NSW Roads and Maritime Services

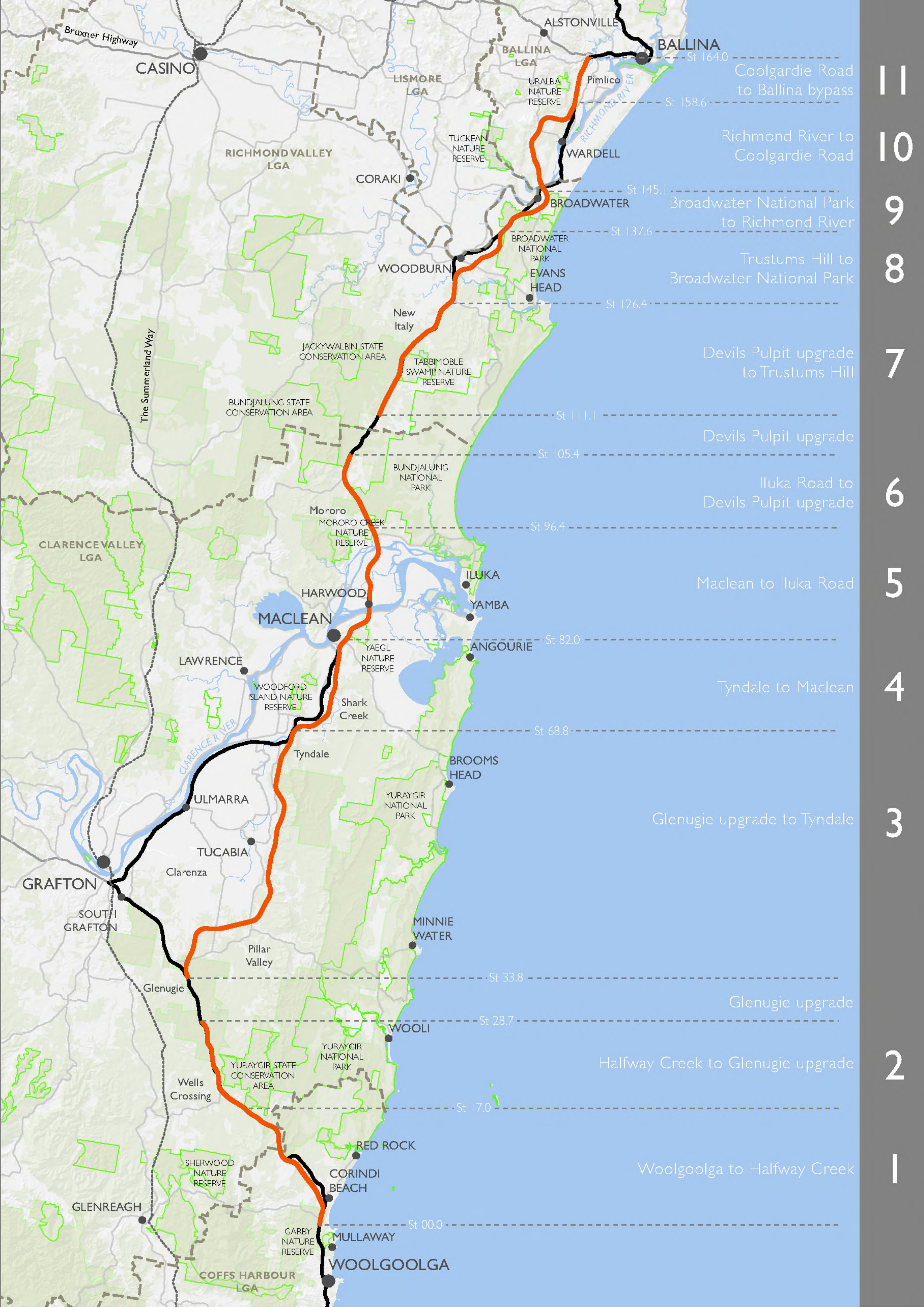
WOOLGOOLGA TO BALLINA | PACIFIC HIGHWAY UPGRADE

KOALA MANAGEMENT PLAN

Sections 1-11

Version 5

June 2019



Bruxner Highway
CASINO
ALSTONVILLE
BALLINA
BALLINA LGA
LISMORE LGA
URALBA NATURE RESERVE
Pimlico
RICHMOND RIVER
St 164.0
Coolgardie Road to Ballina bypass
11
St 158.6
TUCKEAN NATURE RESERVE
WARDELL
Richmond River to Coolgardie Road
10
RICHMOND VALLEY LGA
CORAKI
St 145.1
BROADWATER
Broadwater National Park to Richmond River
9
St 137.6
BROADWATER NATIONAL PARK
WOODBURN
EVANS HEAD
Trustums Hill to Broadwater National Park
8
St 126.4
New Italy
JACKYWALBIN STATE CONSERVATION AREA
TABBIMOBLE SWAMP NATURE RESERVE
The Summerland Way
Devils Pulpit upgrade to Trustums Hill
7
BUNDJALUNG STATE CONSERVATION AREA
St 111.1
Devils Pulpit upgrade
St 105.4
BUNDJALUNG NATIONAL PARK
Iluka Road to Devils Pulpit upgrade
6
Mororo
MORORO CREEK NATURE RESERVE
St 96.4
CLARENCE VALLEY LGA
ILUKA
HARWOOD
YAMBA
MACLEAN
Maclean to Iluka Road
5
St 82.0
ANGOURIE
YAEGL NATURE RESERVE
LAWRENCE
WOODFORD ISLAND NATURE RESERVE
Shark Creek
Tyndale to Maclean
4
St 68.8
CLARENCE RIVER
Tyndale
BROOMS HEAD
ULMARRA
YURAYGIR NATIONAL PARK
Glenugie upgrade to Tyndale
3
TUCABIA
GRAFTON
Clarenza
SOUTH GRAFTON
MINNIE WATER
Pillar Valley
St 33.8
Glenugie
Glenugie upgrade
St 28.7
WOOLI
YURAYGIR NATIONAL PARK
YURAYGIR STATE CONSERVATION AREA
Wells Crossing
Halfway Creek to Glenugie upgrade
2
St 17.0
RED ROCK
SHERWOOD NATURE RESERVE
CORINDI BEACH
Woolgoolga to Halfway Creek
1
GLENREAGH
St 00.0
GARBY NATURE RESERVE
MULLAWAY
WOOLGOOLGA
COFFS HARBOUR LGA

1. Contents

Acronyms and abbreviations

Acronym / abbreviation	Description
BACI	Before After Control Impact
CEMP	Construction Environmental Management Plan
NSW CoA	New South Wales Conditions of Approval
Cth	Commonwealth
DP&E	NSW Department of Planning and Environment
DoE	Commonwealth Department of Environment,
EIS	Environmental Impact Statement
EPA	NSW Environmental Protection Authority
ER	Environmental Representative
EMS	Environmental Management System
EP&A Act	*Environmental Planning and Assessment Act 1979 (NSW)*
EPA	NSW Environment Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EWMS	Environmental Work Method Statement
FFMP	Flora and Fauna Management Plan
LGA	Local Government Area
NSW	New South Wales
OEH	NSW Office of Environment and Heritage
Project area	Area within the project boundary
Qld	Queensland
Roads and Maritime	Roads and Maritime Service
S/PIR	Supplementary Preferred Infrastructure Report
The Project	Woolgoolga to Ballina Pacific Highway Upgrade (Sections 1-8, 11)
TSC Act	*Threatened Species Conservation Act 1995* (NSW)

2. Introduction

2.1 Project overview

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

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

The project will upgrade around 155 kilometres of highway and represents the final priority in achieving a four-lane divided road between Hexham and the NSW/Queensland Border. The project has been divided into 11 Sections as illustrated in the figure above and construction is to be staged. Construction and delivery of the project will be undertaken in a number of separate stages. These stages are detailed in the Staging Report prepared to satisfy NSW Minister's Condition of Approval (MCoA) A7.

Stage 1 (as outlined in W2B Staging Report Version 1, March 2015 and approved) includes:

- Pre-construction activities
- Selected utility relocations
- Archaeological salvage works
- Construction of Section 1 (Woolgoolga to Halfway Creek)
- Construction of Section 2 (Halfway Creek to Glenugie)
- Soft soil early works: Wave 1 - between Koala Drive and Chatsworth Road (Harwood) with material extraction from Tyndale, Green Hill and Mororo cutting; Wave 2 - Whytes Road to Pimlico 2; Wave 3 - Tyndale and Maclean; and Wave 4 - Tuckombil Canal, Woodburn.

