young were present at a moderate level alongside 55% of all female GHFF, similar to the proportion recorded in the previous monitoring event (GeoLINK 2017). In contrast the percentage of female GHFF with dependent young at Bellingen Island has increased substantially from 49% in the previous monitoring event (GeoLINK 2017) to 70% in the current monitoring event.

2.3.3 Phenology of Trees in the Region

December/January bi-monthly flowering of a number of highly productive nectar source trees in the upper North Coast region of NSW includes various *Corymbia* spp. (Bloodwoods and Spotted Gums), New England Blackbutt (*Eucalyptus andrewsii*), River Red Gum (*E. camaldulensis*), Coastal Blackbutt (*E. pilularis* - foothills and ranges), Grey Ironbark (*E. siderophloia* - foothills and ranges), Forest Red Gum (*E. tereticornis – high altitude*) and Black Bean (*Castanospermum australe*). These are considered key diet species for GHFF in the region (Eby 2012; Eby and Law 2008).

Observations when travelling between regional flying-fox camps recorded moderate to heavy flowering of Pink Bloodwood (*Corymbia intermedia*).

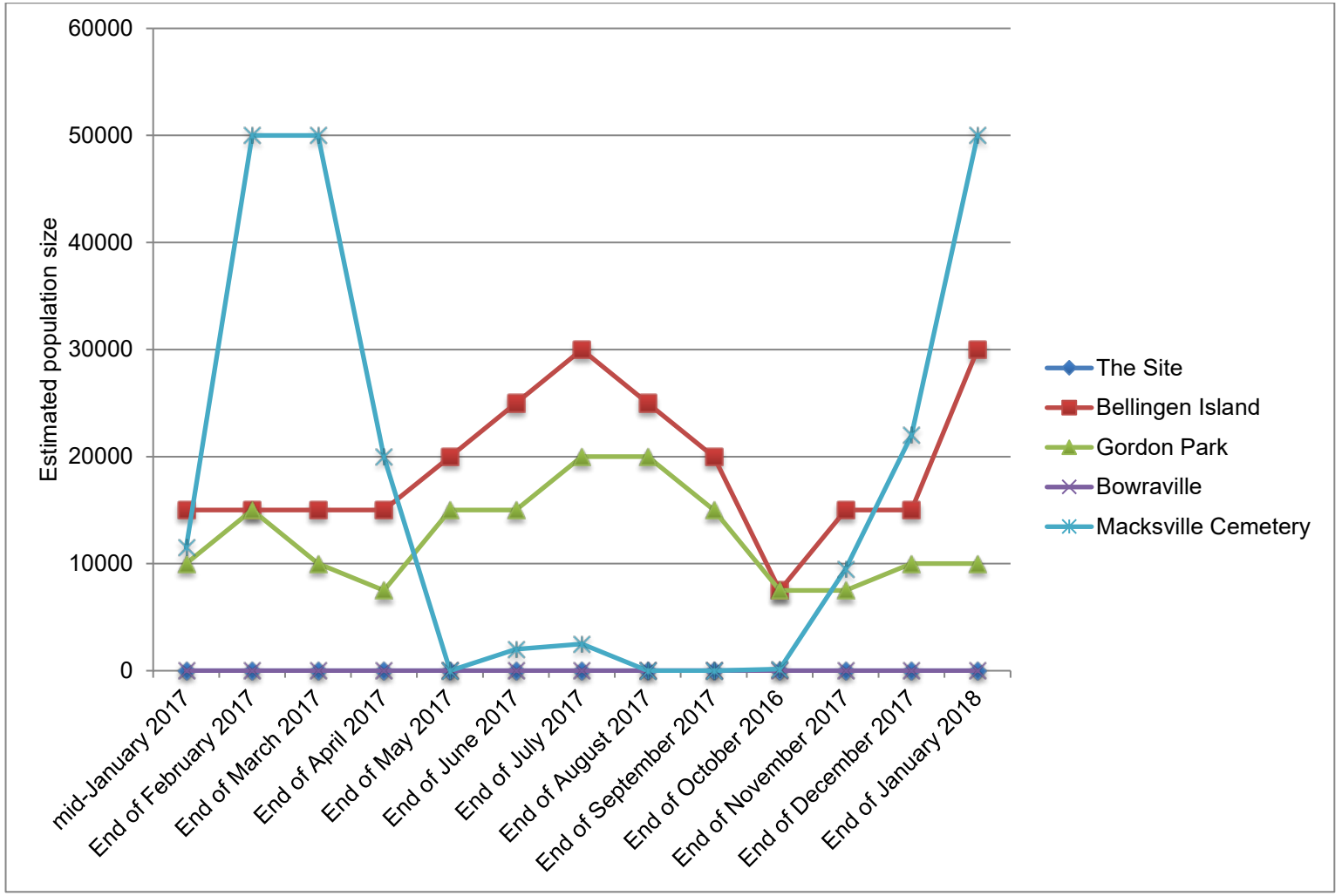


Figure 2.2 Population trends at the site and regional camps over past 12 months

2.4 Summary and Conclusion

The results of the January 2018 flying-fox monitoring indicate that excluding a brief stopover at the site observed in mid-January 2015, flying-foxes have been absent from the site since April 2014. The Macksville Cemetery camp (first recorded in March 2015) appears to be the replacement camp for the site.

The number of flying-foxes at both the Macksville Cemetery and Bellingen Island camps have increased substantially over the last month, and are now at around 50,000 and 30,000 individuals respectively. The relatively high number of flying-foxes at these camps is most likely a reflection of the current availability of key food resources in the locality (e.g. flowering Pink Bloodwood).

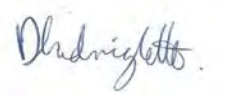
The Gordon Park camp has not seen this recent sharp increase in flying-fox numbers. The comparatively moderate flying-fox numbers at the Gordon Park camp possibly reflects the overall poor condition of the rainforest canopy caused by a consistent flying-fox presence, resulting in an altered (and potentially less favourable) microclimate for roosting.

Flying-foxes remain absent from Bowraville and Wheatley Street, Bellingen.

GHFF dominated the species composition at occupied camps making up between 80% and 95% of all individuals present.

Dependent young GHFF were present at a moderate to high level within occupied camps in the current monitoring event.

Moderate to heavy flowering of Pink Bloodwood, a key diet species for the GHFF, was observed to be currently occurring in the region.



David Andrighetto
Senior Ecologist

References

Eby, P. (2012). *An Assessment of the Flying-fox Camp at Macksville*. Unpublished report to NSW Roads and Maritime Services.

Eby, P. (2013). *A Field Monitoring Program Proposed for the Macksville Flying-fox Roost*. Unpublished report to Sinclair Knight Merz.

GeoLINK. (2017). *Flying-fox Monitoring December 2017: Warrell Creek to Nambucca Heads Pacific Highway Upgrade*. Unpublished report to NSW Roads and Maritime Services.

Appendix C

Threatened Microbat Monitoring Reports

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30/01/2018
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Attention: Mr Alex Dwyer

WC2NH Microbat Flyway Monitoring – Six Monthly Annual Compliance Report January 2018

Introduction

GeoLINK has been engaged by Pacifico to undertake microbat flyway monitoring for the Warrell Creek to Nambucca Heads (WC2NH) Pacific Highway upgrade. In accordance with monitoring requirement *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.

This report presents the findings of the microbat flyway monitoring for the last six months of year 3 of the construction stage of the project (August 2017 to January 2018) and compares the previous 6 months monitoring results with January 2018 to present the 2018 Microbat Flyway monitoring report. Monitoring of microbat flyways is to be undertaken monthly during years 1, 3 and 4 of construction as outlined in the *WC2NH Ecological Monitoring Program* (Lewis, 2014).

Methodology

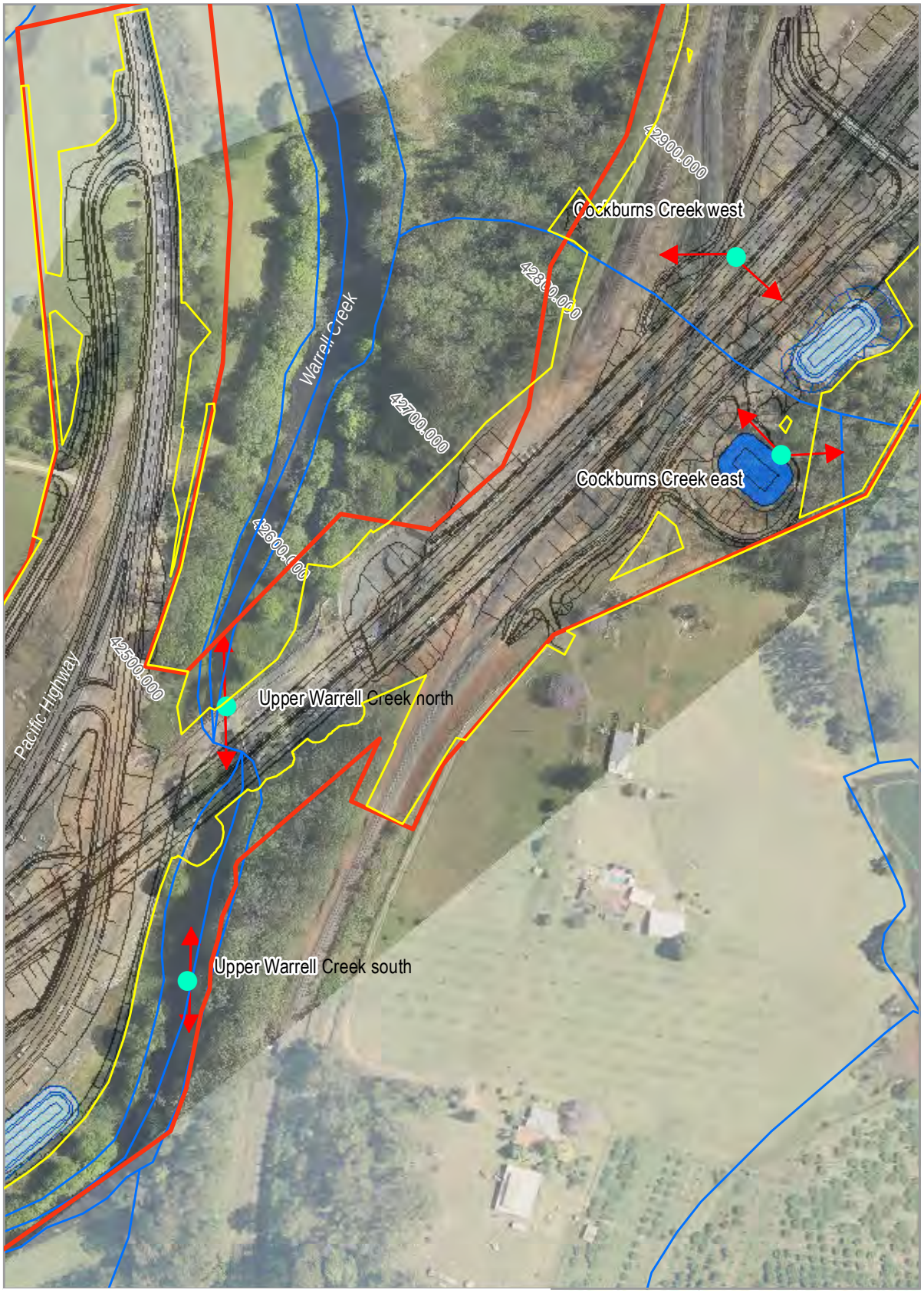
In order to monitor potential microbat flyways, the following riparian zones have been nominated as monitoring sites:

- Crouches Creek;
- Rosewood Creek;
- Butchers Creek;
- Un-named tributary near Cockburns Lane (Cockburns Creek); and
- Upper Warrell Creek (UWC).

Two photo points, one on either side of the nominated creek, have been established. Photographs were taken looking towards the highway construction zone and towards the intact riparian zone adjacent (refer to **Illustrations 1.1** to **1.4** for photo point locations). Global Positioning System (GPS) coordinates for the photo point locations are provided in **Table 1**. The condition of the flyway habitat was recorded, noting changes to the quality of the flyway or any visible obstructions. Dates on which monthly flyway monitoring occurred are provided in **Table 2**.

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: JOL Date: 19/01/2018
Source of base data: RMS & AFJV



LEGEND

- Site Boundary
- Clearing Limit
- Watercourse
- Microbat Habitat Flyway Photo Points
- Photopoint direction

0 60

North

Microbat Flyway Photo **Point** Locations

GeoLINK environmental management and design

WC2NH Microbat Flyway Monitoring - January 2018
2378-1412

Illustration 1.1

Drawn by: AB Checked by: RE Reviewed by: JOL Date: 19/01/2018
Source of base data: RMS & AFJV

Information shown is for illustrative purposes only

LEGEND

- Site Boundary
- Clearing Limit
- Watercourse
- Microbat Habitat Flyway Photo Points
- Photopoint direction

0 60

North

Microbat Flyway Photo **Point** Locations

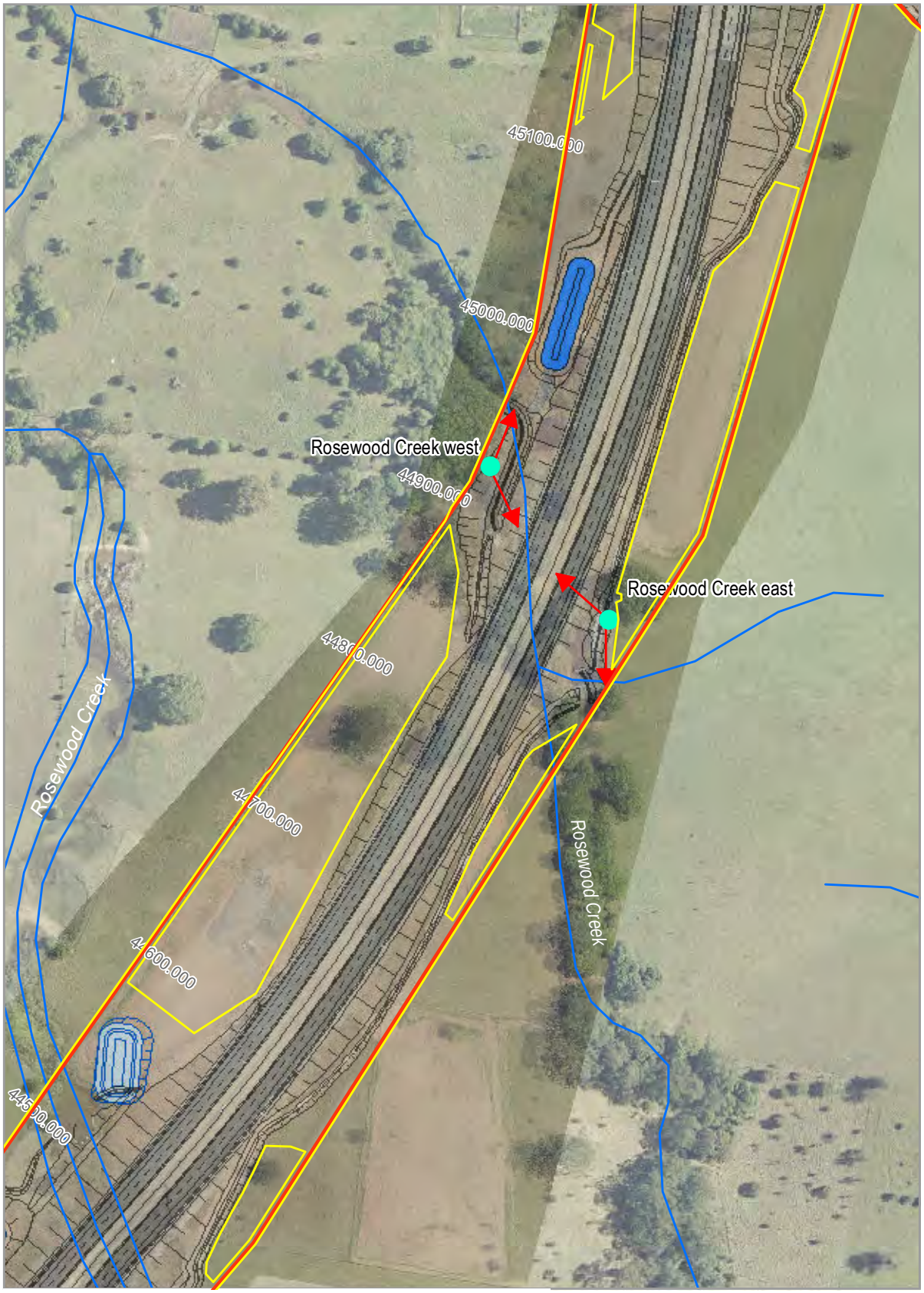
GeoLINK environmental management and design

WC2NH Microbat Flyway Monitoring - January 2018
2378-1412

Illustration 1.2

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: JOL Date: 19/01/2018
Source of base data: RMS & AFJV



LEGEND

- Site Boundary
- Clearing Limit
- Watercourse
- Microbat Habitat Flyway Photo Points

0 60

North

Microbat Flyway Photo **Point** Locations

GeoLINK environmental management and design

WC2NH Microbat Flyway Monitoring - January 2018
2378-1412

Illustration 1.3

Drawn by: AB Checked by: RE Reviewed by: JOL Date: 19/01/2018
Source of base data: RMS & AFJV

Information shown is for illustrative purposes only

LEGEND

- Site Boundary
- Clearing Limit
- Watercourse
- Microbat Habitat Flyway Photo Points

0 60

North

Microbat Flyway Photo **Point** Locations

GeoLINK environmental management and design

WC2NH Microbat Flyway Monitoring - January 2018
2378-1412

Illustration 1.4

Table 1 Flyway Photo Point Monitoring GPS Coordinates (GDA 94)

Photo Point Location	*Easting*	*Northing*
Crouches Creek east	491686	6598052
Crouches Creek west	491579	6598035
Rosewood Creek east	490758	6596127
Rosewood Creek west	490696	6596206
Butchers Creek east	489855	6594879
Butchers Creek west	489766	6594934
Cockburns Creek east	489569	6594435
Cockburns Creek west	489546	6594538
Upper Warrell Creek south	489262	6594163
Upper Warrell Creek north	489282	6594305

Table 2 Flyway Photo Point Monitoring Dates for year 3 February 2017 to January 2018

Date	*Month*	*Year*
15	February	2017
22	March	2017
24	April	2017
25	May	2017
28 and 30	June	2017
16	July	2017
29	August	2017
5	September	2017
16	October	2017
17	November	2017
13	December	2017
15	January	2018

Results

A total of five riparian sites were monitored, with four photographs taken at each site. A comparison of photos between the first and last monitoring sessions listed below are provided in **Appendix A**.

- Year 1 of construction – April 2015 and January 2016;
- The first six months of year 3 – February 2017 and July 2017; and
- The last six months of year 3 – August 2017 and January 2018.

Records of all photos taken are available upon request. An assessment of impacts/ changes for each flyway site is provided in the **Table 3**.

Table 3 Flyway Photo Point Monitoring Results

Site	*Impacts/ Changes*	*Weed Control Required*
Crouches Creek	Substantial changes have occurred within the site associated with the Crouches Creek Bridge construction. However, the bridge does not constrict potential flyways and no weed infestations or vegetation overgrowth has been recorded. Crouches Creek remains unobstructed as a potential flyway. No significant change to flyway opportunities has occurred since the July 2017 monitoring report was issued.	No
Rosewood Creek	Construction in this area has substantially altered the riparian zone reducing the quality of the flyway. Whilst the terrain has changed in this area, aerial passage of microbats is possible over the alignment. Under passage options are also possible through the culvert. Batters have now been hydroseeded with native seed mix.	No
Butchers Creek	Despite substantial changes within the construction site associated with the Butchers Creek culvert, the potential flyway associated with Butchers Creek remains unobstructed. Dense Small-leaved Privet and Lantana grow along the riparian zone to the west (outside) of the project boundary at this location.	No
Cockburns Creek	Substantial changes associated with earthworks have reduced the quality of the flyway due to the removal of vegetation and placement of fill. However, the area remains unobstructed and capable of providing aerial passage above the highway alignment for microbats. Where the basin to the east has been hydroseeded, Acacia saplings have grown and are beginning to obstruct the flyway to east to westerly direction (refer to **Plate 1.65**).	No
Upper Warrell Creek (UWC)	Despite the construction of a temporary crossing over the creek involving minor clearing of the riparian zone and the construction of the UWC Bridge, the potential flyway remains largely unobstructed and capable of supporting microbat aerial passage under the bridge. No significant change to flyway opportunities have occurred since the July 2017 monitoring report was issued.	No

Discussion

In general, the findings of the monitoring to date indicate substantial changes associated with flyways as a result of highway construction. Due to the required clearing and construction of the highway, the quality of flyways has been reduced; particularly for the Cockburn and Rosewood Creek riparian zones where the previously continuous vegetation has been intercepted by the highway alignment and substantial placement of fill on embankments. Although there is limited to no under passage flyway options to adjacent vegetation at Cockburn Creek, flyway passage above the highway alignment is still viable at these locations.

The Rosewood Creek culvert provides under passage options via the single cell box culvert. Over time the hydroseeded batters at Rosewood Creek will grow medium to tall native species which will further restrict the parallel course of the flyway along the riparian zone. Additionally, microbats have been recorded using the culvert structure as roosting habitat during 2016 overwintering structures monitoring undertaken by GeoLINK. No microbats were recorded roosting in this structure during the

2017 overwintering survey. Due to the road height in relation to the adjacent vegetation, there is potential increased risk that microbats will fly over the road in the path of passing vehicles once the highway is operational to traffic.

Butchers Creek culvert offers both under passage and above highway flyways connecting adjacent riparian vegetation. This culvert has recorded the presence of microbats roosting in the joint gaps during 2017 overwintering structures monitoring (GeoLINK, 2017).

UWC and Crouches Creek bridge construction has impacted the flyway through minor clearing, however even with the bridge structures now in place, potential flyways remain viable under the bridge connecting with adjacent vegetation.

Retained areas of vegetation outside the alignment remain unobstructed or as they naturally existed prior to construction and are generally free of weed infestations with the exception of the western side of Butchers Creek, where dense infestations of Lantana and Small- leaved Privet occur outside of the project footprint (as naturally existed prior to construction).

Water quality monitoring for the subject sites (flyways) has been undertaken routinely by Pacifico and is available on request. The water quality of the associated waterways has been managed in accordance with the *Soil and Water Quality Management Plan*.

No remediation measures are currently required for microbat flyways; however assessment of landscape vegetation may need monitoring for obstruction of flyways as vegetation matures.

Conclusion

The riparian zones associated with flyway monitoring locations have been altered or intercepted by the highway upgrade construction. The two bridges and two box cell culverts offer unobstructed flyways connecting adjacent riparian vegetation. The Cockburn Creek flyway is the most restricted due to the placement of fill and less favorable crossing opportunities, due to limited underpass options through the narrow pipe culvert. However, aerial passage is still viable above the highway alignment. Currently no vegetation or weed overgrowth has been noted as an obstruction to microbat flyways in association with the monitoring sites, however over time maturing landscape vegetation may need monitoring for obstruction of flyways as this vegetation matures.

Over time, microbat flyway monitoring to date has indicated that the flyways are largely unobstructed by vegetation overgrowth or weeds. While riparian vegetation is intercepted by construction, flyway opportunities are provided via under passage or viable aerial passage above the highway, hence satisfying the objectives of the *Microchiropteran Bat Management Strategy* (Lewis, 2014).

It is expected that only years 1 and 3 of construction phase monitoring will take place during the construction phase of the project due to the project completion forecast for April 2018. This makes the January and Annual report for year 3 monitoring events potentially the last monitoring event undertaken as part of the construction monitoring contract facilitated by PACIFICO. GeoLINK is awaiting a response from Pacifico as to whether further monitoring is required after the submission of this report.

Please feel free to contact me should you require any additional information.

Yours sincerely
GeoLINK

Jessica O'Leary
Ecologist

References

Lewis, B (2014). *Warrell Creek to Urunga Microchiropteran Bat Management Strategy.* Unpublished report to *Roads and Maritime Service, NSW.*

Lewis, B (2014). *Warrell Creek to Urunga Pacific Highway Upgrade Ecological Monitoring Program. Stage 2 Warrell creek to Nambucca Heads*. Unpublished report to *Roads and Maritime Service, NSW*.

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RMS (2014). *Soil and Water Management Sub Plan - Warrell Creek to Nambucca Heads Pacific Highway Upgrade*. Unpublished report for *Road and Maritime Services*.

Appendix A

Microbat Flyway Photos

Crouches Creek – east looking west


Plate 1.1 April 2015


Plate 1.2 January 2016


Plate 1.3 February 2017


Plate 1.4 July 2017


Plate 1.5 August 2017


Plate 1.6 January 2018

Crouches Creek – east looking east


Plate 1.7 April 2015


Plate 1.8 January 2016


Plate 1.9 February 2017


Plate 1.10 July 2017


Plate 1.11 August 2017


Plate 1.12 January 2018

Crouches Creek – west looking east


Plate 1.13 April 2015


Plate 1.14 January 2016


Plate 1.15 February 2017


Plate 1.16 July 2017


Plate 1.17 August 2017


Plate 1.18 January 2018

Crouches Creek – west looking west


Plate 1.19 April 2015


Plate 1.20 January 2016


Plate 1.21 February 2017


Plate 1.22 July 2017


Plate 1.23 August 2017


Plate 1.24 January 2018

Rosewood Creek – east looking west


Plate 1.25 April 2015


Plate 1.26 January 2016


Plate 1.27 February 2017


Plate 1.28 July 2017


Plate 1.29 August 2017


Plate 1.30 January 2018

Rosewood Creek – east looking east


Plate 1.31 April 2015


Plate 1.32 January 2016


Plate 1.33 February 2017


Plate 1.34 July 2017


Plate 1.35 August 2017


Plate 1.36 January 2018

Rosewood Creek – west looking south-east


Plate 1.37 April 2015


Plate 1.38 January 2016


Plate 1.39 February 2017


Plate 1.40 July 2017


Plate 1.41 August 2017


Plate 1.42 January 2018

Rosewood Creek – west looking north-west


Plate 1.43 April 2015


Plate 1.44 January 2016


Plate 1.45 February 2017


Plate 1.46 July 2017


Plate 1.47 August 2017


Plate 1.48 January 2018

Butchers Creek – east looking east


Plate 1.49 April 2015


Plate 1.50 January 2016


Plate 1.51 February 2017


Plate 1.52 July 2017


Plate 1.53 August 2017


Plate 1.54 January 2018

Butchers Creek – east looking west


Plate 1.55 April 2015


Plate 1.56 January 2016


Plate 1.57 February 2017


Plate 1.58 July 2017


Plate 1.59 August 2017


Plate 1.60 January 2018

Butchers Creek – west looking south


Plate 1.61 April 2015


Plate 1.62 January 2016


Plate 1.63 February 2017


Plate 1.64 July 2017


Plate 1.65 August 2017


Plate 1.66 January 2018

Butchers Creek – west looking east


Plate 1.67 April 2015


Plate 1.68 January 2016


Plate 1.69 February 2017


Plate 1.70 July 2017


Plate 1.71 August 2017


Plate 1.72 January 2018

Cockburns Creek – east looking west


Plate 1.73 April 2015


Plate 1.74 January 2016


Plate 1.75 February 2017


Plate 1.76 July 2017


Plate 1.77 August 2017


Plate 1.78 January 2018

Cockburns Creek – east looking east


Plate 1.79 April 2015


Plate 1.80 January 2016


Plate 1.81 February 2017


Plate 1.82 July 2017


Plate 1.83 August 2017


Plate 1.84 January 2018

Cockburns Creek – west looking west


Plate 1.85 April 2015


Plate 1.86 January 2016


Plate 1.87 February 2017


Plate 1.88 July 2017


Plate 1.89 August 2017


Plate 1.90 January 2018

Cockburns Creek – west looking east


Plate 1.91 April 2015


Plate 1.92 January 2016


Plate 1.93 February 2017


Plate 1.94 July 2017


Plate 1.95 August 2017


Plate 1.96 January 2018

Upper Warrell Creek – south looking north


Plate 1.97 April 2015


Plate 1.98 January 2016


Plate 1.99 February 2017


Plate 1.100 July 2017


Plate 1.101 August 2017


Plate 1.102 January 2018

Upper Warrell Creek – south looking south


Plate 1.103 April 2015


Plate 1.104 January 2016


Plate 1.105 February 2017


Plate 1.106 July 2017


Plate 1.107 August 2017


Plate 1.108 January 2018

Upper Warrell Creek – north looking north


Plate 1.109 April 2015


Plate 1.110 January 2016


Plate 1.111 February 2017


Plate 1.112 July 2017


Plate 1.113 August 2017


Plate 1.114 January 2018

Upper Warrell Creek – north looking south


Plate 1.115 April 2015


Plate 1.116 January 2016


Plate 1.117 February 2017


Plate 1.118 July 2017


Plate 1.119 August 2017


Plate 1.120 January 2018

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7 March 2018
Ref No.: 2378-1429

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DONNELLYVILLE NSW 2447

Attention: Alex Dwyer

WC2NH Microbat Roost Box – Annual Report 2017

Introduction

GeoLINK has been engaged by Pacifico to undertake microbat roost box monitoring for the Warrell Creek to Nambucca Heads (WC2NH) Pacific Highway upgrade. A total of 24 microbat roost boxes were installed to provide compensatory roost habitat for hollow-bearing trees removed during clearing for the highway upgrade alignment (refer to **Maps 1-5** of **Appendix A**). Monitoring of microbat roost boxes is to be undertaken seasonally for four years as outlined in the *Warrell Creek to Urunga Microchiropteran Bat Management Strategy* (Lewis 2014). This annual report summarises the results of Year 3 monitoring undertaken between summer (January) 2017 and spring (September) 2017.

Objectives

Lewis (2014) notes that long term 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 microbats and breeding activity. Information would also be collected as to the roost identification number, date and time of the inspection".

Monitoring Events

Roost boxes were inspected for microbats or evidence of use by microbats using an ecologist and tree climber on four occasions (quarterly) during 'Year 3' of the construction phase as per the required monitoring. Monitoring dates are as follows:

- Summer 2017 – 17 January 2017
- Autumn 2017 – 12 April 2017
- Winter 2017 – 29 June 2017
- Spring 2017 – 5 September 2017.

Results

The results of the four microbat roost box monitoring events during 2017 are summarised in **Table 1**.

Table 1 Summary of 2017 Microbat Roost Box Monitoring Results

Monitoring Event	*Number of Microbats Observed*	*Species Observed*	*Number of Boxes Occupied*	*Number of Boxes with Evidence of Use*	*Repairs Undertaken*	*Invertebrate Pests Observed*	*Comments*
Summer 2017	22	1 x *Myotis macropus* 12 x *Nyctophilus sp.* 9 x *Nyctophilus gouldii* including at least one pup	3	6	■ No maintenance or adjustments to any bat boxes were required	Invertebrate pests (bees, wasps, ants etc.) were not an issue at the time of survey. Spider webs were removed from the entrance or interior of some bat boxes.	This survey recorded the largest number of microbats since the commencement of roost box monitoring.
Autumn 2017	20	6 x *Nyctophilus geoffroyi* 6 x *Nyctophilus geoffroyi* 5 x *Chalinolobus gouldii* 1 x *Nyctophilus Gouldii* 1 x *Nyctophilus geoffroyi* 1 x *Chalinolobus gouldii*	6	6	■ Box 5 - New box installed on Grey Gum to replace previous box which fell into river while attached to supporting tree (Swamp Oak). ■ Box 7 - Repositioned box to a lower branch with a better flyway. New position not likely to be impacted by flood waters. ■ Box 9 - Relocated box to a new tree and higher branch to avoid flood waters inundating the box. Removed debris from box interior. ■ Repositioned (straightened) due to another tree knocking the box during flooding.		This survey observed greater occupation of bat boxes than all monitoring undertaken to date, which was the same observation for autumn 2016. Significant weather event during autumn caused several supporting trees and branches to fall over or break, leading to the replacement of a number of roost boxes.
Winter 2017	7	1 x *Nyctophilus geoffroyi* 1 x *Nyctophilus geoffroyi* 1 x *Nyctophilus geoffroyi* 4 x *Myotis macropus*	4	5	■ Box 11 - Replacement box installed due to supporting branch broken during large weather event.		N/A
Spring 2017	8	6 x *Nyctophilus geoffroyi* 2 x *Chalinolobus gouldii*	2	5	■ Box 22 - Relocated to more accessible tree for climbing.		N/A

Table 2 provides a summary of the bat boxes that have been frequently occupied during each monitoring period.

Table 2 Bat Box Usage 2015-2017

Bat Box No.	*2015 Summer*	*2015 Autumn*	*2015 Spring*	*2016 Summer*	*2016 Autumn*	*2016 Winter*	*2016 Spring*	*2017 Summer*	*2017 Autumn*	*2017 Winter*	*2017 Spring*
1											
2				4 x likely *Myotis* sp.	4 x microbats					*1 x Nyctophilus geoffroyi*	
3	1 x microbat	Guano		Guano	Guano		Guano	Guano	*6 x Nyctophilus geoffroyi*	*1 x Nyctophilus geoffroyi*	Guano
4											
5		Guano									
6											
7		Guano			Guano						
8		Guano									
9											
10						1 x microbat	10 x *Nyctophilus* sp.		6 x *Nyctophilus geoffroyi*	1 x *Nyctophilus geoffroyi*	6 x *Nyctophilus geoffroyi*
11											
12			1 x *Myotis macropus*	1 x microbat	3 x microbats	1 x microbat	1 x microbat	1 x *Myotis macropus*	5 x *Chalinolobus gouldii*		2 x *Chalinolobus gouldii*
13											
14											
15											
16							Guano	Guano	1 x *Nyctophilus Gouldii*	Guano	Guano
17					1 x *Nyctophilus* sp.						
18								12 x *Nyctophilus* sp.	1 x *Nyctophilus geoffroyi*		
19	Guano	Guano	Guano	Guano	2 x	1 x	Guano	Guano	1 x	4 x *Myotis*	Guano

Bat Box No.	2015 Summer	2015 Autumn	2015 Spring	2016 Summer	2016 Autumn	2016 Winter	2016 Spring	2017 Summer	2017 Autumn	2017 Winter	2017 Spring
					Nyctophilus sp.	microbat			*Chalinolobus gouldii*	*macropus*	
20	Guano	Guano	Guano	6 x microbats	1 x *Nyctophilus* sp.	7 x *Nyctophilus* sp.					
21							8 x *Nyctophilus* sp.				
22											
23								9 x *Nyctophilus gouldii* including at least one pup			
24											
Total Bats	**1**	**0**	**1**	**11**	**11**	**10**	**19**	**22**	**20**	**7**	**8**
No. of boxes showing evidence of use	**3**	**6**	**3**	**5**	**7**	**4**	**6**	**6**	**6**	**5**	**5**
No. of boxes occupied	**1**	**0**	**1**	**3**	**5**	**4**	**3**	**3**	**6**	**4**	**2**

Discussion

The highest numbers of microbats were recorded during the summer 2017 monitoring event (n = 22; refer to **Figure 1.1**). This represents the highest number of microbats recorded since the commencement of monitoring. Autumn monitoring recorded the second highest number of microbats (n = 20) during roost box monitoring. Winter and spring 2017 recorded seven and eight microbats respectively. Based on the data to date, the numbers of microbats using roost boxes particularly during summer and autumn monitoring events is increasing over time (refer to **Figure 1.1**)

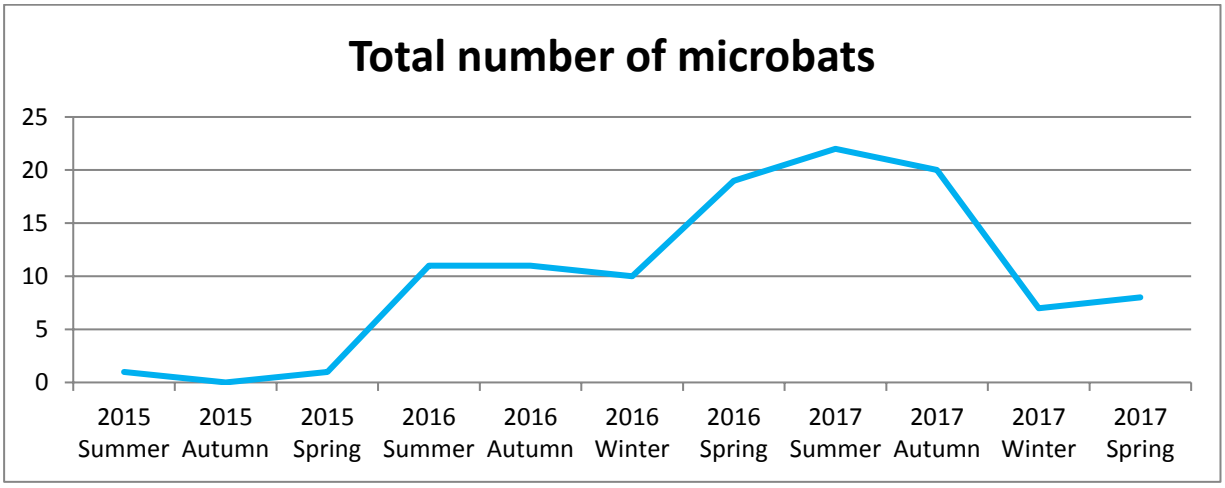


Figure 1.1 Total number of microbats recorded.

Three roost boxes were occupied in summer 2017, six boxes in autumn 2017, four in winter 2017 and two boxes spring 2017 (refer to Figure 1.2). A total of 15 boxes were recorded as occupied for both the 2016 and 2017 seasonal monitoring events, a significant increase in box occupancy from earlier monitoring. The autumn 2017 monitoring event observed the largest number of boxes occupied (six) than all monitoring undertaken to date.

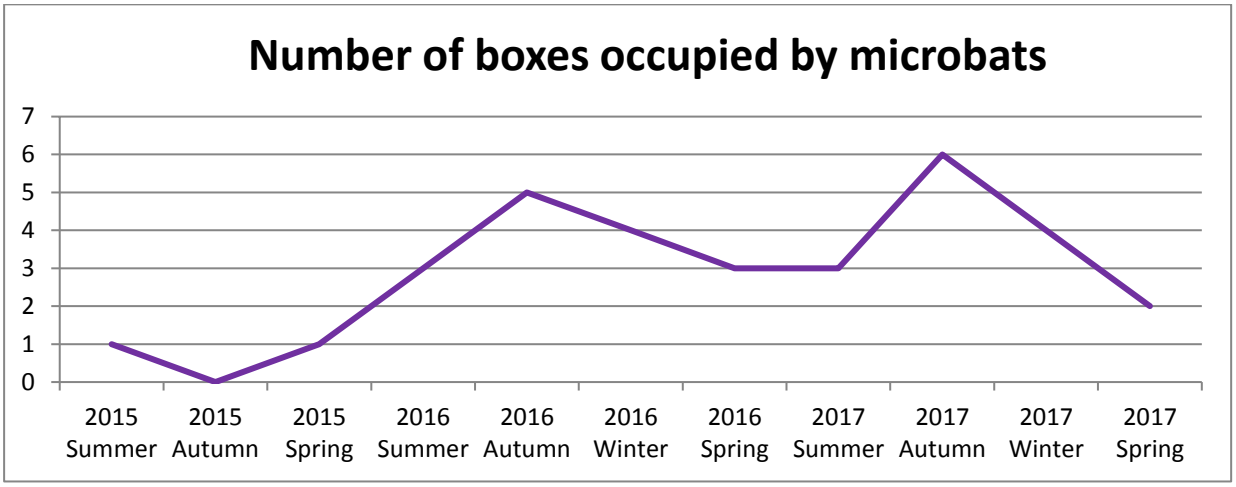


Figure 1.2 Number of boxes occupied by microbats.

The boxes with the greatest frequency of observed occupation since monitoring commenced in summer 2015 are as follows:

- Box 12 (eight occupation events)
- Box 10 (five occupation events)
- Box 19 (four occupation events)
- Box 20 (three occupation events).

The boxes with the greatest frequency of observed occupation or use (by evidence of guano) since monitoring commenced in summer 2015 are as follows:

- Box 19 (11 events)
- Box 3 (nine events)
- Box 20 (six events)
- Box 12 (eight events).

There has been an increase in the total diversity of bat species observed using boxes from one species recorded during the 2015 monitoring period (Southern Myotis, *Myotis macropus*) to at least two (and possibly more) species recorded in the 2016 monitoring period (Southern Myotis, Gould's Long-eared Bat, *Nyctophilus gouldii*). Two additional species were confirmed using the boxes during 2017 monitoring events: Gould's Wattled Bat (*Chalinolobus gouldii*) and Lesser Long-eared Bat (*Nyctophilus geoffroyi*). A total of four confirmed species have been recorded using the microbat roost boxes to date.

During 2017 seasonal monitoring *Nyctophilus* or Long-eared Bat species were the microbat species most frequently recorded, with 10 of 15 boxes occupied by a minimum of 44 Long-eared bats. The remaining five occupied boxes recorded 13 microbats comprising two species (Southern Myotis, Gould's Wattled Bat).

The total minimum number of microbats recorded from each monitoring event is as follows:

- 2015 (two microbats)
- 2016 (51 microbats)
- 2017 (57 microbats).

The increase in total microbat numbers observed over the 2016 and 2017 monitoring periods is an encouraging trend and may be attributed to:

- Seasonal factors in total bat numbers and activity levels within locality (i.e. some species are more active in summer, some species may use different types of roosts during different seasons including for example deep vs shallow, warm vs cold, artificial vs natural).
- The length of time that the bat boxes have been installed and increased familiarity.
- Increased number of bats in the roosting group due to successful breeding events.
- Increased number of bats in the roosting group due to an influx of bats from other areas/ groups in the locality.

The reduced number of microbats recorded in the winter and spring 2017 monitoring is not considered to be a result of construction impacts on roosting microbats. Rather, this is more likely as a result of cooler temperatures and disturbance from the storm events during autumn 2017; these natural factors may trigger microbats to seek alternative roost options. Churchill (2008) notes that Long-eared and Gould's Wattled Bats select new roosts frequently and select roosts which are warmer during the winter months than cooler summer selected roosts, particularly in more protected roosts within forest stands. Several species of microbats are also known to migrate to warmer climate roosts or hibernate for periods of time (including Long-eared Bats), sometimes not emerging from roosts for several days (Van Dyck and Strahan, 2008). Some species of microbats also enter a state of torpor, reducing their

body temperatures to conserve energy consumption and heat loss during cooler periods of the day or year.

Future monitoring will provide further data on roost box usage and occupation to add to the baseline monitoring which may allow better interpretation of results and determination of any emerging trends. It is recommended that consideration be given to relocating the boxes that have never been occupied to provide more suitable locations and hence increase usage and occupation.

A number of boxes have been relocated during the 2017 monitoring period due to storm damage sustained to supporting trees or branches (refer to **Table 1**). Further monitoring will determine whether these repositioned microbat boxes increase occupancy by microbats based on the new position or location of the box.

Conclusion

Overall there has been an increase of total numbers of bats observed using the bat boxes since monitoring commenced in summer (February) 2015, with the total numbers of boxes utilised fluctuating between three and seven boxes. The total diversity of bat species observed is also gradually increasing over time.

Numbers of microbats recorded are largely consistent with seasonal monitoring, with the number of microbat records increasing during the warmer months and lower numbers of microbats recorded during winter months (2016 and 2017) since monitoring commenced. The lower number of recorded microbats during the winter and spring 2017 monitoring event is not considered to be a result of construction impacts, but more associated with seasonal responses.

Over time, microbat roost box monitoring to date has indicated that installed roost boxes are being utilised by a range of microbats, hence satisfying the objectives of the Microchiropteran Bat Management Strategy.

Future monitoring events will be undertaken during summer and autumn of 2018, or for the remainder of construction phase monitoring. The Project is scheduled for completion at the end of autumn 2018. After this time the Project will transition to operational phase monitoring which will be completed under a new monitoring contract managed by RMS.

Please feel free to contact me if you require any additional information.

Yours sincerely
GeoLINK

Jessica O'Leary
Ecologist

References

Churchill, S. (2008). *Australian Bats* (Second Edition). Allen & Unwin, NSW.

Lewis, B. (2014). *Warrell Creek to Urunga Microchiropteran Bat Management Strategy*. Unpublished report to Roads and Maritime Service, NSW.

Van Dyck, S and Strahan, R. (2008). *The Mammals of Australia*. (Third Edition). Reed New Holland, Sydney.

UPR	*Description*	*Date Issued*	*Issued By*
2378-1429	First issue	07/03/2018	Jessica O'Leary

Appendix A

Microbat Roost Locations

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: JOL Date: 5/09/2017
Source of base data: Roads and Maritime Services

0 80

North

Bat Box Locations

Microbat Roost Box Monitoring - Spring 2017
2378-1382

Map 1 of 5

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: JOL Date: 5/09/2017
Source of base data: Roads and Maritime Services

0 80

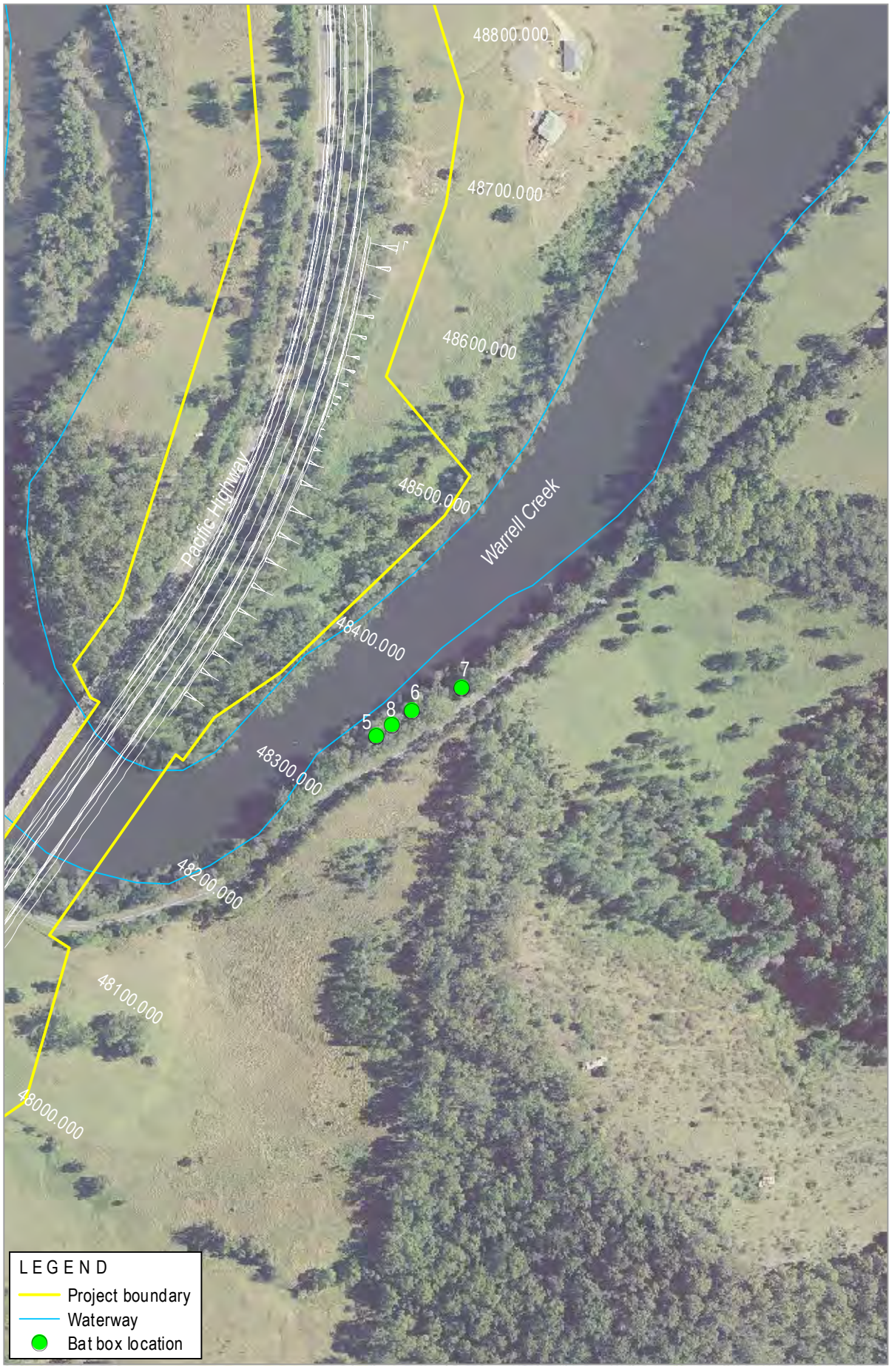
North

Bat Box Locations

Drawn by: AB Checked by: RE Reviewed by: JOL Date: 5/09/2017

Information shown is for illustrative purposes only

Source of base data: Roads and Maritime Services



0 80

North

Bat Box Locations

Microbat Roost Box Monitoring - Spring 2017

2378-1382

Map 3 of 5

Drawn by: AB Checked by: RE Reviewed by: JOL Date: 5/09/2017

Information shown is for illustrative purposes only

Source of base data: Roads and Maritime Services

0 80

North

Bat Box Locations

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: JOL Date: 5/09/2017
Source of base data: Roads and Maritime Services

0 80

North

Bat Box Locations

GeoLINK environmental management and design

Microbat Roost Box Monitoring - Spring 2017
2378-1382

Map 5 of 5

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12 July 2017
Ref No: 2378-1367

Pacifico
124 Albert Drive
DONNELLYVILLE NSW 2447

Attention: Noelene Rutherford

Dear Noelene,

WC2NH Microbat Overwintering Structure Monitoring - 2017

Introduction and Methodology

The Warrell Creek to Nambucca Heads (WC2NH) *Microchiropteran Bat Management Strategy* (MBMS - Lewis, 2014) requires monitoring of overwintering habitat in Year 2 and 3 of the project. This includes:

- The six culverts and two bridges identified as known or potential habitat in the MBMS.
- An assessment of culverts and bridges constructed as part of the WC2NH project to identify potential microbat overwintering habitat and inform management of such areas.

Based on the findings of the surveys, structures were classified into the following three categories based on the criteria defined in the MBMS:

- High Conservation Value
- Moderate Conservation Value
- Low Conservation Value.

A total of 37 structures (culverts and bridges) associated with the WC2NH Project were inspected by GeoLINK Ecologists David Andrighetto and Jessica O'Leary on 28 and 30 June 2017 as part of the Year 3 overwintering habitat monitoring. This included:

- Six existing culverts and two existing bridges (ie those identified as known or potential habitat in the MBMS).
- Twenty-four new culverts (targeting those =/>1 m diameter) and six new bridges constructed as part of the W2B project. This includes structures which were previously identified as high or moderate potential microbat habitat. For example drainage culvert at Butchers and Stoney Creek and Fauna underpasses (concrete box culverts) throughout CC04 and CC05 as well as newly constructed overpass bridge structures.

This included monitoring on several culverts and Crouches Creek Bridge, known to contain microbats, based on the 2016 Overwintering Structures Report.
The locations of the subject structures are provided in **Appendix B**.

Surveys were undertaken by direct ground based torch inspection, with the aid of inspection camera or binoculars where required. Data collected at each structure included:

- Presence/ absence of potential roosting habitat and habitat type.
- Microbat presence/ absence.
- Species and number of individuals.
- Evidence of microbat usage (ie. bat bugs, guano and/ or staining).

Results and Discussion

The results of the overwintering habitat surveys are provided in **Appendix A** and summarised in **Table 1**. Seven culverts and one bridge recorded the presence of microbats, with a total approximate count of 467 individuals. A further eight structures recorded evidence of use by microbats by the presence of staining, guano or bat bugs. In total, 16 structures recorded evidence of use by microbats (presence and/or evidence of usage) during the winter 2017 monitoring event.

Microbat species recorded during the survey included:

- 4 Gould's Long-eared Bat (*Nyctophilus gouldii*). Recorded at one structure.
- 59 Large-footed Myotis (*M. macropus*): This species is listed as Vulnerable under the *Threatened Species Conservation Act 1995* (TSC Act). Recorded at five structures.
- Approximately 404 Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*). This species is listed as Vulnerable under the *Threatened Species Conservation Act 1995* (TSC Act). Recorded at three structures.

Photos of selected roosts or evidence of use within structures are provided in **Plates 1.1**, **1.2**, **1.3** and **1.4**.

Overwintering structures monitored during 2016 recorded ten culverts and one bridge being occupied by microbats. Five culverts were newly constructed or under construction at the time of survey and were observed to be occupied by microbats.

Microbat overwintering structures monitoring has shown that a number existing and newly constructed structures provide roosting habitat at high, moderate and low levels for a number of microbat species (refer to **Appendix A**). Microbat overwintering habitat management recommendations based on the habitat conservation value are outlined in **Appendix A**. Due to the late stage of the project works which are likely to impact microbat habitat structures are now considered to be reduced or of a lesser impact on microbats. This is supported by observations of culverts which recorded the presence of microbats while under construction at the time of monitoring in 2016. Demonstrating that some microbat species are resilient to some perceived disturbances, choosing to roost in culverts which were under construction at the time of uptake or where works were on-going in close proximity of the culverts or bridges.

Table 1 Summary of microbat records 2016/ 2017

Year of monitoring	*Number of structures surveyed*	*Number of structures which recorded evidence of use*	*Number of culverts occupied by microbats*	*Number of bridges occupied by microbats*	*Total approximate number of microbats recorded*
Winter 2016 (Year 2)	30	Not recorded	10	1	1045
Winter 2017 (Year 3)	37	16	7	1	467

Plate 1.1 Structure ID 37 (599205) - Deadman's Gully pipe culvert: approximately 400 Eastern Bentwing Bats in segment gaps.

Plate 1.2 Structure ID 37 (599205) - Deadman's Gully: Eastern Bentwing Bats in segment gaps.

Plate 1.3 Lower Warrell Creek Bridge Structure ID 21 (1871): northern abutment recorded guano and staining beneath.

Plate 1.4 Structure ID 10 Culvert at chainage 56410 north of Sheather access: guano deposits below joint gaps.

Yours sincerely
GeoLINK

Jessica O'Leary
Ecologist

Appendix A

Microbat Overwintering Structure Results

Appendix A WC2NH Overwintering Habitat Monitoring Results

Structure ID	Chainage	Location	Structure description	Approx. size (m - height or diameter)	Evidence of microbat use	Microbats recorded during 2016 overwinter monitoring (Y/N)	Species	Conservation Value as Overwintering Habitat (Based on Section 2 of MBMS Lewis 2014)	Occurring within 200 m of the Project	Mitigation required	Easting	Northing
1	60630	Widened Median 4 fauna underpass	Dedicated fauna box culvert	2.50	Microbats present	N	2 Gould's Long-eared Bat (*Nyctophilus gouldii*)	Moderate	New culvert under highway upgrade alignment	• Qualified Ecologist to perform pre-clearing surveys to assess if bats are using the structure before planned works within 200m of structure (This has been satisfied as part of overwintering and previous monitoring of structures). • Should works be required on the structure itself or high impact works within 100 m of the structure, the project ecologist must be consulted. • Microbat roost monitoring will be undertaken during construction to evaluate the response of microbats to a range of construction activities. This will involve surveys of all structures in winter in accordance with the *Microchiropteran Bat Management Strategy* during construction to update the status of each structure as microbat overwintering habitat. Baseline microbat monitoring results will also inform roost survey requirements. • In the event that microbats are observed leaving the roost site during the day, works are to cease and the project ecologist to attend site and provide advice. • The contractor would manage the integrity of drainage lines and associated riparian vegetation so as not to constrict microbat flyways. • The contractor would manage water quality and velocity of the adjoining waterways to be maintained in accordance with the EPL issued for the project.	497205	6610009
2	59760	Widened Median 1 fauna underpass	Dedicated fauna box culvert	2.40	No	N	N/A	Low	New culvert under highway upgrade alignment	Not required	496650	6609399
3	59550	Fauna underpass north of OC15	Dedicated fauna box culvert	3.00	No	N	N/A	Low	New culvert under highway upgrade alignment	Not required	496589	6609187
4	59100	Fauna underpass CH59100	Dedicated fauna box culvert	3.00	No	N	N/A	Low	New culvert under highway upgrade alignment	Not required	496515	6608746
5	58570	OC13 Fauna underpass	Dedicated fauna box culvert	3.00	No	N	N/A	Low	New culvert under highway upgrade alignment	Not required	496214	6608278
6	58510	OC13 Drainage pipe	Drainage/ fish passage twin cell box culvert	3.00	No	N	N/A	Low	New culvert under highway upgrade alignment	Not required	496254	6608191
7	58060	North of Green-thighed Frog ponds	Drainage single cell pipe culvert	1.05	Guano under lifting points and joint gaps	N	N/A	Moderate	New culvert under highway upgrade alignment	• Qualified Ecologist to perform pre-clearing surveys to assess if bats are using the structure before planned works within 200m of structure (This has been satisfied as part of overwintering and previous monitoring of structures). • Should works be required on the structure itself or high impact works within 100 m of the structure, the project ecologist must be consulted. • Microbat roost monitoring will be undertaken during construction to evaluate the response of microbats to a range of construction activities. This will involve surveys of all structures in winter in accordance with the *Microchiropteran Bat Management Strategy*	495927	6607911

Structure ID	Chainage	Location	Structure description	Approx. size (m - height or diameter)	Evidence of microbat use	Microbats recorded during 2016 overwinter monitoring (Y/N)	Species	Conservation Value as Overwintering Habitat (Based on Section 2 of MBMS Lewis 2014)	Occurring within 200 m of the Project	Mitigation required	Easting	Northing
										during construction to update the status of each structure as microbat overwintering habitat. Baseline microbat monitoring results will also inform roost survey requirements. • In the event that microbats are observed leaving the roost site during the day, works are to cease and the project ecologist to attend site and provide advice. • The contractor would manage the integrity of drainage lines and associated riparian vegetation so as not to constrict microbat flyways. • The contractor would manage water quality and velocity of the adjoining waterways to be maintained in accordance with the EPL issued for the project.		
8	57770	Fauna underpass south of OC12	Dedicated fauna box culvert	3.00	No	N	N/A	Low	New culvert under highway upgrade alignment	Not required	495751	6607663
9	56700	North Selection Drive	Drainage single cell pipe culvert	1.05	No	N	N/A	Low	New culvert under highway upgrade alignment	Not required	495231	6606737
10	56410	Local access north of Sheather property	Drainage single cell pipe culvert	1.20	Moderate level of guano accumulation below most lift holes and suitable joint gaps	N	N/A	Moderate	New culvert under local access alignment	• Qualified Ecologist to perform pre-clearing surveys to assess if bats are using the structure before planned works within 200m of structure (This has been satisfied as part of overwintering and previous monitoring of structures). • Should works be required on the structure itself or high impact works within 100 m of the structure, the project ecologist must be consulted. • Microbat roost monitoring will be undertaken during construction to evaluate the response of microbats to a range of construction activities. This will involve surveys of all structures in winter in accordance with the *Microchiropteran Bat Management Strategy* during construction to update the status of each structure as microbat overwintering habitat. Baseline microbat monitoring results will also inform roost survey requirements. • In the event that microbats are observed leaving the roost site during the day, works are to cease and the project ecologist to attend site and provide advice. • The contractor would manage the integrity of drainage lines and associated riparian vegetation so as not to constrict microbat flyways. • The contractor would manage water quality and velocity of the adjoining waterways to be maintained in accordance with the EPL issued for the project.	495013	6606528
11	56410	North of Sheather property	Combined fauna & drainage single cell box culvert	2.50	Bats and guano	Y	5 Large-footed Myotis (*M. macropus*), 2 Gould's Long-eared Bat (*Nyctophilus gouldii*) and 1 Eastern Bent-	**Moderate**	New culvert under highway upgrade alignment	• Qualified Ecologist to perform pre-clearing surveys to assess if bats are using the structure before planned works within 200m of structure (This has been satisfied as part of overwintering and previous monitoring of structures). • Should works be required on the structure itself or high impact works within 100 m of the structure, the project ecologist must be consulted. • Microbat roost monitoring will be undertaken during construction to evaluate the response of microbats to a range of construction	495082	6606488

Structure ID	Chainage	Location	Structure description	Approx. size (m - height or diameter)	Evidence of microbat use	Microbats recorded during 2016 overwinter monitoring (Y/N)	Species	Conservation Value as Overwintering Habitat (Based on Section 2 of MBMS Lewis 2014)	Occurring within 200 m of the Project	Mitigation required	Easting	Northing
							wing Bat (*Miniopterus schreibersii oceanensis*) All in the same cell joint gap 25mm wide			activities. This will involve surveys of all structures in winter in accordance with the *Microchiropteran Bat Management Strategy* during construction to update the status of each structure as microbat overwintering habitat. Baseline microbat monitoring results will also inform roost survey requirements. • In the event that microbats are observed leaving the roost site during the day, works are to cease and the project ecologist to attend site and provide advice. • The contractor would manage the integrity of drainage lines and associated riparian vegetation so as not to constrict microbat flyways. • The contractor would manage water quality and velocity of the adjoining waterways to be maintained in accordance with the EPL issued for the project.		
12	55850	North of Hartman property	Drainage single cell pipe culvert	1.20	Light guano accumulations mainly below lift holes. Bat bugs and staining in lift holes	N	N/A	Moderate	New culvert under highway upgrade alignment	• Qualified Ecologist to perform pre-clearing surveys to assess if bats are using the structure before planned works within 200m of structure (This has been satisfied as part of overwintering and previous monitoring of structures). • Should works be required on the structure itself or high impact works within 100 m of the structure, the project ecologist must be consulted. • Microbat roost monitoring will be undertaken during construction to evaluate the response of microbats to a range of construction activities. This will involve surveys of all structures in winter in accordance with the *Microchiropteran Bat Management Strategy* during construction to update the status of each structure as microbat overwintering habitat. Baseline microbat monitoring results will also inform roost survey requirements. • In the event that microbats are observed leaving the roost site during the day, works are to cease and the project ecologist to attend site and provide advice. • The contractor would manage the integrity of drainage lines and associated riparian vegetation so as not to constrict microbat flyways. • The contractor would manage water quality and velocity of the adjoining waterways to be maintained in accordance with the EPL issued for the project.	494820	6605989
13	55100	North of Mattick Road	Dedicated fauna box culvert	3.00	Nil	N	N/A	Low	New culvert under highway upgrade alignment	Not required	494551	6605311
14	54930	Local access north of Mattick Road	Drainage single cell pipe culvert	1.50	Nil	N	N/A	Low	New culvert under highway upgrade alignment	Not required	494555	6605144
15	54350	North of compound	Drainage single cell pipe culvert	1.05	No	N	N/A	Low	New culvert under highway upgrade alignment	Not required	494507	6604568
16	52900	Drainage culvert (ID599238) east of new highway, Old Coast Road	Drainage pipe culvert	1.10	Old staining and bat bugs	N	N/A	Moderate	Yes	• Qualified Ecologist to perform pre-clearing surveys to assess if bats are using the structure before planned works within 200m of structure (This has been satisfied as part of overwintering and previous monitoring of structures).	494363	6603105

Structure ID	Chainage	Location	Structure description	Approx. size (m - height or diameter)	Evidence of microbat use	Microbats recorded during 2016 overwinter monitoring (Y/N)	Species	Conservation Value as Overwintering Habitat (Based on Section 2 of MBMS Lewis 2014)	Occurring within 200 m of the Project	Mitigation required	Easting	Northing
										• Should works be required on the structure itself or high impact works within 100 m of the structure, the project ecologist must be consulted. • Microbat roost monitoring will be undertaken during construction to evaluate the response of microbats to a range of construction activities. This will involve surveys of all structures in winter in accordance with the *Microchiropteran Bat Management Strategy* during construction to update the status of each structure as microbat overwintering habitat. Baseline microbat monitoring results will also inform roost survey requirements. • In the event that microbats are observed leaving the roost site during the day, works are to cease and the project ecologist to attend site and provide advice. • The contractor would manage the integrity of drainage lines and associated riparian vegetation so as not to constrict microbat flyways. • The contractor would manage water quality and velocity of the adjoining waterways to be maintained in accordance with the EPL issued for the project.		
17	52800	Cattle underpass (ID599237) west of new highway	Cattle underpass pipe culvert	1.50	Old staining and bat bugs	N	N/A	Moderate	Yes	• Qualified Ecologist to perform pre-clearing surveys to assess if bats are using the structure before planned works within 200m of structure (This has been satisfied as part of overwintering and previous monitoring of structures). • Should works be required on the structure itself or high impact works within 100 m of the structure, the project ecologist must be consulted. • Microbat roost monitoring will be undertaken during construction to evaluate the response of microbats to a range of construction activities. This will involve surveys of all structures in winter in accordance with the *Microchiropteran Bat Management Strategy* during construction to update the status of each structure as microbat overwintering habitat. Baseline microbat monitoring results will also inform roost survey requirements. • In the event that microbats are observed leaving the roost site during the day, works are to cease and the project ecologist to attend site and provide advice. • The contractor would manage the integrity of drainage lines and associated riparian vegetation so as not to constrict microbat flyways. • The contractor would manage water quality and velocity of the adjoining waterways to be maintained in accordance with the EPL issued for the project.	494017	6603143
18	49500	Bald Hill Rd (ID599228)	Cattle underpass - single cell box culvert	2.40	Microbats present and staining	Y	2 Large-footed Myotis (*M. macropus*) and 1 Eastern Bent-wing Bat (*Miniopterus schreibersii oceanensis*)	Moderate	Yes	• Qualified Ecologist to perform pre-clearing surveys to assess if bats are using the structure before planned works within 200m of structure (This has been satisfied as part of overwintering and previous monitoring of structures). • Should works be required on the structure itself or high impact works within 100 m of the structure, the project ecologist must be consulted. • Microbat roost monitoring will be undertaken during construction to	492219	6600293

Structure ID	Chainage	Location	Structure description	Approx. size (m - height or diameter)	Evidence of microbat use	Microbats recorded during 2016 overwinter monitoring (Y/N)	Species	Conservation Value as Overwintering Habitat (Based on Section 2 of MBMS Lewis 2014)	Occurring within 200 m of the Project	Mitigation required	Easting	Northing
										evaluate the response of microbats to a range of construction activities. This will involve surveys of all structures in winter in accordance with the *Microchiropteran Bat Management Strategy* during construction to update the status of each structure as microbat overwintering habitat. Baseline microbat monitoring results will also inform roost survey requirements. • In the event that microbats are observed leaving the roost site during the day, works are to cease and the project ecologist to attend site and provide advice. • The contractor would manage the integrity of drainage lines and associated riparian vegetation so as not to constrict microbat flyways. • The contractor would manage water quality and velocity of the adjoining waterways to be maintained in accordance with the EPL issued for the project.		
19	49000	Lower Warrell Creek (ID599226)	Cattle underpass - single cell box culvert	2.40	Microbats present and staining	Y	26 Large-footed Myotis (*M. macropus*)	**High**	Yes	• Qualified Ecologist to perform pre-clearing surveys to assess if bats are using the structure before planned works within 200m of structure (This has been satisfied as part of overwintering and previous monitoring of structures). • Should works be required on the structure itself or high impact works within 100 m of the structure, the project ecologist must be consulted. • Microbat roost monitoring will be undertaken during construction to evaluate the response of microbats to a range of construction activities. This will involve surveys of all structures in winter in accordance with the *Microchiropteran Bat Management Strategy* during construction to update the status of each structure as microbat overwintering habitat. Baseline microbat monitoring results will also inform roost survey requirements. • In the event that microbats are observed leaving the roost site during the day, works are to cease and the project ecologist to attend site and provide advice. • The contractor would manage the integrity of drainage lines and associated riparian vegetation so as not to constrict microbat flyways. • The contractor would manage water quality and velocity of the adjoining waterways to be maintained in accordance with the EPL issued for the project.	492390	6599710
20	48200	New Lower Warrell Creek Bridge	New bridge	0.00	No	N	N/A	Low	New bridge over highway upgrade alignment	Not required	492259	6598949
21	48200	Existing Lower Warrell Creek Bridge (ID1871)	Existing bridge	0.00	Staining and guano under northern abatement	N	N/A	Low	Yes	Not required	492207	6598934
22	47660	New quarry access road - Scott's Head Rd	Drainage single cell pipe culvert	1.50	No	N	N/A	Low	New bridge over highway upgrade alignment	Not required	491849	6598618
23	47600	New quarry access road - Scott's Head Rd near bridge	Drainage single cell pipe culvert	2.40	Guano	N	N/A	Moderate	New culvert under highway upgrade alignment	• Qualified Ecologist to perform pre-clearing surveys to assess if bats are using the structure before planned works within 200m of	491863	6598544

Structure ID	Chainage	Location	Structure description	Approx. size (m - height or diameter)	Evidence of microbat use	Microbats recorded during 2016 overwinter monitoring (Y/N)	Species	Conservation Value as Overwintering Habitat (Based on Section 2 of MBMS Lewis 2014)	Occurring within 200 m of the Project	Mitigation required	Easting	Northing
		abatement								structure (This has been satisfied as part of overwintering and previous monitoring of structures). • Should works be required on the structure itself or high impact works within 100 m of the structure, the project ecologist must be consulted. • Microbat roost monitoring will be undertaken during construction to evaluate the response of microbats to a range of construction activities. This will involve surveys of all structures in winter in accordance with the *Microchiropteran Bat Management Strategy* during construction to update the status of each structure as microbat overwintering habitat. Baseline microbat monitoring results will also inform roost survey requirements. • In the event that microbats are observed leaving the roost site during the day, works are to cease and the project ecologist to attend site and provide advice. • The contractor would manage the integrity of drainage lines and associated riparian vegetation so as not to constrict microbat flyways. • The contractor would manage water quality and velocity of the adjoining waterways to be maintained in accordance with the EPL issued for the project.		
24	47500	Existing Scott's head cattle underpass (ID599224)	Cattle underpass - single cell pipe culvert	2.40	Staining, bat bugs present in pipe segment gaps	Y	N/A	Moderate	Yes	• Qualified Ecologist to perform pre-clearing surveys to assess if bats are using the structure before planned works within 200m of structure (This has been satisfied as part of overwintering and previous monitoring of structures). • Should works be required on the structure itself or high impact works within 100 m of the structure, the project ecologist must be consulted. • Microbat roost monitoring will be undertaken during construction to evaluate the response of microbats to a range of construction activities. This will involve surveys of all structures in winter in accordance with the *Microchiropteran Bat Management Strategy* during construction to update the status of each structure as microbat overwintering habitat. Baseline microbat monitoring results will also inform roost survey requirements. • In the event that microbats are observed leaving the roost site during the day, works are to cease and the project ecologist to attend site and provide advice. • The contractor would manage the integrity of drainage lines and associated riparian vegetation so as not to constrict microbat flyways. • The contractor would manage water quality and velocity of the adjoining waterways to be maintained in accordance with the EPL issued for the project.	491853	6598434
25	47520	Quarry access overpass bridge	New bridge	0.00	No	N	N/A	Low	New bridge over highway upgrade alignment	Not required	49188	6598448
26	47500	New Scott's Head quarry cattle underpass	Cattle underpass - single cell box culvert	2.10	No	N	N/A	Low	New culvert under highway upgrade alignment	Not required	491869	6598423

Structure ID	Chainage	Location	Structure description	Approx. size (m - height or diameter)	Evidence of microbat use	Microbats recorded during 2016 overwinter monitoring (Y/N)	Species	Conservation Value as Overwintering Habitat (Based on Section 2 of MBMS Lewis 2014)	Occurring within 200 m of the Project	Mitigation required	Easting	Northing
27	47020	Crouches/ Wiliamson Creek Bridge	Existing bridge	0.00	Staining and microbats observed	Y	25 Probable Large-footed Myotis (*M. macropus*)	**High**	Yes	• Qualified Ecologist to perform pre-clearing surveys to assess if bats are using the structure before planned works within 200m of structure (This has been satisfied as part of overwintering and previous monitoring of structures). • Should works be required on the structure itself or high impact works within 100 m of the structure, the project ecologist must be consulted. • Microbat roost monitoring will be undertaken during construction to evaluate the response of microbats to a range of construction activities. This will involve surveys of all structures in winter in accordance with the *Microchiropteran Bat Management Strategy* during construction to update the status of each structure as microbat overwintering habitat. Baseline microbat monitoring results will also inform roost survey requirements. • In the event that microbats are observed leaving the roost site during the day, works are to cease and the project ecologist to attend site and provide advice. • The contractor would manage the integrity of drainage lines and associated riparian vegetation so as not to constrict microbat flyways. • The contractor would manage water quality and velocity of the adjoining waterways to be maintained in accordance with the EPL issued for the project.	491577	6598035
28	46450	Existing cattle underpass (ID599222) Albert Drive	Cattle underpass - twin cell box culvert	2.40	No	Y	N/A	Moderate	Yes	• Qualified Ecologist to perform pre-clearing surveys to assess if bats are using the structure before planned works within 200m of structure (This has been satisfied as part of overwintering and previous monitoring of structures). • Should works be required on the structure itself or high impact works within 100 m of the structure, the project ecologist must be consulted. • Microbat roost monitoring will be undertaken during construction to evaluate the response of microbats to a range of construction activities. This will involve surveys of all structures in winter in accordance with the *Microchiropteran Bat Management Strategy* during construction to update the status of each structure as microbat overwintering habitat. Baseline microbat monitoring results will also inform roost survey requirements. • In the event that microbats are observed leaving the roost site during the day, works are to cease and the project ecologist to attend site and provide advice. • The contractor would manage the integrity of drainage lines and associated riparian vegetation so as not to constrict microbat flyways. • The contractor would manage water quality and velocity of the adjoining waterways to be maintained in accordance with the EPL issued for the project.	491190	6597626
29	46450	New cattle underpass Albert Drive	Cattle underpass - single cell box culvert	2.40	No	Y	N/A	Moderate	New culvert under highway upgrade alignment	• Qualified Ecologist to perform pre-clearing surveys to assess if bats are using the structure before planned works within 200m of structure (This has been satisfied as part of overwintering and previous monitoring of structures).	491239	6597590

Structure ID	Chainage	Location	Structure description	Approx. size (m - height or diameter)	Evidence of microbat use	Microbats recorded during 2016 overwinter monitoring (Y/N)	Species	Conservation Value as Overwintering Habitat (Based on Section 2 of MBMS Lewis 2014)	Occurring within 200 m of the Project	Mitigation required	Easting	Northing
										• Should works be required on the structure itself or high impact works within 100 m of the structure, the project ecologist must be consulted. • Microbat roost monitoring will be undertaken during construction to evaluate the response of microbats to a range of construction activities. This will involve surveys of all structures in winter in accordance with the *Microchiropteran Bat Management Strategy* during construction to update the status of each structure as microbat overwintering habitat. Baseline microbat monitoring results will also inform roost survey requirements. • In the event that microbats are observed leaving the roost site during the day, works are to cease and the project ecologist to attend site and provide advice. • The contractor would manage the integrity of drainage lines and associated riparian vegetation so as not to constrict microbat flyways. • The contractor would manage water quality and velocity of the adjoining waterways to be maintained in accordance with the EPL issued for the project.		
30	46150	New Albert Drive overpass bridge	New bridge	0.00	No	N	N/A	Low	New bridge over highway upgrade alignment	Not required	491036	6597358
31	45600	Stoney Creek	Combined fauna & drainage 5 cell box culvert	4.20	No	Y	N/A	Moderate	New culvert under highway upgrade alignment	• Qualified Ecologist to perform pre-clearing surveys to assess if bats are using the structure before planned works within 200m of structure (This has been satisfied as part of overwintering and previous monitoring of structures). • Should works be required on the structure itself or high impact works within 100 m of the structure, the project ecologist must be consulted. • Microbat roost monitoring will be undertaken during construction to evaluate the response of microbats to a range of construction activities. This will involve surveys of all structures in winter in accordance with the *Microchiropteran Bat Management Strategy* during construction to update the status of each structure as microbat overwintering habitat. Baseline microbat monitoring results will also inform roost survey requirements. • In the event that microbats are observed leaving the roost site during the day, works are to cease and the project ecologist to attend site and provide advice. • The contractor would manage the integrity of drainage lines and associated riparian vegetation so as not to constrict microbat flyways. • The contractor would manage water quality and velocity of the adjoining waterways to be maintained in accordance with the EPL issued for the project.	490880	6596853
32	45300	New Rosewood Road overpass bridge	New bridge	0.00	No	N	N/A	Low	New bridge over highway upgrade alignment	Not required	490860	6596519
33	44900	Rosewood Creek	Drainage single box culvert	1.70	No	Y	N/A	Moderate	New culvert under highway upgrade	• Qualified Ecologist to perform pre-clearing surveys to assess if bats are using the structure before planned works within 200m of	490730	6596113

Structure ID	Chainage	Location	Structure description	Approx. size (m - height or diameter)	Evidence of microbat use	Microbats recorded during 2016 overwinter monitoring (Y/N)	Species	Conservation Value as Overwintering Habitat (Based on Section 2 of MBMS Lewis 2014)	Occurring within 200 m of the Project	Mitigation required	Easting	Northing
									alignment	structure (This has been satisfied as part of overwintering and previous monitoring of structures). • Should works be required on the structure itself or high impact works within 100 m of the structure, the project ecologist must be consulted. • Microbat roost monitoring will be undertaken during construction to evaluate the response of microbats to a range of construction activities. This will involve surveys of all structures in winter in accordance with the *Microchiropteran Bat Management Strategy* during construction to update the status of each structure as microbat overwintering habitat. Baseline microbat monitoring results will also inform roost survey requirements. • In the event that microbats are observed leaving the roost site during the day, works are to cease and the project ecologist to attend site and provide advice. • The contractor would manage the integrity of drainage lines and associated riparian vegetation so as not to constrict microbat flyways. • The contractor would manage water quality and velocity of the adjoining waterways to be maintained in accordance with the EPL issued for the project.		
34	44480	Rosewood Tributary	Drainage 3 cell pipe culvert	1.70	Microbat present	Y	1 Large-footed Myotis (*M. macropus*)	Moderate	New culvert under highway upgrade alignment	• Qualified Ecologist to perform pre-clearing surveys to assess if bats are using the structure before planned works within 200m of structure (This has been satisfied as part of overwintering and previous monitoring of structures). • Should works be required on the structure itself or high impact works within 100 m of the structure, the project ecologist must be consulted. • Microbat roost monitoring will be undertaken during construction to evaluate the response of microbats to a range of construction activities. This will involve surveys of all structures in winter in accordance with the *Microchiropteran Bat Management Strategy* during construction to update the status of each structure as microbat overwintering habitat. Baseline microbat monitoring results will also inform roost survey requirements. • In the event that microbats are observed leaving the roost site during the day, works are to cease and the project ecologist to attend site and provide advice. • The contractor would manage the integrity of drainage lines and associated riparian vegetation so as not to constrict microbat flyways. • The contractor would manage water quality and velocity of the adjoining waterways to be maintained in accordance with the EPL issued for the project.	490483	6595774
35	43340	Butchers Creek	Combined fauna & drainage 5 cell box culvert	3.00	Yes microbats recorded in southern and middle cells	Y	2 Eastern Bent-wing Bats (*M. oceanensis*)	Moderate	New culvert under highway upgrade alignment	• Qualified Ecologist to perform pre-clearing surveys to assess if bats are using the structure before planned works within 200m of structure (This has been satisfied as part of overwintering and previous monitoring of structures). • Should works be required on the structure itself or high impact works within 100 m of the structure, the project ecologist must be	489805	6594909

Structure ID	Chainage	Location	Structure description	Approx. size (m - height or diameter)	Evidence of microbat use	Microbats recorded during 2016 overwinter monitoring (Y/N)	Species	Conservation Value as Overwintering Habitat (Based on Section 2 of MBMS Lewis 2014)	Occurring within 200 m of the Project	Mitigation required	Easting	Northing
										consulted. • Microbat roost monitoring will be undertaken during construction to evaluate the response of microbats to a range of construction activities. This will involve surveys of all structures in winter in accordance with the *Microchiropteran Bat Management Strategy* during construction to update the status of each structure as microbat overwintering habitat. Baseline microbat monitoring results will also inform roost survey requirements. • In the event that microbats are observed leaving the roost site during the day, works are to cease and the project ecologist to attend site and provide advice. • The contractor would manage the integrity of drainage lines and associated riparian vegetation so as not to constrict microbat flyways. • The contractor would manage water quality and velocity of the adjoining waterways to be maintained in accordance with the EPL issued for the project.		
36	42970	New Cockburns Lane overpass bridge	New bridge	0.00	Nil	N	N/A	Low	New bridge over highway upgrade alignment	Not required	489602	6594608
37	47150	Deadman's Gully (ID599205)	Drainage single cell pipe culvert	3.00	Microbats present	Y	~400 Eastern Bent-wing Bats (*M. oceanensis*)	**High**	Yes	• Qualified Ecologist to perform pre-clearing surveys to assess if bats are using the structure before planned works within 200m of structure (This has been satisfied as part of overwintering and previous monitoring of structures). • Should works be required on the structure itself or high impact works within 100 m of the structure, the project ecologist must be consulted. • Microbat roost monitoring will be undertaken during construction to evaluate the response of microbats to a range of construction activities. This will involve surveys of all structures in winter in accordance with the *Microchiropteran Bat Management Strategy* during construction to update the status of each structure as microbat overwintering habitat. Baseline microbat monitoring results will also inform roost survey requirements. • In the event that microbats are observed leaving the roost site during the day, works are to cease and the project ecologist to attend site and provide advice. • The contractor would manage the integrity of drainage lines and associated riparian vegetation so as not to constrict microbat flyways. • The contractor would manage water quality and velocity of the adjoining waterways to be maintained in accordance with the EPL issued for the project.	488463	659364

(ID) = Structure ID name as identified in WC2NH Microchiropteran Bat Management Strategy (Lewis Ecological, 2014)

Mitigation measures are prescribed for structures where occupation or evidence of use by microbats have been recorded during baseline monitoring (Lewis, 2014) and Overwintering Structures Monitoring 2016 & 2017 (GeoLINK).

Stucture ID 599229 South of Upper Warrell Creek Road was not surveyed due to inaccessibility. Both the inlet and outlet were constricted by dense Lantana and therefore considered to very low potential for use by microbats.

Appendix B

Microbat Overwintering Structure Locations

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: JOL Date: 11/07/2017
Source of base data: RMS & AFJV

LEGEND

- Site Boundary
- Clearing Limit
- Microbat overwintering structures

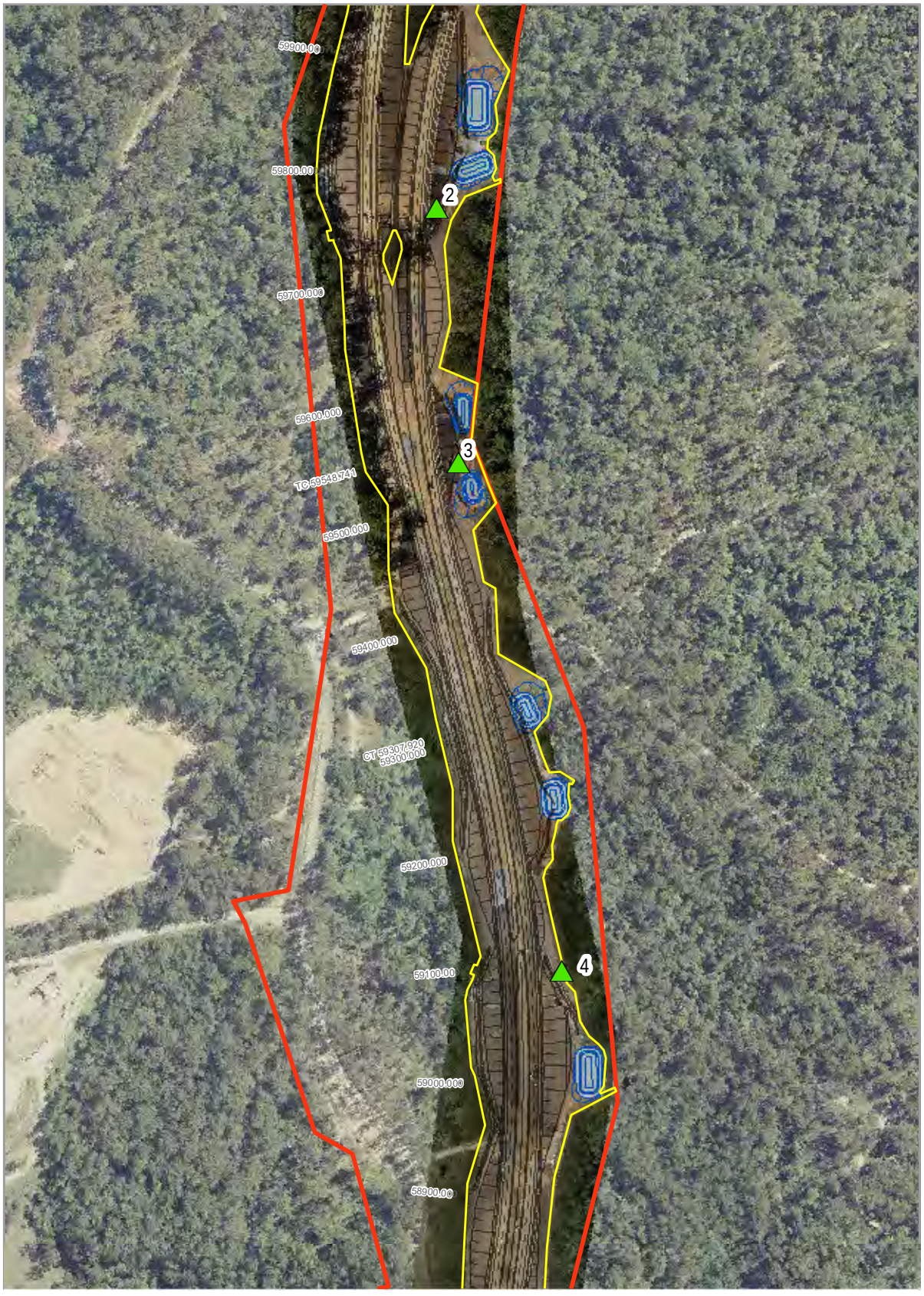
0 100

North

Microbat Overwintering Structures

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: JOL Date: 11/07/2017
Source of base data: RMS & AFJV



LEGEND

- Site Boundary
- Clearing Limit
- Microbat overwintering structures

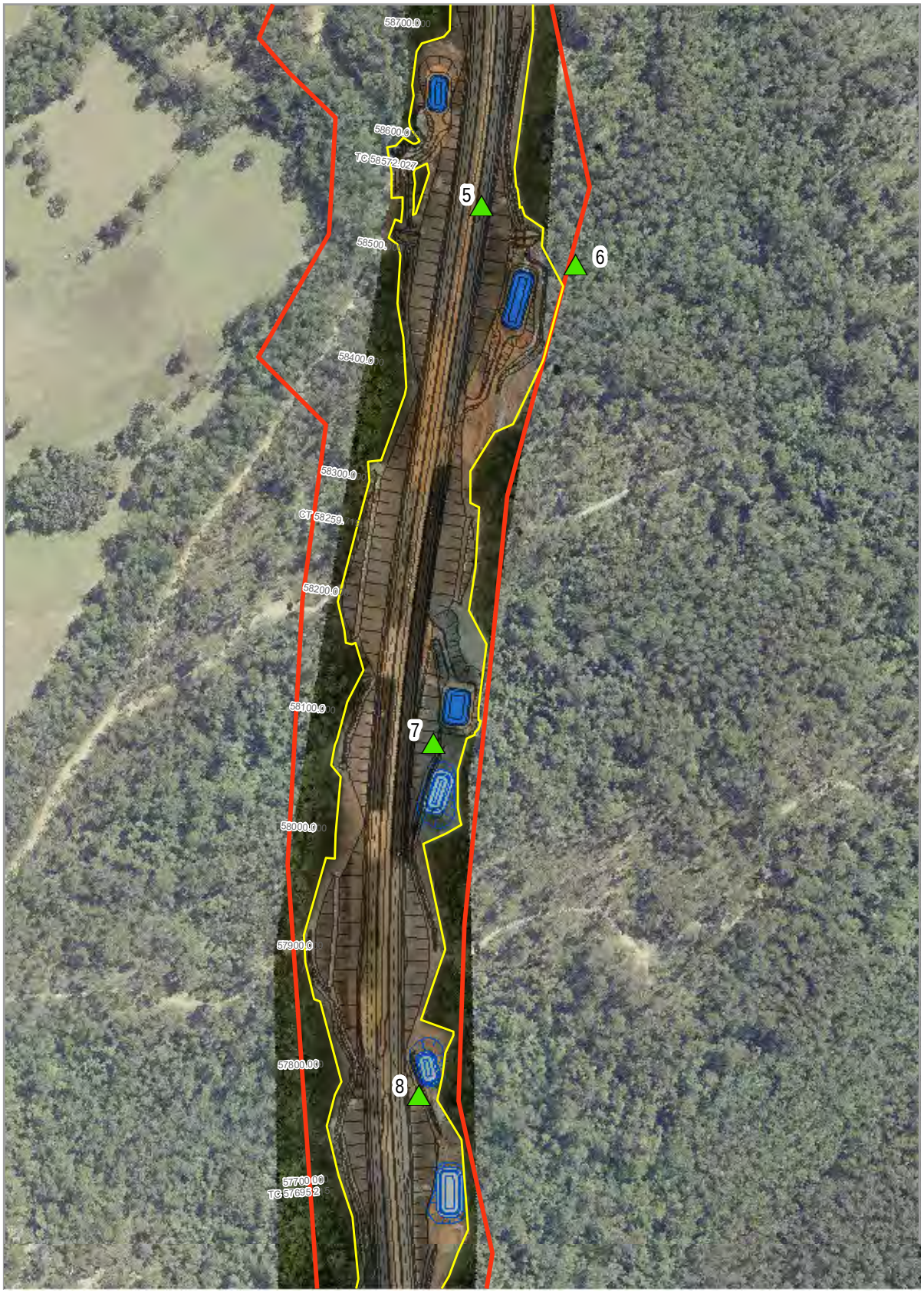
0 100

North

Microbat Overwintering Structures

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: JOL Date: 11/07/2017
Source of base data: RMS & AFJV



LEGEND

- Site Boundary
- Clearing Limit
- Microbat overwintering structures

0 100

North

Microbat Overwintering Structures

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: JOL Date: 11/07/2017
Source of base data: RMS & AFJV

LEGEND

- Site Boundary
- Clearing Limit
- Microbat overwintering structures

0 100

North

Microbat Overwintering Structures

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Drawn by: AB Checked by: RE Reviewed by: JOL Date: 11/07/2017
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LEGEND

- Site Boundary
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0 100

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Microbat Overwintering Structures

Information shown is for illustrative purposes only

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- Site Boundary
- Clearing Limit
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0 100

North

Microbat Overwintering Structures

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LEGEND

- Site Boundary
- Clearing Limit
- Microbat overwintering structures

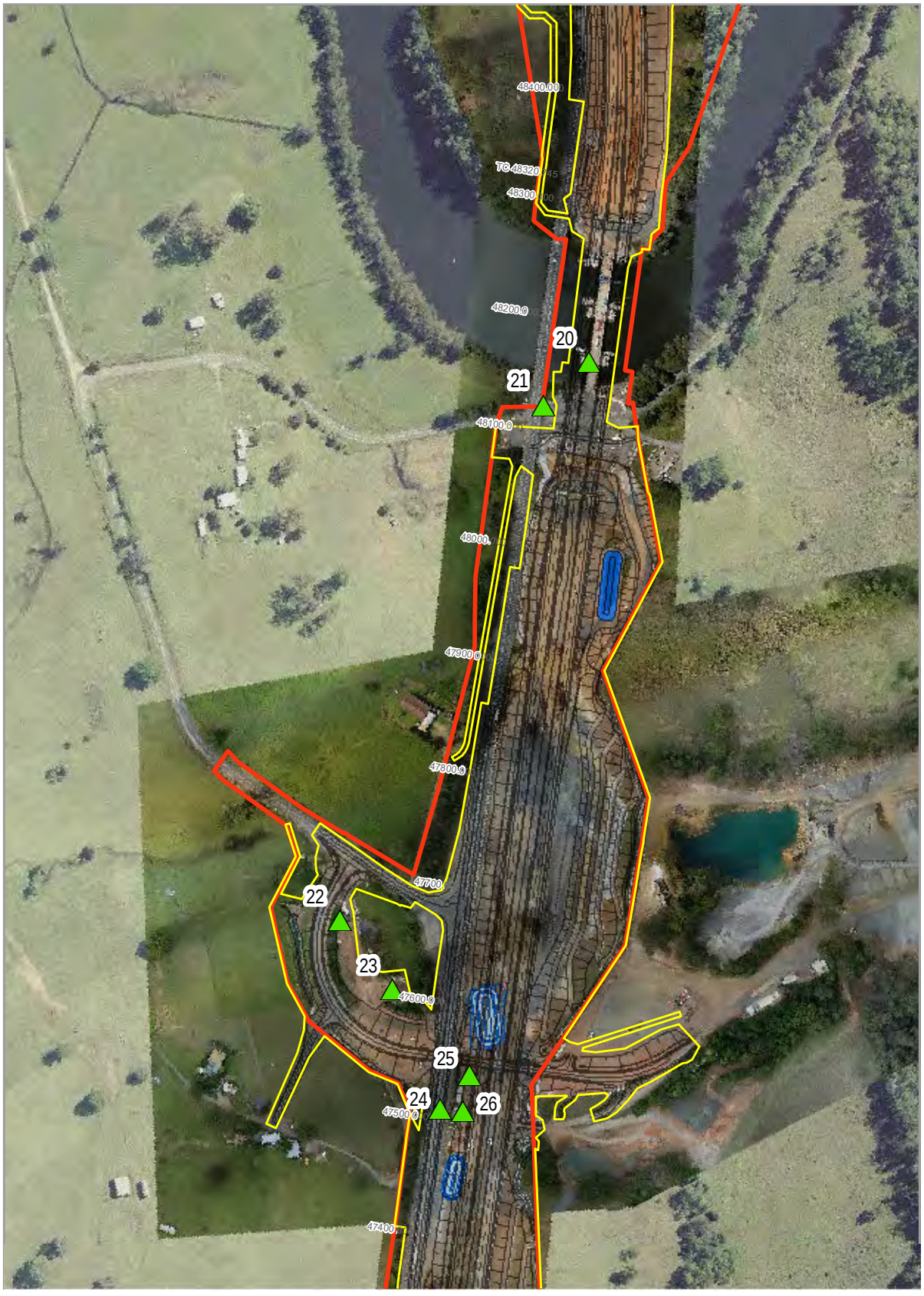
0 100

North

Microbat Overwintering Structures

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: JOL Date: 11/07/2017
Source of base data: RMS & AFJV



LEGEND

- Site Boundary
- Clearing Limit
- Microbat overwintering structures

0 100

North

Microbat Overwintering Structures

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: JOL Date: 11/07/2017
Source of base data: RMS & AFJV

LEGEND

- Site Boundary
- Clearing Limit
- Microbat overwintering structures

0 100

North

Microbat Overwintering Structures

Information shown is for illustrative purposes only

LEGEND

- Site Boundary
- Clearing Limit
- Microbat overwintering structures

0 100

North

Microbat Overwintering Structures

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: JOL Date: 11/07/2017
Source of base data: RMS & AFJV

LEGEND

- Site Boundary
- Clearing Limit
- Microbat overwintering structures

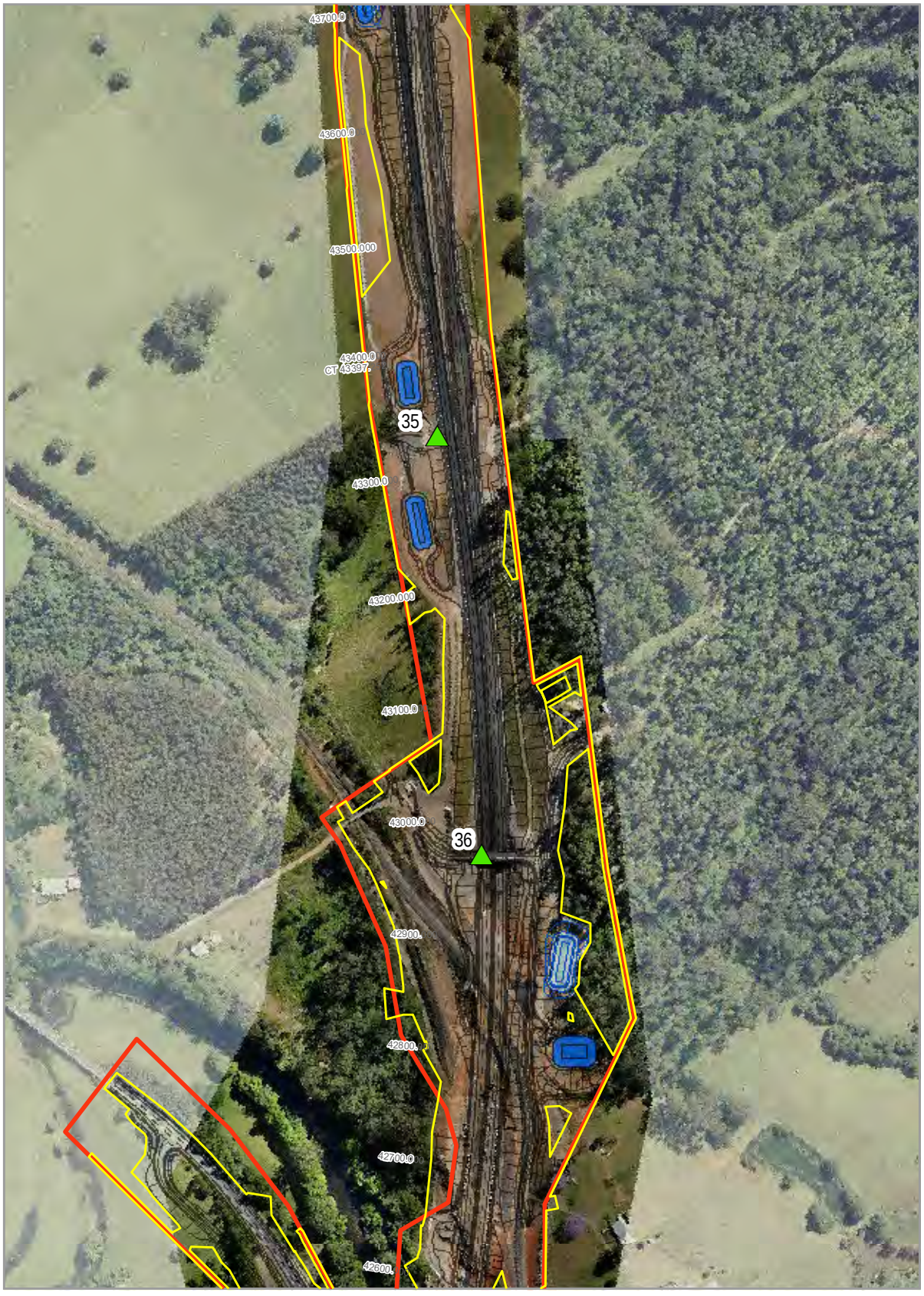
0 100

North

Microbat Overwintering Structures

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: JOL Date: 11/07/2017
Source of base data: RMS & AFJV



LEGEND

- Site Boundary
- Clearing Limit
- Microbat overwintering structures

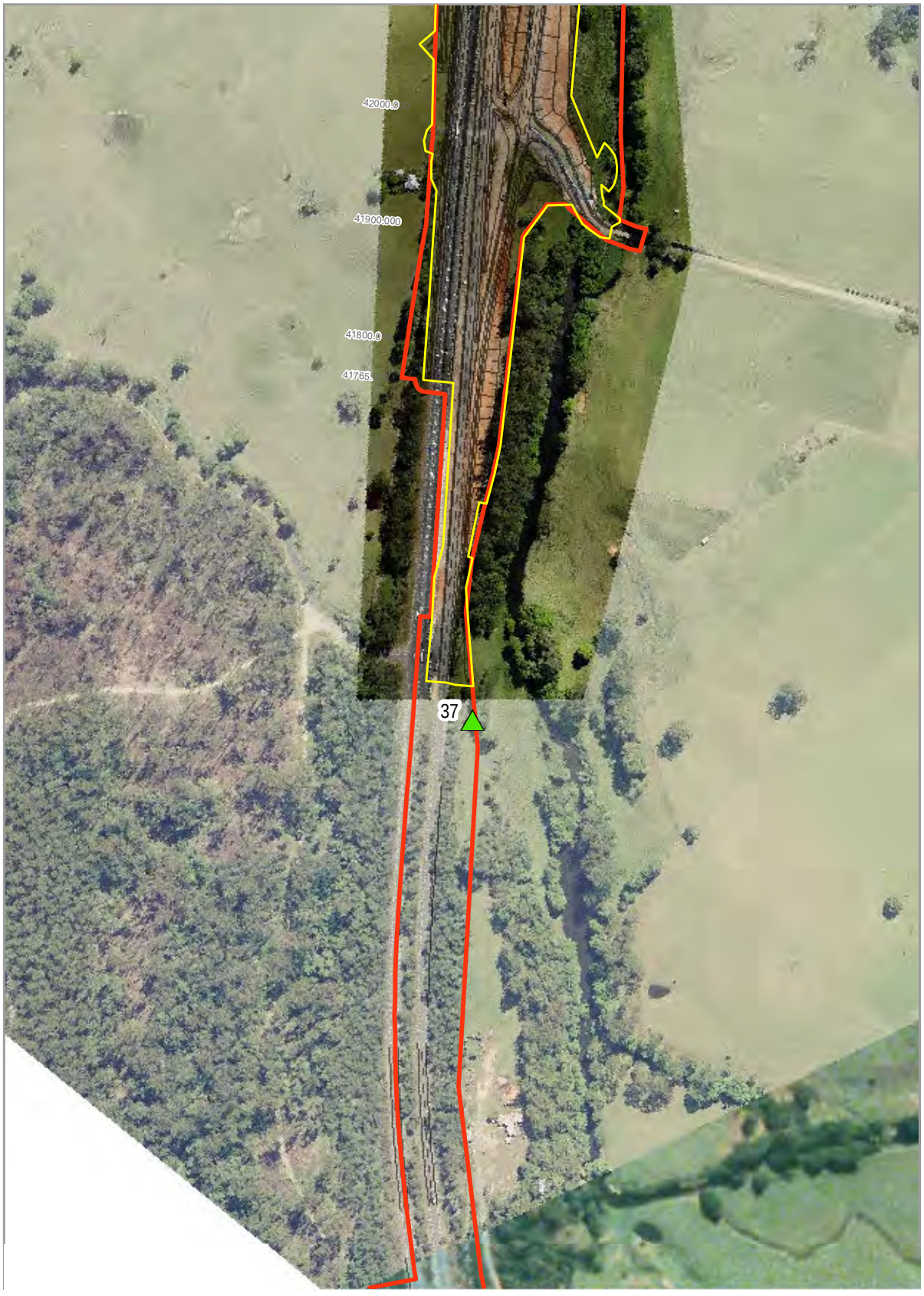
0 100

North

Microbat Overwintering Structures

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: JOL Date: 11/07/2017
Source of base data: RMS & AFJV



LEGEND

- Site Boundary
- Clearing Limit
- Microbat overwintering structures

0 100

North

Microbat Overwintering Structures

Appendix D

Nest Box Monitoring Summer 2018 and Annual Report

GeoLINK
environmental management and design

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1 February 2018
Ref No.: 2378-1409

PACIFICO
124 Albert Drive
DONNELLYVILLE NSW 2447

Attention: Alex Dwyer

Dear Alex

Nest Box Monitoring Report, Summer 2018 and Annual Results Comparison - Warrell Creek to Nambucca Heads Pacific Highway Upgrade

1. Introduction

GeoLINK has been engaged by PACIFICO to undertake nest box (NB) monitoring as part of the Warrell Creek to Nambucca Heads (WC2NH) Pacific Highway Upgrade. This report provides the results of the fourth nest box monitoring event since the installation of the nest boxes in June 2016. Monitoring and maintenance was undertaken between 8 and 16 January 2018 by GeoLINK Ecologist Jessica O'Leary.

Three years of bi-annual (winter/summer – six events in total) monitoring is required in accordance with the *WC2U Nest Box Management Plan* (NBMP - Lewis 2014). It is expected that only two years of bi-annual monitoring will take place during the construction phase of the project due to the project completion forecast for April 2018. This makes the summer 2018 monitoring event potentially the last monitoring event undertaken as part of the construction monitoring contract facilitated by PACIFICO. A 13 kilometre section of the highway alignment from Nambucca Heads to Scotts Head Road has been opened and is now operational for public traffic use.

A total of 143 nest boxes have been installed as part of the WC2NH construction in accordance with the NBMP and were inspected during the summer 2018 monitoring. The general location of the nest boxes is displayed in **Illustration 1.1**. Global Positioning System coordinates for the nest boxes are provided within **Attachment A.**

2. Background

GeoLINK was engaged by PACIFICO to undertake the installation of 60 per cent of the nominated nest boxes required for the WC2NH Pacific Highway Upgrade. The *Nest Box Management Plan* (NBMP) requires that 92 of a total of 152 NBs (60 per cent) are installed prior to or during vegetation clearing operations to provide temporary refuge for hollow-dependent fauna displaced during clearing operations. The installation of the initial 60 per cent of nest boxes was undertaken over six days

between 26 November and 11 December 2014. GeoLINK supervised the installation of the nest boxes, undertaken by experienced tree climbers from George's Tree Services. Each nest box was assigned a specific code depending on box type and the number of boxes required. For example, SF1.1 denotes box type 1, designed for scansorial mammals and .1 denotes 1 of 11 SF boxes allocated for installation. Refer to GeoLINK's WC2NH Pre-Clearing Nest Box Installation Report (ref. 2378-1085) for details of pre-clearing NB installation.

All mainline clearing including the area for the north facing ramps (NFRs) has now been completed.

In addition to the 135 NBs installed for pre and post clearing, as per the initial NB calculations and number required (Lewis, 2014), an additional eight (8) NBs were installed in December 2016 to capture the final clearing quantities and habitat trees removed for the NFRs and other small areas of clearing. These boxes were placed in both the existing or new Nest Box Replacement Zones (NBRZs) in compliance with the NBMP. Details were provided to Pacifico (20/12/2016) in the *WC2NH – Final Nest Box Installation Report: Final Calculations* (Geolink, 2016).

A total of 143 nest boxes were inspected during the summer 2017, winter 2017 and summer 2018 monitoring events.

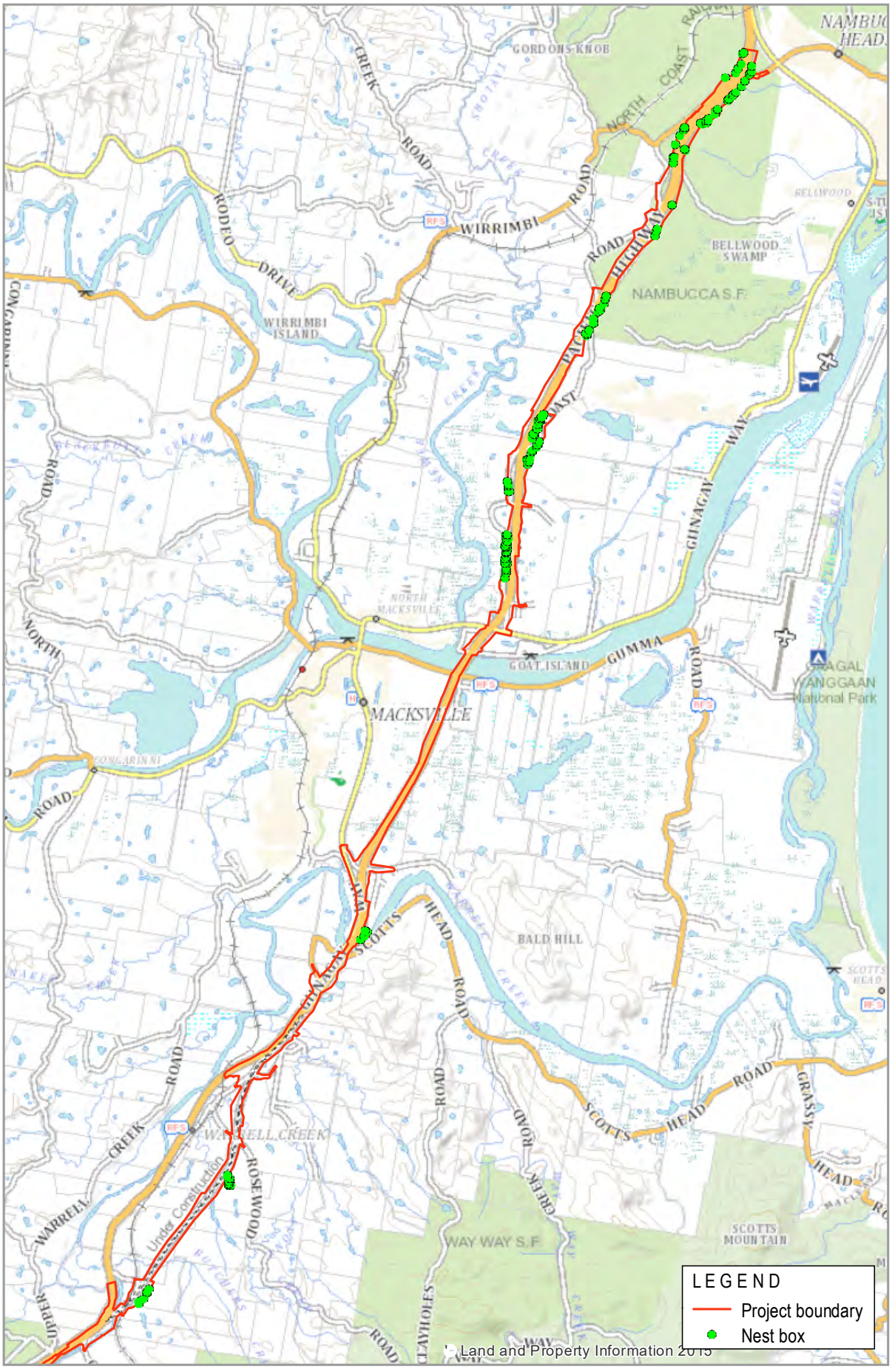
3. Methods

Nest box inspections included:

Direct observations by professional tree climbers: This was the predominant method of inspection due to the high position of nest boxes as per the NBMP (Lewis 2014). All nest boxes are positioned 5 - 12 metres above ground level. Tree climbers looked directly into the boxes, took a photograph and passed the camera to the ecologist for assessment. Once nest boxes were determined to be empty, closer observations were made of the nest boxes to search for potential signs of fauna occupancy. If the box was occupied and maintenance or handling of fauna was required, the boxes were lowered to the ground, checked and then reinstated.

Information shown is for illustrative purposes only

Drawn by: RE Checked by: RE Reviewed by: JOL Date: 23/01/2018
Source of base data: SIX Maps and AFJV



0 1.5 km

North

Site Context

GeoLINK environmental management and design

Nest Box Monitoring Summer and Annual Report
2017/2018 - WC2NH Pacific Highway Upgrade
2378-1413

Illustration 1.1

Information shown is for illustrative purposes only

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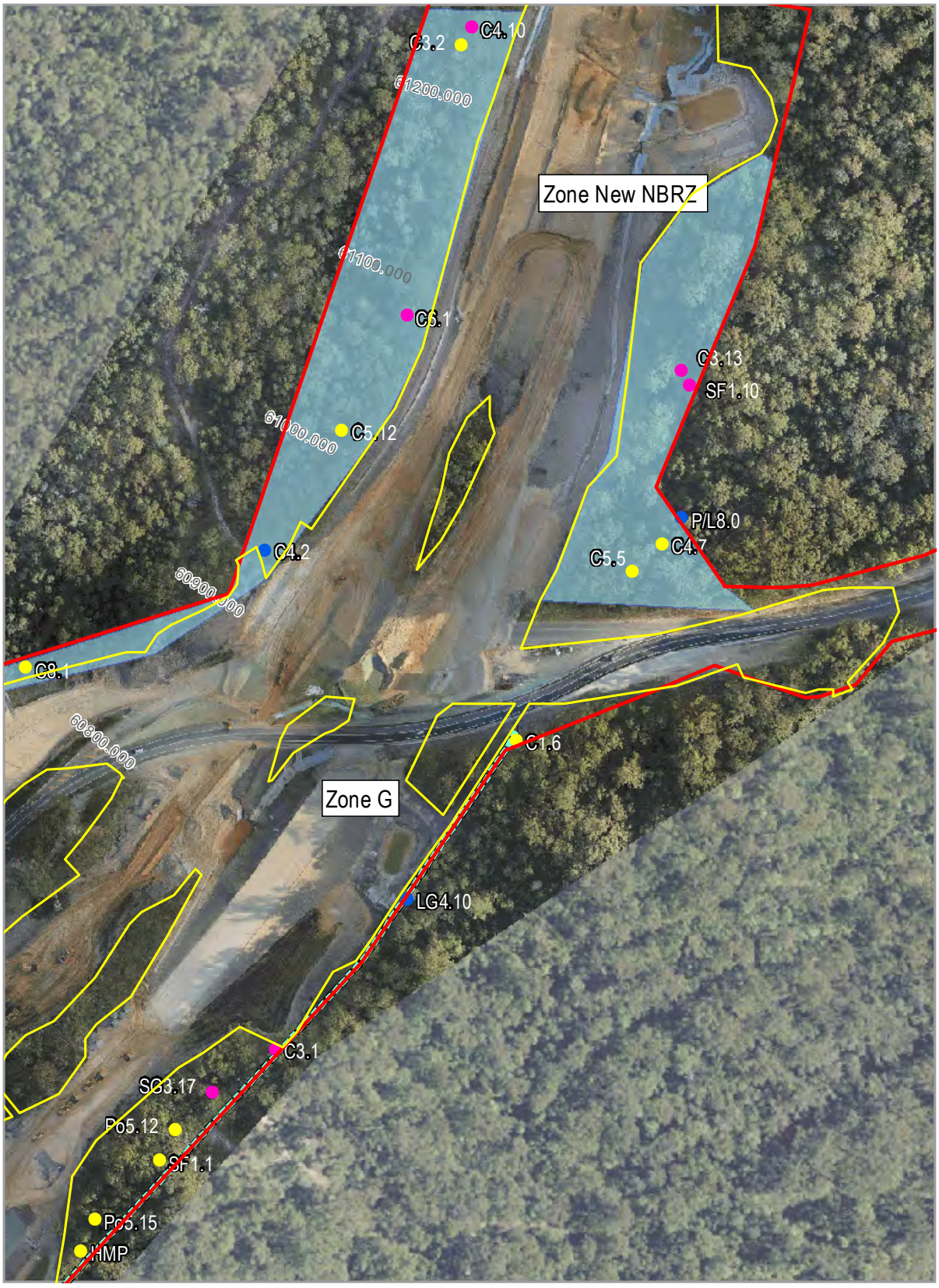
Source of base data: SIX Maps and AFJV



LEGEND

Project boundary
Clearing limit
Nest box replacement zone line
Nest box replacement zone

Nest Box
Not occupied, no evidence of use
Not occupied, evidence of use
Occupied, evidence of use

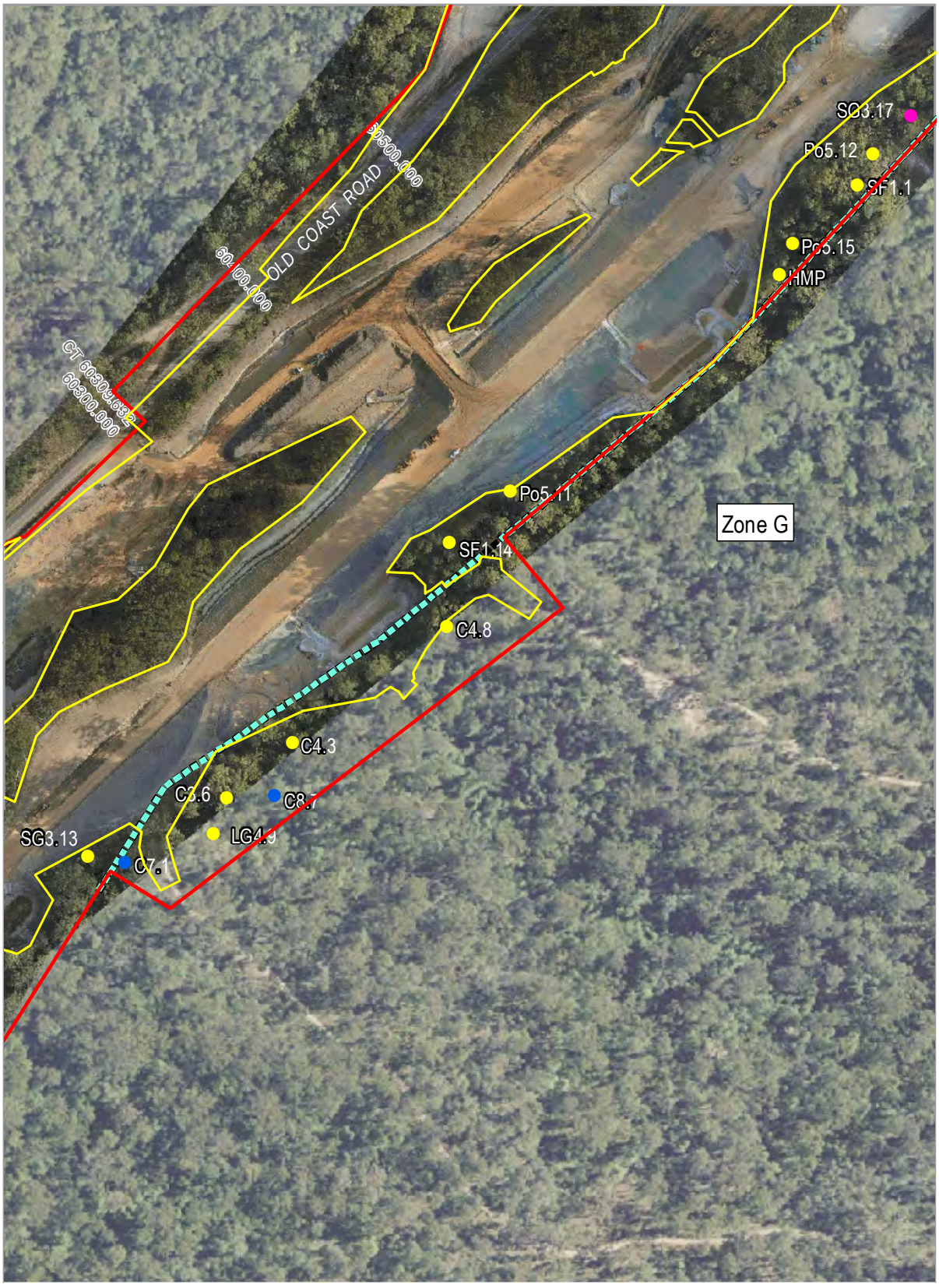
0 60

North

Nest Box Locations and Usage

Information shown is for illustrative purposes only

Drawn by: RE Checked by: RE Reviewed by: JOL Date: 23/01/2018
Source of base data: SIX Maps and AFJV



LEGEND

Project boundary
Clearing limit
Nest box replacement zone line

Nest Box
Not occupied, no evidence of use
Not occupied, evidence of use
Occupied, evidence of use

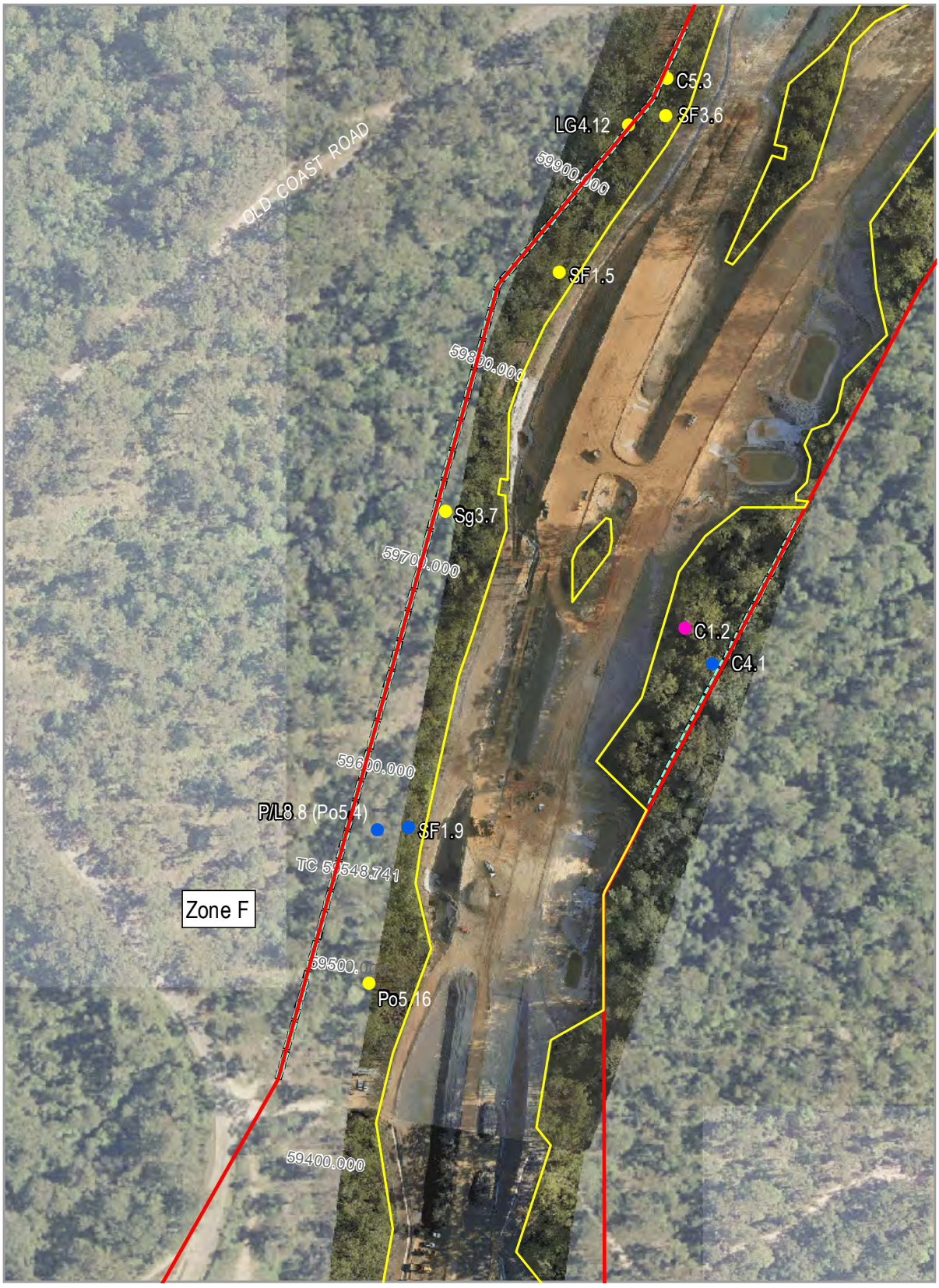
0 60

North

Nest Box Locations and Usage

Information shown is for illustrative purposes only

Drawn by: RE Checked by: RE Reviewed by: JOL Date: 23/01/2018
Source of base data: SIX Maps and AFJV



LEGEND

- Project boundary
- Clearing limit
- Nest box replacement zone line

Nest Box

- Not occupied, no evidence of use
- Not occupied, evidence of use
- Occupied, evidence of use

0 60

North

Nest Box Locations and Usage

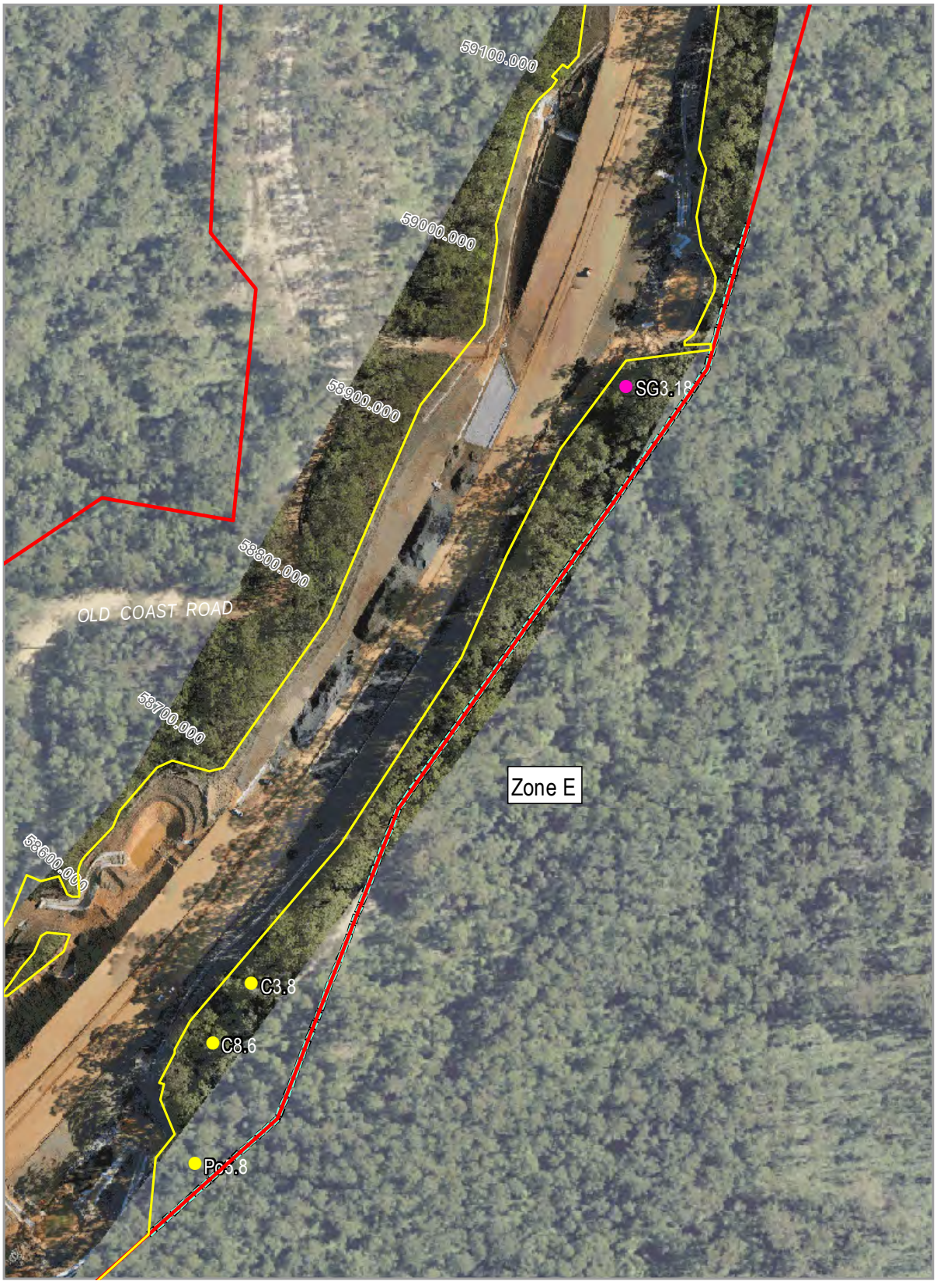
GeoLINK environmental management and design

Nest Box Monitoring – Summer and Annual Report
2017/2018 - WC2NH Pacific Highway Upgrade
2378-1414

Illustration 2.3

Information shown is for illustrative purposes only

Drawn by: RE Checked by: RE Reviewed by: JOL Date: 23/01/2018
Source of base data: SIX Maps and AFJV



LEGEND

Project boundary
Clearing limit
Nest box replacement zone line

Nest Box
Not occupied, evidence of use
Occupied, evidence of use

0 60

North

Nest Box Locations and Usage

GeoLINK environmental management and design

Nest Box Monitoring – Summer and Annual Report
2017/2018 - WC2NH Pacific Highway Upgrade
2378-1414

Illustration 2.4

Information shown is for illustrative purposes only

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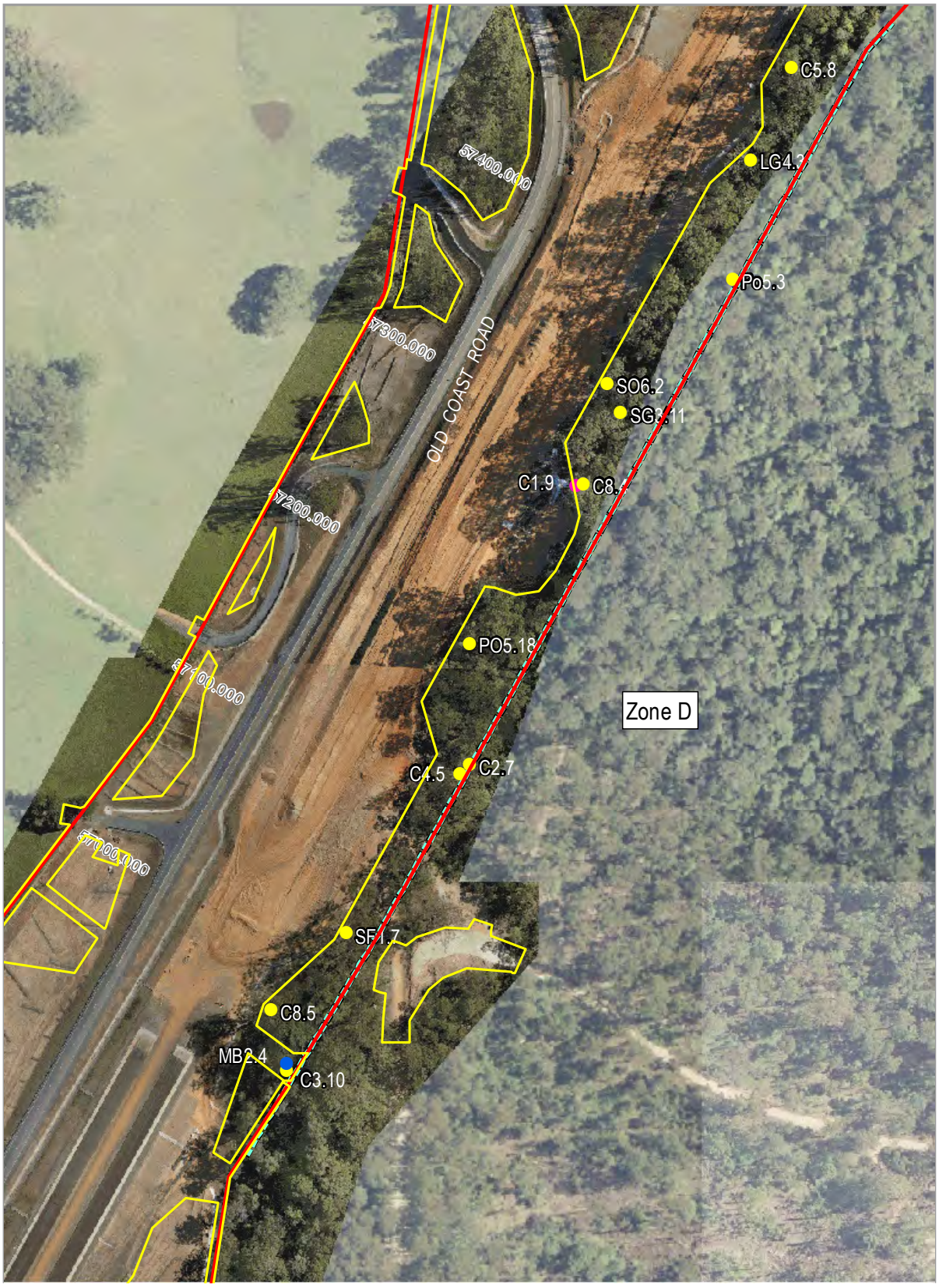
Source of base data: SIX Maps and AFJV



LEGEND

Project boundary
Clearing limit
Nest box replacement zone line

Nest Box
Not occupied, no evidence of use
Not occupied, evidence of use
Occupied, evidence of use

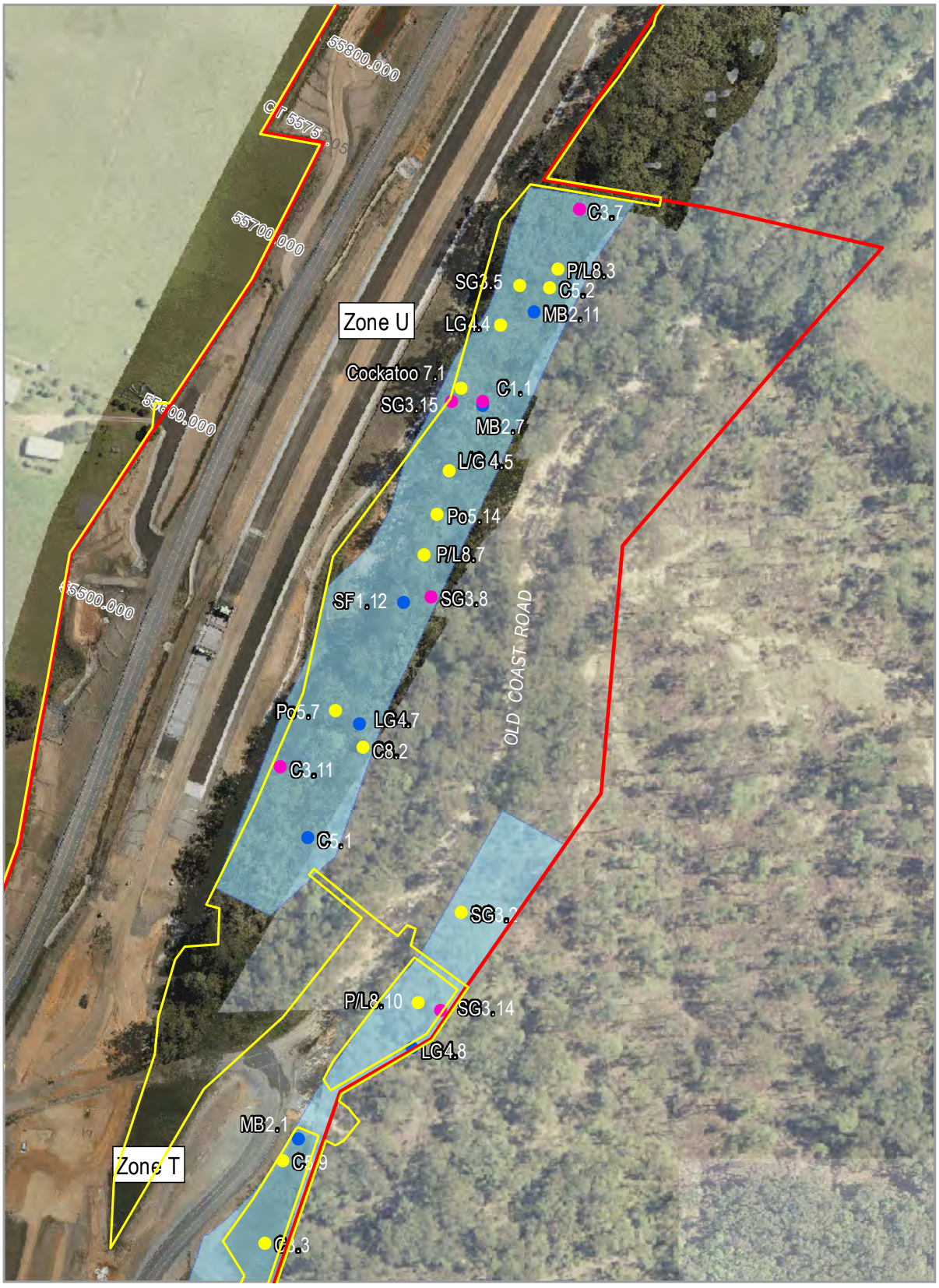
0 60

North

Nest Box Locations and Usage

Information shown is for illustrative purposes only

Drawn by: RE Checked by: RE Reviewed by: JOL Date: 23/01/2018
Source of base data: SIX Maps and AFJV



LEGEND

Project boundary
Clearing limit
Nest box replacement zone

Nest Box
- Not occupied, no evidence of use
- Not occupied, evidence of use
- Occupied, evidence of use

0 60

North

Nest Box Locations and Usage

GeoLINK environmental management and design

Nest Box Monitoring – Summer and Annual Report
2017/2018 - WC2NH Pacific Highway Upgrade
2378-1414

Illustration 2.6

Information shown is for illustrative purposes only

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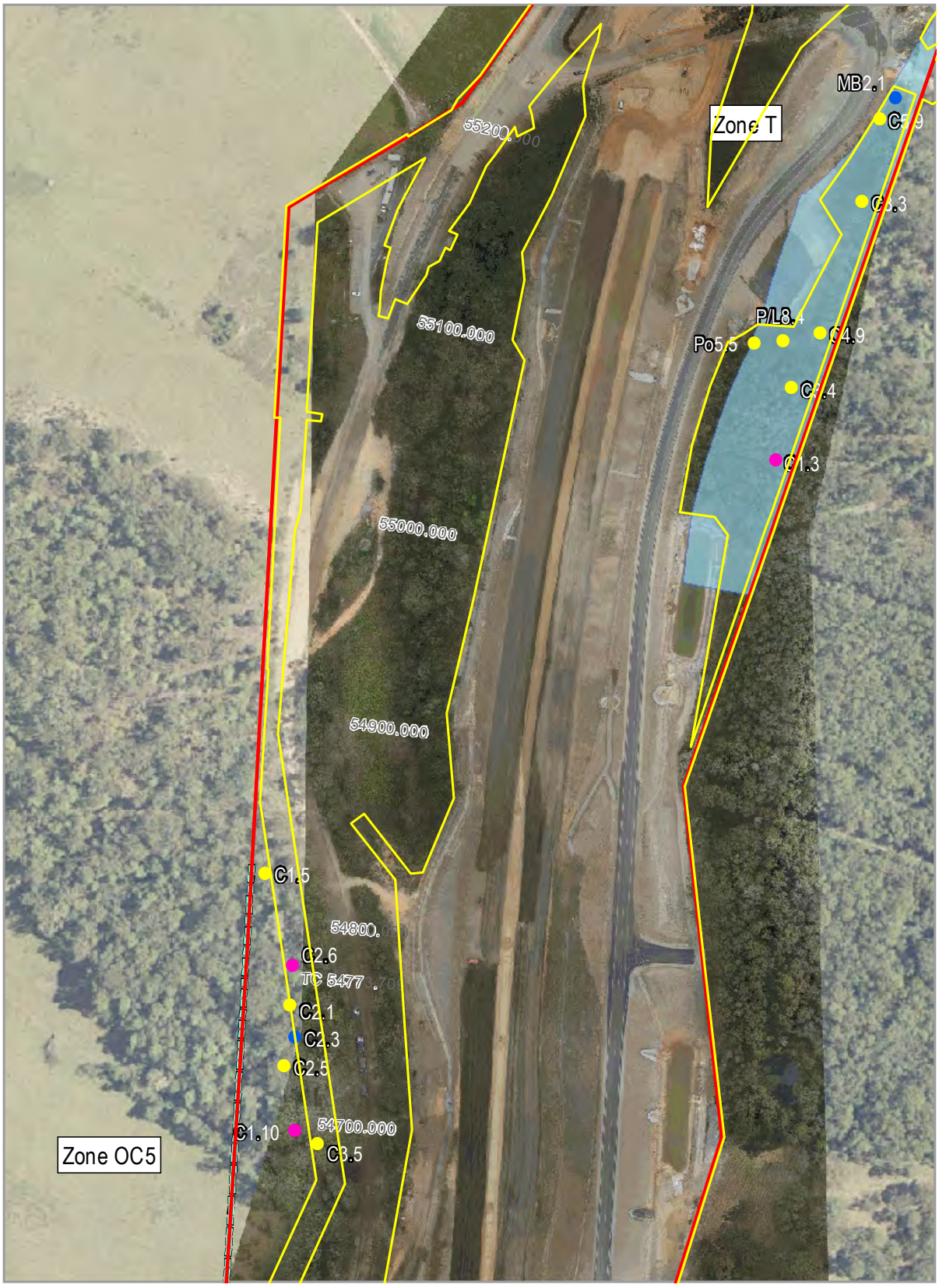
Source of base data: SIX Maps and AFJV



LEGEND

- Project boundary
- Clearing limit
- Nest box replacement zone line
- Nest box replacement zone

Nest Box

- Not occupied, no evidence of use
- Not occupied, evidence of use
- Occupied, evidence of use

0 60

North

Nest Box Locations and Usage

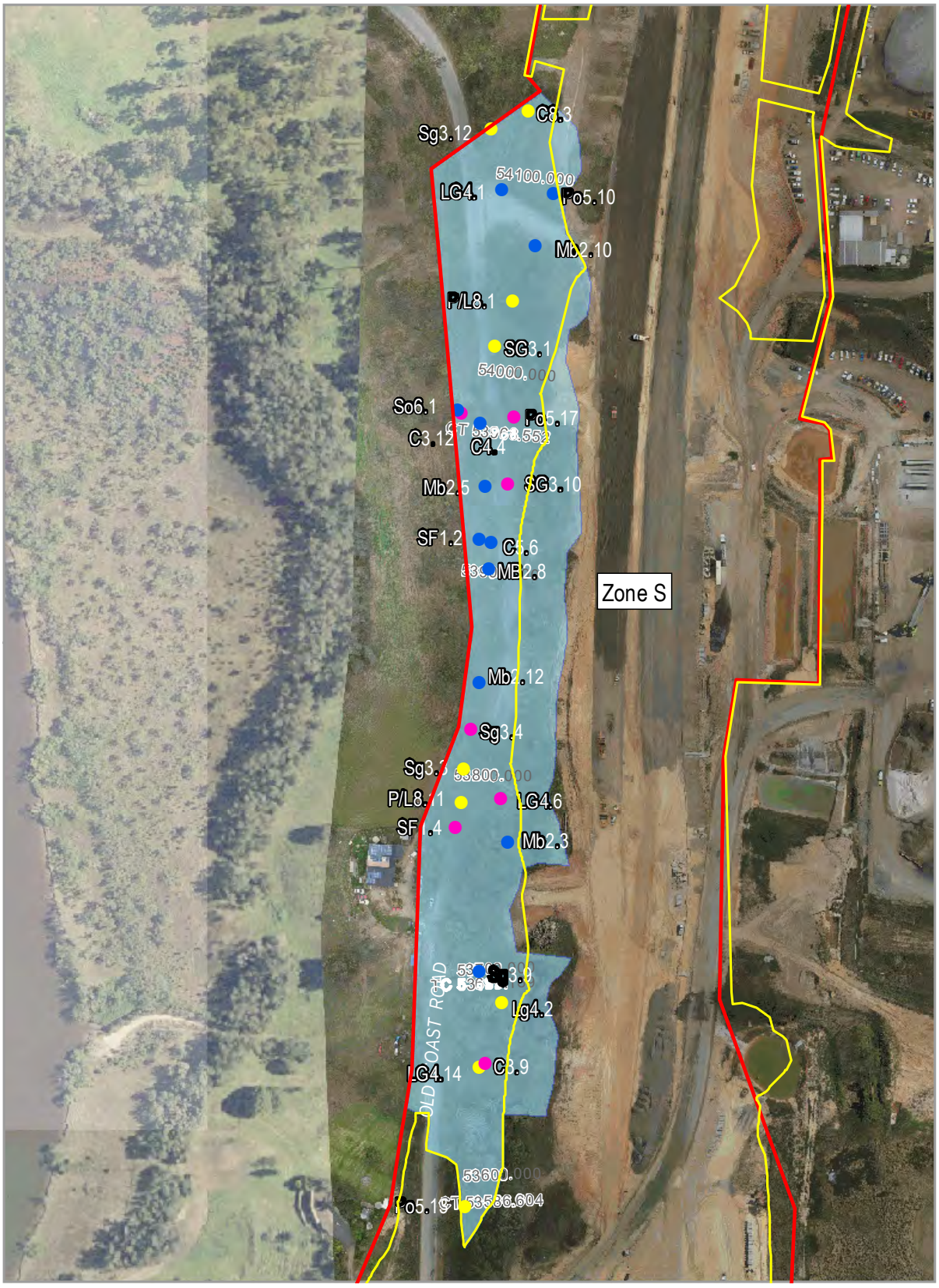
GeoLINK environmental management and design

Nest Box Monitoring – Summer and Annual Report
2017/2018 - WC2NH Pacific Highway Upgrade
2378-1414

Illustration 2.7

Information shown is for illustrative purposes only

Drawn by: RE Checked by: RE Reviewed by: JOL Date: 23/01/2018
Source of base data: SIX Maps and AFJV



LEGEND

- Project boundary
- Clearing limit
- Nest box replacement zone

Nest Box

- Not occupied, no evidence of use
- Not occupied, evidence of use
- Occupied, evidence of use

0 60

North

Nest Box Locations and Usage

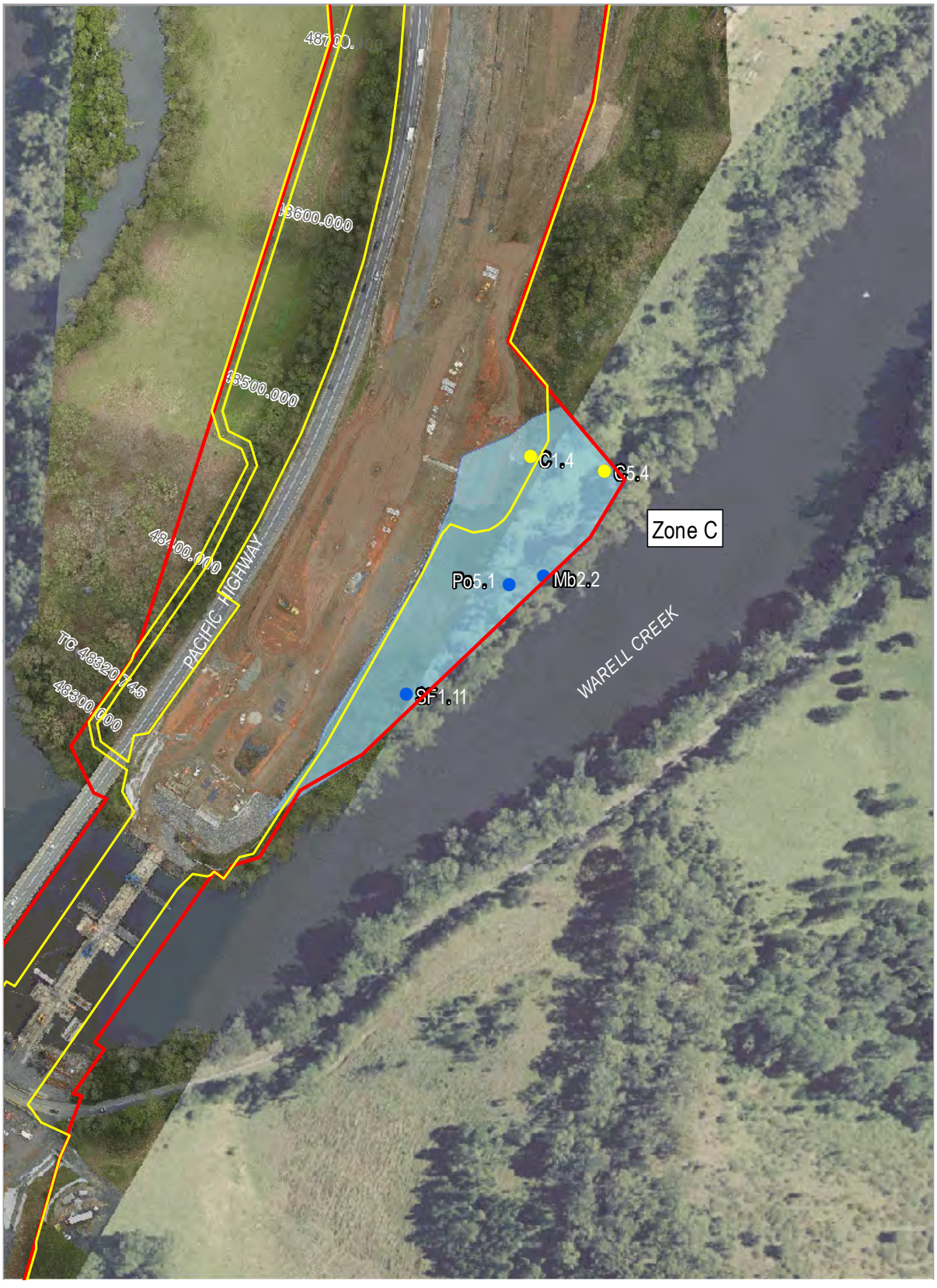
GeoLINK environmental management and design

Nest Box Monitoring – Summer and Annual Report
2017/2018 - WC2NH Pacific Highway Upgrade
2378-1414

Illustration 2.8

Information shown is for illustrative purposes only

Drawn by: RE Checked by: RE Reviewed by: JOL Date: 23/01/2018
Source of base data: SIX Maps and AFJV



LEGEND

Project boundary
Clearing limit
Nest box replacement zone

Nest Box
Not occupied, no evidence of use
Not occupied, evidence of use

0 60

North

Nest Box Locations and Usage

GeoLINK environmental management and design

Nest Box Monitoring – Summer and Annual Report
2017/2018 - WC2NH Pacific Highway Upgrade
2378-1414

Illustration 2.9

Information shown is for illustrative purposes only

Drawn by: RE Checked by: RE Reviewed by: JOL Date: 23/01/2018
Source of base data: SIX Maps and AFJV

LEGEND

Project boundary
Clearing limit
Nest box replacement zone

Nest Box
Not occupied, no evidence of use
Not occupied, evidence of use

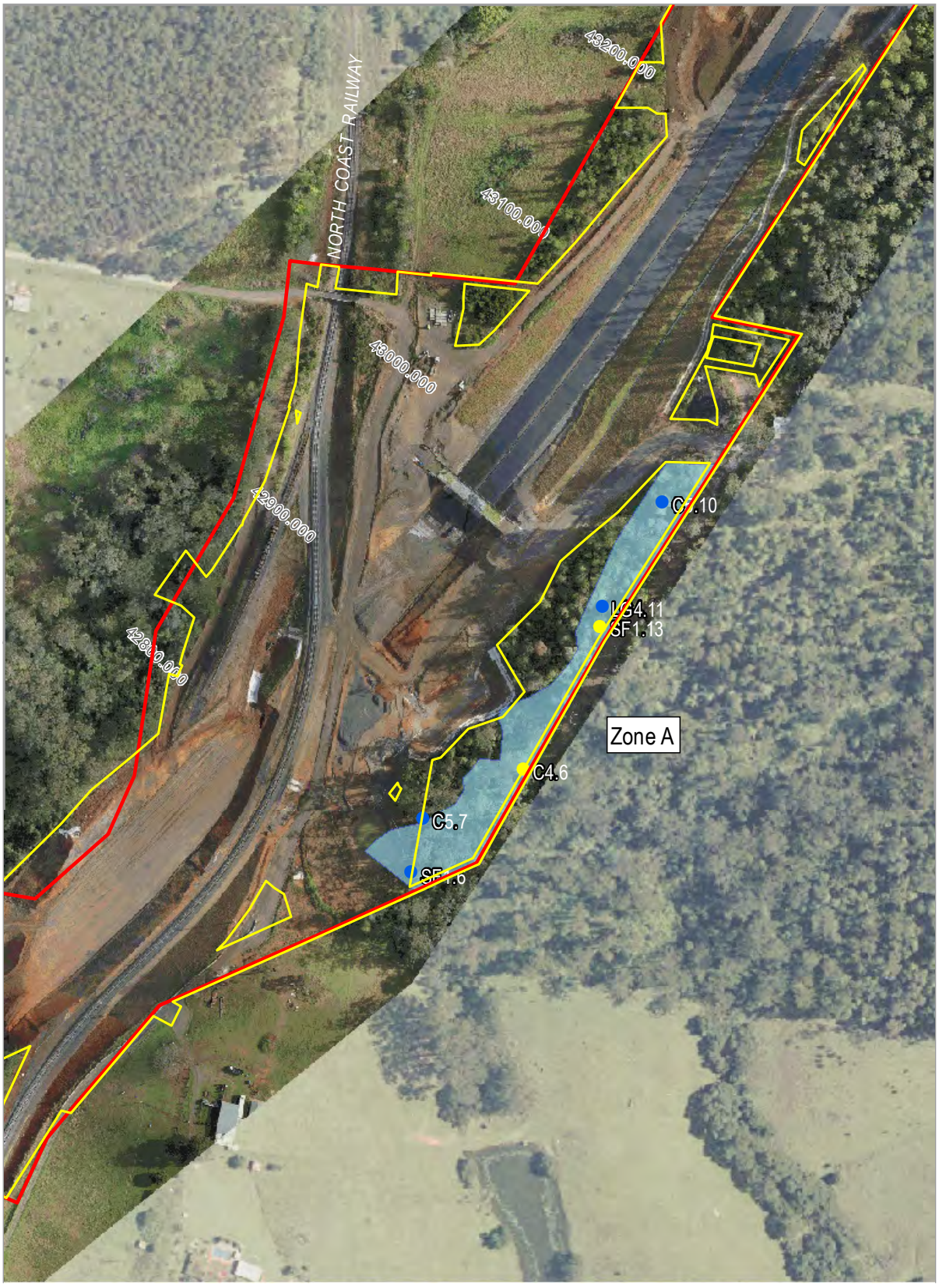
0 60

North

Nest Box Locations and Usage

Information shown is for illustrative purposes only

Drawn by: RE Checked by: RE Reviewed by: JOL Date: 23/01/2018
Source of base data: SIX Maps and AFJV



LEGEND

Project boundary
Clearing limit
Nest box replacement zone

Nest Box
Not occupied, no evidence of use
Not occupied, evidence of use

0 60

North

Nest Box Locations and Usage

GeoLINK environmental management and design

- The following data was collected, or checked to be correct, at each nest box:
- Nest box replacement zone
- Box code
- Global Positioning System waypoints
- Installation and inspection date
- Weather conditions (rain, wind, cloud cover percentage, ambient temperature)
- Box occupied? (Y/N)
- Species of fauna present
- Number of individuals, adult or juvenile (if discernible)
- Evidence of use if not occupied (chewings, nesting material, fur, feathers, and scats)
- Evidence of pest species (European bees, Common Myna *Acridotheres tristis*, Starlings *Sturnus vulgaris*, ants)
- Is maintenance/replacement required? (Y/N)
- What maintenance was undertaken?
- Has the surrounding landscape changed? (clearing/partial clearing)
- Could the box be relocated to a better position or area?
- Does the box hold water? Is leaking from the lid occurring?
- Additional comments
- Photo identification number.

General maintenance (e.g. tightening of cables/adjusting for stability, tightening of fixtures, emptying of pooled water and removal of pest invertebrate fauna) was also undertaken when required.

4. Results and Discussion

The results from the fourth nest box monitoring event (i.e. summer 2018) are provided in **Attachment A** and summarised below.

4.1 Native Fauna Occupancy

A total of 26 nest boxes (approximately 18%) were occupied by fauna at the time of monitoring. This is a decrease from the 27% of nest boxes occupied during the winter 2017 monitoring (38 of a total of 143 nest boxes).

Fauna recorded occupying the nest boxes during the summer 2018 monitoring are listed below. **Plates 1.1** to **1.14** show recorded nest box contents or evidence of use by fauna. The results show a moderate diversity of seven native species recorded utilising the nest boxes (three native mammals, one native bird and two native reptile species). Key findings include:

- One mature Common Brushtail Possum (*Trichosurus vulpecula*) was recorded in one nest box (the fourth time recorded in the same box Po5.17).
- Ten boxes recorded evidence of use by birds with the presence of eggs, feathers, bird excrement or a dead juvenile Rainbow Lorikeet (C8.6*, C5.3*, C8.1*, C4.3, C8.4, C8.5, C5.2, Po5.13, Po5.11 and SG3.12) *Contained a single white egg ~25mm long likely Owlet Night-jar (*Aegotheles cristatus*) eggs.
- Active native stingless bee hives (*Tetragonula* or *Austroplebeia* species) were recorded in five nest boxes (SF1.4. C1.3, SG3.14, SG3.17 and SF1.10).
- A minimum of 45 Sugar Gliders (*Petaurus breviceps*) were recorded from 15 separate nest boxes. This is consistent with the winter and summer 2017 and winter 2016 monitoring results where a minimum of 38, 46 and 42 Sugar Gliders were recorded respectively. The Sugar Glider was the most abundant species observed in occupied nest boxes and occupied 57% of all occupied nest

boxes (i.e. 15 of the 26 occupied nest boxes). For comparison, this represents a decrease from the 22 nest boxes Sugar Gliders occupied during the winter 2016 monitoring. Three atrophied likely Sugar Glider carcasses and one significantly decomposed carcass (considered likely to be a Sugar Glider) were observed within four separate boxes. This is consistent with the summer 2017 monitoring event where four Sugar Glider carcasses were recorded across four separate boxes. Eighty-five nest boxes (79.5% of 107) which showed some indication of previous fauna use showed some evidence of use by a glider species as indicated by leafy nesting material.

A total of 107 nest boxes (75% of 143) showed evidence of use by fauna indicated by the presence of animals (9 nest boxes), mammal nesting material (Ringtail Possum/Glider) (87 nest boxes), bird eggs, feathers, excrement and/or nesting material (8 nest boxes), scats (5 nest boxes), scratches (6 nest boxes), fur (3 nest box), native invertebrates (Native Stingless Bees) (5 nest boxes), or chew marks (10 nest boxes) around the entry hole of the box or a combination of these indicators. These results indicate a steady increase from 44%, 57% and 68% if nest box use in winter 2016, summer 2017 and winter 2017 respectively.

No threatened fauna or signs of nest box occupancy by threatened fauna species were recorded. There is potential for threatened species to use the boxes as the home range of confirmed populations of hollow-obligate threatened fauna are known to overlap with the nest box locations. For example, there are known populations of Yellow-bellied Gliders (*Petaurus australis*) in Nambucca State Forest and in the Cockburn Lane area.

It was not possible to determine whether the NBs showing evidence of glider usage was from activity of the threatened Squirrel Glider (*Petaurus norfolcensis*) (listed as Vulnerable under the *Biodiversity Conservation Act 2016),* or of the common Sugar Glider. Only Sugar Gliders have been recorded in the study area and are therefore the most likely species to have used installed NBs.

Plate 1.1 C1.10 (Zone OC5) Four Sugar Gliders in a scansorial mammal box.

Plate 1.2 Box C4.10 (Zone New NBRZ) Lace Monitor beneath abandoned honeycomb in a large Glider box.

Plate 1.3 Box SG3.8 (Zone U) Carpet Python in a Small Glider box.

Plate 1.4 Box LG4.10 (Zone G) Active European bee hive in a large Glider box, recorded each monitoring event since installation. New *Patriot* cattle ear tags attached.

Plate 1.5 Box C3.12 (Zone S) Four Sugar Gliders in a small Glider box.

Plate 1.6 Box SF1.4 (Zone S) Native Stingless Bees in a scansorial mammal box using the wire hole as entry/exit

Plate 1.7 Box Po5.13 (Zone S) Ringtail Possum or bird nest in a Possum box.

Plate 1.8 Box LG4.6 (Zone S) Sugar Glider exiting the large glider box prior to inspection.

Plate 1.9 Box C3.4 (Zone T) Snake uric acid pellet on Glider nesting material in a small Glider box.

Plate 1.10 Box Po5.17 (Zone S) Common Brushtail Possum in Possum box. This box has recorded a Brushtail Possum during the last four monitoring events.

Plate 1.11 Box Cockatoo 7.1 (Zone U) Nesting material in a Cockatoo box and scratched bark on stick indicates use by climbing fauna. This stick was placed inside the box to facilitate access out of the box due to a dead parrot observed inside the box during summer 2017

Plate 1.12 Box C3.7 (Zone U) Fresh leaves brought into small Glider box as glider nesting material.

Plate 1.13 Box SG3.4 (Zone U) Scratches and chew marks on the exterior of the box with Sugar Gliders inside.

Plate 1.14 Box SG3.4 (Zone U) Heavy use of tree trunk which supports Box SG3.4 likely Glider landing pad.

Plate 1.15 Cockatoo Box 7.1 (Zone U) Lid previously damaged by termites - replaced new lid pictured.

4.2 Nest Box Design and Target Species Occupancy

The type of box designs occupied during summer 2018 were as follows:

- Seven Scansorial Mammal boxes were occupied by three Native Stingless Bee hives, three boxes contained Sugar Gliders and one box was occupied by a Feathertail Glider.
- Two microbat boxes were occupied by Sugar Gliders and another by a possible Feathertail Glider (the animal was not clearly viewed).
- Thirteen Small Glider boxes were occupied by ten Sugar Gliders (one of the two target small glider species), two by Native Stingless Bees and one box occupied by a Carpet Python.
- Two Large Glider Boxes contained Sugar Gliders and one box was occupied by a Lace Monitor.
- One Possum box was occupied by a Brushtail Possum.
- One small Cockatoo/Owl box was occupied by a Lace Monitor.

4.3 Bi-Annual Results Comparison (Winter 2016, Summer 2017, Winter 2017 and Summer 2018)

The results from the summer 2018 monitoring event have been compared to the previous (winter 2016, summer 2017 and winter 2017) monitoring results. **Table 1** summarises and compares the results of the four NB monitoring events carried out to date. **Figures 1** and **2** display trends in nest box occupancy and boxes which have recorded evidence of use. **Table 2** lists all species observed occupying boxes for each monitoring period.

The results indicate that occupation rates of the nest boxes has decreased in the current (summer) monitoring event (from 26.5% during winter 2017 down to 18% of nest boxes occupied). However, the number of boxes occupied during summer 2018 is consistent with numbers of boxes occupied during summer of 2017(16.5%). Nest boxes which recorded evidence of use by fauna have continued to increase (from 68.5% in winter 2017 to 75%). For all four monitoring events, the Sugar Glider was the most commonly recorded species. No threatened species have been recorded to date. **Table 1** also shows that the number of active European Bee hives has doubled (from four to eight) with four hives recorded for winter 2017 in comparison with eight hives recorded for the current event; the highest number of active European bee hives recorded to date. Complete records of nest box occupancy and evidence of use over time is displayed in **Appendix B.**

Table 1 Comparison of Nest Box Monitoring Results: Winter 2016, Summer 2017, Winter 2017 and Summer 2018

Monitoring Event	*No. of Nest Boxes Monitored*	*No. of Occupied Nest Boxes*	*% Occupied*	*No. Nest Boxes with Evidence of Use*	*% Nest boxes With Evidence of Use*	*No. of Species Recorded*	*Active European Bee Hives*
Winter 2016	135	27	20	59	44	7	2
Summer 2017	143	24	16.5	82	57	6	6
Winter 2017	143	38	26.5	98	68.5	9	4
Summer 2018	143	26	18	107	75	7	8

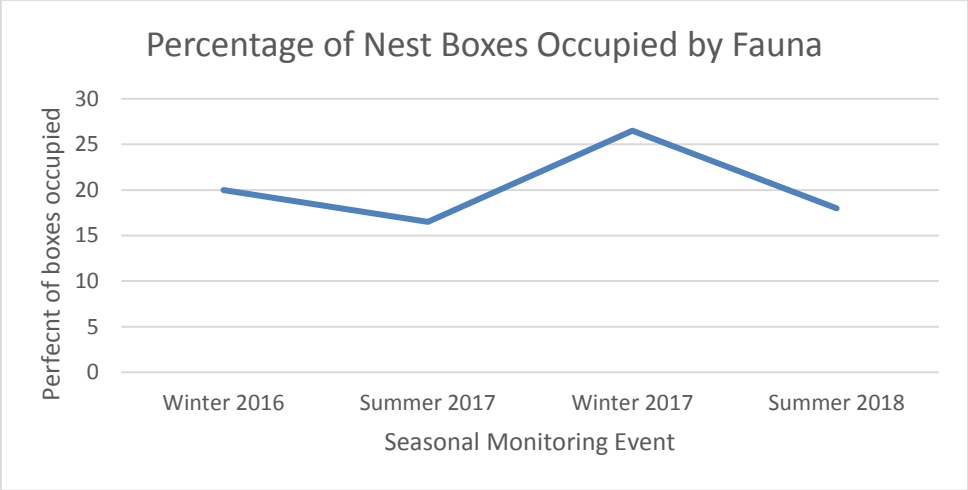


Figure 1 Percentage of nest boxes occupied by fauna

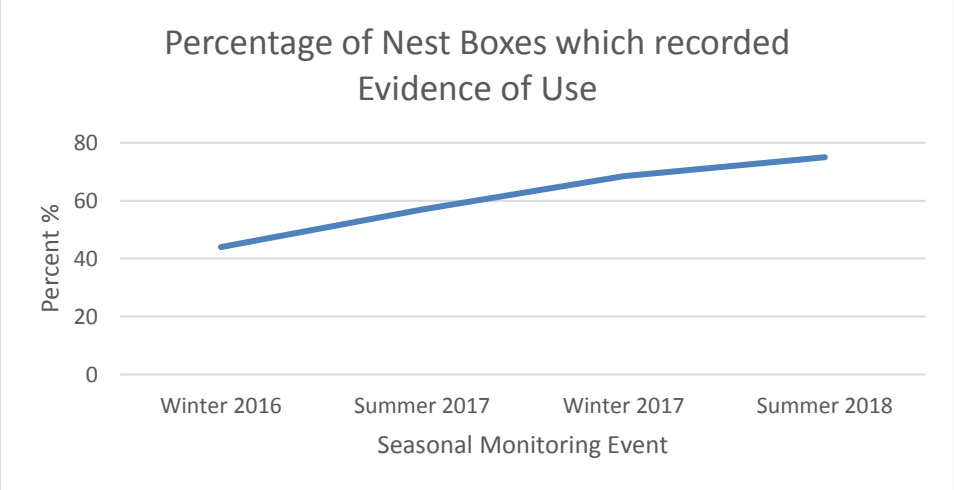


Figure 2 Percentage of nest boxes showing evidence of use by fauna

Note: an adjustment to the number of boxes occupied during summer 2017 monitoring event has been made and is reflected within **Table 1**. Previously 22 boxes were recorded as occupied during

summer 2017 but an update of analysis methods has updated the number of occupied boxes from 22 to 24 due to the inclusion of native stingless bee hives as a record of occupancy. Two box records were removed from the count as they contained dead glider carcasses only. For consistency summer 2018 has recorded NSB hives as an occupancy record but has not counted the boxes containing dead animals only, such as the dead Rainbow Lorikeet or dead Sugar Glider records. Although dead species are not recorded as occupying boxes they are recorded within **Table 2** below.

Table 2 Fauna Species Recorded Occupying Nest Boxes

Scientific Name	*Common Name*	*Winter 2016*	*Summer 2017*	*Winter 2017*	*Summer 2018*	*Native*	*Exotic*
Acrobates pygmaeus	Feathertail Glider	-	-	x	x	x	-
Aegotheles cristatus	Owlet Night-jar	x	x	x	-	x	-
Antechinus sp.	Antechinus	x	-	-	-	x	-
Dendrelaphis punctulatus	Green Tree Snake	x	-	-	-	x	-
Morelia spilota	Carpet Python	-	-	x	x	x	-
Nyctophilus geoffroyi	Lesser Long-eared Bat	-	-	x	-	x	-
Petaurus breviceps	Sugar Glider	x	x	x	x	x	-
Pseudocheirus peregrinus	Ringtail Possum	x		x	-	x	-
Rattus rattus	Black Rat	-	x	-	-	-	x
Tetragonula or Austroplebeia sp.	Native Stingless Bee	x	x	x	x	x	-
Trichoglossus chlorolepidotus	Scaly-breasted Lorikeet	-	x		-	x	-
Trichoglossus haematodus moluccanus	Rainbow Lorikeet	-	-	-	x	x	-
Trichosurus vulpecula	Common Brushtail Possums	x	x	x	x	x	-
Varanus varius	Lace Monitor	-	-	x	x	x	-
Total number of species		**7**	**6**	**9**	**7**	**14**	**1**

Monitoring results have indicated a reduction in the number of occupied NBs by 8.5%, or 12 boxes less than the winter 2017 monitoring event. While the reasons for this reduction are unclear, unseasonably low rainfall was received during July, August and September preceding the summer 2018 monitoring event which may have contributed to a reduction of nest box occupancy. This dry period may have reduced the availability of flowering species within the home ranges for nectarivores such as gliders and nectar feeding birds known from the locality. These conditions may have resulted in some ranging further to forage and occupying natural hollows elsewhere. Monthly rainfall data since monitoring of nest boxes began is shown at **Table 3**.

Table 3 Monthly Rainfall Data (mm) January 2018 rainfall total until 16/01/2018 (source: WC2NH northern weather station, data from weathermation.com)

	Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
2015			93.4	121	207	21	16	25	108	33.6	140	213
2016	99.4	36.2	47.4	90.8	12	328	31	167	37.8	48	35.8	47.8
2017	74.4	95.6	506.4	107	79.2	214	8.2	0.4	0	156	92	147.4
2018	121.6											

Although the number of occupied boxes has decreased since Winter 2017, the rate of occupancy remains consistent with numbers recorded during winter 2016 and summer 2017. The evidence of use by fauna has continued to increase since the commencement of monitoring.

It should be noted that the northern section of WC2NH highway upgrade was opened to public traffic and is now operational. Since the opening of the highway upgrade between Nambucca Heads and Scotts Head Road, road kill monitoring has been conducted one day per week for 2-3 hours since 21 December 2017. Results (not yet published) of the roadkill monitoring have not shown road kill records of fauna species that may utilise installed nest boxes, suggesting that the operational road has not directly impacted fauna that would otherwise occupy installed nest boxes throughout the northern zone of the project.

While operational noise may be contributing to the increased noise experienced within the nest box zone and forest adjacent to the highway, it is expected that fauna would become habituated to this over time.

4.4 Structural Integrity and Maintenance

Forty-nine (49) of the nest boxes required some form of maintenance as follows:

- Thirty-three nest boxes had springs added to their cables in accordance with the NBMP requirements.
- One nest box was repositioned due to the box holding water (Box SF1.1).
- One nest box lid was replaced due to damage (Cockatoo Box 7.1); refer to **Plate 1.15**.
- Ten nest boxes either had new cattle ear tags (which contain a chemical that helps repel Buffalo Flies) placed near entrance holes or previously placed tags replaced with fresh *Patriot* tags in an attempt to cause active European bee hives to be abandoned. Only *Patriot* cattle ear tags were used during summer 2018 maintenance as it is a stronger product than the previously used *Corale Plus* ear tags. The attachment of cattle ear tags was recommended during consultation with Hollow Log Homes, a reputable Australian Nest Box manufacturer as suitable method to deter or to cause European bees to vacate a nest boxes. This method is also a recommendation from the NBMP (Lewis, 2014). However, during summer 2018 monitoring the highest number of active hives was recorded, indicating the cattle ear tags are not effectively deterring or killing European bee hives within the nest boxes.
- Two nest boxes had active ant nests removed (Boxes SG3.1 and LG4.4).
- One nest box contained a dead juvenile Rainbow Lorikeet chick and nesting material which was removed (Box C8.5).
- Three nest boxes contained dead Gliders carcases which were removed from the boxes (C3.10, SG3.5 and C3.3) one box contained an additional carcass. This was not removed as gliders were occupying the box at the time of inspection.
- Two next boxes which were holding water were emptied (Po5.10 and SF1.1).

Light chewing was evident on 12 boxes (SF1.3, Sg3.3, SF1.2, C5.6, C3.3, SG3.2, C1.1, C5.8, SF1.10, SG3.4, P/L8.9 and SG3.12) around the entry hole but had not caused significant damage to the boxes. Overall, very few boxes required maintenance other than the attachment of springs or replacement or attachment of cattle ear tags. Given the relatively short time since installation, it was expected that minimal structural maintenance would be required.

4.5 European Bee Hives

A total of 17 nest boxes (12% of total) recorded evidence of European Bee Hives which is an increase since winter 2017 monitoring where 14 (10%) boxes indicated European Bee activity:

- Eight nest boxes contained active European Bee hives
- Eight nest boxes contained abandoned hives but with evidence of honeycomb within the box
- One nest box contained dead bees in the bottom of the box and evidence of honeycomb as well as live bees flying around the outside of the box. This box was recorded as a new hive record during the winter 2017 monitoring event.

As discussed previously, the active European bee hives were managed by installation of insect deterrent cattle ear tags except for three boxes due to significant hive activity and risk of sting to the tree climbers. Five nest boxes with inactive hives had cattle ear tags attached to deter European bees from returning. It appears that the installation of the cattle ear tags to deter or kill the hives has not been completely effective. LG4.10, LG 4.8 and C6.1 recorded active hives during winter 2017 and continue to persist during the 2018 monitoring event despite cattle ear tags being attached to these bees during winter 2017.

The persistence of hives within certain boxes suggests that the ear tags are not completely effective. A number of previously recorded active hives have become inactive since the ear tags were installed, however it is not known whether the tags have triggered the bees to leave the box or other factors (such as the box being too small, box position or internal temperature) are relevant.

Competition from feral honeybees is listed by the NSW Threatened Species Scientific Committee as a Key Threatening Process under the *Biodiversity Conservation Act 2016*. Not only do European bees establish hives in tree hollows displacing native fauna but they also consume significant nectar resources in direct competition with nectar feeding species, such as Native Stingless Bees and nectivorous birds and mammals.

4.6 Performance and Contingency Measures

The Section 7.3 of the NBMP sites the following performance measures as outlined in **Table 4.** Contingency or corrective actions are outlined and compliance with the objectives of the nest box plan have been addressed.

Table 4 Summary of Key Performance Criteria for Nest Box Monitoring (Construction Phase)

Performance Measure	*Problem*	*Contingency/ Correction Action*	*Compliance*
Use of nest boxes by a range of native fauna	Nest box being used by non-target species	Review the selection and number of nest box designs	Yes - Since monitoring began in winter 2016 a moderate number (14) of native fauna species have been observed within the nest boxes. Only 1 exotic vertebrate species, the Black Rat, has been recorded within one nest box.
Use of nest boxes designed for specific species by those species (i.e. Brush-tailed Phascogale nest box being used by this species)	Nest boxes become occupied by exotic or invasive fauna (i.e. European Bees or 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.	Yes - The failure to record threatened species or other vertebrates (microbats, birds, lizards and frogs) detected during the environmental assessment or clearing phase of the project indicates that the nest boxes do not compensate for the habitat losses for all species. It is considered that the types of boxes prescribed and installed are satisfactory for the target species known to occur within the area. Refer to section 4.2 for further details regarding nest box design and target species occupancy. Recommendations have been made regarding the design of some microbat boxes which support narrow entry holes; these boxes are yet to record any evidence of use. Refer to Section 5 for recommendations regarding microbat nest box design. Yes – to address the incursion of European bees, two types of Buffalo Fly cattle ears tags have been affixed to the boxes which contain active European Bee hives. The cattle ear tags appear to not be completely affective at deterring or killing European Bees from the nest boxes. To relocate nest boxes to another location would require additional nest box replacement zones and approvals and would not be a suggested method of European bee deterrence due to their highly mobile and resourceful nature. Refer to Section 5 for recommendations regarding alternative options for European Bee control.
Low rates of exotic fauna using nest boxes	Poor uptake/usage rate by native fauna	Review the types and numbers of nest box designs	Yes - Low usage by exotic fauna has been recorded within the nest boxes with the exception of European bees. Only one exotic vertebrate species (Black Rat) has been recorded. The number and type of nest boxes prescribed and installed is considered satisfactory for the target fauna species known to occur in the area. Moderate native fauna uptake has been recorded with 14 native fauna species recorded to use the boxes.
Reduced maintenance requirements	Nest boxes deteriorating rapidly and requiring maintenance	Identify causes of nest box failure, modify design and construct accordingly	Yes - Overall maintenance or repair of the boxes has been very low. Only one nest box and one nest box lid has been replaced due to termite damage during winter 2017 and summer 2018 respectively. Otherwise routine maintenance such as emptying water from boxes, removing ant nests or checking attachments for wear should be expected as part of the nest box monitoring program.

4.7 Value of Nest Boxes

The monitoring results to date indicate that the nest boxes are providing valuable compensatory habitat for some species, particularly the (non-threatened) Sugar Glider. Microbat nest boxes did not record new evidence of use by the target species, however the microbat boxes which were constructed for the second round of installation with the wider entry holes recorded use by Sugar Gliders and a Feathertail Glider.

Four dead Sugar Gliders were observed in a total of four separate NBs, and a dead juvenile Rainbow Lorikeet was recorded in another box. Possible reasons for the deaths could be attributed to higher than usual temperatures and/or more prolonged periods of hot weather, limited food resources/flowering over the last few months due to dry conditions, disease, natural mortality of the juvenile species or mortality of the parent animal (or a combination of these factors).

To date, the failure to record other nest box targeted species which were recorded during clearing inspections and/or at the environmental assessment stage of the project (e.g. skinks, geckos, tree frogs and threatened species such as the Yellow-bellied Glider) and very low records of microbat use indicates that the nest boxes are not compensating for the habitat losses for all species

5. Recommendations

The next monitoring event is scheduled for winter 2018. By this time the entire project may have switched to the operational phase in which case monitoring will be undertaken by the successful Ecological consultant engaged under a new contract with RMS. The following recommendations are made to improve the value and longevity of the nest boxes for the WC2NH project:

- Maintenance will be on-going as required (including removal of European bee hives) and will be undertaken at the time of scheduled monitoring events, to maximise the number of boxes which are available for use by native fauna.
- Consider the physical removal of hives (followed by the reinstatement of the nest boxes) by an apiarist or extermination of hives by pest management services.
- Monitor the progression of damage of lid of Cockatoo Box 7.2 which has a partially peeling layer of ply on the lid (not considered structurally damaged as yet).
- Investigate modifying the older style microbat nest boxes which have narrow entry points with the aim to increase uptake by target species (i.e. hollow obligate microbats). Suggest modification of these boxes be undertaken during winter 2018 nest box monitoring event.

We trust this letter report satisfies the project requirements. If you have any questions please call me on phone 0407 756 033 or email joleary@geolink.net.au.

Yours sincerely
GeoLINK

Jessica O'Leary
Ecologist

6. References

Lewis, B. (2014). *WC2U Nest Box Management Plan.* Unpublished document for Roads and Maritime Services, NSW.

Geolink (2016a). *Nest Box Monitoring Report, Summer 2017 Warrell Creek to Nambucca Heads Pacific Highway Upgrade.* Unpublished document prepared for Pacifico.

Geolink (2016a). *Nest Box Monitoring Report, Winter 2016 Warrell Creek to Nambucca Heads Pacific Highway Upgrade.* Unpublished document prepared for Pacifico.

Geolink (2016b). *WC2NH – Final Nest Box Installation Report: Final Calculations.* Unpublished document prepared for Pacifico.

Issue Log

UPR	*Description*	*Date Issued*	*Issued By*
2378-1409	First issue	01/02/2018	JOL

Attachment A WC2NH Nest Box Monitoring Results - Summer 2018

Note: Box Codes are as follows: SF1 – Scanscorial Mammal, MB2 – Microbat, SG3 – Small Glider, LG4 Large Glider, Po5 – Possum, SO6 – Small Owl, Co7 Cockatoo, P/L – Parrot Lorikeet. A 'C' in front of the box number denotes that the boxes were installed as part of the post-clearing stage.

Nest Box Replacement Zone	*Box Code*	*Date of Installation*	*Date of Inspection*	*Weather Conditions*	*Min Temperature*	*Max Temperature*	*Box Height in Metres*	*Box Aspect*	*Tree_Species*	*Tree Height in Metres*	*GPS Coordinate*		*Surrounding Vegetation Type*	*Box Occupied*	*Species Present*	*Number of Animals*	*Evidence of Use by Fauna*	*Evidence of Pest Species*	*Changes to Surrounding Landscape*	*MaintenanceR equired*	*Comments*	*Image Number*
											X	*Y*										
A	SF1.6	29/11/2014	8/01/2018	Hot humid still	18.9	33.1	5 to 8	South east	Tallowwood	15	152.89109	-30.78329	Moist Open Forest - Flooded Gum	No	No	n/a	No	Inactive European hive	No	Yes ear tags installed	Newly started but now inactive euro hive. Comb removed and ear tag attached to outside of box.	0433
A	C5.7	11/12/2016	8/01/2018	Hot humid still	18.9	33.1	5 to 8	East	Crabapple (*Schizomeria ovata)*	20	152.89115	-30.78304	Moist Open Forest - Flooded Gum	No	No	n/a	No	No	No	No	Unoccupied original material	0431
A	LG4.11	20/07/2017	8/01/2018	Hot humid still	18.9	33.1	6	South	Tallowwood	25	152.89210	-30.78207	Moist Open Forest - Flooded Gum	No	No	n/a	No	Inactive European hive	No	No	No new fauna activity or new hive activity	0442
A	C5.10	9/07/2016	8/01/2018	Hot humid still	18.9	33.1	5 to 8	East	Turpentine	20	152.89243	-30.78159	Moist Open Forest - Flooded Gum	No	No	n/a	No	No - original material in box	No	Yes spring attached	Unoccupied, no evidence of use.	0445
B	Mb2.9	30/11/2014	8/01/2018	Hot humid moderate breeze	18.9	33.1	5 to 8	East	Tallowwood	20	152.90318	-30.76958	Camphor Laurel Forest	No	No	n/a	No	No	No	No	Unoccupied, no evidence of use.	0461
B	Po5.9	30/11/2014	8/01/2018	Hot humid moderate breeze	18.9	33.1	5 to 8	South east	Camphor Laurel	20	152.90311	-30.76842	Camphor Laurel Forest	No	No	n/a	No	Ants	No	No	Unoccupied, no evidence of use.	0470
B	Mb2.13	30/11/2014	8/01/2018	Hot humid moderate breeze	18.9	33.1	5 to 8	North east	Camphor Laurel	18	152.90317	-30.76832	Camphor Laurel Forest	No	No	n/a	No	No	No	No	Unoccupied, no evidence of use.	0472
C	SF1.11	30/11/2014	9/01/2018	Hot humid still	18.8	32	5 to 8	South east	Fig *Ficus* sp.	25	152.92105	-30.74093	Mixed Floodplain Forest EEC	No	No	n/a	No	Ants	Highway now operational	Yes remove ants	Unoccupied, no evidence of use.	0483
C	Po5.1	30/11/2014	9/01/2018	Warm humid still	18.8	32	5 to 8	South east aspect	Flooded Gum	30	152.92160	-30.74043	Mixed Floodplain Forest EEC	No	No	n/a	No	No	Highway now operational	No	Unoccupied, no evidence of use.	0481
C	Mb2.2	30/11/2014	9/01/2018	Warm humid still	18.8	32	5 to 8	East	Melaleuca	20	152.92179	-30.74039	Mixed Floodplain Forest EEC	No	No	n/a	No	Spider	Highway now operational	No	Unoccupied, no evidence of use.	0479
S	Mb2.3	16/11/2014	12/01/2018	Hot humid sunny still	21.2	26.8	5 to 8	North east	Tallowwood	25	152.94090	-30.69694	Moist Open Forest - White Mahogany/ Grey Gum	No	No	n/a	No	No	Highway now operational	No	Unoccupied, no evidence of use.	0735
S	Mb2.12	16/11/2016	12/01/2018	Mild humid overcast still	21.2	26.8	5 to 8	North west	Turpentine	18	152.94074	-30.69620	Moist Open Forest - White Mahogany/ Grey Gum	No	No	n/a	No	No	Highway now operational	No	Box empty narrow entry hole	0692
S	MB2.8	16/11/2014	12/01/2018	Mild humid sunny still	21.2	26.8	5 to 8	South west	Turpentine	15	152.94079	-30.69568	Moist Open Forest - White Mahogany/ Grey Gum	No	No	n/a	No	No	Highway now operational	No	Box empty narrow entry hole	0689
S	Mb2.5	16/11/2014	11/01/2018	Warm humid moderate breeze mostly	20.5	28.4	5 to 8	East	Tallowwood	25	152.94077	-30.69530	Moist Open Forest - White Mahogany/ Grey Gum	No	No	n/a	No	No	Highway now operational	No	Box empty quite narrow entry hole	0670

Nest Box Replacement Zone	Box Code	Date of Installation	Date of Inspection	Weather Conditions	Min Temperature	Max Temperature	Box Height in Metres	Box Aspect	Tree_Species	Tree Height in Metres	GPS Coordinate		Surrounding Vegetation Type	Box Occupied	Species Present	Number of Animals	Evidence of Use by Fauna	Evidence of Pest Species	Changes to Surrounding Landscape	MaintenanceR equired	Comments	Image Number
											X	Y										
				sunny																		
S	C4.4	16/07/2016	11/01/2018	Warm humid light breeze mostly sunny	20.5	28.4	5 to 8	South east	Tallowwood	25	152.94075	-30.69501	Moist Open Forest - White Mahogany/ Grey Gum	No	No	n/a	No	No	Highway now operational	Yes spring attached	Original material but looks flatter and more decayed.	0667-0668
S	So6.1	30/11/2014	11/01/2018	Warm humid light breeze mostly sunny	20.5	28.4	10 to 12	North west	Tallowwood	30	152.94063	-30.69495	Moist Open Forest - White Mahogany/ Grey Gum	No	No	n/a	No	Active European Hive	Highway now operational	No	Box continues to be occupied by European bees despite two tags being placed very close to entry hole of box. Tags not replaced due to very active hive today.	No
S	Mb2.10	16/11/2014	11/01/2018	Warm humid light breeze mostly sunny	20.5	28.4	5 to 8	North	Tallowwood	25	152.94105	-30.69420	Moist Open Forest - White Mahogany/ Grey Gum	No	No	n/a	No	No	Highway now operational	No	Box empty no evidence of use, very narrow entry hole	0661
S	Po5.10	30/11/2014	11/01/2018	Warm humid light breeze mostly sunny	20.5	28.4	5 to 8	North west	Blackbutt	25	152.94114	-30.69396	Moist Open Forest - White Mahogany/ Grey Gum	No	No	n/a	No - box emptied due to holding water	No	Highway now operational	Yes emptied water from box	unoccupied no evidence of use, box holding water, emptied.	0658
S	LG4.1	29/11/2014	11/01/2018	Warm humid light breeze mostly sunny	20.5	28.4	8 to 10	North east	Blackbutt	25	152.94087	-30.69394	Moist Open Forest - White Mahogany/ Grey Gum	No	No	n/a	No	No	Highway now operational	No	Unoccupied, no evidence of use.	0656
OC5	C2.3	15/06/2016	11/01/2018	Mild humid overcast showers	20.5	28.4	5 to 8	North	Turpentine	22	152.94118	-30.68809	Open Forest - Blackbutt	No	No	n/a	No	Spider	Highway now operational	Yes spring attached	Box empty. Huntsman spider	0591
T	MB2.1	15/06/2016	12/01/2018	Hot humid overcast	21.2	26.8	5 to 8	South	Bloodwood	16	152.94437	-30.68377	Open Forest - Blackbutt	No	No	n/a	No	No	Highway now operational	No	Box empty very narrow entry hole	0606
T	LG4.8	29/11/2014	11/01/2018	Hot humid some clouds light breeze	20.5	28.4	8 to 10	South	Blackbutt	20	152.94498	-30.68336	Open Forest - Blackbutt	No	No	n/a	No	Active European Hive	Highway now operational	No	Still active European bee hive despite tags being attached during winter. Very active hive therefore tags not replaced due to risk of stings.	No
U	C5.1	30/11/2014	15/01/2018	Warm partly cloudy light breeze	17.7	29	5 to 8	North east	Turpentine	22	152.94443	-30.68239	Open Forest - Blackbutt	No	No	n/a	No	No	Highway now operational	No	Unoccupied original material	3745
U	LG4.7	30/11/2014	15/01/2018	Warm partly cloudy light breeze	17.7	29	8 to 10	South east	Tallowwood	35	152.94470	-30.68187	Open Forest - Blackbutt	No	No	n/a	No - now active European bee hive	Active European Hive	Highway now operational	Yes ear tags installed	Active euro hive tags installed	No
U	SF1.12	30/11/2014	15/01/2018	Warm partly cloudy light breeze	17.7	29	5 to 8	East	Tallowwood	25	152.94494	-30.68131	Open Forest - Blackbutt	No	No	n/a	No - now active European bee hive	Active European Hive	Highway now operational	Yes installed tags	Active euro hive in previously recorded Glider box.	3725

Nest Box Replacement Zone	Box Code	Date of Installation	Date of Inspection	Weather Conditions	Min Temperature	Max Temperature	Box Height in Metres	Box Aspect	Tree_Species	Tree Height in Metres	GPS Coordinate		Surrounding Vegetation Type	Box Occupied	Species Present	Number of Animals	Evidence of Use by Fauna	Evidence of Pest Species	Changes to Surrounding Landscape	MaintenanceR equired	Comments	Image Number
											X	Y										
U	MB2.7	30/11/2014	15/01/2018	Cool overcast light breeze	17.7	29	5 to 8	South east	Tallowwood	25	152.94536	-30.68041	Open Forest - Blackbutt	No	No	n/a	No	No	Highway now operational	No	Unoccupied, no evidence of use.	0796
U	MB2.11	29/11/2014	15/01/2018	Mild overcast light breeze	17.7	29	5 to 8	South east	Turpentine	18	152.94563	-30.67997	Open Forest - Blackbutt	No	No	n/a	No	No	Highway now operational	No	Box empty no evidence of use narrow entry hole	0809-0810
D	MB2.4	11/07/2016	12/01/2018	Hot humid sunny still	21.2	26.8	5 to 8	East	Bloodwood	18	152.95174	-30.67031	Open Forest - Blackbutt	No	No	n/a	No	Cricket	Highway now operational	No	Unoccupied, no evidence of use.	0767-0768
F	P/L8.8 (Po5.4)	29/11/2014	10/01/2018	Hot humid light breeze	20	30.6	5 to 8	East	Grey Gum	28	152.96339	-30.64955	Open Forest - Blackbutt	No	No	n/a	No	Ants	Highway now operational	No	Small ant nest present not removed otherwise empty box. Number on the box says Po5.4. this box replaced P/L8.8 due to termite damage.	0570
F	SF1.9	29/11/2014	10/01/2018	Hot humid light breeze	20	30.6	5 to 8	North east	Turpentine	15	152.96355	-30.64954	Open Forest - Blackbutt	No	No	n/a	No	Ants	Highway now operational	No	Small ants nest not removed	0568
F	C4.1	11/06/2016	10/01/2018	Mild humid skies clearing	20	30.6	8 to 10	South	Tallowwood	25	152.96517	-30.64878	Open Forest - Blackbutt	No	No	n/a	No	No	Highway now operational	Yes spring attached	Unoccupied, no evidence of use.	0537
G	C7.1	12/12/2016	10/01/2018	Hot humid sunny after rain storm	20	30.6	10 to 12	South east	Tallowwood	25	152.96735	-30.64564	Open Forest - Blackbutt	No	No	n/a	No - lace monitor present last monitoring event no other evidence of use	No	Highway now operational	No	Box unoccupied. Lace Monitor present last monitoring event. No springs attached due to size of box tree likely to grow slowly due to large size. Leaves in box but likely from wind.	0544
G	C8.7	10/06/2016	10/01/2018	Hot humid still sunny after rain storm	20	30.6	5 to 8	North	Turpentine	18	152.96815	-30.64534	Open Forest - Blackbutt	No	No	n/a	No - now active European bee hive	Active European Hive	Highway now operational	Needs a spring but not attached due to active bee hive	No ear tags installed due to very active hive. Needs spring but not attached due to hive.	N/A
G	LG4.10	29/11/2014	9/01/2018	Hot humid still	19.9	31.3	8 to 10	South	Turpentine	30	152.97256	-30.64133	Open Forest - Blackbutt	No	No	n/a	No	Active European Hive	Highway now operational	Yes cattle ear tags replaced	Reinstated cattle ear tags as close to the opening as possible	0498
New NBRZ	C4.2	9/06/2016	9/01/2018	Hot humid still	19.9	31.3	8 to 10	South	Blackbutt	35	152.97181	-30.63973	Open Forest - Blackbutt	No	No	n/a	No	Active European Hive	Highway now operational	Yes ear tags installed	Active European bee hive - installed Patriot ear tags	n/a
New NBRZ	P/L8.0	9/06/2016	10/01/2018	Hot humid still	20	30.6	5 to 8	South	Tallowwood	18	152.97403	-30.63958	Open Forest - Blackbutt	No	No	n/a	No	Ants	Highway now operational	No	Unoccupied, no evidence of use. Ants nest removed	0489

Attachment B Nest Box Records of Occupancy and Evidence of Use Over Time

Nest Box Replacement Zone	Box Code	Nest Boxes Occupied				Nest Box Evidence of Use			
		Winter 2016	Summer 2017	Winter 2017	Summer 2018	Winter 2016	Summer 2017	Winter 2017	Summer 2018
A	C4.6	No	No	No	No	Drey	Drey	Glider nesting material	Glider nesting material
A	C5.10	No	No	Lace Monitor	No	No	Drey	Glider nesting material	No original material in box
A	C5.7	Not yet installed	No	No	No	Not yet installed	No	No	No
A	LG4.11	No	No	No	No	Drey	Drey	No	No
A	SF1.13	No	No	No	No	No	No	No	Glider nesting material and scats
A	SF1.6	No	No	No	No	No	No	No	No
B	Cockatoo 7.2	Common Brushtail Possum	No	Common Brushtail Possum	No	No	No	Animal present	Glider nesting material
B	MB2.13	No	No	No	No	No	No	No	No
B	MB2.9	No	No	No	No	No	No	No	No
B	P/L8.6	No	No	No	No	No	No	Glider nesting material	Glider/ Ringtail Possum nesting material
B	P/L8.9	No	Black Rat	Sugar Glider	No	Chewings	Chewings	Chewings	Glider nesting material and chewings around the entry hole
B	Po5.2	No	No	No	No	No	No	No	Scratchings and Fur
B	Po5.6	No	No	No	No	No	No	No	Scats
B	Po5.9	No	No	No	No	No	No	No	No
B	SF1.3	No	No	No	No	No	No	Glider nesting material	Glider nesting material and chewing
C	C1.4	No	No	No	No	No	No	No	Small shredded paperbark bark inside
C	C5.4	No	No	No	No	Scat	No	No	Shredded bark inside
C	MB2.2	No	No	No	No	No	No	No	No
C	Po5.1	No	No	No	No	No	No	No	No
C	SF1.11	No	No	No	No	No	No	No	No
D	C1.9	No	Sugar Glider	No	Sugar Glider	No	Drey	Glider nesting material	Glider nesting material
D	C2.7	No	No	No	No	No	No	Microbat guano and bat bugs	Microbat guano
D	C3.10	No	No	Sugar Glider	Dead juvenile Sugar Glider	No	No	Glider nesting material	Dead Sugar Glider and Glider nesting material
D	C4.5	No	No	No	No	No	No	Glider nesting material	Glider nesting material
D	C5.8	Sugar Glider	No	No	No	Drey	Drey	Chewings and Glider nesting material	Glider nesting material and chewing around entry hole
D	C8.4	No	No	No	No	No	Bird excrement in box.	Bird excrement	Glider nesting material and old bird excrement
D	C8.5	No	No	No	Dead Rainbow Lorikeet Chick	No	No	No	Dead Animal
D	LG4.3	No	No	No	No	No	No	No	Compared winter/ summer photos suggest evidence of use by fauna
D	MB2.4	No	No	No	No	No	No	No	No
D	PO5.18	No	Owlet Nightjar	No	No	No	Owlet Nightjar present	Feathers and bird excrement	Glider nesting material
D	Po5.3	No	No	No	No	Scratching & Drey	Drey	Scats	Feathers
D	SF1.7	No	No	No	No	No	No	No	Glider nesting material

Nest Box Replacement Zone	Box Code	Nest Boxes Occupied				Nest Box Evidence of Use			
		Winter 2016	Summer 2017	Winter 2017	Summer 2018	Winter 2016	Summer 2017	Winter 2017	Summer 2018
D	SG3.11	Sugar Glider	Sugar Glider	Sugar Glider	No	Drey	Drey	Glider nesting material	Glider nesting material
D	SO6.2	No	No	No	No	Drey	Drey	Glider nesting material	Glider nesting material
E	C3.8	Not yet installed	No	Sugar Glider	No	Not yet installed	No	Glider nesting material	Glider nesting material
E	C8.6	Not yet installed	No	No	No	Not yet installed	No	Scats on lid and Glider nesting material	Bird nest and egg, bird excrement and Glider nesting material
E	Po5.8	Common Brushtail Possum	No	No	No	No	Scratching	Scratching	Scratching
E	SG3.18	No	No	Sugar Glider	Sugar Glider	No	No	Glider nesting material	Glider nesting material
F	C1.2	No	No	Lesser Long-eared Bat	Feathertail Glider	Drey	No	Animal present	Animal present
F	C4.1	No	No	No	No	No	No	No	No
F	C5.3	No	No	No	No	Grass and leaves	Grass nest and bird excrement.	Nest and bird excrement	Glider nesting material. Bird nest and egg
F	LG4.12	No	No	No	No	Drey	Drey	No	Glider nesting material
F	P/L8.8 (Po5.4)	No	No	No	No	No	No	No	No
F	Po5.16	No	No	No	No	No	No	No	Small shredded bark
F	SF1.5	No	No	Sugar Glider	No	No	No	Glider nesting material	Glider nesting material
F	SF1.9	No	No	No	No	No	No	No	No
F	SF3.6	Sugar Glider	Sugar Glider	No	No	Scratching & Drey	Drey	Glider nesting material	Glider nesting material
F	SG3.7	No	No	No	No	No	No	No	Glider nesting material
G	C1.6	Sugar Glider	Sugar Glider	Sugar Glider	No	Drey	Drey	Glider nesting material	Glider nesting material
G	C3.1	No	Sugar Glider	No	Sugar Glider	Drey	Drey	Glider nesting material	Glider nesting material
G	C3.6	No	No	No	No	No	No	Glider nesting material	Glider nesting material
G	C4.3	No	No	No	No	No	Fibrous bark drey.	Shredded bark nesting material	Shredded bark (Ringtail Possum) and Glider nesting material and bird excrement
G	C4.8	No	No	No	No	No	Scratching and fibrous bark drey in box.	Scratching and shredded bark Glider nesting material	Glider nesting material, shredded bark and Scratchings
G	C7.1	Not yet installed	No	Lace Monitor	No	Not yet installed	No	Animal present	No - Animal present but no evidence of use during winter 2017
G	C8.7	No	No	Owlet Nightjar egg/nest	No	No	No	Owlet Nightjar nest, feathers and egg	No - now active European Bee hive
G	HMP	No	No	Feather-tailed Glider	No	No	No	Glider nesting material	Glider nesting material
G	LG4.10	No	No	No	No	No	No	No	No
G	LG4.9	No	No	No	No	No	Drey	Glider nesting material	Glider nesting material
G	Po5.11	Owlet-nightjar	No	No	No	Leaves	Bird excrement and drey material.	Bird excrement	Glider nesting material and bird excrement
G	Po5.12	No	No	Lace Monitor	No	Drey	Drey	Glider nesting material	Glider nesting material
G	Po5.15	No	No	No	No	No	Drey	Glider nesting material	Glider nesting material
G	SF1.1	No	Sugar Glider	No	No	Drey	Drey	Glider nesting material	Glider nesting material
G	SF1.14	No	No	Sugar Glider	No	No	No	Glider nesting material	Glider nesting material
G	SG3.13	No	No	No	No	Drey	No	Glider nesting material	Glider nesting material
G	SG3.17	No	No	Sugar Glider	Native Stingless Bees	No	Drey	Glider nesting material	Animal present

Nest Box Replacement Zone	Box Code	Nest Boxes Occupied				Nest Box Evidence of Use			
		Winter 2016	Summer 2017	Winter 2017	Summer 2018	Winter 2016	Summer 2017	Winter 2017	Summer 2018
New NBRZ	C3.13	Not yet installed	No	No	Likely Sugar Glider	Not yet installed	Drey	Glider nesting material	Animal present
New NBRZ	C3.2	Not yet installed	No	No	No	Not yet installed	No	Glider nesting material and Scats	Glider nesting material and likely antichinus scats in the corner
New NBRZ	C4.10	Not yet installed	No	Sugar Glider	Lace Monitor	Not yet installed	No	Glider nesting material	Animal present
New NBRZ	C4.2	No	No	No	No	No	Bird excrement and drey material.	No	No
New NBRZ	C4.7	No	No	No	No	No	No	Glider nesting material	Glider nesting material
New NBRZ	C5.12	No	No	Feather-tailed Glider	No	No	Flattened material in box	Animal Present	Glider nesting material
New NBRZ	C5.5	No	No	No	No	No	Flattened material in box	Glider nesting material	Glider nesting material
New NBRZ	C6.1	Not yet installed	No	No	Lace Monitor	Not yet installed	No	No	Glider nesting material and animal present
New NBRZ	C8.1	No	No	Sugar Glider	No	Drey	Drey	Glider nesting material	Glider nesting material and bird egg
New NBRZ	P/L8.0	No	No	No	No	Drey	Drey	Glider nesting material	No
New NBRZ	SF1.10	No	No	No	Native Stingless Bees	No	Drey	Glider nesting material	Animal present, Chewing around entry hole
OC5	C1.10	No	Sugar Glider	Sugar Glider	Sugar Glider	Drey	Drey	Glider nesting material	Glider nesting material
OC5	C1.5	No	No	Sugar Glider	No	Drey	Drey	Glider nesting material	Glider nesting material
OC5	C2.1	No	No	No	No	Drey	Drey	Glider nesting material	Glider nesting material
OC5	C2.3	No	No	No	No	Leaves	No	No	No
OC5	C2.5	No	No	No	Possible Feathertail Glider or Antichinus present within nesting material.	No	No	No	Glider nesting material
OC5	C2.6	Sugar Glider	Sugar Glider	No	Sugar Glider	Drey	Drey	Glider nesting material	Glider nesting material
OC5	C3.5	No	No	No	No	No	Drey	Glider nesting material	Glider nesting material
S	C3.12	Sugar Glider	No	No	Sugar Glider	Drey	Drey	Glider nesting material	Glider nesting material
S	C3.9	No	Sugar Glider - dead	No	Sugar Glider	No	Drey	Glider nesting material	Glider nesting material
S	C4.4	No	No	No	No	No	No	No	No
S	C5.6	No	No	No	No	No	Chewings around lid and Scat on lid.	Chewings around the lid. Chewed beetle remains	Chewing around entry hole and Cicada remains
S	C8.3	No	Sugar Glider	No	No	No	Drey	Glider nesting material	Glider nesting material
S	LG4.1	No	No	No	No	No	No	No	No
S	LG4.14	Sugar Glider	No	No	No	Drey	Drey	Glider nesting material	Glider nesting material
S	LG4.2	No	No	No	No	No	No	Glider nesting material	Glider nesting material
S	LG4.6	Common Ringtail Possum	No	No	Sugar Glider	Drey	Drey	Glider nesting material	Glider nesting material

Nest Box Replacement Zone	Box Code	Nest Boxes Occupied				Nest Box Evidence of Use			
		Winter 2016	Summer 2017	Winter 2017	Summer 2018	Winter 2016	Summer 2017	Winter 2017	Summer 2018
S	MB2.10	No	No	No	No	No	No	No	No
S	MB2.12	No	No	No	No	No	No	No	No
S	MB2.3	No	No	No	No	No	No	No	No
S	MB2.5	No	No	No	No	No	No	No	No
S	MB2.8	No	No	No	No	No	No	No	No
S	P/L8.1	No	Sugar Glider	No	No	Drey	Drey	Glider nesting material	Glider nesting material
S	P/L8.11	Sugar Glider	No	No	No	Drey	Drey	Glider nesting material	Glider nesting material possible Ringtail Possum use also
S	Po5.10	No	Common Brushtail Possum	No	No	No	1 bird feather in box. No drey material.	Scats	No box emptied of water during winter 2017 and summer 2018
S	Po5.13	No	No	No	No	Drey	Previous record of possum and drey.	No	Ringtail Possum or Bird nest
S	Po5.17	Common Brushtail Possum	Common Brushtail Possum	Common Brushtail Possum	Common Brushtail Possum	Scratching & Drey	Drey	Animal Present	Animal present
S	SF1.2	Sugar Glider	Sugar Glider	Sugar Glider	No	Chewing around opening and drey inside	Chewings and drey	Chewing and Glider nesting material	Chewing around entry hole and scratches on lid. Glider nesting material
S	SF1.4	No	Native bee hive	Native Stingless Bee hive	Native Stingless Bees	Drey	Active native bee hive	NSB hive	Animal present
S	SG3.1	No	No	Sugar Glider	No	Drey	Drey	Glider nesting material	Glider nesting material
S	SG3.10	No	Sugar Glider	No	Sugar Glider + 1 Dead possible Sugar Glider	Drey	Drey	Glider nesting material	Glider nesting material
S	SG3.12	Sugar Glider	No	No	No	Drey	Drey	Glider nesting material	Green feather and chewing around entry hole. Glider nesting material
S	SG3.9	Sugar Glider	Sugar Glider	Sugar Glider	No	Drey	Drey	Glider nesting material	Glider nesting material
S	Sg3.3	No	No	No	No	Drey	Drey	Glider nesting material	Glider nesting material, scratching and chewing
S	Sg3.4	No	No	No	Sugar Glider	Scratching & Drey	Scratching/ chewing and drey	Scratching, chewing and Glider nesting material	Glider nesting material, heavy use of tree trunk
S	So6.1	No	No	No	No	No	No	No	No
T	C1.3	Sugar Glider	No	No	Native Stingless Bees	Drey	Drey	Glider nesting material	Animal present
T	C3.3	Sugar Glider	No	No	Possible dead Sugar Glider (juvenile)	Drey	Drey	Glider nesting material	Fur and chewing at entry hole. Glider nesting material and possible dead Glider
T	C3.4	No	Sugar Glider	Sugar Glider	No	Drey	Drey	Glider nesting material	Glider nesting material with uric acid pellet on top likely Carpet Python
T	C4.9	No	No	No	No	Drey	Drey	No	Glider nesting material
T	C5.9	No	No	No	No	Drey	Drey	Glider nesting material	Glider nesting material
T	LG4.8	Antechinus sp.?	No	No	No	Drey	Drey	No	No
T	MB2.1	No	No	No	No	No	No	No	No
T	P/L8.10	No	No	No	No	No	Drey	No	Glider nesting material
T	P/L8.4	No	No	Native Stingless Bee hive	No	Drey	Drey	Glider nesting material	Glider nesting material
T	Po5.5	Green Tree Snake	No	Carpet Python	No	No	Drey	Glider nesting material	Glider nesting material
T	SG3.14	Native stingless bees	Native bee hive	Native Stingless Bee hive	Native Stingless Bees	No	Active native bee hive	NSB hive	Animal present
T	SG3.2	Sugar Glider	No	Sugar Glider	No	Drey	Drey	Glider nesting material	Glider nesting material and chewing around entry hole

Nest Box Replacement Zone	Box Code	Nest Boxes Occupied				Nest Box Evidence of Use			
		Winter 2016	Summer 2017	Winter 2017	Summer 2018	Winter 2016	Summer 2017	Winter 2017	Summer 2018
U	C1.1	No	No	Sugar Glider	Sugar Glider	No	Drey	Glider nesting material	Glider nesting material and chewing around entry hole
U	C3.11	Sugar Glider	Sugar Glider	Sugar Glider	Sugar Glider	Drey	Drey	Glider nesting material	Glider nesting material
U	C3.7	No	Sugar Glider	Sugar Glider	Sugar Glider	No	Drey	Glider nesting material	Glider nesting material
U	C5.1	No	No	No	No	No	No	No	No
U	C5.2	No	No	Owlet Nightjar	No	No	No	Animal present	Glider nesting material and bird excrement
U	C8.2	No	No	No	No	No	No	Glider nesting material	Glider nesting material
U	Cockatoo 7.1	No	No	No	No	No	Feathers	Feathers	Glider nesting material and stick to assist exit shows heavy signs of use.
U	L/G 4.5	No	Sugar Glider	No	No	No	Drey	Glider nesting material	Glider nesting material
U	LG4.4	No	Native bee hive	No	No	No	Active native bee hive	Glider nesting material	Glider nesting material
U	LG4.7	No	No	No	No	Drey	Drey	Glider nesting material	No - now active European Bee hive
U	MB2.11	No	No	No	No	No	No	No	No
U	MB2.7	No	No	No	No	No	No	No	No
U	P/L8.3	No	No	Common Ringtail Possum	No	Drey	Drey	Leafy branch nesting material	Ringtail Possum Drey
U	P/L8.7	Sugar Glider	No	No	No	Drey	Drey	Glider nesting material	Glider nesting material
U	Po5.14	No	No	Common Brushtail Possum	No	Leaves	Fur and scratching	Scratching, fur and Glider nesting material	Glider and Ringtail Possum nesting material, fur and scratchings on lid
U	Po5.7	No	No	No	No	Drey	Drey	Glider nesting material	Glider nesting material
U	SF1.12	Sugar Glider	No	Sugar Glider	No	Drey	Drey	Glider nesting material	No - now active European Bee hive
U	SG3.15	No	No	No	Sugar Glider	Drey	Drey	Glider nesting material	Glider nesting material
U	SG3.5	Sugar Glider	No	No	Dead Sugar Glider	Drey	Drey	Glider nesting material	Dead Sugar Glider and Glider nesting material
U	SG3.8	Sugar Glider	Sugar Glider - dead	No	Carpet Python	Drey	Drey	Glider nesting material	Glider nesting material
Totals		**27**	**24***	**38**	**26**	**59**	**82**	**98**	**107**

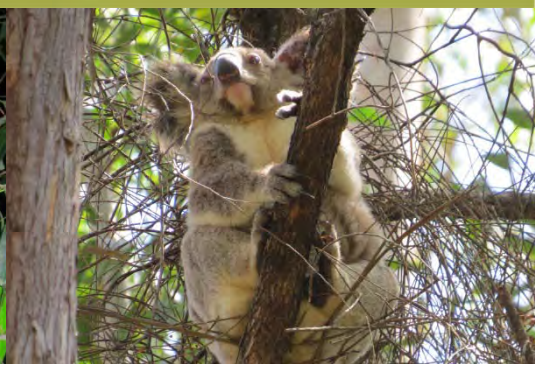
Appendix E

Koala Population Monitoring

Construction Stage (Year 3) Koala Monitoring

Warrell Creek to Nambucca Heads Pacific Highway Upgrade





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Certification

	Name	*Signature*	*Date*
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Reviewed by	Ian Colvin		04/10/2017

UPR	*Description*	*Date Issued*	*Issued By*
2378-1388	First issue	04/10/2017	GJM
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1. Introduction

1.1 Introduction

The Pacific Highway Upgrade Program is a joint commitment by the Australian and New South Wales governments to improve the standard and safety of the Pacific Highway between Hexham and the NSW/Queensland border.