Stage 2 (this report) will be for construction of Sections 3-11, between Glenugie and Ballina. With regards for the need to balance available funding with the completion of a dual separated carriageway, the intent of Stage 2 is to upgrade the section between Glenugie and Ballina to a combination of M and A Class. EIS Sections 3 and 4 will be upgraded to the final M Class. Sections 5 and 6 will be a combination of A and M class. Sections 7, 8 and 9 will be a combination of A and M Class. Sections 10 and 11 will be constructed to the final M Class.

The combination of the A and the M class has been determined such that the available funding is used efficiently while achieving the 2020 project objectives. These works are being managed by Pacific Complete and will include the progressive opening of the highway to traffic in the required configuration to meet the 2020 project objectives.

The detailed design phase is currently underway for the sections between Glenugie and Ballina. Should the available funding not be sufficient to achieve the proposed combination of A and M class outlined above, as a contingency measure, opportunities to re-use existing sections of the existing Pacific Highway are being explored.

Stage 2 of the upgrade includes two options to achieve the 2020 objective. Stage 2 Option A represents the construction of the full combination of the A and M class. Stage 2 Option B represents the potential combination of reused sections of the Pacific Highway.

Stage 3 will involve progressive rehabilitation of pavement reuse areas along the project length. This will see the reused sections upgraded to A or M class as funding becomes available.

Stage 4 will involve the upgrade of the remaining sections of the highway to the ultimate M-Class configuration.

Key features of the upgrade include:

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

The project will be jointly funded by the NSW and Australian governments. Both governments have a shared commitment to finish upgrading the highway to a four-lane divided road as soon as possible. Construction for Sections 1 and 2 commenced in May 2015 and completion of the entire project is planned for 2020. The project does not include the Pacific Highway upgrades at Glenugie and Devils Pulpit which are located between Woolgoolga and Ballina. These are separate projects and are now complete. Altogether, these three projects will upgrade 164 kilometres of the Pacific Highway. The project includes a partial upgrade of the existing dual carriageways at Halfway Creek.

A more detailed description of the Woolgoolga to Ballina Pacific Highway upgrade is found in the *Pacific Highway upgrade: Woolgoolga to Ballina Environmental Impact Statement* prepared by Roads and Maritime in December 2012. Further information is found in the Roads and Maritime Services *Woolgoolga to Ballina Pacific Highway Upgrade – Submissions/Preferred Infrastructure Report* (PIR) dated 2013 and the W2B Staging Plan.

2.2 Purpose of the Plan

The Koala is listed as a vulnerable species under the EPBC Act and the *Threatened Species Conservation Act 1995* (NSW) (TSC Act). This Koala Management Plan has been developed to meet the requirements of the NSW Government Approval – Ministers Condition of Approval D8, and Commonwealth EPBC Approval CoA 8 and 9 for Sections 1-11. The Ministers Condition of Approval D9 applies to parts of Sections 5, 8, 9 and 10 as these include key Koala populations located at Woombah-Iluka, Broadwater and Coolgardie-Bagotville.

The Woombah-Iluka Koala population is defined as the population that occurs within a five kilometre radius of the Iluka Road/ Pacific Highway interchange and which occurs approximately between chainage 94,000 – 102,000. A material extraction site for the Wave 1 works is proposed within the northern extent of the Woombah-Iluka population at Mororo cutting between chainage 97,700 and 98,400. Specific Koala measures are proposed to minimise any potential impacts on Koalas within the proposed Mororo cut (borrow) site (refer to Section 6.3 of this Plan).

The Broadwater Koala population is defined as the animals contained within an area 3-5 km either side of an 11.0 km portion of the Pacific Highway Upgrade from Lang Hill (northern part of Section 8) north to the Richmond River (including all of Section 9). These Sections (part 8-9) are one of two areas of the entire Upgrade (along with Section 10) where the greatest numbers of Koala records were encountered in surveys. These two areas were considered by the authors of the Highway Upgrade Environmental Impact Statement and Supplementary Biodiversity Assessment (SPIR) to contain “important populations” according to the now superceded guidelines for assessment described in the *Interim Koala referral advice for proponents* (DSEWPaC 2012). The Richmond River forms a major barrier to the west and north, restricting the movements of the Broadwater Koala population.

The Coolgardie-Bagotville Koala population is located in Section 10, which extends 13.5 km north of the Richmond River and includes the localities of Bagotville and Coolgardie west of Wardell. As with the Broadwater population, this population was similarly assessed, as meeting the criteria for an “important population” under the Department of Environment’s *Interim Koala referral advice for proponents* (DSEWPaC 2012) (Phillips and Chang (2013). This population has been the subject of detailed field sampling and laboratory studies, culminating in the preparation of a Population Viability Assessment (PVA) (Kavanagh 2016), as part of the associated Ballina Koala Plan for Section 10, in accordance with the Commonwealth CoA 5 and CoA 7. The outcomes of the PVA and BKP have been used to guide the development of the management of Koalas within this area.

It is noted that since the assessments were undertaken to support the Environmental Impact Statement, the Department of Environment have revised its Koala referral guidelines. The revised guideline does not require that ‘important populations’, as defined the Department of Environment’s Significant Impact Guidelines 1.1, to be identified in undertaking impact assessments due to the paucity of information about the distribution of koala populations across the range of the species. The guidelines now focus on habitat assessment, field survey, consideration of the severity of potential impacts and the likely success of mitigation as main factor in assessment.

The requirements of this approval and where they are addressed in this Plan are detailed in Table 2-1 below. This Koala Management Plan forms part of the Roads and Maritime Services’ Biodiversity Mitigation Framework (BMF) which addresses the overall Ministerial Conditions of Approval for the Project. The BMF also details the biodiversity plans, programs and strategies that have been prepared and how they inform and relate to each other.

It is important to note that the Koala Management Plan covering Section 1 through to 8 and Section 11 has previously been approved by DP&E on 4 February 2016 and DoE on 29 February 2016. The current Koala Management Plan has been updated to cover the last remaining sections of the Woolgoolga to Ballina Project i.e. Section 5, 8, 9 and Section 10 and addresses the requirements for NSW MCoA D8 and D9 as well as DoE Condition of Approval 8 and 9.

Table 2-1. Project Approval requirements and where they are addressed.

Approval requirements		Where addressed
NSW approval		
NSW CoA D8	*The Applicant shall prepare and implement Threatened Species Management Plans to detail how impacts of the SSI will be minimised and managed specifically for each species identified as significantly impacted in the documents listed in condition A2 or in accordance with condition D1.*	This Plan

	The Plans shall be developed from the draft Threatened Species Management Plans included in the documents listed in condition A2(c) (subject to condition D9), in consultation with EPA, DPI (Fisheries) and DoE, and to the satisfaction of the Secretary, and shall include but not necessarily be limited to:	
(a)	*demonstration that adequate surveys have been undertaken to assess the impacts of the SSI with reference to the Mitigation Framework developed under condition D1, including baseline data collected from surveys, undertaken by a suitably qualified and experienced ecologist on threatened species and ecological communities within all habitat areas to be cleared of vegetation for the SSI, that are likely to contain these species and that are likely to be adversely impacted by the SSI (as determined by a suitably qualified expert). The data shall address the densities, distribution, habitat use and movement patterns of these species;*	Chapter 3
(b)	*identification of potential impacts on each species;*	Chapter 4
(c)	*details of and demonstrated effectiveness of the proposed avoidance and mitigation and management measures to be implemented for each threatened species including measures to at least maintain habitat values of habitat areas compared to baseline data and maintain connectivity for the relevant species;*	Chapter 5, 6 and 7
(d)	*an adaptive monitoring program to assess the use of the mitigation measures identified in conditions B10 and D2. The monitoring program shall nominate appropriate and justified monitoring periods, performance parameters and criteria against which effectiveness of the mitigation measures will be measured and include operational road kill and fauna crossing surveys to assess the use of fauna crossings and exclusion fencing implemented as part of the SSI;*	Chapter 8
(e)	*monitoring methodology for threatened flora and fauna adjacent to the SSI footprint;*	Chapter 8
(f)	*goals and performance indicators to measure the success of mitigation measures, which shall be specific, measurable, achievable, realistic and timely (SMART), and be compared against baseline data;*	Chapter 8
(g)	*methodology for the ongoing monitoring of road kill, the species densities, distribution, habitat use and movement patterns, and the use of fauna crossings during construction and operation of the SSI, including the proposed timing, and duration of that monitoring;*	Chapter 8
(h)	*provision for the assessment of monitoring data to identify changes to habitat usage and whether this can be attributed to the SSI;*	Chapter 8
(i)	*details of contingency measures that would be implemented in the event of changes to habitat usage patterns, entities, distribution, and movement patterns attributable to the construction or operation of the SSI, based on adequate baseline data;*	Chapter 8
(j)	*mechanisms for the monitoring, review and amendment of these plans;*	Chapter 8
(k)	*provision for ongoing monitoring during operation of the SSI (for operation/ongoing impacts) until such time as the use and effectiveness of mitigation measures can be demonstrated to have been achieved over a minimum of three successive monitoring periods, unless otherwise agreed by the Secretary in consultation with the OEH, DPI (Fisheries) and DoE; and*	Chapter 8
(l)	*provision for annual reporting of monitoring results to the Secretary and the EPA, DPI (Fisheries) and DoE, or as otherwise agreed by those agencies.*	Chapter 8
	In developing the Plans, the Applicant shall demonstrate to the satisfaction of the Secretary and DoE, how the public authorities and	