The NSW Minister for Planning approved the Warrell Creek to Urunga (WC2U) Pacific Highway Upgrade Project (the Project) under Part 3A (now repealed) of the *Environmental Planning and Assessment Act 1979* (EP&A Act) on 19 July 2011, subject to the Minister's Conditions of Approval (CoA) being met.

The WC2U Project comprises approximately 42 km of dual carriageway that would bypass the towns of Warrell Creek, Macksville, Nambucca Heads and Urunga on the Mid North Coast of NSW. The Project has been divided into two stages with Stage 1 consisting of approximately 22.5 km from Nambucca Heads to Urunga (NH2U) and Stage 2 consisting of the remaining 19.5 km of dual carriageway between Warrell Creek and Nambucca Heads (WC2NH). This report relates to Stage 2 (WC2NH) as 'the Proposal' which is shown in **Illustration 1.1**.

Koalas were assessed in the Project Environmental Assessment (Sinclair Knight Merz [SKM] 2010a, SKM 2010b), in regard to relevant State and Federal legislation. At that time, the Koala was listed as a 'Vulnerable' species under the NSW *Threatened Species Conservation Act 1995* (TSC Act), however was not listed under Federal legislation. Since completion of the Project Environmental Assessment and NSW State Government Project approval, Koala (*Phascolarctos cinereus*) populations in Queensland, NSW and the Australian Capital Territory have been listed as 'Vulnerable' under the federal *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

An assessment of the impacts of the WC2NH Pacific Highway Upgrade Proposal on the Koala, in accordance with the *EPBC Act Policy Statement 1.1 Significant Impact Guidelines* (Department of Environment and Heritage – DoE 2013a) and interim Koala referral advice for proponents (Department of Sustainability, Environment, Water, Population and Communities – DSEWPaC 2012) was prepared by GeoLINK (2013). This assessment found that the Proposal will have some substantial negative (incremental and cumulative) impacts to the Koalas/ breeding aggregation/s whose home range encompass the Nambucca State Forest/ Old Coast Road area, mainly through habitat removal and fragmentation. The majority of Koala habitat that supports the locally important Koala population (as per the EPBC Act listing) would not be affected by the Proposal. The Project, with effective implementation of the proposed mitigation measures, was found to be unlikely to result in a significant impact to the local Koala population. Notwithstanding, as the Project adversely affects habitat that satisfies the SEWPaC (2012) definition of 'habitat critical to the survival of the species' (including direct removal of approximately 86.5 ha of vegetation that satisfies this criteria); the Project was considered to constitute a significant impact on the Koala as per the DSEWPaC (2012) and DoE (2013a) guidelines.

1.2 The Monitoring Program

The WC2NH Project includes a number of mitigation measures to minimise impacts on biodiversity. These include:

- Ecological monitoring to monitor the effectiveness of the ecological mitigation measures undertaken as part of the Project.
- Installation of fauna crossing and fauna exclusion fencing to allow for safe passage of fauna (including the Koala) crossing the Pacific Highway.
- Installation of 'floppy-top' fauna exclusion fencing to minimise road strike.

A Draft Pre-clearance Baseline Koala Monitoring Methodology was prepared by SKM (2014) in consultation with GeoLINK for the WC2NH Project. The objective of the baseline monitoring is to supplement previous surveys and provide a more robust estimate of the numbers and distribution of individual Koalas, in relation to proposed mitigation structures, so that a more informed assessment can be made of the impacts of the Project on Koalas in the Nambucca State Forest/ Old Coast Road area.

The baseline monitoring program comprised of surveys in autumn 2014 and spring 2014.

Autumn baseline monitoring results were as follows:

- Diurnal and nocturnal transect surveys yielded no observations of Koalas. Additionally, no Koala faecal pellets or obvious scratches attributable to Koalas were recorded.
- One Koala was recorded during spotlighting surveys being conducted along the Old Coast Road in the vicinity of the Nambucca Heads waste facility, west of the highway alignment. This individual responded to call playback and is likely to be a resident male.
- Vegetation associated with the monitoring area is predominantly Open Blackbutt Forest with some moister gullies comprising Flooded Gum Moist Open Forest.

Spring baseline monitoring results were as follows:

- Diurnal and nocturnal transect surveys again did not yield any observations of Koalas nor were any Koala faecal pellets or obvious scratches detected opportunistically.
- One male Koala was detected calling in response to call playback surveys whilst spotlighting along tracks. This individual was recorded in the southern portion of Nambucca State Forest to the east of the new alignment.
- An additional Koala was also detected, in proximity to the record above, during other monitoring activities (Spotted-tail Quoll baseline) being undertaken on the WC2NH Project prior to the spring surveys.

Records of Koala observations are presented in **Section 4**.

Ongoing monitoring (construction and operational) aims to identify changes in resident Koala activity (abundance, home range and movements) in response to construction of WC2NH and the effectiveness of Koala habitat connectivity mitigation measures (i.e. fauna underpasses and exclusion fencing).

Construction Stage (Year 1) spring 2015 surveys identified one Koala during spotlighting surveys on tracks/ easements on three separate occasions. It is highly likely that this was the same individual observed during diurnal transect surveys and for this reason was represented as one record.

This report documents the results of the Construction Stage (Year 3) spring 2017 surveys and discusses findings of the Construction Stage (Year 3) 2017 surveys in comparison with previous monitoring results.

Information shown is for illustrative purposes only

Drawn by: GJM Checked by: RE Reviewed by: ILC Date: 3/10/2017
Source of base data: Roads and Maritime Services

LEGEND

- Project boundary Rev 5 2015 09 03
- Design alignment 2015 12 08
- Waterway

Taylors Arm
Tilly Willy Creek
JOINS SHEET 2
MACKSVILLE
Nambucca River
Snakey Creek
Warrell Creek
Crouches Creek
Williamsons Creek
Stony Creek
WAY WAY STATE FOREST
Way Way Creek
Butchers Creek
Brians Creek
Chainage 0
(southern end of site)

Boggy Creek
Cedar Creek
Chainage 19500
(northern end of site)
NAMBUCCA STATE FOREST
Taylors Creek
Bellwood Creek
NAMBUCCA HEADS
Swampy Creek
Bellwood Swamp
Newee Creek
Nambucca River
Warrell Creek
JOINS SHEET 1
Nambucca River

0 800

North

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Construction Stage (Year 3) Koala Monitoring - Warrell Creek to Nambucca Heads Pacific Highway Upgrade
2378-1390

The Site

Illustration 1.1

2. Koala Biology and Ecology

2.1 Introduction

Detailed reviews of Koala biology and ecology based on recent research are provided on the Department of the Environment and Energy (DoEE) Species Profile and Threats Database (DoEE 2017) and the NSW Recovery Plan for the Koala (DECC 2008). A summary of this information is provided below.

2.2 Distribution and Habitat

The Koala's distribution extends from north-eastern Queensland to the south-east corner of South Australia, covering coastal and inland areas (ANZECC 1998 cited in DoE 2017, DECC 2008). They inhabit a range of forest and woodland communities dominated by Eucalyptus species. Habitat quality depends on a range of environmental features, including vegetation species composition, soils, climate and disturbance history. The main factor influencing Koala occurrence is the presence of suitable food trees. Shelter trees also provide important habitat features, particularly in harsh climates (DoE 2017, DECC 2008).

2.3 Feeding Requirements

The Koala's diet primarily comprises eucalypt leaves which are low in nutrients and energy, and high in indigestible components (e.g. lignin and cellulose) and toxic compounds (e.g. essential oils and tannins) (Cork *et al.* 1990; Cork and Sanson 1990 cited in DECC 2008). In a given area, the diets of individual Koalas/ subpopulations almost exclusively comprise a small number of preferred species to obtain their nutritional needs. Preferred food trees appear to be associated with the presence of formyl phloroglucinol compounds in the leaves (DECC 2008). Koala's also show strong preferences between individual trees of the same species at individual sites, which is believed to be associated with leaf anti-feedant chemicals (DoE 2017). Foliage from non-preferred food trees are consumed at times to supplement their diet (DoE 2017, DECC 2008). Recognised Koala food tree species for the NSW North Coast region (which encompasses the study area) are listed in **Table 2.1**. Blackbutt (*Eucalyptus pilularis*) which is common at the site is also locally considered a supplementary Koala food tree species in the region (Professor Rob Close, University of Western Sydney. pers. comm. 2013).

Table 2.1 Potential Koala Habitats for the NSW North Coast Region

Foraging Preference	*Species*
Primary food tree species	▪ Cabbage Gum (*E. amplifolia*). ▪ Forest Red Gum (*E. tereticornis*). ▪ Orange Gum (*E. bancroftii*). ▪ Parramatta Red Gum (*E. parramattensis*). ▪ Swamp Mahogany (*E. robusta*). ▪ Tallowwood (*Eucalyptus microcorys*).

Foraging Preference	Species
Secondary food tree species	▪ Craven Grey Box (*E. largeana*). ▪ Grey Box (*E. moluccana*). ▪ Grey Gum (*E. biturbinata*). ▪ Large-fruited Grey Gum (*E. canaliculata*) ▪ Mountain Mahogany (*E. notabilis*). ▪ Narrow-leaved Red Gum (*E. seeana*). ▪ Red Mahogany (*E. resinifera*). ▪ Rudder's Box (*E. rudderi*). ▪ Slaty Red Gum (*E. glaucina*). ▪ Small-fruited Grey Gum (*E. propinqua*). ▪ Steel Box (*E. rummeryi*). ▪ White-topped Box (*E. quadrangulata*). ▪ Yellow box (*E. melliodora*).
Stringybarks/ supplementary species	▪ Blue-leaved Stringybark (*E. agglomerata*). ▪ Diehard Stringybark (*E. cameronii*). ▪ Stringybark (*E. tindaliae*). ▪ Thin-leaved Stringybark (*E. eugeniodes*). ▪ White Stringybark (*E. globoidea*).

(Source: DECC 2008)

Primary Koala food tree species are subject to a significantly higher level of usage than other Eucalyptus species, independent of tree density. Secondary and/or supplementary food trees are generally subject to lower levels of foraging by Koalas than that of primary food trees, except where primary food trees are absent (DECC 2008). The Koala Habitat Study for the Nambucca Shire Council Coastal Area (OEH, 2015) identified Koala scat counts using the Spot Assessment Technique (SAT) as being *significantly higher beneath Tallowwood (65% of all trees with scats) than the other six species (5–10% for each species)*.

2.4 Social Organisation and Reproduction

Koalas live in breeding aggregations which typically comprise a dominant male, a small number of mature females and juveniles of various ages (Phillips 1997, cited in DECC 2008). Home ranges vary in size depending on habitat quality and the number of available food trees, and have been recorded from 0.2 – 500 ha (DECC 2008). Males generally have larger home ranges than females, with the home range of a dominant male overlapping extensively with the home range of females within its aggregation.

The Koala breeding season peaks between September and February, and comprises a period of heightened activity. Offspring rates typically range between 0.3 – 0.8 per year, with birth occurring during October and May (McLean 2003 cited in DoE 2015) following a 35 day gestation period (DECC 2008). Once born the young remain in the pouch for approximately six months, and remain dependent on their mother until about 12 months of age (Mitchell and Martin 1990 cited in DECC 2008). Sub-adult Koalas may remain in the mother's home range for a further two to three years, before young Koalas of both sexes disperse to establish their own home range areas (Ramsay 1999 cited in DECC 2008). Dispersal distances generally range from 1.0 – 11 km (Mitchell and Martin 1990 cited in DECC 2008). Longevity in the wild is >15 years for females and >12 years for males (Martin and Handasyde 1999 cited in DoE 2017).

3. Methodology

3.1 Transect Surveys

Transects were established on each side of the Project footprint within the Nambucca State Forest/ Old Coast Road area between chainage 15,600 and 19,500. Twenty-five transects, 500 m long (or to the limit of vegetation) were spaced approximately 150 m apart running perpendicular to the proposed project footprint on each side of the highway upgrade. The location of transects is shown on **Illustration 3.1**.

Each transect was surveyed by ecologists Grant McLean, Frank Makin and Garon Stains to document Koala presence and occupation. Surveys were undertaken over two monitoring events (19-21 September 2017 and 25-27 September 2017) as follows:

- Diurnal survey: One observer with binoculars walking the transect searching for Koalas.
- Nocturnal survey: One observer spotlighting the transect on foot searching for Koalas at a rate of 0.5 to 1.0 km/hour (depending on vegetation density). Koala call playback was also undertaken on each transect during spotlighting to increase the chance of Koala detection.

Additional spotlighting was undertaken on tracks and easements across this area at a rate of two kilometres/ hour targeting each side of the highway. Koala call playback was undertaken at regular intervals along these tracks and easements during spotlighting to increase the chance of Koala detection.

The following data was collected for any Koalas detected:

- Location (using global positioning system [GPS]).
- Distance from transect line.
- Occupied tree species.
- Habitat type.
- Tree height.
- Diameter at breast height.
- Sex.
- Behaviour.
- Disease status.
- Reproductive status.

3.2 Survey Limitations

Council owned land around the Nambucca Heads waste facility where access was not provided was unable to be accessed at the time of survey.

Extremely dense lower storey vegetation associated with the site created obstacles to viewing the tree canopy within parts of the majority of transects, particularly during nocturnal surveys. Notwithstanding this, the combination of diurnal/ nocturnal target searches, call playback and track surveys were considered appropriate to identify resident Koalas if present.

3.3 Monitoring Triggers

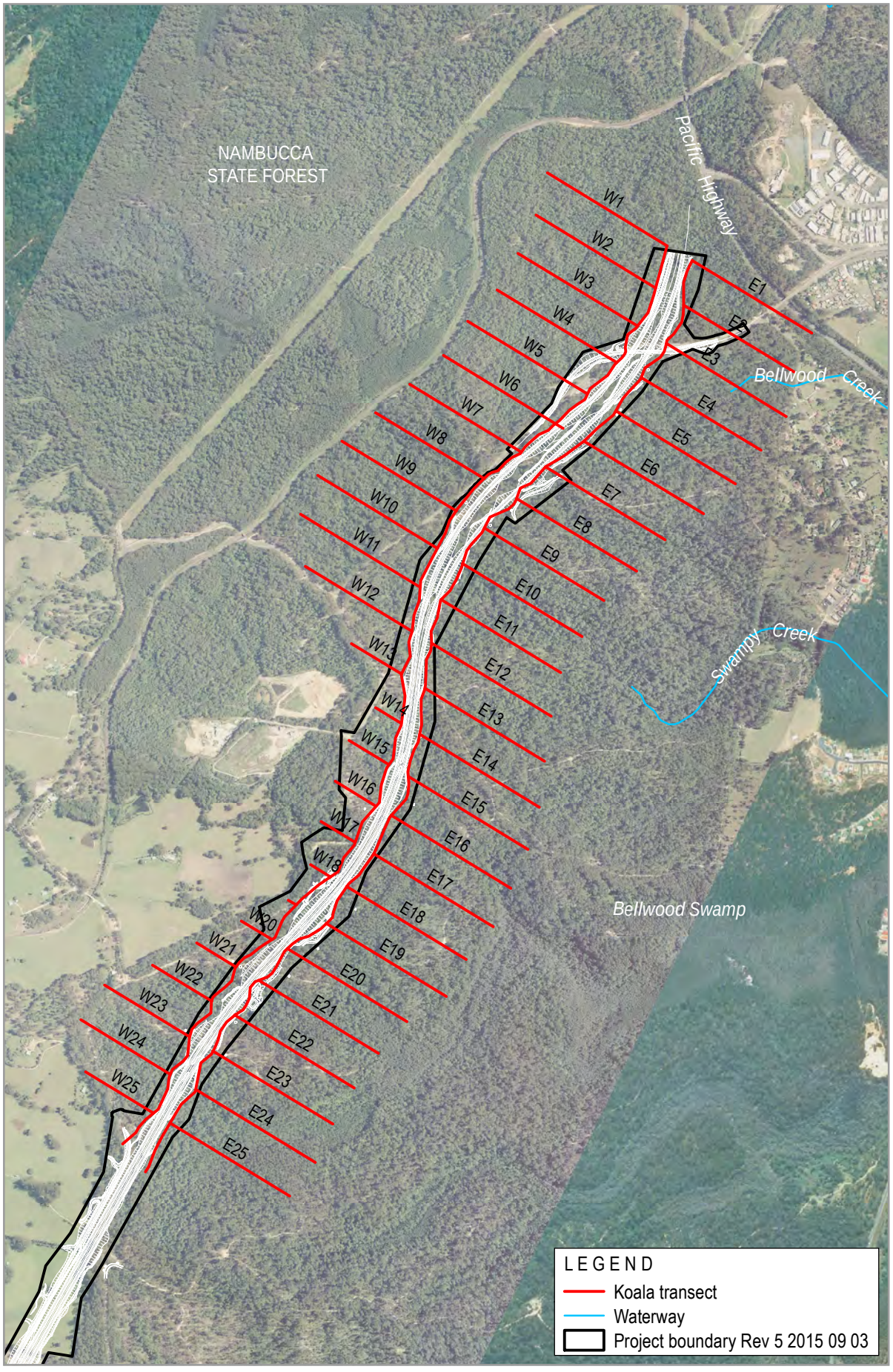
Should adequate data be obtained, population estimates are to be made based on the 'strip (fixed width) transect' or 'line transect' method described in Dique *et al*. (2003).

In accordance with The *Pre-clearance Baseline Koala Monitoring Methodology* (SKM, 2014), in the event that three or more Koalas were recorded during the baseline transect surveys, the provision for GPS/ VHF fitted collars and pit tagging of recorded Koalas and establishment of transect survey control sites would be triggered. This would encompass the following additional pre-construction monitoring activities:

- GPS/ VHF collar-fitted receiver and transmitter and pit-tagging: Locating, capturing and fitting Koalas with GPS receiver/ VHF transmitters; capturing the collared animals after six months or prior to the start of construction (whichever occurs first) to download GPS data, inspect the animals welfare (take any necessary action) and replace collar batteries. The GPS would be set to record the maximum number of location fixes for six months. The VHF transmitter will allow for easier Koala re-location during subsequent capture events. VHF transmitter batteries would be replaced every time the animal is recaptured.
- Transect surveys: Establish 'control' transect survey sites greater than 500 m from the Pacific Highway upgrade alignment to complement 'impact' transect survey sites.

Drawn by: GJM Checked by: RE Reviewed by: ILC Date: 3/10/2017
Source of base data: Roads and Maritime Services

Information shown is for illustrative purposes only



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North

Transect Locations

GeoLINK environmental management and design

Construction Stage (Year 3) Koala Monitoring
Warrell Creek to Nambucca Heads Pacific Highway Upgrade
2378-1391

Illustration 3.1

4. Results and Discussion

4.1 Field Survey Results

4.1.1 Transect Surveys

Koala sightings / observations

No Koalas were observed during nocturnal or diurnal transect surveys during the 2017 spring monitoring event.

Koala evidence

Evidence of Koala activity was identified during diurnal transect surveys on two occasions at the eastern ends of transects E18 and E19 (refer to **Illustration 4.1**). Koala evidence is presented in **Table 4.1**.

Table 4.1 Construction Stage (Year 3) Spring 2017 Transect Survey Koala Evidence

Transect	Evidence	Distance From Alignment (m)	Easting	Northing	Date
E18	Koala scats found under scratched Tallowwood.	465	496644	6607960	25/09/2017
E19	Koala scats below Tallowwood with evidence of use i.e. scratched up bark.	490	496688	6608110	26/09/2017

4.1.2 Spotlighting Surveys on Track Easements

Koala sightings / observations

Three Koalas were identified during spotlighting surveys on tracks/ easements on three separate occasions. Koala encounters occurred as follows:

- One Koala approached on ground in response to call playback then climbed a Blackbutt.
- One Koala called in response to call playback.
- One Koala was detected from eye shine resting in a Tallowwood. This individual was not responsive to call playback.

Koala evidence

No additional Koala evidence (scratches or scats) was observed during spotlighting surveys on tracks/ easements during the 2017 spring monitoring event.

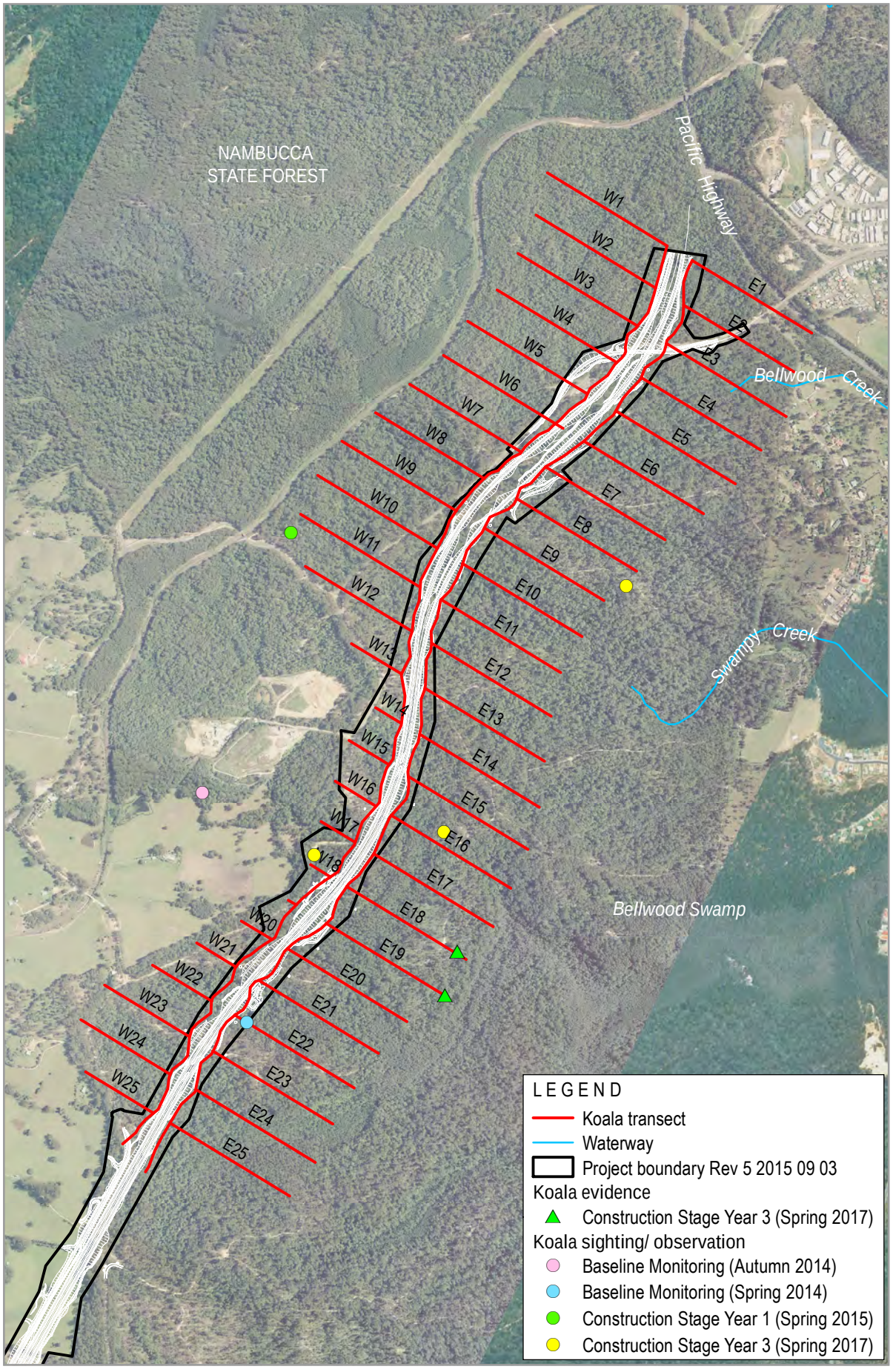
Full details of the monitoring results are presented in **Table 4.2**.

Table 4.2 Construction Stage (Year 3) Spring 2017 Spotlighting Surveys on Track Easements Koala Records

Date	*Easting*	*Northing*	*Closest Transect*	*Distance From Transect*	*Occupied Tree*	*Habitat Type*	*Tree Height*	*Tree Diameter*	*Sex*	*Behaviour*	*Disease status*	*Reproductive status*	*Location*
19/09/2017	497292	6609419	E8	65	Blackbutt	Open Forest - Blackbutt	14	20	Male	Approached on ground in response to call playback, then climbed Blackbutt.	Looked healthy from afar but difficult to determine due to dense canopy. All white rump.	Medium sized adult. Territorial response indicates breeding male	Eastern side of alignment
20/09/2017	496641	6608541	E16	47	n/a	Open Forest - Blackbutt	n/a	n/a	Male	Koala calling in response to call playback.	N/a	Territorial response indicates breeding male	Eastern side of alignment
26/09/2017	496178	6608458	W18	36	Tallowwood	Open Forest - Blackbutt	20	50	Undetermined - possibly female due to small size.	Resting in tree canopy. Detected from eyeshine. No call.	Clean rump noted. Difficult to observe due to dense canopy.	Small - medium size. Adult or dependant subadult.	Western side of alignment

Information shown is for illustrative purposes only

Drawn by: GJM Checked by: RE Reviewed by: ILC Date: 3/10/2017
Source of base data: Roads and Maritime Services



0 400

North

Koala Records

GeoLINK environmental management and design

Construction Stage (Year 3) Koala Monitoring
Warrell Creek to Nambucca Heads Pacific Highway Upgrade
2378-1389

Illustration 4.1

4.2 Discussion and Analysis

4.2.1 Koala Population

A comparison of the total numbers of Koalas detected during baseline (autumn and spring 2014) and Construction Stage (Year 1 and 3) Koala monitoring surveys is shown in **Table 4.3**.

The results of the Construction Stage (Year 3) surveys show an increase in Koalas recorded from the baseline (autumn and spring 2014) and Construction Stage (Year 1) surveys. The number of Koalas recorded (n = 3) is the largest census result with all previous surveys recording one Koala.

The results of the surveys are an indicator of population size rather than an exact measure of the local population. However, based on this indicator, the population size can be interpreted to be larger during this survey event when compared to previous surveys.

Table 4.3 Comparison of Baseline (Autumn and Spring) and Construction Stage (Year 1 and 3) Koala Monitoring Surveys

Stage	*Diurnal / Nocturnal Transect Surveys*		*Spotlighting Surveys on Track Easements*	*Total Koalas*
	Koala sightings/ observations	*Koala evidence (scats/ scratches)*	*Koala sightings/ observations*	
Baseline (autumn 2014)	0	None observed	1 (Cp)	**1**
Baseline (spring 2014)	0	None observed	1 (Cp)	**1**
Construction (Year 1 – spring 2015)	1	Pellets and scratches observed at one site.	3 (Vs)	**1***
Construction (Year 3 – spring 2017)	0	Pellets and scratches observed at two separate sites.	1 (Cp and Vs), 1 (Cp) and 1 (Vs)	**3**

Koala detection method: Cp= Call playback response, Vs=Visual observation.

* Construction Stage (Year 1) spring 2015 surveys identified one Koala during spotlighting surveys on tracks/ easements on three separate occasions. It is highly likely that this was the same individual observed during diurnal transect surveys and for this reason was represented as one record.

The results of the Construction Stage (Year 3) Koala surveys confirm that the Nambucca State Forest/ Old Coast Road area appears subject to low level usage by Koalas.

Previous Koala target surveys undertaken by GeoLINK (2013) as part of the Koala impact assessment for the WC2NH Project surveyed 38 sites using the Spot Assessment Technique (SAT; as per Phillips & Callaghan 2011) within the Nambucca State Forest/ Old Coast Road area. Three (7.9 percent) of the 38 SAT plots surveyed in this area were subject to medium (normal) Koala usage for a low density Koala population, indicating that part of the range of resident Koala/s or breeding aggregation/s overlaps the study area (GeoLINK 2013). Koala records from field surveys associated with the WC2U Project Environmental Assessment (SKM 2010b) and the Atlas of NSW Wildlife (OEH 2015) support these findings.

Insufficient data is available from the previous SAT surveys, baseline monitoring and construction monitoring to provide an accurate population estimate of Koalas in the area. However, given the low levels of Koala usage evidenced by the results of the baseline surveys and previous surveys and that the home range of Koalas in low density populations may exceed 100 ha (Ellis et al. 2002 – cited in Biolink 2009), the number of individual Koalas whose home range encompass the study area is likely to be small.

4.2.2 Tree and Habitat Use

The Koala Management Plan – Warrell Creek to Nambucca Heads Upgrade of the Pacific Highway (GeoLINK, 2016) identified the following Koala food tree species within the study area:

- Primary food trees species – Tallowwood, Forest Red Gum and Swamp Mahogany.
- Secondary food tree species – Small-fruited Grey Gum and Red Mahogany.

In addition to the trees listed above Forest Oak (*Allocasurina torulosa*) is also considered to be an important Koala feed tree species within the NSW North Coast region (Smith, 2004). A 2012 study by Smith undertaken in Pine Creek State Forest in the Coffs Harbour region identified *Allocasuarina* in more scats than all other Eucalypts with the exception of Tallowwood. Blackbutt is also locally considered a supplementary Koala food tree species in the region (Professor Rob Close, University of Western Sydney pers. comm. 2013). Both species occur within the study area.

The Construction Stage (Year 3) surveys identified Koalas in a Blackbutt and a Tallowwood, and Construction Stage (Year 1) surveys identified a single Koala in four different Blackbutt on four separate occasions. Scratches and Koala scats were observed at the base of two Tallowwood on transects E18 and E19 (**Illustration 4.1**) at the eastern side of the study area. Both species are known preferred Koala food tree species within the Nambucca Shire Council Coastal Area (OEH, 2015).

All Koala sightings and observations made during the Construction Stage (Years 1 and 3) surveys were in Open Forest dominated by Blackbutt. Baseline monitoring undertaken in autumn 2014 identified a Koala in Flooded Gum Moist Open Forest. Spring 2014 baseline monitoring identified a Koala in the vicinity of Open Blackbutt Forest with some moister gullies comprising Flooded Gum Moist Open Forest. The south-eastern extent of the study site (particularly at the eastern extent of transects E18 and E19) borders Swamp Forest dominated by Swamp Mahogany/ Broad-leaved Paperbark. It is considered likely that Koalas are using this habitat on the basis of:

- Scratches and Koala scats were observed at the base of two Tallowwood on transects E18 and E19 at the eastern side of the study area.
- Swamp Mahogany is identified as a primary Koala food tree.
- Swamp Forest environments provide cool refuge areas during summer.

The results of monitoring undertaken to date (inclusive of baseline monitoring) indicate that Koalas are using both the dry upper slopes and ridges associated with the northern portion of Nambucca State Forest and the moist gullies that occur predominantly in the southern portion of the study site.

The low levels of Koala usage evidenced by the results of the baseline and construction surveys indicate the number of individual Koalas whose home range encompass the study area is likely to be small. Analysis of resident Koala activity (abundance, home range and movements) would be detailed in the Ecological Monitoring Annual Report (2017/2018).

4.2.3 Monitoring Triggers

The WC2NH Monitoring Strategy states that "*In the event that three or more Koalas are recorded during the transect surveys, the provision for GPS/ VHF fitted collars and pit tagging of recorded Koalas and establishment of transect survey control sites would be triggered*". This trigger is specific to baseline monitoring only and hence does not require further consideration.

5. Conclusions

The Construction Stage (Year 3) Koala monitoring surveys identified three Koalas during spotlighting surveys on tracks/ easements on three separate occasions. Additionally evidence of Koala activity (scratches and scats) was identified during diurnal transect surveys on two occasions in the south-eastern portion the study site. The results of the Construction Stage (Year 3) surveys show an increase in Koalas recorded from the baseline (autumn and spring 2014) and Construction Stage (Year 1) surveys.

The Construction Stage (Year 3) surveys identified Koalas in a Blackbutt and a Tallowwood and scratches and Koala scats in association with two Tallowwood. This is consistent with Construction Stage (Year 1) surveys where a single Koala was identified in four different Blackbutt on four separate occasions. All Koala observations are associated with preferred Koala food tree species within the NSW North Coast region.

All Koala sightings and observations made during the Construction Stage (Years 1 and 3) surveys were in Open Forest – Blackbutt habitat. Previous monitoring has also identified Koalas inhabiting Flooded Gum Moist Open Forest. The south-eastern extent of the study site (particularly at the eastern extent of transects E18 and E19) also borders Swamp Forest (Swamp Mahogany/ Paperbark). It is considered likely that Koalas are using this habitat where Swamp Mahogany provides a preferred feed tree resource and Swamp Forest provides suitable refuge habitat. On this basis, it appears Koalas are using both dry upper slopes and ridges associated with the northern portion of Nambucca State Forest and the moist gullies that occur predominantly in the southern portion of the study site.

The results of the Construction Stage (Years 1 and 3) monitoring and baseline monitoring events support the results of previous Koala surveys, and confirm that the southern and northern parts of the Nambucca State Forest are subject to low level usage by a small number of Koalas.

Ongoing monitoring is required to identify any changes in resident Koala activity (abundance, home range and movements) in response to construction of WC2NH and the effectiveness of Koala habitat connectivity mitigation measures (i.e. fauna underpasses and exclusion fencing).

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Appendix F

Roadkill Monitoring Reports and Field Sheets

WC2NH Road Kill Monitoring – 1st March 2017 – 31st May 2017

Road kill monitoring has been undertaken daily, although only required weekly throughout construction as per Appendix A of the Ecological Monitoring Program Procedure. This report captures from 1st March 2017 through to the 31st May 2017. Field sheets from this period are attached in Appendix A.

Non-EPBC Species Road Kill

During monitoring, nine road kills were identified:

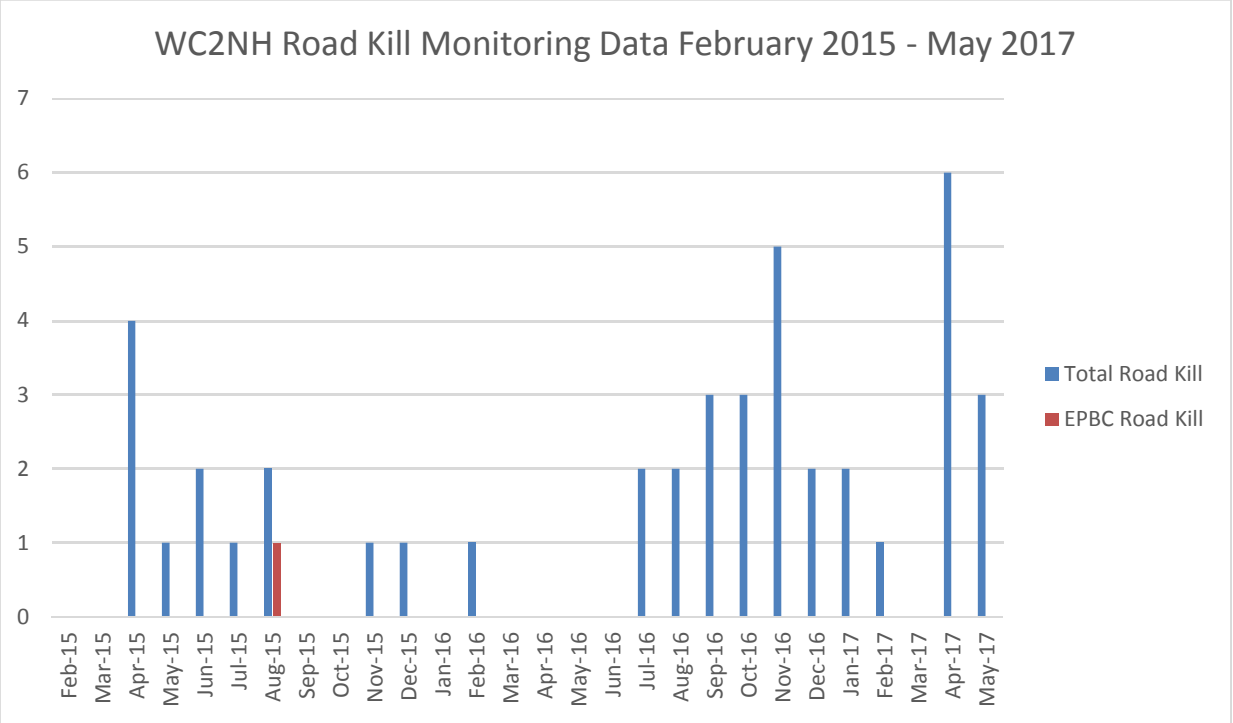
- 1 Pretty-Faced Wallaby (*Macropus parryi*), identified 6th April 2017, at Old Coast Road Central approximate chainage 56,210
- 1 European Hare (*Lepus europaeus*), identified 10th April 2017, at Old Coast Road Central, approximate chainage 55,760
- 1 European Red Fox (*Vulpes vulpes)*, identified 12th April 2017, at Existing Pacific Highway Warrell Creek approximate chainage 48,050
- 1 Black Flying Fox (*Pteropus alecto*), identified 18th April 2017, at Existing Pacific Highway Warrell Creek approximate chainage 47,560
- 1 Echidna (*Tachyglossidae)*, identified 19th April 2017, at Existing Pacific Highway Warrell Creek Township approximate chainage 43,900
- 1 Brushtail Possum (*Trichosurus vulpecula*), identified 26th April 2017, at Existing Pacific Highway Cut 10 approximate chainage 47,600
- 1 European Red Fox (*Vulpes vulpes)*, identified 16th May 2017, at Existing Pacific Highway Warrell Creek approximate chainage 48,050
- 1 Pretty-Faced Wallaby (*Macropus parryi*), identified 18th May 2017, at Existing Pacific Highway Bald Hill Road approximate chainage 49,200
- 1 European Red Fox (*Vulpes vulpes)*, identified 31st May 2017 at Existing Pacific Highway Bald Hill Road approximate chainage 49,200

EPBC Species Road Kill

No EPBC Species were identified during this monitoring period.

Road kill monitoring results to date are summarised in Figure 1.

Figure 1 – WC2NH Road Kill monitoring results for 2015-2017



AppendixA– Road Kill Monitoring Field Sheets March 2017 to May 2017

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: MAL - STEVE - MUZ - TROY		
Date: 27-2-17 - 03-3-17		Time:
Location:	Chainage: SEE BELOW	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PAC + ALBERT + SCOTTS + B/HILL + GUMMA + NURSERY MON 27TH TUE 28TH WED ~~28TH~~ 1ST THU 2ND FRI 3RD NIL ✓ NIL ✓ NIL NIL NIL.		

Observers: MAL - STEVE - ANDREW		
Date: 6-10/03/17		Time: 0700 - 1000
Location:	Chainage: SEE BELOW	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PAC + ALBERT + SCOTTS + B/HILL + GUMMA + NURSERY MON 6TH TUES 7TH WED 8TH THURS 9TH FRI 10TH NIL. NIL NIL NIL. NIL.		

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: MAL / STEVE / ANDREW		
Date: 13-17/03/17		Time: 0700-1000
Location:	Chainage: SEE BELOW	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PAC + ALBERT + SCOTTS + B/HILL + GUMMA + NURSERY MON 13 TUES 14 WED 15 THURS 16 FRI 17. NIL. NIL. NIL. NIL. NIL.		

Observers: MAL / STEVE / ANDREW		
Date: 20-24/03/17.		Time: 0700-1000
Location:	Chainage: SEE BLOW	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PAC + ALBERT + SCOTTS + B/HILL + GUMMA + NURSERY MON 20 TUE 21 WED 22 THURS 23 FRI 24. NIL. NIL NIL. NIL. NIL		

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: MAL - STEVE - ANDREW		
Date: 27/3/17 - 31.3.17		Time: 0700 - 1000
Location:	Chainage: SEE BELOW	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PAC + ALBERT + SCOTTS + B/HILL + GUMMA + NURSERY MON 27TH. TUES 28TH WED 29TH THURS 30TH FRI 31ST NIL NIL. NIL. NIL. NIL.		

Observers: MAL - STEVE - ANDREW		
Date: 3-7/04/17		Time: 0700 - 1000
Location:	Chainage: SEE BELOW	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PAC + ALBERT + SCOTTS + B/HILL + GUMMA + NURSERY MON 3rd TUES 4TH WED 5TH THURS 6TH FRI 7TH. NIL. NIL. NIL 1x squashed wallaby on OCKD (central). NIL		

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: MM, STEVE, ANDREW.		
Date: 10-14/4/2017 - 17/04/17		Time: 0700-1000
Location:	Chainage: see below	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PAC + ALBERT + SCOTTS + B/HILL + GUMMA + NURSERY + OCR MON 10: AM 1 x HARE TUES 11: NIL WED 12: squashed fox pac hwy. new well ck bridge THURS 13: squashed [illegible] pac hwy [illegible] entrance FRI. 14: NIL OCR Central		

Observers:		
Date:		Time:
Location:	Chainage:	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments:		

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: STEVE / ANDREW		
Date: 17-21/4/17		Time: 0700 - 1000
Location:	Chainage: SEE BELOW	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		

Comments: PAC + ALBERT + B/HILL + GUMMA + NURSERY + OCRD

MON 17: NIL

TUES 18: squashed ~~fish~~ bat pacific bay shoulder quarry

WED 19: squashed echinata pacific hwy 5 wombats. shoulder.

THURS 20: NIL

FRI 21: NIL

Observers: MAL + DREW + STEVE		
Date: 24/04/17		Time: 0700 - 1200
Location:	Chainage: See below	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		

Comments: ~~PAC + ALBERT + B/HILL + GUMMA + OC Rd + NURSERY + BRAINS~~

MON 24/04/17: ~~KANGAROO OCRd~~

TUE 25: ~~squashed possum~~ cat 10.

WED 26: squashed possum cat 10

THUR 27: NIL

FRI 28: NIL.

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: MM + DREW + STEVE		
Date: 1-05/05/17		Time: 0700 - 1200
Location:	Chainage: See below	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PAC + ALBERT + BLACK + GUMMA + OLD RD + NURSERY + BROWNS MON 1ST TUES 02 WED 03 THURS 04 FRI 05 NIL NIL NIL NIL NIL		

Observers:		
Date:		Time:
Location:	Chainage:	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments:		

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: MAL + STEVE + DREW		
Date: 08-12/05/17		Time: 0700 - 1200
Location:	Chainage: See below.	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		

Comments: PAC + ALBERT + B/HILL + GUMMA + OCKD + NURSEY + BROWNS.

MON 8	TUES 9	WED 10	THURS 11	FRI 12
NIL	NIL	NIL	NIL.	NIL

Observers: STEVE + DREW		
Date: 15-19/07/17		Time: 0700 - 1200
Location:	Chainage:	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		

Comments: PAC + ALBERT + B/HILL + GUMMA + OCKD + NURSEY + BROWNS

MON 15	TUES 16	WED 17	THURS 18	FRI 19
NIL	Fox squashed Pacific Hwy Worrell Creek Bridge.	NIL	1x Wallaby Pacific Hwy Bald Hill.	NIL

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: STEVE + DREW		
Date: 22-26/05/17		Time: 0700 – 1200
Location:	Chainage: see below	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PAC + ALBERT + B/HILL + GUMMA + OCRD + NURSERY + BROWNS MON 22 TUE 23 WED 24 THURS 25 FRI 26 NIL NIL NIL NIL NIL		

Observers: MAL + STEVE + DREW		
Date: 29/05 – 02/06		Time: 0700 – 1200
Location:	Chainage: see below	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PAC + ALBERT + B/HILL + GUMMA + OCRD + NURSERY + BROWNS MON 29 TUES 30 WED 31 THURS 01 FRI 02 NIL NIL 1x Fox squashed pacific hwy bald hill NIL NIL		

WC2NH Road Kill Monitoring – 1st June 2017 – 31st August 2017

Road kill monitoring has been undertaken daily, although only required weekly throughout construction as per Appendix A of the Ecological Monitoring Program Procedure. This report captures from 1st June 2017 through to the 31st August 2017. Field sheets from this period are attached in Appendix A.

Non-EPBC Species Road Kill

During monitoring, nine road kills were identified:

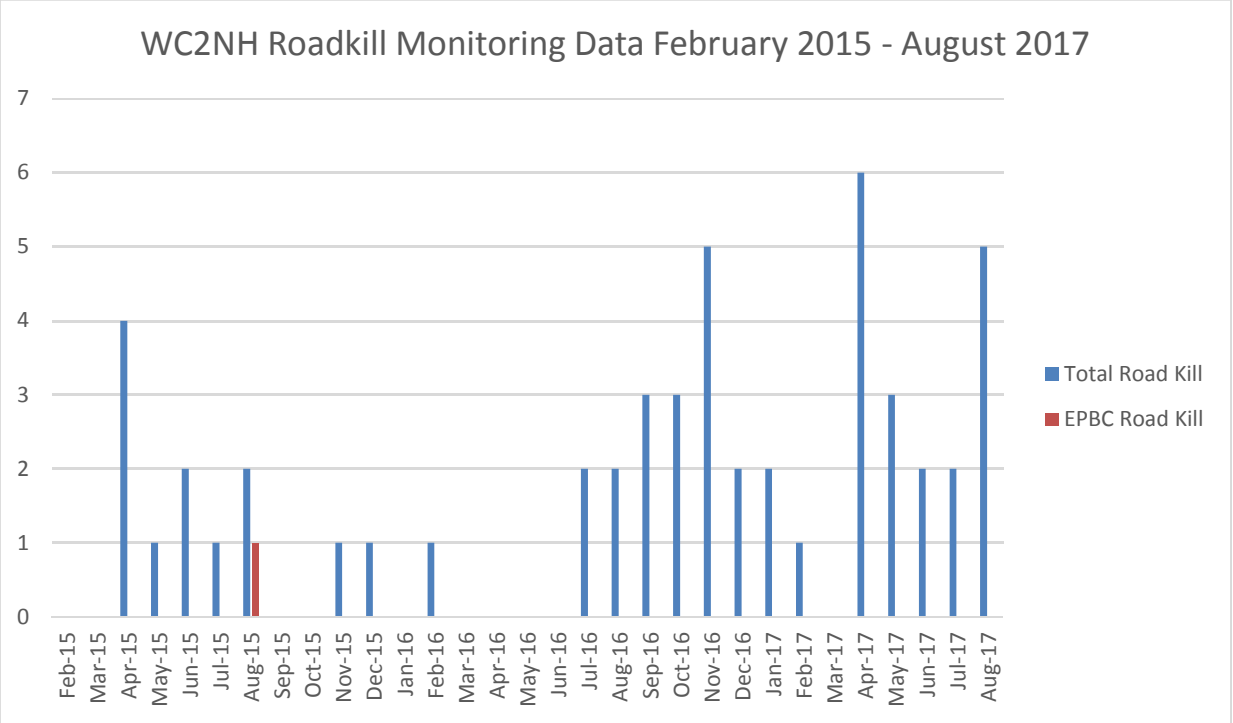
- 1 Eastern Grey Kangaroo (*Macropus giganteus)*, identified 5th June 2017, at Existing Pacific Highway Albert Drive approximate chainage 44,800
- 1 Dog (*Canis lupus familiaris*), identified 16th June 2017, at Existing Pacific Highway Albert Drive approximate chainage 44,800
- 1 Pretty-Faced Wallaby (*Macropus parryi*), identified 24th July 2017, at Existing Pacific Highway Bald Hill Road approximate chainage 49,200
- 1 Dog (*Canis lupus familiaris*), identified 25th July 2017, at Existing Pacific Highway Bald Hill Road approximate chainage 49,200
- 1 Pretty-Faced Wallaby (*Macropus parryi*), identified 7th August 2017, at Existing Pacific Highway Williamson Creek approximate chainage 47,100
- 1 Pretty-Faced Wallaby (*Macropus parryi*), identified 11th August 2017, at Existing Pacific Highway Upper Warrell Creek approximate chainage 41,800
- 1 Long-nosed Bandicoot (*Perameles nasuta*), identified 14th August 2017, at Existing Pacific Highway Albert Drive approximate chainage 44,800
- 1 Laughing Kookaburra (*Dacelo novaeguineae)*, identified 28th August 2017, at Existing Pacific Highway Warrell Creek Township approximate chainage 43,900
- 1 Pretty-Faced Wallaby (*Macropus parryi*), identified 31st August 2017, at Old Coast Road Central approximate chainage 56,210

EPBC Species Road Kill

No EPBC Species were identified during this monitoring period.

Road kill monitoring results to date are summarised in Figure 1.

Figure 1 – WC2NH Road Kill monitoring results for 2015-2017



AppendixA– Roadkill Monitoring Field Sheets June 2017 to August 2017

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: STEVE + DREW		
Date: 22-26/05/17		Time: 0700–1200
Location:	Chainage: See below	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PAC + ALBERT + B/HILL + GUMMA + OCRD + NURSERY + BROWNS MON 22 TUE 23 WED 24 THURS 25 FRI 26 NIL NIL NIL NIL. NIL		

Observers: MAL + STEVE + DREW		
Date: 29/05 – 02/06		Time: 0700–1200
Location:	Chainage: See below	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PAC + ALBERT + B/HILL + GUMMA + OCRD + NURSERY + BROWNS MON 29 TUES 30 WED 31 THURS 01 FRI 02 NIL NIL 1x Fox squashed Bauchop hwy bald hills NIL. NIL		

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: MAL+STEVE + ANDREW		
Date: 5-9/6/2017		Time: 0700-1200
Location:	Chainage: SEE BELOW	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		

Comments: PAC + ALBERT + B/HILL + GUMMA + OCRD + NURSEY + BROWNS

MON 05	TUES 06	WED 07	THURS 08	FRI 09.
1 x kangaroo albert drive sth / pac hwy.	NIL	NIL	NIL	NIL

Observers: MAL / STEVE / ANDREW		
Date: 12-16/06/2017.		Time: 0700-1200
Location:	Chainage: SEE BELOW	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		

Comments: PAC + ALBERT + B/HILL + GUMMA + OCRD + NURSEY + BROWNS

MON 12	TUES 13	WED 14	THURS 15	FRI 16
—	NIL	NIL	NIL	SQUASHED DOG PACIFIC HWY / ALBERT STH

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: MAL + STEVE + ANDREW		
Date: 19-23/06/17		Time: 0700 - 1200
Location:	Chainage: See below	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / femole*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PAE + ALBERT + B/HILL + GUMMA + OCKD + NURSEY + BROWNS MON 19 TUES 20 WED 21 THURS 22 FRI 23 NIL NIL NIL NIL NIL		

Observers: MAL + STEVE + ANDREW		
Date: 26-30/06/17		Time: 0700 - 1200
Location:	Chainage: See below	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PAE + ALBERT + B/HILL + GUMMA + OCKD + NURSEY + BROWNS MON 26 TUES 27 WED 28 THURS 29 FRI 30 NIL NIL. NIL NIL NIL.		

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: STEVE + ANDREW		
Date: 03-07/09/17		**Time:** 0700 - 1200
Location:	**Chainage:** See below	**GPS:**
Species:		
Photos (circle): *Yes / No*		**Photos sent to Ecologist** (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	**Rainfall** (last 24hrs):	**Moon Phase:**
Sex (circle): *male / female*		**Age Class** (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PAC + ALBERT + B/HILL + GUMMA + OCRD + NURSEY + BROWNS MON 03 TUES 04 WED 05 THURS 06 FRI 07. NIL NIL NIL NIL NIL		

Observers: STEVE + ANDREW		
Date: 10-14/07		**Time:** 0700 - 1206
Location:	**Chainage:** See below.	**GPS:**
Species:		
Photos (circle): *Yes / No*		**Photos sent to Ecologist** (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	**Rainfall** (last 24hrs):	**Moon Phase:**
Sex (circle): *male / female*		**Age Class** (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PAC + ALBERT + B/HILL + GUMMA + OCRD + NURSEY + BROWNS MON 10 TUES 11 WED 12 THURS 13 FRI 14 N/L NIL NIL. NIL NIL.		

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: STEVE, ANDREW.		
Date: 17-21/07/17		Time: 0700 - 1200
Location:	Chainage: SEE BELOW	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PAC + ALBERT + B/HILL + GUMMA + OCKD + NURSEY + BROWNS MON 17 TUES 18 WED 19 THURS 20 FRI 2. NIL NIL. NIL NIL NIL.		

Observers: STEVE + ANDREW		
Date: 24-28/07/17		Time: 0700 - 1200
Location:	Chainage: see below	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PAC + ALBERT + B/HILL + GUMMA + OCKD + NURSEY + BROWNS MON 24 TUES 25 WED 26 THURS 27 FRI 28 1x Wallaby squash NIL. NIL NIL Pacific hwy dog? Bald hill Pacific hwy northbound bald hill sthbound.		

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: STEVE + ANDREW		
Date: 31/7 - 4/08/17		Time: 0700 - 1200 DAILY
Location:	Chainage: SEE BELOW	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		

Comments: PAC + ALBERT + B/HILL + GUMMA + OCKD + NURSEY + BROWNS.

MON 31	TUES 1	WED 2	THURS 3	FRI 4
NIL	NIL.	NIL	NIL	NIL

Observers: ANDREW.		
Date: 07/08 – 11/08/17		Time: 0700 - 1200 DAILY
Location:	Chainage: SEE BELOW	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		

Comments: PAC + B/HILL + ALBERT + GUMMA + OCKD + NURSEY + BROWNS

MON 7	TUES 8	WED 9	THURS 10	FRI 11
1x Squashed Wallaby Pacific Hwy Crowdies Ck.	NIL	NIL	NIL	Squashed wallaby pacific hwy southern end project

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: STEVE + ANDREW.		
Date: 14-18/08/2017		**Time:** 0700-1200
Location:	**Chainage:** See below	**GPS:**
Species:		
Photos (circle): *Yes / No*		**Photos sent to Ecologist** (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	**Rainfall** (last 24hrs):	**Moon Phase:**
Sex (circle): *male / female*		**Age Class** (circle): *adult / juvenile*
Pouch Young/Back Young:		

Comments: PAC + ALBERT + B/HILL + GUMMA + OCKD + NURSEY + BROWNS

MON 14	TUES 15	WED 16	THURS 17	FRI 18
squashed bandicoot. northbound past the hwy near albert dr	NIL	NIL	NIL	NIL

Observers: STEVE + ANDREW		
Date: 21-25/08/2017		**Time:** 0700 - 1200.
Location:	**Chainage:** See below	**GPS:**
Species:		
Photos (circle): *Yes / No*		**Photos sent to Ecologist** (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	**Rainfall** (last 24hrs):	**Moon Phase:**
Sex (circle): *male / female*		**Age Class** (circle): *adult / juvenile*
Pouch Young/Back Young:		

Comments: PAC + ALBERT + B/HILL + GUMMA + OCKD + NURSEY + BROWNS

MON 21	TUES 22	WED 23	THURS 24	FRI 25
NIL	NIL	NIL	NIL	NIL

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: STEVE + ANDREW		
Date: 28/08 - 01/09/17		Time: 0700 - 1200 DAILY
Location:	Chainage: SEE BELOW	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		

Comments: PAC + ALBERT + BHILL + GUMMA + OCRD + NURSEY + BROWNS

MON 28: KOOKABURRA S-BENDS PACIFIC HWY.
TUES 29: NIL
WED 30: NIL
THURS 31: 1x Wallaby OLD COAST RD CENTRAL.
FRI 01: NIL.

Observers: STEVE + ANDREW		
Date: 04 to 08/09/16		Time: 0700 - 1200 DAILY
Location:	Chainage: SEE BELOW	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		

Comments: PAC + ALBERT + BHILL + GUMMA + OCRD + NURSEY + BROWNS

MON 04: NIL.
TUES 05: NIL
WED 06: NIL
THURS 07: 1x squashed wallaby pacific hwy S-bends Wauchope.
FRI 08: NIL.

WC2NH Road Kill Monitoring – 1st September 2017 – 30th November 2017

Road kill monitoring has been undertaken daily, although only required weekly throughout construction as per Appendix A of the Ecological Monitoring Program Procedure. This report captures from 1st September 2017 through to the 30th November 2017. Field sheets from this period are attached in Appendix A.

Non-EPBC Species Road Kill

During monitoring, five road kills were identified:

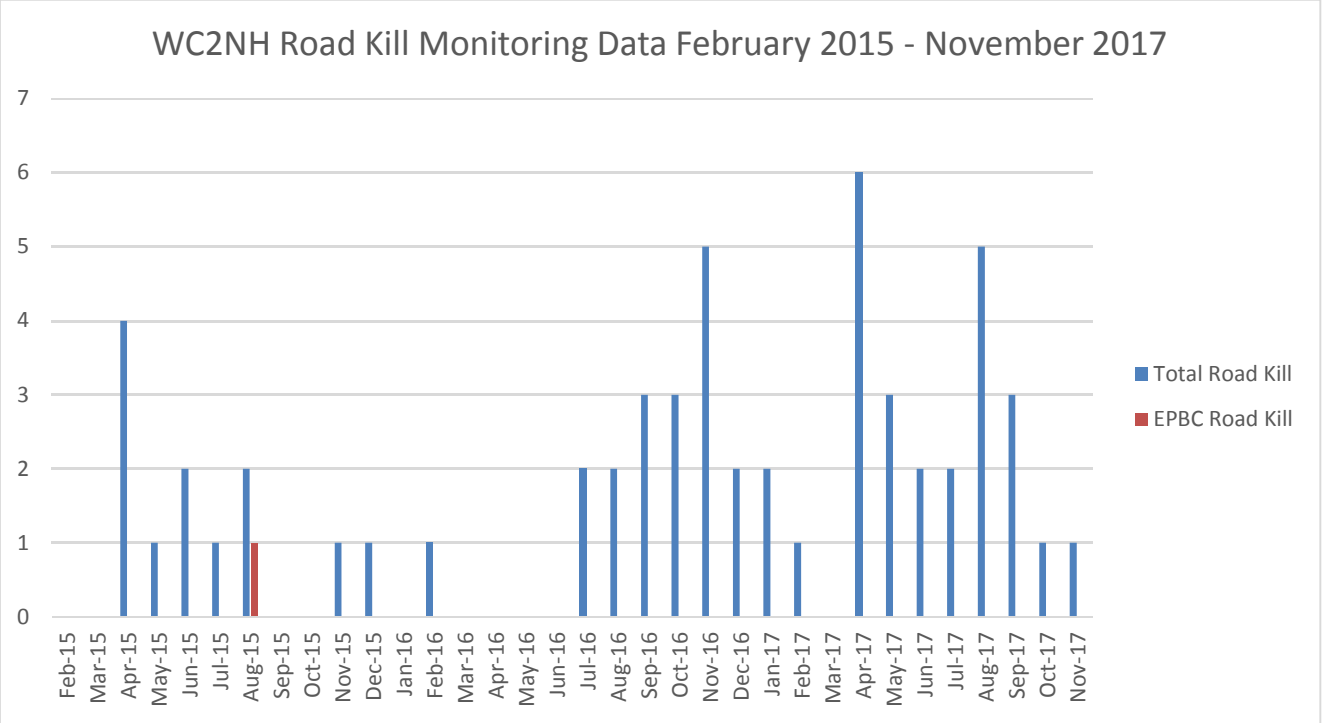
- 1 Pretty-Faced Wallaby (*Macropus parryi*), identified 7th September 2017 at Existing Pacific Highway Warrell Creek Township approximate chainage 43,900
- 1 Pretty-Faced Wallaby (*Macropus parryi*), identified 11th September 2017 at Existing Pacific Highway Browns Crossing Road approximate chainage 42,000
- 1 Brushtail Possum (*Trichosurus vulpecula*), identified 29th September 2017, at Existing Pacific Highway Bald Hill Road approximate chainage 49,200
- 1 Pretty-Faced Wallaby (*Macropus parryi*), identified 16th October 2017 at Existing Pacific Highway Browns Warrell Creek approximate chainage 48,050
- 1 European Rabbit (*Oryctolagus cuniculus*), identified 17th November 2017 at Old Coast Road South approximate chainage 53,100

EPBC Species Road Kill

No EPBC Species were identified during this monitoring period.

Road kill monitoring results to date are summarised in Figure 1.

Figure 1 – WC2NH Road Kill monitoring results for 2015-2017



AppendixA– Road Kill Monitoring Field Sheets September 2017 to November 2017

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: STEVE + ANDREW		
Date: 28/08 - 01/09/17		**Time:** 0700 - 1200 DAILY
Location:	**Chainage:** SEE BELOW	**GPS:**
Species:		
Photos (circle): *Yes / No*		**Photos sent to Ecologist** (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	**Rainfall** (last 24hrs):	**Moon Phase:**
Sex (circle): *male / female*		**Age Class** (circle): *adult / juvenile*
Pouch Young/Back Young:		

Comments: PAC + ALBERT + BHILL + GUMMA + OCRD + NURSEY + BROWNS

MON 28	TUES 29	WED 30	THURS 31	FRI 01
KORKARUKKA S-BENDS PACIFIC HWY.	NIL	NIL	1x Wallaby OLD COASTRD CENTRAL.	NIL.

Observers: STEVE + ANDREW		
Date: 04/08/09/16		**Time:** 0700 - 1200 DAILY
Location:	**Chainage:** SEE BELOW	**GPS:**
Species:		
Photos (circle): *Yes / No*		**Photos sent to Ecologist** (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	**Rainfall** (last 24hrs):	**Moon Phase:**
Sex (circle): *male / female*		**Age Class** (circle): *adult / juvenile*
Pouch Young/Back Young:		

Comments: PAC + ALBERT + BHILL + GUMMA + OCRD + NURSEY + BROWNS

MON 04	TUES 05	WED 06	THURS 07	FRI 08
NIL.	NIL	NIL	1x squashed wallaby Pacific Hwy S-bends Wauchope.	NIL.

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: STEVE + ANDREW		
Date: 11-15/09/17		Time: 0700 - 1200 DAILY
Location:	Chainage: SEE BELOW	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PAC + ALBERT + B/HILL + GYMMA + OCRD + NURSEY + BROWNS MON 11 — TUES 12 — WED 13 — THURS 14 — FRI 15 1 Squashed wallaby picked up by North @ bridge crossing. — NIL — NIL — NIL — NIL		

Observers: STEVE + ANDREW		
Date: 18-22/09/17		Time: 0700-1200 DAILY
Location:	Chainage:	GPS:
Species: SEE BELOW		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PAC + ALBERT + B/HILL + GYMMA + OCRD + NURSEY + BROWNS MON 18 — TUE 19 — WED 20 — THURS 21 — FRI 22. NIL — NIL — NIL — NIL — NIL		

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: STEVE + ANDREW		
Date: 25-29/09/2017		Time: 0700-1200
Location:	Chainage: SEE BELOW	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		

Comments: PAC + ALBERT + B/HILL + GUMMA + OCKD + NURSEY + BROWNS

MON 25	TUES 26	WED 27	THURS 28	FRI 29.
NIL	NIL	NIL	NIL	1x Possum northbound PACIFIC HWY BALD HILL

Observers: STEVE + ANDREW		
Date: 02-06/10/17		Time: 0700-1200.
Location:	Chainage: SEE BELOW	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		

Comments: PAC + ALBERT + B/HILL + GUMMA + OCKD + NURSEY + BROWNS

MON 02	TUES 03	WED 04	THURS 05	FRI 06
—	NIL	NIL	NIL	NIL

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: STEVE + ANDREW.		
Date: 09-13/10/17		Time: 0700 - 1200
Location:	Chainage: SEE BELOW.	GPS:
Species: SEE BELOW		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PACT ALBERT + B/HILL + GUMMA + OCKID + NURSEY + BROWNS. MON 9: NIL; TUES 10: NIL; WED 11: NIL; THURS 12: NIL; FRI 13: NIL		

Observers: STEVE + ANDREW		
Date: 16-20/10/17		Time: 0700 - 1200
Location:	Chainage: SEE BELOW	GPS:
Species: SEE BELOW		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PACT ALBERT + B/HILL + GUMMA + OCKID + NURSEY + BROWNS. MON 16: 1 x Wallaby nth bound pacific hwy warwick; TUES 17: NIL; WED 18: NIL; THURS 19: NIL; FRI 20: NIL		

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: ANDREW		
Date: 20/10 - 24/10 2017.		Time: 0700 - 1200
Location:	Chainage: see below	GPS:
Species: see below		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PAC + ALBERT + BILL HILL + GUMMA + OCEAN NURSERY + BROWNS MON 23 TUES 24 WED 25 THUR 26 FRI 27 NIL NIL NIL NIL NIL		

Observers:		
Date:		Time:
Location:	Chainage:	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *mole / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments:		

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: ~~STEVE + ANDREW~~ ANDREW		
Date: 30-10-17 - 3/11/17		Time: 0700-1200
Location:	Chainage: SEE BELOW	GPS:
Species: SEE BELOW.		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PAC + ALBERT + B/HILL + GUMMA + OCRD + NURSERY + BROWNS. MON 30 TUES 31 WED 01 THURS 02 FRI 03. NIL NIL NIL NIL NIL		

Observers: ANDREW		
Date: 6-10/11/17		Time: 0700-1200
Location:	Chainage: See below	GPS:
Species: See below		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PAC + ALBERT + B/HILL + GUMMA + OCRD + NURSERY + BROWNS MON 6 TUES 7 WED 8 THURS 9 FRI 10 NIL NIL NIL NIL. NIL.		

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: ANDREW		
Date: 13-17/11/17		Time: 0700-1200
Location:	Chainage: SEE BELOW	GPS:
Species: SEE BELOW		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PAC + ALBERT + B/HILL + GUMMA + OCRD + NURSEY + BROWNS MON 13: NIL TUES 14: NIL WED 15: NIL THURS 16: NIL FRI 17: 1x Rabbit old coast road South		

Observers: ANDREW		
Date: 27/11/-1/12/17		Time: 0700 – 1200
Location:	Chainage: SEE BELOW	GPS:
Species: SEE BELOW		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PAC + ALBERT + B/HILL + GUMMA + OCRD + NURSEY + BROWNS MON 27th: NIL TUES 28th: NIL WED 29th: NIL THURS 30th: NIL FRI 1st: NIL		

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: ANDREW		
Date: 20/11 - 24/11		Time:
Location:	Chainage: SEE BELOW	GPS:
Species: SEE BELOW		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: MON 20 NIL TUES 21 NIL WED 22 NIL THURS 23 NIL FRI 24 NIL		

Observers:		
Date:		Time:
Location:	Chainage:	GPS:
Species:		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments:		

WC2NH Road Kill Monitoring – 1st December 2017 – 25th February 2018

Road kill monitoring has been undertaken daily, although only required weekly throughout construction as per Appendix A of the Ecological Monitoring Program Procedure. This report captures from 1st December 2017 through to the 25th February 2018. Field sheets from this period are attached in Appendix A.

Non-EPBC Species Road Kill

During monitoring, six road kills were identified:

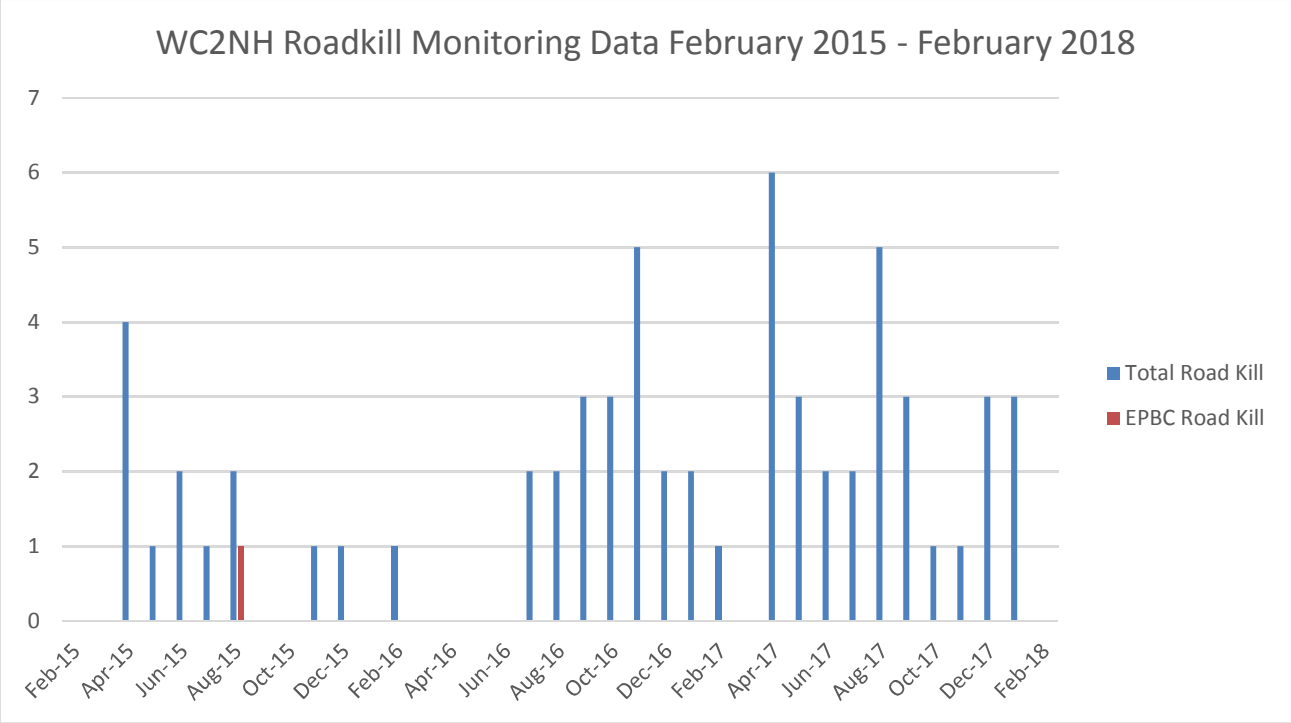
- 1 Cat (*Felis catus*), identified 12th December 2017 at Existing Pacific Highway Bald Hill Road approximate chainage 49,200
- 1 Unidentifiable Bird, identified 20th December 2017 at Existing Pacific Highway Warrell Creek approximate chainage 48,290
- 1 European Rabbit (*Oryctolagus cuniculus*), identified 28th December 2017 at Existing Pacific Highway Albert Drive approximate chainage 44,800
- 1 Unidentifiable Lizard, identified 5th January 2018 at Old Coast Road Central approximate chainage 55,500
- 1 Eastern Grey Kangaroo (*Macropus giganteus)*, identified 8th January 2018 at Old Coast Road Central approximate chainage 55,500
- 1 European Rabbit (*Oryctolagus cuniculus*), identified 25th January 2018 at Existing Pacific Highway Albert Drive approximate chainage 44,800

EPBC Species Road Kill

No EPBC Species were identified during this monitoring period.

Road kill monitoring results to date are summarised in Figure 1.

Figure 1 – WC2NH Road Kill monitoring results for 2015-2018



AppendixA– Roadkill Monitoring Field Sheets December 2017 to February 2018

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: RYAN WATT		
Date: 4-12-17		Time: 7:00-12:00
Location:	Chainage: SEE BELOW	GPS:
Species: SEE BELOW		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PAC + ROSEWOOD + ALBERT + SCOTTS + GUMMA + OLDCOAST MON 4TH TUE 5TH WED 6TH THU 7TH FRI 8TH NIL NIL NIL NIL NIL		

Observers: RYAN WATT		
Date: 11-12-17		Time: 7:00-12:00
Location:	Chainage: SEE BELOW	GPS:
Species: SEE BELOW		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PAC + ROSEWOOD + ALBERT + SCOTTS + GUMMA + OLDCOAST MON 11TH TUE 12TH WED 13TH THU 14TH FRI 15TH NIL 1 DEAD CAT BHR NIL NIL NIL		

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: RYAN WATT		
Date: 18-12-17		Time: 7:00-12:00
Location:	Chainage: SEE BELOW	GPS:
Species: SEE BELOW		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PAC + ROSEWOOD + SCOTTS + GUMMA + ALBERT + OLDCOAST MON 18TH TUE 19TH WED 20TH THU 21st FRI 22ND NIL NIL DEAD LWC BIRD NIL NIL		

Observers: RYAN WATT		
Date: 25-12-17		Time: 7:00-12:00
Location:	Chainage: SEE BELOW	GPS:
Species: SEE BELOW		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: PAC + ROSE + ALBERT + SCOTTS + GUMMA + OLDCOAST MOTORWAY MON 25TH TUE 26TH WED 27TH THU 28TH FRI 29TH NIL NIL NIL DEAD RABBIT ALBERT DRIVE NIL		

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: RYAN WATT		
Date: 1-1-18		Time: 7:00 - 12:00
Location:	Chainage: SEE BELOW	GPS:
Species: SEE BELOW		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: MOTORWAY PAC + BROWNS + ROSE + ALBERT + SCOTTS + OC MON 1ST TUE 2ND WED 3RD THU 4TH FRI 5TH NIL NIL NIL NIL DEAD LIZARD → Old Coast Rd confirmed 7/3		

Observers: RYAN WATT		
Date: 8-1-18		Time: 7:00 - 12:00
Location:	Chainage: SEE BELOW	GPS:
Species: SEE BELOW		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: MOTORWAY PAC + BROWNS + ALBERT + ROSE + SCOTTS + OLD COAST MON 8TH TUE 9TH WED 10TH THU 11TH FRI 12TH DEAD ROO NIL NIL NIL NIL		

Old Coast Rd confirmed 7/3.

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: RYAN WATT		
Date: 15-1-18		Time: 7:00 - 12:00
Location:	Chainage: SEE BELOW	GPS:
Species: SEE BELOW		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: MOTORWAY-PAC+BROWNS+ALBERT+SCOTTS+GUMMA+OLDCOAST		
MON 15TH TUE 16TH WED 17TH THUR 18TA FRI 19TH		
NIL NIL NIL NIL NIL		

Observers: RYAN WATT		
Date: 22-1-18		Time: 7:00-12:00
Location:	Chainage: SEE BELOW	GPS:
Species: SEE BELOW		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: MOTORWAY + PAC + BROWNS + ALBERT + SCOTTS + GUMMA + OC		
MON 22 TUE 23 WED 24TH THU 25TH FRI 26TH		
NIL NIL NIL DEAD RABBIT A/D NIL		

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: RYAN WATT		
Date: 29-1-18		Time: 7:00 - 12:00
Location:	Chainage: SEE BELOW	GPS:
Species: SEE BELOW		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: MOTORWAY + PAC + BROWNS + ALBERT + SCOTTS + GUMMA + OC MON 29TH TUE 30TH WED 31ST THU 1ST FRI 2ND NIL NIL NIL NIL NIL		

Observers: RYAN WATT		
Date: 5-2-18		Time: 7:00 - 12:00
Location:	Chainage: SEE BELOW	GPS:
Species: SEE BELOW		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: MOTORWAY + PAC + BROWNS + ROSE + ALBERT + SCOTTS + OC MON 5TH TUE 6TH WED 7TH THU 8TH FRI 9TH NIL NIL NIL NIL NIL		

WC2NH Road Kill Monitoring Program

Data Recording Sheet

Observers: RYAN WATT		
Date: 12-2-18		Time: 7:00-12:00
Location:	Chainage: SEE BELOW	GPS:
Species: SEE BELOW		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: MOTORWAY + PAC + BROWNS + SCOTTS + ALBERT + GUMA + OC MON 12TH TUE 13TH WED 14TH THU 15TH FRI 16TH NIL NIL NIL NIL NIL		

Observers: RYAN WATT		
Date: 19-2-17		Time: 7:00-12:00
Location:	Chainage: SEE BELOW	GPS:
Species: SEE BELOW		
Photos (circle): *Yes / No*		Photos sent to Ecologist (circle): *Yes / No*
Ecologist Species Identification:		
Is it an EPBC Act Threatened Species (i.e. koala or s-t quoll)? (circle) *Yes / No*		
If the animal is an EPBC Act Thr. Sp., record the following information if possible:		
Temperature:	Rainfall (last 24hrs):	Moon Phase:
Sex (circle): *male / female*		Age Class (circle): *adult / juvenile*
Pouch Young/Back Young:		
Comments: MOTORWAY + PAC + BROWN'S + ALBERT + SCOTTS + GUMMA + OC MON 19TH TUE 20TH WED 21ST THU 22ND FRI 23RD NIL NIL NIL NIL NIL		

Appendix G

In-situ Threatened Flora Monitoring Report

Warrell Creek to Nambucca Heads

Monitoring of In-situ Threatened Flora (Annual Report - Spring 2017)

GeoLINK
environmental management and design

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PO Box 1446
Coffs Harbour NSW 2450
T 02 6651 7666

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Prepared for: Pacifico

UPR	Description	Date Issued	Issued By
2378-1392	First Issue	23/10/2016	JOL
2378-1395	Second Issue	24/10/2016	JOL

Table of Contents

Illustrations

Tables

Plates

1. Introduction

As part of the Warrell Creek to Nambucca Heads (WC2NH) Pacific Highway upgrade project, a Threatened Flora Management Plan (TFMP) has been prepared by Ecos Environmental Pty Ltd (2014) to prescribe measures to manage all threatened flora species occurring on the project. A number of threatened flora occur on the edge of the construction footprint which are to be protected during the construction and operational phases of the upgrade. Measures to be implemented to protect in-situ specimens are outlined in Section 5 of the TFMP.

The TFMP requires that monitoring of in-situ roadside specimens be undertaken. Monitoring is to be undertaken initially after installing protective barriers (prior to the start of clearing) at six-monthly intervals for two years and once a year thereafter. An annual monitoring report is to be prepared at the end of each year describing the results of monitoring. This report represents the third annual monitoring report for the (spring) 2017 calendar year and third year of construction. This is expected to be the final report for the construction phase of the WC2NH project as project completion is scheduled for summer 2017/2018.

2. Methodology

All in-situ threatened flora were located and tagged prior to clearing activities commencing. Temporary fencing (orange bunting) and no-go signage was installed around all plants with ecologist supervision. The location of all threatened flora was shown on project sensitive area plans. Threatened flora within the project footprint were translocated prior to clearing commencing by Ecos Environmental Pty Ltd. A number of threatened plants have been retained in-situ outside the project clearing limit. These plants are the subject of this monitoring report and are shown in **Illustrations 2.1-2.6**. Monitoring of in-situ threatened flora was undertaken by GeoLINK ecologists, Jessica O'Leary, David Havilah and Frank Makin on six occasions at the following times:

- Prior to clearing commencing – 5 - 9 January 2015
- Six-monthly interval (autumn) – 25 - 29 May 2015
- 12-monthly interval (spring)– 26 - 27 November 2015
- 18-monthly interval (autumn) – 23 - 27 May 2016
- 24-monthly interval (spring) – 21 - 23 November 2016
- 36-monthly interval (spring) – 13 - 16 October 2017.

The following threatened flora species were monitored:

- Maundia (*Maundia triglochinoides*)
- Rusty Plum (*Niemeyera whitei*)
- Slender Marsdenia (*Marsdenia longiloba*)
- Spider Orchid (*Dendrobium melaleucaphilum*)
- Woolls' Tylophora (*Tylophora woollsii*).

The following identification/ plant condition data was recorded for each in-situ specimen:

- genus/ species
- plant identification number
- leaf/ plant health condition(see condition class scores in **Tables 2.1 - 2.3** below)
- flower/ fruit presence
- new growth/ shoots
- recruitment
- notes were also made on weed infestations and evidence of any other impacts.

Attributes for evaluating species health and survival are captured in Condition Classes which are scored on a class of 0 to 5 (refer to **Tables 2.1 - 2.3** below) based on the WC2NH Threatened Flora Management Plan (Benwell, 2016).

Table 2.1 Condition Class scores applied to Slender Marsdenia and Woolls' Tylophora

Score	*Condition Class*
0	dead
1	stem died back, no leaves or green stem, may be a live stem stub
2	stem with leaves, no active growth; green leafless stem
3	stem with leaves, active growth – i.e. new shoot growth stem with leaves and plant >75cm tall
4	plant with lots of leaves, mature or nearing maturity
5	plant flowering or seeding

Table 2.2 Condition scores applied to Rusty Plum and Maundia

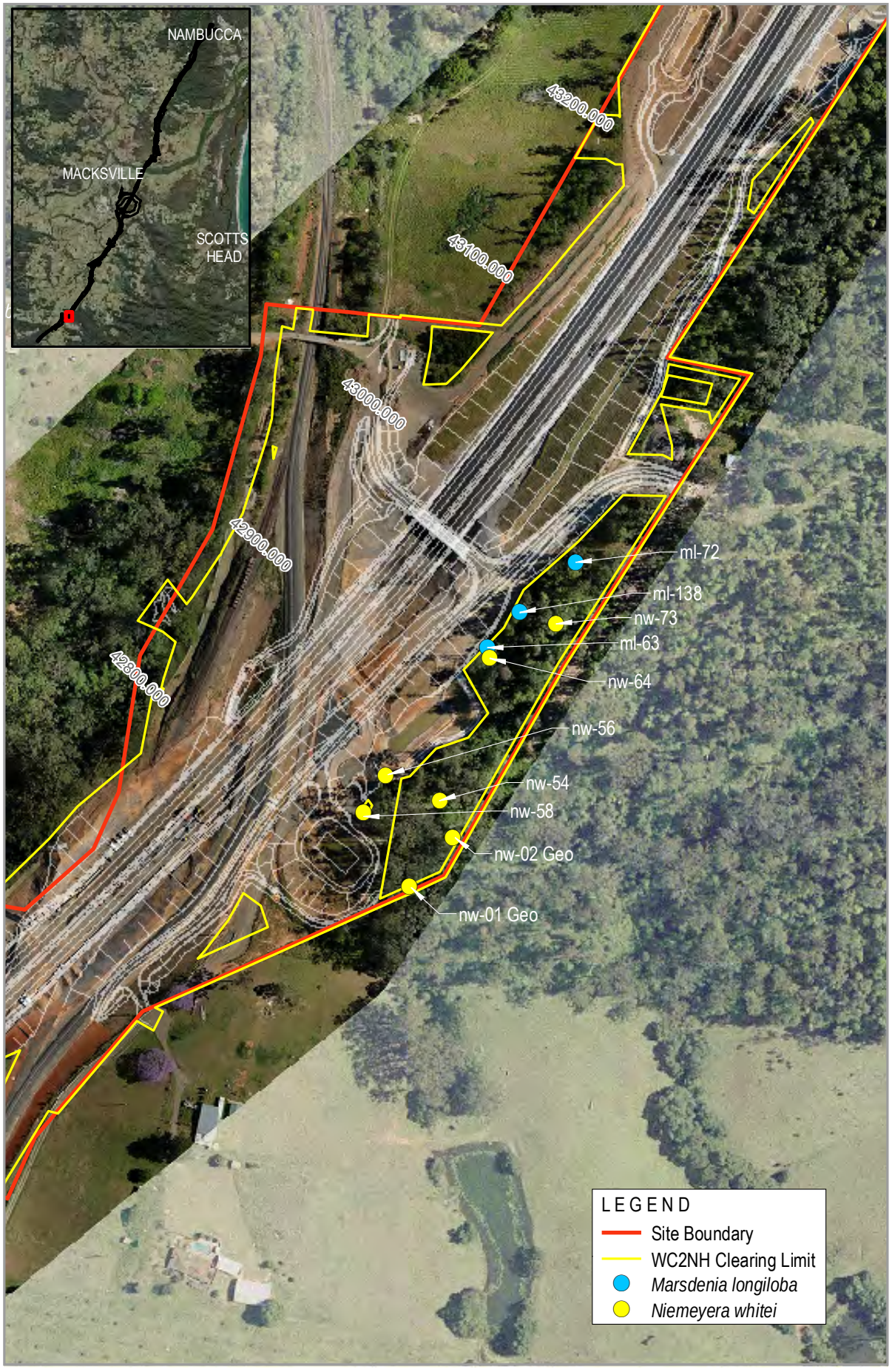
Score	*Condition Class*
0	dead
1	leafless and no sign of re-shooting
2	pruned foliage retained, or small amount of re-shooting after defoliating, or foliage sparse/discoloured
3	vigorous re-shooting
4	crown recovering, foliage healthy
5	growing actively, flowering or seeding recorded

Table 2.3 Condition scores applied to Spider Orchid

Score	*Condition Class*
0	dead
1	pseudobulbs discoloured/being eaten/withering, no new growth
2	pseudobulbs healthy in colour, not withering, no new growth
3	plant small, not many healthy pseudobulbs, new growth occurring
4	several healthy pseudobulbs present, new growth occurring
5	several good sized, healthy pseudobulbs, flowering or seeding recorded

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: JOL Date: 23/10/2017
Source of base data: Roads and Maritime Services and Pacifico



0 60

North

In-situ Threatened Flora Record Locations

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: JOL Date: 23/10/2017
Source of base data: Roads and Maritime Services and Pacifico

North

0 60

In-situ Threatened Flora Record Locations

GeoLINK environmental management and design

WC2NH In-situ Threatened Flora and Habitat Monitoring Spring 2017
2378-1393

Illustration 2.2

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: JOL Date: 23/10/2017
Source of base data: Roads and Maritime Services and Pacifico

0 60

North

In-situ Threatened Flora Record Locations

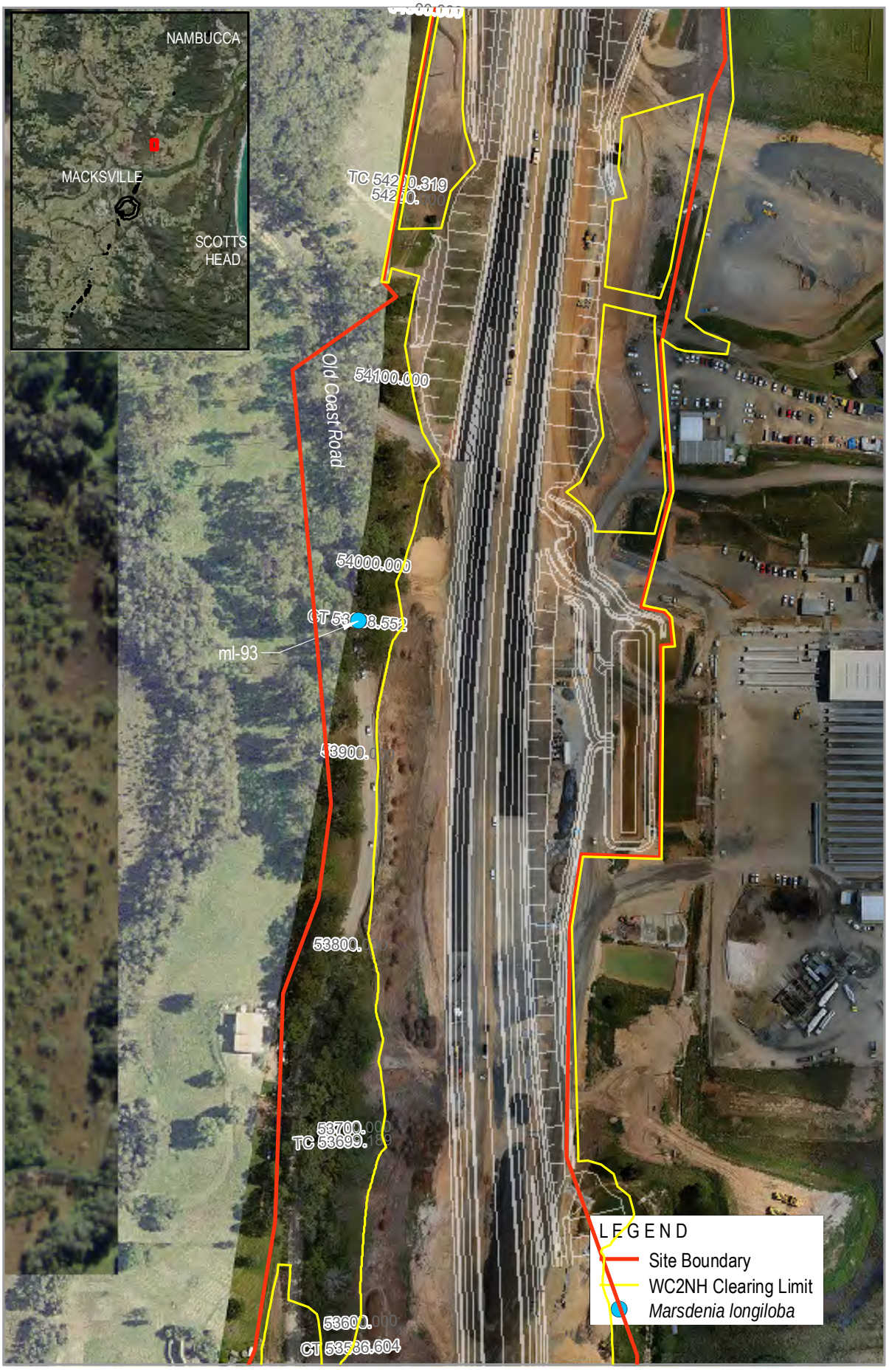
GeoLINK environmental management and design

WC2NH In-situ Threatened Flora and Habitat Monitoring Spring 2017
2378-1393

Illustration 2.3

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: JOL Date: 23/10/2017
Source of base data: Roads and Maritime Services and Pacifico



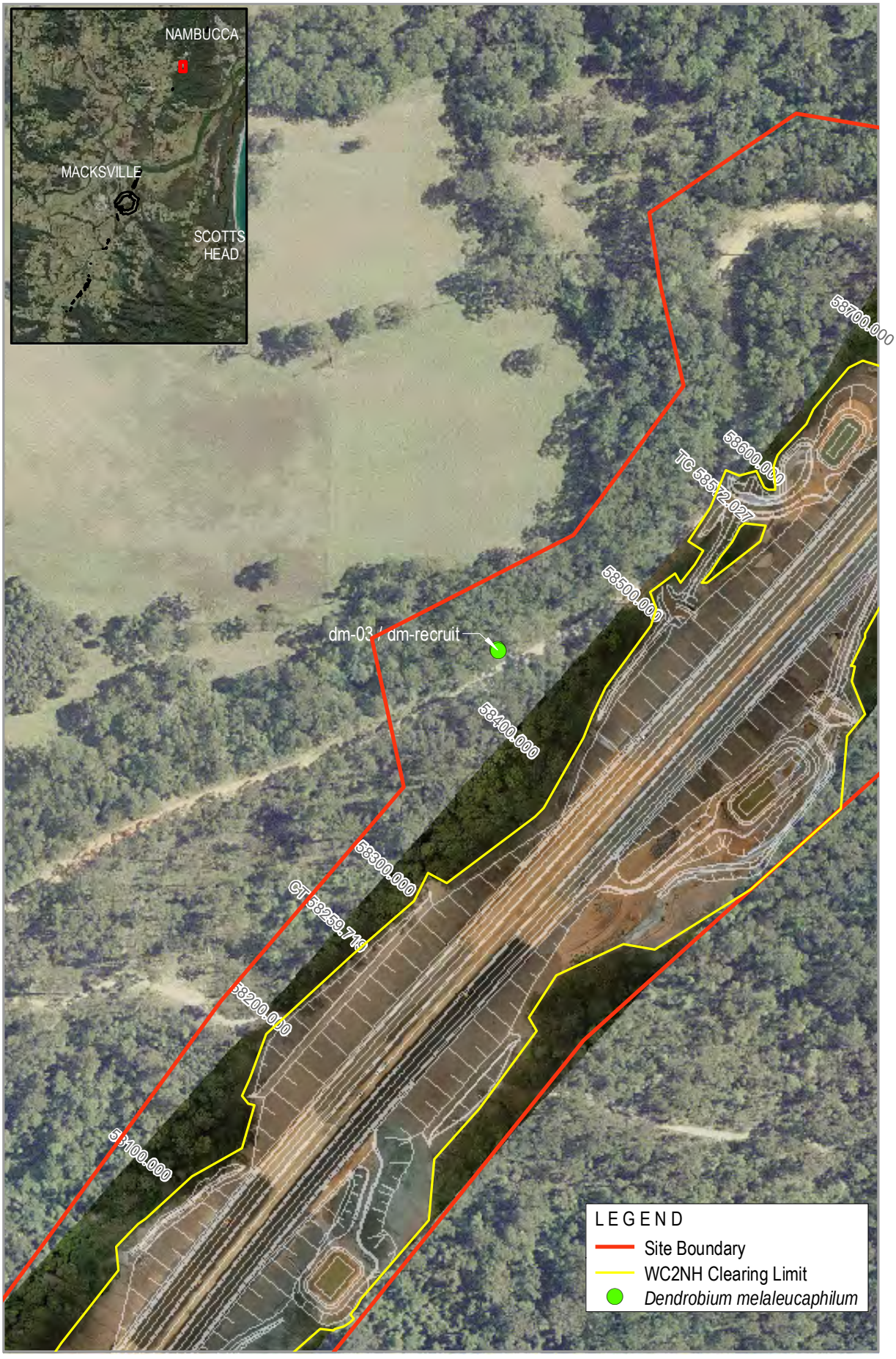
0 60

North

In-situ Threatened Flora Record Locations

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: JOL Date: 23/10/2017
Source of base data: Roads and Maritime Services and Pacifico



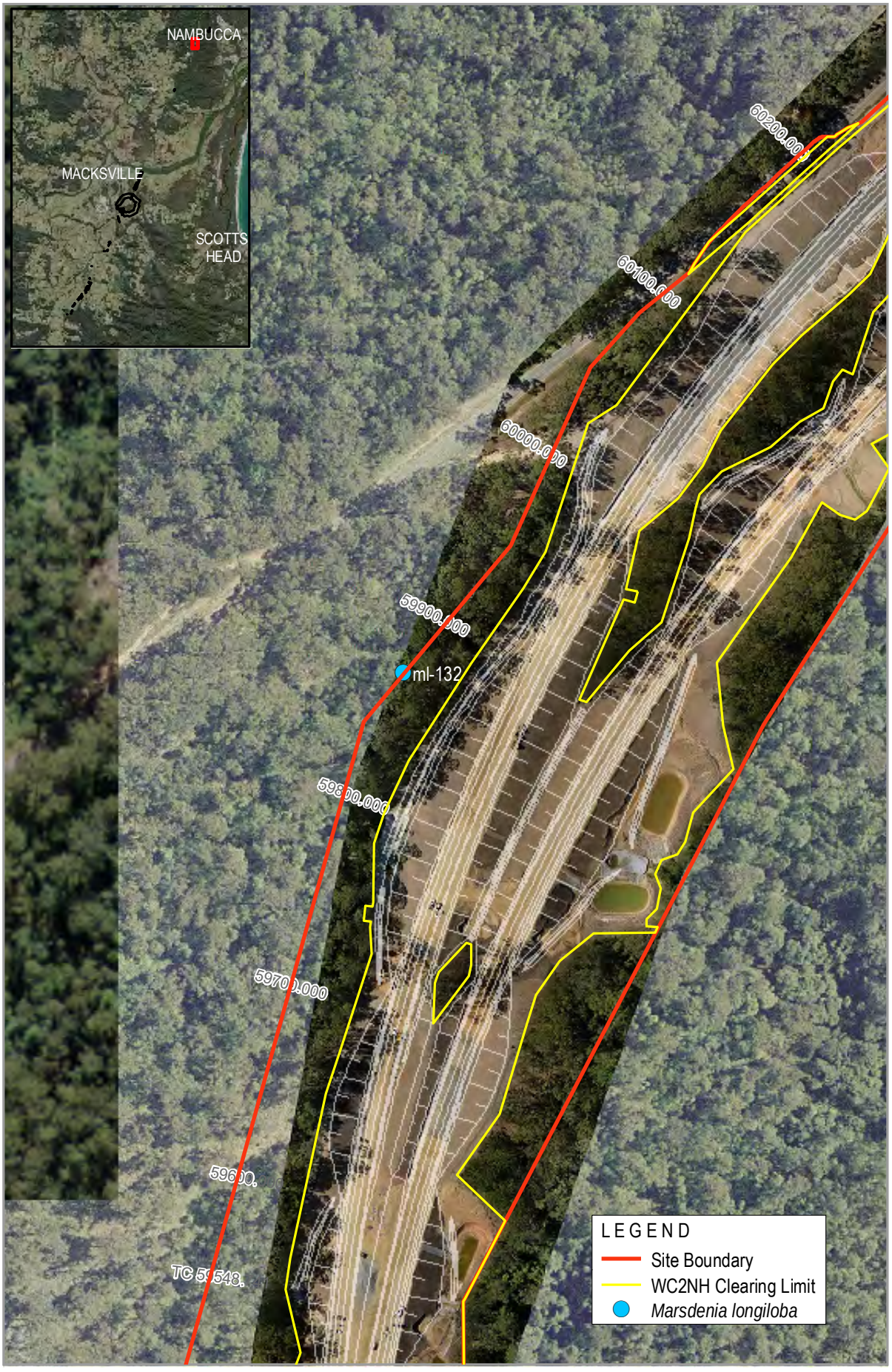
0 60

North

In-situ Threatened Flora Record Locations

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: JOL Date: 23/10/2017
Source of base data: Roads and Maritime Services and Pacifico



0 60

North

In-situ Threatened Flora Record Locations

GeoLINK environmental management and design

WC2NH In-situ Threatened Flora and Habitat Monitoring Spring 2017
2378-1393

Illustration 2.6

3. Results

3.1 In-situ Threatened Flora

3.1.1 Monitoring results

Monitoring results for in-situ threatened flora are included below in **Tables 3.1 – 3.5**. Key points arising from the third and final year of monitoring are summarised below. Photographs of the various species are shown in **Plates 3.1 – 3.11**.

Tall Knotweed (*Persicaria elatior*)

- All Tall Knotweed plants within the monitoring area died back prior to the autumn 2015 monitoring surveys. A reference population of Tall Knotweed located in the Maclean locality (far north coast of NSW) was surveyed at the same time and was also found to have experienced complete die back during this period.
- New plants were identified within the monitoring area in autumn 2016 and were again recorded during spring 2016. This finding appears to be indicative of the natural life cycle of this species suggesting it may have an annual lifecycle. The subject population of this species was persisting in a healthy manner within the monitoring area during spring 2016.
- No Tall Knotweed plants were recorded during the spring 2017 monitoring event. Three months of low rainfall preceded the spring 2017 monitoring event (refer to **Table 3.6**) which may explain the lack of detectable plants at this location as no obvious signs of construction related impacts or disturbance to this population was recorded at the time of monitoring. No signs of project related erosion or sedimentation, entry into the delineated area or excessive or uncontrolled weed incursion was observed. Another nearby reference site in Maclean was surveyed on 18 September 2017 where a number of plants were recorded to be healthy and flowering. More detailed monthly monitoring of Tall Knotweed over differing seasonal conditions would be necessary to gain a further understanding of the lifecycle of this species.

Plate 3.1 No Tall Knotweed recorded during spring 2017, no obvious signs of construction related impacts or excessive weed incursions were observed.

Maundia (*Maundia triglochinoides*)

Nambucca Floodplain

- Favourable growing conditions for Maundia (indicated by generally high rainfall) were present prior to and during construction in 2015. During this period large areas of Maundia were recorded adjacent to the project footprint in the Nambucca floodplain area. Since the commencement of monitoring the cover and abundance scores for this population has fluctuated over time.
- During the months preceding spring 2017 monitoring lower than usual rainfall levels were recorded which may have contributed to the reduction in cover and abundance of Maundia within the Nambucca Floodplain. Although a reduced percentage cover of Maundia has been recorded, these patches are distributed broadly across the monitoring site with good health and leaf condition with a class condition score of 3 to 4. To date this population of Maundia has had periods of higher and lower recorded numbers of cover and abundance which is typical of the lifecycle of this species which can be affected by natural hydrology and weather conditions with natural dieback occurring seasonally. During October 2017 156 mm of rain was recorded within the Macksville area which may make growing conditions favourable for Maundia during the spring/ summer growing season.
- Similar reference populations in the Woodburn locality (far north coast of NSW) showed similar, apparent seasonal decreases in abundance.

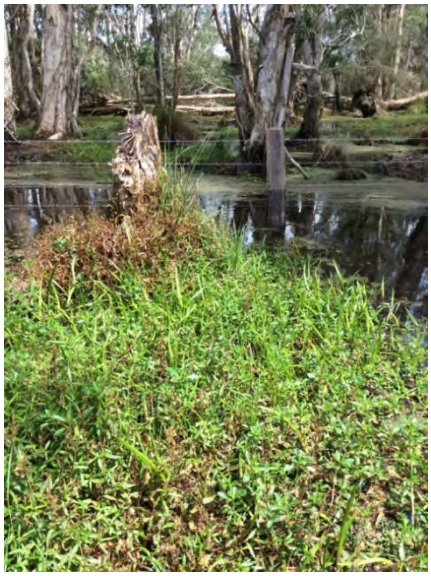


Plate 3.2 Reduced patches of Maundia plants within the Nambucca Floodplain site appear to be in good health.

Plate 3.3 Healthy Maundia plants on the Nambucca Floodplain (centre of image).

Crouches Creek

- The population of Maundia within Crouches Creek was removed as part of the diversion of the creek in this location. Although translocation of this species was not prescribed as part of the WC2NH Threatened Flora Management Plan, salvage translocation was attempted within the new alignment of Crouches Creek. This translocation was considered to have been successful during the spring 2016 monitoring, however no visible Maundia plants were recorded within Crouches Creek during the spring 2017 monitoring event. It is possible that seasonal or natural die-back of this species may be occurring at this location. Alternatively, altered instream parameters due to the creek realignment, such as changes in water depth (Maundia prefers 30 - 60 cm water depth), sedimentation and/or reduced quality of substrate may have attributed to the lack of visible

Maundia plants within Crouches Creek at this time. On-going monitoring at this location would be required to get a better understanding of the success of the translocation of Maundia at this location. However, under the requirements of the TFMP translocation of Maundia within Crouches was not a requirement due the species being locally abundant (within the Mid North Coast) and that the focus would be upon minimising impacts to retained populations of the species in-situ.

Plate 3.4 Maudia translocation site within Crouches Creek, no obvious signs of Maundia within the translocation site.

Plate 3.5 Maudia translocation site within Crouches Creek, no obvious signs of Maundia within the translocation site.

Spider Orchid (*Dendrobium melaleucaphilum)*

- The single in-situ Spider Orchid specimen remains in a healthy condition. The number of pseudobulbs (storage organs) on this plant has increased substantially during recent monitoring events. The recruitment of an additional individual occurring immediately below this plant on the same tree was first recorded during spring 2016. At the time of spring 2017 monitoring the strip of paperbark which the juvenile spider orchid was attached to was nearly detached. Yellow survey tape was wrapped around the bark with the expectation that the juvenile orchid will reattach to the tree trunk.

Plate 3.6 Existing mature Spider Orchid with evidence of flowering on psuedobulbs.

Plate 3.7 Juvenile Spider Orchid with yellow tape to affix strip of paperbark to the tree trunk.

Rusty Plum (*Niemeyera whitei*)

- In-situ Rusty Plums in the Cockburns Lane locality remain generally healthy and in good condition. During spring 2016 one plant (nw-56) recorded signs of edge effects with stunted yellowing leaves and minimal new growth due to its newly exposed position at the edge of the clearing limit. Spring 2017 monitoring has observed this plant to have healthy new growth and an increase in height. After consultation with the WC2NH botanist Dr Andrew Benwell, recommendations were made in spring 2016 report to install shade cloth, place mulch around the base of the tree and undertake supplementary watering of this plant. It appears that the placement of mulch or shade cloth was not implemented by Pacifico however supplementary watering has been undertaken post spring 2016 report last year and more recently during the three months preceding spring 2017 monitoring. It is now not considered necessary to implement these corrective measures given the health and growth of nw-56 has improved during recent months indicating that this plant may be adapting to the exposed conditions and has benefitted from supplementary watering.
- All other retained Rusty Plums were observed to be in good condition with new growth and height measurements recorded. Plants nw-64 and nw-73 recorded evidence of flowering; no fruit was recorded during spring 2017.
- Two Rusty Plums were detected during pre-clearing surveys in May 2017 and have now been added to the monitoring regime for this species. These plants appear to be in good health with no signs of disease or disturbance.

Plate 3.8 Rusty Plum (nw-56) with new growth appears to be improving in condition class compared to spring 2016.

Plate 3.9 Rusty Plum (nw-64) with new growth and evidence of flowering in the leaf axils.

Slender Marsdenia (*Marsdenia longiloba)*

- Slender Marsdenia plants at monitoring locations remain healthy with evidence of new growth. Evidence of regular die back of stems and plants has been a common observation with this species with the origin of stems being difficult due to sharing common rhizomes in some instances. This has made the tracking of individual plants over time problematic. Notwithstanding this, the monitoring to date has demonstrated the perseverance or re-emergence of Slender Marsdenia plants at monitoring locations.
- Consistent with previous results, spring 2017 monitoring recorded a number of plants which have died back. It may be that plants ml-72 and ml-63 have dead stems but that the stem bulb is still

alive below ground. It is also possible that the original ml-132 plant has died back but regrown as a new recruit or new plant from same stem bulb. Some plants have died back and regrown with young green plants now described where older mature plants were recorded previously.

- No Slender Marsdenia monitoring sites recorded any obvious construction related impacts by means of encroachment into protected areas, project related erosion or sedimentation or significant weed incursion.
- Site ml-93 has a healthy and dynamic population of Slender Marsdenia plants which are located directly adjacent to Old Coast Road which at varying times have been observed to receive increased dust deposition from passing traffic. Regardless, this population of plants has recorded large numbers of new recruits during spring 2016 and 2017 monitoring events.
- A number of plants previously included in the monitoring regime have been translocated as part of the approved WC2NH North-facing Ramps project.

Plate 3.10 Spring 2016 (pink tape) recruits of Marsdenia plants Old Coast Road Site (ml-93)

Plate 3.11 Spring 2017 (yellow tape) recruitment of Marsdenia plants Old Coast Road Site (ml-93)

Table 3.1 In-situ Threatened Flora Monitoring Results – Tall Knotweed

Tall Knotweed (Persicaria elatior)																															
Plant ID #	*Height (cm)*					*Leaf Condition*					*Flower/ Fruit Present*					*New Growth*					*Recruitment*					*Damage/ Disturbance*					*Notes*
	PC 2015	*Aut 2015*	*Spr 2015*	*Aut 2016*	*Spr 2016*	*PC 2015*	*Aut 2015*	*Spr 2015*	*Aut 2016*	*Spr 2016*	*PC 2015*	*Aut 2015*	*Spr 2015*	*Aut 2016*	*Spr 2016*	*PC 2015*	*Aut 2015*	*Spr 2015*	*Aut 2016*	*Spr 2016*	*PC 2015*	*Aut 2015*	*Spr 2015*	*Aut 2016*	*Spr 2016*	*PC 2015*	*Aut 2015*	*Spr 2015*	*Aut 2016*	*Spr 2016*	
P1	42	-	-	-	-	5	0	0	0	0	Y	N	N	N	N	Y	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	All plants were found to be dead as of Autumn 2015. Recruitment of new plants was recorded from Autumn 2016 as shown below.
P2	56	-	-	-	-	5	0	0	0	0	Y	N	N	N	N	Y	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	
P3	30	-	-	-	-	5	0	0	0	0	Y	N	N	N	N	Y	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	
P4	26	-	-	-	-	5	0	0	0	0	Y	N	N	N	N	Y	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	
P5	35	-	-	-	-	5	0	0	0	0	Y	N	N	N	N	Y	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	
P6	42	-	-	-	-	5	0	0	0	0	Y	N	N	N	N	Y	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	
P7	25	-	-	-	-	5	0	0	0	0	Y	N	N	N	N	Y	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	
P8	18	-	-	-	-	5	0	0	0	0	Y	N	N	N	N	Y	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	
P9	35	-	-	-	-	5	0	0	0	0	Y	N	N	N	N	Y	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	
P10	54	-	-	-	-	5	0	0	0	0	Y	N	N	N	N	Y	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	
New Plants Recorded as of Autumn 2016 (previous plants had died back)																															
P11	-	-	-	50	100	-	-	-	1	5	-		-	Y	Y	-	-	-	Y	Y	-	-	-	N	Y	-	-	-	N	N	All plants with minor insect presence but otherwise healthy.
P12	-	-	-	65	40	-	-	-	1	2	-		-	Y	N	-	-	-	Y	Y	-	-	-	N	N	-	-	-	N	N	
P13	-	-	-	90	45	-	-	-	3	4	--		-	Y	N	-	-	-	Y	Y	-	-	-	N	N	-	-	-	N	N	
P14	-	-	-	90	60	-	-	-	3	4	--		-	Y	N	-	-	-	Y	Y	-	-	-	N	N	-	-	-	N	N	
All plants previously recorded above have died back, no Tall Knotweed plants were recorded during spring 2017 monitoring, no obvious construction related impacts were recorded																															

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Table 3.2 In-situ Threatened Flora Monitoring Results – Maundia

Maundia (Maundia triglochinoides)																															
Population	*Cover-Abundance and (Condition Class Score)*						*Flower/ Fruit Present*						*New Growth*						*Recruitment*						*Damage/ Disturbance*						*Notes*
	PC 2015	*Aut 2015*	*Spr 2015*	*Aut 2016*	*Spr 2016*	*Spr 2017*	*PC 2015*	*Aut 2015*	*Spr 2015*	*Aut 2016*	*Spr 2016*	*Spr 2017*	*PC 2015*	*Aut 2015*	*Spr 2015*	*Aut 2016*	*Spr 2016*	*Spr 2017*	*PC 2015*	*Aut 2015*	*Spr 2015*	*Aut 2016*	*Spr 2016*	*Spr 2017*	*PC 2015*	*Aut 2015*	*Spr 2015*	*Aut 2016*	*Spr 2016*	*Spr 2017*	
Crouches Creek	20-40% (3)	30-60% (5)	30-60% (4)	-	10-20% (3)	- (0-1)	N	Y	N	-	N	-	N	Y	Y	-	Y	N	N	Y	Y	-	N	N	N	N	N	-	N	N/Y*	Maundia within Crouches Creek were removed as part of creek realignment and temporarily stored during autumn 2016 . There are no requirements for translocation within the TFMP however salvage translocation was successfully undertaken at the time of monitoring during Spring 2016. No visible Maundia plants were recorded within Crouches Creek at the time of spring 2017 monitoring. * No accidental or intentional damage was recorded however potential disturbance through the translocation process may be noted.
Nambucca Floodplain	10-20% (3)	70-80% (5)	70-80% (4)	10-20% (4)	20-40% (5)	10-20% (3)	N	Y	N	N	Y	N	N	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	N	N	N	N	N	N	While Maundia plants are present across the footprint of the monitoring site, the abundance cover percentage for spring 2017 has reduced to smaller patches of healthy Maundia across the site.

Table 3.3 In-situ Threatened Flora Monitoring Results – Spider Orchid

Spider Orchid (Dendrobium melaleucaphilum)																																					
Plant ID #	*Length of longest pseudobulb (cm)*						*Leaf Condition*						*Number of pseudobulbs with leaves*						*New Growth*						*Recruitment*						*Damage/ Disturbance*						*Notes*
	PC 2015	*Aut 2015*	*Spr 2015*	*Aut 2016*	*Spr 2016*	*Spr 2017*	*PC 2015*	*Aut 2015*	*Spr 2015*	*Aut 2016*	*Spr 2016*	*Spr 2017*	*PC 2015*	*Aut 2015*	*Spr 2015*	*Aut 2016*	*Spr 2016*	*Spr 2017*	*PC 2015*	*Aut 2015*	*Spr 2015*	*Aut 2016*	*Spr 2016*	*Spr 2017*	*PC 2015*	*Aut 2015*	*Spr 2015*	*Aut 2016*	*Spr 2016*	*Spr 2017*	*PC 2015*	*Aut 2015*	*Spr 2015*	*Aut 2016*	*Spr 2016*	*Spr 2017*	
DM3	30	35	35	35	35	40	2	2	2	2	3	4	6	6	7	25	25	20	Y	Y	Y	Y	Y	Y	N	N	Y	N	Y	N	N	N	N	N	N	N	Very healthy with signs of increased flowering activity.
DM Recruit	-	-	-	-	8	10	-	-	-	-	3	3	-	-	3	4	-	-	-	-	-	-	Y	Y	-	-	-	-	N	N	-	-	-	-	N	N	This new recruit was first observed during spring 2016 monitoring with increasing psuedobulbs recorded during spring 2017. Flagging tape was used to secure the piece of paperbark on which the plant was secured to the tree trunk in hope that the orchid will continue to attach to the tree or underlying layer of bark.

Table 3.4 In-situ Threatened Flora Monitoring Results – Rusty Plum

Rusty Plum (Niemeyera whitei)																																					
Plant ID #	*Height (cm)*						*Leaf Condition*						*Flower/ Fruit Present*						*New Growth*						*Recruitment*						*Damage/ Disturbance*						*Notes*
	PC 2015	*Aut 2015*	*Spr 2015*	*Aut 2016*	*Spr 2016*	*Spr 2017*	*PC 2015*	*Aut 2015*	*Spr 2015*	*Aut 2016*	*Spr 2016*	*Spr 2017*	*PC 2015*	*Aut 2015*	*Spr 2015*	*Aut 2016*	*Spr 2016*	*Spr 2017*	*PC 2015*	*Aut 2015*	*Spr 2015*	*Aut 2016*	*Spr 2016*	*Spr 2017*	*PC 2015*	*Aut 2015*	*Spr 2015*	*Aut 2016*	*Spr 2016*	*Spr 2017*	*PC 2015*	*Aut 2015*	*Spr 2015*	*Aut 2016*	*Spr 2016*	*Spr 2017*	
NW58	700	700	750	750	750	750	5	5	5	5	4	4	N	N	N	N	N	N	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	Not delineated with orange flagging, recommend install for additional protection.
NW56	100	100	100	110	120	130	5	4	4	3	2	3	N	N	N	N	N	N	Y	N	N	Y	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	Discolouration of leaves due to being exposed (edge effects) during spring 16 however new healthy growth observed during spring 17.
NW73	600	600	600	600	600	650	5	5	5	5	4	5	N	N	N	N	N	Y	Y	N	Y	Y	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	N/A
NW54	400	400	400	420	450	500	5	5	5	5	5	5	N	N	N	N	N	N	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	New growth shooting from roots.
NW64	500	500	500	550	600	650	5	5	5	5	5	5	N	N	N	N	Y	Y	Y	N	Y	Y	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	N/A
NW01-Geo	-	-	-	-	-	450	-	-	-	-	-	5	-	-	-	-	-	N	-	-	-	-	-	Y	-	-	-	-	-	N	-	-	-	-	-	N	Additional plants (not previously included in monitoring regime) appear in good health
NW02-Geo	-	-	-	-	-	500	-	-	-	-	-	5	-	-	-	-	-	N	-	-	-	-	-	Y	-	-	-	-	-	N	-	-	-	-	-	N	Additional plants (not previously included in monitoring regime) appear in good health

Table 3.5 In-situ Threatened Flora Monitoring Results – Slender Marsdenia

Plant ID #	*Slender Marsdenia (Marsdenia longiloba)* Height (cm)						Leaf Condition						Flower/ Fruit Present						New Growth						Recruitment						Damage/ Disturbance						Notes
	PC 2015	Aut 2015	Spr 2015	Aut 2016	Spr 2016	Spr 2017	PC 2015	Aut 2015	Spr 2015	Aut 2016	Spr 2016	Spr 2017	PC 2015	Aut 2015	Spr 2015	Aut 2016	Spr 2016	Spr 2017	PC 2015	Aut 2015	Spr 2015	Aut 2016	Spr 2016	Spr 2017	PC 2015	Aut 2015	Spr 2015	Aut 2016	Spr 2016	Spr 2017	PC 2015	Aut 2015	Spr 2015	Aut 2016	Spr 2016	Spr 2017	
ML93	5	5	5	12	20	5 - 60	3	3	3	3	3	1 - 4	N	N	N	N	N	N	N	N	Y	N	Y	Y	N	N	N	Y	Y	Y	N	N	N	N	N	N	15 live plants now within 1 m radius of subject plant. All range from 2 – 4 in condition class. Some plants recorded during spring 2016 have died back however new recruits have also been recorded and are now at a count of 23 flagged individual plants.
ML92	5	8	10	8	-	-	2	2	2	2	-	-	N	N	N	N	-	-	Y	N	Y	N	-	-	N	N	Y	N	-	-	N	N	N	N	-	-	These plants were translocated as part of the approved north-facing ramps proposal.
ML140	15	15	20	25	-	-	2	2	3	2	-	-	N	N	N	N	-	-	N	N	Y	N	-	-	N	N	Y	N	-	-	N	N	N	N	-	-	
ML131	5	-	-	-	-	-	1	0	0	0	-	-	N	-	-	-	-	N	N	-	-	-	-	-	N	-	-	-	-	-	N	-	-	-	-	-	
ML132	40	40	50	52	30	50	3	3	3	2	3	3	N	N	N	N	N	N	Y	Y	Y	N	N	Y	N	N	N	N	N	Y	N	N	N	N	N	N	During Spring 2016 partially natural die back was recorded. The plant recorded during spring 2017 is fresh, green with new growth indicating possibly a new plant to the one previously recorded.
ML72	5	5	8	15	31	100	2	3	3	3	4	1	N	N	N	N	N	N	N	Y	Y	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	Natural die back of the stem, possibly live stem bulb. No obvious signs of construction related impacts.
Ml138	5	5	5	10	40	230	2	0	0	2	3	4	N	N	N	N	N	N	N	N	N	N	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	Tall plant with mature leaves some yellowing.
ML63	10	10	10	11	13	120	2	0	0	2	3	1	N	N	N	N	N	N	N	N	N	N	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	Natural die back of the stem, possibly live stem bulb. No obvious signs of construction related impacts.

Table 3.6 Monthly Rainfall Data (mm) (source: WC2NH northern weather station, data from weathermation.com)

	Jan	Feb	*Mar*	Apr	*May*	Jun	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
2015			93.4	121	207	21	16	25	108	33.6	140	213
2016	99.4	36.2	47.4	90.8	12	328	31	167	37.8	48	35.8	47.8
2017	74.4	95.6	506.4	107	79.2	214	8.2	0.4	0	156		

3.1.2 Conclusion

Based on the monitoring results, the majority of in-situ threatened flora appear to be persisting with good condition scores for health overall (refer to **Table 3.7**). A number of sites and species including Slender Marsdenia and Maundia have recorded new growth and new recruits while other sites of the same species have undergone what appears to be seasonal or natural die-off. For example, Maundia in Crouches Creek was recorded to have been successfully translocated into the newly constructed creek realignment during spring 2016 monitoring, however does not appear to be present at the site during Spring 2017 monitoring. Slender Marsdenia has recorded plant die-back at a number of locations and also recruitment of new plants at the same sites over time.

Monitoring of the Spider Orchid has recorded a new recruit during spring 2016 which has persisted, with new growth also recorded during spring 2017. This additional plant has now been added to the monitoring regime for future data collection during the project operational phase of monitoring.

Tall Knotweed at the northern end of the Nambucca Floodplain was not recorded at all during spring 2017 monitoring. This result is not unusual for this species, which is known for fluctuations in presence at the subject monitoring site and also reference sites within the Maclean area (northern NSW).

Rusty Plum around the Cockburns Lane area appear to be in good health with all plants recording new growth and condition class scores of three or above during spring 2017. Two mature plants not previously monitored and added to the monitoring regime also appear in good health.

No in-situ threatened flora sites have recorded direct construction related impacts by means of access into protected areas, project related erosion and sedimentation or significant weed incursion. Edge effects as a result of clearing for the project alignment have been recorded to impact Rusty Plum (nw-56); however, the health of this plant seems to have improved with new green leaf growth and increase in height measurements indicating that this plant is adapting to its position on the edge of the clearing footprint. Slender Marsdenia at the edge of Old Coast Road are likely to receive increased levels of dust deposition as a result of traffic, when compared to plants further away from unsealed local roads. However, this site has a healthy and dynamic population of plants with 23 new individual plants recorded since spring 2016.

WC2NH project landscaping has been largely implemented across the project in accordance with the project Urban Design and Landscape Plans and RMS specifications which address the requirements of the TFMP with regard to:

- Re-use of locally sourced weed free topsoil with local topsoil seed bank.
- Revegetation with native ground covers, shrubs and small trees.
- Stabilisation of the soil via revegetation around in-situ threatened flora as soon as earthworks are completed.

Although the survival rates of in-situ threatened flora do not meet the performance indicator minimum requirements, no die-back or direct construction related impacts have been recorded as having contributed to the monitoring results to date. Corrective actions are discussed within the TFMP (refer to **section 5.3.5**) if the performance measures are not met; however, none of the corrective actions have been triggered based on the most recent monitoring results with regard to weed control, plant theft or protection from edge effects (although this measure was recommended during spring 2016).

Overall, the protective measures implemented for the project to safeguard retain threatened flora have been effective with no plant mortality directly associated with impacts from construction activities.

Table 3.7 Performance measures

Species	*Survival rate at finish of clearing (October 2015/ spring 2015) is 100%, no accidental damage due to clearing*	*Survival rate at end of years 1-3 is >80%*	*Of surviving plants at end of each year >75% are in good condition (class 3 or >) healthy foliage, no signs of die-back or disease and new shoot growth present?*			*Any obvious signs of construction related impacts?*	*Considerations*	*Notes*
			Year 1 - 2015	Year 2 - 2016	Year 3 - 2017			
Tall Knotweed (*Persicaria elatior*)	100% of pre-construction plants died back before. No accidental damage due to clearing.	No	No pre-construction plants were recorded during 2015.	100 % of plants recorded during autumn 2016 survived into spring 2016. All plants were recorded in good health with condition class of >3 no signs of disease or die-back. New shoot growth was present.	No 2016 plants were recorded during 2017.	No - construction related disturbances via encroachment into the protected area, project related erosion or sedimentation or excessive weed encroachment have been recorded.	No clearing was undertaken within the vicinity of this population of Tall Knotweed	This population of Tall Knotweed has previously recorded dieback likely due to seasonal or life cycles natural for the species. Three months of very low rainfall preceding the spring 2017 monitoring event may have contributed to the die back of this species.
Spider Orchid (*Dendrobium melaleucaphilum*)	Yes – 100% survival. No accidental damage due to clearing.	Yes - 100% survival.	Yes – 100% in good condition (score 2).	Yes – 100% in good condition, with new recruit. recorded also in good condition (score 3).	Yes – 100% (including new recruit) in good condition (Score 4).	No – these plants are located a safe distance from construction activities.		The health and size of this plant has been improving/ increasing over the monitoring period with a new recruit also recorded.
Maundia (*Maundia triglochinoides*)	Yes - 100% survival. No accidental damage due to clearing.	Yes - 83% survival (10 of 12 monitoring events. recorded presence of healthy Maundia plants across the two sites).	Yes – 100% in good condition (score 4 and 4).	Yes – 100% in good condition (score 3 & 5).	No – Maundia Crouches Creek not observed. Yes – 100% of visible plants in good condition (score 3).	Potential impacts from translocation process may have caused the translocated plants to die-back over time Nambucca Floodplain: No - construction related disturbances via encroachment into the protected area, project related erosion or sedimentation or excessive weed encroachment have been recorded.	Dynamic nature of wetland species therefore cover and abundance are known to fluctuate due to climatic and hydrological conditions. Difficult to accurately count individual plants so percentage cover is used. Species life cycles also factor in fluctuations of abundance.	Three months of very low rainfall preceding the monitoring event may have contributed to some die back of this species.
Rusty Plum (*Niemeyera whitei*)	Yes - 100% survival. No accidental damage due to clearing.	Yes - 100% survival.	Yes – 100% in good condition (score 4 - 5).	Yes – 80% in good condition (score 2 - 5).	Yes – 100% in good condition (score 3 - 5).	Nw-56 recorded discolouration of leaves due to being exposed at edge of clearing footprint (edge effects) during spring 2016. However new healthy growth was observed during spring 2017. No construction related impacts were recorded for other Rusty Plum.	Recommendations to shade mulch and water nw-56 were advised to Pacifico (as per corrective actions) but not implemented however this plant appears to be adapting to the new exposed position with significant new leaf growth and minimal discolouration.	All retained Rusty Plum appear to be in good health. Two additional Rusty Plum records have been recorded and added to the monitoring regime.
Slender Marsdenia (*Marsdenia longiloba*)	No – 62% of plants were recorded as living. No construction related impacts were recorded.	No – 60% (3 of 5 remaining ML records).	No – 62% (5 of 8 records) recorded scores 0 – 3.	Yes -100% (5 of 5 records) recorded scores 3 – 4.	No – 60% (3 of 5 records) recorded scores 1 – 4.	No - construction related disturbances via encroachment into the protected area, project related erosion or sedimentation or excessive weed encroachment have been recorded.	Three plants were translocated for the North Facing Ramps Clearing footprint, so reduced records from 8 to 5. Natural seasonal die-back of this species is common, with die-back and re-emergence of plants from rhizomes typical.	

3.2 Slender Marsdenia and Woolls' Tylophora Habitat Condition Monitoring

3.2.1 Methodology

As required within the WC2NH TFMP, monitoring of potential changes in the habitat of Slender Marsdenia and Woolls' Tylophora is to be conducted within the indirect impact zone – i.e. within 10 m of the edge of clearing construction. Monitoring is to be conducted in areas of this habitat adjacent to the construction footprint and is to be plot based. Permanent plots were established in the indirect impact zones at 10 representative points in Slender Marsdenia and Woolls' Tylophora habitat as mapped by Dr Andrew Benwell in spring 2010. Each plot is 10 m wide and 20 m long, with the long axis parallel to the edge of clearing (refer to **Illustrations 3.1-3.3**). The corners of each plot were marked with pink flagging tape and the GPS co-ordinates of the corners of plots also recorded. Plots were established on 26 November 2015 around the time that clearing operations in the northern zone of the project were being completed. Data was collected at the plots again during autumn (23 - 27 May 2016) and spring (21 - 13 November 2016). The following parameters were measured at each plot (refer to Section 5.4 of the TFMP for more information):

- Native vegetation structure
- Level of weed incursion
- Microclimate class.

Photographs of the monitoring plots are shown in **Plates 3.12 and 3.13**.

3.2.2 Monitoring results

A summary of the results of the monitoring is provided in **Table 3.9**. While there has been changes in light infiltration and potential disturbance via edge effects, monitoring results shows that the quadrat plots have remained largely unchanged since the commencement of monitoring. An increased percentage cover of native vegetation in the groundcover and mid-storey strata has been recorded, but there has been no significant increase in percentage cover of existing weed species.

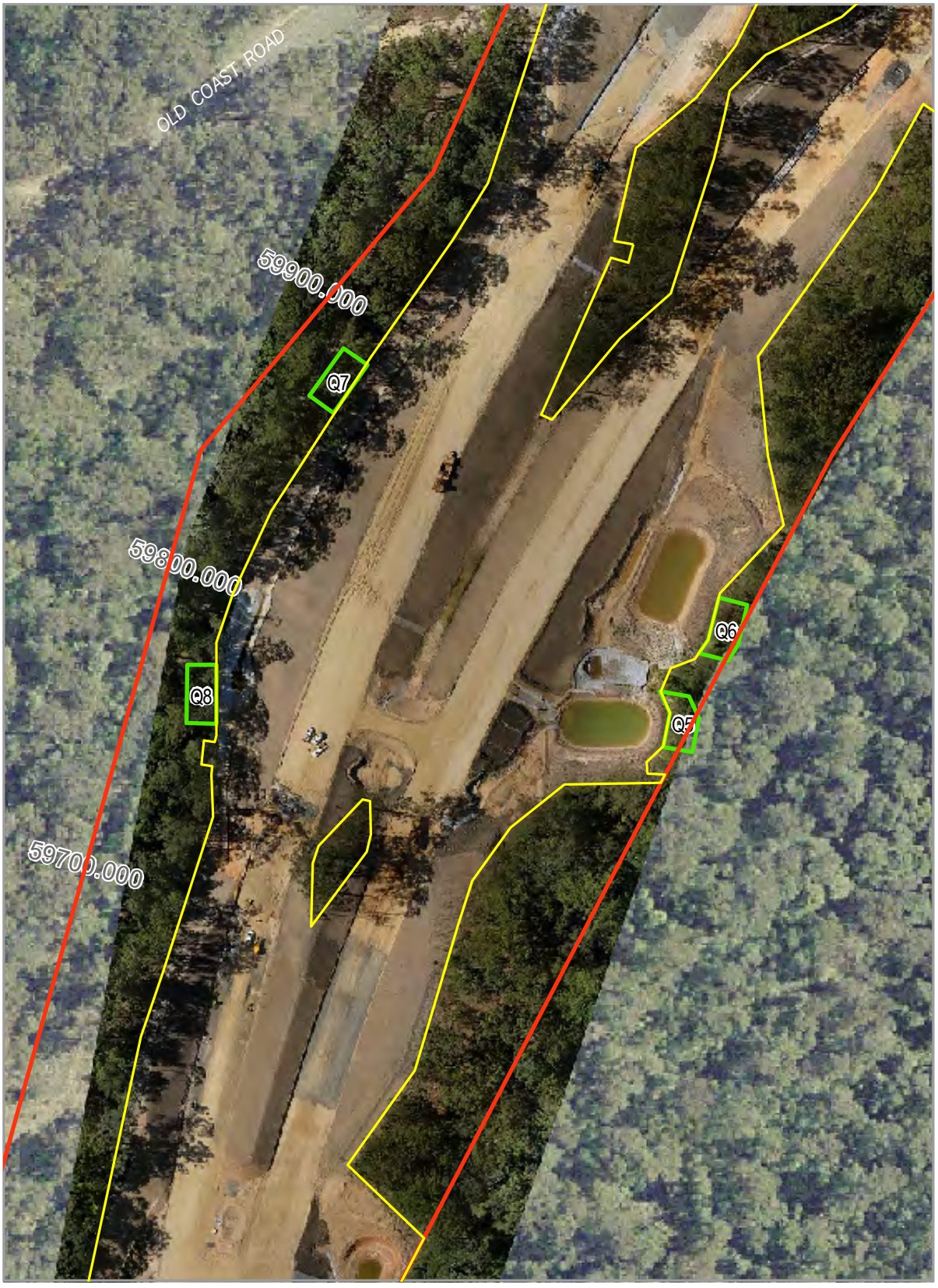
It should be noted that a review of Quadrat 9 (Q9) monitoring location was undertaken due to an increase in the presence of Broad-leaf Paspalum between autumn and spring monitoring (5 - 20 percent). This species is the dominant groundcover within an area of previously cleared access track located within the northern end of Q9. Based on this review, the Q9 quadrat location was relocated 15 m further south to capture a more representative example of Slender Marsdenia and Woolls' Tylophora habitat, excluding the area of previously cleared access track. This has reduced the weed level to less than five percent weed cover for monitoring to date in Q9.

Plate 3.12 Example of Habitat Condition Monitoring Plots

Plate 3.13 Example of Habitat Condition Monitoring Plots

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: JOL Date: 23/10/2017
Source of base data: AFJV



LEGEND

- Project boundary
- Clearing limit
- Quadrat

North

0 40

Slender Marsdenia and Woolls' Tylophora Habitat Monitoring Locations

GeoLINK environmental management and design

WC2NH In-situ Threatened Flora and Habitat Monitoring Spring 2017
2378-1394

Illustration 3.1

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: JOL Date: 23/10/2017
Source of base data: AFJV

LEGEND

- Project boundary
- Clearing limit
- Quadrat

0 40

North

Slender Marsdenia and Woolls' Tylophora Habitat Monitoring Locations

GeoLINK environmental management and design

WC2NH In-situ Threatened Flora and Habitat Monitoring Spring 2017
2378-1394

Illustration 3.2

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: JOL Date: 23/10/2017
Source of base data: AFJV

LEGEND

- Project boundary
- Clearing limit
- Quadrat

North

0 40

Slender Marsdenia and Woolls' Tylophora Habitat Monitoring Locations

GeoLINK environmental management and design

WC2NH In-situ Threatened Flora and Habitat Monitoring Spring 2017
2378-1394

Illustration 3.3

Table 3.6 Slender Marsdenia and Woolls' Tylophora Habitat Condition Monitoring

Quadrat	*Vegetation Structure (dominant species, height, cover)*			*Weed Level*	*Microclimate Class*
	Canopy	*Mid-storey*	*Ground cover*		
1	Flooded Gum, Swamp Turpentine – 25m	Red Ash, Brush Box, Swamp Turpentine, Rosewood – 3-8m	Gristle Fern, Water Vine, Mat-rush, Native Jasmine – 0.5m	Lantana	
Spring 15	5%	50%	40%	<5%	5
Autumn 16	5%	50%	40%	5%	5
Spring 16	5%	45%	45%	5%	5
Spring 17	5%	60%	45%	5%	5
2	Swamp Turpentine, Forest Oak, Tallowwood – 20m	Black Wattle, Red Ash, Brush Box, Rosewood – 3-6m	Gristle Fern, Palm Lily, Mat-rush, Native Jasmine – 0.5m	Lantana	
Spring 15	15%	60%	10%	<5%	5
Autumn 16	15%	65%	15%	5%	5
Spring 16	15%	65%	15%	10%	5
Spring 17	15%	65%	20%	10%	5
3	Swamp Turpentine, Flooded Gum, Ironbark – 22m	Rosewood, Red Ash, Black Wattle, Cabbage Palm – 2-10m	Gristle Fern, Mat-rush, Native Jasmine – 0.5m	Lantana	
Spring 15	5%	70%	10%	<5%	1
Autumn 16	5%	70%	10%	<5%	1
Spring 16	5%	70%	10%	<5%	1
Spring 17	10%	70%	30%	<5%	1
4	Flooded Gum, White Mahogany, Swamp Turpentine – 25m	Red Ash, Forest Oak, Cabbage Palm, Rosewood -3-8m	Water Vine, Palm Lily, Saw-sedge, Gristle Fern – 0.5m	No weeds	
Spring 15	5%	10%	30%	-	2
Autumn 16	5%	10%	30%	-	2
Spring 16	5%	10%	35%	-	2
Spring 17	5%	10%	45%	-	2
5	Ironbark, Brush Box, Tallowwood, Swamp Turpentine – 28m	Forest Oak, Swamp Turpentine, Cabbage Palm, Palm Lily – 3-8m	Mat-rush, Gristle Fern, Palm Lily. Regrowth shrub species Cheese Tree and Banana Bush – 0.5m	Lantana	
Spring 15	50%	15%	15%	<5%	5
Autumn 16	50%	20%	15%	<5%	5
Spring 16	50%	20%	15%	<5%	5
Spring 17	55%	25%	25%	<5%	5
6	White Mahogany, Brush Box, Paperbark – 20m	Black Wattle, Cabbage Palm, Palm Lily, Geebung – 3-8m	Mat-rush, Gristle Fern, Palm Lily <1m	Lantana	
Spring 15	50%	40%	30%	5%	4
Autumn 16	50%	40%	30%	5%	4
Spring 16	50%	40%	35%	5%	4
Spring 17	55%	50%	35%	5%	4
7	Tallowwood – 20m	Red Ash, Rosewood, Acacia sp, Leptospermum sp – 2-8m	Gristle Fern, Bracken Fern, Mat-rush – 0.5m	No weeds	
Spring 15	10%	25%	50%	-	1
Autumn 16	10%	25%	50%	-	1

Quadrat	*Vegetation Structure (dominant species, height, cover)*			*Weed Level*	*Microclimate Class*
	Canopy	*Mid-storey*	*Ground cover*		
Spring 16	10%	25%	50%	-	1
Spring 17	15%	25%	50%	-	1
8	Paperbark, Brush Box, White Mahogany – 18m	Cheese Tree, Rosewood, Geebung, Lilly Pilly – 2-8m	Gristle Fern, Mat-rush, Bracken Fern, Water Vine, Palm Lily – 0.5m	Lantana	1
Spring 15	40%	40%	25%	5%	1
Autumn 16	40%	40%	30%	5%	1
Spring 16	40%	40%	30%	7%	1
Spring 17	40%	40%	35%	5%	1
9	Tallowwood, Swamp Turpentine, Flooded Gum – 28m	Palm Lily, Paperbark, Cabbage Palm, Acacia sp., Cheese Tree – 2-8m	Saw-sedge, Jasmine, Gristle Fern, Mat-rush - <0.5m	Lantana, Broad-leaved Paspalum	
Spring 15	40%	30%	25%	5%	1
Autumn 16	40%	30%	25%	5%	1
Spring 16	40%	30%	30%	<5%	1
Spring 17	45%	30%	40%	<5%	1
10	Flooded Gum – 30m	Sandpaper Fig, Red Ash 6-8m	Jasmine, Bracken Fern – 0.5m (5%)	Lantana <5%	
Spring 15	5%	30%	5%	<5%	4
Autumn 16	5%	30%	10%	<5%	4
Spring 16	5%	30%	20%	<5%	4
Spring 17	10%	30%	25%	<5%	4

3.2.3 Conclusion

To date there are no substantial changes in Woolls' Tylophora and Slender Marsdenia habitat occurring adjacent to the clearing boundary as recorded from the monitoring plots. The minor changes in vegetation strata to date have not affected any microclimate class scores for any of the quadrats monitored (refer to summary of performance measures at **Table 3.10**). It is envisaged that any substantial changes to the condition/ composition of monitoring plots would be likely to be recorded over a longer time period from the initial disturbance associated with clearing for the project. This report is likely to present the complete data for the construction phase of the project as the scheduled project completion date is set for summer 2017/2018.

Table 3.7 Slender Marsdenia and Woolls' Tylophora Habitat Condition Performance Measures

Quadrat	*Plot crown-cover of exotic species is no more than 15% at end of Year 1*	*Plot crown-cover of exotic species is no more than 25% at end of Year 3*	*Baseline vegetation structure (height and crown cover) remains the same or increases in height and crown cover at the end of year compared to the previous year.*	*There is no increase in the microclimate exposure class (e.g. 1 to 2, or 4 to 5) compared to the previous year.*
1	No - weed cover not more than 5%	No - weed cover not more than 5%	No - the mid-storey percent cover recorded a decrease from 50% cover in Year 1 to 45% in Year 2 but an increase in percent cover to 60% in year 3.	No - All microclimate exposure classes were recorded to remain the same between monitoring years.
2	No - weed cover not more than 5%	No - weed cover not more than 10%	Yes - all levels of height and crown cover has remained the same or recorded an increase when compared to previous year.	No - All microclimate exposure classes were recorded to remain the same between monitoring years.
3	No - weed cover not more than 5%	No - weed cover not more than 5%	Yes - all levels of height and crown cover has remained the same or recorded an increase when compared to previous year.	No - All microclimate exposure classes were recorded to remain the same between monitoring years.
4	No weeds were recorded within this quadrat	No weeds were recorded within this quadrat	Yes - all levels of height and crown cover has remained the same or recorded an increase when compared to previous year.	No - All microclimate exposure classes were recorded to remain the same between monitoring years.
5	No - weed cover not more than 5%	No - weed cover not more than 5%	Yes - all levels of height and crown cover has remained the same or recorded an increase when compared to previous year.	No - All microclimate exposure classes were recorded to remain the same between monitoring years.
6	No - weed cover not more than 5%	No - weed cover not more than 5%	Yes - all levels of height and crown cover has remained the same or recorded an increase when compared to previous year.	No - All microclimate exposure classes were recorded to remain the same between monitoring years.
7	No weeds were recorded within this quadrat	No weeds were recorded within this quadrat	Yes - all levels of height and crown cover has remained the same or recorded an increase when compared to previous year.	No - All microclimate exposure classes were recorded to remain the same between monitoring years.
8	No - weed cover not more than 5%	No - weed cover not more than 5%	Yes - all levels of height and crown cover has remained the same or recorded an increase when compared to previous year.	No - All microclimate exposure classes were recorded to remain the same between monitoring years.
9	No - weed cover not more than 5%	No - weed cover not more than 5%	Yes - all levels of height and crown cover has remained the same or recorded an increase when compared to previous year.	No - All microclimate exposure classes were recorded to remain the same between monitoring years.
10	No - weed cover not more than 5%	No - weed cover not more than 5%	Yes - all levels of height and crown cover has remained the same or recorded an increase when compared to previous year.	No - All microclimate exposure classes were recorded to remain the same between monitoring years.

4. Conclusion

Based on the monitoring results, in-situ threatened flora monitoring has observed fluctuations in presence/ absence and health condition scores for a number of the species subject to monitoring. The variation in presence/ absence and plant health amongst species such as Tall Knotweed, Maundia and Slender Marsdenia is not unusual for these species, which may exhibit seasonal or natural die off due to life cycle or seasonal and climatic influences. The fluctuation in results is not considered to be attributable to project related impacts, as no in-situ threatened flora sites have recorded direct construction related impacts by means of access into protected areas, project related erosion and sedimentation or significant weed incursion.

Although the survival rates of in-situ threatened flora do not meet the performance indicator minimum requirements, no die-back or direct construction related impacts have been recorded as having contributed to the monitoring results to date. Overall, the protective measures implemented for the project to safeguard retained threatened flora have been effective with no plant mortality directly associated with impacts from construction activities.

To date there are no substantial changes in Woolls' Tylophora and Slender Marsdenia habitat occurring adjacent to the clearing boundary as recorded from the monitoring plots. An increased percentage cover of native vegetation in the groundcover and mid-storey strata has been recorded, with no significant increase in percentage cover of existing weed species. The minor changes in vegetation strata to date have not affected any microclimate class scores for any of the quadrats monitored.

This report presents a complete set of results for the construction phase monitoring including pre-construction baseline monitoring and Years 1 – 3 of the construction phase. Project completion is scheduled for summer 2017/2018. From this time the project will enter the operational phase of monitoring and will be undertaken by the appointed ecological consultant.

5. References

Benwell, A. (2014). *Warrell Creek to Urunga Upgrade of the Pacific Highway Threatened Flora Management Plan, Version 4.* Unpublished document for Roads and Maritime Services, NSW.

Benwell, A. (2016). *Warrell Creek to Urunga Upgrade of the Pacific Highway Threatened Flora Management Plan, Version 5.* Unpublished document for Roads and Maritime Services, NSW.

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Appendix H

Threatened Flora Translocation Area Monitoring Report

Warrell Creek to Nambucca Heads Upgrade of the Pacific Highway

Threatened Flora Translocation Project

Annual Monitoring Report – Year 3

Prepared for:

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1/2/2018

CONTENTS

EXECUTIVE SUMMARY

This report documents the results of translocations of threatened plant species conducted for the Warrell Creek to Nambucca Heads (WC2NH) upgrade of the Pacific Highway after approximately 3 years (Feb 2015 to November 2017). Methods used during implementation are also described. The translocation project was implemented by Ecos Environmental for Pacifico (Acciona - Ferrovial joint venture) based on the Warrell Creek to Urunga Threatened Flora Management Plan (ECOS Environmental Ver. 4 (24/12/2014) and Ver. 5 (1/7/2016)). Five threatened species were translocated from the highway corridor to adjoining bushland: *Marsdenia longiloba* (Slender Marsdenia), *Tylophora woollsii* (Woolls' Tylophora), *Dendrobium melaleucaphilum* (Spider Orchid), *Niemeyera whitei* (Rusty Plum) and Floyds Grass (*Alexfloydia repens*). One nationally rare species, *Artanema fimbriata* (Koala Bells) was also translocated.

The translocation project aimed to establish populations of the impacted species in habitat adjacent to the highway corridor. To achieve this aim, the translocation program involved the following actions:

- salvage transplanting of impacted individuals from the construction footprint;
- enhancement of the size of the translocation population where possible by propagation and introduction, or direct seeding.
- restoration of good quality habitat to the receival sites.

Potential receival sites were assessed according to physical, biotic and logistical criteria set out in the Threatened Flora Management Plan. Nine receival sites spread out along the 19.6 km road corridor were selected that provided habitat assessed as suitable for each species, whilst minimising the distance plants were moved from the donor sites. Eight were located in the Road Reserve of the new highway and one on adjoining RMS property. Receival sites in the Road Reserve were selected with a buffer of forest ~20 metres wide to the edge of the cleared highway alignment and with State Forest on the other side to provide microclimatic protection.

Salvage of impacted plants was carried out by direct transplanting. Approximately three years after translocation, the survival rate of all species was >70% with the exception of Koala Bells (see Table 1 below). The overall survival rate of Slender Marsdenia, the main species requiring translocation was 74.4% (175 individuals translocated). This survival rate is in line with NH2U (67.9% - 2013-2016) and much higher than Bonville (45% and 25%, two sites, 2007-2010). Plants were transplanted directly to the new sites, watered-in and given follow-up watering, otherwise they received no further treatment. Fertilisers were not applied. Results supported the hypothesis that low survival for Bonville was due to the adverse effect of fertiliser addition and soil improvement. This effect appeared to be field interactions, as in pot cultivation, Slender Marsdenia grew strongly in response to fertiliser addition.

Spider Orchid flowered in spring each year, including Year 1 only 6 months after transplanting, but no seed pods were formed during the three years. Koala Bells started to flower a month after transplanting and set seed. Most plants died at the end of Year 1 and 2 due to its inherently short life cycle and a few persisted to Year 3. A different approach was used to prepare the receival site for Floyds Grass which was heavily infested with Broad-leaved Paspalum and other weeds. Ground layer vegetation and the top 10cm of soil containing most of the soil seedbank was stripped off with an excavator, which created largely weed free soil conditions for Floyds Grass to establish in. Nearly all Floyds Grass clumps survived after three years (94%) and continue to grow.

Assessment of the translocation outcomes after three years according to the performance criteria in Appendix 11 of the WC2U Threatened Flora Management Plan (Ver. 4 24/12/2014) found that all performance criteria had been met. (Corrective action not required for Koala Bells as the species has a naturally short life cycle; plants survived and grew to maturity, seeding the habitat.)

Table 1: Species transplant survival rate over approximately three years – Feb /2015 to Nov/2017. (details of monitoring results can be found in the Excel spreadsheet appended to this report).

Species/Receival Site	**No. plants**	**% survival**			
		Aug 2015 (~6 mth)	**Feb 2016 (~1 Yr)**	**Jan 2017 (~2 Yrs)**	**Nov 2017 (~3 Yrs)**
Slender Marsdenia (*Marsdenia longiloba*)					
Receival Site 1 - Cockburns Lane	27	93	93	75	63
Receival Site 2 (3) – Old Coast Rd	17	100	91	93	88
Receival Site 3 (5a) – Old Coast Rd	22	81	81	91	73
Receival Site 4 (5b) – Old Coast Rd	16	100	94	81	69
Receival Site 5 (7a) – Old Coast Rd	57	90	90	72	74
Receival Site 6 (8a) – Old Coast Rd	8	88	75	75	75
Receival Site 8 (8c) – Old Coast Rd	28	93	100	86	82
Total	175		91	82	74
Rusty Plum (*Niemeyera whitei*)					
Receival Site 1 - Cockburns Lane	7	100	100	88	88
Wooll's Tylophora (*Tylophora woollsii* – unconfirmed)					
Receival Site 6 (8a) – Old Coast Rd	6	100	100	100	83
Spider Orchid (*Dendrobium melaleucaphilum*)					
Receival Site 5 (7a) – Old Coast Rd	2	100	100	100	100
Floyds Grass (*Alexfloydia repens*)					
Receival Site 9 – Warrell Creek	54 clumps	100	94	94	94
Receival Site 9a – Warrell Creek	61 clumps			98	93
Koala Bells (*Artanema fimbriatum*)					
Receival Site 7 (8b) – Old Coast Rd	16	75	63	25	13

1 INTRODUCTION

1.1 Background

The Warrell Creek to Nambucca Heads (WC2NH) project is a 19.6 km section of the Pacific Highway upgrade on the NSW Mid North Coast. Construction began in early 2015 and completion is scheduled in 2018. Threatened plant species management for the project is set out in the Warrell Creek to Urunga Threatened Flora Management Plan (ECOS Environmental Ver. 4 (24/12/2014) and Ver. 5 (1/7/2016)). This plan covers the southern (WC2NH) and northern (NH2U) halves of the 55km Warrell Creek to Urunga upgrade, originally planned as a single project. The Warrell Creek to Urunga Threatened Flora Management Plan (TFMP) was prepared to meet the requirements of Condition of Consent B7 of the NSW Department of Planning's project approval in relation to management of flora listed under the NSW *Threatened Species Conservation Act* 1995. Referral and approval of the TFMP was also required for species listed under the Commonwealth *Environmental Planning and Biodiversity Conservation Act* 1999. This report addresses monitoring and reporting requirements in relation to the translocation component of the TFMP.

Five threatened and one nationally rare plant species were translocated from the construction footprint of the WC2NH project: -

Threatened

- Slender Marsdenia (*Marsdenia longiloba*) (TSC Act, EPBC Act) (Plate 1)
- Woolls' Tylophora (*Tylophora woollsii*) (TSC Act, EPBC Act) (Plate 2)
- Rusty Plum (*Niemeyera whitei*) (TSC Act) (Plate 3)
- Spider Orchid (*Dendrobium melaleucaphilum*) (TSC Act) (Plate 4)
- Floyds Grass (*Alexfloydia repens*) (TSC Act) (Plate 5)

Nationally Rare

- Koala Bells (*Artanema fimbriatum*) (Plate 6)

The translocation component of the TFMP was implemented by Ecos Environmental Pty Ltd for Pacifico (Acciona-Ferrovial joint venture), the principal contractor for the WC2NH project. This is the third annual monitoring report and documents implementation and results of the threatened species translocations from February 2015 to November 2017.

An additional threatened plant species, *Maundia triglochinoides* (TSC Act), was translocated by the principal contractor. Translocation of this species was not proposed in the TFMP (see TFMP Section 3.5.5), although the plan indicated that translocation by transplanting was likely to be successful, as subsequently demonstrated.

1.2 Translocation Strategy and Objectives

The translocation component of the TFMP was prepared according to the ANPC (2004) guidelines for planning threatened flora translocations. The overall translocation strategy was to endeavour to maintain population numbers of each species in the local area by salvaging threatened and rare species impacted by construction and re-establishing them in suitable habitat alongside the highway corridor. A propagation component would make up for losses incurred during salvage transplanting. Translocation of each species involved three main actions:

- Salvage transplanting of impacted individuals and establishing them at receival sites with habitat closely approximating the donor sites;
- Population enhancement by propagating and introducing additional individuals; and

- Habitat restoration to ensure the receival sites provided good quality habitat.

The specific objectives of threatened flora translocation set out in the Warrell Creek to Urunga Threatened Flora Management Plan were as follows:-

- To salvage and re-establish impacted individuals of threatened (TSC/ EPBC Act) species.
- To re-establish species at a relocation site in close proximity to the original site with closely matching habitat and long-term security of tenure.
- To enhance the size and genetic diversity of the translocated population by propagation and introduction of individuals additional to those salvaged from the road footprint.
- To maintain good quality habitat in the receival site(s).
- To preserve individuals of threatened species in situ wherever possible and limit transplanting to plants within the construction footprint and buffer.

1.3 Reporting Requirements

The reporting requirements for the Annual Translocation Monitoring Report are specified in Section 4.8.5 of the TFMP. The table below indicates the sections where reporting requirements are addressed in this report.

Reporting requirement	**Where addressed in the annual monitoring report?**
Background and description of the translocation project;	Section 1, 2 and 3
Implementation of the translocation project;	Section 3
A description of monitoring methods;	Section 3.8
An analysis of monitoring data on a species by species basis;	Section 4
An assessment of causes of plant mortality;	Section 4
A record of the plants transplanted and propagated;	Section 3 Digital Excel spreadsheet appended to report
A description of the population enhancement program;	Section 3
An assessment of the success or failure of the translocation based on criteria set out in the WC2U TFMP Ver.5 (Appendix 11 and Section 4.8.6);	Section 5
An evaluation of the methods and cost-effectiveness of the translocation project; and	Section 5
Work plan for the next twelve months.	Section 5

Plate 1: Slender Marsdenia (*Marsdenia longiloba*) produces umbels of white flowers in the leaf axils. It has similar leaves to Woolls' Tylophora and both species also have clear rather than milky sap, adding to the difficulty of telling non-flowering plants apart

Plate 2: Woolls' Tylophora (*Tylophora woollsii*) has purplish flowers arranged in a short cymose panicle, clearly different to Slender Marsdenia above.

Plate 3: Rusty Plum (*Niemeyeria whitei*) is a medium sized rainforest tree.

Plate 4: Spider Orchid (*Dendrobium melaleucaphilum*) produces large, vanilla scented flowers in August and September.

Plate 5: Floyds Grass (*Alexfloydia repens*) a rare mat-forming grass found along creeks between Coffs Harbour and Warrell Creek. Note small inflorescence in centre.

Plate 6: Koala Bells (*Artanema fimbriatum*). An annual or short-lived perennial herb found in grassy forest on coastal floodplains and edges of tracks.

2 RECEIVAL SITES

2.1 Site Selection

The type of habitat present at a receival site has a major bearing on whether a translocated species survives the introduction process and establishes to grow to maturity. The general approach in selecting a receival site is to pick one that resembles the donor site as closely as possible in terms of topography, soil and vegetation type. Vegetation condition can vary from undisturbed, mature vegetation to regenerating or cleared. Translocation can be successful in a range of different vegetation conditions but effects need to be carefully considered, for example, excessive sun exposure in a regenerating site, or high interspecific competition in a mature site. For the WC2NH project, receival sites were limited largely to forested habitat within the Road Reserve next to the new highway, as offsets were still being planned and parcels of residual RMS land were mostly cleared paddock that would have required extensive habitat restoration work. The Road Reserve includes all land between the property boundaries of the road corridor. Where the WC2NU corridor was cleared through Nambucca State Forest there was usually a strip of uncleared forest 20 to 40+ metres wide left within the Road Reserve, abutting State Forest on one or both sides. Small sections of forested road reserve adjoining private property were also present south of Warrell Creek.

Potential receival sites within the Road Reserve were identified by desktop review of aerial imagery overlaid with topography, vegetation type and the road design. Twenty potential sites were inspected and assessed according to selection criteria shown in Table 2. As Slender Marsdenia was impacted at several locations along the length of the WC2NH project, several receival sites were selected specifically for this species to maintain approximately the current distribution and to minimise distance individuals were translocated. A total of nine receival sites were finally selected, seven in the road reserve where the highway corridor crossed Nambucca State Forest. The other two were in the road reserve at the southern end of the project and on RMS land adjacent to the new highway bridge at Warrell Creek outside the project boundary.

Table 1: Translocation Receival Sites. The identifier in brackets is the original one used during site selection and subsequent monitoring.

Receival Site	Species
1 (Cockburns Lane)	Slender Marsdenia, Rusty Plum
2 (3)	Slender Marsdenia
3 (5a)	Slender Marsdenia
4 (5b)	Slender Marsdenia
5 (7a)	Slender Marsdenia, Spider Orchid, Rusty Plum direct seeding, Slender Marsdenia population enhancement.
6 (8a)	Slender Marsdenia, Woolls' Tylophora(?)
7 (8b)	Koala Bells
8 (8c)	Slender Marsdenia
9 (Warrell Creek)	Floyds Grass, Koala Bells population enhancement

Receival sites for Slender Marsdenia had moist open forest habitat with a light mesic understorey. The sites were in hilly terrain on lower slopes with a sheltered south to east aspect alongside the highway. Species composition, structure and soil type were very similar to the donor sites. The forest generally consisted of mature regrowth logged 30-50 years ago with a fairly open understorey structure, which the species seems to prefer. Canopy species included Grey Gum (*E. propinqua*),

Ironbark (*E. siderophloia*), Tallowwood (*E. microcorys*), White Mahogany (*E. acmenoides*), Pink Bloodwood (*Corymbia intermedia*), Blackbutt *(E. pilularis*) and Turpentine (*Syncarpia glomulifera*), proportions varying from site to site. Woolls' Tylophora is also suited to this type of habitat.

The receival site for Floyds Grass was selected on RMS land adjoining the project boundary next to Warrell Creek. Habitat consisted of a narrow floodplain with alluvial soil supporting patchy, riparian forest regrowth with a weedy understorey of Broad-leaved Paspalum (*Paspalum mandiocanum*) and Lantana.

Koala Bells was translocated to a small area of Broad-leaved Paperbark alongside a track inside the Road Reserve. Propagated Koala Bells were planted into the Floyds Grass receival site.

Brief descriptions of the nine receival sites are provided below. Photos of the receival sites are included with the plates at the end of the report.

2.2 Receival Site 1

Receival Site 1 is located in the road reserve on the eastern side of the highway alignment adjacent to Cockburn's Lane at the southern end of the project. The road reserve is relatively narrow here and exposed to the west, although timbered on the eastern side, providing a reasonable level of microclimatic protection. The soil type is a red loam formed on a dark glassy rock which differs from the metasediment geology found along most of the alignment (ie the Nambucca Beds). Slender Marsdenia and Rusty Plum impacted at Cockburns Lane were translocated to Receival Site 1 which has the same red loam soil type. A buffer of forest and landscaping approximately 20m wide separates the receival site from the cleared road corridor.

2.3 Receival Site 2 (3)

(Note – the original numbering from the site selection process is shown in brackets).

Receival Site 2 is located north of the Nambucca River in a strip of moist open forest between Old Coast Road and the highway alignment. The site faces east and is situated on a mid-slope. A buffer of forest approximately 30m wide separates the translocation area from the cleared road corridor.

2.4 Receival Site 3 (5a)

Receival Site 3 is located on the western side of the alignment in a narrow strip of forested road reserve. As the site adjoins Nambucca State Forest on the western side, which extends upslope for more than 100 metres, the site is relatively protected. The site is situated on a lower slope and has an easterly aspect. A buffer of forest approximately 15m wide separates the translocation area from the cleared road corridor.

2.5 Receival Site 4 (5b)

Receival Site 4 is located about 100 metres north of site 3 on the other side of a gully which intersects the alignment at right angles (site 3 is on the southern side of the gully). A buffer of forest approximately 30m wide separates the translocation area from the cleared road corridor.

2.6 Receival Site 5 (7a)

Receival Site 5 is located further north between Old Coast Road and the highway alignment, adjacent to the turn-off to the Council waste recycling depot. This site has similar aspect and topographic position to site 3 and is well protected on the western side by a wide strip of Nambucca State Forest between Old Coast Road and the new highway.

2.7 Receival Site 6 (8a)

Receival Site 6 is located a few hundred metres south of where the alignment crosses Old Coast Road south of Nambucca Heads. The site is located in the Road Reserve in a narrow strip of forest next to an easement with a fiber-optic cable and water main, on the western side of the highway. The site aspect is east and topographic position lower slope. There is a forested buffer approximately 20 metres wide between the site and the highway. The site is well protected on the western side by Nambucca State Forest.

2.8 Receival Site 7 (8b)

Receival Site 7 selected for Koala Bells (*Artanema fimbriatum*) is located about 50 metres south of site 6 in a small area of Paperbark swamp forest next to a boundary access track for underground utilities, which generally meets the habitat requirements easement of Koala Bells. Although Koala Bells is not listed as a threatened species, it is rare and would probably qualify for listing if nominated. Translocation was undertaken more as a pre-cautionary measure and to extend translocation work with this species on other highway upgrade projects, which has produced puzzling results.

2.9 Receival Site 8 (8c)

Receival Site 8 is accessed by the same utilities easement as sites 6 and 7, and is located further south. The site is well protected on the western side by Nambucca State Forest. Site aspect is east and topographic position lower slope. A buffer of forest approximately 30m wide separates the translocation area from the cleared road corridor.

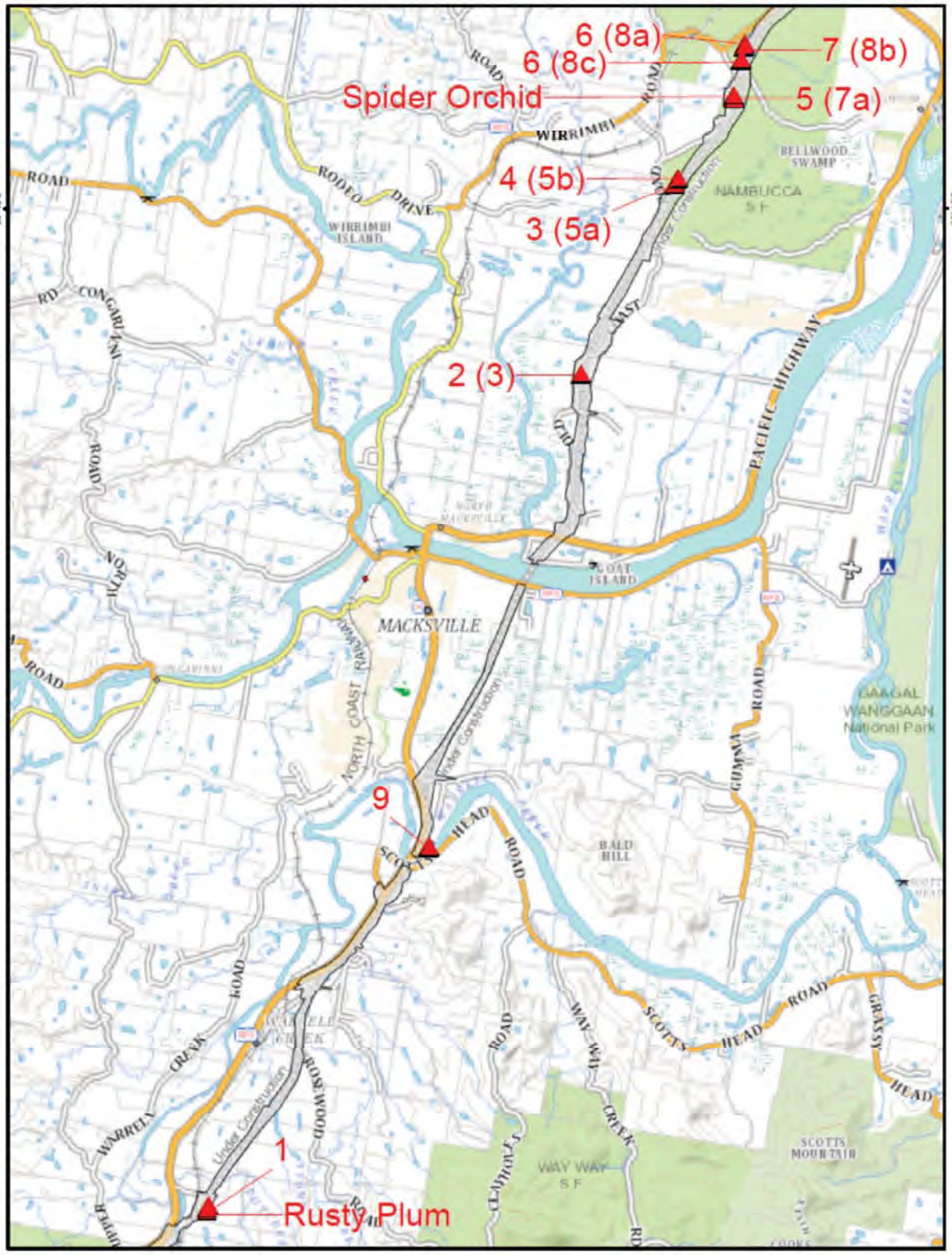
2.10 Receival Site 9

Receival Site 9 was selected for the Floyds Grass. The site is on alluvial soil next to Warrell Creek and is approximately 100 metres north of the donor/impact site at the new bridge site. Floyds Grass occurs in Swamp Oak (*Casuarina glauca*) swamp forest, or moist open forest dominated by Flooded Gum (*Eucalyptus grandis*), *Melaleuca* spp. and rainforest species. Both of these communities are usually situated on the banks of, or close to, coastal creeks and estuaries. Receival Site 9 supports the moist open forest type with rainforest trees. This type of habitat is extensive on the northern side of Warrell Creek, although overrun with Broad-leaved Paspalum (*Paspalum mandiocanum*). Two areas in Receival Site 9 were marked out for conducting the Floyds Grass translocation, each covering approximately 30 m x 20 m.

The site is on RMS land outside the project boundary and is part of an area identified in project documents for habitat restoration after completion of road construction.

Table 2: Site attributes of nine receival sites selected for translocation of threatened species on the WC2NH project

Receival Site/ Site Attributes	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Physical									
slope aspect (S-south,E-east)	S	E	E	E	E	E	E	E	flat
slope angle (m-low to mod.)	M	m	m	M	M	m	m	m	flat
topographic position	Mid	mid	lower	Lower	lower	lower	lower	lower	plain
landform	Hills	hills	hills	Hills	Hills	hills	hills	hills	plain
geology (✓ matching donor site)	✓	✓	✓	✓	✓	✓	✓	✓	✓
soil (✓ matching donor site)	✓	✓	✓	✓	✓	✓	✓	✓	✓
proximity to donor site (✓ <1km)	✓	✓	✓	✓	✓	✓	✓	✓	✓
area of potential habitat available (✓ adequate)	✓	✓	✓	✓	✓	✓	✓	✓	✓
Vegetation									
plant community (✓ matching donor site)	✓	✓	✓	✓	✓	✓	✓	✓	✓
threatened species already present (p-possible)	P	p	p	p	p	p	p	p	n
invasive/difficult to control weeds present (y-yes; n-no)	N	n	n	n	n	n	n	n	y
Logistical									
accessibility (g-good; f-fair; p-poor)	G	f	f	f	f	g	g	g	g
available water source (y-yes; n-no; water cart)	N	n	n	n	n	n	n	n	n
distance to water source	Kms	kms	kms	kms	kms	kms	kms	kms	kms
likelihood of disturbance during construction (u-unlikely; p-possible)	u	u	u	u	u	u	u	u	u
Tenure/conservation									
land ownership/ protection mechanism	RMS	RMS	RMS	RMS	RMS	RMS	RMS	RMS	RMS
potential disturbance by future road widening (p – possible)	p	p	p	p	p	p	p	p	p
other project conservation uses (y-yes, forest habitat)	y	y	y	y	y	y	y	y	y


6 (8a)
7 (8b)
6 (8c)
Spider Orchid
5 (7a)
4 (5b)
3 (5a)
2 (3)
9
1
Rusty Plum
MACKSVILLE
WIRRIMBI
RODEO DRIVE
WIRRIMBI ISLAND
BELLWOOD SWAMP
NAMBUCCA S F
PACIFIC HIGHWAY
COAT ISLAND
NORTH COAST ROAD
GUMMA ROAD
GAAGAL WANGGAAN National Park
BALD HILL
SCOTTS HEAD ROAD
WAY WAY S F
SCOTTS MOUNTAIN
ROSEWOOD
WARRELL CREEK
Under Construction
ECOS ENVIRONMENTAL
Receival Sites
WC2NH road corridor
Receival Sites for the WC2NH Threatened Flora Translocation Project

3 TRANSLOCATION METHODS

3.1 Direct Transplanting

All species were translocated from the construction footprint using the direct transplanting method. Direct transplanting involves excavation, transport to the receival site and replanting in one action rather than as a gradual process. Excavation is carried out with an excavator or with hand tools if plants are small. The objective is to remove the shoot system and enough of the root system to enable regeneration and plant survival. Basic horticultural measures are applied such as pruning and watering to minimise transpiration stress, which is the principal cause of mortality during transplanting. Substantial pruning of the shoot system and watering to ensure high soil moisture is maintained in the first months are essential to achieve a high survival rate using the direct transplanting method.

Advantages of direct transplanting over other transplanting methods include:-

- Relatively fast and cost-effective.
- Suited to rough terrain and significant numbers of individuals.
- Minimises duration of the translocation process and therefore potential risk of disease and pest transfer to the wild (a risk of propagation).
- Natural soil microflora conditions are maintained by transferring plant and soil material together.

Primack (1996) pointed out other advantages of transplanting: "There are nonetheless ecological advantages to using transplanted plants rather than seeds in reintroduction (translocation) efforts. Plants, particularly adult plants have a higher likelihood of successful establishment than seeds (or seedlings) if they are planted into a suitable site and well tended. These plants have overcome the most vulnerable stages in their life cycle (seed germination and seedling establishment) so that their chances of surviving in the new habitat are greatly increased. These individuals also have proven genotypes that are free of lethal mutations and adapted to the general environmental conditions. When reintroduction efforts involve reproductively mature adult plants, the new population has the potential to flower, produce and disperse seeds and create a second generation of plants within a year (or so) of transplantation".

Translocation methods applied to each species are described in more detail below.

3.2 Slender Marsdenia

3.2.1 Salvage Transplanting

Slender Marsdenia transplanting began by marking plants with pink tape at the base and higher up so as not to damage them while digging. The stem usually with leaves was removed in a block of soil about 40cm square and 20cm deep with a spade. Mapped points from the TFMP often included more than one stem at varying distance apart (e.g.10-50cm or more). All stems were transplanted, each being treated as a ‘stem-individual’, although some may have been connected underground. Plants and soil were kept damp during transport to the receival site. The ‘stem-individuals’ were planted in approximate rows at points pre-marked with pink tape. These points were at regular intervals (5m) along a row and therefore essentially random (ie planting location determined by distance and not a selective bias).

A total of 169 Slender Marsdenia plants (stem individuals) were salvaged and planted at seven receival sites (refer to Table 1) in February 2015. Additional plants

were translocated in Year 2 due to a modification to the road design to construct north facing ramps at the southern end of Old Coast Road. Any individuals found that were not specified in the Management Plan were also salvaged. It is not unusual for Slender Marsdenia plants to be missed during surveys because of their sparse, well disguised growth form.

The transplants were watered in as soon as planted, then watered once every second day for a week and once a week for four weeks to keep the soil damp. Chicken wire cylinders were installed around each individual to prevent damage by animal grazing, to act as a climbing frame and to facilitate monitoring. Flagging tape was attached to the base of each stem just above the ground, which made it easier to check any stems that died back to see if it was still alive. Flagging tape was attached to each wire cage showing the individual's monitoring number and source code as per the TFMP. Multiple individuals at the same mapped point were indicated by an additional suffix on the source code – e.g. MI46-7

3.2.2 No fertiliser

As previous use of fertiliser and soil improvement during translocation of Slender Marsdenia had an adverse effect on growth and survival, fertiliser was not applied during the WC2H translocation. Experimental comparison of fertiliser and no fertiliser treatments on the NH2U project indicate that even light applications of slow release fertiliser resulted in depressed plant growth (Ecos Environmental 2016).

3.2.3 Propagation of population enhancement plants

Propagation of Slender Marsdenia from pieces rhizome collected during transplanting had poor results, as on the NH2U project. Less than 5% of cuttings produced shoots and shoot growth was very slow. The few plants propagated were grown-on for two years and planted out in Nov/17 (Plate 40).

Flowering of Slender Marsdenia occurs in November and ripe pods have been collected in December (only a single pod from two projects). It is not known if pods grow rapidly to maturity after flowering (i.e in one or two months), or take longer, although the scant observations suggest they grow rapidly to maturity. On the NH2U project approximately 100 seedlings of Slender Marsdenia were propagated from one seed pod. In contrast to rhizome/tuber cuttings, seedlings grew rapidly, both in the nursery and after planting-out (Ecos Environmental 2016). Propagation of Slender Marsdenia from seed to 30cm tall seedlings ready for planting-out took only about 8 months on the NH2U project (Ecos Environmental 2016).

Seed propagation was the preferred method of propagation on WC2NH, but no seed pods were found. Large individuals of Slender Marsdenia were located and checked for pods adjacent to the Nambucca Heads to Urunga and the Sapphire to Woolgoolga sections of the Pacific Highway, and Nambucca State Forest adjacent to WC2NH in Dec/16.

The study of population genetic structure in Slender Marsdenia conducted for the WC2NH and NH2U projects (Shapcott *et al.* 2016) found genetic evidence that out-crossing was common in Slender Marsdenia, which implied that seed production also occurs quite frequently. Given the difficulty of finding seed pods for propagation this was perplexing. However, the findings may represent the genetic imprint of recent, pre-European ecological conditions when cross-pollination and seed production were more frequent. It is possible that forestry, clearing and other impacts have disrupted this species ecology, so cross-pollination and seed set occur less frequently. It is also

possible that seed pods are more common than realised. They may be forming on tall individuals in the forest mid-stratum, where the sparse foliage and similar green colouration of Slender Marsdenia vines make them very hard to see. However, tall individuals with thicker stems (still only a few millimetres in diameter) are few and far between. Most stem individuals are small. Also, only one instance of possible seedling recruitment has been observed under natural conditions (a cluster of small plants, probably seedlings on NH2U). These observations suggest that seed production in current populations is rare.

3.3 Woolls' Tylophora

3.3.1 Species Identification

Woolls' Tylophora has not been positively identified on the WC2NH project. A few plants were identified as possibly this species during TFMP surveys, based on leaf features. However, the leaves of Slender Marsdenia vary in shape and texture and some have leaves similar to Woolls Tylophora, as evident in Plates 1 and 2. Typical Slender Marsdenia has a more elongated leaf, pinnate venation, cordate leaf base, paler green colour and is glabrous (without hairs). Woolls' Tylophora in Plate 2 has a broader leaf with purplish tinges, tends to be more 3-veined at the base and is sparsely hairy. The two species flower at different times - Woolls' Tylophora from the Bonville project flowered in late August, whereas Slender Marsdenia populations from the Mid North Coast flowered in November and occasionally later as well.

About 10 flowering vines were positively identified as Slender Marsdenia on the WC2NH footprint prior to clearing and translocation, but no flowering plants of Woolls Tylophora were found. If present it appears to be much rarer than Slender Marsdenia.

3.3.2 Salvage Transplanting and Population Enhancement

Individuals tentatively identified as Woolls' Tylophora were transplanted using the same method applied to Slender Marsdenia. Both species are vines with tuberous roots. Woolls' Tylophora was translocated to Receival Site 8a, which also received some Slender Marsdenia.

No population enhancement was carried out for Woolls Tylophora as it was not possible to positively identify the species in the absence of flowers. Without knowing we were definitely dealing with plants of this species, propagation efforts were likely to be a waste of time and resources. Seed pods are likely to be as rare as for Slender Marsdenia.

3.4 Rusty Plum

3.4.1 Salvage Transplanting

Direct transplanting of larger Rusty Plums trees (~10m high) began by trenching to form a soil-root ball about 1-1.5 metre wide and 0.7m deep. After undercutting the root ball, the trunk-branch system was cut back at least 50% and all foliage removed. Depending on the size and intactness of the root ball, the trunk was sometimes reduced further. Previous transplanting of this species had shown that survival rate was increased by cutting down the trunk to bring the shoot system (ie above ground plant) into balance with the reduced root system of the relatively small root ball (compared to the original in situ root system).

All Rusty Plums were translocated at Cockburn's Lane at the southern end of the project, from the footprint to Receival Site 1 in the adjacent Road Reserve. Several Rusty Plums remained in-situ in the same area as Receival Site 1. The transplants received additional watering for a month. Sugar cane mulch was spread around each plant to provide a mild growth stimulant and hessian barriers erected for additional shade as the site was exposed to the afternoon sun. No other fertilisers were used.

3.4.2 Population Enhancement by Direct Seeding

The enhancement component of the Rusty Plum translocation aimed to establish additional individuals by direct seedling. Only three Rusty Plum seed were found in State Forest in November 2016. The same location was searched at the start of November 2017 and about 50 fruits collected. Three seeds were also found beneath a Rusty Plum in the Coffs Harbour Regional Botanical Gardens. Rusty Plum produces a large black fruit containing a single seed about the size of a golf-ball. Seeds were separated from the fleshy outer layer and direct seeded into an area next to Receival Site 5 (7a) on 7/12/2017. This site is a minor gully with moist open forest and a mesic, small tree mid-stratum. As seeds may be taken by animals, and seedlings can also be grazed quite heavily (NH2U), seed were sown inside wire mesh cylinders. Fourteen cylinders were set up and three or four seeds placed on the soil surface in each cylinder then covered lightly with leaf litter (Plate 11). The cylinders were tagged for monitoring and location recorded with a GPS.

3.5 Spider Orchid

3.5.1 Salvage Transplanting

Two mature Spider Orchid plants were salvaged from the highway footprint from Prickly Paperbark (*Melaleuca stypheloides*) trees. The orchids were translocated by cutting out the stem or branch section supporting the orchid. These were tied onto the trunks of understory rainforest trees in a gully at Receival Site 5 (7a) (Plate 47). Apart from watering during transport, no additional watering or other treatments were applied.

3.5.2 Population Enhancement

The TFMP aims to propagate additional Spider Orchid plants for population enhancement. As there were not sufficient wild plants to sacrifice some for vegetative division, it was proposed to propagate from seed. Both of the plants translocated on WC2NH flowered in spring 2015, 2016 and 2017, but no seed pods were formed. On the NH2U project, one seed pod was formed in a translocated population of 55 Spider Orchids in spring 2016, but the pod opened in November between site visits before seed could be collected.

3.6 Koala Bells

3.6.1 Salvage Transplanting

Koala Bells was transplanted by digging out plants in a block of soil 40 cm square and 20cm deep with a spade, pruning the tops back, then planting into a shaded site and watering. Receival Site 8b was the only site found in the road reserve with swamp forest similar to typical Koala Bells habitat. The edges of sed basins could also have been used, but this presents management difficulties. Follow-up watering was carried out. No fertilisers were applied.

3.6.2 Population Enhancement

Cuttings of Koala Bells were propagated in summer 2015/2016 at Ecos Environmental's nursery and grown-on in pots during 2016. The propagated plants grew rapidly in the nursery and flowered in summer-autumn 2016, died back over winter then reshot in spring/2016. The regrowth was less vigorous than the first year's growth and small adventitious shoots were also produced around the edge of the pots as also observed in some transplanted specimens in the field (NH2U). Twenty of these plants were introduced to the Floyds Grass receival site (Area 2) at Warrell Creek in January 2017. This site is on alluvial soil and has open ground layer habitat with little competition from other plants, which Koala Bells seems to prefer.

3.7 Floyds Grass

3.7.1 Topsoil Stripping

As the receival site for Floyds Grass next to Warrell Creek was heavily infested with Broad-leaved Paspalum (BLP), it was necessary to kill or remove this exotic grass before translocating Floyds Grass to the site. Killing BLP with herbicide would have left the soil seedbank to contend with. Follow-up spraying of weed germination from the soil seedbank was impractical, as it was impossible to spray small weed plants without hitting Floyds Grass which also sends out long runners.

To create conditions suitable for establishment of Floyds Grass, BLP and the uppermost topsoil seedbank was stripped off with an excavator bucket. As the site was on a floodplain with relatively deep topsoil, it was expected that sufficient depth of topsoil would remain for Floyds Grass to establish after carrying out the stripping operation. Preparation of the site was carried out as follows. Firstly, the ground layer vegetation consisting mainly of BLP and Lantana was scrapped off with an excavator bucket. After exposing the soil surface, the top 10cm of soil was scrapped off and placed to the side of the site. The soil beneath the uppermost 10cm was slightly more clayey in texture, but had reasonable texture and drainage for young plant growth. Sed fencing was installed around the site to prevent run-off to Warrell Creek and to act as a fence to deter wallaby grazing.

3.7.2 Salvage Transplanting

Small clumps of Floyds Grass approximately 10cm square were dug up with a spade and planted at the receival site. The clumps were watered thoroughly and sugar cane mulch (weed free) spread lightly over the soil surface to protect from raindrop compaction. Follow-up watering was carried out as conditions were dry. 'Seasol' seaweed and fish emulsion fertiliser was applied two weeks after introduction to stimulate growth. As the site was exposed to the afternoon sun, shade-cloth fences approximately 1m high and running N-S were erected to provide additional shade (Plate 45). These have now been removed from Area 1 (Plate 42).

3.7.3 Population Enhancement

To promote population establishment by increasing initial population size, approximately 100 additional Floyds Grass plants were propagated at Ecos Environmental's nursery and planted out in a second area at Receival Site 9 in March 2016. These plants were propagated from small pieces of runner that broke off during transplanting. As Area 2 was more exposed than Area 1 and had little shade, shade cloth fences installed to protect the young Floyds Grass plants also had a roof to protect from the overhead sun (Plate 45). Hand weeding to remove competing

exotic and native species was carried out by Pacifico workers under the supervision of the plant ecologist, as in Area 1. Although, most the soil seedbank had been removed, seed germination occurred from seed buried deeper in the soil of a range of native and exotic species. The density of exotic species was very low but some grew rapidly into large plants, particularly *Phytolacca octanda* (Ink Weed), a large herbaceous shrub. Very little BLP germinated.

3.8 Monitoring and Data Analysis

Each individual was identified by a monitoring number (as well as the source identification code from the TFMP). Additional individuals from the same point location were indicated by an additional suffix on the source identification code – e.g. Ml146-7

Monitoring of plant growth and survival was required every 3 months during the first year and six months in the second year. As the spring monitoring session was missed in year 1, an additional monitoring session was carried out in the second year. Monitoring was conducted at the following dates:-

Year 1
February 2015 – start translocation
June 2015 – 3 months
August 2015 – 6 months
Missed – 9 months
February 2016 – 12 months
Year 2
June 2016 – 6 monthly
November 2016 (additional to make up for one missed session)
January 2017 – 6 monthly
Year 3
November 2017 – yearly

Data were recorded as per Section 3.8 of the WC2U TFMP. The main data fields recorded were as follows:-

> Slender Marsdenia and other species except Spider Orchid: Monitoring Number, Date, Line, Source Label, Species (Translocation Plan Label), Species (Current ID), Condition, Height (cm), New Shoots (Y/N), Comment, sig. growth (+) or sig. dieback (-), Waypoint, Coordinates
>
> Spider Orchid: Monitoring Number, Date, Source Label, Species, Number of pseudobulbs with leaves, Length of the longest pseudobulb, New growth, Condition, Waypoint, Coordinates

Field data were entered into an Excel file with separate sheets for each monitoring event. The latest digital file is appended to this report. Note – the gps coordinates of each translocated plant are provided in the sheets labelled Feb 2016.

In analysing the results, species performance and survival were evaluated primarily in terms of plant Condition, which is scored on a scale of 0 to 5, where zero is dead and 5 is fully mature and reproductive. The scale is defined slightly differently for different species, as indicated in Tables 3-5 below.

Species Percent Survival was calculated as follows:
number of individuals in condition classes (2+3+4+5/total)*100.

When mean species height was calculated it was averaged for all plants present at the start of monitoring in June 2015, therefore included plants that had died back to ground level (i.e. height = 0; condition class 1 in the case of Slender Marsdenia).

Table 3: Condition scores applied to Slender Marsdenia and Woolls' Tylophora

Score	Condition
0 dead	dead, no sign of reshooting after 1 year
1 poor	stem died back to ground level, possibly dead; live stem stub may be present
2 fair	plant < 75 cm tall; with leaves or leafless, new shoots/ active growth present or absent
3 good	plant > 75 cm tall, stem with leaves, new shoots/active growth present or absent; if stem leafless or leaves discoloured score as 2
4 advanced	plant > 2.5m tall with > 15 leaves
5 mature	mature; plant flowering or seeding

Table 4: Condition scores applied to Rusty Plum and Koala Bells

Score	Condition
0	Dead
1	leafless and no sign of re-shooting
2	pruned foliage retained, or small amount of re-shooting after defoliating, or foliage sparse/discoloured (<40 cm tall Koala Bells)
3	vigorous re-shooting (>40 cm tall Koala Bells)
4	crown recovering, foliage healthy
5	growing actively, flowering or seeding recorded

Table 5: Condition scores applied to Spider Orchid

Score	Condition
0	Dead
1	pseudobulbs discoloured/grazed/withering, no new growth
2	pseudobulbs healthy in colour, not withering, no new growth
3	plant small, not many healthy pseudobulbs, new growth occurring
4	several healthy pseudobulbs present, new growth occurring
5	several good sized, healthy pseudobulbs, flowering or seeding recorded

As an individual only has to be alive to contribute to species survival, the survival rate does not really indicate how individuals are performing. Some may be thriving and others may be barely alive. Breaking down survival into condition classes provides more information on how a species is responding to translocation, but in the case of Slender Marsdenia, a more nuanced response was evident, so that a closer analysis could shed more light on factors underlying individual growth and survival. Although

survival rates for Slender Marsdenia on WC2NH are quite high, plants often remain small or repeatedly grow and die back, and flowering has not been recorded over three years, even though some plants have grown substantially.

To analyse the response of Slender Marsdenia to translocation (ie transplanting) in more detail, thirteen response categories were defined in terms of the pattern of change in plant height over three years, as shown in Table 6. These were derived by merging the seven monitoring events into a single sheet for each receival site (see Excel spreadsheet, 'Site 3 all', 'Site 7a all' etc tabs) and subjectively identifying the main syndromes of height change. The response syndromes of individuals at each site were tallied and expressed as a percentage of the site total.

Table 6: Definition of categories of plant response ('response syndromes') over three years in Slender Marsdenia after translocation (ie. transplanting).

Code	Response syndromes of transplanted individuals
D	**Died**
D1	Didn't reshoot
D2	Small shoot then died
D3	Reshot, small to medium (<1.2m) died back to ground; some bell-shaped pattern; some dieback-reshoot-dieback; dead or probably dead Nov/17
D4	Reshot, grew tall (~2m+) then died back to ground, probably dead
	Sub-total
S	**Alive but small, growing very slowly, or declining**
S1	Stayed small, most less than 10cm tall (to 40cm), little change in 3 years
S2	Small (mostly <0.5m), dieback to ground and reshot once or twice, still alive
S3	Declining or bell shaped (increase-decrease), to ~130cm at peak, not tiny, alive
S4	Large fluctuation – ie 'small-tall-small'; or 'grew large then died back to small'
S5	Delayed response – no reshooting for 6-12 months, small (<1m)
	Sub-total
T	**Thriving, plant continuing to grow, or maintaining size, healthy**
T1	Thriving– tall (1.5m+) , substantial increase in ht/no. of leaves, or ~maintained tall height (some decreased slightly Nov/17)
T2	Thriving – moderate increase in height (0.5 - 1m+); or constant height (1m+)
T3	Died back to ground then reshot vigorously (>1m)
T4	Small for 5 or 6 monitoring events then suddenly grew tall
	Sub-total

Initial plant size is one of the many factors that may affect an individuals' regrowth response and survival. For Slender Marsdenia, the size of each stem-individual including its rhizome was not recorded during transplanting as this would have meant separating the rhizome from soil. The direct transplanting method aimed to keep soil and rhizome as intact as possible to promote survival. Instead, initial plant size (including rhizome) was approximated by plant height at the first monitoring event. Regression analysis was used to test if there was a relationship between initial and final plant height in each receival site.