	expert reviewer recommendations provided for each draft plan in the documents listed in condition A2(c) have been addressed, including detailed justification of any variance from the recommendations of the expert reviewer of the management plans, including analysis of potential risk to the threatened species.	
	The Plans must be submitted and approved by the Secretary prior to commencement of construction of the relevant stages of the action, and implemented prior to commencement of construction of the relevant stages, unless otherwise agreed by the Secretary.	
NSW CoAD9	*As part of the Threatened Species Management Plans required under condition D8, the Applicant shall prepare and implement a Koala Management Plan to demonstrate the ongoing survival of the Koala populations at Coolgardie/Bagotville, Broadwater and Woombah/Iluka. The Plan shall be prepared by a suitably qualified and experienced species expert and shall include, but not necessarily be limited to:*	This Plan
(a)	*results of detailed surveys to determine:*	Chapter 3
(a) (i)	*the population status of the Coolgardie/Bagotville, Broadwater and Woombah/Iluka Koala populations;*	Chapter 3
(a) (ii)	*habitat use and movement patterns of Koala populations within five kilometres of the proposed upgrade, or such area as determined by the independent ecologist; and*	Chapter 3
(a) (iii)	*habitat areas likely to be fragmented by the SSI;*	Chapter 3 and 4
	including the results of SPOT assessment and radio tracking. *The results and adequacy of surveys shall be verified by an independent suitably qualified and experienced ecologist with appropriate qualifications and experience in Koala and road ecology. Where appropriate, the Applicant may vary the required area of survey specified under condition D9(a)(ii) to the satisfaction of the independent ecologist;*	Chapter 3
(b)	*a detailed assessment of the impacts to the Koala populations based on the survey results required by condition D9(a), including population impacts and the identification of habitat likely to be fragmented and/or isolated as a result of the SSI;*	Chapter 4
(c)	*a detailed description, including the location and design, of all proposed avoidance and mitigation measures;*	Chapter 4
(d)	*justification that the location and design of mitigation measures:*	Chapter 4
(d)(i)	*have been designed with the objective of no Koala road kill from the commencement of construction of the SSI. In the event that a Koala is injured or killed during construction or operation, this shall be reported on the Applicant's website within 24 hours of this occurring, and the record shall remain available for a period of at least five years, unless otherwise agreed by the Secretary;*	Chapter 4

(d)(ii)	*include permanent fencing of the entire SSI for the length of the distribution of the Coolgardie/Bagotville, Broadwater and Woombah/Iluka populations and for two kilometres beyond the distribution of the Coolgardie/Bagotville, Broadwater and Woombah/Iluka population, following the highway or to the nearest natural barrier to Koala movement (e.g. river), after baseline surveys are complete in accordance with condition D9(a) and prior to operation;*	Chapter 5 and 6
(d)(iii)	*result in the complete, safe crossing of fauna crossings by the Koala. Fauna crossings shall be provided at a sufficient frequency to ensure that habitat connectivity is maintained or improved from pre-construction conditions, as determined by the independent ecologist and agreed by EPA;*	Chapter 6
(d)(iv)	*provide sufficient opportunities for species dispersal and re-colonisation as determined by the independent ecologist and EPA;*	Chapter 6
(d)(v)	*are in areas that, and are at a sufficient frequency to, achieve (i) - (iv), based on site specific information contained in the survey results required by condition D9(a) and the ecological requirements of the Koala, including but not limited to home range size, local movement patterns and habitat use, in accordance with the advice of the independent ecologist and EPA;*	Chapter 3
(d)(vi)	*all Koala underpass structures shall have a minimum height and width of 2.4 metres and a maximum length of 40 metres, or a minimum height and width of 3 metres and a maximum length of 50 metres. The underpass/culvert entrance shall be located at ground level, and no higher in the fill. Structures that provide passage over the road shall have a minimum width of 30 metres and shall be treated with contiguous habitat features;*	Chapter 6
(d)(vii)	*provide passage for Koalas under or over the existing highway (where the existing highway forms part of the SSI) and service roads or local roads (servicing over 100 vehicles per day);*	Chapter 6
(d)(viii)	*effectively minimise the risk of predation from dogs in both dedicated and combined crossings;*	Chapters 3, 4 & 5
(d)(ix)	*provide dry passage for dedicated fauna crossings and for combined fauna crossings to the satisfaction of EPA and DoE, at a flood immunity level determined in accordance with condition D2(c)(j);*	Chapter 6
(d)(x)	*provide habitat linkages to crossing structures from adjacent Koala habitat; and*	Chapter 6
(d)(xi)	*ensures that pathways to connectivity structures are not impeded by ancillary facilities, rest areas, service roads or local roads;*	Chapter 6
(e)	*if the mitigation measures discussed in condition D9(d) cannot be demonstrated to be effective to the satisfaction of the Secretary, in consultation with EPA and DoE, provision for the Plan to be revised to include the design and construction of a minimum of one dedicated underpass or land bridge every 500 metres. Underpass structures shall have a minimum height and width of three metres and a maximum length of 50 metres;*	Section 6.3.9

(f)	*provision for the installation and vegetation planting of fauna overpasses prior to the commencement of construction;*	Section 6.3.9
(g)	*a revegetation strategy to be implemented to increase connectivity adjacent to the SSI and leading to crossing locations, and the provision of vegetation planting on land bridges, to ensure the establishment of the vegetation prior to the commencement of construction;*	Section 6.3.11
(h)	*details of the proposed monitoring methodology to ensure the effectiveness of the mitigation measures and the ongoing survival of the Coolgardie/Bagotville, Broadwater and Woombah/Iluka Koala populations. Monitoring shall:*	Chapter 8
(h)(i)	*include goals that demonstrate the mitigation measures are effective, including clear objectives, milestones, performance measures, corrective actions, and thresholds for corrective actions, and timeframes for completion;*	Section 8.6
(h)(ii)	*occur until such time as the mitigation measures are demonstrated to be effective for three consecutive monitoring periods, or as agreed by the Secretary, to the satisfaction of the independent ecologist and OEH; and*	Chapter 8
(h)(iii)	*for the purposes of the Coolgardie/Bagotville population, consider the results of the surveys undertaken in the Koala habitat and population assessment: Ballina Shire Council LGA (Biolink Ecological Consultants Pty Ltd, November 2013) in determining the baseline population;*	Chapter 3, 6 & 7
(i)	*where the results of monitoring undertaken in accordance with condition D9(h) suggests that the mitigation measures are ineffective or changes to the population have occurred, the Applicant shall provide the Secretary, within one month of recording the changes, the corrective actions that have been implemented and/or proposed to be implemented, or a procedure for demonstrating that this change is not a result of the SSI. Should the Applicant be unable to demonstrate to the satisfaction of the Secretary that any change to the population is not attributable to the SSI, the SSI shall be deemed as the cause of the impact and the Applicant shall, within one month of these findings, provide, to the satisfaction of the Secretary, in consultation with the EPA and DoE, the proposed corrective actions to address the impacts of the SSI. Any required corrective actions shall include, but not necessarily be limited to:*	Chapter 8
(i)(i)	*installation of further crossings or modifications to existing crossings and the provision of evidence of the complete, safe crossing of these fauna crossings by the Koala. Any additional crossings shall be provided at a sufficient frequency to ensure that habitat connectivity is maintained or improved from pre-construction conditions, within two years of their installation; and*	Chapter 8
(i)(ii)	*reassessment of all revegetation areas and frequent reporting and maintenance including addressing failures;*	Chapter 8