4 RESULTS

4.1 Species Survival Summary

Transplant survival rates after three years were 74-100% for the five threatened species (Table 7). The survival rate of Koala Bells was only 13% after three years, but this was due to most individuals exhibiting an annual or biennial life cycle (ie rapid growth, flowering and seeding, then dying off) after transplanting. Results are described in more detail for each species below.

Table 7: Species survival rates three years after translocation (transplanting) on the WC2NH project.

Species/Receival Site	**No. plants**	**% survival**			
		Aug 2015 (~6 mth)	**Feb 2016 (~1 Yr)**	**Jan 2017 (~2 Yrs)**	**Nov 2017 (~3 Yrs)**
Slender Marsdenia (*Marsdenia longiloba*)					
Receival Site 1 - Cockburns Lane	27	93	93	75	63
Receival Site 2 (3) – Old Coast Rd	17	100	91	93	88
Receival Site 3 (5a) – Old Coast Rd	22	81	81	91	73
Receival Site 4 (5b) – Old Coast Rd	16	100	94	81	69
Receival Site 5 (7a) – Old Coast Rd	57	90	90	72	74
Receival Site 6 (8a) – Old Coast Rd	8	88	75	75	75
Receival Site 8 (8c) – Old Coast Rd	28	93	100	86	82
Total	175		91	82	74
Rusty Plum (*Niemeyera whitei*)					
Receival Site 1 - Cockburns Lane	7	100	100	88	88
Wooll's Tylophora (*Tylophora woollsii* – unconfirmed)					
Receival Site 6 (8a) – Old Coast Rd	6	100	100	100	83
Spider Orchid (*Dendrobium melaleucaphilum*)					
Receival Site 5 (7a) – Old Coast Rd	2	100	100	100	100
Floyds Grass (*Alexfloydia repens*)					
Receival Site 9 – Warrell Creek	54 clumps	100	94	94	94
Receival Site 9a – Warrell Creek	61 clumps			98	93
Koala Bells (*Artanema fimbriatum*)					
Receival Site 7 (8b) – Old Coast Rd	16	75	63	25	13

4.2 Slender Marsdenia (*Marsdenia longiloba*)

4.2.1 Summary

Combining the receival sites, the survival rate of Slender Marsdenia after three years was 74.4%. Survivorship per site varied from 63% to 88%, down from 72% to 93% in Year 2 (Table 7). Most individuals translocated to Site 5b turned out to be *Marsdenia liisae* (see Plate 27).

Mean plant height stayed about the same between Years 2 and 3 in four receival sites and increased in two sites (Table 8 – sites 2 and 6). (Note - as mean height was averaged across all individuals including those with zero height, the mean height of live plants is under-estimated to a minor degree.) There was very little evidence of insect grazing, no disease was recorded, leaf discolouration (e.g. pale green, yellow, blotchy) was relatively rare and generally preceded leaf fall, and no flowering or seed production were recorded.

Table 8: Mean height (cm) of Slender Marsdenia per receival site from the first monitoring in June 2015 to November 2017 three years after translocation.

Receival site	n	June 2015 (6 months)	Feb 2016 (~1 yr)	Jan 2017 (~2 yrs)	Nov 2017 (~3 yrs)
Receival Site 1	27	26.51±6.48	39.0±10.43	39.26±10.60	31.07
Receival Site 2 (3)	11	25.64±10.09	60.82±15.50	67.27±13.57	97.09
Receival Site 3 (5a)	22	29.29±7.46	49.76±11.16	46.41±9.51	45.73
Receival Site 4 (5b)	16	38.69±11.44	47.00±14.84	29.44±9.45	31.88
Receival Site 5 (7a)	57	29.54±3.72	51.74±6.78	47.74±7.62	43.78
Receival Site 6 (8a)	8	55.13±22.24	53.00±17.92	60.57±17.55	84.79
Receival Site 8 (8b)	28	43.68±6.39	69.57±9.16	50.82±5.29	43.96

The survival rate of 104 Slender Marsdenia transplants on the NH2U project was 67.9% after three years (2013-2016), slightly less than WC2NH.

The survival rate of Slender Marsdenia transplants on the Bonville project was 45% (Site 1) and 25% (Site 2) after three years (2007-2010). The low survival rate was attributed to the adverse effect of added fertiliser, which appears to be supported by results of the fertiliser experiment conducted for NH2U up to 2016. (Monitoring from 2017 has been conducted by another consultant.)

Approximately 25% of transplants died in the first 3 years at WC2NH. There was wide variation in the response syndrome of transplanted individuals, which is analysed in more detail below. Understanding why mortalities occur and why individual's exhibit different patterns of regrowth and survival is important for improving translocation methods and assessing whether translocation/transplanting is feasible for a species.

4.2.2 Causes of mortality

Possible causes of mortality identified in previous monitoring reports included:

- Disturbance and damage to the stem and/or root system during transplanting.
- Interactions between plant and habitat, including environmental stress arising from lack of sunlight, water, soil nutrients; or inter-specific competition for scarce resources.

- Inherent growth processes (e.g. stem individuals genetically programed to grow suddenly drawing on stored food reserves in the tuberous rhizome, but unable to maintain growth; an imbalance between growth and resources available to sustain growth.)

- Natural thinning due to factors that affect survival.

- Sensitivity to microsite/microhabitat heterogeneity

With regard to the last point, within an area of generally suitable habitat, a central factor determining whether a translocated individual survives or not is the microsite or point at which it happens to be planted (either deliberately or haphazardly). This is particularly the case for small plant species. Natural habitats generally have high microsite heterogeneity, which partly underlies the difficulty of translocating most small plant species. Some microsites may favour survival and growth more than others. Planting points were essentially random with respect to a variable microsite surface, although points with more shade, near rotting logs and away from tree trunks etc were preferred by some planters. Perhaps this was a mistake and points next to large trees and away from rotting logs would have been better. Regardless of slight biases in choice of site, planting points were random with respect microsite patterning, so a degree of thinning or population decrease over time seems inevitable.

4.2.3 Response syndromes of transplanted individuals

As described in the methods section, responses of Slender Marsdenia individuals to transplanting after three years were placed into three main categories (dead, surviving but weak or declining, and thriving) and 13 sub-categories, as defined in Table 6 and 9.

Looking at the 'dead' category in more detail in Table 9 it can see that: (i) a small proportion did not reshoot at all (D1); (ii) a small proportion produced a small shoot then died (D2); and (iii) most grew weakly then died (D3).

In the second major category – alive but small or declining – there are five sub-categories. Most individuals fall into S1 (often less than 10cm, little change in 3 years). S2 includes small individuals that shot, died off, then reshot again, sometimes twice in three years. They accounted for 18% of individuals in Receival Site 1. Overall, the second category accounted for about half of surviving plants.

The third category includes the most vigorous plants, including the tallest and those with most leaves, which account for roughly the other half of surviving plants. They accounted for 22% to 77% of individuals in the different receival sites. The most vigorous plants were in the T1 category, which varied from a low of 7% in Receival Site 8c to 64% in Receival Site 8a.

The overall picture is one of wide variation in individual response to transplanting. In other species such variation is generally related to initial plant size, microsite factors such as sun exposure and a range of other variables related to implementation, follow-up maintenance and other physiological and ecological factors. Slender Marsdenia is a particularly difficult species to interpret results for as many occurrences are clonal and clones are probably broken up during transplanting. Some transplants clearly had larger rhizomes than others, but it was difficult to record this trait consistently during transplanting of 176 individuals. Each individual was

excavated in a roughly standardised volume of soil, but the size of the rhizome in that volume varied.

Table 9: Percentage of transplanted individuals with specific response syndromes in each receival site. Data not shown for Receival Site 4 (5b) as transplants are now known to be mostly Marsdenia liisae.

		Receival Sites						
	Response syndromes of transplanted individuals	**1**	**2 (3)**	**3 (5a)**	**4 (5b)**	**5 (7a)**	**6 (8a)**	**8 (8c)**
D	**Dead**				**liisae**			
D1	Didn't reshoot	7.4	0	4.8		5.3	7.1	0.0
D2	Small shoot then died	11.1	9.1	0.0		1.8	0.0	0.0
D3	Reshot, reached small to medium ht (<1.2m) then died back to ground; some bell-shaped; some db-rs-db;	22.2	9.1	19.0		17.5	14.3	14.8
D4	Reshot, grew tall (~2m+) then died back to ground, possibly dead	0.0	0.0	0.0		0.0	0.0	3.7
	Sub-total	40.7	18.2	23.8		24.6	21.4	18.5
S	**Alive but small, growing very slowly, or declining**							
S1	Stayed small, most less than 10cm tall (to 40cm), little change in 3 years	18.5	9.1	9.5		26.3	0.0	14.8
S2	Small (mostly <0.5m), dieback to ground and reshot once or twice, still alive	18.5	0.0	9.5		3.5	0.0	14.8
S3	Declining or bell shaped (increase-decrease), to ~130cm at peak, not tiny, alive	0.0	0.0	19.0		12.3	0.0	11.1
S4	Large fluctuation – ie 'small-tall-small'; or 'grew large then died back to small'	0.0	0.0	0.0		3.5	0.0	3.7
S5	Delayed response – no reshooting for 6-12 months, small (<1m)	0.0	0.0	9.5		0.0	0.0	0.0
	Sub-total	37	9.1	47.5		45.6	0.0	44.4
T	**Thriving, plant tall, continuing to grow, or maintaining size, healthy**							
T1	Thrived– tall (1.5m+) , substantial increase in ht/no. of leaves, or ~maintained tall height (some decreased slightly Nov/17)	11.1	54.5	9.5		21.1	64.3	7.4
T2	Thrived – moderate increase in height (0.5 - 1m+); or constant height (1m+)	11.1	18.2	19.0		5.3	14.3	29.6
T3	Died back to ground then reshot vigorously (>1m)	0.0	0.0	0.0		1.8	0.0	0.0
T4	Small for 5 or 6 events then suddenly grew big	0.0	0.0	0.0		1.8	0.0	0.0
	Sub-total	22.2	72.7	28.5		30	78.6	37

	% Survivorship 3 yrs	63	88	73		74	75	82
	Total individuals	27	11	21	12	57	14	27

1. The regrowth response of individuals after transplanting was highly variable. The commonest responses recorded over three years were:

- D1+D2 (5-15%) – either did not reshoot or produced small shoot then died
- D3 (10-20%) - reshot but probably dead; reached small to medium height (0.5 – 1m+) then died back to the ground.
- S1 (10-25%) – reshot, stayed small mostly <20cm tall, little change in 3 years.
- S2 (5-15%) – reshot, died back to the ground, reshot again, sometimes twice over seven monitoring events.
- T1 (10-60%) – tall (>1.5m), substantial increase in height/number of leaves
- T2 (10-25%) – med. (<1.5m) moderate increase in height/number of leaves.

2. Initial plant size (including rhizome), which is one of the many factors that may affect an individuals' regrowth response, was approximated by plant height at the first monitoring event. Regression of plant height at the first and final monitoring showed that in receival sites with a high frequency of thriving individuals (ie. Nos. 2 (3) and 8 (8a)) there was an inverse relationship between initial and final height that approached statistical significance (e.g. 8a: P=0.076). At sites with a higher proportion of dead or declining individuals there was no relationship between initial and final height (e.g. 7a: P = 0.234).

3. Compared to the other receival sites, sites 2 (3) and 8 (8a) both have a less sheltered microclimate and tend to be more exposed to wind and/or morning sun. This suggests that sites closer to the moist open forest ecotone rather thin inside moist open forest may favour growth and survival.

4. Physically separating stems that form part of a clone during transplanting may affect performance. In a typical Slender Marsdenia patch there are usually a higher number of small shoots, some medium sized shoots and perhaps one or two tall stems that grow into the forest mid-stratum. The genetic study indicated a high level of clonality in localised patches, but it is not known to what extent stems are connected underground. Rhizomes over a metre long were found during transplanting on NH2U. The function of small stems that remain small for several years may be to channel food reserves to growth of a central flowering stem, rather than potentially forming separate plants. Little success was achieved attempting to propagate from rhizome pieces, suggesting the tuberous rhizomes are not designed for vegetative reproduction, but more for food and possibly water storage. The root system of Slender Marsdenia is poorly understood, but appears to be made of tuberous rhizomes, which send up occasional plant stems, and sections with fibrous roots.

6. The analysis of transplanting response syndromes shows that the pattern of regeneration of Slender Marsdenia individuals after salvage translocation is highly complex. It is difficult to relate individual survival to any particular factor, unlike other species where survival can be linked with initial plant size, habitat/micro-habitat variables, level of damage during transplanting, and post-transplanting maintenance.

4.3 Rusty Plum (*Niemeyera whitei*)

Seven out of eight individuals survived after 3 years. All continued to increase in height and foliage area. It will probably be at least another three years before the largest transplants reach reproductive maturity.

Causes of mortality
The single mortality was caused by installation of a shade cloth shelter including a roof so the plant was completely enclosed. The shade cloth was high density and with additional shade from vegetation, light exclusion was probably ~80%. This together with increased humidity probably encouraged fungal rot which killed the whole plant, not just the leaves. The plant failed to reshoot after removal of the shade cloth roof.

4.4 Wooll's Tylophora (*Tylophora woollsii* – unconfirmed)

Five out of six possible Woolls' Tylophora in Receival Site 6 were alive after 3 years and are in reasonable condition.

Causes of mortality
See Slender Marsdenia above.

4.5 Spider Orchid (*Dendrobium melaleucaphilum*)

The two translocated Spider Orchid plants survived after three years and are in good condition. Both plants flowered in spring 2015 six months after translocation and again in 2016 and 2017. No seed pods have been produced possibly due to a lack of pollinators. New pseudobulbs (stem units) were produced each year since translocation demonstrating active growth.

Causes of mortality
No morality recorded.

4.6 Floyds Grass (*Alexfloydia repens*)

The survival rate of 54 clumps of Floyds Grass translocated to Area 1 in Receival Site 9 remained at 94% after three years. Growth and expansion of the translocated clumps continued in the lower (creek side) half of Area 1, but was checked by vigorous growth of the competing native species *Ottochloa gracillima* in the upper half of Area 1. The survival rate of propagated plants introduced to Area 2 was the same as Area 1, although growth rate was slower, possibly as this site is more exposed.

Removal of exotic ground layer vegetation and topsoil stripping proved to be an effective method of restoring relatively threat-free habitat for Floyds Grass to recolonise. Maintenance was still necessary to remove low numbers of exotics and thin out native tree and shrub regeneration.

Causes of mortality
The low level of mortality recorded was probably due to water and heat stress as the receival sites were relatively exposed and there were long periods of hot dry weather during the last three years.

4.7 Koala Bells (*Artanema fimbriatum*)

The survival rate of Koala Bells in Receival Site 7 was 76% after six months, 63% after one year and 13% after three years. Most transplants flowered and produced seed in Year 1. A fairly rapid decline was recorded in Year 2, similar to the pattern of survival recorded for this species on the NH2U translocation project. Only a few plants survived to Year 3 (also similar to NH2U, Area 2).

Causes of mortality

Koala Bells generally flowers and sets seed in the first six months after transplanting in spring or summer, then it gradually dies back in autumn and winter. Most plants die completely but a few reshoot the following spring in the second year or even third year. This appears to be the plant's natural life cycle rather than a response induced by translocation. In the bush, Koala Bells can appear suddenly on disturbed sites such as roadsides, then disappear the following year. Some populations have been observed persisting for more than one year, so longevity can apparently vary depending on site conditions, but overall Koala Bells is a relatively short-lived species. Observations on translocated plants indicate that for plants that survive into the second year, regrowth occurs from adventitious shoots produced from persistent lateral roots.

Fertiliser addition during translocation appears to speed up the life cycle, causing plants to flower and seed prolifically then die out in the first year, leaving behind dormant seed in the soil. Fertilisers were not applied to Koala Bells on WC2NH so this factor did not influence results.

Corrective action because of low survival rate is not appropriate or warranted, as Koala Bells is a naturally short-lived species. Most plants are annual or biennial, which is why they die out quickly. Translocation goals were achieved by plants growing to reproductive maturity and seeding their habitat. If the right disturbance occurs in future, chances are it will reappear from dormant seed in the soil formed as a result of translocation. (Note – Koala Bells is a nationally rare (ROTAP) species, but not a listed threatened species under environmental legislation.)

4.8 Maundia (*Maundia triglochinoides*)

Maundia, an aquatic plant found in freshwater swamps and streams of the North Coast is listed as Vulnerable under the TSC Act. This species was originally included in the TFMP but was taken out on the advice of RMS, as it was not translocated on the Frederickton to Eungai (F2E) project. Translocation on F2E did not seem to be warranted as the species had built up a large population which extended well beyond the F2E corridor, but also because a previous attempt to translocate Maudia by the Royal Botanic Gardens (Sydney) by propagation of seedlings and planting had failed (Ecos Environmental 2012).

Smaller occurrences of Maundia were present within the WC2NH corridor and larger stands just outside the alignment. A trial translocation of Maundia from the Williamson's Creek bridge site south of Warrell Creek was implemented by Pacifico following discussions with Ecos Environmental on the practicality of translocating this species. As Maundia grows from a network of rhizomes in the bottom mud, it was considered feasible to translocate this species by scooping up the plant with its rhizomes using an excavator bucket and depositing it in suitable wetland habitat. If the leaves were damaged the plant would most likely regrow from its rhizomes.

Pacifico initially translocated Maundia to a site downstream of the Williamson's Creek bridge site. The clumps survived and grew, but it became necessary to move them again. This time they were transplanted to a nearby sedimentation basin where the water level was managed to maintain a suitable depth for Maundia. The plants thrived while being held in the sedimentation basin and after completion of the creek realignment, Maundia was translocated back to the new creek course using the same direct transplanting method. Five patches of Maundia have been established over a distance of approximately 30 metres at the bridge and plants are growing well (Plate 7). The results show that Maundia can be translocated with a high degree of success by direct transplanting of plants with their rhizomes and mud substrate.

Plate 7: Clumps of Maundia (the sword-leaved aquatic plant) reinstated along Williamson's Creek two years after salvaging Maundia from the creek prior to construction of a new bridge and stabilisation of the creek banks.

4.9 Habitat Restoration

4.9.1 Site 9 - Floyds Grass

Habitat restoration was required mainly for the Floyds Grass site which was originally covered by dense Broad-leaved Paspalum (BLP). Although the topsoil seedbank was removed, some weed growth has occurred from seed blown onto the site, carried on boots etc, or deeply buried seed, particularly *Phytolacca octandra* (Ink Weed) in Year 1. Both exotic and native species regenerating from seed tend to reduce the growth of Floyds Grass by competing for space, light and nutrients. Fortunately, the level of weed regeneration was low after removing ground layer vegetation and the top 10cm of soil, so that it has been practical to weed out competing exotic and native species to maintain Floyds Grass expansion.

No maintenance was carried out in first six months after introduction (to February 2016). After six months the most abundant weeds in terms of crown cover were Ink Weed (*Phytolacca octandra*) and Tobacco Bush (*Solanum mauritanicum*). Ink Weed had grown 1-1.5 metres tall and covered most of the site, but survival of Floyds Grass clumps was unaffected as it can grow in the shade or full sun. Other common native 'weeds' included the grass *Ottochloa gracillima* and herb *Commelina cyanea*. These species germinated at low density but grew rapidly. Ottochloa is difficult to weed out as it produces runners that root at nodes and its leaves look very similar to Floyds Grass. Red Ash (*Alphitonia excelsa*) and *Acacia floribunda* also germinated across the site at low density and have been thinned out with other native species. Seedlings of the above species germinated from seed buried deeper than 10cm in soil. Very little Broad-leaved Paspalum germinated indicating that nearly all of its seedbank was in the surface layer.

Four half days of hand weeding by two people were carried out in Years 2 and 3 to control regrowth and remove weeds.

Swamp Oak (*Casuarina glauca*) were planted over the site three months after introduction. These were heavily grazed by wallabies, killing most of them. The site has now been fenced to keep wallabies out. Wallabies did not graze Floyds Grass.

The same topsoil stripping method could be used to rehabilitate the rest of this area, which has apparently been identified by RMS for ecological restoration after the completion of construction.

4.9.2 Site 1 (Rusty Plum and Slender Marsdenia)

Receival Site 1 was moderately infested with Lantana. This has been removed by hand, requiring half a day once a year. Some weed spraying of BLP near the transplanted Rusty Plums was also carried out.

5 ASSESSMENT

5.1 Introduction

This section assesses the outcomes of the WC2NH translocation project after three years according to performance criteria in Section 4.8.6 and Appendix 11 of the Warrell Creek to Urunga Threatened Flora Management Plan Ver. 5 (1/7//2016)(TFMP).

5.2 Performance Assessment

Table 8: Assessment of outcomes of the threatened flora translocation project after three years according to performance criteria in TFMP.

Project Phase	**Were Performance Criteria Met?**
Pre-construction phase (Appendix 11, Table 1)	
• Salvage translocation (transplanting) of all directly impacted threatened flora completed according to the TFMP, Sections 4.5, 4.6 & 4.7.	Yes - all directly impacted individuals were translocated, including all tagged individuals and additional individual found during pre-translocation surveys and while transplanting
• No loss or damage to threatened flora occurs prior to translocation being implemented.	Yes - no loss or damage prior to translocation
Construction phase (Appendix 11, Table 2)	
• All translocation actions required during the construction phase are implemented including monitoring and preparation of the annual monitoring report.	Yes – maintenance, monitoring and reporting implemented. The monitoring schedule was changed from four times in Year 1 and twice in Year 2 to three times in both years in Ver. 5 of the TFMP.
• Annual monitoring report provides full description of management plan implementation and results, as per the required contents in Section 4.8.5, and an evaluation of outcomes according to criteria listed in Section 4.8.6 of the TFMP.	Yes - annual reports including detailed descriptions of plan implementation, results and an evaluation of outcomes according to criteria in the TFMP were prepared.
Summary (Appendix 11, Table 4)	
1. All recorded directly impacted individuals are translocated.	Yes
2. At least 60% of transplant and enhancement individuals are surviving after the first year, 50% after five years and 40% after eight years.	Yes – survival rate greater than 60%
3. At the end of the monitoring program at least 50% of surviving individuals have a Condition Class of 3.	not applicable yet

5.3 Evaluation of Methods and Cost-effectiveness

The translocation methods applied for the WC2NH threatened flora translocation achieved relatively high survival rates for all species after three years (>70%) for all threatened species except the annual/biennial species Koala Bells. The general approach to translocation was based on the ANPC guidelines for the translocation of threatened plants in Australia (ANPC 2004). Methods were developed for WC2NH taking into consideration the results of previous translocation projects involving the subject threatened species, including the NH2U, Bonville and S2W threatened flora translocation projects.

Methods were applied that aimed to achieve a satisfactory translocation outcome while keeping costs to a reasonable level. A full evaluation of the costs of the project would require an analysis of input to the threatened flora translocation project by ECOS Environmental, Geolink and Pacifico which is beyond the scope of this report.

5.4 Work Plan for Year 4 (February 2018 – February 2019)

Task	**Time**
Monitoring	
Monitoring (once a year)	November 2018 (to coincide with flowering of Slender Marsdenia and Rusty Plum)
Population enhancement	
Seed collection Rusty Plum (provisional if results of 2017 direct seeding are poor) and direct seed into same receival site using same methods	November 2018
Maintenance	
Weeding, maintain shade fences – Floyds Grass site	May 2018, November 2018
Reporting	
Supply monitoring summary	November 2018
Prepare Year-4 annual monitoring report	January 2019

6 REFERENCES

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APPENDIX 1: Plates 8 to 48. Photo record of WC2NH threatened flora translocation project in Year 3, ended November 2017.

Rusty Plum (*Niemeyera whitei*) translocation

Plate 8: Rusty Plum (Niemeyera whitei) No. 5, three years after transplanting. New branches have reshot from near top of bare trunk cut down to about 1 metre high.

Plate 9: Rusty Plum (Niemeyera whitei) No. 6, three years after transplanting

Plate 10: Rusty Plum (Niemeyera whitei) No. 7, three years after transplanting

Plate 11: Rusty Plum seeds were directed seeded into wire enclosures at Receival Site 5 (7a) in Nov/17. This measure addressed the population enhancement requirement of the Management Plan for Rusty Plum, which aimed to replace possible translocation losses and maintain population number at the pre-construction level.

Koala Bells (*Artanema fimbriatum*) translocation

Plate 12: Koala Bells (Artanema fimbriatum) No. 10, three years after transplanting. A tree has fallen on the edge of the wire guard but the plant has reshot in and outside the cage. Only two plants were still alive after 3 years. Most plants responded as annuals, flowering and dying in the first year.

Plate 13: Propagated Koala Bells (Artanema fimbriatum) six months after planting out in the Floyds Grass translocation area (Area 2).

Slender Marsdenia (*Marsdenia longiloba*) translocation – Receival Site 1

Plate 14: Slender Marsdenia (*Marsdenia longiloba*). Site 1 (Cockburns Lane) No.11. The height of this plant recorded over 3 years starting 2015 was 5 (cm), 5, 5, 0, 0, 2, 4, an example of how little above ground growth can occur over a long period of time in this species.

Plate 15: Site 1, No. 13. This plant started as an old pruned stem when transplanted. It shot a new stem off the old one and maintained growth. Height over 3 years starting 2015 was 124 (cm), 133, 144, 137, 12, 170, 205.

Plate 16: Slender Marsdenia. Site 1, No.14. This plant had produce a second small shoot at the Nov/17 monitoring. The height of this plant recorded over 3 years starting 2015 was 26 (cm), 20, 9, 0, 10, 10, 4. After appearing to die off it shot again.

Plate17: Site 1, No. 23. This plant maintained size but only a small number of leaves and these were often yellowish. Plant height over 3 years starting 2015 was 119(cm), 120, 49, 15, 62, 76, 102.

Plate 18: Slender Marsdenia. Site 1, No.25. The height of this plant recorded over 3 years starting 2015 was 10 (cm), 10, 25, 4, 3, 3, 3. About 20% of plants remained small like this over 3 years in Site 1 – Response Syndrome S1.

Plate 19: Slender Marsdenia. Site 1, No.9. The height of this plant recorded over 3 years starting 2015 was 52 (cm), 41, 32, 6, 0, 0, 4. After dying off this plant had reshot in Nov/17. Response Syndrome S2.

Slender Marsdenia (*Marsdenia longiloba*) – Receival Site 2 (3)

Plate 20: Slender Marsdenia. Site 2 (3), No.3. The height of this plant over 3 years starting 2015 was 7 (cm), 7, 72, 87, 85, 88, 181, an example of Response Syndrome T1.

Plate 21: Slender Marsdenia. Site 2 (3), No. new 3. The height of this plant over 3 years starting 2015 was 7 (cm), 7, 72, 87, 85, 88, 181, an example of Response Syndrome T1.

Plate 22: Receival Site 2 (3). Habitat – moist open forest with fern and leaf litter ground layer, mature forest regrowth. This site was more open than most other sites, less protected from the cleared road corridor and more exposed to wind, yet the translocated plants performed well.

Slender Marsdenia (*Marsdenia longiloba*) – Receival Site 3 (5a)

Plate 23: Slender Marsdenia. Site 3 (5a), No. 1. The height of this plant over 3 years starting 2015 was 46 (cm), 44, 45, 45, 45, 46, 72. This plant was either leafless or had only 1-3 leaves over 3 years.

Plate 24: Slender Marsdenia. Site 3 (5a), No. 6. Plant height over 3 years starting 2015 was 25 (cm), 25, 125, 130, 118, 70, 147. This is an example of Response Syndrome T1 'large, thriving'.

Plate 25: Slender Marsdenia. Site 3 (5a), No. 16. Plant height over 3 years starting 2015 was 64 (cm), 64, 124, 140, 64, 78, 28. This is an example of Response Syndrome S3 'bell-shaped'.

Plate 26: Receival Site 3 (5a). Habitat – moist open forest with leaf litter and fern ground layer in mature forest regrowth.

Slender Marsdenia (*Marsdenia longiloba*) – Receival Site 4 (5b)

Plate 27: Most *Marsdenia* plants transplanted to Receival Site 4 (5b) appear to be *Marsdenia liisae* (Large-flowered *Marsdenia*), which has larger leaves than *M. longiloba*. This wasn't clear at the time of transplanting. *M. liisae* is a rare species (ROTAP) but not listed as threatened.

Plate 28: Receival Site 4 (5b) habitat – moist open forest with fern and leaf litter ground layer.

Plate 29: Receival Site 4 (5b), No. 16. This was an important individual for translocation and research on the ecology of *Marsdenia longiloba*. It was the only plant found with seed pods (2 in total), one of which was collected before the start of construction of WC2NH. Seedlings propagated from the pod were introduced to the NH2U translocation area for *M. longiloba*, which started two years earlier. This plant also had flowers allowing positive species identification and it was used as one of the marker plants for the *M. longiloba* genetic study (Shapcott et al. 2016), which investigated genetic variation across the species' range from the Mid North Coast to South East Qld. After transplanting successfully it was damaged by an animal colliding with its cage and then reshot again. Plant height over 3 years starting 2015 was 145 (cm), 145, 221, 110, 110, 119, 132.

Slender Marsdenia (*Marsdenia longiloba*) – Receival Site 5 (7a)

Plate 30: Receival Site 5 (7a) No. 3. Plant with actively growing shoot and 19 leaves in Nov/17. Plant height over 3 years starting 2015 was 48 (cm), 46 118, 110, 130, 132, 130.

Plate 31: Receival Site 5 (7a) No. 34. Plant height over 3 years starting 2015 was 45 (cm), 45 124, 115, 112, 34, 35

Plate 32: Receival Site 5 (7a) No. 17. A second shoot appeared in Year 2. Plant height over 3 years starting 2015 was 27 (cm), 22, 13, 3, 10, 10, 10. This is an example of Response Syndrome S1 'stayed small'.

Plate 33: Receival Site 5 (7a) habitat – moist open forest regrowth with fern and leaf litter ground layer. Highway embankment in the background, wire cages at each *M. longiloba* transplant in the foreground.

Slender Marsdenia (*Marsdenia longiloba*) – Receival Site 6 (8a)

Plate 34: Receival Site 6 (8a) No. 3. Plant height over 3 years starting 2015 was 5 (cm), 5, 66, 97, 150, 135, 175. This is an example of Response Syndrome T1 'large, thriving'.

Plate 35: Receival Site 6 (8a) habitat – moist open forest with fern and leaf litter ground layer.

Slender Marsdenia (*Marsdenia longiloba*) – Receival Site 8 (8c)

Plate 36: Receival Site 8 (8c) No. 6. Plant height over 3 years starting 2015 was 21 (cm), 15, 18, 4, 6, 6, 10. This is an example of Response Syndrome S1 'stayed small'.

Plate 37: Receival Site 8 (8c) No. 7. Plant height over 3 years starting 2015 was 55 (cm), 53, 40, 0, 7, 10, 13. This is an example of Response Syndrome S2 'small, died off, reshot again'

Plate 38: Receival Site 8 (8c) No. 24. Plant height over 3 years starting 2015 was 10 (cm), 13, 106, 94, 108, 102, 112. This is an example of Response Syndrome S2 ‘medium, increased height’

Plate 39: Receival Site 6 (8c) habitat – moist open forest regrowth with fern and leaf litter ground layer.

Plate 40: Planting propagated Slender Marsdenia plants for population enhancement in Nov/17 next to Receival Site 5 (7a). Only a small number of population enhancement plants were propagated (12) due the low strike rate of rhizome cuttings (<5%) and absence of seed.

Floyds Grass (*Alexfloydia repens*) translocation

Plate 41: Floyds Grass (*Alexfloydia repens*) Receival Site 9, Area 1. Floyds Grass spreads by runners and now covers most of the receival site closest to Warrell Ck, which started as bare ground after topsoil and ground layer plant removal. Sapling regrowth was removed during maintenance in Nov/17 to reduce competition and shading. Markers show where initial plants were introduced.

Plate 42: Overall shot of Area 1 above. Floyds Grass dominates the left hand side closest to Warrell Creek and the native creeping grass Ottochloa gracillima dominates the right hand side. Nov/17, 2.5 years after transplanting.

Plate 43: Floyds Grass, Receival Site 9, Area 1. Close-up of Floyds Grass clump.

Plate 44: Floyds Grass, Receival Site 9, Area 1. The majority of clumps were producing flowers and seeds in Nov/17 although they were relatively sparse.

Plate 45: Floyds Grass, Receival Site 9, Area 2. Propagated, population enhancement plants were introduced this site following the same weed and topsoil removal treatment. The shade cloth rows with an awning are for shade as there is no tree shade to the west. Nov/17, 1.5 years after planting.

Plate 46: Floyds Grass, Receival Site 9, Area 2. Floyds Grass pots were planted in pairs at each tagged point. Clumps grew slower than in Area 1, apparently due to slightly poorer soil (deeper excavation by different operator) and less shade. The site was hand weeded, herbicide was only used in dense Broad-leaved Paspalum around the receival site.

Spider Orchid (*Dendrobium melaleucaphilum*) translocation

Plate 47: Large Spider Orchid clump relocated with its supporting branch to the trunk of a tree in the gully next to Receival Site 5 (7a). The branch with orchid has been tied onto the trunk resulting in minimal disturbance to the orchid and it epiphytic roots.

Plate 48: Close up of Spider Orchid showing leaves at the apex of the pseudobulbs, and just visible, the short dead inflorescence axes projecting at the tip. These are the remains from flowering in August-September/17. No pods were formed probably indicating an absence of insect pollinators, or insufficient food reserves although this seems unlikely considering the health of the plants.

Appendix I

Pacifico Landscape Rehabilitation Seasonal Monitoring Reports

MEMORANDUM

WC2NH PACIFIC HIGHWAY UPGRADE

Date 9th June 2017

Subject Autumn Landscape Monitoring Summary 2017

Background and Scope

Landscape monitoring was undertaken by the Pacifico Environment Team on the 25th and 26th May 2017. Landscape monitoring is required quarterly during Year 3 of construction in accordance with the Ecological Monitoring Program (EMP) and the Urban Design and Landscape Plan (UDLP). The purpose of the monitoring is to determine if the objectives of the UDLP have been met and whether any maintenance/management measures are required. The UDLP also requires monthly photo points to be taken of the landscape monitoring sites to track the progress. The photographs collected during the previous quarter are attached in Appendix A of this memorandum.

The landscape monitoring scope was originally determined by Geolink to cover the RMS Specification, UDLP and EMP requirements. Upon review of the scope provided by Geolink, Pacifico have devised a brief checklist which covers the general requirements of the monitoring scope. The completed checklist for each of the monitoring locations is provided in Appendix B of this memorandum.

The landscape monitoring scope includes 12 monitoring sites that have been determined across the Project. Monthly photo points are taken for each of the monitoring locations. A 50m transect is walked each quarter and the checklists attached in Appendix B are completed for each transect.

Results

The Pacifico Environment Team undertook a review of the monitoring sites on the 25th and 26th May in order to determine if the objectives in the UDLP were being achieved.

Monitoring Site no.	Location	General Cover %	% of cover = native species	General plant health	Condition of soil and batter	Maintenance Comments	Compliance with UDLP objectives
1	Fill 4	90	7	Good	Good – no evidence of rilling or slumping	Nil – Weed's appear well managed. Seteria grass most common species present due to presence in nearby pasture. Batter meets the objectives of the UDLP as the batter assimilates with the surrounding landscape. Batter is stable with good robust growth.	SM1 mix (Native grasses) Although there is mostly Seteria grass present, the batter has assimilated with the surrounding landscape.
2	Fill 4	90	5	Good	Good – no evidence of rilling or slumping	Nil – Weed's appear well managed. Seteria grass most common species present due to presence in nearby pasture. Batter meets the objectives of the UDLP as the batter assimilates with the surrounding landscape. Batter is stable with good robust growth.	SM2 mix (Native Pasture grasses) Although there is mostly Seteria grass present, the batter has assimilated with the surrounding landscape.
3	Cut 2	90	2-3	Good	Good – no evidence of rilling or slumping	Concrete waste on batter to be removed. Seteria grass most common species present due to nearby pasture. Native shrub species are emerging and growing. Continue to monitor shrub growth and native emergent to determine compliance with UDLP.	SM3 mix (Native shrub mix). Average compliance, however shrub growth is improving over time. Continue to monitor.

Monitoring Site no.	Location	General Cover %	% of cover = native species	General plant health	Condition of soil and batter	Maintenance Comments	Compliance with UDLP objectives
4	Fill 19 West	20	0	Poor	Good – no evidence of rilling or slumping	Native species growth is minimal. Area to be revegetated by tractor seeding and application of fertiliser.	SM4 mix (Pastoral Grass, Ancillary Site Mix). Poor compliance, area to be revegetated using tractor seeding method.
5	Fill 5	70	2	Good	Good – no evidence of rilling or slumping	Native species growth is ok, some native shrub species emerging, however the swale is now concreted and therefore does not require swale species.	SM5 mix (Indigenous Swale Drain grasses and plants). Poor compliance, suggest changing plant species for this area as swale is concreted.
6	Cut 22 East	15	10	Good	Good – no evidence of rilling or slumping	Native growth good, minimal weed growth. Re-spray with hydroseed upper section of batter.	BRC – North CC05. Good compliance, batter is assimilating with surrounding landscape.
7	Cut 22 West	50	80	Good	Good – no evidence of rilling or slumping (previous slumping has been fixed)	Native growth good, minimal weed growth. Re-spray with hydroseed lower section of batter where previous slumps have been rectified. Sterile cover crop is providing good coverage.	BRC – North CC05. Good compliance, batter is assimilating with surrounding landscape.
8	Fill 20	75	10	Good	Good – no evidence of	Native growth emerging through Seteria grass growth. No other weed species to	BRC – North CC04. Good compliance, batter is

Monitoring Site no.	Location	General Cover %	% of cover = native species	General plant health	Condition of soil and batter	Maintenance Comments	Compliance with UDLP objectives
					rilling or slumping	treat. Native species will continue to grow and shade out Seteria grass.	assimilating with surrounding landscape.
9	Cut 18 East	40	35	Good	Good – no evidence of rilling or slumping	Very good native species growth, native species growth dominant on batter with minimal weed growth. Good progress on growth.	BRC – North CC04 Very good compliance, batter is assimilating with surrounding landscape.
10	Williamsons Creek	50	1	Good – minimal native species	Good	Poor native species growth. Re-planting will be required in this area.	Williamsons Creek. Poor compliance, replanting will be required in this area.
11	Stony Creek	65	25	Good	Good	Good native species growth and stabilisation of waterway. Successful use of soft treatments. Mechanical removal of weeds needed prior to planting of tree species.	Stoney Creek. Very good compliance, soft landscaping treatment has been successful at stabilising the creek line.
12	Butchers Creek	2 (100% cover with scour rock)	1	Average	Good	Planting of lomandra into sandbags of topsoil has not been successful. Area has been hydroseeded into pockets of sediment collected in scour rock. Will monitor growth to determine success.	Butchers Creek. Poor success of soft scour treatments. Will monitor hydroseeding into sediment pockets to determine success.

Recommendations

1. Commence weed removal program leading up to road opening for priority areas and weed species.
2. Mechanical removal of weeds near Stoney Creek to be undertaken prior to planting tree species.
3. Continue to monitor growth and re-apply hydroseed or hydromulch where appropriate for areas of poor growth.
4. Investigate changing swale vegetation if drain is now concreted.
5. Remove concrete waste left during fencing and paving.

Noelene Rutherford

Environment Manager
Pacifico Acciona Ferrovial JV

Appendix A – Photo records

Site 1

March 2017

April 2017

May 2017

Site 2

March 2017

April 2017

May 2017

Site 3

March 2017

April 2017

May 2017

Site 4

March 2017

April 2017

May 2017

Site 5

March 2017

April 2017

May 2017

Site 6

March 2017

April 2017

May 2017

Site 7

March 2017

April 2017

May 2017

Site 8

March 2017

April 2017

May 2017

Site 9

March 2017

April 2017

May 2017

Site 10

March 2017

April 2017

May 2017

Site 11

March 2017

April 2017

May 2017

Site 12

March 2017

April 2017

May 2017

Appendix B

Date: 25/5/2017

Photo Taken? Y/N

Site	1
Location	Fill 4
Weather	Fine
Rainfall Average	
Walk 50m transect (as per photo) what general species are present?	Setaria Kennedia, Senecio, Dandelion, Banksia, Acacia.
What is general total ground cover?	90%
What percentage of native vegetation cover?	7%. natives.
What is the general plant height?	500mm + Shrubs + grass.
Comments on growth of batter: e.g condition of soil?	Growth appear robust, no rilling, erosion, etc.
Maintenance recommendations: e.g are there any weeds that need treating?	Nil - no weed issues Verbana has died off naturally.
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	Good - batter is 3m1 pasture grass + currently meets objectives.

Date: 25/5/2017

Photo Taken? Y/N

Site	2.
Location	FW 4
Weather	Fine
Rainfall Average	
Walk 50m transect (as per photo) what general species are present?	Setaria, Verbena, hardenbergia, Acacia, Hakea, Centella. Banksia, Kennedia, Callistemon. Paddy's Lucerne., Leptospermum.
What is general total ground cover?	90%.
What percentage of native vegetation cover?	5%.
What is the general plant height?	500mm+
Comments on growth of batter: e.g condition of soil?	Large scour of Secondary bench needs repair
Maintenance recommendations: e.g are there any weeds that need treating?	Nil weed treatment Fi
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	Good, batter compliant with SM1 + adjacents landscape.

Date: 25/5/2017

Photo Taken? (Y)/N

Site	3
Location	Cut 2
Weather	Fine - no rainfall.
Rainfall Average	
Walk 50m transect (as per photo) what general species are present?	Setaria ~~[illegible]~~ Banksia. Acacia spp. Hardenbergia Callistemon. ~~[illegible]~~a. Daviesia.
What is general total ground cover?	90% grasses mostly.
What percentage of native vegetation cover?	2-3%.
What is the general plant height?	300-500mm Shrubs + grasses.
Comments on growth of batter: e.g condition of soil?	Resprayed in may with sm3 hydroseed. Concrete waste on batter Batter in good condition, no rilling, scour, etc.
Maintenance recommendations: e.g are there any weeds that need treating?	Concrete waste on batter to be removed. Nil weed treatment.
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	In progress, shrubs are actively growing. Setaria due to surrounding pasture land. Overall compliance is ~~good~~ average.

Date: 26/5/2017

Photo Taken? Y/N

Site 4
Location Fill 19 West
Weather Fine
Rainfall Average
Walk 50m transect (as per photo) what general species are present? - Sterile cover - dying off - Setaria - sedges in drain
What is general total ground cover? 20%
What percentage of native vegetation cover? Nil
What is the general plant height? N/A
Comments on growth of batter: e.g condition of soil? - Dieback of sterile crop - lack of pastural grasses
Maintenance recommendations: e.g are there any weeds that need treating? Tractor seed w/SM4 + fertiliser reapplication
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape? Not compliant - requires respray

Lockwood Cut & both batters mod hand picking
cut & - hand pull - west side

Date: 25/5/2017

Photo Taken? Y/N

Site	5.
Location	Fill S
Weather	Fine
Rainfall Average	
Walk 50m transect (as per photo) what general species are present?	Acacia, Pseteria, Pea-Kennedia, Couch, Purple Verbane, Banksia, Lantana, Tobacco bush
What is general total ground cover?	70%
What percentage of native vegetation cover?	2%
What is the general plant height?	500mm
Comments on growth of batter: e.g condition of soil?	Good growth, no dieback / plant stress sighs
Maintenance recommendations: e.g are there any weeds that need treating?	Nil
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	Matches agricultural paddock surroundings

Date: 26/5/2017

Photo Taken? (Y)/N

Site	6
Location	cut 22 East
Weather	Fine
Rainfall Average	
Walk 50m transect (as per photo) what general species are present?	- Acacia sp. (several) - Kennedia rubicunda - Hardenbergia violacea - ~~Centella asiatica~~ - ~~Eragrostis curvula~~ - Callistemon sp. - Indigofera australis - Goodenia heterophylla - Acacia myrtifolia - Acacia longifolia - Dolichandra triquetra - Kunzea capitata
What is general total ground cover?	15%
What percentage of native vegetation cover?	10%
What is the general plant height?	200 - 500mm
Comments on growth of batter: e.g condition of soil?	- Good growth no signs stress - minimal weeds noted. -
Maintenance recommendations: e.g are there any weeds that need treating?	- hydroseed ~~seed~~ spray required. upper 15m of batter (zone 17)
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	yes. upper section out needs respray (minimal natives ≥1%

Date: 26/5/2017

Photo Taken? Y/N

Site	7
Location	Cut 22 west
Weather	Fine
Rainfall Average	
Walk 50m transect (as per photo) what general species are present?	- Acacia sp. - Kennedia rubicunda - Hardenbergia violacea - ~~Callistemon sp.~~ - ~~Eucalyptus sp.~~ - ~~Acacia longifolia~~ - Goodenia sp. - Acacia falcata - Acacia
What is general total ground cover?	50% ground cover
What percentage of native vegetation cover?	8% native cover.
What is the general plant height?	200mm
Comments on growth of batter: e.g condition of soil?	- Good growth no signs of stress or predation - sterile cover crop providing good cover on transect.
Maintenance recommendations: e.g are there any weeds that need treating?	- hydroseed May 17 on lower section (slips) w/ good sterile cover growth. - no weeds noted. - no sign stress / yellowing off of natives etc.
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	yes compliant w/ UDLP. respray area May 17 w/ slips. on lower 10m of bench.

Date: 26/5/2017

Photo Taken? (Y)/N

Site	8
Location	Fill 20
Weather	Fine
Rainfall Average	
Walk 50m transect (as per photo) what general species are present?	- Acacia sp. - Hardenbergia violacea - Centella asiatica - Kennedia rubicunda - Solanum laciniatum - Setaria
What is general total ground cover?	75%
What percentage of native vegetation cover?	10%
What is the general plant height?	300 - 1000mm
Comments on growth of batter: e.g condition of soil?	Good growth, natives coming through setaria
Maintenance recommendations: e.g are there any weeds that need treating?	Nil
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	Compliant 4/BRC - Good health - no signs of stress/disease

Date: 26/5/2017

Photo Taken? Y/N

Site	9
Location	Cut 18 East
Weather	Fine
Rainfall Average	
Walk 50m transect (as per photo) what general species are present?	- Acacia sp. - Kennedia rubicunda - Hardenbergia violacea - Callistemon sp. - Eucalyptus sp - Acacia longifolia Connersonia sp. - Solanium prino phyllum - Cymbopogon refractus - Dolonaea triquetra - Kunzea capitata - Gonocarpus teucrioides - Acacia fimbriata - Centella asiatica - Setaria
What is general total ground cover?	40%
What percentage of native vegetation cover?	35%
What is the general plant height?	500 - 800mm
Comments on growth of batter: e.g condition of soil?	Good growth, soil intact
Maintenance recommendations: e.g are there any weeds that need treating?	Nil
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	Compliant w/UDLP, healthy growth no signs of stress/predation/disease

Date: 25/5/2017

Photo Taken? Y/N

Site	10
Location	Williamsons Creek
Weather	Fine
Rainfall Average	
Walk 50m transect (as per photo) what general species are present?	- Setaria - Maundia - Paddys lucerne - Eleocharis acuta - Paspalem
What is general total ground cover?	50%
What percentage of native vegetation cover?	1%
What is the general plant height?	300mm
Comments on growth of batter: e.g condition of soil?	Good regrowth
Maintenance recommendations: e.g are there any weeds that need treating?	Reto edging needed
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	Not compliant currently - complete reto req'd

WBC

Pacifico
Acciona Ferrovial JV

Date: 25/5/17

Photo Taken? Y/N

Site	~~Stony~~ 11			
Location	Stony Creek			
Weather	Fine			
Rainfall Average				
Walk 50m transect (as per photo) what general species are present?	Juncus Leucadra longipolia 11 histrix	Caryx Setaria Purple verbena Indigofera australis	Blue L. Illygant weed Baumea articulata Fleabane Banksia	Scotch thistle Eliocharis acuta Farmers Friends Centella asiatic	Crofton weed Tobacco bush
What is general total ground cover?	65%			
What percentage of native vegetation cover?	25%			
What is the general plant height?	200mm			
Comments on growth of batter: e.g condition of soil?	Growth looks good, robust, weed incursion main issue. Possibly spot weed top of batters, hand pull in creek area			
Maintenance recommendations: e.g are there any weeds that need treating?	weed hand pull needed			
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	Riparian zone re-establishment working Sft treatment working } Yes	Shrubbery + trees establishing on upper bank		

Date: 25/5/2017

Photo Taken? Y/N

Site	12.
Location	Butchers ck.
Weather	Fine
Rainfall Average	
Walk 50m transect (as per photo) what general species are present?	Lomandra Setaria. Dianella. Senecio.
What is general total ground cover?	2% veg (note 100% not needed due to presence of scour rock).
What percentage of native vegetation cover?	<1%. (as above note).
What is the general plant height?	200-300mm.
Comments on growth of batter: e.g condition of soil?	Healthy veg growth. Freshly hydromulched w/sm5 in May.
Maintenance recommendations: e.g are there any weeds that need treating?	Handpulling of weeds - Fireweed recommended.
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	Average - Soft treatments are in progress.

MEMORANDUM

WC2NH PACIFIC HIGHWAY UPGRADE

Date 30th August 2017

Subject Winter Landscape Monitoring Summary 2017

Background and Scope

Landscape monitoring was undertaken by the Pacifico Environment Team on the 29th August 2017. Landscape monitoring is required quarterly during Year 3 of construction in accordance with the Ecological Monitoring Program (EMP) and the Urban Design and Landscape Plan (UDLP). The purpose of the monitoring is to determine if the objectives of the UDLP have been met and whether any maintenance/management measures are required. The UDLP also requires monthly photo points to be taken of the landscape monitoring sites to track the progress. The photographs collected during the previous quarter are attached in Appendix A of this memorandum.

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Results

The Pacifico Environment Team undertook a review of the monitoring sites on the 29th August 2017 in order to determine if the objectives in the UDLP were being achieved.

Monitoring Site no.	Location	General Cover %	% of cover = native species	General plant health	Condition of soil and batter	Maintenance Comments	Compliance with UDLP objectives
1	Fill 4 East	92	10	Good – slight die-back on some natives likely due to low rainfall in Winter 2017	Good – no evidence of rilling or slumping	Nil – Weed's appear well managed. Seteria grass most common species present due to presence in nearby pasture. Batter meets the objectives of the UDLP as the batter assimilates with the surrounding landscape. Batter is stable with good robust growth. Pest Management completed in this zone in July 2017	SM1 mix (Native grasses) Although there is mostly Setaria grass present, the batter has assimilated with the surrounding landscape.
2	Fill 4 West	95	8	Good	Good – Scour noted on secondary bench which requires repair (outside of transect). This is currently included in defect actions	Nil – Weed's appear well managed. Setaria grass most common species present due to presence in nearby pasture. Batter meets the objectives of the UDLP as the batter assimilates with the surrounding landscape. Batter is stable with good robust growth. Pest Management completed in this zone in July 2017	SM2 mix (Native Pasture grasses) Although there is mostly Setaria grass present, the batter has assimilated with the surrounding landscape.

Monitoring Site no.	Location	General Cover %	% of cover = native species	General plant health	Condition of soil and batter	Maintenance Comments	Compliance with UDLP objectives
					for AFJV close out.		
3	Cut 2 East	90	5	Good	Good – no evidence of rilling or slumping	Setaria grass most common species present due to nearby pasture. Native shrub species are emerging and growing. Hydroseeding of SM3 occurred on this batter in June 2017 with natives noted during inspection. Weed's appear well managed.	SM3 mix (Native shrub mix). Average compliance, however shrub growth is improving over time. Hydroseeding occurred in June 2017 with native cover increasing from Autumn 2017. Continue to monitor.
4	Fill 19 West	15	0	Poor	Good – no evidence of rilling or slumping	Native species growth is minimal. Area was revegetated by tractor seeding and application of fertiliser in July 2017. Poor strike rate to date due to low rainfall during Winter 2017. Sparse cover crop noted during inspection.	SM4 mix (Pastoral Grass, Ancillary Site Mix). Poor compliance, area was revegetated with tractor seeding and fertiliser application in July 2017. Poor growth attributed to low rainfall since rehabilitation. Continue to monitor.
5	Fill 5	75	5	Good	Good – no evidence of rilling or slumping	Native species growth is reasonable, some native shrub species emerging, however the swale is now concreted and therefore does not require swale species.	SM5 mix (Indigenous Swale Drain grasses and plants). Poor compliance, suggest changing plant species for this area as swale is concreted.

Monitoring Site no.	Location	General Cover %	% of cover = native species	General plant health	Condition of soil and batter	Maintenance Comments	Compliance with UDLP objectives
6	Cut 22 East	18	15	Good	Good – no evidence of rilling or slumping	Native growth good, minimal weed growth. Re-spray with hydroseed upper section of batter. Hydroseeding programmed for September 2017.	BRC – North CC05. Good compliance, batter is assimilating with surrounding landscape.
7	Cut 22 West	50	10	Good	Good – no evidence of rilling or slumping	Native growth good, minimal weed growth. Re-spray with hydroseed completed May 2017 on lower section of batter where previous slumps have been rectified. Sterile cover crop is providing good coverage.	BRC – North CC05. Good compliance, batter is assimilating with surrounding landscape.
8	Fill 20 East	80	12	Good	Good – no evidence of rilling or slumping	Native growth emerging through Setaria grass growth. No other weed species to treat. Native species will continue to grow and shade out Setaria grass. Slight die back on natives likely due to low rainfall during Winter 2017.	BRC – North CC04. Good compliance, batter is assimilating with surrounding landscape.
9	Cut 18 East	60	55	Good	Good – no evidence of rilling or slumping	Very good native species growth, native species growth dominant on batter with minimal weed growth. Good progress on growth. Slight die back on natives likely due to low rainfall during Winter 2017.	BRC – North CC04 Very good compliance, batter is assimilating with surrounding landscape.
10	Williamsons Creek	50	5	Good – minimal native species	Good	Poor native species growth. Re-planting will be required in this area during landscape planting. Two (2) additional beds have been prepared post temporary waterway crossing removal. Planting of	Williamsons Creek. Poor compliance, replanting will be required in this area. Planting of additional beds

Monitoring Site no.	Location	General Cover %	% of cover = native species	General plant health	Condition of soil and batter	Maintenance Comments	Compliance with UDLP objectives
						additional beds programmed for September 2017	programmed for September 2017
11	Stony Creek	75	30	Good	Good	Good native species growth and stabilisation of waterway. Successful use of soft treatments. Mechanical removal of weeds needed prior to planting of tree species.	Stoney Creek. Very good compliance, soft landscaping treatment has been successful at stabilising the creek line.
12	Butchers Creek	3 (100% cover with scour rock)	< 2	Average	Good	Planting of lomandra into sandbags of topsoil has not been successful. Area has been hydromulched into pockets of sediment collected in scour rock with SM5 Mix. Camphour laurels noted within scour rock hand removal required at this location.	Butchers Creek. Poor success of soft scour treatments. Hydromulching with SM5 showing early signs of successful treatment with various new natives noted during inspection.

Recommendations

1. Commence weed removal program leading up to road opening for priority areas and weed species.
2. Mechanical removal of weeds near Stoney Creek and Butchers Creek to be undertaken prior to planting tree species.
3. Continue to monitor growth and re-apply hydroseed or hydromulch where appropriate for areas of poor growth.
4. Plant out additional planting beds prepared at Williamson Creek in September 2017

5. Investigate changing swale vegetation if drain is now concreted. This could be replaced with Butchers Creek as this has now had a SM5 swale vegetation mix applied.
6. Repair scour on Fill 4 West as per defect close out requirements

Alex Dwyer 

Environment Manager

Pacifico Acciona Ferrovial JV

Appendix A – Photo records

Site 1 (Fill 4 EAST)

June 2017

July 2017

August 2017

Site 2 (Fill 4 WEST)

June 2017

July 2017

August 2017

Site 3 (Cut 2 EAST)

June 2017

July 2017

August 2017

Site 4 (Fill 19 WEST)

June 2017

July 2017

August 2017

Site 5 (Fill 5 WEST)

June 2017

July 2017

August 2017

Site 6 (Cut 22 EAST)

June 2017

July 2017

August 2017

Site 7 (Cut 22 WEST)

June 2017

July 2017

August 2017

Site 8 (Fill 20 EAST)

June 2017

July 2017

August 2017

Site 9 (Cut 18 (EAST)

June 2017

July 2017

August 2017

Site 10 (Williamson Creek)

June 2017

July 2017

August 2017

Site 11 (Stony Creek)

June 2017

July 2017

August 2017

Site 12 (Butchers Creek)

June 2017

July 2017

August 2017

Appendix B – Landscape Monitoring Checklists (Winter 2017)

Date: 29/8/2017

Photo Taken? (Y)/N

Site	1
Location	Fill 4 EAST
Weather	Fine
Rainfall Average	1-2mm in August 2017
Walk 50m transect (as per photo) what general species are present?	Setaria Acacia sp. (several) Banksia Kennedia rubicunda Hardenbergia violacea Centella asiatica
What is general total ground cover?	92%
What percentage of native vegetation cover?	10% natives
What is the general plant height?	600mm + Shrubs + Grass
Comments on growth of batter: e.g condition of soil?	- Good growth with no rills/erosion noted - Slight die back on some native likely due to low rainfall during winter 2017
Maintenance recommendations: e.g are there any weeds that need treating?	Nil - minimal weeds noted. Pest Spray completed July 2017
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	Good - batter is SM1 and meets UDLP objectives, Native strike is average but note SM1 treatment not SM3 treatment.

Date: 29/8/2017

Photo Taken? (Y)/N

Site	2
Location	Fill 4 WEST
Weather	Fine
Rainfall Average	1.2mm in August 2017
Walk 50m transect (as per photo) what general species are present?	Setaria Acacia sp. Callistemon sp. Kennedia Hakea Centella Leptospermum Paddy's Lucerne Verbena
What is general total ground cover?	95%
What percentage of native vegetation cover?	8% natives
What is the general plant height?	600mm+
Comments on growth of batter: e.g condition of soil?	Large scour on secondary bench requires repair - on fenceline defect walk
Maintenance recommendations: e.g are there any weeds that need treating?	Nil - weed treatment completed July 2017
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	Compliant with UDLP with SMP matches adjacent agricultural landscape

Date: 29/8/2017

Photo Taken? (Y)/N

Site	3
Location	Lot 2 EAST
Weather	Fine
Rainfall Average	1-2mm in August 2017
Walk 50m transect (as per photo) what general species are present?	Setaria Acacia spp. Callistemon sp Hardenbergia Banksia
What is general total ground cover?	90%
What percentage of native vegetation cover?	5% natives
What is the general plant height?	300mm - 600mm
Comments on growth of batter: e.g condition of soil?	Batter in good condition no rilling or scouring Good native plant growth (above setaria) Hydroseed occored May 17
Maintenance recommendations: e.g are there any weeds that need treating?	Nil - weed treatment not required
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	Overall compliant w/ UDLP outcomes native strike noted post hydroseeding of SM3 consistent with adjacent land

Date: 29/8/2017

Photo Taken? (Y)/N

Site	4
Location	Fill 19 WEST
Weather	Fine
Rainfall Average	0.8mm in August 2017
Walk 50m transect (as per photo) what general species are present?	Sterile cover crop - respray Setaria
What is general total ground cover?	15%
What percentage of native vegetation cover?	Nil
What is the general plant height?	N/A .
Comments on growth of batter: e.g condition of soil?	Sterile cover crop starting to strike lack of pastural grasses. poor rainfall during the period since tractor seeding (July 17)
Maintenance recommendations: e.g are there any weeds that need treating?	Tractor seeding completed July 2017
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	awaiting growth post reapplication of seed. rainfall required for seed strike to occor

Date: 29/8/2017

Photo Taken? (Y)/N

Site	5
Location	Fill 5
Weather	Fine
Rainfall Average	1-2mm in August 2017
Walk 50m transect (as per photo) what general species are present?	Acacia Sp. Setaria Couch Banksia Tobacco Bush Lantana Kennedia-pea
What is general total ground cover?	75%
What percentage of native vegetation cover?	5%
What is the general plant height?	500mm - 2000mm
Comments on growth of batter: e.g condition of soil?	Good growth limited die-back or predation
Maintenance recommendations: e.g are there any weeds that need treating?	Nil
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	compliant with UDLP outcomes matches agricultural landscape

Date: 29/8/2017

Photo Taken? (Y)/N

Site	6
Location	Cut 22 East
Weather	Fine
Rainfall Average	0.8mm August 2017
Walk 50m transect (as per photo) what general species are present?	Acacia Sp. (several) Callistemon sp. Kennedia rubicunda Hardenbergia violacea Indigofera australis Acacia longifolia Kunzea capitata
What is general total ground cover?	18%
What percentage of native vegetation cover?	15%
What is the general plant height?	200mm - 600mm
Comments on growth of batter: e.g condition of soil?	no weeds noted minimal growth due to low rainfall r no major signs of stress
Maintenance recommendations: e.g are there any weeds that need treating?	Hydroseed spray required upper 15 m of batter
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	Compliant w/ UDLP - respray top 15m >1% natives.

Date: 29/8/2017

Photo Taken? (Y)/N

Site	7
Location	Cut 22 WEST
Weather	Fine
Rainfall Average	0·8mm August 2017
Walk 50m transect (as per photo) what general species are present?	Acacia Sp. (various) Kennedia rubiconda Goodenia sp. Hardenbergia violacea
What is general total ground cover?	50%
What percentage of native vegetation cover?	10% native cover
What is the general plant height?	200mm - 300mm
Comments on growth of batter: e.g condition of soil?	Minimal growth due to low rainfall no sign of stress or predation no weeds noted
Maintenance recommendations: e.g are there any weeds that need treating?	Hydroseed required on 15m of lower bench (May 17) cover crop noted no weeds noted
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	Compliant w/ UDLP

Date: 29/8/2017

Photo Taken? (Y)/N

Site	8
Location	Fill 20 EAST
Weather	Fine
Rainfall Average	0.8mm in August 2017
Walk 50m transect (as per photo) what general species are present?	Acacia sp (several) Hardenbergia violacea Centella asiatica Solanum lacianatum Setaria Kennedia rubicanda
What is general total ground cover?	80%
What percentage of native vegetation cover?	12%
What is the general plant height?	300mm – 800mm
Comments on growth of batter: e.g condition of soil?	Good Growth, natives noted above Seteria Slight browning of natives likely due to low rainfall
Maintenance recommendations: e.g are there any weeds that need treating?	Nil
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	Compliant w/ Bushland Reconstruction – no signs of predation or major stress.

Date: 29/8/2017

Photo Taken? (Y)/N

Site	9
Location	Cut 18 East
Weather	Fine
Rainfall Average	0.8mm in August 2017
Walk 50m transect (as per photo) what general species are present?	Acacia Sp. (several) Kennedia rubicunda Hardenbergia violacea Callistemon sp. Eucalyptus sp. Cymbropogon rafractus Setaria Centella asiatica
What is general total ground cover?	60%
What percentage of native vegetation cover?	55%
What is the general plant height?	500mm – 1000mm
Comments on growth of batter: e.g condition of soil?	Good growth, no slips noted minimal new growth due to low raintall
Maintenance recommendations: e.g are there any weeds that need treating?	Nil
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	Compliant with UDLP, no signs of stress or predation

Date: 29/8/2017

Photo Taken? (Y)/N

Site	10
Location	Williamson Creek
Weather	Fine
Rainfall Average	1.2mm of August 2017
Walk 50m transect (as per photo) what general species are present?	Setaria Paspalen maundia Eleocharis acuta
What is general total ground cover?	50%
What percentage of native vegetation cover?	5%
What is the general plant height?	100mm
Comments on growth of batter: e.g condition of soil?	Regrowth has been good especially maundia (healthy)
Maintenance recommendations: e.g are there any weeds that need treating?	2x additional beds ready for landscape planting (Sep 17)
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	not compliant some replanting required Area does look like sorrounding landscape (Williamson Creek)

Date: 29/8/2017

Photo Taken? (Y)/N

Site	11
Location	Stony Creek
Weather	Fine
Rainfall Average	1.2mm in August 2017
Walk 50m transect (as per photo) what general species are present?	Junkus Lomandra longifolia Lomandra hystrix Setaria Caryx Indigo Australis Billygoat weed Wild Tobacco Scotch Thistle Centella asiatic Fleabane Banksia Crofton Weed.
What is general total ground cover?	75%
What percentage of native vegetation cover?	30%
What is the general plant height?	300mm
Comments on growth of batter: e.g condition of soil?	Good growth for low rainfall conditions Creek flowing
Maintenance recommendations: e.g are there any weeds that need treating?	Weed removal required (Hand pull) prior to landscaping
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	Compliant with UDLP. good regrowth soft landscape treatment working well

Date: 29/8/2017

Photo Taken? Y/N

Site	12
Location	Butchers Creek
Weather	Fine
Rainfall Average	1·2mm in August 2017
Walk 50m transect (as per photo) what general species are present?	Lomandra, Fireweed, Dianella, Camphor laurels, Setaria
What is general total ground cover?	3% (note - hard scour treatment at this location)
What percentage of native vegetation cover?	<2% natives
What is the general plant height?	200mm - 300mm
Comments on growth of batter: e.g condition of soil?	Healthy Growth noted good strike w/ hydromulch (May 2017)
Maintenance recommendations: e.g are there any weeds that need treating?	Handpull of weeds required - camphoor + fire weed.
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	Average compliance with UDLP. Note hard scour treatment is transitioning to soft treatment

MEMORANDUM

WC2NH PACIFIC HIGHWAY UPGRADE

Date 20th November 2017

Subject Spring Landscape Monitoring Summary 2017

Background and Scope

Landscape monitoring was undertaken by the Pacifico Environment Team on the 17th November 2017. Landscape monitoring is required quarterly during Year 3 of construction in accordance with the Ecological Monitoring Program (EMP) and the Urban Design and Landscape Plan (UDLP). The purpose of the monitoring is to determine if the objectives of the UDLP have been met and whether any maintenance/management measures are required. The UDLP also requires monthly photo points to be taken of the landscape monitoring sites to track the progress. The photographs collected during the previous quarter are attached in Appendix A of this memorandum.

The landscape monitoring scope was originally determined by Geolink to cover the RMS Specification, UDLP and EMP requirements. Upon review of the scope provided by Geolink, Pacifico have devised a brief checklist which covers the general requirements of the monitoring scope. The completed checklist for each of the monitoring locations is provided in Appendix B of this memorandum.

The landscape monitoring scope includes 12 monitoring sites that have been determined across the Project. Monthly photo points are taken for each of the monitoring locations. A 50m transect is walked each quarter and the checklists attached in Appendix B are completed for each transect.

Results

The Pacifico Environment Team undertook a review of the monitoring sites on the 17th November 2017 in order to determine if the objectives in the UDLP were being achieved.

Monitoring Site no.	Location	General Cover %	% of cover = native species	General plant health	Condition of soil and batter	Maintenance Comments	Compliance with UDLP objectives
1	Fill 4 East	93	15	Good	Good – no evidence of rilling or slumping	Nil – Weed's appear well managed. Seteria grass most common species present due to presence in nearby pasture. Batter meets the objectives of the UDLP as the batter assimilates with the surrounding landscape. Batter is stable with good robust growth.	SM1 mix (Native grasses) Although there is mostly Setaria grass present, the batter has assimilated with the surrounding landscape.
2	Fill 4 West	95	10	Good	Good – no evidence of rilling or slumping	Nil – Weed's appear well managed. Setaria grass most common species present due to presence in nearby pasture. Batter meets the objectives of the UDLP as the batter assimilates with the surrounding landscape. Batter is stable with good robust growth.	SM2 mix (Native Pasture grasses) Although there is mostly Setaria grass present, the batter has assimilated with the surrounding landscape.
3	Cut 2 East	90	7	Good	Good – no evidence of rilling or slumping	Setaria grass most common species present due to nearby pasture. Native shrub species are emerging and growing. Hydroseeding of SM3 occurred on this batter in June 2017 with natives noted during inspection. Weeds appear well managed.	SM3 mix (Native shrub mix). Average compliance, however shrub growth is improving over time. Hydroseeding occurred in June 2017 with native cover increasing from

Monitoring Site no.	Location	General Cover %	% of cover = native species	General plant health	Condition of soil and batter	Maintenance Comments	Compliance with UDLP objectives
							Winter 2017. Continue to monitor.
4	Fill 19 West	15	2	Poor	Good – no evidence of rilling or slumping	Native species growth is minimal. Area was revegetated by tractor seeding and application of fertiliser in July 2017. Poor strike rate to date due to low rainfall during Winter 2017.	SM4 mix (Pastoral Grass, Ancillary Site Mix). Poor compliance, area was revegetated with tractor seeding and fertiliser application in July 2017. Some natives beginning to emerge. Continue to monitor.
5	Fill 5	77	10	Good	Good – no evidence of rilling or slumping	Native species growth is reasonable, some native shrub species emerging, however the swale is now concreted and therefore does not require swale species.	SM5 mix (Indigenous Swale Drain grasses and plants). Poor compliance, suggest changing plant species for this area as swale is concreted.
6	Cut 22 East	20	18	Good	Good – no evidence of rilling or slumping	Native growth good, minimal weed growth. Re-spray with Hydroseed upper section of batter undertaken September 2017.	BRC – North CC05. Good compliance, batter is assimilating with surrounding landscape.
7	Cut 22 West	55	15	Good	Good – no evidence of rilling or slumping	Native growth good, minimal weed growth. Re-spray with hydroseed completed May 2017 on lower section of batter where previous slumps have been rectified.	BRC – North CC05. Good compliance, batter is assimilating with surrounding landscape.

Monitoring Site no.	Location	General Cover %	% of cover = native species	General plant health	Condition of soil and batter	Maintenance Comments	Compliance with UDLP objectives
						Sterile cover crop is providing good coverage.	
8	Fill 20 East	80	15	Good	Good – no evidence of rilling or slumping	Native growth emerging through Setaria grass growth. No other weed species to treat. Native species will continue to grow and shade out Setaria grass.	BRC – North CC04. Good compliance, batter is assimilating with surrounding landscape.
9	Cut 18 East	70	60	Good	Good – no evidence of rilling or slumping	Very good native species growth, native species growth dominant on batter with minimal weed growth. Good progress on growth.	BRC – North CC04 Very good compliance, batter is assimilating with surrounding landscape.
10	Williamsons Creek	60	10	Good – minimal native species	Good	Poor native species growth. Re-planting will be required in this area during landscape planting. Two (2) additional beds have been prepared post temporary waterway crossing removal. Planting of additional beds undertaken September 2017 post removal of haul road crossing point.	Williamsons Creek. Average compliance, planting of additional beds undertaken September 2017. Continue to monitor.
11	Stony Creek	80	35	Good	Good	Good native species growth and stabilisation of waterway. Successful use of soft treatments. Spot spray required of seed species prior to operation	Stoney Creek. Very good compliance, soft landscaping treatment has been successful at stabilising the creek line.
12	Butchers Creek	5 (100% cover	2	Average	Good	Planting of lomandra into sandbags of topsoil has not been successful. Area has	Butchers Creek. Poor success of soft scour

Monitoring Site no.	Location	General Cover %	% of cover = native species	General plant health	Condition of soil and batter	Maintenance Comments	Compliance with UDLP objectives
		with scour rock)				been hydromulched into pockets of sediment collected in scour rock with SM5 Mix. Spot Spray of lantana required prior to operation.	treatments. Hydromulching with SM5 showing early signs of successful treatment with various natives noted during inspection in Spring 2017

Recommendations

1. Commence weed removal program leading up to road opening for priority areas and weed species.
2. Continue to monitor growth and re-apply hydroseed or hydromulch where appropriate for areas of poor growth.
3. Continue to monitor planting beds prepared at Williamson Creek
4. Investigate changing swale vegetation if drain is now concreted. This could be replaced with Butchers Creek as this has now had a SM5 swale vegetation mix applied.

Jack Henderson

Environment Officer

Pacifico Acciona Ferrovial JV

Appendix A – Photo records

Site 1 (Fill 4 EAST)

September 2017

October 2017

November 2017

Site 2 (Fill 4 WEST)

September 2017

October 2017

November 2017

Site 3 (Cut 2 EAST)

September 2017

October 2017

November 2017

Site 4 (Fill 19 WEST)

September 2017

October 2017

November 2017

Site 5 (Fill 5 WEST)

September 2017

October 2017

November 2017

Site 6 (Cut 22 EAST)

September 2017

October 2017

November 2017

Site 7 (Cut 22 WEST)

September 2017

October 2017

November 2017

Site 8 (Fill 20 EAST)

September 2017

October 2017

November 2017

Site 9 (Cut 18 (EAST)

September 2017

October 2017

November 2017

Site 10 (Williamson Creek)

September 2017

October 2017

November 2017

Site 11 (Stony Creek)

September 2017

October 2017

November 2017

Site 12 (Butchers Creek)

September 2017

October 2017

November 2017

Appendix B – Landscape Monitoring Checklists (Spring 2017)

Date: 17/11/2017

Photo Taken? Y/N

Site 1
Location Fill 4 East
Weather
Rainfall Average
Walk 50m transect (as per photo) what general species are present? Setaria — Kennedia rubicunda Acacia sp. — Hardenbergia violacea Banksia — verbana
What is general total ground cover? 95%
What percentage of native vegetation cover? 15%
What is the general plant height? 600 - 1800mm
Comments on growth of batter: e.g condition of soil? - Good growth, no rills/erosion on batter - No signs stress/predation
Maintenance recommendations: e.g are there any weeds that need treating? Nil - minimal weeds noted
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape? Good - compliant w/UDLP for SM1. Native strike growing above grasses - trees/shrubs

Date: 17/11/2017

Photo Taken? (Y)/N

Site	2
Location	Fill 4 West
Weather	Cloudy
Rainfall Average	Below average for spring
Walk 50m transect (as per photo) what general species are present?	Setaria, Kennedia, Paddys lucerne, Acacia sp., Hakea, Verbena, Callistemon sp., Centella, Leptospermum
What is general total ground cover?	95%
What percentage of native vegetation cover?	10%
What is the general plant height?	600mm - 1400mm
Comments on growth of batter: e.g condition of soil?	Batter good condition. No signs of predation / major stress
Maintenance recommendations: e.g are there any weeds that need treating?	Nil
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	Compliant w/UDLP

Date: 17/11/2017

Photo Taken? (Y)/N

Site	3
Location	Cut 2 East
Weather	Cloudy
Rainfall Average	Below Spring average
Walk 50m transect (as per photo) what general species are present?	Setaria Hardenbergia Acacia Sp. Banksia Callistemon sp.
What is general total ground cover?	90%
What percentage of native vegetation cover?	7%
What is the general plant height?	300–1000mm
Comments on growth of batter: e.g condition of soil?	Natives growing above Setaria No signs of predation or stress No rilling in batter
Maintenance recommendations: e.g are there any weeds that need treating?	Nil
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	Overall compliant w/UDLP Native strike noted post hydroseed SM3 Consistent with surrounding landscape

Date: 17/11/2017

Photo Taken? Y/N

Site 4
Location Fill 19 West
Weather Cloudy
Rainfall Average Below average for Spring
Walk 50m transect (as per photo) what general species are present? Setaria Acacia sp.
What is general total ground cover? 15%
What percentage of native vegetation cover? 2%
What is the general plant height? 100 mm
Comments on growth of batter: e.g condition of soil? Lack of pastural grasses Some natives beginning to grow
Maintenance recommendations: e.g are there any weeds that need treating? Tractor seeding completed July 2017
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape? Ongoing monitoring required

Date: 17/11/2017

Photo Taken? Y/N

Site	S
Location	Fill S west
Weather	Cloudy
Rainfall Average	Below Spring average
Walk 50m transect (as per photo) what general species are present?	Acacia sp. Tobacco bus Carch ~~Lantana~~ Setaria Bankisia Kennedia
What is general total ground cover?	77%
What percentage of native vegetation cover?	10%
What is the general plant height?	500mm - 2200mm
Comments on growth of batter: e.g condition of soil?	Good growth No sign of stress or predation
Maintenance recommendations: e.g are there any weeds that need treating?	Nil
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	Compliant w/UDLP Matches surrounding landscape

Date: 17/11/2017

Photo Taken? Y/N

Site	6
Location	Cut 2A East
Weather	Cloudy
Rainfall Average	Below average for spring
Walk 50m transect (as per photo) what general species are present?	Acacia sp. (Several) Callistemon sp. Kennedia rubicunda Hardenbergia violacea Indigofera australis Acacia longifolia Kunzea capitata
What is general total ground cover?	20%
What percentage of native vegetation cover?	18%
What is the general plant height?	300mm - 700mm
Comments on growth of batter: e.g condition of soil?	No weeds noted No major signs of stress
Maintenance recommendations: e.g are there any weeds that need treating?	Nil
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	Compliant w/UDLP

Date: 17/11/2017

Photo Taken? Y/N

Site	7
Location	Cut 22 West
Weather	Cloudy
Rainfall Average	Below average for spring
Walk 50m transect (as per photo) what general species are present?	Acacia sp. (various) Hardenbergia violacea Kennedia rubicunda Goodenia sp.
What is general total ground cover?	55%
What percentage of native vegetation cover?	15%
What is the general plant height?	200mm - 400mm
Comments on growth of batter: e.g condition of soil?	No weeds noted No signs of stress or predation
Maintenance recommendations: e.g are there any weeds that need treating?	Nil
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	Compliant w/UDLP

Date: 17/11/2017

Photo Taken? (Y)N

Site	8
Location	Fill 20 East
Weather	Cloudy
Rainfall Average	Below average for Spring
Walk 50m transect (as per photo) what general species are present?	Acacia sp. (several) Solanum laciniatum Hardenbergia violacea Setaria Centella asiatica Kennedia rubicunda
What is general total ground cover?	80%
What percentage of native vegetation cover?	15%
What is the general plant height?	300mm - 800mm
Comments on growth of batter: e.g condition of soil?	Good growth, natives growing above setaria Slight browning of some natives - likely from low rainfall No signs of predation or major stress
Maintenance recommendations: e.g are there any weeds that need treating?	Nil
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	Compliant w/ UDLP

Date: 17/11/2017

Photo Taken? (Y)/N

Site	9
Location	Cut 18 East
Weather	Cloudy
Rainfall Average	Below average
Walk 50m transect (as per photo) what general species are present?	Acacia sp. (several) · Callistemon sp. · Setaria Kennedia rubicunda · Eucalyptus sp. · Centella asiatica Hardenbergia violacea · Cymbopogon refractus
What is general total ground cover?	70%
What percentage of native vegetation cover?	60%
What is the general plant height?	700 - 1300mm
Comments on growth of batter: e.g condition of soil?	Good growth, no slips noted
Maintenance recommendations: e.g are there any weeds that need treating?	N.I
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	Compliant w/UDLP, no signs of stress or predation

Date: 17/11/2017

Photo Taken? (Y)/N

Site 10
Location Williamson's Creek
Weather Fine
Rainfall Average Below Spring average
Walk 50m transect (as per photo) what general species are present? Setaria Paspalum Maurlia Eleocharis acuta Jointed twig rush Bulrush Spikerush > new planting bed.
What is general total ground cover? 60%
What percentage of native vegetation cover? 5%
What is the general plant height? 200-400mm
Comments on growth of batter: e.g condition of soil? Regrowth has been good Sep 17 plants installed when haul rd removed PM4C
Maintenance recommendations: e.g are there any weeds that need treating? Removal of weeds/grasses prior to plant replacement (Feb 18)
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape? Area looks like surrounding landscape (Williamsons creek)

Date: 17/11/2017

Photo Taken? (Y)/N

Site	11
Location	Stony Creek
Weather	Fine
Rainfall Average	Below spring average
Walk 50m transect (as per photo) what general species are present?	Juncus, Carex, Fleabane, Lomandra sp., Indigo australis, Banksia, Setaria, Purple verbena
What is general total ground cover?	80%
What percentage of native vegetation cover?	35%
What is the general plant height?	300 - 600mm
Comments on growth of batter: e.g condition of soil?	Good growth creek flowing
Maintenance recommendations: e.g are there any weeds that need treating?	spot spray required to remove weed species.
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	Compliant w/ UDLP soft landscape treatment working well

Date: 17/11/2017

Photo Taken? (Y)/N

Site 12
Location Butcher's Creek
Weather Cloudy
Rainfall Average Below Spring average
Walk 50m transect (as per photo) what general species are present? Commelina — Camphor laurels Pianella — Lantana Setaria
What is general total ground cover? 5% (Hard scour treatment at this site)
What percentage of native vegetation cover? 2%
What is the general plant height? 200-400mm
Comments on growth of batter: e.g condition of soil? Healthy growth
Maintenance recommendations: e.g are there any weeds that need treating? Treatment of lantana (spot spray required)
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape? Average compliance w/ UDLP - hard scour treatment transitioning to soft treatment

MEMORANDUM

WC2NH PACIFIC HIGHWAY UPGRADE

Date 28th February 2018

Subject Summer Landscape Monitoring Summary 2018

Background and Scope

Landscape monitoring was undertaken by the Pacifico Environment Team on the 27th of February 2018. Landscape monitoring is required quarterly during Year 3 of construction in accordance with the Ecological Monitoring Program (EMP) and the Urban Design and Landscape Plan (UDLP). The purpose of the monitoring is to determine if the objectives of the UDLP have been met and whether any maintenance/management measures are required. The UDLP also requires monthly photo points to be taken of the landscape monitoring sites to track the progress. The photographs collected during the previous quarter are attached in Appendix A of this memorandum.

The landscape monitoring scope was originally determined by Geolink to cover the RMS Specification, UDLP and EMP requirements. Upon review of the scope provided by Geolink, Pacifico have devised a brief checklist which covers the general requirements of the monitoring scope. The completed checklist for each of the monitoring locations is provided in Appendix B of this memorandum.

The landscape monitoring scope includes 12 monitoring sites that have been determined across the Project. Monthly photo points are taken for each of the monitoring locations. A 50m transect is walked each quarter and the checklists attached in Appendix B are completed for each transect.

Results

The Pacifico Environment Team undertook a review of the monitoring sites on the 27th of February 2018 in order to determine if the objectives in the UDLP were being achieved.

Monitoring Site no.	Location	General Cover %	% of cover = native species	General plant health	Condition of soil and batter	Maintenance Comments	Compliance with UDLP objectives
1	Fill 4 East	95	20	Good	Good – no evidence of rilling or slumping	Nil – Weed's appear well managed. Seteria grass most common species present due to presence in nearby pasture. Batter meets the objectives of the UDLP as the batter assimilates with the surrounding landscape. Batter is stable with good robust growth. Annual Ragweed was noted within verge topsoiled areas with treatment undertaken 23/2/2018.	SM1 mix (Native grasses) Although there is mostly Setaria grass present, the batter has assimilated with the surrounding landscape.
2	Fill 4 West	95	15	Good	Good – no evidence of rilling or slumping	Nil – Weed's appear well managed. Setaria grass most common species present due to presence in nearby pasture. Batter meets the objectives of the UDLP as the batter assimilates with the surrounding landscape. Batter is stable with good robust growth. Annual Ragweed was noted within verge topsoiled areas with treatment undertaken 23/2/2018.	SM2 mix (Native Pasture grasses) Although there is mostly Setaria grass present, the batter has assimilated with the surrounding landscape.
3	Cut 2 East	95	10	Good	Good – no evidence of	Setaria grass most common species present due to nearby pasture. Native shrub species are emerging and growing.	SM3 mix (Native shrub mix). Good compliance, shrub growth is improving

Monitoring Site no.	Location	General Cover %	% of cover = native species	General plant health	Condition of soil and batter	Maintenance Comments	Compliance with UDLP objectives
					rilling or slumping	Hydroseeding of SM3 occurred on this batter in June 2017 with natives noted during inspection. Weeds appear well managed.	over time. Hydroseeding occurred in June 2017 with native cover increasing from Spring 2017.
4	Fill 19 West	20	3	Average	Good – no evidence of rilling or slumping	Native species growth is minimal however additional natives noted from Spring 2017. Area was revegetated by tractor seeding and application of fertiliser in July 2017.	SM4 mix (Pastoral Grass, Ancillary Site Mix). Poor compliance, area was revegetated with tractor seeding and fertiliser application in July 2017. Natives noted during Summer 2017 in line with surrounding vegetation
5	Fill 5	80	15	Good	Good – no evidence of rilling or slumping	Native species growth is good, native shrub species emerging, however the swale is now concreted and therefore does not require swale species (SM5)	This location was originally designated as SM5 (Indigenous Swale Drain grasses and plants). As swale is now concrete at this location mix design has been changed to SM2 (Native Pasture grasses) as per areas adjacent to the swale drain. Although there is mostly Setaria grass present, the batter has assimilated with the surrounding landscape

Monitoring Site no.	Location	General Cover %	% of cover = native species	General plant health	Condition of soil and batter	Maintenance Comments	Compliance with UDLP objectives
							with native species noted during Summer 2017.
6	Cut 22 East	40	20	Good	Good – no evidence of rilling or slumping	Native growth good, minimal weed growth. Re-spray with Hydroseed upper section of batter undertaken September 2017 with new native growth noted during Summer 2018.	BRC – North CC05. Good compliance, batter is assimilating with surrounding landscape.
7	Cut 22 West	60	20	Good	Good – no evidence of rilling or slumping	Native growth good, minimal weed growth. Re-spray with hydroseed completed May 2017 on lower section of batter where previous slumps have been rectified. New Native Growth noted in Summer 2018.	BRC – North CC05. Good compliance, batter is assimilating with surrounding landscape.
8	Fill 20 East	90	20	Good	Good – no evidence of rilling or slumping	Native growth emerging through Setaria grass growth. No other weed species to treat. Native species will continue to grow and shade out Setaria grass.	BRC – North CC04. Good compliance, batter is assimilating with surrounding landscape.
9	Cut 18 East	80	65	Good	Good – no evidence of rilling or slumping	Very good native species growth, native species growth dominant on batter with minimal weed growth. Good progress on growth.	BRC – North CC04 Very good compliance, batter is assimilating with surrounding landscape.
10	Williamsons Creek	80	5	Good – minimal native species	Good	Poor native species growth. Planting of additional beds undertaken September 2017 post removal of haul road crossing point. Planting pockets are overgrown with exotic grasses (i.e. Seteria). Removal of	Williamsons Creek. Average compliance, planting of additional beds undertaken September 2017. Maintenance items

Monitoring Site no.	Location	General Cover %	% of cover = native species	General plant health	Condition of soil and batter	Maintenance Comments	Compliance with UDLP objectives
						weeds from planting pockets is required, application of jute mat required to supress exotic species and replanting of planting pockets required. To be completed during Autumn 2018.	to be actioned in Autumn 2018. Continue to monitor
11	Stony Creek	80	40	Good	Good	Good native species growth and stabilisation of waterway. Successful use of soft treatments. Spot spray completed September 2017 with an additional spot spray required prior to opening of Stage 2B.	Stoney Creek. Very good compliance, soft landscaping treatment has been successful at stabilising the creek line.
12	Butchers Creek	10 (100% cover with scour rock)	4	Good	Good	Planting of lomandra into sandbags of topsoil has not been successful. Area has been hydromulched into pockets of sediment collected in scour rock with SM5 Mix. Spot spray required prior to operation.	Butchers Creek. Poor success of soft scour treatments. Hydromulching with SM5 (Indigenous Swale Drain grasses and plants) showing signs of successful treatment with various natives noted during inspection in Summer 2019. Good compliance with SM5.

Recommendations

1. Commence weed removal program leading up to road opening for priority areas and weed species.
2. Continue to monitor growth and re-apply hydroseed or hydromulch where appropriate for areas of poor growth.
3. SM5 swale mix has been changed from Site 5 (Fill 5) to Site 12 (Butchers Creek).
4. Williamson Creek shall have maintenance items listed above completed in Autumn 2018 with a jute mat applied to the planting pockets post weed removal. Replanting is to be undertaken in Autumn 2018.

Alex Dwyer

Environment Manager

Pacifico Acciona Ferrovial JV

Appendix A – Photo records

Site 1 (Fill 4 EAST)

December 2017

January 2018

February 2018

Site 2 (Fill 4 WEST)

December 2017

January 2018

February 2018

Site 3 (Cut 2 EAST)

December 2017

January 2018

February 2018

Site 4 (Fill 19 WEST)

December 2017

January 2018

February 2018

Site 5 (Fill 5 WEST)

December 2017

January 2018

February 2018

Site 6 (Cut 22 EAST)

December 2017 January 2018 February 2018

Site 7 (Cut 22 WEST)

December 2017

January 2018

February 2018

Site 8 (Fill 20 EAST)

December 2017

January 2018

February 2018

Site 9 (Cut 18 (EAST)

December 2017

January 2018

February 2018

Site 10 (Williamson Creek)

December 2017

January 2018

February 2018

Site 11 (Stony Creek)

December 2017

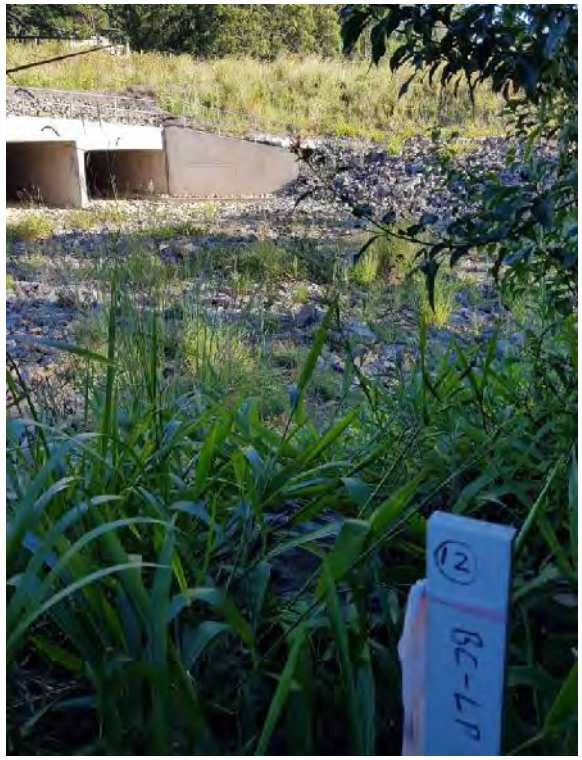
January 2018

February 2018

Site 12 (Butchers Creek)

December 2017

January 2018



February 2018

Appendix B – Landscape Monitoring Checklists (Summer 2018)

Date: 27/2/18

Photo Taken? (Y)/N

Site	1
Location	Fill 4 EAST
Weather	Overcast
Rainfall Average	Below average for Summer (288mm recorded vs 430mm median)
Walk 50m transect (as per photo) what general species are present?	Seteria Acacia sp. Banksia sp. Kennedia rubicunda Hardenbergia violacea Indigofera australis
What is general total ground cover?	95%
What percentage of native vegetation cover?	20%
What is the general plant height?	800mm - 2000mm
Comments on growth of batter: e.g condition of soil?	Good growth on batter no rills or erosion noted no signs of stress noted
Maintenance recommendations: e.g are there any weeds that need treating?	Nil NT - ragweed treated on verge in Feb 18 (browning noted)
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	compliant with UDLP. for SMI Natives noted w/ good growth above seteria grass

Date: 27/2/18

Photo Taken? Y/N

Site	2
Location	Fill 4 WEST
Weather	Overcast
Rainfall Average	Below average for Summer (288mm recorded vs 430mm median)
Walk 50m transect (as per photo) what general species are present?	Acacia sp. Paddy's lucerne Kennedia rubicunda Glycine clandestine Hardenbergia violacea Indigofera australis.
What is general total ground cover?	95%
What percentage of native vegetation cover?	15%
What is the general plant height?	700mm - 2000mm
Comments on growth of batter: e.g condition of soil?	Good growth noted w/ established native vegetation no signs of stress or predation
Maintenance recommendations: e.g are there any weeds that need treating?	Nil NT - verge spray of annual ragweed completed Feb 18 - stress of weeds noted (browning off)
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	compliant w/ UDLP. Setaria is noted from adjacent agricultural paddocks.

Date: 27/2/18

Photo Taken? (Y)/N

Site	3
Location	Cut 2 EAST
Weather	Overcast
Rainfall Average	Below average rainfall Summer
Walk 50m transect (as per photo) what general species are present?	Acacia Sp. Banksia sp. Seteria Grass
What is general total ground cover?	95%
What percentage of native vegetation cover?	10%
What is the general plant height?	500mm – 1200mm
Comments on growth of batter: e.g condition of soil?	Natives growing above and within seteria no rills on batter
Maintenance recommendations: e.g are there any weeds that need treating?	Nil seteria due to adjacent agricultural grasses.
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	compliant with UDLP. Native strike noted post hydroseed SM3 seteria consistent with adjacent land (agricultural)

Date: 27/2/18

Photo Taken? (Y)/N

Site	4
Location	Fill 19 WEST
Weather	Overcast
Rainfall Average	Below average rainfall (Summer)
Walk 50m transect (as per photo) what general species are present?	Seteria rhodes grass acacia sp.
What is general total ground cover?	20%
What percentage of native vegetation cover?	3%
What is the general plant height?	150mm
Comments on growth of batter: e.g condition of soil?	only small amount of pastoral grasses, high mulch content native strike noted improved cover from Spring 2017
Maintenance recommendations: e.g are there any weeds that need treating?	Tractor seeding completed July 17. Continue monitoring of growth.
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	ongoing monitoring required. natives noted as per adjacent vegetation

Date: 27/2/18

Photo Taken? (Y)/N

Site	5
Location	Fill 5 WEST
Weather	Overcast
Rainfall Average	Below average rainfall (Summer)
Walk 50m transect (as per photo) what general species are present?	Acacia Sp. couch Setaria
What is general total ground cover?	80%
What percentage of native vegetation cover?	15%
What is the general plant height?	600mm - 2000mm
Comments on growth of batter: e.g condition of soil?	Good growth adjacent to drain No sign of stress to natives. reduction in weed spies from spring 2017.
Maintenance recommendations: e.g are there any weeds that need treating?	Nil
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	compliant with UDLP and matches surrounding landscape Note - shotcrete lined drain so no SMS SMS applied to Butchers Creek so SMS now at site 12.

Date: 27/2/18

Photo Taken? Y/N

Site	6
Location	Cut 22 EAST
Weather	Overcast
Rainfall Average	Below average rainfall (Summer)
Walk 50m transect (as per photo) what general species are present?	Acacia Sp. Callistermon Sp. Indigofera australis Acacia longifolia Kennedia rubicunda Hardenbergia violacea
What is general total ground cover?	40%
What percentage of native vegetation cover?	20%
What is the general plant height?	400mm – 700mm
Comments on growth of batter: e.g condition of soil?	no weeds noted no signs of stress or disease
Maintenance recommendations: e.g are there any weeds that need treating?	Nil
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	Compliant with UDLP (Bushland Reconstruction)

Date: 27/2/18

Photo Taken? (Y)/N

Site	7
Location	Lot 22 WEST
Weather	Overcast
Rainfall Average	Below average rainfall (Sommer)
Walk 50m transect (as per photo) what general species are present?	Acacia sp. Hakea sericea Kennedia rubicunda Hardenbergia violacea Goodenia sp.
What is general total ground cover?	60%
What percentage of native vegetation cover?	20%
What is the general plant height?	300mm – 500mm
Comments on growth of batter: e.g condition of soil?	no weeds noted no signs of stress or disease
Maintenance recommendations: e.g are there any weeds that need treating?	Bottom half of batter shows poor growth. Respray occured 2017 awaiting native strike
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	Compliant w/ UDLP (Bushland Reconstruction).

Date: 27/2/18

Photo Taken? Y/N

Site	8
Location	Fill 20 EAST
Weather	Overcast
Rainfall Average	Below average rainfall Summer
Walk 50m transect (as per photo) what general species are present?	Acacia Sp. Seteria Echinochloa sp. Hardenbergia violacea Kennedia Rubicunda centella asiatica Solanum lacianatum
What is general total ground cover?	90%
What percentage of native vegetation cover?	20%
What is the general plant height?	400mm – 900mm
Comments on growth of batter: e.g condition of soil?	Good growth with natives above seteria no sign of stress or predation no slips noted
Maintenance recommendations: e.g are there any weeds that need treating?	Nil
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	Complaint w/ BDLP (Bushland Reconstruction) w/ seteria from adjacent lands.

Date: 27/2/18

Photo Taken? Y/N

Site	9
Location	Cut 18 EAST
Weather	Overcast
Rainfall Average	Below average rainfall (Summer)
Walk 50m transect (as per photo) what general species are present?	Acacia Sp. Kennedia rubiconda Hardenbergia violacea Callistemon sp. Eucalyptus sp. seteria cymbopogon refractus. Centella asiatica
What is general total ground cover?	80%
What percentage of native vegetation cover?	65%
What is the general plant height?	700mm - 1500mm
Comments on growth of batter: e.g condition of soil?	good growth. no slips noted no signs of stress or predation
Maintenance recommendations: e.g are there any weeds that need treating?	Nil
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	Compliant w/ UDLP (Bushland Reconstruction)

Date: 27/2/18

Photo Taken? Y/N

Site	10
Location	Williamson Creek
Weather	Overcast
Rainfall Average	Below average rainfall (Summer)
Walk 50m transect (as per photo) what general species are present?	Seteria paspalum (BL) maundia Bolrush Spike rush cotton bush
What is general total ground cover?	80%
What percentage of native vegetation cover?	5%
What is the general plant height?	300mm - 400mm
Comments on growth of batter: e.g condition of soil?	Good growth on new beds (PM4A) but high amount grasses noted
Maintenance recommendations: e.g are there any weeds that need treating?	removal of weeds and replacement of dead natives (PM4A) post spray and jute mat in beds required (March 18)
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	average compliance with UDLP replacement planting and installation of jute mat in planting beds required.