(j)	*if the measures in condition D9(i) cannot be demonstrated to be successful within one year of their implementation, procedure for the submission of further offsets in accordance with conditions D5 and D6(j), to be provided within one year of these findings. Further offsets may include:*	Chapter 8
(j)(i)	*the legal protection and conservation management of additional areas of existing habitat that actively regenerated and secured into conservation management; and/or*	Chapter 3
(j)(ii)	*strategic revegetation of cleared areas to improve connectivity; and/or*	Chapter 6
(j)(iii)	*development of a supplementary feeding program and/or breeding program; and/or*	na
(j)(iv)	*development of a long term predator control program; and*	Chapter 7 and 8
(k)	*evidence of consultation with species experts, EPA and DoE in addressing the requirements of this condition, and demonstration of how comments provided by the species experts, EPA and DoE, as a result of this consultation, have been addressed.*	Chapter 2 and Appendix D
	The Koala Management Plan shall be submitted and approved by the Secretary prior to the commencement of construction of the relevant stages of the SSI. The approved Koala Management Plan shall be implemented prior to the commencement of construction of the relevant stages.	
EPBC-5	*In order to ensure the long-term viability of the **Ballina Koala population**, the **approval holder** must engage a **suitably qualified expert** to undertake population viability modelling of the **Ballina Koala population** over a time period of no less than 50 years, taking into account the impacts resulting from the road upgrade in **Section 10**. This modelling should consider the current proposed route and any proposed avoidance or mitigation measures as appropriate.*	Ballina Koala Plan (Niche 2016)
EPBC-6	*The **approval holder** must have the modelling required by Condition 5 peer reviewed by a second **suitably qualified expert**.*	Ballina Koala Plan (Niche 2016)
EPBC-7	*In addition to the Koala Management Plan(s) required by **NSW approval conditions** D8 and D9, to ensure that an unacceptable impact will not occur to the **Ballina Koala population**, the **approval holder** must submit for the **Minister's** approval, a Ballina Koala Plan no less than 3 months prior to **commencement** of **Section 10** of the action, if the impacts to the **Ballina Koala population** are demonstrated to be acceptable within the Ballina Koala Plan. The Ballina Koala Plan must include:* *a. the modelling required by Condition 5 and the results of this modelling, and the peer review required by Condition 6;* *b. discussion of the future viability of the **Ballina Koala population**;*	Ballina Koala Plan (Niche 2016)

	c. *in the context of relevant environmental social and economic considerations, and additional avoidance, mitigation or offsets, beyond those required by the NSW approval conditions, proposed to minimise the impacts to the Ballina Koala population; and* d. *evidence that any additional avoidance and mitigation measures proposed have been considered in the modelling required in Condition 5.* *The approval holder must not **commence Section 10** unless the Ballina Koala Plan has been approved by the **Minister**. The approved Plan must be implemented.*	
EPBC-8	*The **approval holder** must develop a Koala Management Plan(s) pursuant to the requirements of **NSW approval conditions** D8 and D9 for each **relevant stage(s)**. The Koala Management Plan must minimise impacts to the Koala to the satisfaction of the **Minister** and must be submitted to the **Minister** for approval. The relevant **stage(s)** cannot **commence** until the Koala Management Plan for that **stage** is approved by the **Minister**. The approved Plan(s) must be implemented.*	This Plan
EPBC-9	The Koala Management Plan, relevant to **Section 10**, must be consistent with the approved Ballina Koala Plan and can only be submitted to the Minister for approval after the Ballina Koala Plan has been approved by the Minister.	This Plan
EPBC-10	Should further offsets be required in accordance with **NSW approval condition** D9(d)j or be proposed as part of the Ballina Koala Plan, these must be in accordance with the **EPBC Offsets Policy**.	Chapter 8
S/PIR Environmental management measure		
EMM-B11	*The threatened species management plans prepared for the project will be finalised, as relevant to the element of the project to be constructed. Development of the plans will include responding, where feasible and reasonable to:* • *Recommendations from expert review undertaken as part of the Submissions / Preferred Infrastructure Report (and detailed in section 1.4 of the management plans).* • *Any conditions of approval.* • *Results from baseline monitoring undertaken.* *The threatened species management plans will be finalised in consultation with the relevant State and Federal government agencies*	This Plan

This Plan identifies the potential impacts of the Pacific Highway upgrade on the Koala (*Phascolarctos cinereus*) populations and areas of potential Koala habitat between Woolgoolga and Ballina. The Plan outlines existing knowledge of Koala populations, their habitat and distribution, the proposed mitigation measures to be implemented for the Koala, and a program for monitoring the effectiveness of these measures and the viability of identified key populations.

The objectives of the Koala Management Plan include providing:

- An effective process for ensuring the long-term conservation of the Koala in the region, including consideration of the concerns of key stakeholders, and expert review.

- A summary of the locations where Koala populations and their habitat occur, together with those areas which would likely be impacted by the project.
- Management and mitigation measures that would be implemented during the pre-construction, construction and operational phases of the highway upgrade to minimise impacts on Koala populations.
- A monitoring program to be implemented during pre-construction, construction and operation of the project to assess the effectiveness of the mitigation measures and to assess any changes to the status of the Koala population in the region.

2.3 Management structure and plan updates

2.3.1 Management structure

This Koala Management Plan provides a monitoring and management framework for all parts of the proposed upgrade between Woolgoolga to Ballina (Sections 1-11).

This Plan informs future monitoring and reporting, identifies the locations proposed for conducting monitoring and the methods, variables and timing of the proposed monitoring program.

General responsibilities for environmental management are outlined in the Construction Environmental Management Plan (CEMP) and the Construction Flora and Fauna Management Plan (FFMP). Responsibilities for implementation of the Koala Management Plan have been described throughout this Plan and are summarised in Chapter 9. This plan operates in conjunction with the (CEMP) and project-specific flora and fauna management plans (FFMP), and will be incorporated into a wider framework that includes such plans.

Following approval of the Plan, the construction contractor and the ecologists engaged for the relevant project sections will implement the Plan during the construction phase with oversight and responsibility for its implementation by the Roads and Maritime Services, including all operational phase and management measures associated with this Plan.

2.3.2 Plan updates

Development of this Plan has been an iterative and consultative process. It has included input from relevant experts and agencies as well as data from specifically designed scientific studies to fill identified knowledge gaps with respect to Koala populations and habitat within the Project area. This Management Plan has been updated as required to meet the mitigation and management measures committed to in the Environmental Impact Statement (EIS) and Submission/Preferred Infrastructure (SPIR) reports, and complies with the relevant Conditions of Approval (CoA) for the project. Closely associated with this Plan is the Ballina Koala Plan (Niche 2016) which details a Population Viability Analysis (PVA) of the Koala population within the locality of Section 10 of the Upgrade, near Wardell. The PVA was undertaken in accordance with Australian Government condition No. 5 to determine the potential impact of the proposed Highway Upgrade on the population of Koalas occurring specifically within the northern Sections of the Upgrade (Section 10). This Plan draws on the information from the PVA with management actions for Section 10 consistent with the outcomes of that assessment. The Ballina Koala Plan (BKP) is included in Appendix A.

Version 4. has been updated following independent expert review and review by DoE, EPA and DP&E (see Appendix C and Appendix D) so that it addresses the changes arising from those reviews. Version 4also addresses the Conditions of Approval set down by the NSW State Government and the Australian Government (Table 2-1).

Version 5 includes (this plan) includes an Addendum to Appendix I the Koala Revegetation Strategy as at February 2019.

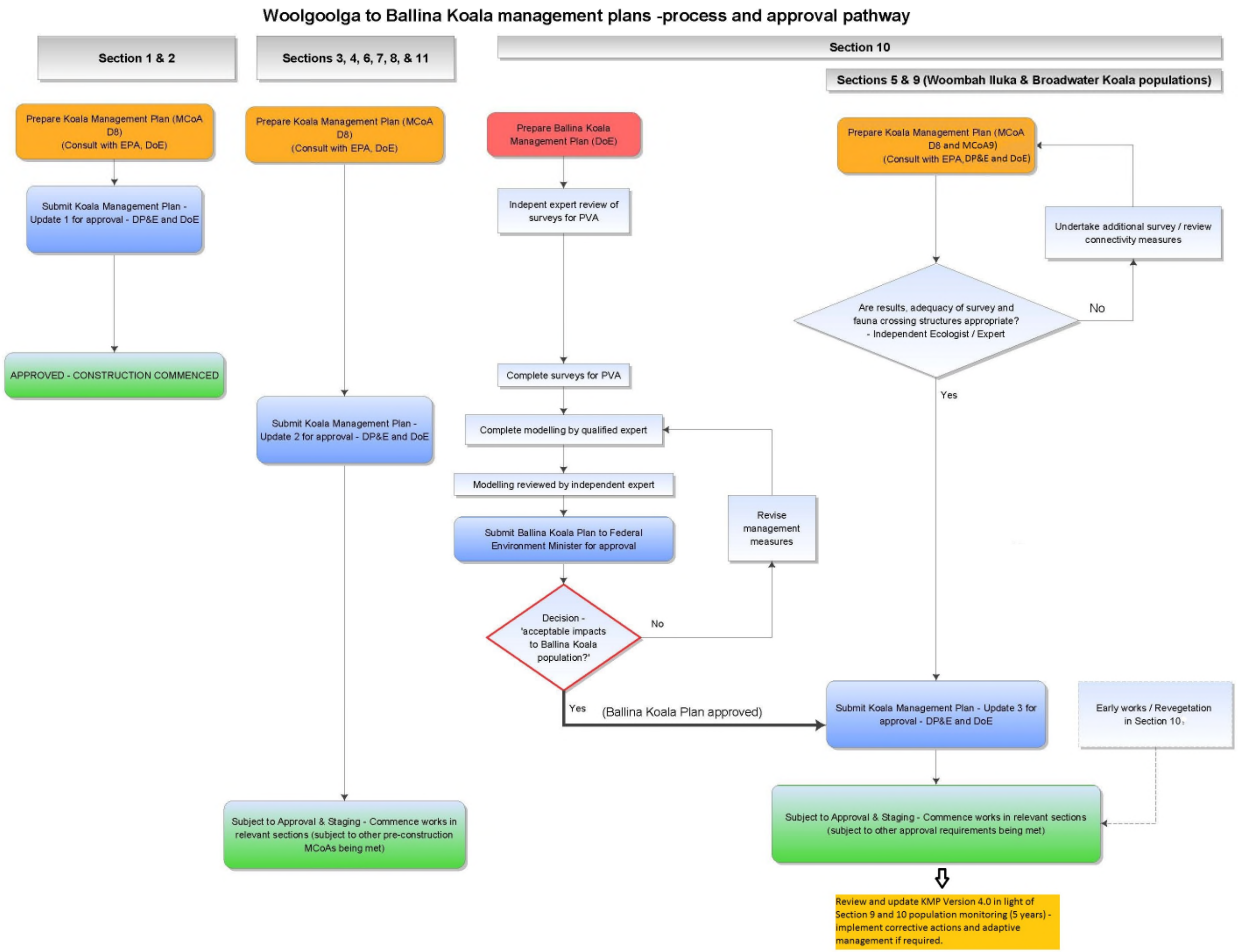
A summary of the process for updating the Plan is illustrated below in Figure 2-1.

NSW CoA D8 and D9 requires the Plan to be submitted and approved by the Secretary of the NSW Department of Planning and Environment (DP&E) prior to commencement of construction of the relevant stages of the action, and implemented prior to commencement of construction of the relevant stages, unless otherwise agreed by the Secretary.

The Australian Government (EPBC Act) Project Approval Condition 8 requires that a Koala Management Plan be developed pursuant to the requirements of the NSW approval conditions D8 and D9 for each relevant stage. The Plan must minimise impacts to the Koala to the satisfaction of the federal Minister and must be submitted to the Minister for approval. The relevant stage cannot commence until the Koala Management Plan for that stage is approved by the Minister (Table 2-1).

The Australian Government Condition 23 states that any activity not in accordance with this Plan requires that the Plan be revised and submitted to the Department of Environment for the Minister's written approval. The varied activity shall not commence until the Minister has approved the revised Plan or agreement in writing.

Figure 2-1 Process to develop management plan



2.4 Plan authors and expert review

2.4.1 Authors

Table 2-2 details the qualifications and experience of authors of this Koala Management Plan. The first three authors prepared Version 1 of the Plan, Drs Kavanagh and McLean prepared Version 2, and Dr Kavanagh prepared Versions 3 and 4 of this Plan. Preparation of Version 4 was assisted by Dr Griffith.

Table 2-2. Author qualifications and experience

Personnel	Qualifications	Experience
Chris Thomson	Bachelor of Applied Science and Graduate Certificate in Natural Resources	Chris is a SKMs practice leader for terrestrial fauna and has a Bachelor of Applied Science and Graduate Certificate in Natural Resources and seventeen years professional experience managing biodiversity assessments and scientific reporting. He is a highly experienced field ecologist with extensive experience on major road projects with the Roads and Maritime, having worked widely throughout NSW as the technical lead on a range of environmental assessments including several Pacific Highway upgrades, in addition to the Hume Highway, Great Western Highway, Princes Highway and New England Highway along with numerous large and small arterial road projects including the M5, M4, Westlink M7 and Westconnex. Chris has comprehensive knowledge of Commonwealth and NSW threatened species legislation, policies and guidelines and has extensive experience in the design of avoidance and mitigation measures for minimising impacts on threatened species with a high level of experience on infrastructure projects including the development of compensatory habitat and offset strategies, biodiversity connectivity strategies, mitigation and monitoring strategies and threatened species management plans.
Valerie Hagger	Bachelor of Applied Science (Environmental Science) with Honours in Ecology (First Class), University of Queensland (2001) Masters of Science (Conservation Biology), University of Queensland (2011)	Valerie is a Senior Ecologist and has ten years environmental consulting experience specialising in environmental impact assessment (EIA), ecological survey and monitoring, ecological assessment, management and approvals, and project management. She has successfully managed numerous environmental and ecological projects for Defence and mining clients, and has been the ecology technical lead on many EIA projects for water supply infrastructure and mining. Valerie is competent in conducting baseline flora and fauna surveys, vegetation (regional ecosystem) surveys and mapping, assessing impacts on ecological values, developing management plans and monitoring strategies for threatened species, ecological communities, weeds and pest animals and rehabilitation, and developing offsets strategies. She is also accomplished in climate change vulnerability assessments on biodiversity
Dr Chris Schell	BAppSc (Hons), PhD	Fourteen years consulting experience and 24 years research experience (flora and fauna). Chris assisted with updating the plan following the initial agency review.
Dr Rod Kavanagh	Dip.Appl.Sc.(Agriculture), Grad.Dip.Nat.Res.(Wildlife Management)-University of New England, M.Sc. (Forest Ecology)-Australian National University, Ph.D (Conservation Biology)-University of Sydney.	35 years as a senior wildlife research scientist with State Forests of NSW and the NSW Department of Primary Industries, and three years as an ecological consultant with Niche Environment and Heritage. Rod has published more than 80 peer-reviewed papers in scientific journals about Australian forest fauna. His research and consulting work has included numerous studies investigating the distribution, habitat and ecology of the Koala in NSW, as well as the response of this species to logging, drought, high temperatures and habitat restoration.
Dr Amanda Griffith	BSc (Hons), PhD – University of NSW	Amanda Griffith is an ecological consultant with over 15 years' experience and a strong background in mammalian ecology, research and management. She has a PhD in behavioural ecology of Red Kangaroos (focussing on population dynamics and reproduction) and a sound understanding of the application of scientifically rigorous, field-based studies. Amanda has had recent experience with four Koala management plans in addition to the W2B KPoM.

Personnel	Qualifications	Experience
Dr Chris McLean	BEnSc (Hons) – University of Newcastle, PhD – University of Wollongong.	10 years experience in undertaking ecological management and research projects, including four years as an ecological consultant. Chris has undertaken research both as the lead researcher and as a supervisor of research students on a range of Australian mammals, including the Koala.

2.4.2 Expert review

An expert review of Version 1 of the plan was undertaken in August 2013 by Associate Professor Robert Close from the University of Western Sydney and Australian Museum Business Services. Robert's principal field of interest is marsupial biology, which includes cytogenetics, formation of new species, hybridisation of existing species, fertility of hybrids, and ecology. Robert has conducted a study of Koalas in the Campbelltown region since 1990 that has included supervision of graduated PhD students. The Campbelltown study has largely been ecological and genetic but has become a community-associated research program, with feedback from the community leading to increased sightings of Koalas. Since October 1995, Robert and his colleagues have published a weekly column in the Macarthur Advertiser principally describing their Koala research. The project has provided long-term family data for Koalas that include four generations of Koalas.

In 1999 Robert joined the Australian Museum Consulting team to conduct research on the effects of the Pacific Highway upgrades at Yelgun to Chindera and at Bonville on the respective local Koala populations. Robert has published over 50 articles on mammals and marsupials, nine of these have been specifically on the Koala.

A curriculum vitae for Associate Professor Robert Close is provided in Appendix B, and a copy of his review is provided as Appendix C. The recommendations provided in this review, and the responses by RMS to the recommendations, are summarised in Appendix C.

An expert review of Version 4 of the plan was undertaken by Associate Professor Jonathan Rhodes from the University of Queensland. Jonathan is based in the School of Geography, Planning and Environmental Management at The University of Queensland (UQ), and a member of the Centre for Biodiversity and Conservation Science at UQ. He is an ecologist with a broad range of interests in conservation biology, spatial modelling, and environmental decision making. Jonathan is a part of the Koala Expert Advisory Committee (KEAC) for the Project and has also provided advice on the population viability analysis modelling and mitigation measures for the Ballina Koala population. A copy of his review is provided in Appendix K.