Date: 27/2/18

Photo Taken? (Y)/N

Site	11
Location	Stoney Creek
Weather	Overcast
Rainfall Average	Below average rainfall (Summer)
Walk 50m transect (as per photo) what general species are present?	Lomandra longifolia Carex appressa juncus usitatus. Indigofera australis centella asiatica Eleocharis acuta setaria purple verbena fleabane.
What is general total ground cover?	80%
What percentage of native vegetation cover?	40%
What is the general plant height?	400mm – 800mm
Comments on growth of batter: e.g condition of soil?	Good growth noted no rills creek flowing with clear water tadpoles noted during inspection
Maintenance recommendations: e.g are there any weeds that need treating?	Spot spray completed - sep 17
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	compliant with UDLP soft landscape treatment is established no movement of placed logs / structure noted

Date: 27/2/18

Photo Taken? (Y)/N

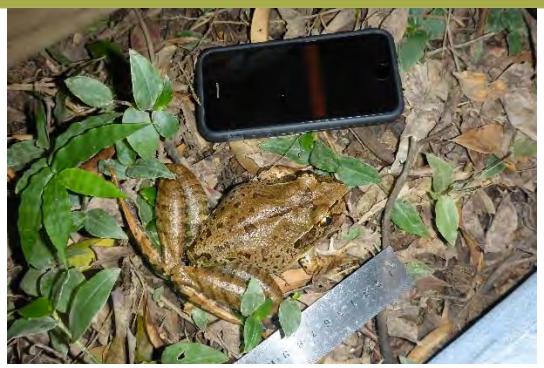
Site	12
Location	Butcher's Creek
Weather	Overcast
Rainfall Average	Below average rainfall (Summer)
Walk 50m transect (as per photo) what general species are present?	lomandras, camphor laurels, bullrush, seteria, Dianella sp., lantana (minor), juncos planifolios.
What is general total ground cover?	10% Hard scour treatment
What percentage of native vegetation cover?	4%
What is the general plant height?	300mm
Comments on growth of batter: e.g condition of soil?	Good growth post SMS application
Maintenance recommendations: e.g are there any weeds that need treating?	Spot Spray completed - Feb 18
Overall compliance / UDLP Comments e.g does batter look like surrounding landscape?	compliant with UDLP Hard scour treatment transitioning to soft treatment

Appendix J

Giant Barred Frog Summer 2018/ Annual Monitoring Report

Annual Report

WC2NH Giant Barred Frog Population Monitoring 2017/2018 - Year 3



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Prepared for: PACIFICO

UPR	Description	Date Issued	Issued By
2378-1421	First issue	06/03/2018	Jessica O'Leary
2378-1432	Second issue	09/03/2018	Jessica O'Leary
2378-1433	Third issue	12/03/2018	Jessica O'Leary
2378-1434	Fourth issue	16/03/2018	Jessica O'Leary

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Executive Summary

A population of Giant Barred Frogs (GBF) (*Mixophyes iteratus*) inhabit the Upper Warrell Creek (UWC) system which intercepts the Warrell Creek to Nambucca Heads (WC2NH) Pacific Highway Upgrade route alignment. As such, this population of GBF and construction works are required to be managed in accordance with the *WC2NH Giant Barred Frog Management Strategy* (Lewis Ecological, 2014).

GeoLINK have been engaged by PACIFICO to undertake seasonal monitoring of two GBF management zones within the Project alignment. UWC has a resident population of GBF which has been previously studied by Lewis Ecological (2013/2014) to establish a population baseline. A total of 47 GBF were recorded, including records of juveniles and sub-adults (and recaptures). Since the unexpected find of GBF tadpoles within Butchers Creek, a new GBF management area was established with eight survey zones created for monitoring. No GBF have been recorded within the Butchers Creek survey zones during seasonal population monitoring for Years 1 or 3 of construction.

Population monitoring undertaken in 2015/2016 (Year 1) returned fewer records of GBF across the three monitoring periods of autumn, spring and summer, with a total of 16 frogs captured at UWC. No sub-adults or juveniles were recorded during this survey period. Population monitoring undertaken in 2017/2018 (Year 3) returned again fewer records of GBF across the three monitoring periods of autumn, spring and summer, with a total of 14 frogs captured at UWC. Only one sub-adult was recorded during the Year 3 during monitoring. No juveniles were recorded during any survey periods. No GBF tagged in the baseline population monitoring of 2013/2014 have been recaptured during seasonal monitoring for Years 1 or 3 of construction.

It can be reasonably expected that a reduced number of GBF have been recorded during construction phase monitoring as a result of an area of high GBF activity (and breeding habitat) has now been fully or partially impacted by construction works. During baseline population monitoring these areas recorded the highest number of frog captures with 21 records in Zones 8 and 9 and six in Zone 10 (i.e. a total of 27 GBF). Prior to construction works, pre-clearing surveys resulted in the capture and relocation of three GBF to outside of the works footprint; no other GBF were accounted for. Despite meeting the mitigation measure requirements via pre-clearing surveys, spotter/catcher presence during clearing works and installation of exclusion fencing, it appears GBF within the construction zone have been substantially affected and this population has declined.

Other factors which may explain the considerable reduction in GBF records and no further recaptures since baseline population monitoring may include:

- Non-favourable survey conditions due to lower than usual rainfall, particularly in the lead up to spring 2017 monitoring.
- Lower than average monthly rainfall records and smaller than usual flood events.
- The apparent lack of successful breeding events during the years between monitoring (and therefore no recruitment of juveniles).
- GBF previously captured or recorded in baseline studies have moved out of the survey area seeking better dispersal or breeding opportunities.

Section 7.0 of the *Giant Barred Frog Management Strategy* (GBFMS) states that the objectives of the GBF monitoring program are as follows:

- *To demonstrate through the life of the Project that mitigation has maintained or improved population sizes and habitat of the Giant Barred Frog. The use of preconstruction, during construction and post construction monitoring to measure both frog distribution, abundance and habitat quality with defined thresholds will used to measure the overall performance of the mitigation; and*
- *To ensure that mitigation measures are effective in maintaining Giant Barred Frog connectivity near the Project.*

Based on the results to date, the UWC GBF population has not been maintained or improved, but has declined. However, the reduction in GBF population is not attributable to non-compliance with mitigation measures, as all construction mitigation measures as recommended within the GBFMS have been implemented. While this is the last monitoring event to be conducted during the construction phase, operational phase monitoring will now commence and continue over a six-year period with three monitoring events during Years 1, 3 and 5 of operational phase. Continued monitoring during the operational phase will provide further information on the GBF population post-revegetation of the habitat and operational phase of the project. This will provide information on the longer-term trends of the GBF population at UWC.

A summary of the Key Performance Indicators (KPIs) which informs the GBF monitoring during the construction phase of the project has been completed (refer to **Table 6.1**) and indicates all monitoring complies with KPIs (or objectives) where relevant. Despite this, the objective of maintaining or improving the GBF population at UWC has not been achieved.

Future GBF monitoring as part of the operational phase of works will continue to provide data which will provide further insight into the GBF population trajectory at UWC. Implementation of targeted restoration works at UWC will also assist in embellishing GBF habitat where construction works have occurred.

1. Introduction

1.1 Project Overview

The Pacific Highway Upgrade Program is a joint commitment by the Australian and New South Wales governments to improve the standard and safety of the Pacific Highway between Hexham and the Queensland border.

The NSW Minister for Planning approved the Warrell Creek to Urunga (WC2U) Pacific Highway Upgrade Project (the Project) under Part 3A (now repealed) of *the Environmental Planning and Assessment Act 1979* (EP&A Act) on 19 July 2011, subject to the Minister's Conditions of Approval (CoA) being met.

The WC2U Project comprises approximately 42 km of dual carriageway road that would bypass the towns of Warrell Creek, Macksville, Nambucca Heads and Urunga on the Mid North Coast of NSW. The Project has been divided into two stages with Stage 1 consisting of approximately 22.5 km from Nambucca Heads to Urunga (NH2U) and Stage 2 consisting of the remaining 19.5 km of dual carriageway between Warrell Creek and Nambucca Heads (WC2NH). This report relates to Stage 2 (WC2NH) as 'the Proposal' which is shown in **Illustration 1.1**.

The Giant Barred Frog (GBF) (*Mixophyes iteratus*) was assessed in the Project Environmental Assessment (Sinclair Knight Merz [SKM] 2010a, SKM 2010b) with regard to relevant State and Federal legislation. The GBF is listed as a 'Endangered' under both the NSW *Biodiversity Conservation Act 2016* (BC Act) and the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

An assessment of the impacts of the WC2NH Pacific Highway Upgrade Proposal on the GBF, in accordance with the *EPBC Act Policy Statement 1.1 Significant Impact Guidelines* (Department of Environment and Heritage – DoE 2013a) was prepared by Lewis Ecological (2014). This assessment found that the Proposal will have some substantial negative (incremental and cumulative) impacts to the GBF/ breeding aggregation/s whose home range encompass the Upper Warrell Creek and Butchers Creek Systems, mainly through habitat removal and fragmentation. None of the habitats present in the study area are registered on the current list of recommended or declared critical habitat in NSW (SKM, 2010). The majority of GBF and habitat that supports the subject GBF population at Upper Warrell Creek would not be affected by the Proposal.

The EA described the Project as unlikely to result in a significant impact to the subject local GBF population, provided effective implementation of proposed mitigation measures occurred.

1.2 Giant Barred Frog Habitat

Potential GBF habitat was identified during the Project Environmental Assessment; subsequently Lewis Ecological was engaged by Roads and Maritime Services (RMS) to conduct field surveys throughout nominated potential GBF habitat within the Project route alignment. A GBF population was recorded at Upper Warrell Creek and a management strategy prepared by Lewis Ecological to mitigate impacts to this species namely the *WC2NH Giant Barred Frog Management Strategy* (GBFMS).

As part of construction works, scheduled de-fishing activities were undertaken at Butcher's Creek on the 31 August 2015. Suspected GBF tadpoles were trapped and their identification confirmed by Professor Michael Mahony (University of Newcastle). Targeted GBF surveys were undertaken over several nights however no GBF were recorded within the survey area. Differing opinions were also received on the identification of Barred Frogs at the site, leading to the current thinking that *M. iteratus* do not currently occur at the site. Based upon the precautionary principle Butchers Creek is currently being managed as potential GBF habitat in accordance with the GBFMS and *Butchers Creek – Mixophyes Unexpected Find Summary (ref: 2378-1166) (GeoLINK 2015)*.

GBF population monitoring has been undertaken within both the Upper Warrell Creek and Butchers Creek systems within 450 m and 200 m (respectively) either side of the project route alignment. **Illustration 1.2** shows the location of the Butchers Creek GBF management zones. UWC GBF management zones (including results of the monitoring) are provided at **Illustration 2.1**.

1.3 Giant Barred Frog Description

The GBF (Mixophyes iteratus) is a very large frog with a snout to vent length of up to 115 mm in length. They are dark brown to olive green in colour and a distinctive golden iris with a vertical pupil. There have irregular dark spots or mottling on the flanks with a series of dark and pale crossbars of similar width on the limbs. Male GBF are generally smaller than females (with females generally >78mm snout to vent length) (Anstis, 2012) with adult males having small, dark pads (nuptial pads) present on the inside of thumbs to assist with holding females during mating.

GBF typically inhabit the riparian zone of permanent freshwater rivers and creeks along east of the Great Dividing Range to an elevation of 700 m above sea level. GBF is a terrestrial species which is typically found amongst deep leaf litter on a relatively open forest floor or understory, they prefer a vegetation canopy cover consisting of rainforest or sclerophyll species and are known to inhabitant riparian zones where the dominant canopy species is Camphor Laurel (*Cinnamomum camphora*) (Byron Creek near Bangalow NSW) (GeoLINK, 2013). Specific breeding habitat requirements consist of steep or undercut creek banks where they can flick the eggs up onto the banks. This occurs after the eggs are laid and fertilised within the water below. The eggs attach to the underside of the creek bank until the eggs hatch and the tadpoles drop into the stream or river below (Mahony, 2012). They need moderate to deep leaf litter on the forest floor for shelter and overwintering opportunities. They are typically found to occupy a narrow strip of riparian zone along the edge no more than 20 m from the stream edge. Particularly during the breeding season where males are known to defend a territory at the edge of the bank (Lemckert and Brassil 2000). Females however are known to travel over larger distances to seek new breeding habitats and opportunities.

The male call sounds like a deep guttural “ork” from the forest floor or from crevices under rocks, banks or overhanging tree roots (Cogger et al. 1983, Straughan 1968) during early spring to late autumn.

Survey effort for GBF is best undertaken when minimum night time air temperatures are above 18°C. GBF are recorded to be more active during warmer temperatures and higher humidity and male GBFs are heard to call more frequently above) 18°C (Koch and Hero 2007).

Lemckert and Brassil (2000) found that GBF are sensitive to impacts of riparian habitats and studies showed that undisturbed riparian zones, where a 30 m buffer was established, recorded a higher abundance when compared to nearby logged sites or sites impacted by cattle and other riparian zone disturbances.

A detailed description of the biology and ecology of the GBF is provided within the *WC2NH Giant Barred Frog Management Strategy* (Lewis Ecological, 2014).

1.4 Purpose of this Report

The purpose of this report is to document the findings of the seasonal GBF population monitoring for the periods of autumn and spring of 2017 and summer 2018 (Year 3) of the construction phase of GBF population monitoring, as prescribed in the GBFMS (Lewis Ecological, 2014). Similar monitoring was also completed in Year 1 of the construction phase, as per the GBFMS.

This report documents a summary of findings for the third monitoring event for Year 3 (summer 2018) and the analysis of the combined results of Year 3 monitoring (autumn and spring of 2017 and summer of 2018). The summer 2018 monitoring event is to be the last monitoring event undertaken as part of the construction phase monitoring contract facilitated by PACIFICO. Ongoing GBF population and habitat monitoring will be undertaken as part of the operational phase of the project, subject to the monitoring contract being awarded by RMS.

Information shown is for illustrative purposes only

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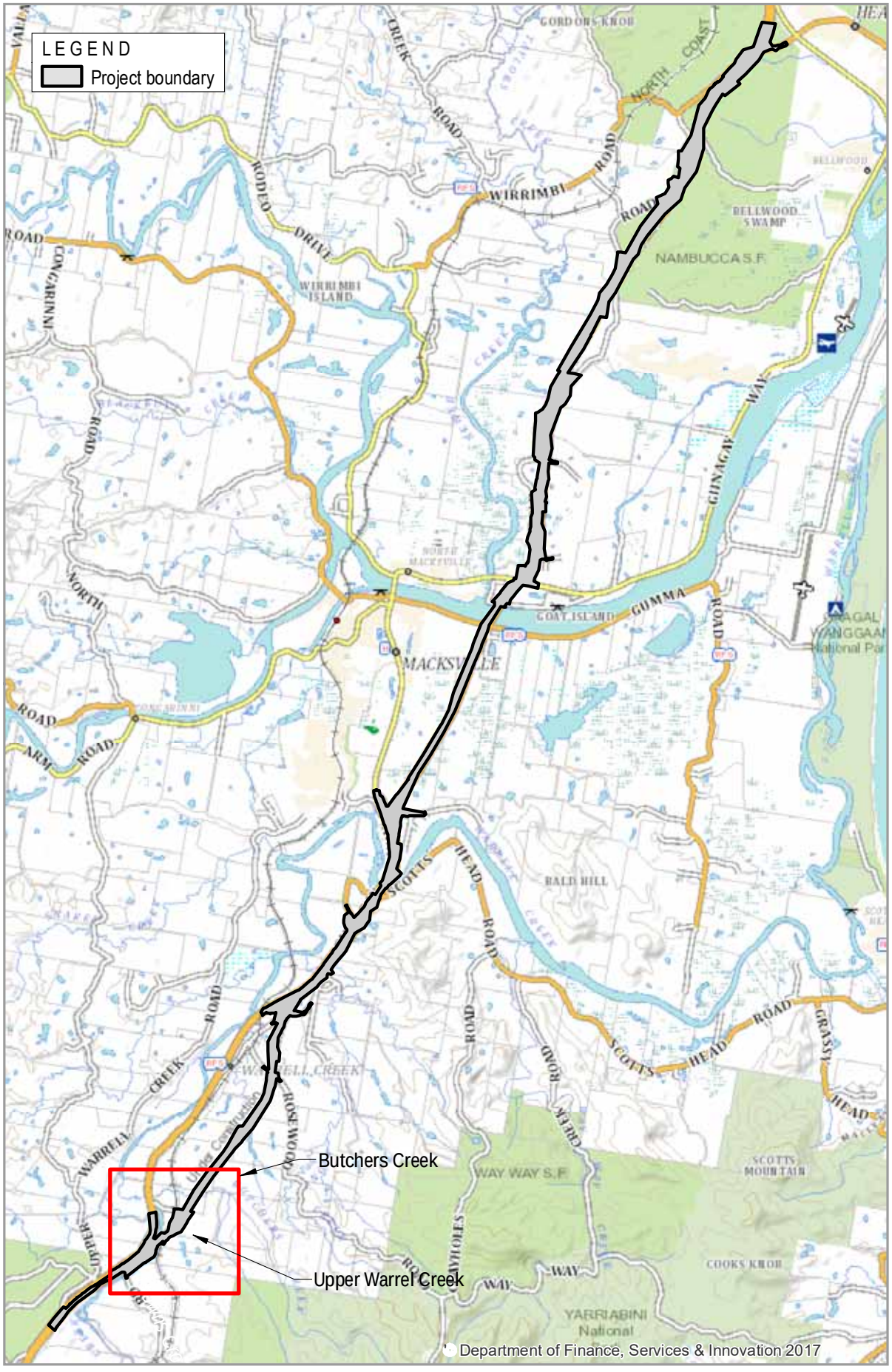
Source of base data: SIX Maps



0 1.5 km

North

Site Context

GeoLINK environmental management and design

WC2NH GBF Population Monitoring Annual Report
2378-1425

Illustration 1.1

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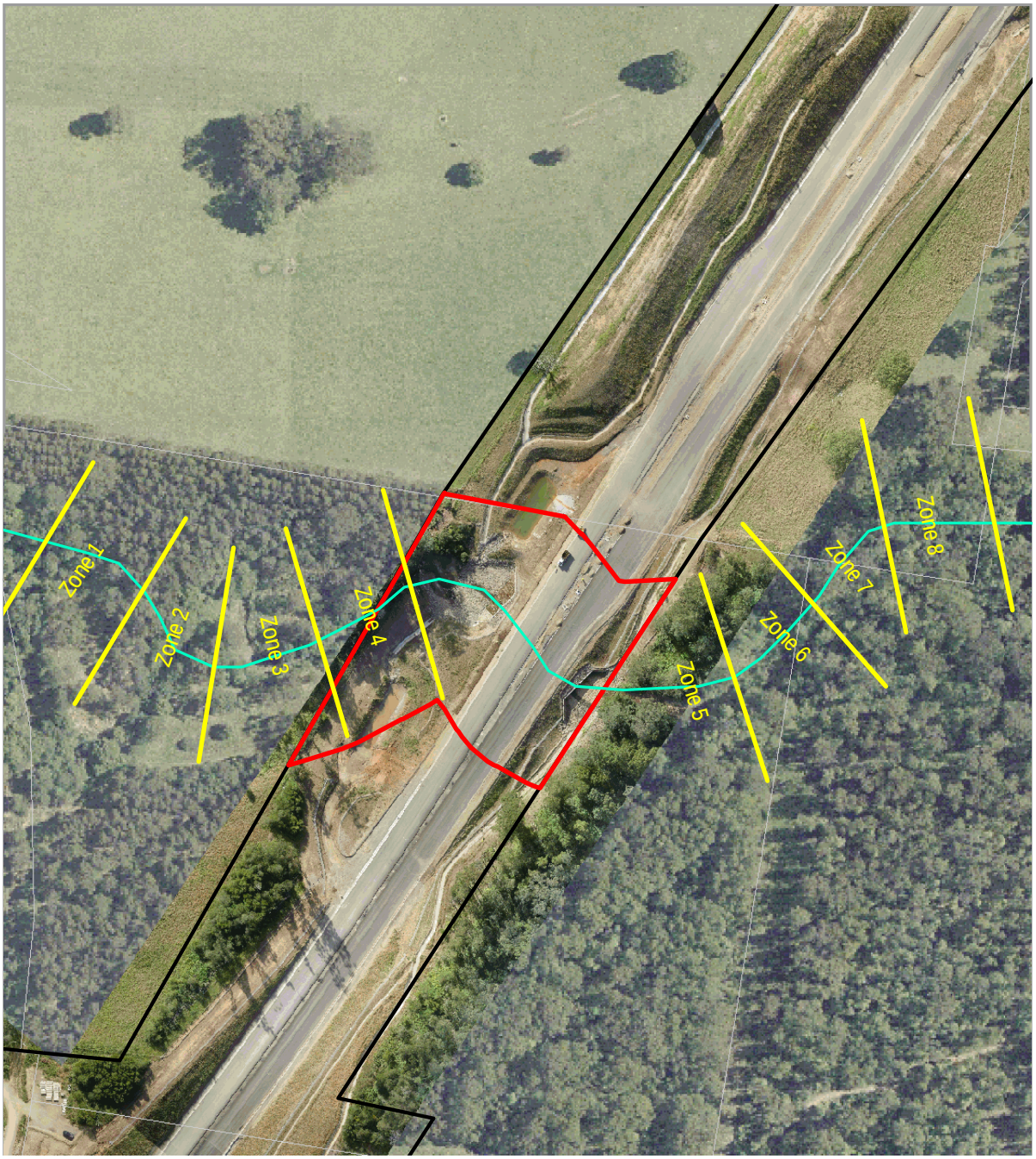
Source of base data: Pacifico



LEGEND
- Project boundary
- Butchers Creek
- 50 Metre buffer

North

0 60

Butchers Creek GBF Management Zones

2. Methodology

Field surveys were performed in accordance with the methodology outlined in the *Giant Barred Frog Management Strategy* and *Baseline Monitoring for Giant Barred Frog* for the project (Lewis 2013). Both of the aforementioned plans have been approved by the Department of Planning and Environment (DP&E) and the Environmental Protection Authority (EPA). A summary of the monitoring methodology is included below.

2.1 Timing of Surveys

Field surveys were undertaken during the following periods:

- **Autumn 2017 sampling**:
  - Field surveys were undertaken on 4 and 6 April 2017 in response to a rainfall trigger event of 52.4 mm recorded on 31 March 2017 with an additional 74 mm being recorded in the seven days leading up to the first day of monitoring (4 April 2017).
  - Upper Warrell Creek tadpole, water quality, habitat, abiotic and weather data was collected on 4 April 2017 with GBF population data collected over nights 4 and 6 April 2017.
  - Butchers Creek tadpole, water quality, habitat, abiotic, weather and GBF population data was collected on 6 April 2017.
  - GBF population monitoring (nocturnal) survey effort included 2 x 4 hours with a combined total of 16-person hours across 4 and 6 April 2017 at the UWC and Butchers Creek sites.
- **Spring 2017 sampling**:
  - Field surveys were undertaken on 6 and 7 November 2017, following a rainfall trigger event of 14.6 mm on 5 November 2017.
  - Upper Warrell Creek tadpole, water quality, habitat, abiotic and weather data was collected on 7 November 2017 with GBF population data collected over nights 6 and 7 November 2017 for a total of 13-person hours of nocturnal GBF surveys.
  - Butchers Creek tadpole, water quality, habitat, abiotic, weather and GBF population data was collected on 6 November 2017. Nocturnal GBF population survey effort included four-person hours at Butchers Creek.
- **Summer 2018 sampling**:
  - Field surveys were undertaken on 5 and 7 February 2018, following a rainfall trigger event of 22.6 mm on 4 February 2018.
  - Upper Warrell Creek tadpole, water quality, habitat, abiotic and weather data was collected on 5 February 2018 with GBF population data collected over nights 5 and 7 February 2018 for a total of 14-person hours of nocturnal GBF surveys.
  - Butchers Creek tadpole, water quality, abiotic, weather and GBF population data was collected on 7 February 2018. Nocturnal GBF population survey effort was 4.5-person hours at Butchers Creek. Habitat data was collected on 9 February 2018.

2.2 Frog Surveys

Frog surveys involved:

- Surveys completed within seven days of a rainfall event exceeding 10 mm in 24 hours using the Project weather station located at Warrell Creek Construction (Southern) Compound with data readings taken from the online data provider WeatherMation.
- Butcher's Creek has a 400 m transect with 200 m either side of the construction footprint (~100 m represents construction footprint) and divided into eight 50 m survey zones (refer to **Illustration 1.2**).
- Upper Warrell Creek has a one kilometre transect with 450 m either side of the construction footprint (~100 m represents construction footprint) and divided into 20 x 50 m survey zones (refer to **Illustration 2.1**).
- Each field survey involved a meandering, nocturnal transect on both sides of the stream bank with all GBF captured during autumn, spring and summer permanently marked (i.e. micro-chipped) using a PIT tag (Trovanunique ID100). Survey periods ranged from two to five hours per transect with variability in time length attributed to the site, variations in habitat, accessibility and the number of frogs being processed.

All GBF captured were scanned using a Trovan Microchip scanner (LID560) to detect existing PIT tags (i.e. micro-chips). Any frogs that scanned a negative result and had no visual signs of having been previously PIT tagged, were subsequently PIT tagged. The following information was collected for each frog:

- GPS location within demarcated survey zones.
- Distance from the stream edge measured to the nearest 0.1 m.
- Position within the microhabitat (i.e. under litter, above litter, exposed, on rock/ log).
- Sex (male, female, unknown).
- Age class (adult = >60 mm; sub-adult = 40-60 mm; juvenile = <40 mm).
- Snout-vent length (mm).
- Weight (grams).
- Breeding condition:
    - Males were assessed on the colouration of their nuptial pads (i.e. no colour, light, moderate, dark) in accordance with the classification developed by Lewis (2014; refer to **Table 2.1**). females were assessed based on whether gravid (i.e. egg bearing, with the adult weighing typically >100 grams) or not gravid.
    - Frogs measuring >78 mm snout to vent length were recorded as female unless they were confirmed to elicit a male breeding call.
    - Frogs with a snout vent length of <60 mm were classified as immature.

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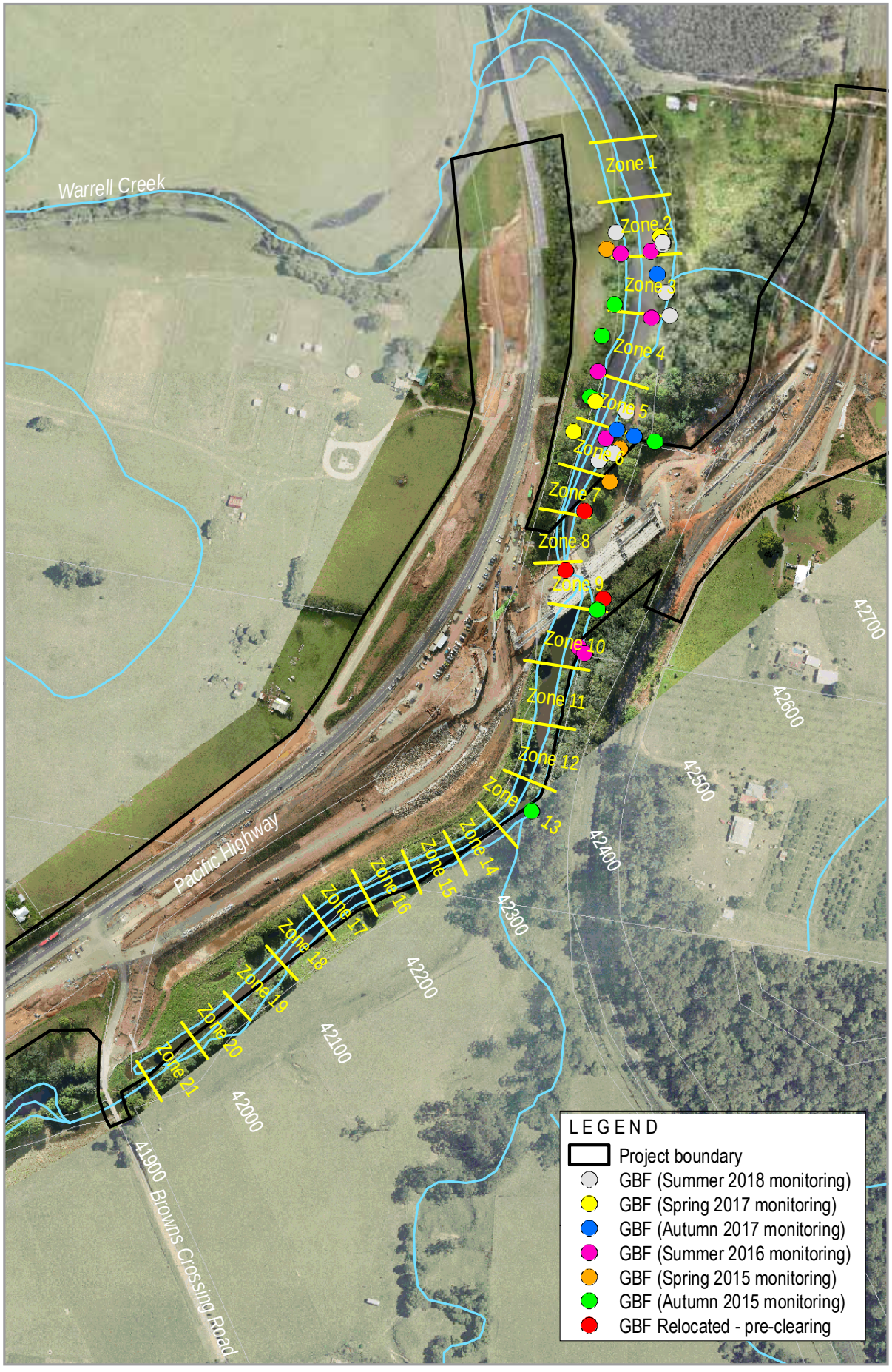
Source of base data: Pacifico



0 100

North

Upper Warrell Creek GBF Management Zones and GPS Capture Locations

Table 2.1 Key for Determining Reproductive Condition in Male GBF

Nuptial Pad Colour	*Comments*
No Colour	■ Males may be active or dormant but don't present as being sexually active to mate with females. ■ No colour can occur at any time throughout the year but pronounced periods include dry springs and late autumn with the onset of winter.
Light	■ Some colouration, indicating frogs are likely to become active (late winter) or have been active but generally not breeding. For example, prevailing weather conditions are unsuitable. ■ Frogs with light nuptials are generally on the shoulder periods of breeding events and a small percentage of the male population is likely to fall in this category at almost any time of the year apart from June and July.
Moderate	■ Males are normally active, will often readily respond to calls. Ready to mate with gravid females if weather conditions are suitable. These frogs may occasionally be involved in intraspecific aggression indicating their readiness to mate with females. ■ Colouring may be evident between August-May and is considered cyclic and surrounding breeding events.
Very Dark	■ Males are normally active, ready to mate with gravid females if conditions are suitable. ■ Some observations of intraspecific aggression can occur between males at this stage. ■ Colouring may be evident between August-May and is considered cyclic with early season suspected of being driven through warming air temperature whilst prevailing rainfall conditions are considered the primary cue during summer and autumn.

2.3 Swabbing for Chytrid Fungus

Swabbing for Chytridiomycosis (Chytrid fungus) was undertaken during Year 3 autumn, spring and summer monitoring events. The objective of the swabbing was to record the presence of Chytrid fungal disease in the population during construction and record any observations of frog health condition during construction in comparison to the pre-construction baseline monitoring. Chytrid Fungus is currently listed as a key threatening process in the BC Act.

The swabbing of frogs involved the use of a sterile swab and wiping the outer skin with a sterile cotton-tipped swab. The swab is wiped over the body creases, such as under the arms and inside of the thighs and groin, to collect loose skin samples. Swabs were then placed into a sterile container and held in a refrigerator until they could be delivered to Newcastle University for testing. All handling procedures were undertaken in accordance with the *Hygiene Protocols for the Control of Disease in Frogs* (DECW 2008).

2.4 Tadpole Surveys

Tadpole surveys were undertaken during the Year 3 monitoring events using the following procedure:

- At the Upper Warrell Creek site the one kilometre transect was divided up into 20 x 50 m zones with seven zones in the downstream corridor, five zones partially or totally within the construction corridor and eight zones upstream of the road corridor.
- Within each zone, one bait trap (~300 mm x 200 mm) was installed and left operating for a minimum of three hours. This equated to 20 bait traps and a minimum of 60 hours of survey effort per seasonal monitoring event.
- At the Butcher's Creek site, the 400 m transect was divided up into eight 50 m zones with four zones in the downstream corridor and four zones in the upstream corridor.

Dip-netting (at approximately every third transect) was undertaken to confirm the presence of GBF tadpoles during the Year 3 seasonal monitoring events. During these surveys the presence of exotic and native fish, bivalves and shrimp were also recorded.

2.5 Abiotic Data

The following abiotic data variables were collected during the survey:

- Rainfall measured in four scales:
    - During the survey
    - Within past 24 hours
    - Within past seven days
    - Within past 30 days.
- Relative humidity and air temperature measured at the start and finish of the nocturnal GBF survey using weather data collected from Southern Compound weather station; data was downloaded from the WeatherMation online portal.
- Wind speed measured in subjective scale (0= no wind, 1 = light rustles of leaves on trees, 2 = leaves and branches moving and 3 = whole canopy moving).
- Water level measured with a permanently installed water staff or an electronic device if available from the Bureau of Meteorology (BOM).

2.6 Habitat Data

The following habitat data was recorded at each of the 20 demarcated zones at Upper Warrell Creek and eight zones at Butchers Creek:

- Land use: Description of existing land uses of dairy cattle farming, beef cattle farming, private natural reserve.
- Broad vegetation type within the immediate riparian zone (primary stream bank): Riparian Rainforest, Dry Sclerophyll Forest, Woodland, Mallee; Heath/Shrub; Sedgeland, Grassland or Cleared Land.
- In stream physical characteristics including:
    - Stream width and depth (metres)
    - Presence of pools and/or riffles
    - Bed composition (sand, clay, rock, organic or other to be specified)
    - Type of emergent vegetation if present.

- Stream bank characteristics including bank profile expressed as steep, benched or a gradual incline from the water's edge.
- Vegetation associated with the stream bank in terms of foliage projection cover (FPC) for overstorey trees, shrubs and groundcover.
- Groundcover composition including a measure of vegetative ground cover, leaf litter cover, soil cover and exposed rock expressed as a composition percentage of 100 percent.
- The depth of leaf litter was also measured and assigned to one of the following categories:

    - Deep (>10 mm)
    - Moderate (20-100 mm)
    - Shallow (>0-20 mm)
    - Absent (0 mm).

2.7 Water Quality Data

Water quality monitoring via water samples (analysed in a lab) and in-situ water quality monitoring using a Horiba Multiprobe was undertaken as follows:

UWC:

- 4 April 2017
- 7 November 2017 and
- 5 February 2018.

Butchers Creek:

- 6 April 2017
- 6 November 2017 and
- 7 February 2018.

The following parameters were sampled for:

- Heavy metals including arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc.
- Hydrocarbons from the following groups:

    - Naphthalene group including TRH>C10-C16, TRH>C10-C16 less Naphthalene (F2), TRH>C16-C34, TRH>34-C40, TRH C6-C10 and TRH C6-C10 LESS BTEX (F1).
    - BTEX group including Benzene, Ethylbenzene, m&p-Xylenes, o-Xylene, Toluene and Xylenes – total.

- Nutrients including Nitrogen (as N), Suspended Solids and Total Phosphorus.
- Field physicochemical data including dissolved oxygen, conductivity, pH, temperature and turbidity.

Water quality data was analysed by Coffs Harbour Environmental Laboratory (Nata Accredited Laboratory); refer to **Section 3.4.6** for results.

3. Results

3.1 Abiotic Data

Autumn sampling was undertaken on 4 and 6 April 2017 in response to a rainfall trigger event of 52.4 mm recorded on the 31 March 2017 with an additional 74 mm being recorded in the seven days leading up to the first day of monitoring (4 April 2017). A total of 13.6 mm of rain fell during the nocturnal GBF survey period on the 6 April 2017 which was the only time where significant rainfall was received during a nocturnal survey period for any of the Year 3 monitoring events. This monitoring was conducted during the wettest month compared to both spring and summer survey efforts, with 467.2 mm of rain falling within 30 days prior to monitoring at UWC on 4 April 2017. The highest relative humidity of the three survey periods was recorded for autumn sampling starting at 82.1 percent increasing to 100 percent by 22:30 on 4 April 2017 at UWC and 85.2 percent increasing to 100 percent at Butchers Creek on 6 April 2017. Autumn 2017 did not record the lowest air temperatures (which could be reasonably expected) of the three seasonal monitoring periods. Autumn air temperatures at UWC ranged from 21.6°C at 17:30 decreasing to 15.2°C by 22:30. The lowest air temperature was recorded during spring 2017 sampling.

Spring sampling was undertaken at the Upper Warrell Creek site on 7 November 2017 and at Butcher's Creek on 6 November 2017, following a rainfall trigger event of 14.6 mm on 5 November 2017. Spring temperatures ranged from 18.7°C and 23.1°C decreasing to 16.9°C and 17.8°C respectively across both sites. Air temperatures recorded at UWC on 7 November were the lowest (18.7°C to 16.9°C) recorded for the seasonal monitoring events of Year 3. Humidity levels remained high throughout the monitoring period with records ranging from 64.3 percent and 77.8 percent increasing to 70.3 percent and 93 percent towards midnight.

Summer sampling was undertaken at Butcher's Creek on 7 February 2018 in response to a rainfall trigger event of 22.6 mm on 4 February 2018 with an additional 0.6 mm of rain recorded in the seven days leading up to the field survey. High relative humidity was recorded throughout the monitoring period ranging from 56 percent to 94.6 percent at 23:00. The temperature at the commencement of monitoring recorded 25.8°C dropping to 16°C at 23:00, the highest temperatures recorded for all Year 3 monitoring events. Wind conditions were still throughout the survey period.

Upper Warrell Creek summer sampling was undertaken on 5 and 7 February 2018 in response to a rainfall trigger event of 22.6 mm on 4 February 2018. Only 49.6 mm of rain fell in the 30 days prior to the monitoring period. This is considerably lower than the monthly average rainfall for January/ February, where monthly average rainfall for January is 145.8 mm and for February is 169.9 mm (based on historical measurements at Smokey Cape Lighthouse BOM, 2018). Summer sampling at this location recorded the highest air temperatures on 7 April and high relative humidity (89.7 percent increasing to 94.7 percent on 7 April).

All weather data records (except for wind) were collected by the Southern Compound Weather station with results downloaded from the online portal *WeatherMation*.

Abiotic data is summarised at **Tables 3.1 – 3.3**.

Table 3.1 Abiotic Conditions during Giant Barred Frog Population Monitoring 2017/ 2018

Date	Time	Time (24 hours)	Air Temp °C	Water Temp °C	Relative Humidity %	Wind	Rain during the survey (mm)
04/04/2017 UWC	Start time	17:30	21.6	20.74 Daytime	82.1	1 @ 14:30	0.6 (4/4/2017)
	Finish time	22:30	15.2		100		13.6 (6/4/2017)
06/04/2017 Butchers	Start time	14:00	20.7	19.23 Daytime	85.2	1 @ 15:00	13.6 (6/4/2017)
	Finish time	22:00	15.9		100		
07/11/207 UWC	Start time	19:30	18.7	19.11 Daytime	64.3	2 @ 10:00	0
	Finish time	24:30	16.9		70.3		0
06/11/2017 Butchers	Start time	19:30	23.1	18.04 Daytime	77.8	0 @ 20:00	0
	Finish time	21:30	17.8		93		0
05/02/2018 UWC	Start time	21:30	19.5	23.45 Daytime	89.7	1 @ 17:40	0
	Finish time	01:00	16.3		94.7		0
07/02/2018 Butchers	Start time	18:30	25.8	21.76 Daytime	56	0 @ 20:00	0
	Finish time	23:00	16		94.6		0

Table 3.2 Rainfall Data During Nocturnal Giant Barred Frog Population Monitoring 2017/ 2018

Rain	During (mm)	Past 24 hours (mm)	Past 7 days (mm)	Past 30 Days (mm)
04/04/2017 UWC	0.6	1.8	74	467.2
06/04/2017 UWC	13.6	17.4	77	465
06/04/2017 Butchers	13.6	17.4	77	465
07/11/207 UWC	0	6.8	22	152.8
06/11/2017 UWC	0	15	15.8	146
06/11/2017 Butchers	0	15	15.8	146
05/02/2018 UWC	0	0	25.2	49.6
07/02/2018 UWC	0	0	23	49.6
07/02/2018 Butchers	0	0	23	49.6

Table 3.3 Monthly Rainfall Data (mm) 23 January 2015 – 7 February 2018 (source: WC2NH southern weather station, data from weathermation.net.au)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2015	71.8	368.6	57.2	128.6	199.2	17	16.2	18.2	95.8	41.8	134.4	150.2
2016	115.8	83.4	32.6	79.8	7.2	379.2	25.4	143.2	29.2	38.2	20.2	23.4
2017	63.6	71.2	483	67.4	53.6	165.6	8.6	1.4	0	187	70	140.2
2018	100.6	23										

Table 3.4 Average Monthly Rainfall Data (mm) Smoky Cape, NSW (source: BOM, 2018)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
145.8	169.9	184.2	169.9	131.0	139.9	76.0	79.4	55.9	90.8	115.2	118.3

3.2 Giant Barred Frog Demography

3.2.1 Summary of Summer 2018 GBF Population and Habitat Monitoring

Eight GBF were recorded in total during the summer 2018 monitoring event, with all GBF recorded at UWC (refer to **Illustration 2.1**). One GBF could not be captured for data collection and was located north of the causeway on the eastern creek bank. Of the seven frogs captured, four frogs (00078ABC66, 00078ABBF2, 00078AA3F2 and 00078ABB9B) (all recorded as adult) were new records which had not been previously microchipped (refer to **Table A17** of **Appendix A**). Three frogs were recaptures (00077E9664, 00077E9014 and 00078ABD42). Frog 00077E9664 was first captured and microchipped during spring 2017 monitoring; Frog 00078ABD42 was first captured and microchipped during summer 2016; and Frog 00077E9014 was first captured and microchipped during spring 2015 and has since been captured during summer 2016, autumn 2017 and now summer 2018 (i.e. four times during construction phase monitoring).

A summary of frog recaptures over the total monitoring period is presented in **Table 3.5**.

Three of the eight frogs captured during summer 2018 were very large in size and weight and as such were recorded as females (refer to **Table 3.5**). Frog two (00078ABC66) (refer to **Plate 3.1**) weighed 130 grams and had a snout to vent (S2V) length of 95 mm. Frog 3 (microchip #00078ABBF2) (refer to **Plates 3.2 and 3.3**) weighed 152 grams and had a S2V length of 100 mm with the fourth frog captured (00077E9014) weighing 159 grams and 96 mm S2V (the largest frog captured since the commencement of monitoring; refer to **Plate 3.5**).

Anstis (2013) states that GBF measuring over 78 mm S2V can be classified as female, however at least one frog (00077E9664), possibly two (00078ABB9B), were confirmed to be male due to their detection via audible vocal calls (a male only behaviour); however, both frogs were measured with an 80mm S2V. Frog 00078ABB9B was captured on the first night of nocturnal surveys at UWC and was detected via eye shine, not calling. On the second night of surveys at UWC a frog was clearly seen via eye shine and through binoculars and calling from the same location. Therefore, the presumption has been made that frog 00078ABB9B is a male yet also measured 80 mm S2V.

No GBF were recorded at the Butchers Creek, consistent with all previous monitoring surveys.

Table 3.5 Records of Recaptured Frogs Overtime – Years 1 and 3 of Construction Monitoring

Date of Capture	*Frog Microchip ID #*	*Weight (grams)*	*Snout to Vent Length (mm)*	*Sex*	*Age Class*	*Nuptial Pad colour*	*Recaptured Y/N*
20/11/2015	00077E9014	85	80	Unknown	Adult	Light grey	No
10/02/2016		99	91	Unknown	Adult	Dark	Yes - in spring 2015
6/04/2017		131	88	Female	Adult	Light	Yes – in spring 2015 and Summer 2016
5/02/2018		159	96	Female	Adult	Moderate	Yes – in spring 2015, summer 2016 and autumn 2017
20/11/2015	00077E8297	93	82	Male	Adult	Light grey	No
10/02/2016		95	83	Unknown	Adult	Dark	Yes - in spring 2015
10/02/2016	00078ABD42	71	76*	Male	Adult	Moderate	No
7/02/2018		61	72	Male	Adult	Light	Yes - in summer 2016
6/11/2017	00077E9664	61	66	Unknown	Adult	Moderate	No
5/02/2018		66	80	Male	Adult	Moderate	Yes - in spring 2017

*A discrepancy regarding measurements of this frog has been recorded with a larger number recorded for February 2016 capture. February 2018 is the accurate figure.

Plate 3.1 Frog 00078ABC66 (new capture) measured 95 mm snout to vent length and 130 grams

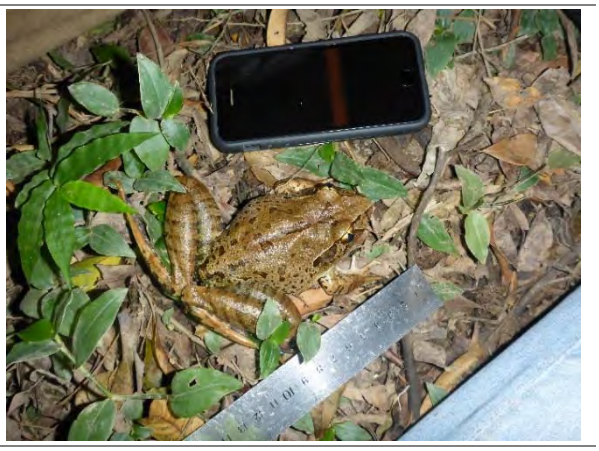


Plate 3.2 Frog 00078ABBF2 (new capture) was the longest frog measured at 100 mm snout to vent length and 152 grams

Plate 3.3 00078ABBF2 (new capture) photo of nuptial pads recorded as moderately grey (note this frog was recorded as female)

Plate 3.4 Frog 00077E9014 (recapture) is the heaviest frog captured weighing 159 grams and has been captured four times over Years 1 and 3, first in spring 2015

Habitat Monitoring

Based on habitat monitoring to date GBF habitat along the transects has largely remained unchanged (refer to **Table A20** of **Appendix A**). The exception to this is where riparian habitat has been removed within Zones 9 and 10 as part of the highway construction, and Zone 5 due to utility relocation work (undertaken by previous contractors). This includes habitat areas where a concentration of GBF captures were made during baseline surveys.

Additionally, water levels at Butchers Creek have dropped considerably since the commencement of monitoring, with a drop of ~105 cm since the initial water level measurement was taken in April of 2015. Below average monthly rainfall was received in the lead up to spring 2017 and summer 2018 monitoring. Rainfall averages are compared from the Smokey Cape monthly rainfall averages (refer to **Table 3.4)** to the rainfall received at the Southern Compound weather station (refer to **Table 3.3**). A number of pools and sections with stream flow which previously recorded moderate water depth and flow are now completely dry or significantly reduced (refer to **Plate 3.5** and **3.6**). Weeds have begun to encroach on the now dry creek bed and along the creek bank at Zones 6 and 7. Pasture grasses such as Broad-leaved Paspalum (*Paspalum mandiocanum*) and Pigeon Grass (*Setaria sphacelata*) have started to invade the dry creek bed. Along with dense infestations of Lantana (*Lantana camara*) and Small-leaved Privet (*Ligustrum sinense*) growing along the banks of Zones 6 and 7 these weed infestations have the potential to become a barrier to frog movement. However, Butchers Creek is not considered as confirmed GBF habitat, based on the monitoring results to date.

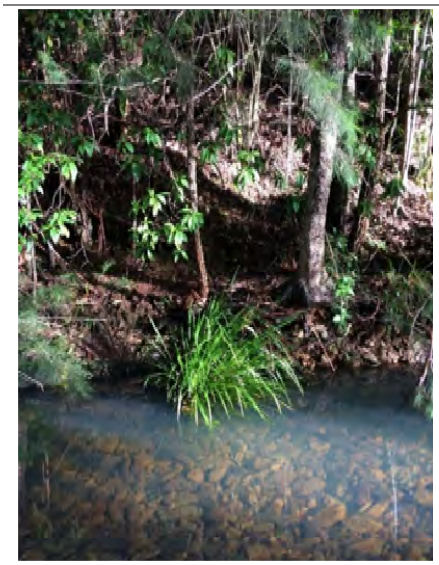


Plate 3.5 Butchers Creek water level between Zones 5 and 6 autumn 2017

Plate 3.6 Butchers Creek water level between Zones 5 and 6 summer 2018

3.2.2 Year 3 Seasonal Monitoring Captures and Age Classes

A total of 14 GBF were recorded during the autumn and spring 2017 and summer 2018 population monitoring for Year 3 of construction, with all frogs were recorded within the Upper Warrell Creek system. Three frogs were recorded during autumn, three during spring (one individual recorded twice over two nights) and eight during summer (the current monitoring period). This indicates a reduction in GBF records when compared to Year 1 results, where 16 GBF were recorded for the monitoring period. These numbers also include recaptured frogs and frogs which were not captured but could be confirmed as male GBF by their calling behaviour. The results of both monitoring events (Years 1 and 3) indicate a reduction in the GBF population at UWC when compared with baseline monitoring, where 47 GBF were recorded during spring/summer of 2013 and autumn of 2014.

During Year 3 seasonal monitoring, eight confirmed males were captured (two of which were recaptures), four females (two of which were recaptures of the same frog) were captured, and two frogs were captured and recorded as sex unknown, with one frog (0077E9664 a recapture) later being sexed as male. All frogs were classified as adults except for one sub-adult recorded on the 6 April 2017. The sub-adult frog (00077E7E20) recorded the shortest S2V length captured was a likely a male which weighed 54 g and 72 mm S2V. The frog (00078ABC23) with the lightest weight was recorded at 60 grams and 76 mm during summer 2016.

A summary of GBF numbers captured during Years 1 and 3 of construction monitoring is provided in **Figure 3.1** with locations of frogs captured shown in **Illustration 2.1**. A summary of capture data including weight, snout to vent length and microchip data for GBF captured during the monitoring is summarised in **Table 3.6;** all raw data recorded is provided in **Appendix A**.

Since the commencement of construction phase monitoring no GBF previously captured and microchipped by Lewis have been recorded (refer to **Section 3.4.4** for further discussion).

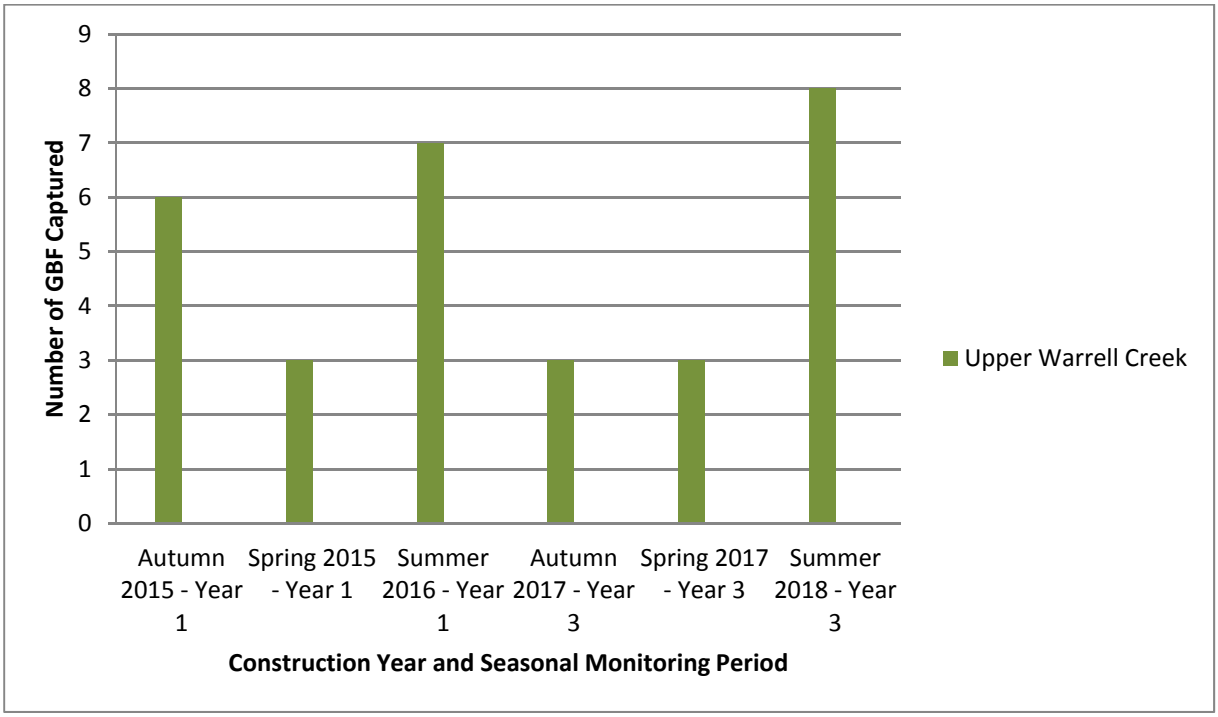


Figure 3.1 Giant Barred Frog records over six seasonal monitoring events during Years 1 and 3 of construction

Notes:

- Four male frogs recorded across the monitoring events were identified by calling behaviour but could not be located due to being buried beneath leaf litter or due to cessation of calling.
- Due to technical equipment issues no microchip capture data was collected during autumn 2015 surveys.

Table 3.6 Summary of Giant Barred Frog capture/ record data during seasonal population monitoring for Years 1 and 3 of construction

Monitoring season and year	*Date of Capture/ record*	*Frog Microchip ID #*	*Weight (grams)*	*Snout to Vent Length (mm)*	*Sex*	*Age Class*	*Nuptial Pad colour*	*Recaptured Y/N*
Autumn 2015 – Year 1	5/05/2015	Unknown	97	81	Male	Adult	Moderate	Unknown
	5/05/2015	Unknown	142	103	Female	Adult	Light	Unknown
	5/05/2015	Unknown	124	86	Unknown	Adult	Light	Unknown
	5/05/2015	Unknown	115	86	Unknown	Adult	Black	Unknown
	5/05/2015	Unknown	123	100	Unknown	Adult	Dark	Unknown
	5/05/2015	Unknown	121	91	Unknown	Adult	Med/dark	Unknown
Spring 2015 – Year 1	20/11/2015	00077E8DB9	97	85	Male	Adult	Light grey	No
	20/11/2015	00077E8297	93	82	Male	Adult	Light grey	No
	20/11/2015	00077E9014	85	80	Unknown	Adult	Light grey	No

Monitoring season and year	Date of Capture/ record	Frog Microchip ID #	Weight (grams)	Snout to Vent Length (mm)	Sex	Age Class	Nuptial Pad colour	Recaptured Y/N
Summer 2016 – Year 1	10/02/2016	00077E9014	99	91	Unknown	Adult	Dark	Yes - in spring 2015
	10/02/2016	00077E8297	95	83	Unknown	Adult	Dark	Yes - in spring 2015
	10/02/2016	00078ABC23	60	76	Male	Adult	Moderate	No
	10/02/2016	00078ABD42	71	76	Male	Adult	Moderate	No
	11/02/2016	00078ABE43	109	92	Unknown	Adult	Light	No
	11/02/2016	00078ABC3B	74	75	Unknown	Adult	Light	No
	11/02/2016	00078ABC9A	74	78	Unknown	Adult	Light	No
Autumn 2017 – Year 3	4/04/2017	Identified by visual observation and response to call playback			male	Adult	Not captured	
	6/04/2017	00077E9014	131	88	Female	Adult	Light	Yes – in spring 2015 and Summer 2016
	6/04/2017	00077E7E20	72	54	Unknown likely male	Adult	Moderate	No
Spring 2017 – Year 3	6/11/2017	00077E9664	61	66	Unknown	Adult	Moderate	No
	6/11/2017	00077E8FEF	69	72	Unknown	Adult	Moderate	No
	6/11/2017	Identified by response to call playback			Male	Adult	Not captured	
	7/11/2017	Identified by response to call playback			Male	Adult	Not captured	
Summer 2018 – Year 3	5/02/2018	00077E9664	66	80	Male	Adult	Moderate	Yes - in spring 2017
	5/02/2018	00078ABC66	130	95	Female	Adult	Moderate	N
	5/02/2018	00078ABBF2	152	100	Female	Adult	Moderate	N
	5/02/2018	00077E9014	159	96	Female	Adult	Moderate	Yes – in spring 2015, summer 2016 and autumn 2017
	7/02/2018	00078ABD42	61	72	Male	Adult	Light	Yes - in summer 2016
	7/02/2018	00078AA3F2	67	73	Male	Adult	Moderate	N
	7/02/2018	Identified by response to call playback			Male	n/a	Not captured	
	7/02/2018	00078ABB9B	71	80	Male	Adult	Moderate	N

3.2.3 Calculating Population Size

As per the GBFMS (Lewis Ecological, 2014; refer to **Figure 3.2**), the Lincoln-Peterson method was used to calculate GBF population size using GBF capture data from two monitoring events. Lewis Ecological used autumn and summer results to produce the population size estimate provided in the Baseline monitoring report. However, GeoLINK used spring and summer results for two reasons:

1. No microchip data was collected during autumn 2015 and therefore the confirmation of frog ID could not be used to input individual animals and recaptures into the equation; and
2. Because the spring and summer monitoring events for both Years 1 and 3 were undertaken across closer time periods. The Lincoln-Peterson equation assumes that the population being studied is closed, with visits to the study area close enough together so that no individuals die, are born or move into or out of the survey area between visits. It would be expected that over a three-month period there would be some decrease/ increase in population numbers over this timeframe, however the use of this equation is in keeping with the requirements of the GBFMS.

GBF capture data was used from spring 2013 and summer of 2014 for baseline monitoring, spring 2015 and summer 2016 for Year 1 and spring 2017 and summer 2018 for Year 3. To perform analysis on comparative data sets spring and summer results have been used for Baseline, Year 1 and 3 monitoring events.

Results of the population size estimates and equation workings are provided in **Table 3.7**.

The Lincoln-Peterson equation population size figures are based on GBF capture/ recapture data and the calculation population size estimate is in keeping with the actual catch/ recapture data trend. There has been a decline in GBF captures since baseline monitoring was undertaken during 2013/2014. The population estimate of the Lincoln-Peterson equation is higher for Year 3 than Year 1 due to the slightly lower number (one) of recaptured frogs within Year 3, making the population estimate slightly higher.

Table 3.7 Data input and Results of the Lincoln-Peterson Population Size Estimate Calculation for Year 1 and 3 of Construction Monitoring

Lewis Baseline Spring 2013 and Summer 2014 GBF Capture Data					
			Results		
N=((M+1)(C+1)/R+1)-1			**41**		
SE=sqrt{((M+1)*(C+1)*(M-R)*(C-R))/(R+1)*(R+1)*(R+2)}		420	**20.49**		Interval
95% confidence			**81.17**	0.83	80.34
Spring 2013 captures = **1** (not including recaptures or none captured frogs) FIRST VISIT = M	Summer 2014 Captures = **20** (not including recaptures or none captured frogs) SECOND VISIT = C	Number of animals captured on the first visit that were then recaptured on the second visit = R (**0**)			
735ADA8	7356782	zero			
	7352C35				
	7359051				
	735D187				
	7354569				
	735ABA3				
	735C8FA				
	7358816				

Lewis Baseline Spring 2013 and Summer 2014 GBF Capture Data					
	735B63D				
	7358320				
	7357C02				
	7357E40				
	7358A4D				
	735AFF6				
	73542F8				
	735339E				
	735B207				
	735BEA5				
	7352E8E				
	73542E6				

Year 1 Spring 2015 and Summer 2016 GBF Capture Data					
			Results		
N=((M+1)(C+1)/R+1)-1			**7**		
SE=sqrt{((M+1)*(C+1)*(M-R)*(C-R))/(R+1)*(R+1)*(R+2)}		2	**1.41**		Interval
95% confidence			**9.77**	4.23	5.54
Spring 2015 captures = **3** (not including recaptures or none captured frogs) FIRST VISIT = M	Summer 2016 Captures = **5** (not including recaptures or none captured frogs) SECOND VISIT = C	Number of animals captured on the first visit that were then recaptured on the second visit = R (**2**)			
00077E8DB9	00078ABC23	00077E9014			
00077E8297	00078ABD42	00077E8297			
00077E9014	00078ABE43				
	00078ABC3B				
	00078ABC9A				

Year 3 Spring 2017 and Summer 2018 GBF Capture Data					
			Results		
N=((M+1)(C+1)/R+1)-1			**8.33**		
SE=sqrt{((M+1)*(C+1)*(M-R)*(C-R))/(R+1)*(R+1)*(R+2)}		3.111111111	**1.76**		
95% confidence			**10.46**	4.88	5.58
Spring 2017 captures = **2** (not including recaptures or none captured frogs) FIRST VISIT = M	Summer 2018 Captures = **6** (not including recaptures or none captured frogs) SECOND VISIT = C	Number of animals captured on the first visit that were then recaptured on the second visit = R (**1**)			
00077E9664	00078ABC66	00077E9664			
00077E8FEF	00078ABBF2				
	00077E9014				
	00078ABD42				
	00078AA3F2				
	00078ABB9B				

Table 3.8 Results of the Lincoln-Peterson Population Size Estimate Calculation for Baseline, Year 1 and 3 of Construction Monitoring

	Baseline (2013/2014)	*Year 1 (2015/2016)*	*Year 3 (2017/2018)*
GBF Population Estimate	41	7	8.3
Standard Error	20.49	1.41	1.76
95 % confidence interval	81.17	9.77	10.46

2.7 Determining Population Size

The Lincoln–Petersen method (also known as the Petersen–Lincoln index) was used to calculate the population size. This method was used in preference to the triple catch calculation given the low numbers of frogs recorded during the spring survey would only inflate the population estimate. The Lincoln–Petersen method is used to estimate population size when only two visits are made to the study area and assumes the study population is "closed". In other words, the two visits to the study area are close enough in time so that no individuals die, are born, move into the study area or move out of the study area between visits. The model also assumes that no marks fall off animals between visits to the field site by the researcher, and that the researcher correctly records all marks.

The Lincoln–Peterson estimator is asymptotically unbiased as sample size approaches infinity, but is biased at small sample sizes. An alternative less biased estimator of population size is given by the Chapman estimator.

- $$N = \frac{(M+1)(C+1)}{R+1} - 1,$$

Where, as before:

N = Estimate of total population size
M = Total number of animals captured and marked on the first visit
C = Total number of animals captured on the second visit
R = Number of animals captured on the first visit that were then recaptured on the second visit

An approximately unbiased variance of N, or var (N), can be estimated as:

- $$\mathrm{var}(N) = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)(R+1)(R+2)}.$$

As in all estimates, it is also useful to have some information about the uncertainty of the estimate (as measured by the standard error (SE), and/or by 95% confidence intervals). The standard error of the estimate of N is given by the following formula:

SE = sqrt { [(M+1)(C+1)(M-R)(C-R)] / (R+1)²(R+2) }

The standard error gives an idea of where the sample mean is likely to be found if the experiment were conducted repeatedly. From the standard error, we can also calculate the 95% confidence limits of the estimate (which defines the range of values within which the true population size is likely to lie with 95% certainty), using the following formula:

- 95% confidence interval = $N \pm (1.96)(SE)$

Figure 3.2 The Lincoln-Peterson Equation to calculate population size (excerpt from page 8 of Baseline Monitoring Report within the GBFMS (Lewis Ecological, 2014))

3.2.4 Sex Classes

No juveniles and only one sub-adult was recorded over all seasonal monitoring periods for Years 1 and 3 of construction. The single sub-adult (54 mm in length) was captured and microchipped (00077E7E20) during autumn 2017. No confirmed females were observed as being gravid during the monitoring period; larger females were gently felt around the abdomen for the presence of eggs but no gravid females were confirmed. Any GBF weighing over 100 grams were recorded as females, as per Anstis (2013). For Year 3 monitoring, frogs measuring greater than 78 mm were also recorded as female unless they were confirmed to elicit a vocal breeding call suggesting the animal was male. Male GBF were heard calling during all seasonal monitoring events during Year 3.

During Year 1 summer 2016 two males were confirmed by calling in response to call playback; the remaining summer GBF were recorded as 'unknown sex'. Two GBF were recorded side by side within 1.0 m from each other in Zone 10; one large individual may have been a female due its significant weight of 109 grams. Spring 2015 monitoring recorded two confirmed males and one unknown. Autumn 2015 monitoring recorded one male, one female (142 g) and four frogs of undeterminable sex. Details of nuptial pads for each frog captured are shown in **Table 3.3**. It should be noted that all frogs handled displayed swollen pads, with the scale of grey difficult to be decisively determined with regards to the breeding condition of male frogs (as per Lewis Ecological 2014).

During spring 2017 monitoring, a tadpole was captured within a tadpole trap set within a pool in Zone 7 of Butchers Creek. Using the keys in Anstis (2013), it was concluded that the tadpole was the Greater Barred Frog (*Mixophyes fasciolatus*); refer to **Plates 3.7** and **3.8**) and not the GBF.

The following descriptors of the tadpole were noted:

- Venter is a whitish-blue sheen no gold or bronze as in *M. iteratus*.
- Dorsum is dark golden brown not bright gold with distinct gold patches as in *M. iterates.*
- The tadpole is approximately stage 25-27 but does not have a distinct dark band across the base of the body or around the mid ventral region or gills area. The dorsum is not predominantly gold as for *M. iteratus*.
- Gold iris is present but no gold ring around the pupil as for *M. iteratus.*
- The eye is more flattened in the head not prominent (slightly bulging) as for *M. iteratus.*
- Although it does have more dark and angular spots on the tail than is typical for *M. fasciolatus.*
- Total approximate length 85 mm.

Plate 3.7 *Mixophyes fasciolatus* (Great Barred Frog) tadpole, top/side view - Butchers Creek – Zone 7

Plate 3.8 *Mixophyes fasciolatus* (Great Barred Frog) tadpole, ventral view - Butchers Creek – Zone 7

No tadpoles were recorded during any opportunistic dip netting or bait trap surveys during Year 1 seasonal monitoring events.

3.3 Presence of Chytrid Fungus

All frogs captured during the spring 2015 and summer 2016 and Year 3 sampling periods were swabbed for Chytrid fungus (*Batrachochytrium dendrobatidis*). No GBF were observed to be in poor health or show any obvious signs of Chytridiomycosis during the sampling period. Chytrid swab analysis is performed in Michael Mahony's laboratory at the University of Newcastle.

Of the 10 frog captures for Year 1 monitoring, two frogs (00078ABD42 and 00078ABE43) returned a positive result for Chytrid at 5.48 (m/µl) and 3.31 (m/µl) respectively of three analyses (refer to **Table 3.9**). Of the 11 frog captures for Year 3 monitoring, one frog (00078ABBF2) returned a positive result for Chytrid at 0.02828 mean infection level of three analyses.

One frog (00078ABD42) that was sampled during summer 2016 was recaptured during summer 2018, showed a very low infection level in summer 2016, and was clear of infection two years later in summer 2018.

The sampling methodology and discussion of results regarding Chytrid sampling has been provided by Michael Mahony for the WC2NH GBF Annual Report, refer to **Appendix D**.

Table 3.9 Chytrid Swab analysis results

Monitoring Year	*Frog ID #*	*Date*	*Mean Chytrid infection (molecules/µl)*
Year 1	00077E8DB9	20 November 2015	0.0
	00077E8297	20 November 2015	0.0
	00077E9014	20 November 2015	0.0
	00077E9014	10 February 2016	0.0
	00077E8297	10 February 2016	0.0
	00078ABC23	10 February 2016	0.0
	00078ABD42*	10 February 2016	5.48
	00078ABE43	11 February 2016	3.31
	00078ABC3B	11 February 2016	0.0
	00078ABC9A	11 February 2016	0.0
Year 3	00077E7E20	6 April 2017	0.0
	00077E9014	6 April 2017	0.0
	00077E9664	6 November 2017	0.0
	00077E8FEF	6 November 2017	0.0
	00077E9014	5 February 2018	0.0
	00077E9664	5 February 2018	0.0
	00078ABBF2	5 February 2018	0.2828
	00078ABC66	5 February 2018	0.0
	00078AA3F2	7 February 2018	0.0
	00078ABD42*	7 February 2018	0.0
	00078ABB9B	7 February 2018	0.0

*Denotes Frog 00078ABD42 which tested positive for Chytrid during Year 1 and returned a negative result during Year 3.

3.4 Habitat Use

3.4.1 Frog Distribution along the Transect

During Year 3 population monitoring frogs were captured within Zones 2-6 only, while during Year 1 monitoring frogs were captured within Zones 2-10 and Zone 13. Only during baseline monitoring were GBF recorded in Zones 2-20 (refer to Lewis Ecological, 2014). A core section of GBF habitat has been removed within Zones 8-10 due to construction of the piling pad and creek crossing. This area was where the highest number of frogs were captured during baseline monitoring, with 21 GBF captured in Zones 8 and 9 and a further six GBF were captured in Zone 10. Zones 8, 9 and 10 have now been fully or partially impacted by construction works.

3.4.2 Distance between GBF location and the stream edge

During Year 3 monitoring the mean distance from the stream edge of captured frogs during autumn was 1.6 m. Spring monitoring also recorded a mean distance from the stream edge of 1.6 m with the summer monitoring recording an average distance of 2.2 m from the stream edge. Summer 2018 monitoring recorded both the closest distance (0.5 m) and the furthest distance (7.5 m) from the stream edge for Year 3 monitoring. The GBF recorded 7.5 m from the stream edge during summer was the greatest distance from the stream edge of all records for Years 1 and 3 of construction phase monitoring.

During Year 1 monitoring the mean distance from the stream edge of captured frogs was 1.7 during summer was 1.7 m, 2.3 m during spring and 2.6 m during autumn. One frog was recorded 7.0 m from the stream edge during autumn (the greatest distance from the stream edge of all records in Year 1).

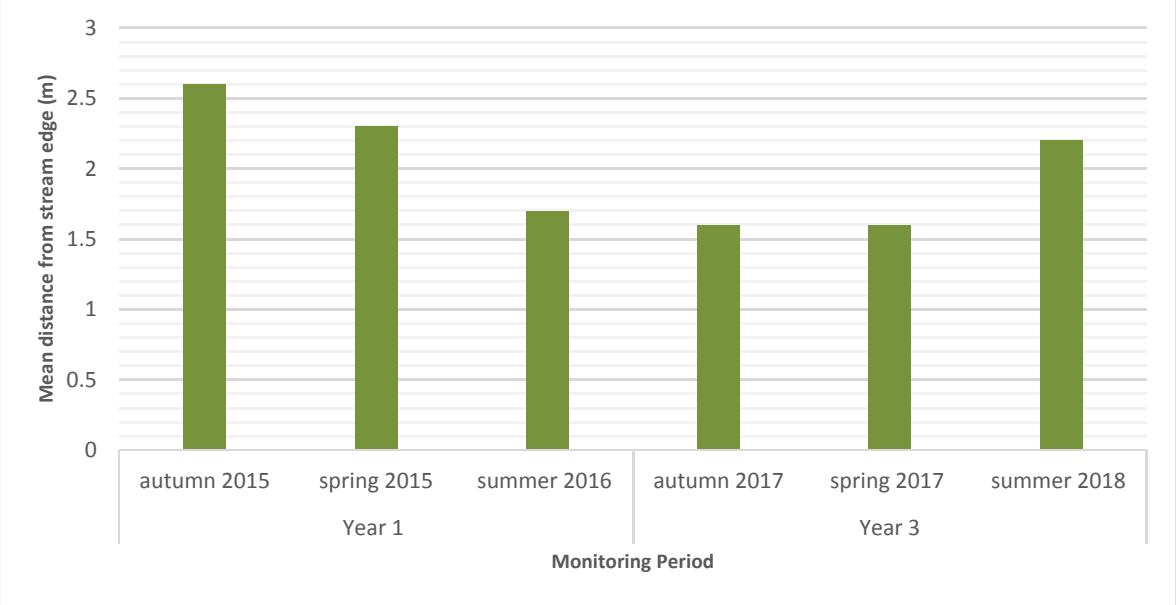


Figure 3.3 Mean distance of Giant Barred Frogs captured in proximity to the stream edge over six seasonal monitoring periods during Years 1 and 3 of construction

3.4.3 Position within the microhabitat

During Year 3 autumn and spring monitoring all GBF were captured from their position above leaf litter and riparian vegetated canopy cover. During summer of Year 3 monitoring, 5 of 8 GBF captured were completely or partially buried amongst leaf litter and soil (one GBF could not be located for this reason); two GBFs were located above leaf litter but under low riparian vegetation with the first frog capture on the 5 February 2018 captured from an exposed position on exposed soil under a tall riparian canopy.

3.4.4 Movements of recaptured frogs within the habitat

During Year 3 two GBF were recaptured during the summer monitoring that were previously captured and microchipped during autumn and spring 2017 (refer to **Table 3.5** and **Illustration 3.1**). Frog ID # 00077E9014 increased in length by eight millimetres and weight by 28 grams between autumn 2017 and summer 2018. This frog was first captured in spring 2015 (Year 1) on the western bank of Zone 2 and was recaptured during summer in Zone 4 having moved south by a minimum distance of 100 m. During Year 3 the same frog was captured during autumn in Zone 5 on the eastern bank and in summer 2018 was recorded within Zone 6, approximately 40 m from its autumn capture point.

During Year 1 this female frog was captured twice on the western bank and during Year 3 has now been recorded twice on the eastern bank indicating that this frog has crossed to the opposite bank either by swimming across UWC (approximate width of 23 m) or over land making the crossing near the downstream side of the causeway and GBF exclusion fence within Zone 8. Frog 00078ABD42 (male) was first captured in spring 2015 in Zone 2 on the western side of the creek while in summer 2018 monitoring the same frog was captured within Zone 3 on the eastern side of the creek indicating that this frog has also crossed the creek or travelled over land to the eastern creek bank. Frog 00077E9664 was first detected within Zone 6 during spring 2017 on the western bank and by summer 2018 monitoring had travelled a minimum distance of ~170m to Zone 2. All frogs have been recorded within 7.5 m from the edge of the stream.

No GBF which were captured and microchipped by Lewis during 2013/2014 baseline monitoring have been captured.

It appears that all frogs microchipped and recaptured at a later date have moved from their original capture location with the shortest distance being a minimum distance of 40 m and longest distance of 170 m over four captures events. Two frogs have been recorded moving from the western bank to the eastern bank across monitoring events.

3.4.5 Habitat Condition

Habitat conditions have been described in detail within the *WC2NH GBF Baseline Monitoring* (Lewis Ecological, 2014). Since the UWC habitat conditions were originally described (including the riparian zone and instream physical features), little has changed within the GBF management area in terms of vegetation. More dynamic characteristics such as ground cover, leaf litter, water levels have recorded change as would be expected, however riparian zone data largely remains the same (refer to Upper Warrell Creek habitat data in **Appendix A)**.

The general land use and broad classification type has been described in detail within the Baseline Monitoring of the GBFMS (Lewis Ecological, 2014). Since the GBFMS was completed the site land use has remained largely the same, with the exception of the construction of the WC2NH project alignment. To facilitate construction of the Upper Warrell Creek bridge, piling pads have been

installed on both sides of the creek bank and a large trafficable rock and concrete creek crossing has been installed within Zones 8 and 9, with some impacts to Zone 10. These structures have directly impacted GBF habitat. A number of frogs were captured and relocated outside of the works footprint as part of pre-clearing surveys and the establishment of the GBF temporary fence and frog exclusion zone.

3.4.5.1 UWC Habitat Changes

Changes to GBF habitat during Year 3 of monitoring within the UWC system are as follows:

- Zone 5 has had a corridor of vegetation cleared for powerlines which has left a 20 m wide corridor of felled tree trunks, limbs and branches which obstructs north to south passage along the width of the western bank from the water level to the top of bank.
- Increased growth of grass and herbaceous species within Zone 8 (refer to **Plate 4.3** in Section 4.2).

3.4.5.2 Butchers Creek Habitat Changes

Changes to GBF habitat during Year 3 of monitoring within the Butchers Creek system are as follows:

- The most significant change to the potential GBF habitat at Butchers Creek is the reduction in the water level of the creek since the commencement of monitoring.
- Increased growth of weed species within Zones 6-8.

The UWC GBF habitat has been effectively separated without options for natural GBF movement from one side of the causeway to the other, with the exception of flood events when GBF exclusion fencing is pulled back to allow free movement of flood waters (and potentially GBF) over the causeway in a northerly direction and downstream through the creek system.

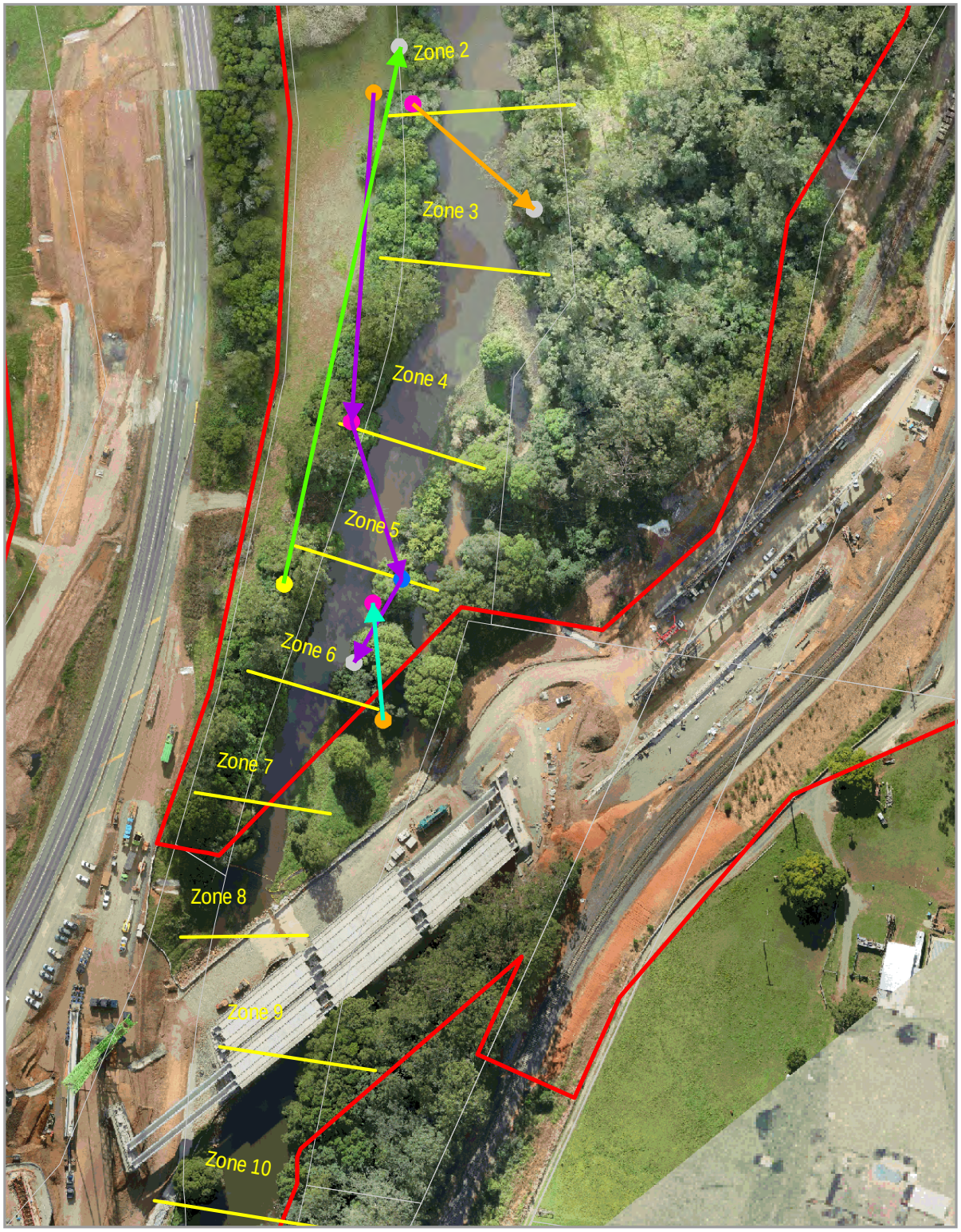
3.4.6 Water Quality Monitoring

Results from water quality monitoring undertaken during autumn and spring 2017 and summer 2018 at Upper Warrell Creek and Butchers Creek are presented in **Appendix B** with summary of results compared against the ANZECC water quality guidelines presented in **Appendix C**. There were no exceedances of the Australian and New Zealand guidelines for fresh and marine water quality (ANZECC/ ARMCANZ 2009) for 95 percent species levels of protection (for trigger values for freshwater) for metals or hydrocarbons. Where there was no trigger level available for metal or hydrocarbons from ANZECC/ ARMCANZ (2000) there were no recorded exceedances of the laboratory PQL (practical quantitation limit (PQL).

Nutrient concentrations (Total P and Total N) were recorded above the ANZECC/ ARMCANZ (2000) default trigger values for lowland rivers in south eastern Australia. Agricultural run-off from surrounding farmland is a likely source for such nutrients. Results for turbidity from the 2018 summer monitoring event at Upper Warrell Creek (upstream site) and Butchers Creek and results for pH (at Butchers Creek only) were below the ANZECC/ ARMCANZ (2000) default trigger values for lowland rivers in south eastern Australia.

Information shown is for illustrative purposes only

Drawn by: AB Checked by: RE Reviewed by: JOL Date: 28/02/2018
Source of base data: Pacifico



LEGEND

- Project boundary
- GBF (Summer 2018 monitoring)
- GBF (Spring 2017 monitoring)
- GBF (Autumn 2017 monitoring)
- GBF (Summer 2016 monitoring)
- GBF (Spring 2015 monitoring)

Frog Movement

- Frog Microchip ID: 00077E8297
- Frog Microchip ID: 00077E9014
- Frog Microchip ID: 00077E9664
- Frog Microchip ID: 00078ABD42

North

0 100

Giant Barred Frog Movements Within Habitat

3.4.7 The Addition of Butchers Creek GBF Management Zone

The previous land use within the surrounding area is predominantly cleared agricultural land for livestock grazing, however prior to construction the creek riparian zone was previously intact and comprised a predominantly native riparian zone. The remaining riparian vegetation within Zones 1-8 consists of Moist Open Forest (Flooded Gum) and is recognised as a mapped vegetation community for Project vegetation tracking purposes. Riparian species consist predominantly of Flooded Gum (*Eucalyptus grandis*), Turpentine (*Syncarpia glomulifera),* Brush Box (*Lophostemon confertus*), Bangalow Palm (*Archontophoenix cunninghamiana*), Maiden's Blush (*Sloanea australis*), Red Ash (*Alphitonia excelsa*), Camphor Laurel (*Cinnamomum camphora*) and Forest Oak (*Allocasuarina torulosa*).

Although habitat monitoring during Year 3 of construction has noted a change in species composition within Zones 6-8 with weed species such as Lantana, Small-leaved Privet and Camphor Laurel increasing in the upper strata and considerable encroachment into the presently dry (spring 2017 and summer 2018) creek bed by Broad-leaved Paspalum (*Paspalum mandiocanum*) and Pigeon Grass (*Setaria sphacelata*).

Butchers Creek does not flow permanently and has a pebble and sand substrate which encourages water to flow under the creek bed except during high flow events. Selected pools are retained during dry periods with these pools expanding and retracting depending on the frequency and size of rainfall events within the catchment.

Since the potential GBF unexpected find at Butchers Creek, this area has been nominated as a GBF management zone, with temporary exclusion fencing installed and the area under management in accordance with the *WC2NH GBF Management Strategy*. Monitoring zones have been established and habitat and abiotic data recorded for this area; refer to raw data in **Appendix A**. As noted previously, no GBF of any age class have been recorded at the Butchers Creek monitoring site. However, a known population of Great Barred Fogs (*Mixohyes fasciolatus*) occur at the site and have been recorded either visually or audibly during all monitoring events except for summer 2018.

4. Discussion

4.1 Capture and Age Class

A smaller number of GBF (n = 16) have been recorded during Year 1 seasonal population monitoring period than were recorded during the baseline population monitoring undertaken in 2013/2014, where a total of 47 GBF were recorded (including juveniles and sub-adult animals; this figure includes recaptured animals). Two less GBF (n = 14) were recorded during Year 3 seasonal monitoring than were recorded during Year 1.

A total of 14 GBF were recorded during the autumn/ spring/ summer Year 3 population monitoring, with all frogs captured within the Upper Warrell Creek system. All frogs were classified as adults except for one sub-adult recorded during autumn of 2017; no juveniles have been recorded during Year 1 or 3 population monitoring events. During Year 3 seasonal monitoring three frogs were recorded during autumn, four during spring and eight during summer. All frogs captured appeared to be in good health with no visible signs of disease or illness.

Data from Years 1 and 3 GBF population monitoring was input into the Lincoln-Peterson equation to estimate the population size of the UWC GBF habitat (refer to **Section 3.2.3**). Population size estimate figures for baseline, Year 1 and Year 3 seasonal monitoring were 41, 7 and 8.3 animals respectively. The population estimate largely supports the trend in reduced frog records at the site, with construction impacting core habitat zones likely to account for a reduction in frogs following the baseline monitoring.

The failure to record any tadpoles and just one sub-adult is a poor indication of population increase within the monitoring zone. Further monitoring during the operational phase of the project will provide better long-term data to determine how the GBF population may be persisting and recovering.

4.1.1 Recaptured Frogs

Three frogs were captured during autumn 2017 surveys; one was a recapture, one a new capture and one frog could not be located and was therefore not microchipped. During spring 2017 monitoring one frog was a recapture, one was a new capture and two of the four frogs recorded could not be captured and hence were not microchipped. Of the eight frogs recorded during summer 2018 monitoring three frogs were recaptures and four were new captures; one frog was not located and consequently not microchipped. No frogs captured and microchipped during Lewis Ecological surveys have been identified or recaptured during the population survey efforts of Years 1 and 3 seasonal monitoring.

This may be attributed to two hypotheses:

1. All frogs previously captured and microchipped by Lewis no longer occur within the survey area. This could be due to a combination of factors such as direct impacts from construction activities (i.e. direct frog mortality), or other causes such as population decline, natural mortality, flood events or other unknown triggers which have caused the frogs to move out of the survey area.
2. There is a technological issue with the chips used by Lewis during baseline monitoring and/or the scanner presently used by GeoLINK (refer to **Section 4.3** for further discussion).

4.1.2 Decrease in GBF recorded at UWC since baseline monitoring

A decrease in GBF detected within the survey area has been recorded. A key factor to the reduced number of GBF records during construction phase monitoring is likely due to the core GBF habitat through Zones 8-10 being directly impacted by the construction of the concrete causeway and bridge piling platforms. This impact was initially assessed and approved by the Department of Planning and Environment for the WC2NH Project.

Other factors which may explain the considerable reduction in GBF records since the baseline population monitoring include:

- Non-favourable survey conditions due to lower than usual rainfall.
- Lower than average monthly rainfall records and smaller than usual flood events.
- High mortality rate of the high number of juvenile and sub-adult frogs which made up a significant portion of the GBFs captured during baseline surveys.
- No successful breeding events during the years between monitoring and therefore no recruitment of juveniles.
- GBF previously captured or recorded by Lewis have moved out of the survey area (eg.to find better breeding opportunities or have been displaced due to flood events).
- Reduced health or death in the population due to disease. However, this seems unlikely as all frogs captured appeared to be in good health and results of Chytrid swabbing have only returned three positive results in the lower range, one of which was swabbed the following year and returned a negative result to Chytrid testing.

Detectability of GBF is considerably difficult when they are submerged beneath leaf litter and soil, particularly if they are female and do not call. Additionally, some male frogs which can be clearly heard calling from the leaf litter cannot always be successfully located and captured. This suggests that there is the potential for higher numbers of GBF to exist within the population of the UWC system yet have gone undetected during monitoring events. Nonetheless, this is unlikely to account for the substantial difference in GBF records since the baseline monitoring.

Although there has been a reduction in GBF recorded at the UWC monitoring site, this reduction is not considered to be because of non-compliance prescribed mitigations measures as outlined within the GBFMS. It is likely that numbers of GBF have declined as a result of construction impacts to Zones 8-10 where core GBF habitat was impacted by construction activities.

4.1.3 Butchers Creek Potential GBF Habitat

Since the observation of GBF tadpoles (confirmed at the time to be *M. iteratus*), within Butchers Creek, an additional GBF management area has been established with eight survey zones created for monitoring. No GBF have been recorded within the Butchers Creek survey zones to date. It could be reasonably considered that the tadpoles captured within Butchers Creek were *Mixophyes fasciolatus* tadpoles and misidentified as *M. iteratus.* A population of GBF are known to occur within the Butchers Creek system and no GBF have ever been recorded at Butchers Creek. During summer 2018 monitoring of Butchers Creek a *Mixophyes fasciolatus* tadpole was captured within a tadpole trap set within a pool in Zone 7.

On this basis, a review of the Butchers Creek area to be managed as a GBF habitat or monitoring site should be considered.

4.2 Habitat Use

A core section of riparian habitat has been removed or impacted within Zones 8-10 due to construction of the bridge piling pads and creek causeway crossing. This is the area where the highest number of GBF were captured during baseline monitoring. Twenty-one GBF were captured in Zones 8 and 9 and a further six frogs were captured in Zone 10 during the population baseline monitoring. During pre-clearing surveys (prior to disturbance to these areas) three frogs were captured and relocated outside of the works footprint, refer to **Illustration 2.1.**

During 2015/2016 surveys frogs were observed within Zones 2-13 whereas, during population baseline monitoring, frogs were recorded to be using the creek system more broadly with records spaning Zones 2-20. Records show that Year 3 records are even more concentrated with all being located north of the causeway (downstream) and gathered between Zones 2-6.

A number of GBF were not located or very difficult to locate due to the position buried beneath leaf litter and soil. A number of male GBF have been heard and identified to be present within the UWC system due to vocal calls but not located for capture. This suggests that a number of female or sub-adult GBF are not being captured or counted due to their cryptic behaviour. Surprisingly five of eight GBF recorded during summer 2018 monitoring were either partially or completely submerged amongst leaf litter and soil which is a behaviour typically recorded during cooler temperatures or drier habitat conditions. The temperature ranges (in °C) on the nights of summer 2018 monitoring were 19.5 to 16.3 on 5 February 2018 and 22.5 to 16 on 7 February 2018 during the nocturnal GBF surveys at UWC.

Plate 4.1 UWC construction area through Zones 9 and 10 view to the north

Plate 4.2 UWC construction area through Zones 9 and 10 view to the south

Plate 4.3 Western side of UWC causeway view to the north through Zone 8

4.2.1 GBF habitat rehabilitation and landscaping once construction is complete

The removal of the causeway crossing at UWC will require consideration and consultation with the Project Ecologist. The aim is to rehabilitate the creek bank and riparian vegetation to enhance and improve GBF habitat and connectivity from the northern and southern sections of the creek. It is important to note that allowing the invasion of pasture grasses and dense weed infestations not only has the potential to reduce the quality of GBF habitat but also to restrict passage from one area to another. As per the GBFMS the Urban and Landscape Design Plan (SMM, 2015) should be reviewed to ensure native regeneration species are selected for planting and that connectivity is maintained.

4.3 Recaptured Frogs

Recaptured frogs appear to be increasing in size and weight over time, suggesting these individuals are healthy and persisting within the survey area. For Years 1 and 3 the distribution of GBF within the habitat was largely concentrated within Zone 2 to 8 with a number of frogs moving along the banks of UWC for a minimum distance of ~180 m between spring 2015 and summer 2018. For the first time since the commencement of monitoring individual recaptured frogs (two) have been recorded on both sides of the banks, thereby demonstrating that the frogs have crossed to the opposite bank, either by swimming across UWC or dispersing over land.

Since the commencement of construction phase monitoring none of the 36 GBF previously captured and microchipped by Lewis have been recorded. It would be expected that some of these frogs would still persist within the UWC system and at least be detected during Year 1 of construction monitoring. Mahony (pers. comm., 2018) predicts that the average lifespan of a GBF would be five to six years with females starting to breed during the second breeding season of life. Mahony has recaptured an individual GBF at Bucca Creek monitoring site within the Bruxner Park Flora Reserve west of Coffs Harbour, which was microchipped nine years ago (it is not known how old the frog was at the time of first capture). This suggests the species may be relatively long-lived.

The supplier of the microchips and scanning equipment used by both Lewis Ecological and GeoLINK (Microchips Australia) have advised that the scanner GeoLINK uses to scan the frogs is compatible to successfully detect the chips used by Lewis in the baseline monitoring. However, the chip type/size used by Lewis (Nanotransponder) has a scan radius of up to one centimetre whereas the Trovanunique ID100 chips (used by GeoLINK) are larger in size and have a scan radius of up to three centimetres. If at first a frog does not provide a positive reading for chip detection the frog is scanned twice more (once over the back of the body and once over the underside of the body), within the one centimetre radius of the frog and should therefore be able to detect Nanotransponder chips. The chips that GeoLINK use have a confirmed effective life of >40 years as these same chips have been used in long-lived birds such as cockatoos. These chips are still being effectively scanned by Veterinarians using Trovan chip scanning devices such as the LID560 which GeoLINK uses (pers. comm Microchips Australia). The Nanotransponder chips (which are now a discontinued product) have no known successful lifespan, according to the supplier.

If GBF at the study area now carry two chip types (Nanotransponder and a Trovanunique ID100) the scanner will detect the Trovanunique ID100 chip over the Nanotransponder chip due to the stronger emitting capacity of the larger chip (pers. comm. Microchips Australia).

On this basis, potential reasons that no GBF microchipped during baseline surveys have been recaptured by GeoLINK may include:

- GBF have moved to another part of the UWC system but occur outside of the survey area therefore avoiding detection.
- The GBF population has declined due to natural causes (e.g. disease, low fecundity, lack of food resources); however, this seems highly unlikely given the results to date.
- The majority of GBF recorded within Zones 8-10 were directly impacted by construction works and any surviving frogs have moved out of the survey area.
- The Nanotransponder chips have failed and cannot be detected by the GeoLINK Trovan LID560 scanner.

5. Recommendations

Based on the Year 3 GBF population monitoring results the following recommendations apply:

1. The removal of the causeway crossing at UWC will require consideration and consultation with the Project Ecologist. Landscaping and rehabilitation of the creek riparian vegetation will be undertaken with the aim to enhance or improve GBF habitat and maintain connectivity within the system for GBFs. This is an opportunity to complete high quality restoration works for GBF and careful selection of species and appropriate aftercare and maintenance are critical. Proposed landscaping plans are to be reviewed to ensure optimal riparian revegetation outcomes can be achieved.
2. A requirement of the GBFMS is to continue monitoring of the UWC GBF population during autumn, spring and summer of Years 1, 3 and 5 of the operational phase of the Project. It is recommended that the results of future monitoring be analysed in reference to both baseline and Years 1 and 3 of construction phase monitoring to determine long term population trends in relation to abiotic, habitat and biological factors impacting the GBF population at UWC. The results should be considered in relation to the objectives of the GBF monitoring plan.

6. Objectives and Performance Measures

Section 7.0 of the GBFMS states the objectives of the GBF monitoring program as follows:

- *To demonstrate through the life of the Project that mitigation has maintained or improved population sizes and habitat of the Giant Barred Frog. The use of preconstruction, during construction and post construction monitoring to measure both frog distribution, abundance and habitat quality with defined thresholds will used to measure the overall performance of the mitigation; and*
- *To ensure that mitigation measures are effective in maintaining Giant Barred Frog connectivity near the Project.*

Based on the results to date, the UWC GBF population has not been maintained or improved, but has declined. However, the reduction in the GBF population is not attributable to non-compliance with mitigation measures, as all construction mitigation measures as recommended within the GBFMS have been implemented. In this respect, the decline in GBF at UWC is likely to be directly related to disturbance of high quality GBF breeding habitat, with prescribed mitigation measures appearing ineffective in maintaining the population.

A summary of the Key Performance Indicators (KPIs) which informs the GBF monitoring during the construction phase of the project has been completed (refer to **Table 6.1**) and indicates all monitoring complies with KPIs (or objectives) where relevant. Despite this, the objective of maintaining or improving the GBF population at UWC has not been achieved.

While this is the last monitoring event to be conducted during the construction phase, operational phase monitoring will now commence and continue over a six-year period with three monitoring events during Years 1, 3 and 5 of operational phase. Continued monitoring during the operational phase will provide further information on the GBF population post-revegetation of the habitat and operational phase of the project. This will provide information on the longer-term trends of the GBF population at UWC. Implementation of targeted restoration works at UWC will also assist in embellishing GBF habitat where construction works have occurred.

Table 6.1 Summary of Key Performance

Minimise habitat loss for the GBF from clearing.	GBF habitat to be cleared to not exceed approvals. Final Sensitive Area Plans identify sensitive areas and 100% of clearing drawings identify clearing extents. Clearing limit does not exceed approved limits (State and Commonwealth).	Yes – as evidenced in the vegetation quantity tracking register. Yes – as illustrated on Project Sensitive Area Plans. Yes – clearing limits are verified by survey and delineation checked during joint pre-clearing walkthroughs.	No action currently required.
No injury/ mortality to GBF from construction activities.	No GBF injuries/ mortalities of adults or tadpoles as a consequence of construction activities.	Yes – Pre-clearing surveys were undertaken prior to disturbance of GBF habitat and a spotter/ catcher was present during disturbances to GBF habitat. No GBF injuries or fatalities have been recorded directly as a result of construction activities, although core habitat within zones 8-10 have been directly impacted by construction at UWC.	No action currently required.
To collect data to demonstrate that mitigation has maintained the population size and habitat of the GBF similar to results of the preconstruction baseline surveys.	GBF recorded along the monitoring transect. The detection of Chytrid fungus. No breaches in fauna exclusion fencing.	Yes – 16 GBF were recorded during Year 1 of construction along the monitoring transect in accordance with baseline survey methodology. Year 3 – Autumn and spring 2017 and summer 2018 recorded 14 GBFs collectively. Two frogs swabbed for Chytrid for Year 1 of construction tested positive (in the low range) for Chytrid. One frog swabbed positive (very low range) during Year 3 monitoring. Yes – unavoidable breaches to frog exclusion fencing have occurred due to periodic flooding during construction however GBF surveys have been conducted to ensure no GBF have entered the active work zone during flood evets. No GBF were detected during these surveys.	All Construction phase GBF population monitoring is now complete. Ongoing population monitoring will be undertaken yearly during the operational phase of the Project as scheduled in the *GBFMS* and *Ecological Monitoring Program*.
Minimise road kill of GBF during construction activities.	No roadkill of GBF resulting from the Project.	Yes – no GBF road kill has been recorded along the existing highway or as a result of the Project. Once the new highway becomes operational road kill monitoring for compliance will be undertaken.	No action currently required.
Undertake habitat rehabilitation works within identified areas of the Project Site to create or improve existing GBF habitat.	Successful establishment of GBF habitat in the nominated areas.	Rehabilitation of GBF habitat has not yet commenced due to construction phase currently active.	Discussions regarding creek bank and landscape rehabilitation within GBF habitat will occur prior to the removal of the causeway crossing.