2.4.3 Agency review

Version 2 of the Plan was reviewed in February 2015 by NSW Department of Planning and Environment (DP&E), NSW Environment Protection Authority (EPA) and the Commonwealth Department of Environment (DoE). Version 3 of the Plan was reviewed in September 2015 and in December 2015 by DP&E, EPA and DoE. Version 4 of the plan was reviewed in June 2016 by DP&E, EPA and DoE. The comments and requirements of the three Agencies are listed in Appendix D, together with the responses by RMS to them.

3. Koala populations

Figure 3-1 to Figure 3-11, at the end of this chapter show the distribution of Koala records, habitat quality classes for the species, and the distribution of vegetation types containing preferred Koala food tree species.

3.1 Existing knowledge

3.1.1 Conservation status

The Koala (*Phascolarctos cinereus*) is listed as a vulnerable species under the New South Wales *Threatened Species Conservation Act 1995* (TSC Act).

The Koala (*Phascolarctos cinereus*) (combined population in Queensland, New South Wales and the Australian Capital Territory) is listed as a vulnerable species under the Australian Government *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

3.1.2 Habitat requirements

The Koala inhabits a range of *Eucalyptus*-dominated forest and woodland communities where favoured food trees are present (Hindell and Lee 1990, DECC 2008), which may also include isolated paddock trees (White 1999). The quality of the habitat for Koalas is influenced by a range of factors (Reed *et al.* 1990, DECC 2008), such as:

- Species and size of trees present.
- Structural diversity of the vegetation.
- Soil nutrients.
- Climate and rainfall.
- Size and disturbance history of the habitat patch.

The Koala is a folivore with a diet restricted primarily to the foliage of *Eucalyptus* species, however the species is also known to consume the foliage of related genera, including *Corymbia*, *Angophora* and *Lophostemon* species. *Leptospermum* and *Melaleuca* species have also been identified as a source of fodder for the Koala (DSEWPaC 2013).

A list of Koala food trees, categorised as primary, secondary and supplementary food trees, for the NSW North Coast is provided in Appendix 2 of the NSW Koala Recovery Plan (DEC 2008). The presence of these tree species as either canopy dominants or main associated species in each of the BioMetric Vegetation Types known to be present along the highway upgrade are shown in Table 3-1 (see Vegetation Types Database at: http://www.environment.nsw.gov.au/resources/nature/BioMetric_Vegetation_Type_CMA.xls).

Table 3-1. Occurrences of Koala food tree species on the NSW north coast listed according to the BioMetric Vegetation Types known to be present along the highway upgrade.

BioMetric vegetation types showing the dominant or associated tree species known to be food trees for the Koala	Koala food tree species		
	Primary	Secondary	Supplementary
Angophora paludosa shrubby forest and woodland on sandstone or sands of the North Coast (NR101)	Forest Red Gum (*E. tereticornis*)	Red Mahogany (*E. resinifera*)	-
Angophora robur shrubby forest and woodland on sandstones of the North Coast (NR102)	Orange gum (*E. bancroftii*)	-	Tindal's Stringybark (*E. tindaliae*)
Black Bean-Weeping Lilly Pilly riparian rainforest of the North Coast (NR110)	-	-	-
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast (NR115)	-	Red mahogany (*E. resinifera*)	-
Blackbutt-Tallowwood dry grassy open forest of the central parts North Coast (NR119)	Tallowwood (*E. microcorys*)	-	-
Blackbutt grassy open forest of the lower Clarence Valley of the North Coast (NR125)	Tallowwood (*E. microcorys*)	Red mahogany (*E. resinifera*)	-
Brush Box - Tallowwood shrubby open forest of the northern ranges of the North Coast (NR140)	Tallowwood (*E. microcorys*)		
Coast Cypress Pine shrubby open forest of the North Coast Bioregion (NR148)	-	-	-
Coastal floodplain sedgelands, rushlands, and forblands (NR149)	-	-	-
Coastal heath on sands of the North Coast (NR152)	-	-	-
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal ranges of the North Coast (NR159)	Tallowwood (*E. microcorys*)	-	-
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast (NR161)	Forest red gum (*E. tereticornis*)	-	-
Forest Red Gum grassy open forest of the coastal ranges of the North Coast (NR162)	Forest red gum (*E. tereticornis*)		
Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the North Coast (NR173)	-	Small-fruited grey gum (*E. propinqua*)	-
Hoop Pine-Yellow Tulipwood dry rainforest of the North Coast (NR179)	-	-	-
Mangrove-Grey Mangrove low closed forest of the NSW Coastal Bioregions (NR182)	-	-	-
Narrow-leaved Ironbark dry open forest of the North Coast (NR193)	Forest red gum (*E. tereticornis*)		
Narrow-leaved Red Gum woodlands of the lowlands of the North Coast (NR197)	Cabbage gum (*E. amplifolia*)	Narrow-leaved red gum (*E. seeana*)	-
Needlebark Stringybark - Red Bloodwood heathy woodland on sandstones of the lower Clarence of the North Coast (NR200)	-	-	-
Orange Gum (*Eucalyptus bancroftii*) open forest of the North Coast (NR216)	Orange gum (*E. bancroftii*)	-	-
Paperbark swamp forest of the coastal lowlands of the North Coast (NR217)	Swamp mahogany (*E. robusta*) Forest red gum (*E. tereticornis*)	-	-
Pink Bloodwood - Tallowwood moist open forest of the far northern ranges of the North Coast (NR219)	Tallowwood (*E. microcorys*)	Small-fruited grey gum (*E. propinqua*)	
Red Mahogany open forest of the coastal lowlands of the North Coast (NR222)	-	Red mahogany (*E. resinifera*)	-
Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast (NR227)	-	-	-
Scribbly Gum – Red Bloodwood heathy open forest of the coastal lowlands of the North Coast (NR228)	-	-	-
Spotted Gum - Grey Box - Grey Ironbark dry open forest of the Clarence Valley lowlands of the North Coast (NR244)	Forest red gum (*E. tereticornis*)	Grey box (*E. moluccana*)	Thin-leaved Stringybark (*E. eugenoides*)

BioMetric vegetation types showing the dominant or associated tree species known to be food trees for the Koala	Koala food tree species		
	Primary	Secondary	Supplementary
Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast (NR246)	-	Small-fruited grey gum (*E. propinqua*)	-
Swamp Box swamp forest of the coastal lowlands of the North Coast (NR253)	Swamp mahogany (*E. robusta*) Cabbage gum (*E. amplifolia*)	-	-
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast (NR254)	Swamp mahogany (*E. robusta*) Forest red gum (*E. tereticornis*)	Red mahogany (*E. resinifera*)	-
Swamp Oak swamp forest of the coastal lowlands of the North Coast (NR255)	Forest red gum (*E. tereticornis*)	-	-
Tallowwood dry grassy forest of the far northern ranges of the North Coast (NR267)	Tallowwood (*E.microcorys*)	Small-fruited grey gum (*E. propinqua*)	-
Tuckeroo-Riberry-Yellow Tulipwood littoral rainforest of the North Coast (NR273)	-	-	-
Turpentine moist open forest of the coastal hills and ranges of the North Coast (NR274)	Tallowwood (*E.microcorys*)	Red mahogany (*E. resinifera*) Small-fruited grey gum (*E. propinqua*)	-
Wet heathland and shrubland of coastal lowlands of the North Coast (NR278)	-	-	-
White Booyong-Fig subtropical rainforest of the North Coast (NR280)	-	-	-

Koalas exhibit strong feeding preferences for individual trees within a species. This variability creates a nutritional patchiness such that species-based assessments of habitat may result in overestimates of the availability of high quality habitat, as Koalas selectively utilise only a portion of the habitat perceived to be of a high quality (DSEWPaC 2013). In addition, many other unrelated factors (e.g. predation, disease, human impacts) could increase Koala mortality and thus explain low abundance of this species in its preferred habitat.

The list of tree species known to be important as food for the Koala is large and expanding as more information becomes available. Table 3-2 provides a list of Koala food trees from the Australian Koala Foundation (Mitchell 2012) for the local government areas Coffs Harbour, Grafton and Ballina.

Table 3-2. Koala food tree species in Coffs Harbour, Clarence Valley and Ballina LGAs (source: Mitchell 2012)

LGA	Scientific name and/or subspecies	Common name and ecology
Clarence Valley	*E. amplifolia ssp. sessiliflora*	Cabbage gum; by streams or in lower moister sites, in deeper loamy soils
	E. bancroftii	Orange Gum; infertile, sandy lowland sites
	E. biturbinata	Grey Gum; slopes on soils of medium fertility, annual rainfall>1000 mm
	E. crebra	Narrow-leaved red ironbark, Ironbark, Narrow-leaved ironbark; well-drained shallower or sandy/sandy clay soils of medium fertility, >550 mm rainfall
	E. glaucina	Slaty Red Gum; deep, moderately fertile moist soils
	E. grandis	Flooded Gum, Rose Gum; moist, fertile, well-drained, deep, loamy soils of alluvial or volcanic origin, 725-3500 mm
	E. laevopinea	Silvertop stringybark; hills and eastern escarpments, medium to high fertility basalt soils in wetter areas

LGA	Scientific name and/or subspecies	Common name and ecology
	E. melanophloia	Silver-leaved ironbark; moderately fertile silts, loams, sandy clays on foothills
	E. microcorys	Tallowwood; on slopes in deeper moderate to fertile soils, well-drained but moist
	E. moluccana	Coastal Grey Box, Grey box, Gum-topped box; loam soils of moderate to high fertility on coastal plains and ranges, tolerates saline soils
	E. obliqua	Messmate Stringybark; fertile acidic well-drained loams, > 600 mm rainfall, drought tolerant
	E. planchoniana	Bastard Tallowwood, Needlebark stringybark; dry sclerophyll forest or woodland on sandy soils or coastal sand
	E. propinqua	Small-fruited Grey Gum; wet coastal forest on soils of low to medium fertility, drought and frost tolerant
	E. racemosa ssp. racemosa	Scribbly Gum; shallow infertile sandy soil, coastal areas or over sandstone
	E. resinifera ssp. hemilampra	Red mahogany; sandy or well drained fertile soils, drought and frost tolerant
	E. robusta	Swamp Mahogany; swampy, seasonally waterlogged soils, very moist fertile soils, heavy clay, sandy clay, alluvial sand soils
	E. seeana	Narrow-leaved Red Gum; poorly drained shallow soils, swampy sandy soils
	E. siderophloia	Ironbark, Broken Back Ironbark; wet forest on soils of moderate fertility
	E. tereticornis ssp. tereticornis	Forest red gum, Blue gum, Red Iron-gum; alluvial soils, 600-2500 mm, tolerates salt-laden coastal winds, tolerates saline soils, medium-heavy clays, does not tolerate waterlogged soils
	E. tindaliae	Tindal's Stringybark; poorer soils in high rainfall areas, often derived from granite
Coffs Harbour	*E. bancroftii*	Orange Gum; infertile, sandy lowland sites
	E. biturbinata	Grey Gum; slopes on soils of medium fertility, annual rainfall>1000 mm
	E. crebra	Narrow-leaved red ironbark, Ironbark, Narrow-leaved ironbark; well-drained shallower or sandy/sandy clay soils of medium fertility, >550 mm rainfall
	E. globoidea	White Stringybark; moist well drained soils in foothills
	E. grandis	Flooded Gum, Rose Gum; moist, fertile, well-drained, deep, loamy soils of alluvial or volcanic origin, 725-3500 mm
	E. microcorys	Tallowwood; on slopes in deeper moderate to fertile soils, well-drained but moist
	E. moluccana	Coastal Grey Box, Grey box, Gum-topped box; loam soils of moderate to high fertility on coastal plains and ranges, tolerates saline soils
	E. planchoniana	Bastard Tallowwood, Needlebark stringybark; dry sclerophyll forest or woodland on sandy soils or coastal sand
	E. propinqua	Small-fruited Grey Gum; wet coastal forest on soils of low to medium fertility, drought and frost tolerant
	E. racemosa ssp. racemosa	Scribbly Gum; shallow infertile sandy soil, coastal areas or over sandstone
	E. resinifera ssp. hemilampra	Red mahogany; sandy or well drained fertile soils, drought and frost tolerant
	E. robusta	Swamp Mahogany; swampy, seasonally waterlogged soils, very moist fertile soils, heavy clay, sandy clay, alluvial sand soils
	E. seeana	Narrow-leaved Red Gum; poorly drained shallow soils, swampy sandy soils
	E. siderophloia Ironbark,	Broken Back Ironbark; wet forest on soils of moderate fertility
	E. tereticornis ssp. tereticornis	Forest red gum, Blue gum, Red Iron-gum; alluvial soils, 600-2500 mm, tolerates salt-laden coastal winds, tolerates saline soils, medium-heavy clays, does not tolerate waterlogged soils
	E. tindaliae	Tindal's Stringybark; poorer soils in high rainfall areas, often derived from granite
Ballina	*E. bancroftii*	Orange Gum; infertile, sandy lowland sites
	E. grandis	Flooded Gum, Rose Gum; moist, fertile, well-drained, deep, loamy soils of alluvial or volcanic origin, 725-3500 mm
	E. microcorys	Tallowwood; on slopes in deeper moderate to fertile soils, well-drained but moist
	E. moluccana	Coastal Grey Box, Grey box, Gum-topped box; loam soils of moderate to high fertility on coastal plains and ranges, tolerates saline soils

LGA	Scientific name and/or subspecies	Common name and ecology
	E. propinqua	Small-fruited Grey Gum; wet coastal forest on soils of low to medium fertility, drought and frost tolerant
	E. racemosa ssp. racemosa	Scribbly Gum; shallow infertile sandy soil, coastal areas or over sandstone
	E. resinifera ssp. hemilampra	Red mahogany; sandy or well drained fertile soils, drought and frost tolerant
	E. robusta	Swamp Mahogany; swampy, seasonally waterlogged soils, very moist fertile soils, heavy clay, sandy clay, alluvial sand soils
	E. seeana	Narrow-leaved Red Gum; poorly drained shallow soils, swampy sandy soils
	E. siderophloia	Ironbark, Broken Back Ironbark; wet forest on soils of moderate fertility
	E. tereticornis ssp. tereticornis	Forest red gum, Blue gum, Red Iron-gum; alluvial soils, 600-2500 mm, tolerates salt-laden coastal winds, tolerates saline soils, medium-heavy clays, does not tolerate waterlogged soils
	E. tindaliae	Tindal's Stringybark; poorer soils in high rainfall areas, often derived from granite

The Koala resides in a specific home-range, however the home-ranges of individual animals are not mutually exclusive, often overlapping extensively (Kavanagh *et al*. 2007). Individuals tend to use the same set of trees, but generally not at the same time, and social interactions are uncommon outside of the breeding season. Koalas tend to move relatively short distances under most conditions, changing trees only a few times each day (DSEWPaC 2013).

Home ranges for the Koala are variable depending on the location, with Koalas occurring in "poorer" habitats having larger home ranges than individuals established in higher quality habitats (DSEWPaC 2013). On average, male Koalas have larger home ranges than females (Kavanagh *et al*. 2007, Goldingay and Dobner 2014, de Oliviera *et al*. 2014). For example, at Bonville on the NSW North Coast, approximately 40 kilometres south of Woolgoolga, male home ranges were estimated at approximately 20 hectares and female home ranges were approximately 10 hectares (Lassau *et al*. 2008).

Recent genetic research identified major roads as a barrier to gene flow for Koalas (Lee *et al* 2010 and Dudaniec *et al* 2013). The Project will fragment habitat links for Koalas seeking to access preferred habitats either side of the highway, particularly where these animals are most abundant (e.g. along Section 10, between Bagotville and Wardell and the southern parts of Coolgardie, and Section 9, between Broadwater National Park and Rileys Hill, of this Project.

Koala movements are expected to be more frequent and extensive during the breeding season (September to February) with the peak dispersal period (July to August) due to expansion of home ranges and movement of juveniles away from natal areas (Lassau *et al*. 2008). Therefore, these periods would be likely to represent peaks in Koala movement, resulting in potentially greater incidence of road mortality, but also higher rates of usage of connectivity structures and thus higher detection rates.

3.2 Distribution of the Koala and its habitat

The distribution of potential habitat for the Koala throughout the footprint area of the Pacific Highway upgrade between Woolgoolga and Ballina was assessed by means of vegetation assessments, identification of the presence of known Koala food trees, assessments of habitat connectivity, patch area and evidence of Koala presence using assessments of the presence of faecal pellets. The Spot Assessment Technique (SAT) (scat-search method) of Phillips and Callaghan (2011), which involves inspection of the ground below 30 trees greater than 10 cm diameter at breast height within 0.1-0.2 ha plots, was used to identify Koala presence and relative use of different vegetation types. A total of 212 scat-search plots was sampled along the length of the Pacific Highway upgrade, and evidence of Koala presence was found at 16 of these plots.