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Appendix A

GBF Population Monitoring (Raw Data) - Summer 2018

GBF Upper Warrell Creek Autumn - 4 and 6 April 2017

Table A1 GBF monitoring data sheet

	Frog # 1 (04/04/2017)	*Frog # 2 (06/04/2017)*	*Frog # 3 (06/04/2017)*
GPS Location and survey zone #:	E 489357/ N 6594553	E 489328 / N 6594411	E 489328 / N 6594411
GPS release point: if frog is located within the work zone (must be <100m from capture point)	Did not capture frog, visual observation only	Same as above	Same as above
Distance from stream edge:	2	1.5	1.5
Position within the microhabitat: (under leaf litter/above litter/ exposed/on a rock)	On top of substrate litter under taller canopy cover	above leaf litter under low vegetation canopy	above leaf litter under low vegetation canopy
Sex: (female/male/unknown)	Male - heard calling	Female	Male
Age class: (adult >60mm; sub-adult 40-60mm; juvenile <40mm	n/a	Adult	Adult
Snout to vent length (mm):	n/a	88	72
Weight (grams):	n/a	131	54
Breeding condition: Males: colour of nuptial pads no colour/light/moderate/dark see table 2.1 of GBFMP for classification Females: gravid (typically weighing >100 grams) or not Immature = Frogs <60mm	n/a	light	Moderate
Chytrid Swab taken Y/N Wipe the swab under armpits and in groin, keep sample in fridge until delivered to lab	n/a	y	y
Microchip ID:	n/a	00077E9014 (3rd re-capture)	00077E7E20 (new capture)

Table A2 Abiotic data taken once at start of survey on 4/04/2017 (using WeatherMation data for rainfall)

Survey start time: 15:30
Survey end time: 22:30

Component	*Data*
Rainfall During the survey:	.6 mm
Rainfall within the past 24 hrs:	1.8
Rainfall within the past 7 days:	74 mm
Rainfall within the past 30 days:	467.2 mm
Relative humidity start of survey:	82.1
Relative humidity end of survey:	100
Air temperature start of survey:	21.6
Air temperature end of survey:	15.2
Wind speed: 0=no wind; 1=light rustles in the leaves; 2=branches moving; 3=whole canopy moving	1

Table A3 Water quality data taken once at start of survey on 4/04/2017

Component	*Data*
Water level:	40 cm above marker
Location:	GPS point WQN E 489509 N 6594432
DO:	5.33 mg/L / 61.2 %DO
Conductivity:	0.183 mS/cm
pH:	6.39
Temperature:	20.74
Turbidity:	0
Samples taken for lab analysis: Y/N	Y

Lab Analysis:
Heavy Metals - arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc.
Hydrocarbons - Naphthalene TRH>C10-C16, TRH>C10-C16 less naphthalene (F2), TRH>C16-C34, TRH>34-C40, TRHC6-C10, and TRHC6-C10 less BTEX (F1)
BTEX Group including Benzene, Ethylbenzene, m&P-xylenes, o-Xylene, Toluene and Xylene - total
Nutrients - Nitrogen (as N), Suspended Solids and Total Phosphorus

Notes:

- UWC Water Quality, Habitat and weather data was collected on 4 April 2017
- UWC GBF population data was collected over nights 4 and 6 April 2017.

Table A4 Habitat data collected on 4/04/2017 at the 20 demarcated zones

	Zone # 1	*Zone # 2*	*Zone # 3*	*Zone # 4*	*Zone # 5*	*Zone # 6*	*Zone # 7*	*Zone # 8*	*Zone # 9*	*Zone # 10*
Landuse: dairy or beef cattle grazing etc.	Beef cattle	Beef cattle	Beef cattle	Beef cattle	Beef cattle	Beef cattle	Beef cattle	bridge construction site	bridge construction site	rock crossing
Broad veg type within the immediate riparian zone: riparian rainforest/ dry sclerophyll/ woodland mallee/ heath/ shrub sedgeland or cleared land	Cleared pasture	Sclerophyll - Water Gum	Sclerophyll - Water Gum	flooded gum, water gum, camphor laurel	red ash, water gum, camphor laurel, scentless rosewood	red ash, water gum, camphor laurel, flooded gum	red ash, water gum, camphor laurel, small leaf privet	red ash, water gum, camphor laurel, small leaf privet. Part open no tree veg.	red ash, water gum, camphor laurel, small leaf privet. Part open no tree veg.	nil
Instream physical features	small logs	log	nil	nil	nil	log	nil	nil	nil	piped rock crossing with riffles
Stream width (m):	21	27	37	37	26	31	31	16	15	10
Stream depth (m):	>1.5	>1.5	>1.5	>1.5	>1.5	>1.5	>1	>1	>1.5	1.3cm
Presence of pools and or riffles:	deep channel	deep channel	deep channel	deep channel	deep channel	deep channel	deep channel	deep channel	deep channel	riffles pools either side of the piped crossing
Bed composition:	gravel covered in mud/silt layer	gravel covered in detritus layer	gravel covered in detritus layer	gravel covered in detritus layer	gravel covered in detritus layer	gravel covered in detritus layer	gravel covered in detritus layer	gravel covered in detritus layer	gravel covered in detritus layer	rock
Type of emergent vegetation if present:	*Juncus sp. Persicaria strigosa, Eleocharis sp. Nymphaea sp.*	*Nymphaea caerulea*	*Lomandra sp.*	*Lomandra sp.*	*Lomandra sp.*	*Lomandra sp., Juncus usitatus*	*Lomandra sp.*	*Lomandra sp.*	*Lomandra sp.*	*Juncus sp. Persicaria strigosa, Setaria sphacelata, Lomandra sp.*
Stream bank characteristics:	sandy soil - loam	sandy soil - loam	sandy soil - loam	sandy soil - loam	sandy soil - loam	sandy soil - loam	sandy soil - loam	sandy soil - loam	sandy soil - loam	imported rock
Bank profile: Undercut/ steep/ benched/ gradual incline from the water's edge	gradual incline	benched	steep incline	undercut to steep	steep	moderate	steep	moderate	gradual incline	not natural
Vegetation associated with the stream bank regarding foliage projection cover (FPC) for overstorey trees/ shrubs/ groundcover	Ground cover	5-7 m	5-7 m	5-7 m	5-7 m	5 m	5 m	5 m	5 m	wetland species no tree or shrub canopy
Groundcover composition: including a measure of vegetative groundcover/ litter cover/ soil cover/ exposed rock expressed as a composition %	kikuyu 100%	Moss 20% Leaf litter 35% Exposed soil 20% Grass 25%	Moss 10% Leaf litter 30% Exposed soil 10% Grass 50%	Moss 10% Leaf litter 70% Exposed soil 10% Fern 10%	Moss 15% Leaf litter 70% Exposed soil 10% Grass 5%	Moss 10% Leaf litter and bark 70% Exposed soil 10% Grass 10%	Moss 10% Leaf litter 70% Exposed soil 10% Grass 10%	Moss 10% Leaf litter 50% Exposed soil 30% Grass 10%	Moss 30% Leaf litter 50% Exposed soil 20% Grass 0%	Setaria 100 % to bank
Depth of Litter: Deep = >100mm/ Moderate = 20 -100mm/ Shallow = <20mm/ Absent	nil	shallow	moderate	moderate	moderate	shallow	moderate	shallow	shallow	nil
Tadpole Trap Data Traps to be placed 1 per survey zone and in the water for 3 hours	nil	nil	nil	nil	nil	1 x Gudgeon	nil	nil	nil	nil
Dip net results:			2 x Gambusia			nil			1 x Shrimp	
Notes:					Clearing for powerlines has occurred within this transect. 20 m wide fallen timbers lay where felled.					

	Zone # 11	*Zone # 12*	*Zone # 13*	*Zone # 14*	*Zone # 15*	*Zone # 16*	*Zone # 17*	*Zone # 18*	*Zone # 19*	*Zone # 20*
Landuse: dairy or beef cattle grazing etc.	bridge construction site	Beef cattle	Beef cattle	Beef cattle	Beef cattle	Beef cattle	Beef cattle	Beef cattle	Dairy cattle	Dairy cattle
Broad veg type within the immediate riparian zone: riparian rainforest/dry sclerophyll/woodland mallee/heath/shrub sedgeland or cleared land	water gum	creek sandpaper fig water gum	creek sandpaper fig water gum	water gum	water gum, camphor	water gum, camphor	water gum, camphor	water gum	water gum, sandpaper fig, large leaf privet	water gum
Instream physical features	nil	dead tree	log	Nil	Nil	Log	log	Emergent vegetation	Emergent vegetation	Emergent vegetation
Stream width (m):	20	18	18	15	12	12	13	15	8	3 small islands
Stream depth (m):	1.5m	>2	>2	>1.5	>1.5	>1.5	>1.5	>1.5	>1	1
Presence of pools and or riffles:	deep channel	deep channel	deep channel	shallow channel ~1m	shallow channel ~1m	shallow channel ~1m	shallow channel ~1m	shallow channel ~1m	shallow channel ~1m	shallow channel ~1m
Bed composition:	gravel covered in detritus layer	gravel covered in detritus layer	gravel covered in detritus layer	gravel covered in detritus layer	gravel covered in detritus layer	gravel covered in detritus layer	gravel covered in detritus layer	gravel covered in detritus layer	gravel covered in detritus layer	gravel covered in detritus layer
Type of emergent vegetation if present:	*Juncus sp.*	nil	*Nymphaea caerulea, Persicaria strigosa*	*Lomandra sp.*	*Lomandra sp.*	*Lomandra sp.*	*Lomandra sp.*	*Lomandra sp.*	*Lomandra sp., Persicaria sp.*	Lomandra
Stream bank characteristics:	sandy soil - loam	sandy soil - loam	sandy soil - loam	sandy soil - loam	sandy soil - loam	sandy soil - loam	sandy soil - loam	sandy soil - loam	sandy soil - loam	sandy soil - loam
Bank profile: Undercut/ steep/ benched/ gradual incline from the water's edge	moderate	steep	steep	steep	steep	steep benched	steep benched	moderate benched	moderate	moderate
Vegetation associated with the stream bank regarding foliage projection cover (FPC) for overstorey trees/ shrubs/ groundcover	4 m	4 m	4 m	3 m	4 m	5 m	5 m	3 m	3 m	3 m
Groundcover composition: including a measure of vegetative groundcover/ litter cover/ soil cover/ exposed rock expressed as a composition %	Moss 20% Leaf litter 20% Exposed soil 20% Grass 40%	Moss0 % Leaf litter 30% Exposed soil 0% Grass 70%	Moss 0% Leaf litter 0% Exposed soil 0% Grass 100%	Moss 10% Leaf litter 20% Exposed soil 10% Grass 70%	Moss 10% Leaf litter 30% Exposed soil 30% Grass 30%	Moss 10% Leaf litter 30% Exposed soil 20% Grass 40%	Moss 10% Leaf litter 30% Exposed soil 10% Grass 50%	Moss 5% Leaf litter 10% Exposed soil 10% Grass 75%	Moss 10% Leaf litter 10% Exposed soil 40% Grass 40%	Moss 10% Leaf litter 20% Exposed soil 30% Grass 40%
Depth of Litter: Deep = >100mm/ Moderate = 20 -100mm/ Shallow = <20mm/ Absent	shallow	moderate	nil	shallow	moderate	moderate	moderate	shallow	moderate	shallow
Tadpole Trap Data Traps to be placed 1 per survey zone and in the water for 3 hours	nil	nil	nil	nil	nil	1 x Gudgeon	1 x Shrimp	nil	nil	1 x Shrimp
Dip net results:		nil			1 x Gambusia			nil		

Notes:

- All emergent vegetation was observed at the edge of the creek on or close to the bank.
- Tadpole traps were set for a minimum of three hours from 4:00 pm to 10:00pm.
- Increased grass cover was observed at the majority of site dues to favourable growth season.
- Water visibly more turbid due to recent rainfall events.
  Construction site rubbish to be collected form downstream of the site.

GBF Butchers Creek Autumn - 6 April 2017

Table A5 GBF monitoring data sheet

	Frog # 1	*Frog # 2*	*Frog # 3*	*Frog # 4*	*Frog # 5*
GPS Location and survey zone #:	No Giant Barred Frogs (*Mixophyes iteratus*) were recorded visually or audibly at the Butchers Creek site.				
GPS release point: if frog is located within the work zone (must be <100m from capture point)					
Distance from stream edge:					
Position within the microhabitat: (under leaf litter/above litter/ exposed/on a rock)					
Sex: (female/male/unknown)					
Age class: (adult >60mm; sub-adult 40-60mm; juvenile <40mm					
Snout to vent length (mm):					
Weight (grams):					
Breeding condition: Males: colour of nuptial pads no colour/light/moderate/dark see table 2.1 of GBFMP for classification Females: gravid (typically weighing >100 grams) or not Immature = Frogs <60mm					
Chytrid Swab taken Y/N Wipe the swab under armpits and in groin, keep sample in fridge until delivered to lab					
Microchip ID:					

Table A6 Abiotic data taken once at start of survey on 6/04/2017 (using WeatherMation data for rainfall)

Survey start time: 14:00
Survey end time: 22:00

Component	*Data*
Rainfall During the survey:	13.6 mm
Rainfall within the past 24 hrs:	17.4 mm
Rainfall within the past 7 days:	77 mm
Rainfall within the past 30 days:	465 mm
Relative humidity start of survey:	85.2%
Relative humidity end of survey:	100%
Air temperature start of survey:	20.7
Air temperature end of survey:	15.9
Wind speed: 0=no wind; 1=light rustles in the leaves; 2=branches moving; 3=whole canopy moving	1

Table A7 Water quality data taken once at start of survey on 6/04/2017

Component	*Data*
Water level:	50 cm above marker
Location:	E494531 N6604304
DO:	9.86 mg/L or 108%
Conductivity:	0.108 mS/cm
pH:	6.84
Temperature:	19.23
Turbidity:	0.0 NTU
Samples taken for lab analysis: Y/N	Y

Lab Analysis:
Heavy Metals - arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc.
Hydrocarbons - Naphthalene TRH>C10-C16, TRH>C10-C16 less naphthalene (F2), TRH>C16-C34, TRH>34-C40, TRHC6-C10, and TRHC6-C10 less BTEX (F1)
BTEX Group including Benzene, Ethylbenzene, m&P-xylenes, o-Xylene, Toluene and Xylene - total
Nutrients - Nitrogen (as N), Suspended Solids and Total Phosphorus

Notes:

- Water quality, habitat, abiotic, weather and GBF survey data was collected on 6 April 2017.

Table A8 Habitat data and tadpole trap data collected on 6/04/2017 at the eight demarcated zones

	Zone # 1 - east	*Zone # 2*	*Zone # 3*	*Zone # 4*	*Zone # 5*	*Zone # 6*	*Zone # 7*	*Zone # 8 - west*
Landuse: dairy or beef cattle grazing etc.	Forest riparian zone	Forest riparian zone	Forest riparian zone	Forest riparian zone	Project alignment	Forestry/Cattle	Forestry/Cattle	Forestry/Cattle
Broad veg type within the immediate riparian zone: riparian rainforest/dry sclerophyll/woodland mallee/ heath/shrub sedgeland or cleared land	Maidens Blush Bangalow Palm Flooded Gum	Bangalow Palm Blackbutt Tallowwood Turpentine Maidens Blush	Casuarina Flooded Gum Camphor Laurel Syzygium	Callicoma Casuarina Flooded Gum Camphor Laurel	Callicoma Flooded Gum Camphor Laurel	Camphor Laurel Red Ash Blue Gum	Camphor Laurel Privet Lantana	Camphor Laurel Brush Box Casuarina Blackbutt
Instream physical features	Riffles	Pool	Riffles	Natural rock	Pool and emergent vegetation	Pool	Riffles	Pool
Stream width (m):	4	5	3.5	2.5	4	3	4	4
Stream depth (m):	0.4	1-1.5	0.6	.4	1	0.5	1	1.2
Presence of pools and or riffles:	Pool	Pool	Pool	Pool	Pool	Pool	Pool	Pool
Bed composition:	Rock	Rock	Rock	Rock	Rock and detritus	Rock	Rock	Rock
Type of emergent vegetation if present:	nil	nil	nil	nil	lomandra along bank	nil	nil	nil
Stream bank characteristics:	sandy soil - loam	sandy soil - loam	sandy soil - loam	sandy soil - loam	sandy soil - loam	sandy soil - loam	sandy soil - loam	sandy soil - loam
Bank profile: Undercut/steep/benched/gradual incline from the water's edge	gradual	undercut and gradual slope	undercut / tree roots	gradual/ undercut	Benched	undercut	gradual	undercut
Vegetation associated with the stream bank regarding foliage projection cover (FPC) for overstorey trees/shrubs/groundcover	joined canopy	2 m	joined canopy	3 m	4 m	close canopy almost joined	4 m	3 m
Groundcover composition: including a measure of vegetative groundcover/litter cover/soil cover/exposed rock expressed as a composition %	Moss 0% Leaf litter 50% Exposed soil 0% Rock 30% Grass 20%	Moss 0% Leaf litter 20% Exposed sand 10% Rock 70% Grass 0%	Moss 0% Leaf litter 50% Exposed soil 0% Rock 50% Grass 0%	Moss 0% Leaf litter 40% Exposed soil 0% Rock 40% Grass 20%	Moss 20% Leaf litter 30 % Exposed soil 20 % Rock 10 % Flood debris 20 %	Moss 0 % Leaf litter 20% Exposed soil 0 % Rock 20% Grass 60%	Moss % Leaf litter % Exposed soil % Rock % Grass 100 %	Moss 0 % Leaf litter 20 % Exposed soil 0 % Rock 20 % Grass 60 %
Depth of Litter: Deep = >100mm / Moderate = 20 -100mm / Shallow = < 20mm / Absent	Shallow	Shallow	nil	Shallow	Shallow	Moderate	Shallow	Deep
Tadpole Trap Data Traps to be placed 1 per survey zone and in the water for 3 hours	nil	nil	nil	nil	nil	nil	nil	nil
Dip net results:	nil	nil	nil	nil	Waterboatman (*Corixidae*)	nil	nil	nil

Notes:

- All emergent vegetation was observed at the edge of the creek on or close to the bank.
- Tadpole traps were set for approximately six hours. Very little aquatic fauna was observed.
- Construction site rubbish to be collected form downstream of the site.

GBF Upper Warrell Creek Spring – 6 and 7 November 2017

Table A9 GBF monitoring data sheet

	Frog # 1 (6/11/2017)	*Frog # 2 (6/11/2017)*	*Frog # 3 (6/11/2017)*	*Frog # 4 (7/11/2017)*
GPS Location and survey zone #:	E 489282/ N 6594412	E 489302/ N 6594439	E 489360/ N 6594586	E 489360/ N 6594586
GPS release point: if frog is located within the work zone (must be <100m from capture point)	Same as above	Same as above	Did not capture. Frog detection via call only	Did not capture. Frog detection via call only. Likely to be same individual recorded at this location on 6/11/2017 (i.e. Frog #3).
Distance from stream edge:	2.5	0.7	n/a	n/a
Position within the microhabitat: (under leaf litter/above litter/ exposed/on a rock)	above leaf litter under tall vegetation canopy	above leaf litter under low overhanging vegetation canopy	n/a	n/a
Sex: (female/male/unknown)	Male	Male	Male	Male
Age class (adult >60mm; sub-adult 40-60mm; juvenile <40mm):	Adult	Adult	Adult	Adult
Snout to vent length: (mm)	66	72	n/a	n/a
Weight (grams):	61	69	n/a	n/a
Breeding condition: Males: colour of nuptial pads no colour/light/moderate/dark see table 2.1 of GBFMP for classification Females: gravid (typically weighing >100 grams) or not Immature = Frogs <60mm	Moderate	Moderate	n/a	n/a
Chytrid Swab taken Y/N Wipe the swab under armpits and in groin, keep sample in fridge until delivered to lab	Y	Y	N	N
Microchip ID:	00077E9664 (new capture)	00077E8FEF (new capture)	n/a	n/a

Table A10 Abiotic data collected at start of nocturnal GBF survey on 7/11/2017 (using WeatherMation data for rainfall)

Nocturnal GBF Survey 6/11/2017 from 9:30 pm to 12:30 pm
Nocturnal GBF Survey 6/11/2017 from 7:30 pm to 11:00 pm

Component	*Data*
Rainfall During the survey:	0 mm
Rainfall within the past 24 hrs:	6.8 mm
Rainfall within the past 7 days:	22 mm
Rainfall within the past 30 days:	152.8 mm
Relative humidity start of survey:	64.3%
Relative humidity end of survey:	70.3%
Air temperature start of survey:	18.7
Air temperature end of survey:	16.9
Wind speed: 0=no wind; 1=light rustles in the leaves; 2=branches moving; 3=whole canopy moving	2 @ 10 am

Table A11 Water quality data collected at 9:00am on 7/11/2017

Component	*Data*
Water level:	16 cm below marker
Location:	GPS point WQN E 489509 N 6594432
DO:	1.96 mg/L or 21.9 % DO
Conductivity:	0.265 mS/cm
pH:	6.32
Temperature:	19.11
Turbidity:	12.7
Samples taken for lab analysis: Y/N	Y

Lab Analysis:
Heavy Metals - arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc.
Hydrocarbons - Naphthalene TRH>C10-C16, TRH>C10-C16 less naphthalene (F2), TRH>C16-C34, TRH>34-C40, TRHC6-C10, and TRHC6-C10 less BTEX (F1)
BTEX Group including Benzene, Ethylbenzene, m&P-xylenes, o-Xylene, Toluene and Xylene - total
Nutrients - Nitrogen (as N), Suspended Solids and Total Phosphorus

Notes:

- UWC Water quality, habitat and weather data was collected on 7 November 2017.
- UWC GBF population data was collected over nights 6 and 7 November 2017.

Table A12 Habitat data collected on 7/11/2017 at the 21 demarcated zones

	Zone # 1		*Zone # 2*		*Zone # 3*		*Zone # 4*		*Zone # 5*		*Zone # 6*		*Zone # 7*		*Zone # 8*		*Zone # 9*		*Zone # 10*	
Creek Bank	East	West	East	West	East	West	East	West	East	West	East	West	East	West	East	West	East	West	East	West
Landuse: dairy or beef cattle grazing etc.	Riparian vegetation	Beef cattle grazing	Riparian vegetation	Beef cattle grazing	Riparian vegetation	Beef cattle grazing	Riparian vegetation	Beef cattle grazing	Riparian vegetation	Beef cattle grazing	Riparian vegetation	Beef cattle grazing	Riparian vegetation	Beef cattle grazing	Bridge construction site		Bridge construction site		Bridge construction site	
Broad veg type within the immediate riparian zone: riparian rainforest/dry sclerophyll/woodland mallee/ heath/ shrub sedgeland or cleared land	Blue Gum, Casuarina, Water Gum	Cleared pasture	Blue Gum, Casuarina, Water Gum	Sclerophyll - Water Gum	Flooded Gum	Sclerophyll - Water Gum	Flooded Gum, Water Gum	Flooded Gum, Water Gum, Camphor Laurel	Sedgeland species and Water Gum	Red Ash, Water Gum, Camphor Laurel, Scentless Rosewood	Water Gum, Sandpaper Fig	Red Ash, Water Gum, Camphor Laurel, Flooded Gum	Water Gum, Setaria, Paspalum	Red Ash, Water Gum, Camphor Laurel, Small-leaf Privet	Water Gum, Setaria, Paspalum	Red Ash, Water Gum, Camphor Laurel, Small-leaf Privet Part open no trees/ veg.	Black Booyong, Red Ash, Water Gum, Camphor Laurel, Small-leaf Privet	No riparian vegetation	Water Gum, Blue gum	No riparian vegetation
Instream physical features	small logs		log		nil		nil		nil		log		nil		nil		western edge of piped rock crossing with riffles		western edge of piped rock crossing with riffles	
Stream width (m):	18		23		25		27		20		25		20		16		15		10	
Stream depth (m):	>1.5		>1.5		>1.5		>1.5		>1.5		>1.5		>1		>1		0.8		0.8	
Presence of pools and or riffles:	deep channel		deep channel		deep channel		deep channel		deep channel		deep channel		deep channel		deep channel		riffles pools either side of the piped crossing		riffles pools either side of the piped crossing	
Bed composition:	gravel covered in mud/silt layer		gravel covered in detriatus layer		gravel covered in detriatus layer		gravel covered in detriatus layer		gravel covered in detriatus layer		gravel covered in detriatus layer		gravel covered in detriatus layer		gravel covered in detriatus layer		gravel covered in detriatus layer and scour rock		gravel covered in detriatus layer and scour rock	
Type of emergent vegetation if present:	Juncus sp. *Persicaria Strigosa*, Eleocharis sp. Nymphaea sp.		*Nymphaea caerulea*		Lomandra		Lomandra, Marsh Club Rush (*Bolboschoenus fluviatilis*) Persicaria spp.		Lomandra, Marsh Club Rush (*Bolboschoenus fluviatilis*) Persicaria spp.		Lomandra, *Juncus usutatus*		Lomandra, Persicaria strigosa, Juncas sp.		Lomandra		Lomandra		Juncus spp. *Persicaria strigosa*, Setaria lomandra	
Stream bank characteristics:	sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		imported rock	
Bank profile: Undercut/steep/benched/gradual incline from the water's edge	steep	gradual incline	steep	benched	gradual	steep incline	moderate incline	undercut to steep	gradual	steep	gradual	moderate	gradual	moderate to steep	gradual	moderate	moderate incline	gradual incline	not natural	
Vegetation associated with the stream bank regarding foliage projection cover (FPC) for overstorey trees/shrubs/groundcover	3m	Ground cover	2-3 m	5-7 m	3 m	5-7 m	2 m	5-7 m	nil	5-7 m	nil	5 m	0 m	5 m	0 m	5 m	3 m	5 m	2 m	Wetland species no tree or shrub canopy
Groundcover composition: including a measure of vegetative groundcover/litter cover/soil cover/ exposed rock expressed as a composition %	Moss 10% Leaf litter 50% Exposed soil 25% Grass/ groundcover sp. 10%	kikuyu 100%	Moss 10% Leaf litter 60% Exposed soil 30% Grass/ groundcover sp. 10%	Moss 10% Leaf litter 15% Exposed soil 10% Grass 65%	Moss 15% Leaf litter 40% Exposed soil 35% Grass 10%	Moss 10% Leaf litter 30% Exposed soil 5% Grass 55%	Moss 10% Leaf litter 70% Exposed soil 20% Fern 20%	Moss 5% Leaf litter 65% Exposed soil 10% Fern 20%	Moss 15% Leaf litter 70% Exposed soil 10% Grass 5%	Fallen logs 45 % Moss 0% Leaf litter 55% Exposed soil 0% Grass 5%	Moss 10 % Leaf litter 20% Exposed soil 10% Grass 70%	Moss 10% Leaf litter and bark 60% Exposed soil 10% Grass 20%	Moss 0% Leaf litter 10% Exposed soil 5% Grass 75%	Moss 10% Leaf litter 70% Exposed soil 10% Grass 10%	Moss 0% Leaf litter 20% Exposed soil 5% Grass 75%	Moss 10% Leaf litter 50% Exposed soil 30% Grass 10%	Moss 15% Leaf litter 55% Exposed soil 20% Grass 10%	Scour rock and fringing aquatic species (bridge structure overhead)	GBF exclusion fencing not natural edge of bank	Setaria 100 % to bank
Depth of Litter: Deep = >100mm/ Moderate = 20 - 100mm/ Shallow = <20mm/ Absent	Shallow	nil	Moderate	Shallow	Moderate	Moderate	Moderate	Moderate	Moderate	deep	Shallow	Moderate	Shallow	Moderate	Shallow	Shallow	Shallow	nil	Shallow	nil
Tadpole Trap Data Traps to be placed 1 per survey zone and in the water for 3 hours	nil		nil		nil		nil		1 x Mosquito Fish		nil		nil		nil		nil		nil	
Dip net results:	5 x Glass Shrimp 1 x Gudgeon sp. 15 x Mosquito Fish		nil		nil		1 x Mosquito Fish		nil		nil		1 x Mosquito Fish 2 x Insect Larve		nil		nil		nil	
Notes:									Powerline clearing has occurred in this transect; 20 m wide fallen timbers lay where felled											

	Zone # 11		Zone # 12		Zone # 13		Zone # 14		Zone # 15		Zone # 16		Zone # 17		Zone # 18		Zone # 19		Zone # 20	
Creek Bank	East	West	East	West	East	West	East	West	East	West	East	West	East	West	East	West	East	West	East	West
Landuse: dairy or beef cattle grazing etc.	Bridge construction site		Riparian vegetation	WC2NH project. Former grazing land	Riparian vegetation	WC2NH project. Former grazing land	Dairy cattle grazing	WC2NH project. Former grazing land	Dairy cattle grazing	WC2NH project. Former grazing land	Dairy cattle grazing	WC2NH project. Former grazing land	Dairy cattle grazing	WC2NH project. Former grazing land	Dairy cattle grazing	WC2NH project. Former grazing land	Dairy cattle grazing	WC2NH project. Former grazing land	Dairy cattle grazing	WC2NH project. Former grazing land
Broad veg type within the immediate riparian zone: riparian rainforest/dry sclerophyll/woodland mallee/heath/shrub sedgeland or cleared land	Water Gum, Blue gum, dense Lantana		Water Gum	Water Gum, Blue gum, dense Lantana	Creek Sandpaper Fig, Water Gum	Water Gum, Blue gum	Creek Sandpaper Fig, Water Gum	No riparian vegetation (pasture grasses)	Water Gum	No riparian vegetation (pasture grasses)	Water Gum, Camphor Laurel									
Instream physical features	nil		dead tree		log		Nil		Nil		Log		log		Emergent vegetation		Emergent vegetation		Emergent vegetation	
Stream width (m):	18		15		15		18		1		10		11		13		5		8	
Stream depth (m):	>1.5m		>2		>2		>1.5		>1.5		>1.5		>1.5		>1.5		>1		>1	
Presence of pools and or riffles:	deep channel		deep channel		deep channel		shallow channel ~1m		shallow channel ~1m		shallow channel ~1m		shallow channel ~1m		shallow channel ~1m		shallow channel ~1m		shallow channel ~1m	
Bed composition:	gravel covered in detriatus layer		gravel covered in detriatus layer		gravel covered in detriatus layer		gravel covered in detriatus layer		gravel covered in detriatus layer		gravel covered in detriatus layer		gravel covered in detriatus layer		gravel covered in detriatus layer		gravel covered in detriatus layer		gravel covered in detriatus layer	
Type of emergent vegetation if present:	Juncus spp.		nil		Nymphaea caerulea, Persicaria spp.		Lomandra, Persicaria sp.		Lomandra, Persicaria sp.		Lomandra, Nymphaea cerulea		Lomandra		Lomandra		Persicaria spp., Setaria and Eleocharis sp.		Lomandra, Persicaria spp.	
Stream bank characteristics:	sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam	
Bank profile: Undercut/steep/benched/gradual incline from the water's edge	steep	moderate	steep	steep	moderate	steep	gradual	steep	gradual	steep	gradual	steep benched	gradual	steep benched	gradual	moderate benched	gradual	gradual	moderate	gradual
Vegetation associated with the stream bank regarding foliage projection cover (FPC) for overstorey trees/shrubs/groundcover	2 m	4 m	3 m	4 m	2.5 m	4 m	0 m	3 m	nil	4 m	nil	5 m	nil	5 m	nil	3 m	1 m	nil	3 m	nil
Groundcover composition: including a measure of vegetative groundcover/litter cover/soil cover/exposed rock expressed as a composition %	Moss 10% Leaf litter 60% Exposed soil 15% Grass 15%	Moss 0% Leaf litter 10% Exposed soil 10% Grass 80%	Moss 10 % Leaf litter 60% Exposed soil 20% Grass 10%	Moss0 % Leaf litter 30% Exposed soil 0% Grass 70%	Moss 0% Leaf litter 60% Exposed soil 10% Grass 20%	Moss 0% Leaf litter 0% Exposed soil 0% Grass 100%	Pasture grasses 100%	Moss 10% Leaf litter 20% Exposed soil 10% Grass 70%	Pasture grasses 100%	Moss 10% Leaf litter 30% Exposed soil 30% Grass 30%	Pasture grasses 100%	Moss 10% Leaf litter 30% Exposed soil 20% Grass 40%	Leaf litter 10% Pasture grasses 90%	Moss 10% Leaf litter 30% Exposed soil 10% Grass 50%	Pasture grasses 100%	Moss 5% Leaf litter 10% Exposed soil 10% Grass 75%	Moss 0% Leaf litter 15% Exposed soil % Grass 85%	Pasture grasses 100%	Moss 10% Leaf litter 10% Exposed soil 40% Grass 40%	Pasture grasses 100%
Depth of Litter: Deep = >100mm/ Moderate = 20 - 100mm/ Shallow = <20mm/ Absent	Moderate	Shallow	Moderate	Moderate	Shallow	nil	nil	Shallow	nil	Moderate	nil	Moderate	Shallow	Moderate	nil	Moderate	Shallow	nil	Moderate	
Tadpole Trap Data Traps to be placed 1 per survey zone and in the water for 3 hours	nil		nil		1 x Mosquito Fish		nil		nil		nil		nil		nil		nil		nil	
Dip net results:	nil		nil		nil		nil		nil		1 x likely juvenile Bullrout (*Notesthes robusta*) 1 x Mosquito Fish		nil		nil		3 x Mosquito Fish		nil	
Notes																				

	Zone # 21	
Creek Bank	East	West
Landuse: dairy or beef cattle grazing etc.	Dairy cattle grazing	WC2NH project. Former grazing land
Broad veg type within the immediate riparian zone: riparian rainforest/dry sclerophyll/woodland mallee/heath/shrub sedgeland or cleared land	Water Gum	No riparian vegetation (pasture grasses)
Instream physical features	Emergent vegetation	
Stream width (m):	3 small islands	
Stream depth (m):	>1 m	
Presence of pools and or riffles:	shallow channel ~1m	
Bed composition:	gravel covered in detriatus layer	
Type of emergent vegetation if present:	Lomandra	
Stream bank characteristics:	sandy soil - loam	
Bank profile: Undercut/steep/benched/gradual incline from the water's edge	moderate	gradual
Vegetation associated with the stream bank regarding foliage projection cover (FPC) for overstorey trees/shrubs/groundcover	3 m	nil
Groundcover composition: including a measure of vegetative groundcover/litter cover/soil cover/exposed rock expressed as a composition %	Moss 10% Leaf litter 20% Exposed soil 30% Grass 40%	Pasture grasses 100%
Depth of Litter: Deep = >100mm/ Moderate = 20 - 100mm/ Shallow = <20mm/ Absent	Shallow	nil
Tadpole Trap Data Traps to be placed 1 per survey zone and in the water for 3 hours	nil	
Dip net results:	nil	
Notes		

Notes:

- All emergent vegetation was observed at the edge of the creek on or close to the bank.
- Tadpole traps were set before 11:00 am and collected approximately seven hours later.
- Water visibly more turbid due to recent rainfall events however very low rainfall during July/August/September has preceded this monitoring period.
- Percentage of grass cover was generally similar to that recorded during autumn 2017.
- Construction site rubbish to be collected from downstream of the site.

GBF Butchers Creek Spring – 6 November 2017

Table A13 GBF monitoring data sheet

	Frog # 1	*Frog # 2*	*Frog # 3*	*Frog # 4*
GPS Location and survey zone #:	No Giant Barred Frogs (*Mixophyes iteratus*) were recorded visually or audibly at the Butchers Creek site.			
GPS release point: if frog is located within the work zone (must be <100m from capture point)				
Distance from stream edge:				
Position within the microhabitat: (under leaf litter/above litter/ exposed/on a rock)				
Sex: (female/male/unknown)				
Age class (adult >60mm; sub-adult 40-60mm; juvenile <40mm):				
Snout to vent length: (mm)				
Weight (grams):				
Breeding condition: Males: colour of nuptial pads no colour/light/moderate/dark see table 2.1 of GBFMP for classification Females: gravid (typically weighing >100 grams) or not Immature = Frogs <60mm				
Chytrid Swab taken Y/N Wipe the swab under armpits and in groin, keep sample in fridge until delivered to lab				
Microchip ID:				

Table A14 Abiotic data collected at start of nocturnal GBF survey on 6/11/2017 (using WeatherMation data for rainfall)

Survey start time: 19:30
Survey end time: 21:30

Component	*Data*
Rainfall During the survey:	0 mm
Rainfall within the past 24 hrs:	15 mm
Rainfall within the past 7 days:	15.8 mm
Rainfall within the past 30 days:	146 mm
Relative humidity start of survey:	77.80%
Relative humidity end of survey:	93%
Air temperature start of survey:	23.1
Air temperature end of survey:	17.8
Wind speed: 0=no wind; 1=light rustles in the leaves; 2=branches moving; 3=whole canopy moving	0 at 20:00

Table A15 Water quality data collected at 20:30 on 6/11/2017

Component	*Data*
Water level:	45 cm below marker
Location:	GPS point WQN E 494531 N 6604304
DO:	.87mg/L or 9.5%
Conductivity:	.214 mS/cm
pH:	5.38
Temperature:	18.04
Turbidity:	0.7
Samples taken for lab analysis: Y/N	Y

Lab Analysis:
Heavy Metals - arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc.
Hydrocarbons - Naphthalene TRH>C10-C16, TRH>C10-C16 less naphthalene (F2), TRH>C16-C34, TRH>34-C40, TRHC6-C10, and TRHC6-C10 less BTEX (F1)
BTEX Group including Benzene, Ethylbenzene, m&P-xylenes, o-Xylene, Toluene and Xylene - total
Nutrients - Nitrogen (as N), Suspended Solids and Total Phosphorus

Notes:

- Water quality, habitat, abiotic, weather and GBF population data was collected on 6 November 2017.

Table A16 Habitat data and tadpole trap data collected on 6/11/2017 at the eight demarcated zones

	Zone # 1 East		*Zone # 2*		*Zone # 3*		*Zone # 4*		*Zone # 5*		*Zone # 6*		*Zone # 7*		*Zone # 8 West*	
Creek Bank	North	South	North	South	North	South	North	South	North	South	North	South	North	South	North	South
Landuse: dairy or beef cattle grazing etc.	Forest riparian zone		Forest riparian zone		Forest riparian zone		Forest riparian zone		Project alignment		Forestry / Cattle		Forestry / Cattle		Forestry / Cattle	
Broad veg type within the immediate riparian zone: riparian rainforest/dry sclerophyll/woodland mallee/heath/shrub sedgeland or cleared land	Maiden's Blush, Bangalow Palm, Flooded Gum		Brushbox, Bangalow palm, Blackbutt, Tallowwood, Turpentine, Maiden's Blush		Casuarina, Flooded Gum, Camphor Laurel, Syzigium		Callicoma, Casuarina, Flooded Gum, Camphor Laurel		Casuarina, Water Gum, Callicoma, Flooded Gum, Camphor Laurel		Camphor Laurel, Red Ash, Blue Gum, Small Leaved Privet, Lantana		Camphor Laurel, Small Leaved Privet, Lantana		Camphor Laurel, Brush Box, Casuarina Blackbutt, Lantana, Small Leaved-Privet	
Instream physical features	Nil		Nil		Nil		Nil		Lomandra emergent		Small branches		Nil		Nil	
Stream width (m):	0		3		0		0		3		2		0		3	
Stream depth (m):	0		<1		0		0		0.6		0.35		0		0.8	
Presence of pools and or riffles:	Nil dry creek bed		Black tannin water in Pool		Nil dry creek bed		Nil dry creek bed		Pool		Pool		Nil dry creek bed		Pool	
Bed composition:	Rock		Rock		Rock		Rock		Rock and detriatus		Rock and detritus		Rock		Rock little leaf litter	
Type of emergent vegetation if present:	nil		nil		nil		nil		Lomandra along bank		nil		nil		nil	
Stream bank characteristics:	sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam	
Bank profile: Undercut/steep/benched/gradual incline from the water's edge		gradual	undercut	gradual slope	undercut	undercut and steep with tree roots	gradual	undercut	Benched	Steep	undercut	undercut	gradual	steep to undercut	undercut/ steep	undercut
Vegetation associated with the stream bank regarding foliage projection cover (FPC) for overstorey trees/shrubs/groundcover	Joined canopy		2 m	2 m	Joined canopy		2 m	almost joined canopy - 3 m	3 m	4 m	Close canopy almost joined Privet to Privet		3m	2m	Closed or joined canopy. 2-3 m of riparian veg then thick	
Groundcover composition: including a measure of vegetative groundcover/litter cover/soil cover/exposed rock expressed as a composition %	Moss 0% Leaf litter 50% Exposed soil 0% Rock 30% Grass 20%	Moss 0% Leaf litter 55% Exposed soil 0% Rock 35% Grass 10%	Moss 0% Leaf litter 45% Exposed sand 10% Rock 45% Grass 0%	Moss 0% Leaf litter 35% Exposed sand 10% Rock 55% Grass 0%	Moss 0% Leaf litter and bark 45% Exposed soil 0% Rock 35% Grass 20%	Moss 0% Leaf litter and bark 65% Exposed soil 0% Rock 35% Grass 5%	Moss 0% Leaf litter 45% Exposed soil 0% Rock 25% Grass 30%	Moss 0% Leaf litter 45% Exposed soil 0% Rock 45% Grass 10%	of natural bank remaining (5m) Moss 20% Leaf litter 30% Exposed soil 20% Rock 10% Flood debris 20%	of natural bank remaining (5m) Moss 20% Leaf litter 30% Exposed soil 20% Rock 10% Flood debris 20%	Moss 0 % Leaf litter 30% Exposed soil 0 % Rock 10% Grass 60%	Moss 0 % Leaf litter 30% Exposed soil 0 % Rock 10% Grass 60%	Moss % Leaf litter 15 % Exposed soil % Rock 5% Grass 80 %	Moss % Leaf litter 35 % Exposed soil % Rock 5% Grass 60 %	Moss 0 % Leaf litter 25% Exposed soil 10 % Rock 30 % Grass 45 %	Moss 0 % Leaf litter 35% Exposed soil 10 % Rock 30 % Grass 35 %
Depth of Litter: Deep = >100mm/ Moderate = 20 - 100mm/ Shallow = <20mm/ Absent	Moderate	Moderate	Shallow	Shallow	Moderate	Moderate	Moderate	Moderate	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Moderate
Tadpole Trap Data Traps to be placed 1 per survey zone and in the water for 3 hours	Nil water to place trap in this quadrat. Set trap in closest available pool 10 m further east		nil		Nil water to place trap in this quadrat. Set trap in closest available pool 50 m further east		Nil water to place trap in this quadrat		nil		Nil water to place trap in this quadrat. Set trap in closest available pool 20 m further west		nil		nil	
Dip net results:	Aquatic insect larvae (unknown species) and Waterboatman (*Corixidae*)		nil		nil		nil		>100 tadpoles 8 to 15 mm long - not Mixophyes species		nil		nil		nil	

Notes:

- All emergent vegetation was observed at the edge of the creek on or close to the bank.
- Tadpole traps were set for approximately 4.5 hours.
- Very low water levels in the creek compared to typical water levels.
- Very little aquatic fauna was observed.
- Construction site rubbish to be collected from downstream of the site.

GBF Upper Warrell Creek Summer – 5 and 7 February 2018

Table A17 GBF monitoring data sheet

	Frog # 1 (05/02/2018)	*Frog # 2 (05/02/2018)*	*Frog # 3 (05/02/2018)*	*Frog # 4 (05/02/2018)*	*Frog # 5 (07/02/2018)*	*Frog # 6 (07/02/2018)*	*Frog # 7 (07/02/2018)*	*Frog # 8 (07/02/2018)*
GPS Location and survey zone #:	Lat -30.78173 / Long 152.88831	Lat -30.78350 long 15.288823	Lat -30.78314 / long 152.88846	Lat -30.78348 / long 152.88835	Lat -30.78207 / long 152.88876	Lat -30.78178 / long 152.88854	Lat -30.78178 / long 152.88855	Lat -30.78235 / long 152.88892
GPS release point: if frog is located within the work zone (must be <100m from capture point)	as above	as above	as above	as above	as above	as above	not captured	as above
Distance from stream edge (m):	1	7.5	3	1.5	1	1.5	1.5	0.5
Position within the microhabitat: (under leaf litter/above litter/ exposed/on a rock)	on exposed soil under high canopy cover	on leaf litter at base of tree	on leaf litter under shrub	semi buried under leaf litter	completely buried under leaf litter and soil	completely buried under leaf litter and soil	not captured - heard calling but could not locate	completely buried under leaf litter under lomandra
Sex: (female/male/unknown)	Male - observed by eye shine (following night confirmed by calling)	Female - >100 g	Female - >100 g	Female - >100 g	Male - confirmed by call	Male - confirmed by call	Male - confirmed by call	Male - confirmed by call
Age class: (adult >60mm; sub-adult 40-60mm; juvenile <40mm	Adult	Adult	Adult	Adult	Adult	Adult	n/a	Adult
Snout to vent length (mm):	80	95	100	96	72	73	n/a	80
Weight (grams):	66	130	152	159	61	67	n/a	71
Breeding condition: Males: colour of nuptial pads no colour/light/moderate/dark see table 2.1 of GBFMP for classification Females: gravid (typically weighing >100 grams) or not Immature = Frogs <60mm	moderate grey pads	moderate grey pads	moderate grey pads, large frog with slender body type	moderate grey pads, very large frog but with very muscly body type	light grey pads	moderate grey pads	n/a	moderate grey pads
Chytrid Swab taken Y/N Wipe the swab under armpits and in groin, keep sample in fridge until delivered to lab	Y	Y	Y	Y	Y	Y	n/a	Y
Microchip ID	00077E9664 - recapture	00078ABC66 - new capture	00078ABBF2 - new capture	00077E9014 - recapture	00078ABD42 - recapture	00078AA3F2 - new capture	n/a	00078ABB9B - new record

Note:
Water quality, habitat and weather data was collected on the 5/02/2018, GBF population data was collected on 5 and 7/02/2018 at UWC.

Table A18 Abiotic data collected at start of nocturnal GBF survey on 5/02/2018 (using WeatherMation data for rainfall)

Nocturnal GBF Survey 5/02/2018 from 10:30pm to 1:00 am
Nocturnal GBF Survey 7/02/2018 from 9:00pm to 11:30pm

Component	*Data*
Rainfall During the survey:	0 mm
Rainfall within the past 24 hrs:	0 mm
Rainfall within the past 7 days:	25.2 mm
Rainfall within the past 30 days:	49.6 mm
Relative humidity start of survey:	89.7% @ 21:30
Relative humidity end of survey:	94.7% @ 01:00
Air temperature start of survey:	19.5 @ 21:30
Air temperature end of survey:	16.3 @ 01:00
Wind speed: 0=no wind; 1=light rustles in the leaves; 2=branches moving; 3=whole canopy moving	1 @ 5:40 pm

Table A19 Water quality data collected between 5:40 pm and 7:40 pm on 5/02/2018

Component	*Data*	
	Downstream @ 5:40 pm	Upstream @ 7:40 pm
Water level:	35 cm below marker	
Location:	E 489300 N 6594442	E 488872 N 6593811
DO:	4.05 mg/L or 48.7 %	5.15 mg/L or 61.1%
Conductivity:	0.249 mS/cm	0.235 mS/cm
pH:	6.87	7.05
Temperature:	23.45	22.67
Turbidity:	2.9	6.6
Samples taken for lab analysis: Y/N	Y	Y

Heavy Metals - arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc.
Hydrocarbons - Naphthalene TRH>C10-C16, TRH>C10-C16 less naphthalene (F2), TRH>C16-C34, TRH>34-C40, TRHC6-C10, and TRHC6-C10 less BTEX (F1)
BTEX Group including Benzene, Ethylbenzene, m&P-xylenes, o-Xylene, Toluene and Xylene - total
Nutrients - Nitrogen (as N), Suspended Solids and Total Phosphorus

Note:

- UWC Water quality, habitat and weather data was collected on the 5 February 2018.
- UWC GBF population data was collected on 5 and 7 February 2018.

Table A20 Habitat data collected on 5/02/2018 at the 20 demarcated zones

	Zone # 1		Zone # 2		Zone # 3		Zone # 4		Zone # 5		Zone # 6		Zone # 7		Zone # 8		Zone # 9		Zone # 10	
Creek Bank	East	West	East	West	East	West	East	West	East	West	East	West	East	West	East	West	East	West	East	West
Landuse: dairy or beef cattle grazing etc.	Riparian vegetation	Beef cattle grazing	Riparian vegetation	Beef cattle grazing	Riparian vegetation	Beef cattle grazing	Riparian vegetation	Beef cattle grazing	Riparian vegetation	Beef cattle grazing	Riparian vegetation	Beef cattle grazing	Riparian vegetation	Beef cattle grazing	Bridge construction site		Bridge construction site		Bridge construction site	
Broad veg type within the immediate riparian zone: riparian rainforest/dry sclerophyll/woodland mallee/ heath/ shrub sedgeland or cleared land	Blue Gum, Casuarina, Water Gum	Cleared pasture	Blue Gum, Casuarina, Water Gum	Sclerophyll - Water Gum	Flooded Gum	Sclerophyll - Water Gum	Flooded Gum, Water Gum	Flooded Gum, Water Gum, Camphor Laurel	Sedgeland species, *Setaria sphacelata* and Water Gum	Red Ash, Water Gum, Camphor Laurel, Scentless Rosewood	Water Gum, Sandpaper Fig	Red Ash, Water Gum, Camphor Laurel, Flooded Gum	Water Gum, Setaria, Paspalum	Red Ash, Water Gum, Camphor Laurel, Small-leaf Privet	Water Gum, Setaria, Paspalum	Red Ash, Water Gum, Camphor Laurel, Small-leaf Privet Part open no trees/ veg.	Black Booyong, Red Ash, Water Gum, Camphor Laurel, Small-leaf Privet	No riparian vegetation	Water Gum, Blue gum	No riparian vegetation
Instream physical features	small logs		log		exposed log east bank		nil		exposed log east bank		log		nil		nil		western edge of piped rock crossing with riffles		Eastern edge of piped rock crossing with riffles	
Stream width (m):	~17		~22		~25		~27		~22		~24		~19		~16		~15		~10	
	>1.5		>1.5		>1.5		>1.5		>1.5		>1.5		>1		>1		0.8		0.8	
Presence of pools and or riffles:	deep channel		deep channel		deep channel		deep channel		deep channel		deep channel		deep channel		deep channel		riffles pools either side of the piped crossing		riffles pools either side of the piped crossing	
Bed composition:	gravel covered in mud/silt layer		gravel covered in detritus layer		gravel covered in detritus layer		gravel covered in detritus layer		gravel covered in detritus layer		gravel covered in detritus layer		gravel covered in detritus layer		gravel covered in detritus layer		gravel covered in detritus layer and scour rock		gravel covered in detritus layer and scour rock	
Type of emergent vegetation if present:	nil	*Juncus* sp. *Persicaria Strigosa*, *Eleocharis* sp. *Nymphaea* sp.	Lomandra	*Nymphaea caerulea*	*Persicaria* sp.	Lomandra	Lomandra, Marsh Club Rush (*Bolboschoenus fluviatilis*) *Persicaria* spp.	nil	Lomandra, Marsh Club Rush (*Bolboschoenus fluviatilis*) *Persicaria* spp.	nil	Lomandra, *Juncus usitatus*	nil		Lomandra, Persicaria *strigosa*, *Juncas* sp.	Lomandra	Lomandra	Lomandra	Lomandra		*Juncus* spp. Persicaria strigosa, Setaria lomandra
Stream bank characteristics:	sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		imported rock	
Bank profile: Undercut/steep/benched/gradual incline from the waters edge	steep	gradual incline	steep	benched	gradual	steep incline	moderate incline	undercut to steep	gradual	steep	gradual	moderate	gradual	moderate to steep	gradual	moderate	moderate incline	gradual incline	not natural	
Vegetation associated with the stream bank regarding foliage projection cover (FPC) for overstorey trees/shrubs/groundcover	3m	groundcover	2-3 m	5-7 m	3 m	5-7 m	2 m	5-7 m	nil	5-7 m	nil	5 m	0 m	5 m	0 m	5 m	3 m	5 m	2 m	wetland species no tree or shrub canopy
Groundcover composition: including a measure of vegetative groundcover/litter cover/soil cover/exposed rock expressed as a composition %	Moss 10% Leaf litter 50% Exposed soil 25% Grass/ groundcover sp. 10%	kikuyu 100%	Moss 10% Leaf litter 60% Exposed soil 30% Grass/ groundcover sp. 10%	Moss 5% Leaf litter 20% Exposed soil 10% Grass 65%	Moss 15% Leaf litter 40% Exposed soil 35% Grass 10%	Moss 10% Leaf litter 30% Exposed soil 5% Grass 55%	Moss 10% Leaf litter 70% Exposed soil 20% Fern 20%	Moss 5% Leaf litter 65% Exposed soil 15% Fern 15%	Moss 15% Leaf litter 70 % Exposed soil 10% Grass 5%	Fallen logs 45 % Moss 0% Leaf litter 50 % Exposed soil 5% Grass 5%	Moss 10 % Leaf litter 20 % Exposed soil 10 % Grass 70 %	Moss 10% Leaf litter and bark 65 % Exposed soil 10% Grass 15%	Moss 0% Leaf litter 10% Exposed soil 5% Grass 75%	Moss 10% Leaf litter 60% Exposed soil 10% Grass 10% Sticks and bark 10%	Moss 0% Leaf litter 20% Exposed soil 5% Grass 75 %	Moss 5% Leaf litter 40% Exposed soil 10% Grass 45 %	Moss 15% Leaf litter 55% Exposed soil 20% Grass 10%	Scour rock and fringing aquatic species (bridge structure overhead)	GBF exclusion fencing not natural edge of bank	Setaria 100 % to bank
Depth of Litter: Deep = >100mm / Moderate = 20 -100mm / Shallow = < 20mm / Absent	Shallow	nil	Moderate	shallow	moderate	moderate	moderate	moderate	moderate	deep	Shallow	moderate	shallow	moderate	shallow	shallow	shallow	nil	shallow	nil
Tadpole Trap Data Traps to be placed 1 per survey zone and in the water for 3 hours	nil		nil		nil		nil		1 x Gudgeon		nil		nil		1 x likely juvenile Bullrout (*Notesthes robusta*)		nil		3 x Gudgeons	
Dip net results:	n/a		nil		n/a		n/a		1 x Mosquito Fish and 1 x Mussel (*Hyridella australis)*		n/a		n/a		10 x Glass Shrimp		n/a		nil	
Notes:									Clearing for powerlines has occurred within this transect. 20 m wide fallen timbers lay where felled.											

	Zone # 11		*Zone # 12*		*Zone # 13*		*Zone # 14*		*Zone # 15*		*Zone # 16*		*Zone # 17*		*Zone # 18*		*Zone # 19*		*Zone # 20*	
Creek Bank	East	West	East	West	East	West	East	West	East	West	East	West	East	West	East	West	East	West	East	West
Landuse: dairy or beef cattle grazing etc.	Bridge construction site		Riparian vegetation	WC2NH project. Former grazing land	Riparian vegetation	WC2NH project. Former grazing land	Dairy cattle grazing	WC2NH project. Former grazing land	Dairy cattle grazing	WC2NH project. Former grazing land	Dairy cattle grazing	WC2NH project. Former grazing land	Dairy cattle grazing	WC2NH project. Former grazing land	Dairy cattle grazing	WC2NH project. Former grazing land	Dairy cattle grazing	WC2NH project. Former grazing land	Dairy cattle grazing	WC2NH project. Former grazing land
Broad veg type within the immediate riparian zone: riparian rainforest/dry sclerophyll/woodland mallee/ heath/ shrub sedgeland or cleared land	Water Gum, Blue gum, dense Lantana	Water Gum	Water Gum, Blue gum, dense Lantana	Creek Sandpaper Fig, Water Gum	Water Gum, Blue gum	Creek Sandpaper Fig, Water Gum	No riparian vegetation (pasture grasses)	Water Gum	No riparian vegetation (pasture grasses)	Water Gum, Camphor Laurel	No riparian vegetation (pasture grasses)	Water Gum, Camphor Laurel, Cockspur	Pasture Grasses and single Water Gum	Water Gum, Camphor Laurel, Red Ash	No riparian vegetation	Water Gum	Flooded Gum, Water Gum,	No riparian vegetation (pasture grasses)	Water Gum, Creek Sandpaper Fig, Large-leaf Privet	No riparian vegetation (pasture grasses)
Instream physical features	nil		dead tree		log		Nil		Nil		Log		log		Emergent vegetation		Emergent vegetation		Emergent vegetation	
Stream width (m):	~17		~15		~15		~17		~15		~10		~11		~13		~5		~8	
	>1.5m		>2		>2		>1.5		>1.5		>1.5		>1.5		>1.5		>1		>1	
Presence of pools and or riffles:	deep channel		deep channel		deep channel		shallow channel ~1m		shallow channel ~1m		shallow channel ~1m		shallow channel ~1m		shallow channel ~1m		shallow channel ~1m		shallow channel ~1m	
Bed composition:	gravel covered in detritus layer		gravel covered in detritus layer		gravel covered in detritus layer		gravel covered in detritus layer		gravel covered in detritus layer		gravel covered in detritus layer		gravel covered in detritus layer		gravel covered in detritus layer		gravel covered in detritus layer		gravel covered in detritus layer	
Type of emergent vegetation if present:	*Juncus* sp.		nil		Lomandra	*Nymphaea caerulea, Persicaria* spp.	*Persicaria* sp.	Lomandra	*Persicaria* sp.	Lomandra	nil	Lomandra, *Nymphaea caerulea*	*Persicaria* sp.	Lomandra	*Persicaria* spp., Setaria and *Eleocharis* sp.	Lomandra	*Persicaria* spp., Setaria and *Eleocharis* sp.	nil	Lomandra, *Persicaria* spp.	nil
Stream bank characteristics:	sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam	
Bank profile: Undercut/steep/benched/gradual incline from the waters edge	steep	moderate	steep	steep	moderate	steep - landslip into creek 10 m wide	gradual	steep	gradual	steep	gradual	steep benched	gradual	steep benched	gradual	moderate benched	gradual	gradual	moderate	gradual
Vegetation associated with the stream bank regarding foliage projection cover (FPC) for overstorey trees/shrubs/groundcover	2 m	4 m	3 m	4 m	2.5 m	4 m	0 m	3 m	nil	4 m	nil	5 m	nil	5 m	nil	3 m	1 m	nil	3 m	nil
Groundcover composition: including a measure of vegetative groundcover/litter cover/soil cover/exposed rock expressed as a composition %	Moss 10% Leaf litter 60% Exposed soil 15% Grass 15%	Moss 0% Leaf litter 10% Exposed soil 10% Grass 80%	Moss 10 % Leaf litter 60% Exposed soil 20% Grass 10 %	Moss0 % Leaf litter 30% Exposed soil 0% Grass 70 %	Moss 0% Leaf litter 60% Exposed soil 10% Grass 20%	Moss 0% Leaf litter 0% Exposed soil 0% Grass 100%	Pasture grasses 100%	Moss 10% Leaf litter 10% Exposed soil 10% Grass 80%	Pasture grasses 100%	Moss 10% Leaf litter 30% Exposed soil 30% Grass 30%	Pasture grasses 100%	Moss 10% Leaf litter 30% Exposed soil 10% Grass 50%	Leaf litter 10% Pasture grasses 90%	Moss 10% Leaf litter 30 % Exposed soil 10% Grass 50%	Pasture grasses 100%	Moss 5% Leaf litter 10% Exposed soil 10% Grass 75%	Moss 0% Leaf litter 15% Exposed soil % Grass 85%	Pasture grasses 100%	Moss 10% Leaf litter 10% Exposed soil 40% Grass 40%	Pasture grasses 100%
Depth of Litter: Deep = >100mm / Moderate = 20 -100mm / Shallow = < 20mm / Absent	moderate	shallow	moderate	moderate	Shallow	nil	nil	shallow	nil	moderate	nil	Shallow	shallow	shallow to moderate	nil	moderate	shallow	nil	moderate	nil
Tadpole Trap Data Traps to be placed 1 per survey zone and in the water for 3 hours	nil		1 x Gudgeon		nil		nil		nil		nil		nil		nil		nil		1 x Gudgeon	
Dip net results:	n/a		n/a		nil		n/a		n/a		1 x Gudgeon and 1 x Glass Shrimp		n/a		nil		n/a		n/a	
Notes:																				

Notes:

All emergent vegetation was observed at the edge of the creek on or close to the bank at the cross section of each transect.

Tadpole traps were set from approximately 5pm to 8 pm with traps 1 - 10 being set for approximately five hours. Traps 11 - 21 were collected the following morning due to fatigue management. Aside from reduced water level of UWC the visible water quality appeared consistent with typical stream characteristics for this system. Percentage of grass cover was generally similar to that recorded during spring 2017. Construction site rubbish to be collected from downstream of the site.

GBF Butchers Creek Summer – 5 and 7 February 2018

Table A21 GBF monitoring data sheet

	Frog # 1	*Frog # 2*	*Frog # 3*	*Frog # 4*	*Frog # 5*	*Frog # 6*
GPS Location and survey zone #:	No Giant Barred Frogs (*Mixophyes iteratus*) were recorded visually or audibly at the Butchers Creek site.					
GPS release point: if frog is located within the work zone (must be <100m from capture point)						
Distance from stream edge:						
Position within the microhabitat: (under leaf litter/above litter/ exposed/on a rock)						
Sex: (female/male/unknown)						
Age class: (adult >60mm; sub-adult 40-60mm; juvenile <40mm						
Snout to vent length (mm):						
Weight (grams):						
Breeding condition: Males: colour of nuptial pads no colour/light/moderate/dark see table 2.1 of GBFMP for classification Females: gravid (typically weighing >100 grams) or not Immature = Frogs <60mm						
Chytrid Swab taken Y/N Wipe the swab under armpits and in groin, keep sample in fridge until delivered to lab						
Microchip ID:						

Table A22 Abiotic data collected at start of nocturnal GBF survey on 7/02/2018 (using WeatherMation data for rainfall)

Nocturnal GBF Survey 7/02/2018 from 6:30pm to 7:45pm
Nocturnal GBF Survey 7/02/2018 from 12:00am to 1:00am

Component	*Data*
Rainfall During the survey:	0 mm
Rainfall within the past 24 hrs:	0 mm
Rainfall within the past 7 days:	23 mm
Rainfall within the past 30 days:	49.6 mm
Relative humidity start of survey:	56 %
Relative humidity end of survey:	94.6%
Air temperature start of survey:	25.8
Air temperature end of survey:	16
Wind speed: 0=no wind; 1=light rustles in the leaves; 2=branches moving; 3=whole canopy moving	0 at 20:00

Table A23 Water quality data collected at 9:00pm on 7/02/2018

Component	*Data*
Water level	105 cm below marker
Location:	E 489642 N 6594927
DO:	2.06mg/L or 4.1%
Conductivity:	.227 mS/cm
pH:	5.53
Temperature:	21.76
Turbidity:	0
Samples taken for lab analysis: Y/N	Y

Heavy Metals - arsenic, cadmium, chromium, copper, lead, mercury, nickel and zinc.
Hydrocarbons - Naphthalene TRH>C10-C16, TRH>C10-C16 less naphthalene (F2), TRH>C16-C34, TRH>34-C40, TRHC6-C10, and TRHC6-C10 less BTEX (F1)
BTEX Group including Benzene, Ethylbenzene, m&P-xylenes, o-Xylene, Toluene and Xylene - total
Nutrients - Nitrogen (as N), Suspended Solids and Total Phosphorus

Notes:
- Water quality, abiotic, weather and GBF population data was collected on 7 February 2018.
- Habitat data was collected on 8 February 2018.

Table A24 Habitat data collected on 7/02/2018 at the eight demarcated riparian zones

	Zone # 1 - east		*Zone # 2*		*Zone # 3*		*Zone # 4*		*Zone # 5*		*Zone # 6*		*Zone # 7*		*Zone # 8 - west*	
Creek Bank	North	South	North	South	North	South	North	South	North	South	North	South	North	South	North	South
Landuse: dairy or beef cattle grazing etc.	Forest riparian zone		Forest riparian zone		Forest riparian zone		Forest riparian zone		Project alignment		Forestry / Cattle		Forestry / Cattle		Forestry / Cattle	
Broad veg type within the immediate riparian zone: riparian rainforest/dry sclerophyll/woodland mallee/ heath/shrub sedgeland or cleared land	Maiden's Blush, Bangalow Palm, Flooded Gum		Brush Box, Bangalow palm, Blackbutt, Tallowwood, Turpentine, Maiden's Blush		Casuarina, Flooded Gum, Camphor Laurel, Syzygium. A number of snapped Casuarina have fallen into the creek channel covered in Cissus vines 15 m width within the quadrat		Callicoma, Casuarina, Flooded Gum, Camphor Laurel		Casuarina, Water Gum, Callicoma, Flooded Gum, Camphor Laurel		Camphor Laurel, Red Ash, Blue Gum, Small Leaved Privet, Lantana		Significant weed infestation in this quadrat - Camphor Laurel, Small Leaved Privet, Lantana. Encroachment of Broad-leaved Paspalum and Setaria into dry creek bed.		Camphor Laurel, Brush Box, Casuarina Blackbutt, Lantana, Small Leaved-Privet	
Instream physical features	Nil		Nil		Nil		Nil		Lomandra emergent		Small branches		Nil		Nil	
Stream width (m):	0		0		0		0		2.8		3		0		2.5	
Stream depth (m):	0		0		0		0		0.5		0.25		0		0.04	
Presence of pools and or riffles:	Nil dry creek bed		Black tannin water in pool nearby but no water at monitoring point		Nil dry creek bed		Nil dry creek bed		Pool		Pool		Nil dry creek bed		Spring fed pool	
Bed composition:	Rock		Rock		Rock		Rock		Rock and detritus		Rock and detritus		Rock		Rock little leaf litter	
Type of emergent vegetation if present:	nil		nil		nil		nil		Lomandra along bank and *Juncus planifolius*		nil		Pasture grass encroachment into dry creek bed		nil	
Stream bank characteristics:	sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam		sandy soil - loam	
Bank profile: Undercut/steep/benched/gradual incline from the water's edge	gradual	gradual	undercut	gradual slope	undercut	undercut and steep with tree roots	gradual	undercut	Benched	Steep	undercut	undercut	gradual	steep to undercut	undercut/ steep	undercut
Vegetation associated with the stream bank regarding foliage projection cover (FPC) for overstorey trees/shrubs/groundcover	joined canopy		2m	2 m	joined canopy		2 m	almost joined canopy - 3 m	3 m	4 m	close canopy almost joined Privet - to Privet		3m	2m	closed or joined canopy. 2-3 m of riparian veg then thick	
Groundcover composition: including a measure of vegetative groundcover/litter cover/soil cover/exposed rock expressed as a composition %	Moss 0% Leaf litter 40% Exposed soil 0% Rock 30% Grass 30%	Moss 0% Leaf litter 45% Exposed soil 0% Rock 35% Grass 20%	Moss 0% Leaf litter 55% Exposed sand 10% Rock 35% Grass 0%	Moss 0% Leaf litter 45% Exposed sand 10% Rock 45% Grass 0%	Moss 0% Leaf litter and bark 45% Exposed soil 0% Rock 35% Grass 20%	Moss 0% Leaf litter and bark 65% Exposed soil 0% Rock 35% Grass 5%	Moss 0% Leaf litter 45% Exposed soil 0% Rock 25% Grass 30%	Moss 0% Leaf litter 45% Exposed soil 0% Rock 45% Grass 10%	of natural bank remaining (5m) Moss 20% Leaf litter 30% Exposed soil 20% Rock 15% Flood debris 15%	of natural bank remaining (5m) Moss 20% Leaf litter 30% Exposed soil 20% Rock 15% Flood debris 15%	Moss 0% Leaf litter 10% Exposed soil 0% Rock 10% Grass 80%	Moss 0% Leaf litter 10% Exposed soil 0% Rock 10% Grass 80%	Moss 0% Leaf litter 25% Exposed soil % Rock 5% Grass 70%	Moss % Leaf litter 30% Exposed soil % Rock 5% Grass 60%	Moss 0% Leaf litter 25% Exposed soil 10% Rock 30% Grass 45%	Moss 0% Leaf litter 30% Exposed soil 10% Rock 35% Grass 35%
Depth of Litter: Deep = >100mm / Moderate = 20 - 100mm / Shallow = < 20mm / Absent	Moderate	Moderate	Shallow	Shallow	Moderate	Moderate	Moderate	Moderate	Shallow	Shallow	Shallow	Shallow	Shallow	Shallow	Moderate	Moderate
Tadpole Trap Data Traps to be placed 1 per survey zone and in the water for 3 hours	nil water to place trap in this quadrat. Set trap in closest available pool 10m further east		nil		nil water to place trap in this quadrat. Set trap in closest available pool 50m further east		nil water to place trap in this quadrat		nil		nil water to place trap in this quadrat. Set trap in closest available pool 20m further west		*Mixophyes fasciolatus* tadpole ~80 mm		nil	
Dip net results:	n/a		Water invertebrates		n/a		n/a		Water invertebrates		n/a		Water invertebrates		n/a	

Notes:

No *M. fasciolatus* were heard calling at any time during the survey nor in response to call playback. Typically, Great Barred Frogs (*M. fasciolatus*) at Butchers Creek call readily and always in response to call playback. All emergent vegetation was observed at the edge of the creek on or close to the bank. Tadpole traps were set for approximately 4.5 hours. Very low water levels in the creek compared to typical water levels. Very little aquatic fauna was observed. Construction site rubbish to be collected from downstream of the site.

Appendix B

Water Quality Results Compared Against ANZECC Trigger Values

		ANZECC / ARMCANZ (2009) Trigger Value for freshwater **95% species Level of protection**		Autumn 2017		Spring 2017		Summer 2018		
				Upper Warrell Creek (downstream)	Butchers Creek	Upper Warrell Creek (downstream)	Butchers Creek	Upper Warrell Creek (downstream)	Upper Warrell Creek (upstream)	Butchers Creek
				4/04/2017	6/04/2017	7/11/2017	6/11/2017	5/02/2018	5/02/2018	7/02/2018
pH	pH unit	6.5 - 8.0		-	-	-	-	6.5	6.5	6.1
Conductivity	µS/cm	125–2200		-	-	-	-	250	249	177
Turbidity	NTU	6 to 50		-	-	-	-	7.4	4.1	0.85
Total Suspended Solids	mg/L	-		3	<2	8	<2	9	6	<2
Total Nitrogen	mg/L	0.35		0.44	0.14	0.56	0.13	0.49	0.39	0.05
Total Phosphorus	mg/L	0.025		<0.03	<0.03	<0.03	<0.03	0.03	0.03	<0.03
Arsenic - Total	ug/L	13	AsV	<0.001	<0.001	1.3	<1	1.6	1.6	<1
Cadmium	mg/L	0.0002		<0.002	<0.002	<0.002	<0.002	<0.0001	<0.0001	<0.0001
Chromium	mg/L	0.001	CrVI	<0.003	<0.003	<0.003	<0.003	<0.001	<0.001	<0.001
Copper	mg/L	0.0014		<0.004	<0.004	<0.004	<0.004	<0.001	<0.001	<0.001
Lead	mg/L	0.0034		<0.010	<0.010	<0.010	<0.010	<0.001	<0.001	<0.001
Mercury - Total	ug/L	0.06	inorganic	<0.0001	<0.0001	<0.1	<0.1	<0.1	<0.1	<0.1
Nickel	mg/L	0.011		<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Selenium	ug/L	5	total	-	-	<1	<1	-	-	-
Zinc	mg/L	0.008		0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.007
TRH C6-C9	ug/L	-		<20	<20	<25	<25	<25	<25	<25
TRH C10-C14	ug/L	-		<50	<50	<25	<25	<25	<25	<25
TRH C15-C28	ug/L	-		<100	<100	<100	<100	<100	<100	<100
TRH C29-C36	ug/L	-		<50	<50	<100	<100	<100	<100	<100
TRH C10-C36 (sum)	ug/L	-		<50	<50	<100	<100	<100	<100	<100
TRH C6- C10	ug/L	-		<20	<20	<25	<25	<25	<25	<25
TRH C6- C10 less BTEX(F1)	ug/L	-		<20	<20	<25	<25	<25	<25	<25
TRH>C10-C16	ug/L	-		<100	<100	<25	<25	<25	<25	<25
TRH>C16-C34(F3)	ug/L	-		<100	<100	<25	<25	<100	<100	<100
TRH>C34-C40(F4)	ug/L	-		<100	<100	<100	<100	<100	<100	<100
>C10 - C40 Fraction (sum)	ug/L	-		<100	<100	<100	<100	-	-	-
>C10-C16 Fraction-Naphthalene	ug/L	-		<100	<100	-	-	-	-	-
Benzene	ug/L	950		<1	<1	<1	<1	<1	<1	<1
Toluene	ug/L	ID		<2	<2	<1	<1	<1	<1	<1
Ethyl Benzene	ug/L	ID		<2	<2	<1	<1	<1	<1	<1
m,p-Xylene	ug/L	ID		<2	<2	<2	<2	<2	<2	<2
o-Xylene	ug/L	350		<2	<2	<1	<1	<1	<1	<1
Total Xylenes	ug/L	-		<2	<2	-	-	-	-	-
Sum of BTEX	ug/L	-		<1	<1	-	-	-	-	-
Naphthalene	ug/L	16		<5	<5	-	-	-	-	-

Appendix C

Water Quality Laboratory Results – Autumn, Spring and Summer – Year 3

GEOLINK
JESSICA O'LEARY
P.O. BOX 1446
COFFS HARBOUR NSW 2450

BATCH NUMBER: 17/0767
No. of SAMPLES: 2
DATE COLLECTED: 4-6/04/17
DATE RECEIVED: 10/04/17
TIME RECEIVED: 09:55
DATE TESTING COMMENCED: 10/04/17

REPORT OF ANALYSIS

PROJECT REFERENCE: 2378-WC2NH

SAMPLE REFERENCE	SAMPLE DESCRIPTION
17/0767/1	UWC - GBF
17/0767/2	BUTCHERS CREEK - GBF

ANALYSIS	UNITS	17/0767/1	17/0767/2			METHOD NO
Total Suspended Solids	mg/L	3	<2			APHA 2540 D
Total Nitrogen	mg/L	0.44	0.14			EL30F
Total Phosphorus	mg/L	<0.03	<0.03			EL18F

ANALYSIS	UNITS	17/0767/1	17/0767/2			METHOD NO
METAL SUITE						
Arsenic*	mg/L	<0.001	<0.001			EG020T
Cadmium	mg/L	<0.002	<0.002			EL9A
Chromium	mg/L	<0.003	<0.003			EL9A
Copper	mg/L	<0.004	<0.004			EL9A
Mercury*	mg/L	<0.0001	<0.0001			EG035T
Lead	mg/L	<0.010	<0.010			EL9A
Nickel	mg/L	<0.005	<0.005			EL9A
Selenium*	mg/L	<0.01	<0.01			EG020T
Zinc	mg/L	0.003	<0.003			EL9A
TOTAL PETROLEUM HYDROCARBONS*						
TPH C6-C9 Fraction	ug/L	<20	<20			EP080/071
TPH C10-C14 Fraction	ug/L	<50	<50			EP080/071
TPH C15-C28 Fraction	ug/L	<100	<100			EP080/071
TPH C29-C36 Fraction	ug/L	<50	<50			EP080/071
TPH C10-C36 Fraction (sum)	ug/L	<50	<50			EP080/071
TOTAL RECOVERABLE HYDROCARBON*						
C6-C10 Fraction	ug/L	<20	<20			EP080/071

NATA

Accredited for compliance with ISO/IEC 17025.
[Accreditation Numbers: 12359 (Chemical) & 14565 (Microbiological)]

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian and International standards.

ANALYSIS	UNITS	17/0767/1	17/0767/2			METHOD NO
C6 - C10 Fraction minus BTEX	ug/L	<20	<20			EP080/071
>C10 - C16 Fraction	ug/L	<100	<100			EP080/071
>C16 - C34 Fraction	ug/L	<100	<100			EP080/071
>C34 - C40 Fraction	ug/L	<100	<100			EP080/071
>C10 - C40 Fraction (sum)	ug/L	<100	<100			EP080/071
>C10-C16 Fraction-Naphthalene	ug/L	<100	<100			EP080/071
BTEX*						
Benzene	ug/L	<1	<1			EP080
Toluene	ug/L	<2	<2			EP080
Ethylbenzene	ug/L	<2	<2			EP080
meta- & para-Xylene	ug/L	<2	<2			EP080
ortho-Xylene	ug/L	<2	<2			EP080
^Total Xylenes	ug/L	<2	<2			EP080
^Sum of BTEX	ug/L	<1	<1			EP080
Naphthalene	ug/L	<5	<5			EP080

Comments

Sample(s) collected by client and analysed as received in accordance with "Standard Methods for the Examination of Water & Wastewater", 22nd Edition, 2012, APHA. Raw data sheets stating analysis dates are available upon request.
Tests marked with '#' are not covered by NATA Accreditation.
Note: Microbiological results are membrane presumptive.
*Analysis conducted by a subcontracted laboratory (NATA Accreditation Number 825) WO/N:EB1707643.
Report Date: 23/02/18

Approved:
B J Wadleigh
Laboratory Manager

GEOLINK
JESSICA O'LEARY
23 GORDON STREET
COFFS HARBOUR NSW 2450

BATCH NUMBER: 17/2390
No. of SAMPLES: 2
DATE COLLECTED: 06-07/11/17
DATE RECEIVED: 08/11/17
TIME RECEIVED: 15:00
DATE TESTING COMMENCED: 08/11/17

REPORT OF ANALYSIS

SAMPLE REFERENCE	SAMPLE DESCRIPTION
17/2390/1	UPPER WARRELL CREEK
17/2390/2	BUTCHERS CREEK

ANALYSIS	METHOD NO	UNITS	17/2390/1	17/2390/2
Total Suspended Solids	APHA 2540 D	mg/L	8	<2
Total Nitrogen	EL30F	mg/L	0.56	0.13
Total Phosphorus	EL18F	mg/L	<0.03	<0.03

ANALYSIS	METHOD NO	UNITS	17/2390/1	17/2390/2
METAL SUITE				
Arsenic - Total*	NT2_47	ug/L	1.3	<1
Cadmium	EL9A	mg/L	<0.002	<0.002
Chromium	EL9A	mg/L	<0.003	<0.003
Copper	EL9A	mg/L	<0.004	<0.004
Lead	EL9A	mg/L	<0.010	<0.010
Mercury - Total*	NT2_47	ug/L	<0.1	<0.1
Nickel	EL9A	mg/L	<0.005	<0.005
Selenium - Total*	NT2_47	ug/L	<1	<1
Zinc	EL9A	mg/L	<0.003	<0.003
TOTAL RECOVERABLE HYDROCARBONS				
TRH C6-C9*	NGCMS_1121	ug/L	<25	<25
TRH C10-C14*	NGCMS_1112	ug/L	<25	<25
TRH C15-C28*	NGCMS_1112	ug/L	<100	<100
TRH C29-C36*	NGCMS_1112	ug/L	<100	<100
TRH C10-C36 (sum)	NGCMS_1112	ug/L	<100	<100
TOTAL RECOVERABLE HYDROCARBON*				
TRH C6- C10	NGCMS_1121	ug/L	<25	<25

ANALYSIS	METHOD NO	UNITS	17/2390/1	17/2390/2
TRH C6- C10 less BTEX (F1)	NGCMS_1121	ug/L	<25	<25
TRH>C10-C16	NGCMS_1112	ug/L	<25	<25
TRH>C10 - C16 less Naph(F2)	NGCMS_1112	ug/L	<25	<25
TRH>C16-C34(F3)	NGCMS_1112	ug/L	<100	<100
TRH>C34-C40(F4)	NGCMS_1112	ug/L	<100	<100
BTEX*				
Benzene	NGCMS_1121	ug/L	<1	<1
Toluene	NGCMS_1121	ug/L	<1	<1
Ethyl Benzene	NGCMS_1121	ug/L	<1	<1
m,p-Xylene	NGCMS_1121	ug/L	<2	<2
o-Xylene	NGCMS_1121	ug/L	<1	<1

Comments

Sample(s) collected by client and analysed as received in accordance with "Standard Methods for the Examination of Water
& Wastewater", 22nd Edition, 2012, APHA. Raw data sheets stating analysis dates are available upon request.
Tests marked with '#' are not covered by NATA Accreditation.
*Analysis conducted by a subcontracted laboratory (NATA Accreditation Number 198) R/N: 1178203

Approved: 21/11/17
B J Wadleigh
Laboratory Manager

NATA

Accredited for compliance with ISO/IEC 17025.
[Accreditation Numbers: 12359 (Chemical) & 14565 (Microbiological)]

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian and International standards.

GEOLINK
JESSICA O'LEARY
23 GORDON STREET
COFFS HARBOUR NSW 2450

BATCH NUMBER: 18/0339
No. of SAMPLES: 3
DATE COLLECTED: 05-07/02/18
DATE RECEIVED: 09/02/18
TIME RECEIVED: 15:10
DATE TESTING COMMENCED: 09/02/18

REPORT OF ANALYSIS

SAMPLE REFERENCE	SAMPLE DESCRIPTION
18/0339/1	UWC - GBF - UPSTREAM
18/0339/2	UWC - GBF - DOWNSTREAM
18/0339/3	BUTCHERS - GBF - DOWNSTREAM

ANALYSIS	METHOD NO	UNITS	18/0339/1	18/0339/2	18/0339/3
pH	APHA 4500-H+ B	pH unit	6.5	6.5	6.1
Conductivity	APHA 2510 B	µS/cm	250	249	177
Turbidity	APHA 2130 B	NTU	7.4	4.1	0.85
Total Suspended Solids	APHA 2540 D	mg/L	9	6	<2
Total Nitrogen	EL30F	mg/L	0.49	0.39	0.05
Total Phosphorus	EL18F	mg/L	0.03	0.03	<0.03

ANALYSIS	METHOD NO	UNITS	18/0339/1	18/0339/2	18/0339/3
METAL SUITE					
Arsenic - Total*	NT2_47	ug/L	1.6	1.6	<1
Cadmium	EL9A	mg/L	<0.002	<0.002	<0.002
Chromium	EL9A	mg/L	<0.003	<0.003	<0.003
Copper	EL9A	mg/L	<0.004	<0.004	<0.004
Lead	EL9A	mg/L	<0.010	<0.010	<0.010
Mercury - Total*	NT2_47	ug/L	<0.1	<0.1	<0.1
Nickel	EL9A	mg/L	<0.005	<0.005	<0.005
Zinc	EL9A	mg/L	<0.003	<0.003	0.007
TOTAL RECOVERABLE HYDROCARBONS					
TRH C6-C9*	NGCMS_1121	ug/L	<25	<25	<25
TRH C10-C14*	NGCMS_1112	ug/L	<25	<25	<25
TRH C15-C28*	NGCMS_1112	ug/L	<100	<100	<100
TRH C29-C36*	NGCMS_1112	ug/L	<100	<100	<100
TRH C10-C36 (sum)	NGCMS_1112	ug/L	<100	<100	<100
TOTAL RECOVERABLE HYDROCARBON*					

ANALYSIS	METHOD NO	UNITS	18/0339/1	18/0339/2	18/0339/3
TRH C6- C10	NGCMS_1121	ug/L	<25	<25	<25
TRH C6- C10 less BTEX (F1)	NGCMS_1121	ug/L	<25	<25	<25
TRH>C10-C16	NGCMS_1112	ug/L	<25	<25	<25
TRH>C10 - C16 less Naph(F2)	NGCMS_1112	ug/L	<25	<25	<25
TRH>C16-C34(F3)	NGCMS_1112	ug/L	<100	<100	<100
TRH>C34-C40(F4)	NGCMS_1112	ug/L	<100	<100	<100
BTEX*					
Benzene	NGCMS_1121	ug/L	<1	<1	<1
Toluene	NGCMS_1121	ug/L	<1	<1	<1
Ethyl Benzene	NGCMS_1121	ug/L	<1	<1	<1
m,p-Xylene	NGCMS_1121	ug/L	<2	<2	<2
o-Xylene	NGCMS_1121	ug/L	<1	<1	<1

Comments

Sample(s) collected by client and analysed as received in accordance with "Standard Methods for the Examination of Water
& Wastewater", 22nd Edition, 2012, APHA. Raw data sheets stating analysis dates are available upon request.
Tests marked with '#' are not covered by NATA Accreditation.
*Analysis conducted by a subcontracted laboratory (NATA Accreditation Number 198) RN 1186771, 1186921, 1187338.

Approved: 28/02/18
B J Wadleigh
Laboratory Manager

NATA

Accredited for compliance with ISO/IEC 17025.
[Accreditation Numbers: 12359 (Chemical) & 14565 (Microbiological)]

The results of the tests, calibrations and/or measurements included in this document are traceable to Australian and International standards.

Appendix D

Chytrid Results Analysis and Discussion

Detection and quantification of the amphibian chytrid fungus *Batrachochytrium dendrobatidis* on amphibian epidermal swabs

For GEOLINK

Over a period of time swabs were delivered to the Conservation Biology Research Laboratory at the University of Newcastle for the detection and quantification of Batrachochytrium dendrobatidis. The methodology employed and some general comments on the results obtained are described.

Methodology

The detection and quantification of B. dendrobatidis on swabs was conducted with a TaqMan real-time PCR assay following standard procedures1, with the exception of the quantity of PrepMan Ultra used to extract DNA. The TaqMan real-time PCR assay was conducted on a Rotor Gene 6000 DNA amplification system. This test is highly sensitive and can detect the genomic equivalent of 0.01 zoospores.

Each swab was analysed in triplicate and a positive result in all three replicates was indicative of a swab with B. dendrobatidis. A negative result in all three replicates was indicative that *B. dendrobatidis* was not present on the swab, was present at a density below the assays detection efficiency or the PCR reaction was inhibited. To detect inhibition within the reactions, internal positive controls were included in one replicate of each swab. Where inhibition is detected, a 1/100 dilution of the originally extracted DNA is prepared to dilute inhibitory agents and the reaction repeated.

Equivocal results can occur when less than 3 of the replicates return positive results. This may be the result of a low density of *B. dendrobatidis* in the original sample or the result of contamination. To detect the presence of contamination, negative template controls were included in all assays. The number of genomic equivalents detected in positive replicates of each swab was summarized as the geometric mean and provides a relative measure of the infection load in an individual. This infection load can be compared between individuals provided a standardised swabbing technique was employed.

Results

Outcomes are reported under two headings; 1) Prevalence of Chytrid in the sample (population sample). This is usually a raw number (e.g. 2 out or 10 samples) and is converted to a population prevalence (e.g. 20% of the sample were infected). 2) Zoospore Number. This refers to the number of infectious zoospores (single motile cells) obtained from the swab. This number relies on a specific capacity for rtPCR to count the number of gene sequences which is directly related to the number of zoospores in the swab. The assumption is that swabs are taken in a standardised fashion, and that the size of the frogs in the sample are equivalent.

Most reports will also mention if the swab was contaminated. This can be from other organic matter (algae, bacteria or other fungi), and its important is that this can inhibit the reaction used to count the number of zoospores. Serial dilutions and additional runs are required to deal with this difficulty.

Lastly, for all rtPCR processes negative controls and positive controls are employed.

Interpretation of Results

Swabs found to be positive for the presence of *B. dendrobatidis* (Chytrid Bd) are reflective of true presence of the disease organism on the frog that was sampled. The significance of these results with respect to season of sampling and the chronic and acute states of the disease requires further epidemiological and demographic data to be able to make any statement that it can lead to death of the individual frog and thus to population decline.

When positive results are found in a population it is assumed that Bd occurs in an enzootic condition in location and population sampled.

The swabs found to be negative for the presence of *B. dendrobatidis*, are likely to be reflective of a true absence or densities below the detectable limit of the TaqMan real time PCR assay. The importance of negative template controls included in each assay, are to demonstrate all swabs found to be negative for *B. dendrobatidis* were not caused by contamination.

The number of genomic equivalents detected on an individual generally reflects its infection load. However, when the number detected are in the low quantities, caution should be taken in identifying these as true infections. Low quantities on the swab of a frog may also be the result of a light swabbing technique or the presence of *B. dendrobatidis* (viable cells or inviable DNA), from the environment or a previous infection, adhering to the epidermal surface of the animal.

Numerous investigations of the level of infection of *B. dendrobatidis* in anurans associated with acute infection and death of the individual are being reported from around the world and for a number of species in Australia. A feature of the examples where a species that is known to be susceptible to infections that proceeds to death among individuals is that the number of zoospores observed to result in death varies among species. Thus, in some species an infection level above 1,000 zoospores is linked with death of individuals, while in other species an infection level above 10,000 zoospores is linked with deaths. There is evidently a species-specific level of infection that is associated with death.

At this time there are no laboratory studies that indicate the level of infection that *Mixophyes iteratus* can withstand before it succumbs to the infection, if it does succumb.

In a previous study that included a population sample of over 60 individuals of *M. iteratus* from one stream the infection levels (in zoospore numbers) ranged from 12 to 1640, with no apparent signs of illness in any of the frog swabbed (*Mahony unpubl data*).

Another finding of recent investigations is that numerous species have developed mechanisms to deal with Chytrid infections. It is an active area of research to identify the mechanisms involved but to date natural selection for innate immunity and acquired immunity have been demonstrated. One of the interesting features of the populations of *M. iteratus* that have been investigated is that repeated captures of marked animals may demonstrate whether an individual that is infected in one sampling period has survived and cleared the infection by the next sampling period. Such information would prove invaluable in determining whether this threatened species has an adaptive capacity to deal with infection by *B. dendrobatidis*. At least one individual (00078ABD42) that was sampled during summer 2016 was recaptured during summer 2018, showed a very low infection level in the first sampling season, and was clear of infection in the second season sample.

Report prepared by: Prof Michael Mahony
Conservation Biology Research Laboratory
The University of Newcastle
Callaghan NSW 2309
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Appendix K

Weed and Pathogen Monitoring Report

December/ Annual 2017

ABN 79 896 839 729
ACN 101 084 557

Return address:
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NSW 2478

LENNOX HEAD
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T 02 6651 7666

ARMIDALE
T 0488 677 666

LISMORE
T 02 6621 6677

www.geolink.net.au

20 December 2017
Ref No: 2378-1408

Pacifico
124 Albert Drive
Donnellyville NSW 2447

Attention: Alex Dwyer

Warrell Creek to Nambucca Heads - Six Monthly and Annual Weed and Pathogen Monitoring Report – December 2017

Background

A Weed and Pathogen Management Plan (WPMP) has been prepared as part of the Warrell Creek to Nambucca Heads (WC2NH) Construction Environment Management Plan (CEMP). The WPMP requires that weed monitoring is undertaken to identify occurrences of noxious/ environmental weeds and signs of plant pathogens. The weed monitoring program comprises the following:

1) *"Fixed photograph points are to be established at 15 locations within the project site to monitor the change in weed levels and detect any signs of plant pathogens. Photo points are to be placed in areas of native vegetation outside the clearing limits (but inside the project boundary) and should be spread across different vegetation types, EECs and threatened flora/ fauna habitats associated with the site. The locations of the photo points are to be determined by the project ecologist during the first weed monitoring session. A star picket and metal tag (with identification code) would be used to mark all locations with a photograph to be taken during monitoring sessions always facing in the same direction.*
2) *Surveys of the entire project site will be undertaken routinely by the project ecologist to identify noxious/ environmental weed infestations. Substantial weed infestations are to be mapped and provided to the AFJV Environmental team in a brief report. AFJV will also monitor weed infestations on the construction site through the Weekly Environmental Checklist process.*
3) *Searches for signs of dieback (indicative of Phytophthora cinnamoni) and Myrtle Rust will be undertaken in areas of native vegetation retained within the project site. Any such signs are to be investigated further with testing to be undertaken if required".*

When the WC2NH Project was awarded, the *Noxious Weeds Act 1993* (NW Act) legislated the control of noxious weed species within NSW. The NW Act has since been repealed and replaced with the *Biosecurity Act 2015*. As the project approved CEMP and the Weed and Pathogen Management Plan (GeoLINK, 2014) were approved referencing the NW Act, the recommendations in this report will be in accordance with the approved CEMP which references the NW Act.

This report presents the December 2017 weed and pathogen monitoring results and discusses the annual results for 2017. Monitoring for December six monthly monitoring was undertaken by GeoLINK Ecologist Frank Makin on 6 and 13 December 2017. Six monthly monitoring is scheduled until the end of the project; however, the next monitoring event may be earlier as Stage 2B is scheduled to open in April 2018.

It should be noted that at the time of writing the report Stage 2A of the WC2NH Highway alignment was open to traffic, and the project from chainage 48100 to 61250 is now considered to be operational. However, the road and associated project alignment will remain the responsibility of Pacifico until RMS sign the construction completion certificate. Weed infested areas within Stage 2A have been surveyed and recommendations for management are included within this report.

Fixed Photograph Points

The locations of fixed photograph monitoring points are shown in **Appendix A**. Fixed photograph points were established during the May 2015 survey. December 2017 monitoring photos are compared with the May 2015 "baseline" photos in **Appendix B**.

General Weed Surveys

The December 2017 weed assessment captures the six month period between July and December 2017. A range of noxious and environmental weeds were recorded, with Lantana (*Lantana camara*) being most prevalent. The Class 3 noxious weed Salvinia (*S. molesta*) was recorded in low levels (mostly as a dry or decaying mat of vegetation) within the project boundary on the Gumma Floodplain (ch. 51,100 and 50,490). Due to recent dry weather conditions through the months of July – September and November the Gumma Floodplain is currently experiencing seasonally dry conditions. Salvinia is a species that can withstand dry periods as the plant has the ability to retain water at times when the surrounding environment is dry. As wet conditions return to the environment the plants begin to regenerate. As a Class 3 Regionally Controlled Weed, Salvinia must be fully and continuously suppressed and destroyed. Low levels of Salvinia may be manually removed from the water column within the project boundary. A Geofab silt fence is currently limiting the encroachment of Salvinia into the project boundary at Floodplain Bridge 2 from the adjacent waterbody to the east of the highway alignment where a considerable infestation of Salvinia occurs.

During the June 2017 monitoring event, the Class 3 noxious weed Groundsel Bush (*Baccharis halimifolia*) was also detected in low numbers within the project boundary within the Gumma Floodplain along the eastern edge of the project alignment. Groundsel Bush within the project boundary was recorded as being treated with herbicide during June. During December monitoring 2017, these plants were not observed, suggesting that Groundsel Bush control measures have been effective. Should small infestations regrow, individual plants may be manually removed. As a Class 3 Regionally Controlled Weed Groundsel Bush must be fully and continuously suppressed and destroyed.

Fixed point monitoring photos (refer to **Appendix B**) indicates a low presence of weeds across the project area no photo point monitoring sites require action via weed control. Previous weed control measures and newly landscaped batters have resulted in a low level of weeds across the site; however, there are several isolated areas that still require active weed control, as detailed in **Table 1** (below).

The presence of weed infestations is lowest within the northern half of the project, north of the Pacific Highway and Old Coast Road intersection, with very few areas of weed encroachment recorded.

Areas of concern which currently or have the potential to develop weed infestation are creeks and drainage lines, particularly in the southern section of the project such as Rosewood Creek, Butchers Creek and Upper Warrell Creek (UWC). Weed control and proposed landscape plantings within the UWC riparian zone is of key importance due to the presence of the threatened Giant Barred Frog (GBF). Typical GBF habitat comprises mostly open ground with a deep layer of leaf litter beneath with a vegetated forest canopy. Dense pasture grass infestations may limit the dispersal of GBF within habitat areas and limit available breeding habitat for the species, which typically occupies habitat within 20 m of the water's edge of freshwater streams and occasionally dams. It is recommended to plan for the future control of weeds around the riparian zone of UWC to protect GBF habitat. In accordance with the GBF Management Strategy (Lewis, 2014) the proposed landscape planting will

maintain or enhance connectivity of GBF habitat post-construction and into the operational phase of the highway (Stage 2B). Stage 2B is forecast to open to traffic in April of 2018.

As works on the Philip Hughes (Nambucca River) Bridge is now complete, the area beneath the bridge will be decommissioned and all construction related materials removed. This area is now at risk of encroachment by weeds which thrive in disturbed areas. The area beneath the Nambucca River Bridge comprises the Threatened Ecological Community *Freshwater Wetlands on coastal floodplains* and weed management within this area should be implemented to assist the regeneration of native wetland species.

One of the goals of the WPMP is *"the ongoing suppression/ control of noxious and environmental weeds during the construction and post-construction (landscape maintenance period) stages".* Based on the results of the assessment, this goal is being met under current weed management measures.

As the project transitions from the construction phase to becoming operational, further consultation between Nambucca Valley Council and Pacifico (and in the future, RMS) will be required to address future control of weed species adjacent to the project boundary to reduce cross flow/ drift from adjacent weed infestations. It is expected that the future weed control requirements will be managed in accordance with the *Biosecurity Act 2015*.

Weed and pathogen monitoring and control will be undertaken across the project until the opening of Stage 2B (currently scheduled for April 2018). Weed surveys will continue to be prepared by the project ecologist with input from the Pacifico environmental team in order to identify priority weed control areas. The results of these surveys will inform future weed control activities on the project.

Plant Pathogen Surveys

Searches for signs of Phytophthora (*P.cinnamomi*) and Myrtle rust were undertaken during December 2017 in areas of native vegetation retained within the site boundary. No signs were found and no indications of plant pathogens have been identified during the project to date.

If you require any further information, please feel free to contact me on 0407 756 033.

Yours sincerely
GeoLINK

Jessica O'Leary
Ecologist

Table 1 Priority Weed Control Areas

Chainage	*Location Description*	*Ecological Constraints*	*Description of Weed Infestations*	*Weed Classification**	*Class***	*Control Required/ Completed*
42,400 - 42,700	Upper Warrell Creek riparian zone within project boundary	Giant Barred Frog habitat and proximity to waterway.	Blackberry (*Rubus fruticosus* species *aggregate*), Camphor Laurel (*Cinnamomum camphora*), Large-leaved Privet (*Ligustrum lucidum*), Wild Tobacco (*Solanum mauritianum*), Winter Senna (*Senna pendula var. glabrata*), Blackberry Nightshade (*Solanum nigrum*), Spear Thistle (*Cirsium vulgare*).	Noxious (Blackberry)	N4	Generally weeds including environmental weed species should be controlled at this location to preserve/ improve GBF habitat within the riparian zone of the project boundary. Weed control measures and landscaping of the riparian zone should be planned for to ensure the riparian zone is handed over to RMS in the best possible condition to maintain habitat of the GBF population.
			Dense impenetrable infestations of pasture grasses - Pigeon Grass (*Setaria sphacelata*) and Broad-leaved Paspalum (*P. mandiocanum*) along non-vegetated creek banks.			Propose landscaping the grass dominated creek banks with semi established native tubestock species and removal of pasture grasses to increase GBF suitable habitat availability. Species suitable for planting can be provided in consultation with Pacifco
43,280 – 43,400	Butchers Creek	Proximity to waterway; unconfirmed GBF habitat.	Fireweed (*Senecio madagascariensis*), Narrow-leaved Privet (*Ligustrum sinense*), Winter Senna, Lantana, White Passionflower	Noxious	N4 (Fireweed) N4 (Narrow-leaved Privet)	Low levels of Fireweed occur at the outer edges of the project boundary near adjacent agricultural lands. Spot foliar spraying of this species is recommended. Dense infestation of

Chainage	Location Description	Ecological Constraints	Description of Weed Infestations	Weed Classification*	Class**	Control Required/ Completed
			(*Passiflora subpeltata*), Paddy's Lucerne (*Sida rhombifolia*), Purple Top (*Verbena bonariensis*).			Lantana occurs outside the project boundary, especially to the west of the alignment.
44,800 – 45,000	Rosewood Creek	Proximity to Rosewood Creek	Annual Ragweed (*Ambrosia artemisiifolia*), Fireweed, Winter Senna, Lantana, White Passionflower, Paddy's Lucerne, Purple Top	Noxious WoNS (Lantana)	N5 (Annual Ragweed) N4 (Fireweed) N4 (Lantana)	Foliar spraying required.
48,260 – 48,300	Northern Abutment, Lower Warrell Creek	Proximity to Lower Warrell Creek	Infestations of Lantana along edge of riparian zone.	Noxious WoNS	N4	Lantana at this location has been treated; however, ongoing foliar spraying is required to reduce infestations levels.
48,300 – 49,600	Highway verge north of Bald Hill Road south to Lower Warrell Creek	Proximity to waterway	Lantana	Noxious WoNS	N4	Foliar spraying required.
49,500 – 49,600	Northern corner of Pacific Highway and Bald Hill Road – infestation extends north behind compound.	None	Lantana and assorted environmental weeds including Camphor Laurel, Wild Tobacco, Billygoat Weed (*Ageratum houstonianum*).	Noxious WoNS (Lantana and Camphor Laurel only) Environmental weeds	N4	Although weeds in the area have been reduced through physical removal as part of the new Bald Hill Road works, ongoing foliar spraying of remaining weeds is required.
50,490 - 51,100	Gumma Floodplain	*Maundia triglochinoides*	Salvinia (*S. molesta*).	Noxious WoNS	N3	Salvina is currently experiencing die-back likely due to recent low rainfall levels Low level of infestation to

Chainage	Location Description	Ecological Constraints	Description of Weed Infestations	Weed Classification*	Class**	Control Required/ Completed
						be manually removed. Geofabric fencing is assisting to prevent encroachment of Salvinia into the project boundary from the east.
51,200	Gumma Floodplain - Floodplain Bridge 2 eastern side of alignment	Proximity to waterway	Groundsel Bush (*Baccharis halimifolia*).	Noxious	N3	Foliar spraying of plants within the project boundary has been undertaken, individual remaining plants are to be manually removed. Note: Groundsel Bush remains within RMS owned land adjacent to the project boundary.
52,500 – 52,700	Nursery Road to Pacific Highway	Freshwater Wetland TEC	Lantana, Wild Aster (*Aster subulatus*), Balloon Cotton Bush (*Gomphocarpus physocarpus*), White Passionflower Paddy's Lucerne and Blackberry Nightshade.	Noxious (Lantana only) WoNS (Lantana only) Environmental weeds	N4	Selected foliar spraying required.
52750 - 52850	Nursery Road to Pacific Highway	Freshwater Wetland EEC near to Tall Knotweed	Annual Ragweed, Paddy's Lucerne, Billygoat Weed, Blackberry Nightshade, Coastal Morning Glory (*Ipomoea cairica*), White Passionflower	Noxious (Annual Ragweed only)	N5	No requirements to control noxious weeds; however, control of weeds should be undertaken to allow native Freshwater wetland species to generate. Selected foliar spraying of weeds required.
52,870 – 52,760	Corner of Pacific Highway and southern side of new Nambucca River Bridge	Nil	Lantana	Noxious WoNS	N4	Foliar spraying required.

Chainage	*Location Description*	*Ecological Constraints*	*Description of Weed Infestations*	*Weed Classification**	*Class***	*Control Required/ Completed*
54,950 – 55,000	Old Coast Road near old QBirt Compound between old coast road and the new highway alignment	Nil	Lantana, Billygoat Weed.	Noxious WoNS	N4	Foliar spraying required.
59,130 to 59,250	Opposite the Tip Road turnoff	Nil	Lantana	Noxious WoNS	N4	Foliar spraying of dense infestation required.

* Noxious weeds as classified under the *Noxious Weeds Act 1993*; WoNS = Weed of National Environmental Significance

** Class 3 (Regionally Controlled Weed) requirements: The plant must be fully and continuously suppressed and destroyed
** Class 4 (Locally Controlled Weed) requirements: The growth of the plant must be managed in a manner that continuously inhibits the ability of the plant to spread
** Class 5 (Locally Controlled Weed) requirements: There are no requirements to control existing plants of Class N5 weeds. However, the weeds are "notifiable" and a range of restrictions on their sale and movement exists.

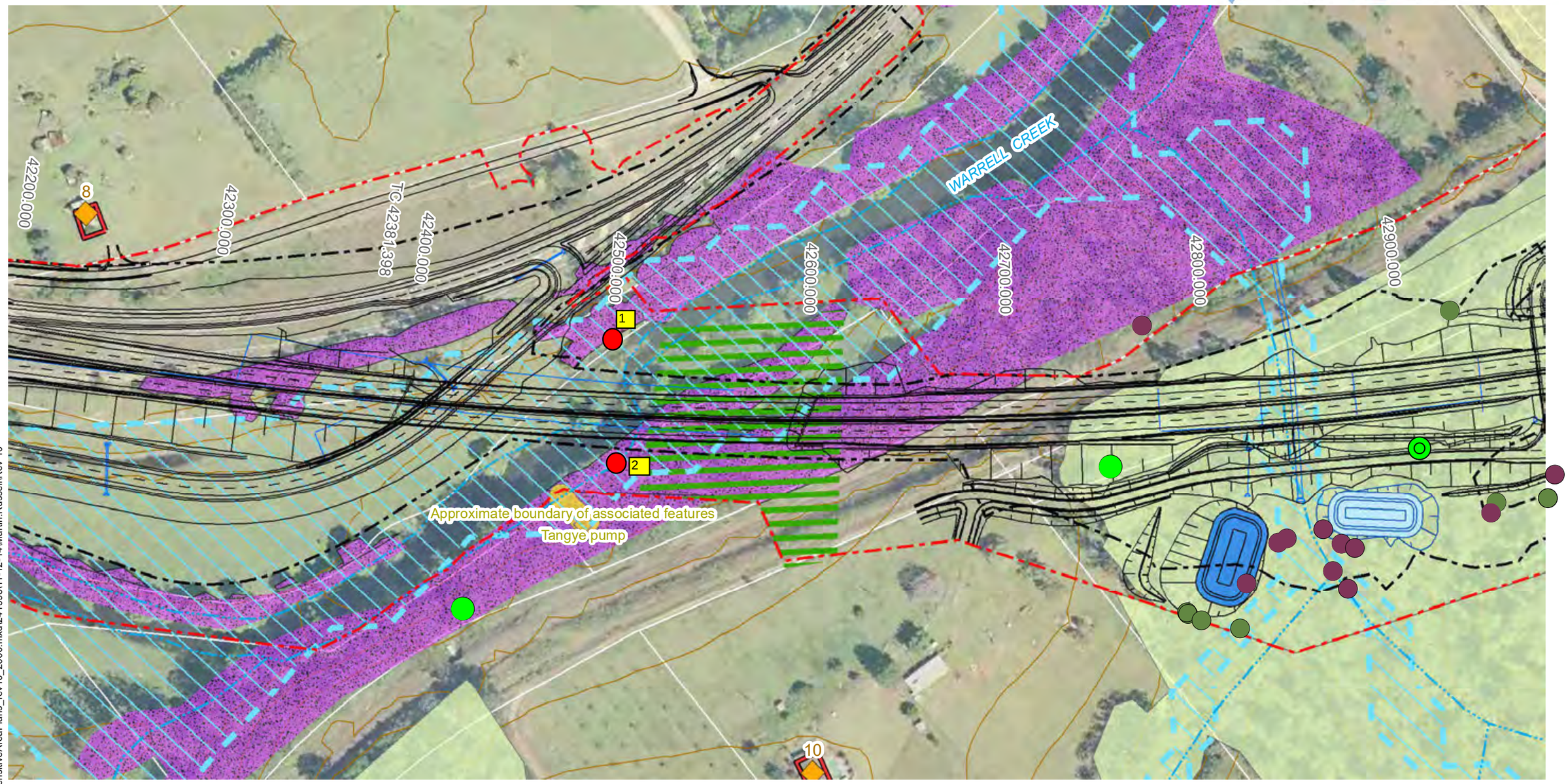
References

GeoLINK (2014) *Weed and Pathogen Management Plan, Warrell Creek to Nambucca Heads Pacific Highway Upgrade*. Unpublished document for use Roads and Maritime Services NSW.

Lewis Ecological (2014) *Warrell Creek to Urunga Giant Barred Frog Management Strategy*. Unpublished document for use Roads and Maritime Services NSW.

Appendix A

Locations of Fixed Photograph Points



Project boundary #
Clearing limit (Appendix 4)
500m Grey-headed Flying Fox buffer zone
300m Grey-headed Flying Fox buffer zone
Construction protection area
5m contours
20yr ARI flood
Natural drainage
SEPP14 wetland

Stormwater management
Drainage basin (Permanent)
Drainage basin (Temporary)

Heritage
Archaeological PAD/site
Heritage item
Non-Aboriginal heritage site
Cabbage tree palm resource site

Acoustic
Facade treatments to noise receivers
Sensitive noise receiver

Contamination
Potential contaminated site

Biodiversity - Flora
Alexfloydia repens
Artanema fimbriatum
Dendrobium melaleucaphilum
Eucalyptus ancophila
Goodenia fordiana
Marsdenia longiloba
Maundia triglochinoides
Niemeyera whitei
Tylophora woollsii
Hollow-bearing tree/Habitat tree
Microbat habitat (observations 2012)
Green-thighed frog breeding pond
Green-thighed frog habitat
Likely Green-thighed frog habitat
Giant Barred frog habitat
Flying Fox camp (Feb 2014)

Location of Maundia
Location of riparian zone vegetation

DPI Fisheries
Mangrove and pneumataphores
Salt marsh

Vegetation Community (EEC)
Freshwater Wetlands
Mixed Floodplain Forest
Swamp Forest - Swamp Mahogany/ Paperbark
Swamp Oak Forest

Vegetation
Mangrove Forest
Moist Open Forest - Flooded Gum
Moist Open Forest - White Mahogany - Grey Gum
Open Forest - Blackbutt
Hardwood Plantation - mostly cleared
Regrowth Acacia/ Weeds
Regrowth Swamp Oak

Regrowth and Weeds: Moist Open Forest - White Mahogany, Grey Gum, Swamp Oak, Camphor Laurel
Garden Plantings
Camphor Laurel Forest (Environmental Weed)

Vegetation Community (EEC)
Freshwater Wetlands
Lowland Rainforest
Mixed Floodplain Forest

Swamp Forest - Swamp Mahogany / Paperbark
Swamp Forest - Swamp Oak
Saltmarsh

Vegetation Community
Mangroves
Moist Open Forest - Flooded Gum
Moist Open Forest - White Mahogany / Grey Gum / Ironbark
Open Forest - Blackbutt
Open Forest - Scribbly Gum

Hardwood Plantation
Softwood Plantation
Unidentified/modified vegetation

 # denotes: Project boundary based on WC2NH_Approved_Project_Boundary_20141202_V2.shp received 02/12/2014

1:2,000 @ A3

0 50 100m

Note: Ground-truthed vegetation has been shown within the project boundary and in proposed areas of ancillary site facilities

Projection: GDA 1994 MGA Zone 56
Source: RMS, AFJV, AADJV

PACIFIC HIGHWAY UPGRADE WC2NH **CEMP**

FIGURE: Sensitive Area Plans (Map 2 of 28)

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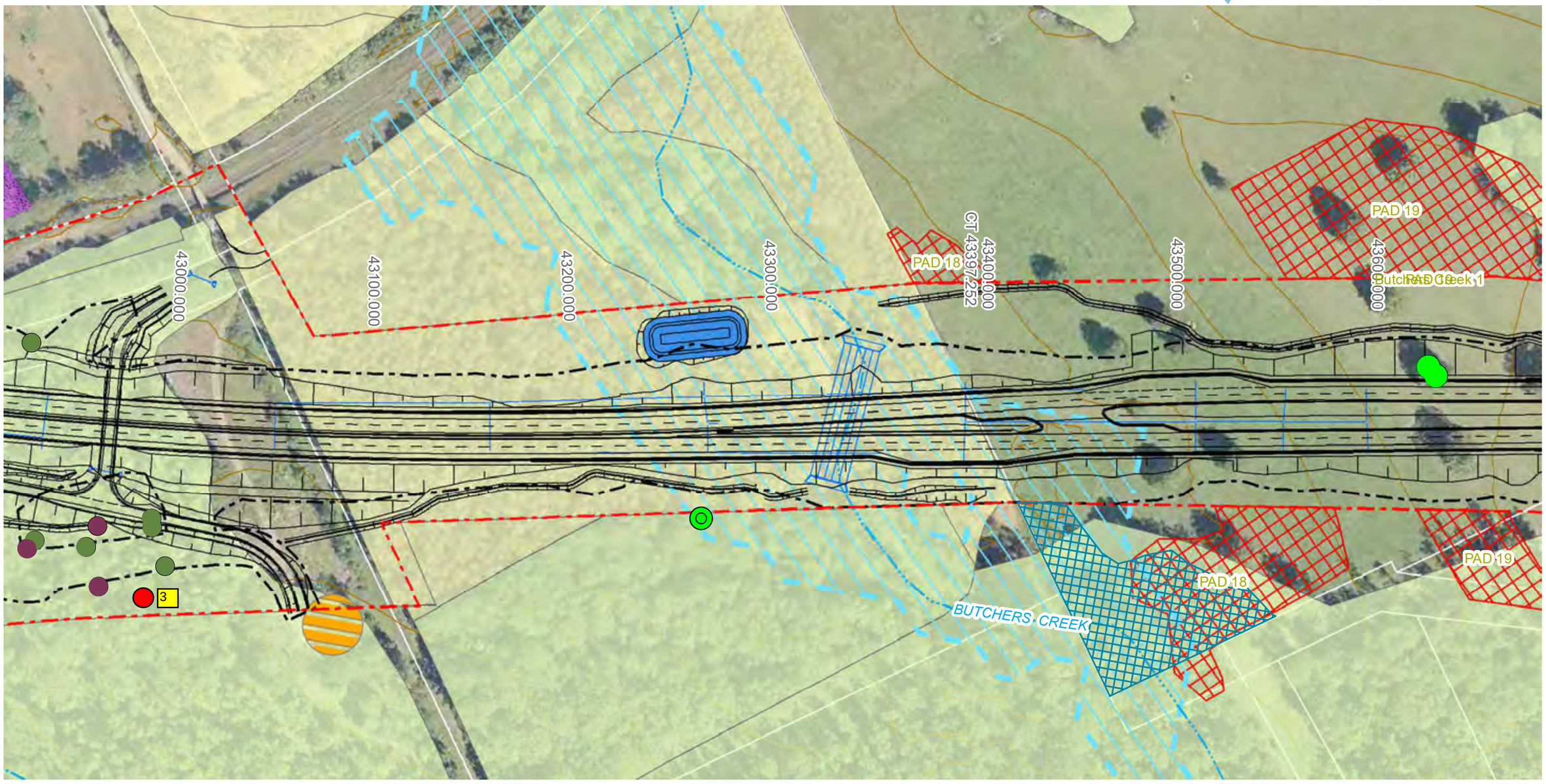

Project boundary #
Clearing limit (Appendix 4)
500m Grey-headed Flying Fox buffer zone
300m Grey-headed Flying Fox buffer zone
Construction protection area
5m contours
20yr ARI flood
Natural drainage
SEPP14 wetland

Stormwater management
Drainage basin (Permanent)
Drainage basin (Temporary)

Heritage
Archaeological PAD/site
Heritage item
Non-Aboriginal heritage site
Cabbage tree palm resource site

Acoustic
Facade treatments to noise receivers
Sensitive noise receiver

Contamination
Potential contaminated site

Biodiversity - Flora
Alexfloydia repens
Artanema fimbriatum
Dendrobium melaleucaphilum
Eucalyptus ancophila
Goodenia fordiana
Marsdenia longiloba
Maundia triglochinoides
Niemeyera whitei
Tylophora woollsii
Hollow-bearing tree/Habitat tree
Microbat habitat (observations 2012)
Green-thighed frog breeding pond
Green-thighed frog habitat
Likely Green-thighed frog habitat
Giant Barred frog habitat
Flying Fox camp (Feb 2014)
Location of Maundia
Location of riparian zone vegetation

DPI Fisheries
Mangrove and pneumataphores
Salt marsh

Vegetation Community (EEC)
Freshwater Wetlands
Mixed Floodplain Forest
Swamp Forest - Swamp Mahogany/ Paperbark
Swamp Oak Forest

Vegetation
Mangrove Forest
Moist Open Forest - Flooded Gum
Moist Open Forest - White Mahogany - Grey Gum
Open Forest - Blackbutt
Hardwood Plantation - mostly cleared
Regrowth Acacia/ Weeds
Regrowth Swamp Oak
Regrowth and Weeds: Moist Open Forest - White Mahogany, Grey Gum, Swamp Oak, Camphor Laurel
Garden Plantings
Camphor Laurel Forest (Environmental Weed)

Vegetation Community (EEC)
Freshwater Wetlands
Lowland Rainforest
Mixed Floodplain Forest
Swamp Forest - Swamp Mahogany / Paperbark
Swamp Forest - Swamp Oak
Saltmarsh

Vegetation Community
Mangroves
Moist Open Forest - Flooded Gum
Moist Open Forest - White Mahogany / Grey Gum / Ironbark
Open Forest - Blackbutt
Open Forest - Scribbly Gum
Hardwood Plantation
Softwood Plantation
Unidentified/modified vegetation

 # denotes: Project boundary based on WC2NH_Approved_Project_Boundary_20141202_V2.shp received 02/12/2014

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0 50 100m

Note: Ground-truthed vegetation has been shown within the project boundary and in proposed areas of ancillary site facilities

Projection: GDA 1994 MGA Zone 56
Source: RMS, AFJV, AADJV

PACIFIC HIGHWAY UPGRADE WC2NH **CEMP**

FIGURE: Sensitive Area Plans (Map 3 of 28)

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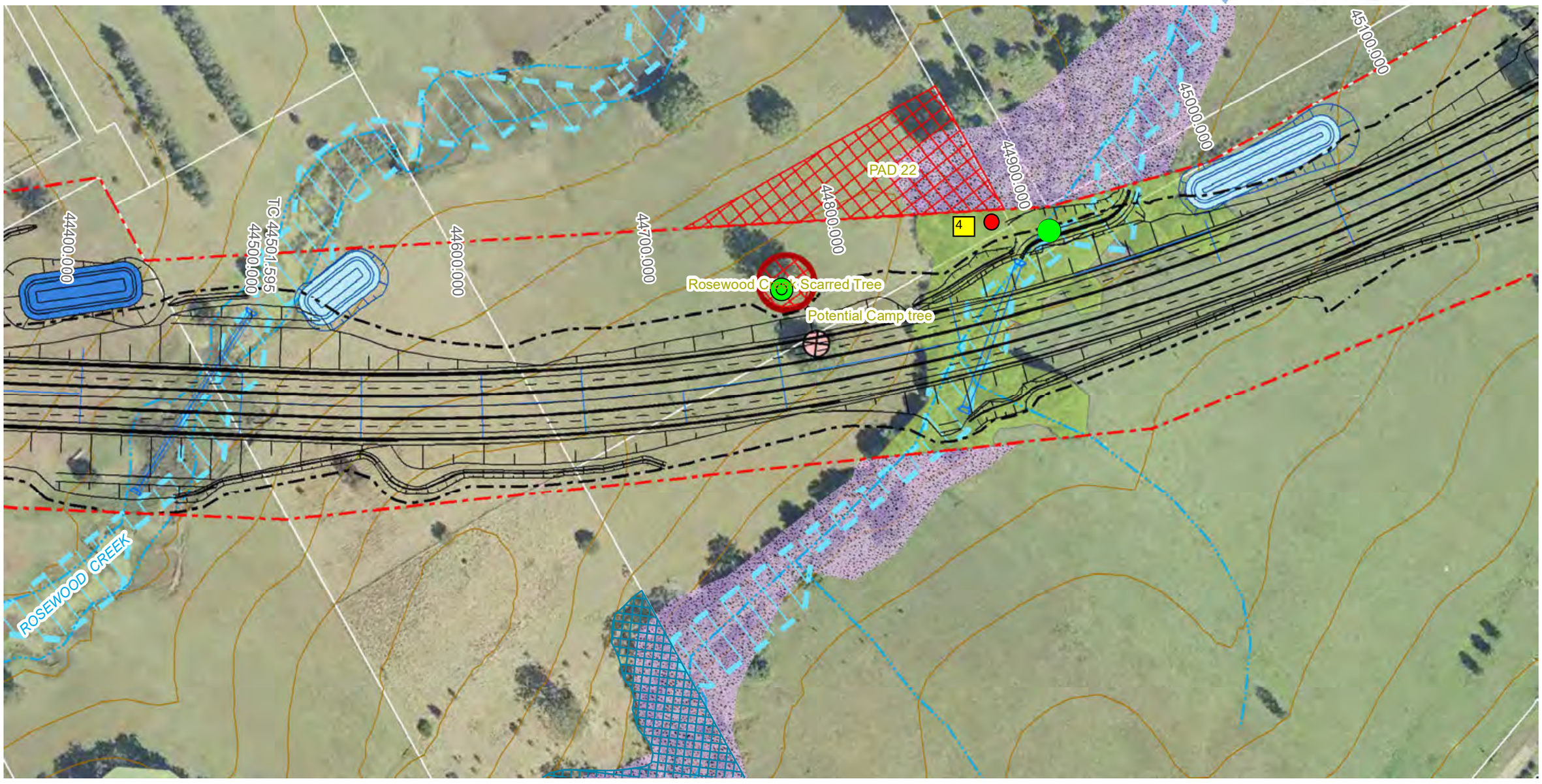

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5m contours
20yr ARI flood
Natural drainage
SEPP14 wetland

Stormwater management
Drainage basin (Permanent)
Drainage basin (Temporary)

Heritage
Archaeological PAD/site
Heritage item
Non-Aboriginal heritage site
Cabbage tree palm resource site

Acoustic
Facade treatments to noise receivers
Sensitive noise receiver

Contamination
Potential contaminated site

Biodiversity - Flora
Alexfloydia repens
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Goodenia fordiana
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Flying Fox camp (Feb 2014)
Location of Maundia
Location of riparian zone vegetation

DPI Fisheries
Mangrove and pneumataphores
Salt marsh

Vegetation Community (EEC)
Freshwater Wetlands
Mixed Floodplain Forest
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Camphor Laurel Forest (Environmental Weed)

Vegetation Community (EEC)
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Vegetation Community
Mangroves
Moist Open Forest - Flooded Gum
Moist Open Forest - White Mahogany / Grey Gum / Ironbark
Open Forest - Blackbutt
Open Forest - Scribbly Gum
Hardwood Plantation
Softwood Plantation
Unidentified/modified vegetation

denotes: Project boundary based on WC2NH_Approved_Project_Boundary_20141202_V2.shp received 02/12/2014

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0 50 100m

Note: Ground-truthed vegetation has been shown within the project boundary and in proposed areas of ancillary site facilities

Projection: GDA 1994 MGA Zone 56
Source: RMS, AFJV, AADJV

PACIFIC HIGHWAY UPGRADE WC2NH **CEMP**

FIGURE: Sensitive Area Plans (Map 5 of 28)

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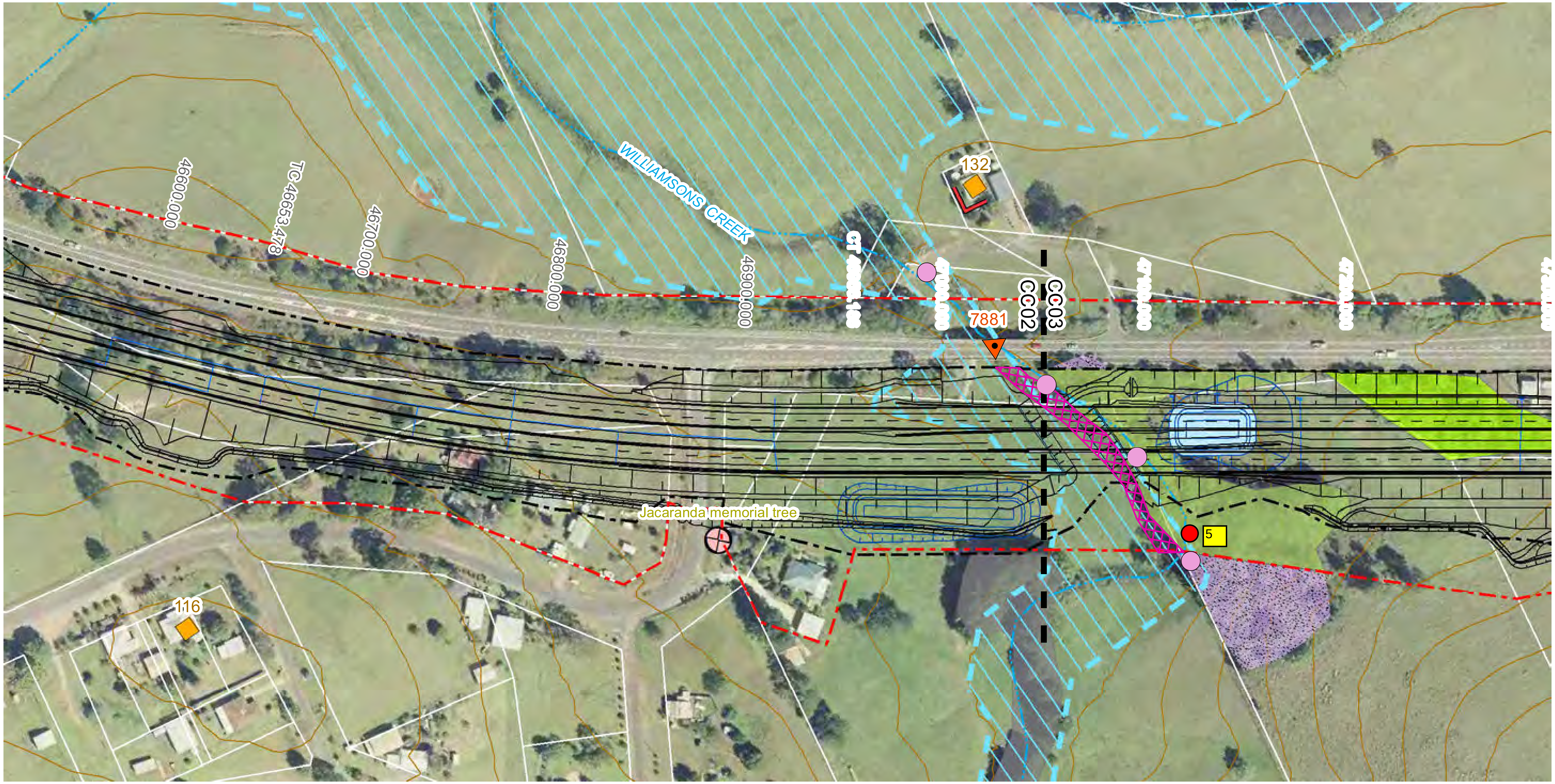
AFJV ARUP aurecon Design Joint Venture



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Heritage item
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Facade treatments to noise receivers

Sensitive noise receiver
Contamination
Potential contaminated site
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Location of Maundia
Location of riparian zone vegetation
DPI Fisheries
Mangrove and pneumataphores
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Ground-truthed (inside project bdy)
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Open Forest - Blackbutt
Open Forest - Scribbly Gum

Hardwood Plantation
Softwood Plantation
Unidentified/modified vegetation

 # denotes: Project boundary based on WC2NH_Approved_Project_Boundary_20141202_V2.shp received 02/12/2014

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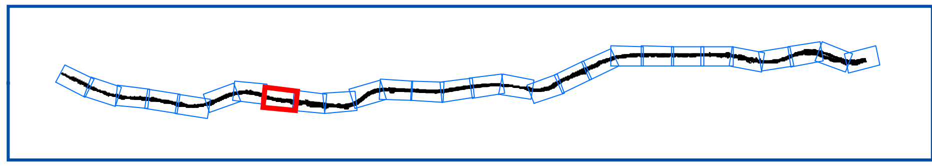
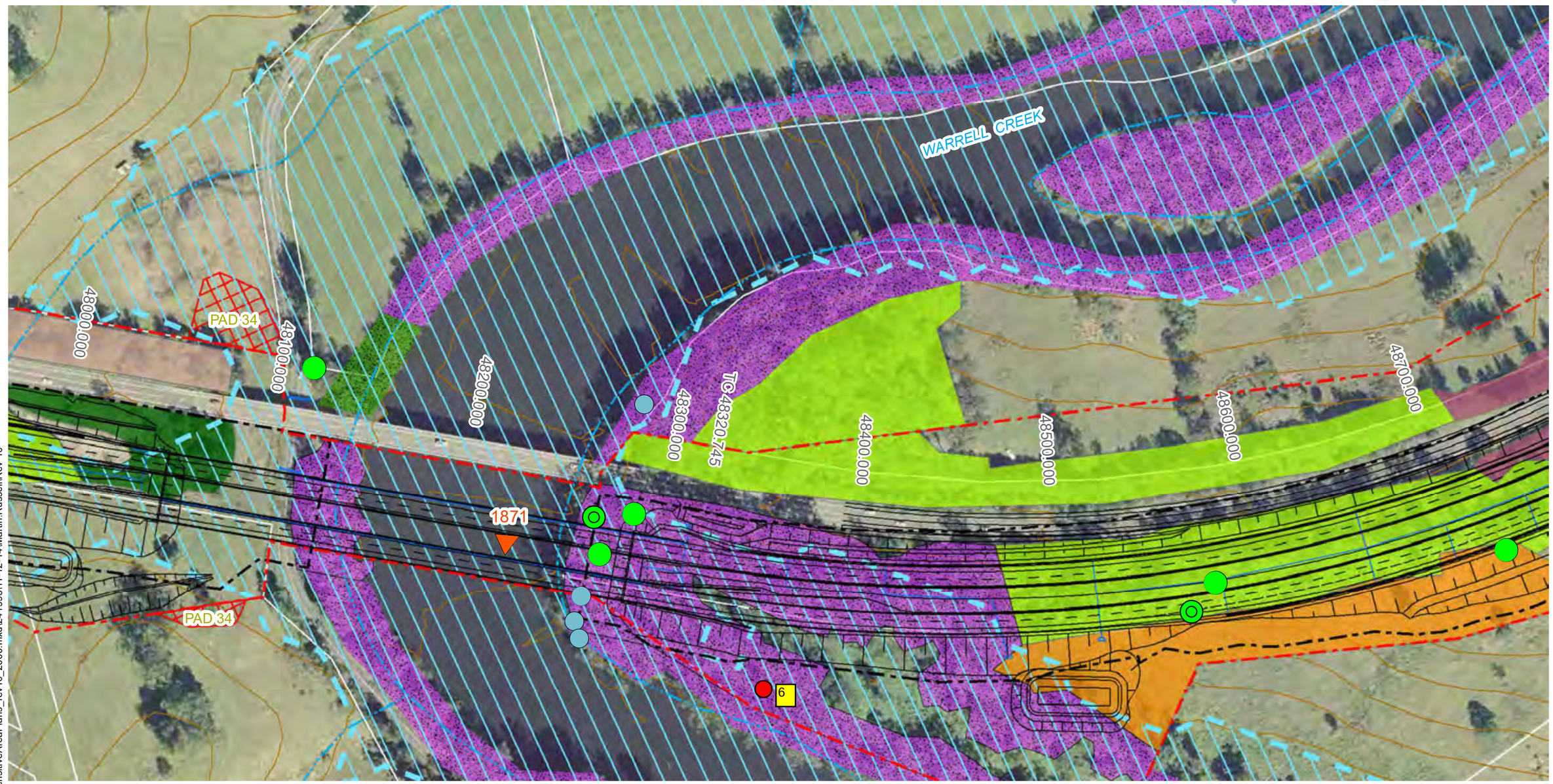


Note: Ground-truthed vegetation has been shown within the project boundary and in proposed areas of ancillary site facilities

Projection: GDA 1994 MGA Zone 56
Source: RMS, AFJV, AADJV

PACIFIC HIGHWAY UPGRADE WC2NH **CEMP**

FIGURE: Sensitive Area Plans (Map 8 of 28)



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Giant Barred frog habitat
Flying Fox camp (Feb 2014)

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Mangrove and pneumataphores
Salt marsh
278_Vegetation_MASTER_Geol_NW_14dec14
Ground-truthed (inside project bdy)

Vegetation Community (EEC)
Freshwater Wetlands
Mixed Floodplain Forest
Swamp Forest - Swamp Mahogany/ Paperbark
Location of Maundia
Location of riparian zone vegetation

Swamp Oak Forest

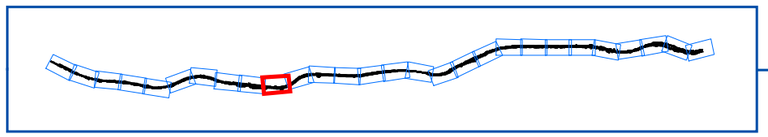
Vegetation
Mangrove Forest
Moist Open Forest - Flooded Gum
Moist Open Forest - White Mahogany - Grey Gum
Open Forest - Blackbutt
Hardwood Plantation - mostly cleared
Regrowth Acacia/ Weeds
Regrowth Swamp Oak
Regrowth and Weeds: Moist Open Forest - White Mahogany, Grey Gum, Swamp Oak, Camphor Laurel
Garden Plantings
Camphor Laurel Forest (Environmental Weed)
EA Vegetation (outside project bdy)

Vegetation Community (EEC)
Freshwater Wetlands
Lowland Rainforest
Mixed Floodplain Forest
Swamp Forest - Swamp Mahogany / Paperbark
Swamp Forest - Swamp Oak
Saltmarsh

Vegetation Community
Mangroves
Moist Open Forest - Flooded Gum
Moist Open Forest - White Mahogany / Grey Gum / Ironbark
Open Forest - Blackbutt
Open Forest - Scribbly Gum
Hardwood Plantation
Softwood Plantation
Unidentified/modified vegetation

 # denotes: Project boundary based on WC2NH_Approved_Project_Boundary_20141202_V2.shp received 02/12/2014

1:2,000 @ A3
0 50 100m



Note: Ground-truthed vegetation has been shown within the project boundary and in proposed areas of ancillary site facilities

Projection: GDA 1994 MGA Zone 56
Source: RMS, AFJV, AADJV

PACIFIC HIGHWAY UPGRADE WC2NH **CEMP**

FIGURE: Sensitive Area Plans (Map 10 of 28)

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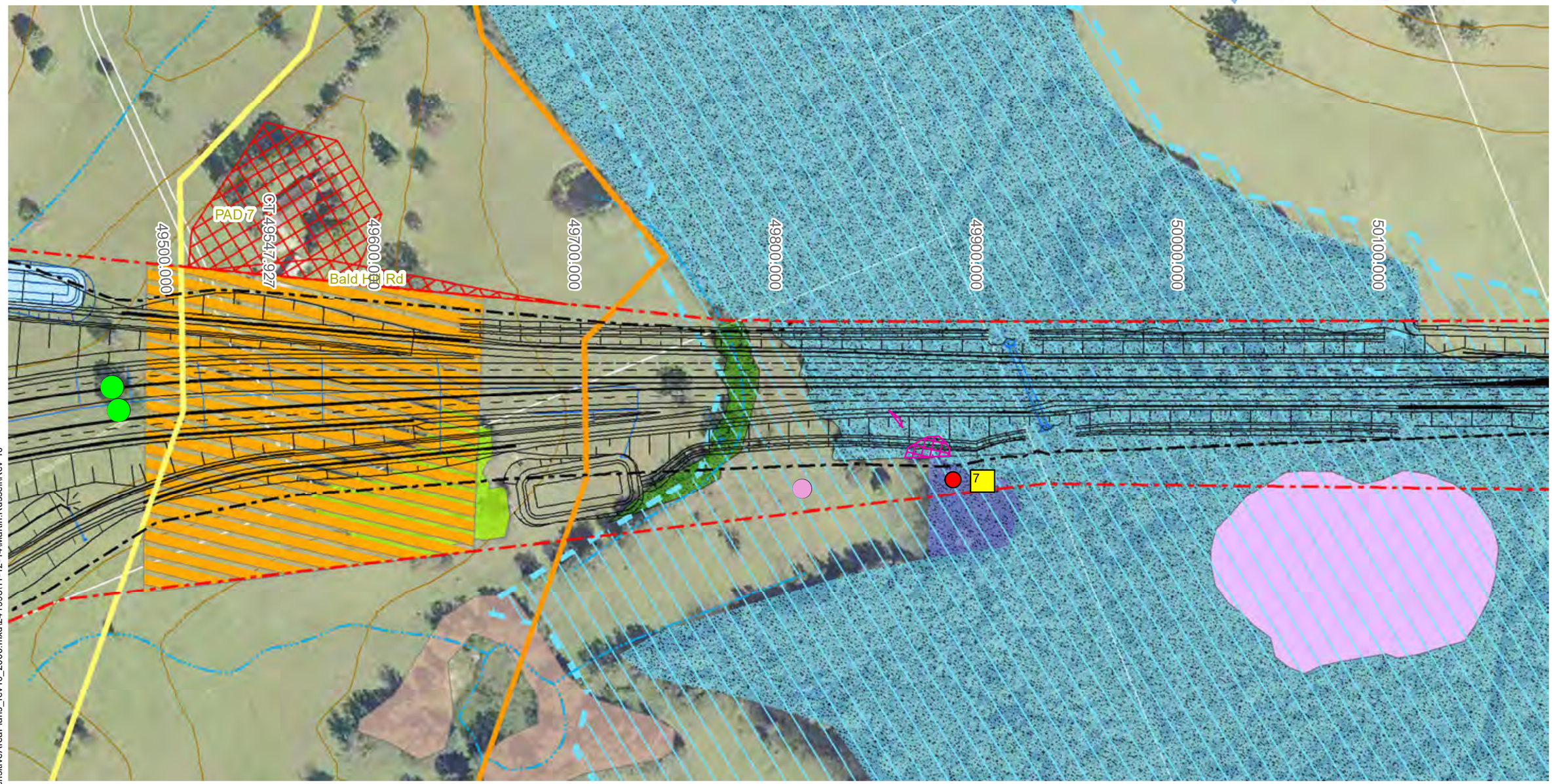

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Project boundary #
Clearing limit (Appendix 4)
500m Grey-headed Flying Fox buffer zone
300m Grey-headed Flying Fox buffer zone
Construction protection area
5m contours
20yr ARI flood
Natural drainage
SEPP14 wetland

Stormwater management
Drainage basin (Permanent)
Drainage basin (Temporary)

Heritage
Archaeological PAD/site
Heritage item
Non-Aboriginal heritage site
Cabbage tree palm resource site

Acoustic
Facade treatments to noise receivers
Sensitive noise receiver

Contamination
Potential contaminated site

Biodiversity - Flora
Alexfloydia repens
Artanema fimbriatum
Dendrobium melaleucaphilum
Eucalyptus ancophila
Goodenia fordiana
Marsdenia longiloba
Maundia triglochinoides
Niemeyera whitei
Tylophora woollsii
Hollow-bearing tree/Habitat tree
Microbat habitat (observations 2012)
Green-thighed frog breeding pond
Green-thighed frog habitat
Likely Green-thighed frog habitat
Giant Barred frog habitat
Flying Fox camp (Feb 2014)
Location of Maundia
Location of riparian zone vegetation

DPI Fisheries
Mangrove and pneumataphores
Salt marsh

Ground-truthed (inside project bdy)
2378_Vegetation_MASTER_Coal_INK_14#8#14

Vegetation Community (EEC)
Freshwater Wetlands
Mixed Floodplain Forest
Swamp Forest - Swamp Mahogany/ Paperbark
Swamp Oak Forest

Vegetation
Mangrove Forest
Moist Open Forest - Flooded Gum
Moist Open Forest - White Mahogany - Grey Gum
Open Forest - Blackbutt
Hardwood Plantation - mostly cleared
Regrowth Acacia/ Weeds
Regrowth Swamp Oak
Regrowth and Weeds: Moist Open Forest - White Mahogany, Grey Gum, Swamp Oak, Camphor Laurel
Garden Plantings
Camphor Laurel Forest (Environmental Weed)

EA Vegetation (outside project bdy)

Vegetation Community (EEC)
Freshwater Wetlands
Lowland Rainforest
Mixed Floodplain Forest
Swamp Forest - Swamp Mahogany / Paperbark
Swamp Forest - Swamp Oak
Saltmarsh

Vegetation Community
Mangroves
Moist Open Forest - Flooded Gum
Moist Open Forest - White Mahogany / Grey Gum / Ironbark
Open Forest - Blackbutt
Open Forest - Scribbly Gum
Hardwood Plantation
Softwood Plantation
Unidentified/modified vegetation

 # denotes: Project boundary based on WC2NH_Approved_Project_Boundary_20141202_V2.shp received 02/12/2014

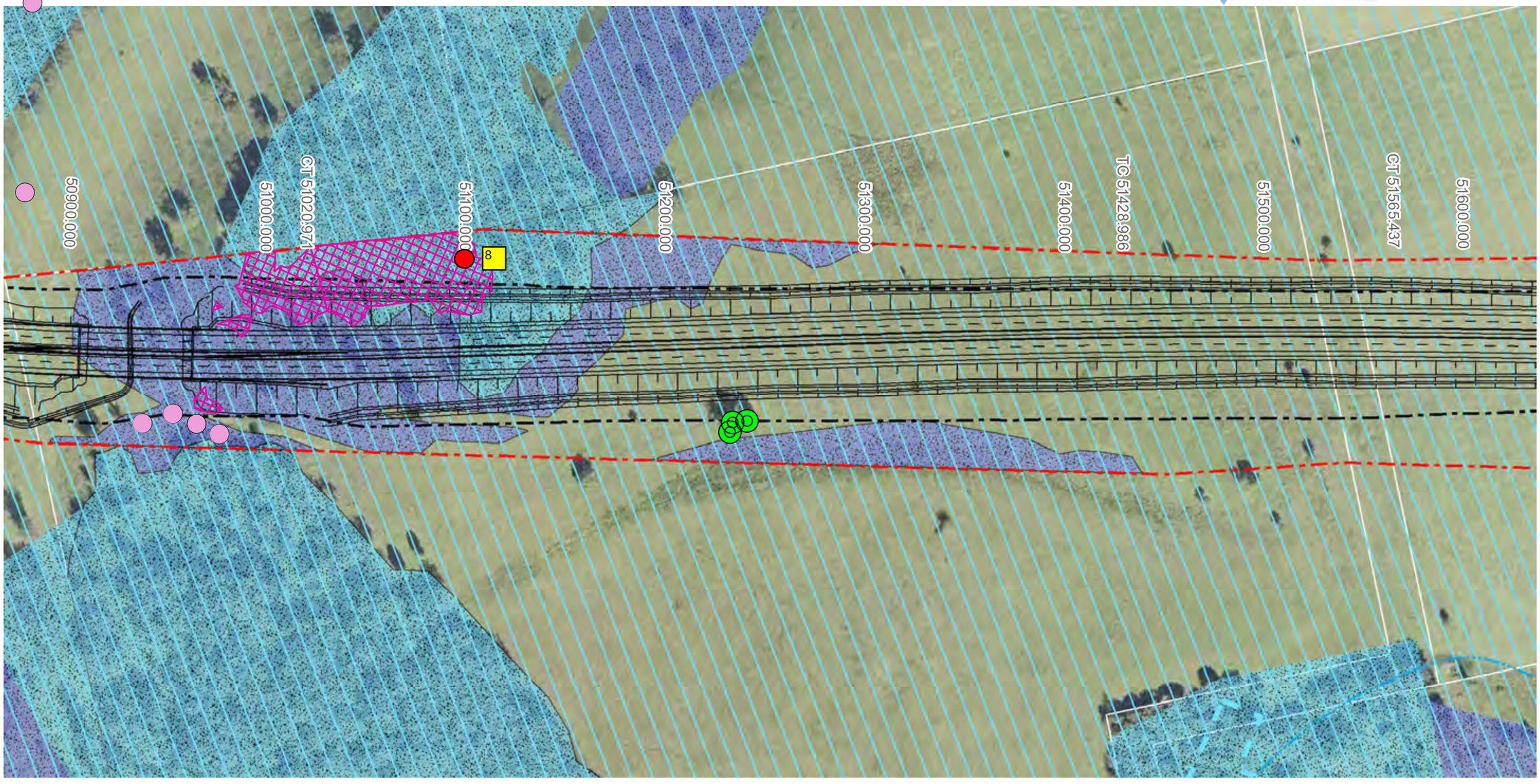
1:2,000 @ A3
0 50 100m

Note: Ground-truthed vegetation has been shown within the project boundary and in proposed areas of ancillary site facilities

Projection: GDA 1994 MGA Zone 56
Source: RMS, AFJV, AADJV

PACIFIC HIGHWAY UPGRADE WC2NH **CEMP**

FIGURE: Sensitive Area Plans (Map 12 of 28)



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Project boundary #
Clearing limit (Appendix 4)
500m Grey-headed Flying Fox buffer zone
300m Grey-headed Flying Fox buffer zone
Construction protection area
5m contours
20yr ARI flood
Natural drainage
SEPP14 wetland

Stormwater management
Drainage basin (Permanent)
Drainage basin (Temporary)

Heritage
Archaeological PAD/site
Heritage item
Non-Aboriginal heritage site
Cabbage tree palm resource site

Acoustic
Facade treatments to noise receivers

Sensitive noise receiver

Contamination
Potential contaminated site

Biodiversity - Flora
Alexfloydia repens
Artanema fimbriatum
Dendrobium melaleucaphilum
Eucalyptus ancophila
Goodenia fordiana
Marsdenia longiloba
Maundia triglochinoides
Niemeyera whitei
Tylophora woollsii
Hollow-bearing tree/Habitat tree
Microbat habitat (observations 2012)
Green-thighed frog breeding pond
Green-thighed frog habitat
Likely Green-thighed frog habitat
Giant Barred frog habitat
Flying Fox camp (Feb 2014)

Location of Maundia
Location of riparian zone vegetation

DPI Fisheries
Mangrove and pneumataphores
Salt marsh

Vegetation Community (EEC)
Freshwater Wetlands
Mixed Floodplain Forest
Swamp Forest - Swamp Mahogany/ Paperbark

Swamp Oak Forest

Vegetation
Mangrove Forest
Moist Open Forest - Flooded Gum
Moist Open Forest - White Mahogany - Grey Gum
Open Forest - Blackbutt
Hardwood Plantation - mostly cleared
Regrowth Acacia/ Weeds
Regrowth Swamp Oak

Regrowth and Weeds: Moist Open Forest - White Mahogany, Grey Gum, Swamp Oak, Camphor Laurel
Garden Plantings
Camphor Laurel Forest (Environmental Weed)

Vegetation Community (EEC)
Freshwater Wetlands
Lowland Rainforest
Mixed Floodplain Forest

Swamp Forest - Swamp Mahogany / Paperbark
Swamp Forest - Swamp Oak
Saltmarsh

Vegetation Community
Mangroves
Moist Open Forest - Flooded Gum
Moist Open Forest - White Mahogany / Grey Gum / Ironbark
Open Forest - Blackbutt
Open Forest - Scribbly Gum

Hardwood Plantation
Softwood Plantation
Unidentified/modified vegetation

 # denotes: Project boundary based on WC2NH_Approved_Project_Boundary_20141202_V2.shp received 02/12/2014

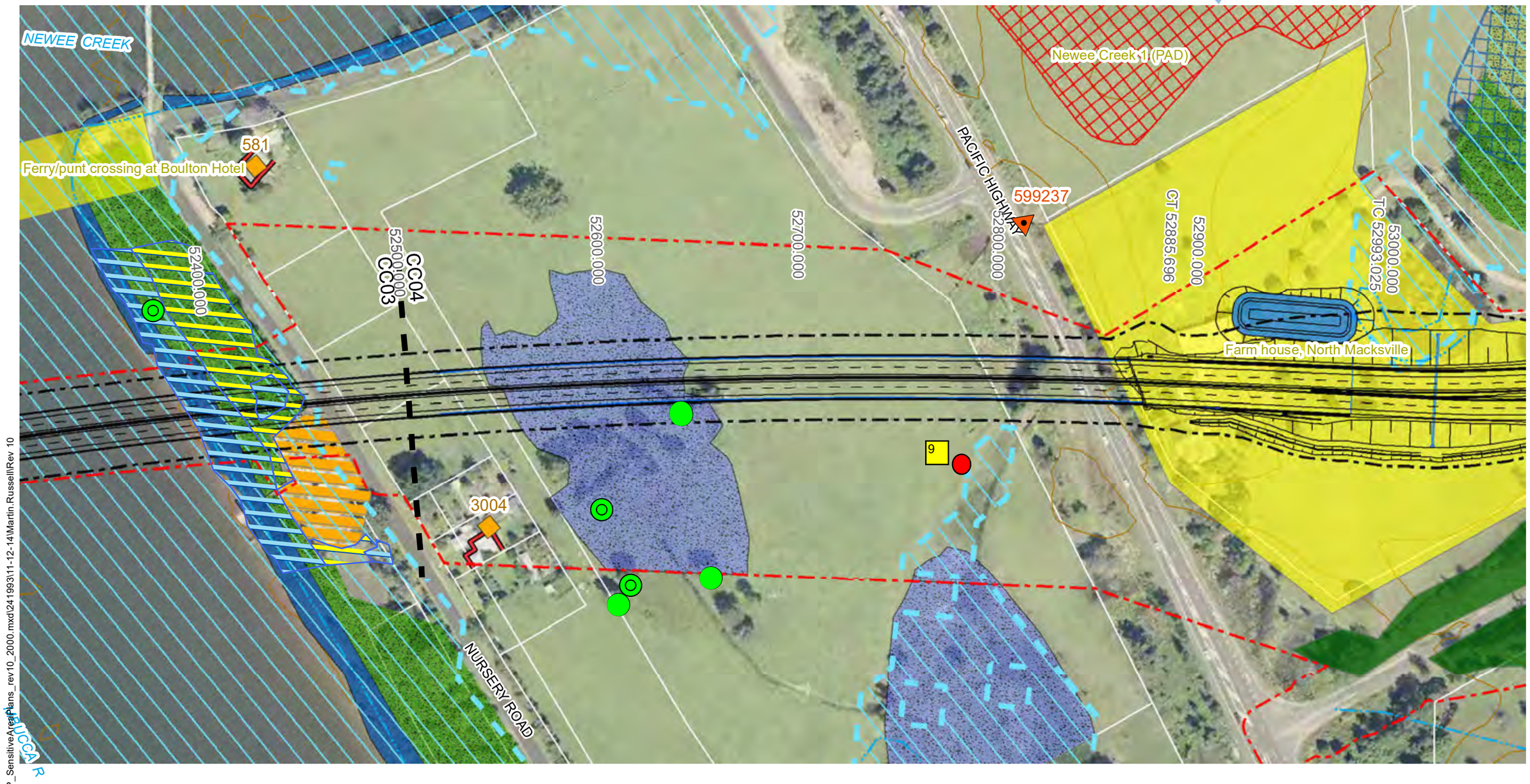
1:2,000 @ A3
0 50 100m

Note: Ground-truthed vegetation has been shown within the project boundary and in proposed areas of ancillary site facilities

Projection: GDA 1994 MGA Zone 56
Source: RMS, AFJV, AADJV

PACIFIC HIGHWAY UPGRADE WC2NH **CEMP**

FIGURE: Sensitive Area Plans (Map 14 of 28)



Project boundary #
Clearing limit (Appendix 4)
500m Grey-headed Flying Fox buffer zone
300m Grey-headed Flying Fox buffer zone
Construction protection area
5m contours
20yr ARI flood
Natural drainage
SEPP14 wetland

Stormwater management
Drainage basin (Permanent)
Drainage basin (Temporary)

Heritage
Archaeological PAD/site
Heritage item
Non-Aboriginal heritage site
Cabbage tree palm resource site

Acoustic
Facade treatments to noise receivers
Sensitive noise receiver

Contamination
Potential contaminated site

Biodiversity - Flora
Alexfloydia repens
Artanema fimbriatum
Dendrobium melaleucaphilum
Eucalyptus ancophila
Goodenia fordiana
Marsdenia longiloba
Maundia triglochinoides
Niemeyera whitei
Tylophora woollsii
Hollow-bearing tree/Habitat tree
Microbat habitat (observations 2012)
Green-thighed frog breeding pond
Green-thighed frog habitat
Likely Green-thighed frog habitat
Giant Barred frog habitat
Flying Fox camp (Feb 2014)
Location of Maundia
Location of riparian zone vegetation

DPI Fisheries
Mangrove and pneumataphores
Salt marsh

Ground truthed (inside project bdy)

Vegetation Community (EEC)
Freshwater Wetlands
Mixed Floodplain Forest
Swamp Forest - Swamp Mahogany/ Paperbark
Swamp Oak Forest

Vegetation
Mangrove Forest
Moist Open Forest - Flooded Gum
Moist Open Forest - White Mahogany - Grey Gum
Open Forest - Blackbutt
Hardwood Plantation - mostly cleared
Regrowth Acacia/ Weeds
Regrowth Swamp Oak
Regrowth and Weeds: Moist Open Forest - White Mahogany, Grey Gum, Swamp Oak, Camphor Laurel
Garden Plantings
Camphor Laurel Forest (Environmental Weed)

EA Vegetation (outside project bdy)

Vegetation Community (EEC)
Freshwater Wetlands
Lowland Rainforest
Mixed Floodplain Forest
Swamp Forest - Swamp Mahogany / Paperbark
Swamp Forest - Swamp Oak
Saltmarsh

Vegetation Community
Mangroves
Moist Open Forest - Flooded Gum
Moist Open Forest - White Mahogany / Grey Gum / Ironbark
Open Forest - Blackbutt
Open Forest - Scribbly Gum
Hardwood Plantation
Softwood Plantation
Unidentified/modified vegetation

 # denotes: Project boundary based on WC2NH_Approved_Project_Boundary_20141202_V2.shp received 02/12/2014

1:2,000 @ A3
0 50 100m

Note: Ground-truthed vegetation has been shown within the project boundary and in proposed areas of ancillary site facilities

Projection: GDA 1994 MGA Zone 56
Source: RMS, AFJV, AADJV

PACIFIC HIGHWAY UPGRADE WC2NH **CEMP**

FIGURE: Sensitive Area Plans (Map 16 of 28)

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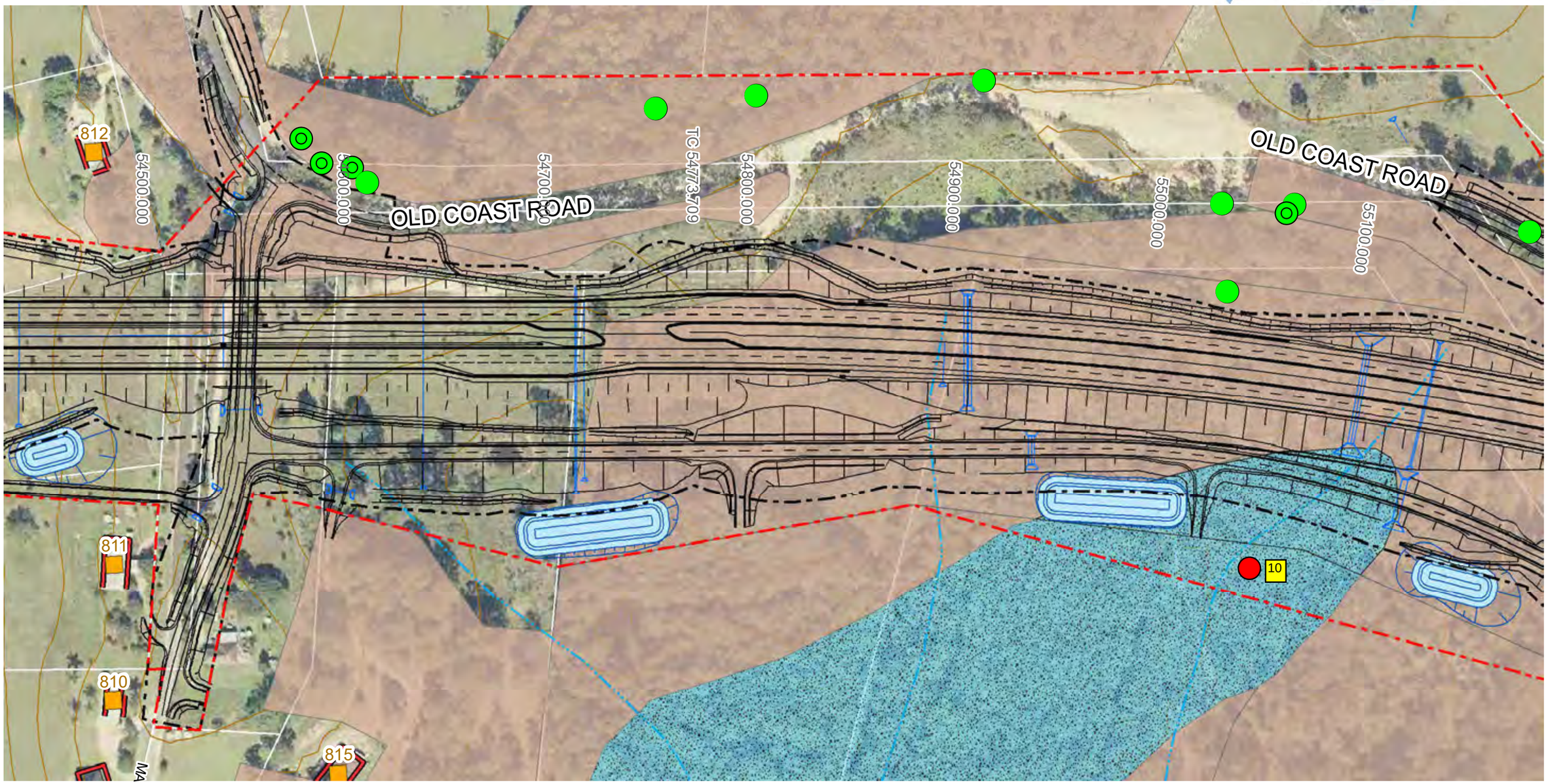

Project boundary #
Clearing limit (Appendix 4)
500m Grey-headed Flying Fox buffer zone
300m Grey-headed Flying Fox buffer zone
Construction protection area
5m contours
20yr ARI flood
Natural drainage
SEPP14 wetland

Stormwater management
Drainage basin (Permanent)
Drainage basin (Temporary)

Heritage
Archaeological PAD/site
Heritage item
Non-Aboriginal heritage site
Cabbage tree palm resource site

Acoustic
Facade treatments to noise receivers

Sensitive noise receiver

Contamination
Potential contaminated site

Biodiversity - Flora
Alexfloydia repens
Artanema fimbriatum
Dendrobium melaleucaphilum
Eucalyptus ancophila
Goodenia fordiana
Marsdenia longiloba

Maundia triglochinoides
Niemeyera whitei
Tylophora woollsii
Hollow-bearing tree/Habitat tree
Microbat habitat (observations 2012)
Green-thighed frog breeding pond
Green-thighed frog habitat
Likely Green-thighed frog habitat
Giant Barred frog habitat
Flying Fox camp (Feb 2014)

Location of Maundia
Location of riparian zone vegetation

DPI Fisheries
Mangrove and pneumataphores
Salt marsh

2378_Vegetation_MASTER_Coal_NK_14418014
Ground-truthed (inside project bdy)

Vegetation Community (EEC)
Freshwater Wetlands
Mixed Floodplain Forest
Swamp Forest - Swamp Mahogany/ Paperbark

Swamp Oak Forest

Vegetation
Mangrove Forest
Moist Open Forest - Flooded Gum
Moist Open Forest - White Mahogany - Grey Gum
Open Forest - Blackbutt
Hardwood Plantation - mostly cleared
Regrowth Acacia/ Weeds
Regrowth Swamp Oak

Regrowth and Weeds: Moist Open Forest - White Mahogany, Grey Gum, Swamp Oak, Camphor Laurel
Garden Plantings
Camphor Laurel Forest (Environmental Weed)

EA Vegetation (outside project bdy)

Vegetation Community (EEC)
Freshwater Wetlands
Lowland Rainforest
Mixed Floodplain Forest

Swamp Forest - Swamp Mahogany / Paperbark
Swamp Forest - Swamp Oak
Saltmarsh

Vegetation Community
Mangroves
Moist Open Forest - Flooded Gum
Moist Open Forest - White Mahogany / Grey Gum / Ironbark
Open Forest - Blackbutt
Open Forest - Scribbly Gum

Hardwood Plantation
Softwood Plantation
Unidentified/modified vegetation

 # denotes: Project boundary based on WC2NH_Approved_Project_Boundary_20141202_V2.shp received 02/12/2014

1:2,000 @ A3
0 50 100m

Note: Ground-truthed vegetation has been shown within the project boundary and in proposed areas of ancillary site facilities

Projection: GDA 1994 MGA Zone 56
Source: RMS, AFJV, AADJV

PACIFIC HIGHWAY UPGRADE WC2NH **CEMP**

FIGURE: Sensitive Area Plans (Map 19 of 28)

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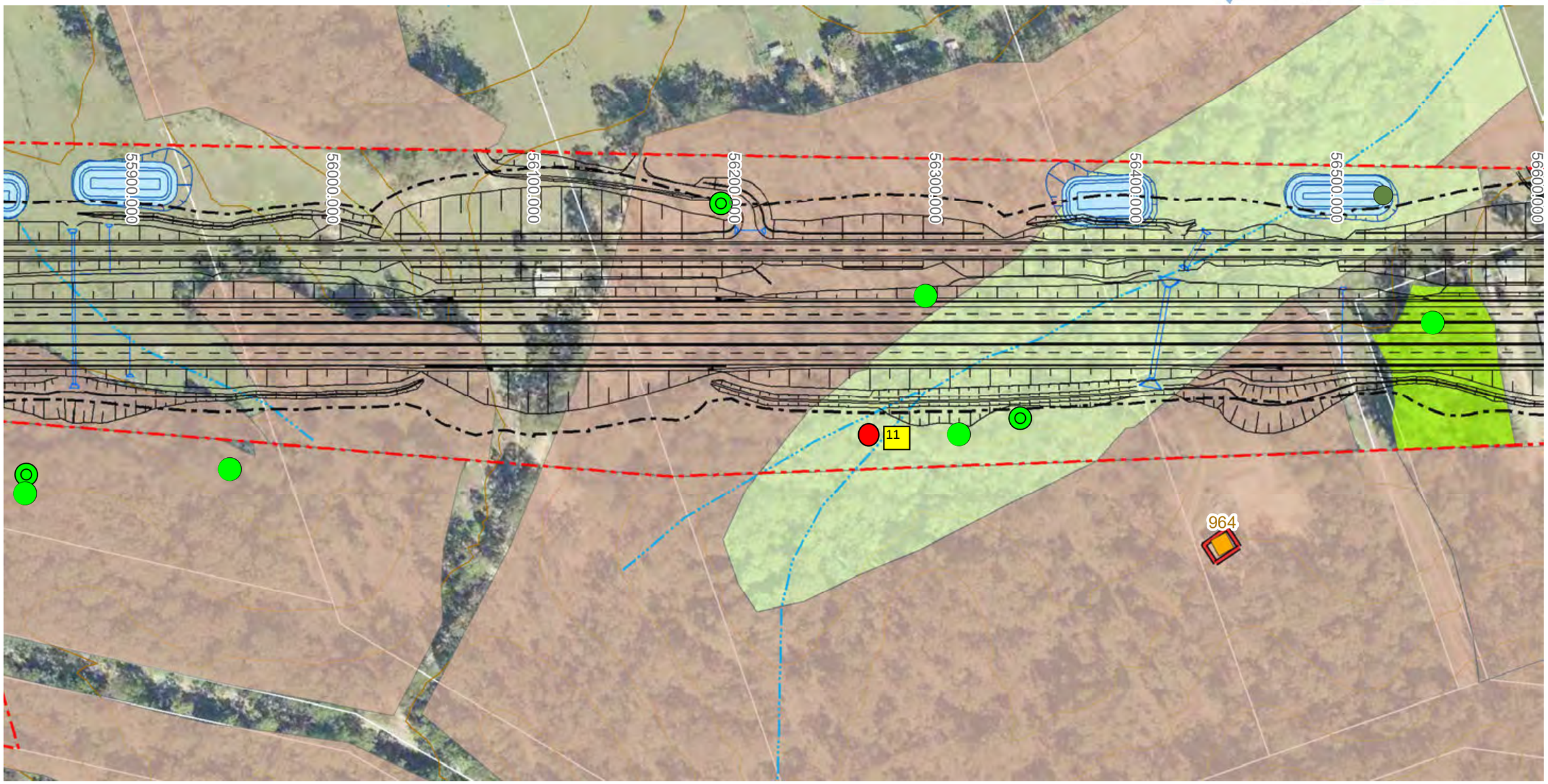

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Project boundary #
Clearing limit (Appendix 4)
500m Grey-headed Flying Fox buffer zone
300m Grey-headed Flying Fox buffer zone
Construction protection area
5m contours
20yr ARI flood
Natural drainage
SEPP14 wetland

Stormwater management
Drainage basin (Permanent)
Drainage basin (Temporary)

Heritage
Archaeological PAD/site
Heritage item
Non-Aboriginal heritage site
Cabbage tree palm resource site

Acoustic
Facade treatments to noise receivers
Sensitive noise receiver

Contamination
Potential contaminated site

Biodiversity - Flora
Alexfloydia repens
Artanema fimbriatum
Dendrobium melaleucaphilum
Eucalyptus ancophila
Goodenia fordiana
Marsdenia longiloba
Maundia triglochinoides
Niemeyera whitei
Tylophora woollsii
Hollow-bearing tree/Habitat tree
Microbat habitat (observations 2012)
Green-thighed frog breeding pond
Green-thighed frog habitat
Likely Green-thighed frog habitat
Giant Barred frog habitat
Flying Fox camp (Feb 2014)

DPI Fisheries
Location of Maundia
Location of riparian zone vegetation
Mangrove and pneumataphores
Salt marsh
378 Vegetation MASTER Coal NW 14414014
Ground truthed (inside project bdy)

Vegetation Community (EEC)
Freshwater Wetlands
Mixed Floodplain Forest
Swamp Forest - Swamp Mahogany/ Paperbark
Swamp Oak Forest

Vegetation
Mangrove Forest
Moist Open Forest - Flooded Gum
Moist Open Forest - White Mahogany - Grey Gum
Open Forest - Blackbutt
Hardwood Plantation - mostly cleared
Regrowth Acacia/ Weeds
Regrowth Swamp Oak
Regrowth and Weeds: Moist Open Forest - White Mahogany, Grey Gum, Swamp Oak, Camphor Laurel
Garden Plantings
Camphor Laurel Forest (Environmental Weed)
EA Vegetation (outside project bdy)

Vegetation Community (EEC)
Freshwater Wetlands
Lowland Rainforest
Mixed Floodplain Forest
Swamp Forest - Swamp Mahogany / Paperbark
Swamp Forest - Swamp Oak
Saltmarsh

Vegetation Community
Mangroves
Moist Open Forest - Flooded Gum
Moist Open Forest - White Mahogany / Grey Gum / Ironbark
Open Forest - Blackbutt
Open Forest - Scribbly Gum
Hardwood Plantation
Softwood Plantation
Unidentified/modified vegetation

 # denotes: Project boundary based on WC2NH_Approved_Project_Boundary_20141202_V2.shp received 02/12/2014

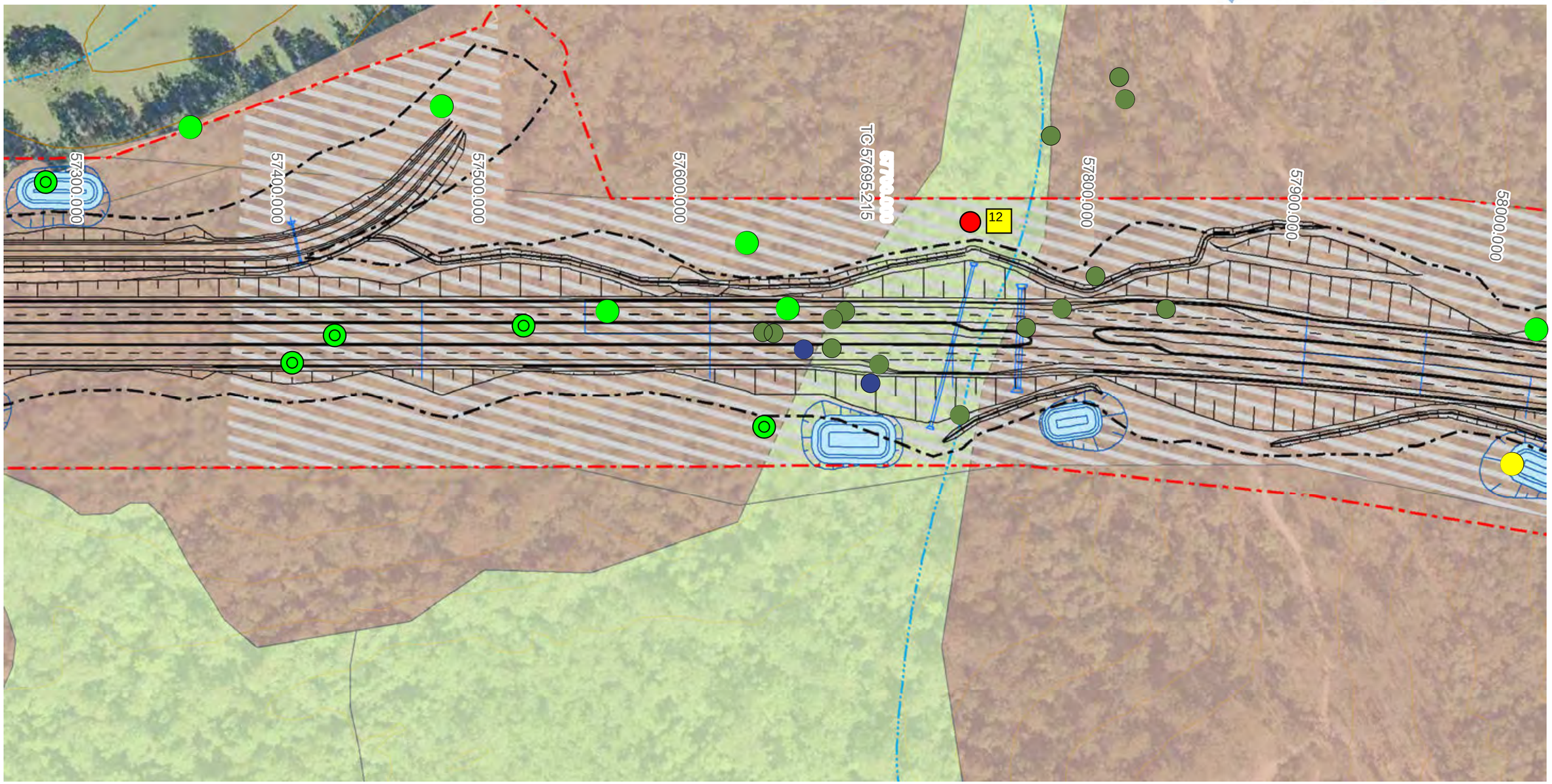
1:2,000 @ A3
0 50 100m

Note: Ground-truthed vegetation has been shown within the project boundary and in proposed areas of ancillary site facilities

Projection: GDA 1994 MGA Zone 56
Source: RMS, AFJV, AADJV

PACIFIC HIGHWAY UPGRADE WC2NH **CEMP**

FIGURE: Sensitive Area Plans (Map 21 of 28)



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Project boundary #
Clearing limit (Appendix 4)
500m Grey-headed Flying Fox buffer zone
300m Grey-headed Flying Fox buffer zone
Construction protection area
5m contours
20yr ARI flood
Natural drainage
SEPP14 wetland

Stormwater management
Drainage basin (Permanent)
Drainage basin (Temporary)

Heritage
Archaeological PAD/site
Heritage item
Non-Aboriginal heritage site
Cabbage tree palm resource site

Acoustic
Facade treatments to noise receivers
Sensitive noise receiver

Contamination
Potential contaminated site

Biodiversity - Flora
Alexfloydia repens
Artanema fimbriatum
Dendrobium melaleucaphilum
Eucalyptus ancophila
Goodenia fordiana
Marsdenia longiloba
Maundia triglochinoides
Niemeyera whitei
Tylophora woollsii
Hollow-bearing tree/Habitat tree
Microbat habitat (observations 2012)
Green-thighed frog breeding pond
Green-thighed frog habitat
Likely Green-thighed frog habitat
Giant Barred frog habitat
Flying Fox camp (Feb 2014)
Location of Maundia
Location of riparian zone vegetation

DPI Fisheries
Mangrove and pneumataphores
Salt marsh

Ground-truthed (inside project bdy)
2378_Vegetation_MASTER_Coal_INK_14118014

Vegetation Community (EEC)
Freshwater Wetlands
Mixed Floodplain Forest
Swamp Forest - Swamp Mahogany/ Paperbark

Vegetation
Swamp Oak Forest
Mangrove Forest
Moist Open Forest - Flooded Gum
Moist Open Forest - White Mahogany - Grey Gum
Open Forest - Blackbutt
Hardwood Plantation - mostly cleared
Regrowth Acacia/ Weeds
Regrowth Swamp Oak
Regrowth and Weeds: Moist Open Forest - White Mahogany, Grey Gum, Swamp Oak, Camphor Laurel
Garden Plantings
Camphor Laurel Forest (Environmental Weed)

EA boundary (outside project bdy)

Vegetation Community (EEC)
Freshwater Wetlands
Lowland Rainforest
Mixed Floodplain Forest
Swamp Forest - Swamp Mahogany / Paperbark
Swamp Forest - Swamp Oak
Saltmarsh

Vegetation Community
Mangroves
Moist Open Forest - Flooded Gum
Moist Open Forest - White Mahogany / Grey Gum / Ironbark
Open Forest - Blackbutt
Open Forest - Scribbly Gum
Hardwood Plantation
Softwood Plantation
Unidentified/modified vegetation

 # denotes: Project boundary based on WC2NH_Approved_Project_Boundary_20141202_V2.shp received 02/12/2014

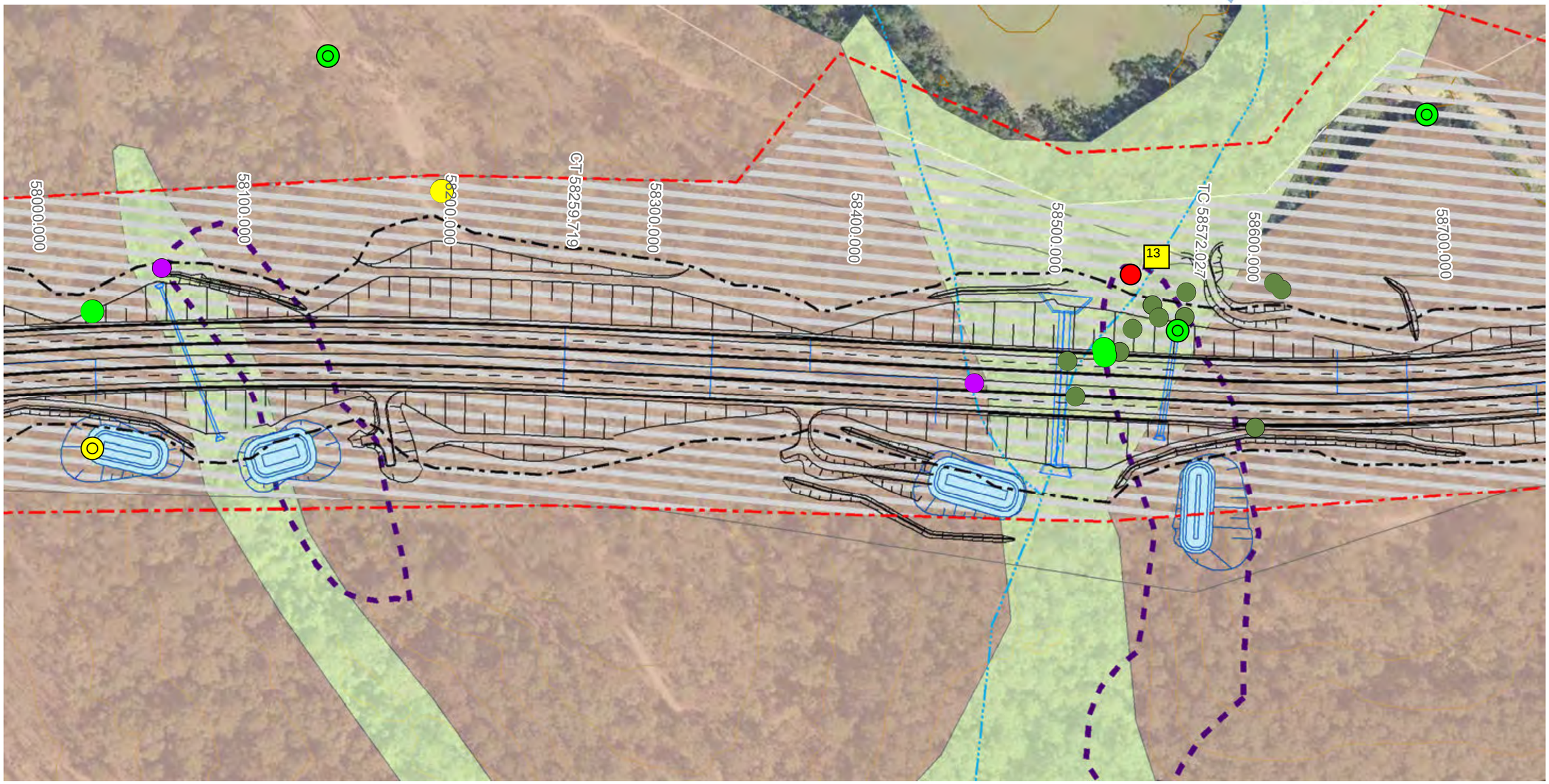
1:2,000 @ A3
0 50 100m

Note: Ground-truthed vegetation has been shown within the project boundary and in proposed areas of ancillary site facilities

Projection: GDA 1994 MGA Zone 56
Source: RMS, AFJV, AADJV

PACIFIC HIGHWAY UPGRADE WC2NH **CEMP**

FIGURE: Sensitive Area Plans (Map 23 of 28)



Project boundary #
Clearing limit (Appendix 4)
500m Grey-headed Flying Fox buffer zone
300m Grey-headed Flying Fox buffer zone
Construction protection area
5m contours
20yr ARI flood
Natural drainage
SEPP14 wetland

Stormwater management
Drainage basin (Permanent)
Drainage basin (Temporary)

Heritage
Archaeological PAD/site
Heritage item
Non-Aboriginal heritage site
Cabbage tree palm resource site

Acoustic
Facade treatments to noise receivers

Sensitive noise receiver

Contamination
Potential contaminated site

Biodiversity - Flora
Alexfloydia repens
Artanema fimbriatum
Dendrobium melaleucaphilum
Eucalyptus ancophila
Goodenia fordiana
Marsdenia longiloba

Maundia triglochinoides
Niemeyera whitei
Tylophora woollsii
Hollow-bearing tree/Habitat tree
Microbat habitat (observations 2012)
Green-thighed frog breeding pond
Green-thighed frog habitat
Likely Green-thighed frog habitat
Giant Barred frog habitat
Flying Fox camp (Feb 2014)

Location of Maundia
Location of riparian zone vegetation

DPI Fisheries
Mangrove and pneumataphores
Salt marsh

Ground-truthed (inside project bdy)
Vegetation Community (EEC)
Freshwater Wetlands
Mixed Floodplain Forest
Swamp Forest - Swamp Mahogany/ Paperbark

Swamp Oak Forest

Vegetation
Mangrove Forest
Moist Open Forest - Flooded Gum
Moist Open Forest - White Mahogany - Grey Gum
Open Forest - Blackbutt
Hardwood Plantation - mostly cleared
Regrowth Acacia/ Weeds
Regrowth Swamp Oak

Regrowth and Weeds: Moist Open Forest - White Mahogany, Grey Gum, Swamp Oak, Camphor Laurel
Garden Plantings
Camphor Laurel Forest (Environmental Weed)

EA Vegetation (outside project bdy)
Vegetation Community (EEC)
Freshwater Wetlands
Lowland Rainforest
Mixed Floodplain Forest

Swamp Forest - Swamp Mahogany / Paperbark
Swamp Forest - Swamp Oak
Saltmarsh

Vegetation Community
Mangroves
Moist Open Forest - Flooded Gum
Moist Open Forest - White Mahogany / Grey Gum / Ironbark
Open Forest - Blackbutt
Open Forest - Scribbly Gum

Hardwood Plantation
Softwood Plantation
Unidentified/modified vegetation

 # denotes: Project boundary based on WC2NH_Approved_Project_Boundary_20141202_V2.shp received 02/12/2014

1:2,000 @ A3
0 50 100m

Note: Ground-truthed vegetation has been shown within the project boundary and in proposed areas of ancillary site facilities

Projection: GDA 1994 MGA Zone 56
Source: RMS, AFJV, AADJV

PACIFIC HIGHWAY UPGRADE WC2NH **CEMP**

FIGURE: Sensitive Area Plans (Map 24 of 28)

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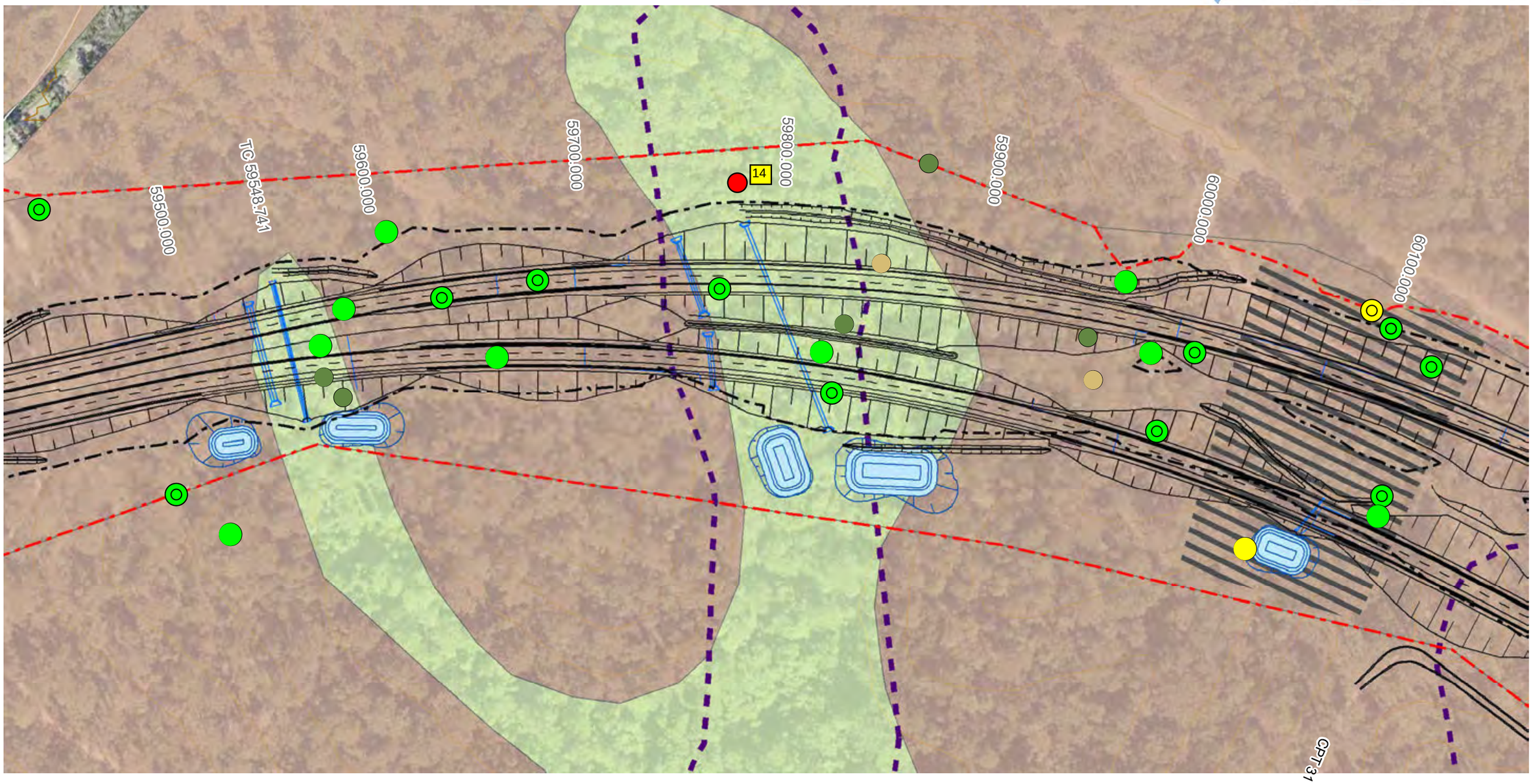

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Project boundary #
Clearing limit (Appendix 4)
500m Grey-headed Flying Fox buffer zone
300m Grey-headed Flying Fox buffer zone
Construction protection area
5m contours
20yr ARI flood
Natural drainage
SEPP14 wetland

Stormwater management
Drainage basin (Permanent)
Drainage basin (Temporary)

Heritage
Archaeological PAD/site
Heritage item
Non-Aboriginal heritage site
Cabbage tree palm resource site

Acoustic
Facade treatments to noise receivers
Sensitive noise receiver

Contamination
Potential contaminated site

Biodiversity - Flora
Alexfloydia repens
Artanema fimbriatum
Dendrobium melaleucaphilum
Eucalyptus ancophila
Goodenia fordiana
Marsdenia longiloba
Maundia triglochinoides
Niemeyera whitei
Tylophora woollsii
Hollow-bearing tree/Habitat tree
Microbat habitat (observations 2012)
Green-thighed frog breeding pond
Green-thighed frog habitat
Likely Green-thighed frog habitat
Giant Barred frog habitat
Flying Fox camp (Feb 2014)
Location of Maundia
Location of riparian zone vegetation

DPI Fisheries
Mangrove and pneumataphores
Salt marsh

2378_Vegetation_MASTER_Coal_INK_14118014
Ground-truthed (inside project bdy)

Vegetation Community (EEC)
Freshwater Wetlands
Mixed Floodplain Forest
Swamp Forest - Swamp Mahogany/ Paperbark
Swamp Oak Forest

Vegetation
Mangrove Forest
Moist Open Forest - Flooded Gum
Moist Open Forest - White Mahogany - Grey Gum
Open Forest - Blackbutt
Hardwood Plantation - mostly cleared
Regrowth Acacia/ Weeds
Regrowth Swamp Oak
Regrowth and Weeds: Moist Open Forest - White Mahogany, Grey Gum, Swamp Oak, Camphor Laurel
Garden Plantings
Camphor Laurel Forest (Environmental Weed)

EA Vegetation (outside project bdy)

Vegetation Community (EEC)
Freshwater Wetlands
Lowland Rainforest
Mixed Floodplain Forest
Swamp Forest - Swamp Mahogany / Paperbark
Swamp Forest - Swamp Oak
Saltmarsh

Vegetation Community
Mangroves
Moist Open Forest - Flooded Gum
Moist Open Forest - White Mahogany / Grey Gum / Ironbark
Open Forest - Blackbutt
Open Forest - Scribbly Gum
Hardwood Plantation
Softwood Plantation
Unidentified/modified vegetation

 # denotes: Project boundary based on WC2NH_Approved_Project_Boundary_20141202_V2.shp received 02/12/2014

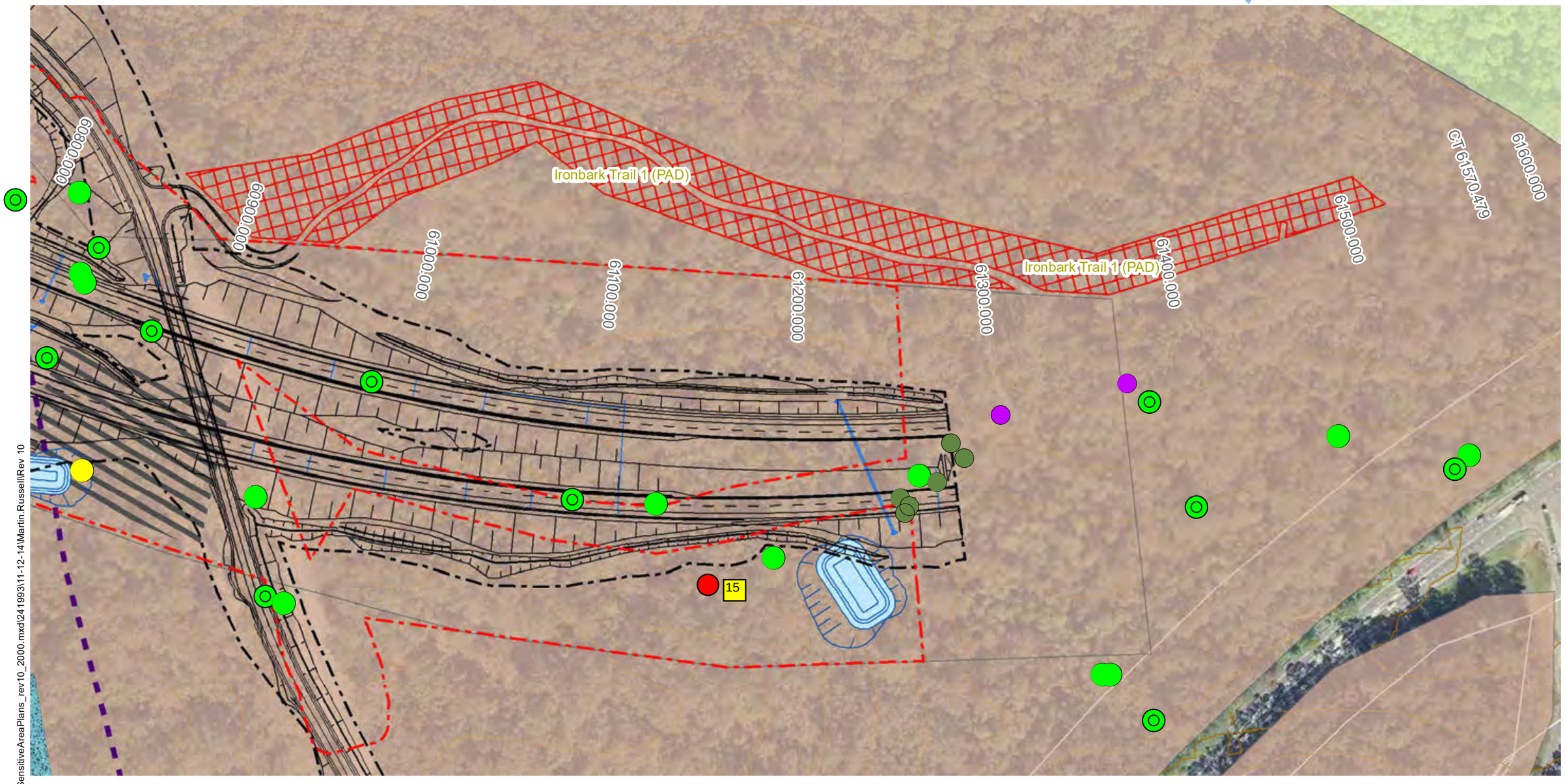
1:2,000 @ A3
0 50 100m

Note: Ground-truthed vegetation has been shown within the project boundary and in proposed areas of ancillary site facilities

Projection: GDA 1994 MGA Zone 56
Source: RMS, AFJV, AADJV

PACIFIC HIGHWAY UPGRADE WC2NH **CEMP**

FIGURE: Sensitive Area Plans (Map 26 of 28)



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Project boundary #
Clearing limit (Appendix 4)
500m Grey-headed Flying Fox buffer zone
300m Grey-headed Flying Fox buffer zone
Construction protection area
5m contours
20yr ARI flood
Natural drainage
SEPP14 wetland

Stormwater management
Drainage basin (Permanent)
Drainage basin (Temporary)

Heritage
Archaeological PAD/site
Heritage item
Non-Aboriginal heritage site
Cabbage tree palm resource site

Acoustic
Facade treatments to noise receivers
Sensitive noise receiver

Contamination
Potential contaminated site

Biodiversity - Flora
Alexfloydia repens
Artanema fimbriatum
Dendrobium melaleucaphilum
Eucalyptus ancophila
Goodenia fordiana
Marsdenia longiloba
Maundia triglochinoides
Niemeyera whitei
Tylophora woollsii
Hollow-bearing tree/Habitat tree
Microbat habitat (observations 2012)
Green-thighed frog breeding pond
Green-thighed frog habitat
Likely Green-thighed frog habitat
Giant Barred frog habitat
Flying Fox camp (Feb 2014)
Location of Maundia
Location of riparian zone vegetation

DPI Fisheries
Mangrove and pneumataphores
Salt marsh

Ground-truthed (inside project bdy)
2378_Vegetation_MASTER_Coal_INK_14418014

Vegetation Community (EEC)
Freshwater Wetlands
Mixed Floodplain Forest
Swamp Forest - Swamp Mahogany/ Paperbark
Swamp Oak Forest

Vegetation
Mangrove Forest
Moist Open Forest - Flooded Gum
Moist Open Forest - White Mahogany - Grey Gum
Open Forest - Blackbutt
Hardwood Plantation - mostly cleared
Regrowth Acacia/ Weeds
Regrowth Swamp Oak
Regrowth and Weeds: Moist Open Forest - White Mahogany, Grey Gum, Swamp Oak, Camphor Laurel
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Camphor Laurel Forest (Environmental Weed)

EA Vegetation (outside project bdy)

Vegetation Community (EEC)
Freshwater Wetlands
Lowland Rainforest
Mixed Floodplain Forest
Swamp Forest - Swamp Mahogany / Paperbark
Swamp Forest - Swamp Oak
Saltmarsh

Vegetation Community
Mangroves
Moist Open Forest - Flooded Gum
Moist Open Forest - White Mahogany / Grey Gum / Ironbark
Open Forest - Blackbutt
Open Forest - Scribbly Gum
Hardwood Plantation
Softwood Plantation
Unidentified/modified vegetation

 # denotes: Project boundary based on WC2NH_Approved_Project_Boundary_20141202_V2.shp received 02/12/2014

1:2,000 @ A3
0 50 100m

Note: Ground-truthed vegetation has been shown within the project boundary and in proposed areas of ancillary site facilities

Projection: GDA 1994 MGA Zone 56
Source: RMS, AFJV, AADJV

PACIFIC HIGHWAY UPGRADE WC2NH **CEMP**

FIGURE: Sensitive Area Plans (Map 28 of 28)

Appendix B

Fixed Point Monitoring Photographs

Plate 1.1 **Photo point 1 – facing north (May 2015)**

Plate 1.2 **Photo point 1 – facing south (May 2015)**

Plate 1.3 **Photo point 1 – facing north (December 2017)**

Plate 1.4 **Photo point 1 – facing south (December 2017)**

Plate 1.5 **Photo point 2 – facing north (May 2015)**

Plate 1.6 **Photo point 2 – facing south (May 2015)**

Plate 1.7 **Photo point 2 – facing north (December 2017)**

Plate 1.8 **Photo point 2 – facing south (December 2017)**

Plate 1.9 **Photo point 3 – facing north (May 2015)**

Plate 1.10 **Photo point 3 – facing south (May 2015)**

Plate 1.11 **Photo point 3 – facing north (December 2017)**

Plate 1.12 **Photo point 3 – facing south (December 2017)**

Plate 1.13 **Photo point 4 – facing north (May 2015)**

Plate 1.14 **Photo point 4 – facing south (May 2015)**

Plate 1.15 **Photo point 4 – facing north (December 2017)**

Plate 1.16 **Photo point 4 – facing south (December 2017)**

Plate 1.17 **Photo point 5 – facing north (May 2015)**

Plate 1.18 **Photo point 5 – facing south (May 2015)**

Plate 1.19 **Photo point 5 – facing north (December 2017)**

Plate 1.20 **Photo point 5 – facing south (December 2017)**

Plate 1.21 **Photo point 6 – facing north (May 2015)**

Plate 1.22 **Photo point 6 – facing south (May 2015)**

Plate 1.23 **Photo point 6 – facing north (December 2017)**

Plate 1.24 **Photo point 6 – facing south (December 2017)**

Plate 1.25 **Photo point 7 – facing north (May 2015)**

Plate 1.26 **Photo point 7 – facing south (May 2015)**

Plate 1.27 **Photo point 7 – facing north (December 2017)**

Plate 1.28 **Photo point 7 – facing south (December 2017)**

Plate 1.29 **Photo point 8 – facing north (May 2015)**

Plate 1.30 **Photo point 8 – facing south (May 2015)**

Plate 1.31 **Photo point 8 – facing north (December 2017)**

Plate 1.32 **Photo point 8 – facing south (December 2017)**

Plate 1.33 **Photo point 9 – facing north (May 2015)**

Plate 1.34 **Photo point 9 – facing south- east (May 2015)**

Plate 1.35 **Photo point 9 – facing north (December 2017)**

Plate 1.36 **Photo point 9 – facing south-east (December 2017)**

Plate 1.37 **Photo point 10 – facing north (May 2015)**

Plate 1.38 **Photo point 10 – facing south (May 2015)**

Plate 1.39 **Photo point 10 – facing north (December 2017)**

Plate 1.40 **Photo point 10 – facing south (December 2017)**

Plate 1.41 **Photo point 11 – facing north (May 2015)**

Plate 1.42 **Photo point 11 – facing south (May 2015)**

Plate 1.43 **Photo point 11 – facing north (December 2017)**

Plate 1.44 **Photo point 11 – facing south (December 2017)**

Plate 1.45 **Photo point 12 – facing north (June 2015)**

Plate 1.46 **Photo point 12 – facing south (June 2015)**

Plate 1.47 **Photo point 12 – facing north (December 2017)**

Plate 1.48 **Photo point 12 – facing south (December 2017)**

Plate 1.49 **Photo point 13 – facing north (May 2015)**

Plate 1.50 **Photo point 13 – facing south (May 2015)**

Plate 1.51 **Photo point 13 – facing north (December 2017)**

Plate 1.52 **Photo point 13 – facing south (December 2017)**

Plate 1.53 **Photo point 14 – facing north (May 2015)**

Plate 1.54 **Photo point 14 – facing south (May 2015)**

Plate 1.55 **Photo point 14 – facing north (December 2017)**

Plate 1.56 **Photo point 14 – facing south (December 2017)**

Plate 1.57 **Photo point 15 – facing north (July 2015)**

Plate 1.58 **Photo point 15 – facing south (July 2015)**

Plate 1.59 **Photo point 15 – facing north (December 2017)**

Plate 1.60 **Photo point 15 – facing south (December 2017)**

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Customer feedback
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March 2018