Each vegetation polygon was also assessed and ranked from 0 (lowest) to 10 (highest) in terms of its habitat suitability for the Koala (based on the above criteria), and in terms of the likelihood of each vegetation type to contain preferred (primary and secondary) Koala food trees. The methodology was in accordance with the EPBC Act's Environmental Offset Policy (October 2012) and Offsets Assessment Guide. These assessments were undertaken for each of the eleven sections of the highway upgrade, the results of which are mapped in Figs 2-1 to 2-11. In addition, the locations of all NSW Wildlife Atlas records of the Koala are indicated on these maps. References to previously cleared land noted below refer to land cleared historically (for grazing or other purposes) prior to the project.

3.2.1 Section 1: Woolgoolga to Halfway Creek

Koala habitat quality (HQ) was scored in 181 vegetation polygons encompassing a total of 199.20 ha (including 74.16 ha previously cleared) along the 17 km stretch of Section 1. The median HQ score was 7 (average 6.4, range 3-7; Biosis 2014), indicating that potential Koala habitat was widespread along this section of the highway upgrade (Figure 3-1; Table 4-1). These relatively high scores may be due to the large continuous areas of State Forest and National Park near the highway footprint area, leading to higher weightings for patch size and connectivity. Figure 3-1 indicates that habitat suitable for the Koala is widespread along Section 1 of the highway upgrade. However, only few records of the Koala were obtained during vegetation assessments, faecal pellet searches, other surveys, and from the NSW Wildlife Atlas (EIS 2011, S/PIR 2013, Biosis 2014). A total of 30 scat-search plots were surveyed in Section 1 across nine vegetation types, but no Koala faecal pellets were observed. A small number of Koala faecal pellets were observed at one additional site in August 2012 during opportunistic searches near the Range Road Interchange (GeoLink 2012). Studies during the early 1990s also found that the Koala was very uncommon in the State Forests that adjoin Section 1 (and Section 2) of the highway (Kavanagh *et al*. 1995). Others have reported similar findings of low Koala population densities in these forests during the past decade (Brian Tolhurst, *personal communication November 2014*; previously Regional Forest Ecologist, Forestry Corporation of NSW). It was concluded that Koalas occur at very low population densities along Section 1 of the Pacific Highway Upgrade, despite the existence of potentially suitable habitat.

3.2.2 Section 2: Halfway Creek to Glenugie

Sixty-four mapped vegetation polygons totalling 129.81 ha (including 37.66 ha previously cleared) were assessed along the 15 km stretch of Section 2. The median Koala HQ score was 8 (average 7.4, range 5-9; Ecosure 2014), indicating that potential Koala habitat was widespread along this section of the highway upgrade (Figure 3-2; Table 4-1). A total of 24 scat-search plots was surveyed in Section 2 across eight vegetation types, and Koala faecal pellets were observed at only one plot. This plot was located in vegetation type NR217 (Paperbark swamp forest of the coastal lowlands of the North Coast). Overall, vegetation floristics and condition were very good for Koalas, with good connectivity to State Forest, particularly at the northern end of the Section. However, while there were several records of the Koala in or near Section 2 of the project area, Koalas appear to occur at very low population densities in this area, and these findings were also supported by those of Kavanagh *et al*. (1995) and B. Tolhurst (*personal communication*). It was concluded that Koalas occur at very low population densities along Section 2 of the Pacific Highway Upgrade, despite the existence of potentially suitable habitat.

3.2.3 Section 3: Glenugie to Tyndale

Ninety-five mapped vegetation polygons totalling 364.09 ha (including 56.52 ha previously cleared) were assessed along the 35 km stretch of Section 3. The median Koala HQ score was 5 (average 5, range 3-8; Geolink 2015), which was relatively low compared to other sections (Figure 3-3; Table 4-1).

However, a number of communities within this section support primary Koala food trees, including Swamp Mahogany swamp forest and Forest Red Gum- Swamp Box forest (Geolink 2015). Many older (> 10 years) and few recent Bionet records of the Koala occur along the southern parts of Section 3, particularly within nearby Glenugie, Bom Bom and Devines State Forests which maintain good connectivity. Much of the northern part of this Section has been cleared for agriculture, with minimal vegetation connectivity between the east and the west. However, Pine Brush State Forest occurs in the east which maintains good north-south connectivity to larger tracts of native vegetation. It was concluded that Koalas occur at low population densities along Section 3 of the Pacific Highway Upgrade, despite the existence of potentially suitable habitat.

3.2.4 Section 4: Tyndale to Maclean

Forty mapped vegetation polygons totalling 161.35 ha were assessed along the 13.2 km of Section 4. The median Koala HQ score was 5 (average 5.1, ranging from 3-6; Geolink 2015). Some of the vegetation communities contain primary Koala habitat, including Flooded Gum-Tallowwood-Brush Box moist open forest and Grey Gum-Grey Ironbark forest (Figure 3-4; Table 4-1). This Section consists predominantly of land used for intensive agriculture (sugar cane) in low-lying areas, with remnant native vegetation located mainly to the east. Limited connectivity exists to the west of the project area due to agricultural lands and the Clarence River. It was concluded that Koalas occur at very low population densities along Section 4 of the Pacific Highway Upgrade, despite the existence of potentially suitable habitat.

3.2.5 Section 5: Maclean to Iluka Road

Section 5 includes part of the identified Woombah- Iluka Koala Population (Clarence Valley Council Draft Comprehensive Koala Plan of Management) that is located near the Iluka Road intersection with the Pacific Highway. The approximate distribution of this population, in relation to the Highway Upgrade, is from chainage 94000 (near the Clarence River bridge) to chainage 102000 (in Section 6). Further discussion of this population will be deferred until the next two sections (Sections 3.3 and 3.4) of this Koala Management Plan.

Thirty three mapped vegetation polygons totalling 212.54 ha were assessed along the 14.4 km stretch of Section 5. The median Koala HQ score was 5 (average 5, range 3-7; Geolink 2015) (Figure 3-5; Table 4-1). A further six sites were surveyed using the Spot Assessment Technique (SAT) to determine Koala habitat utilisation within the area (Ecosure 2014). The highest value Koala habitat consists of Flooded Gum-Tallowwood Brush Box moist open forest and Grey Gum-Grey Ironbark forest, which are located on both sides of the Highway. The landscape is predominantly cleared for intensive agriculture along the Clarence River but substantial forest areas occur to the north (e.g. Mororo Creek Nature Reserve, Bundjalung National Park), albeit with limited connectivity.

3.2.6 Section 6: Iluka Road to Devils Pulpit upgrade

Sixty-eight mapped vegetation polygons totalling 113.37 ha (including 43.67 ha previously cleared) were assessed along the 9.2 km stretch of Section 6. The median Koala HQ score was 7 (average 6, range 3-8; AECOM 2014). Eight vegetation communities were mapped, all of which have the potential to be used by Koalas (Figure 3-6; Table 4-1). In general, most communities contained primary Koala feed trees, such as Swamp Mahogany, Tallowwood and Forest Red Gum. A number of Bionet Koala records occur within adjacent State Forests, which are often attributed to Forestry Corporation pre harvest surveys. A high degree of connectivity occurs both to the north and south, and east to west, via State Forests in the area. It was concluded that Koalas occur at very low population densities along Section 6 of the Pacific Highway Upgrade, despite the existence of potentially suitable habitat.

3.2.7 Section 7: Devils Pulpit upgrade to Trustums Hill

Section 7 is 15.3 km long and 85 mapped vegetation polygons totalling 172.34 ha (including 69.19 ha previously cleared) were assessed (Biosis 2014). The median Koala HQ score was 6 (average 6, range 3-7) and the Section includes a number of vegetation types that contain primary Koala feed trees including Red Mahogany Open Forest and Narrow-leaf Redgum woodland (Figure 3-7; Table 4-1). This Section has some Koala records within adjacent native vegetation, suggesting a low density Koala population. Connectivity is less than some Sections, however moderate sized corridors occur in both north-south and east-west directions. It was concluded that Koalas occur at very low population densities along Section 7 of the Pacific Highway Upgrade, despite the existence of potentially suitable habitat.

3.2.8 Section 8: Trustums Hill to Broadwater National Park

Koala habitat quality was scored in 57 vegetation polygons encompassing a total of 122.30 ha (including 88.98 ha previously cleared) along the 11.1 km stretch of Section 8. The median Koala HQ score was 4 (average 4.1, range 3-9; Ecosure 2014) (Figure 3-8, Table 4-1). This Section includes native vegetation around Trustums Hill in the south and Broadwater National Park in the north. In the centre of the Section, the predominant land use is intensive agriculture for sugar cane. Koala records occur within the south and north of the Section. Connectivity in the north of the section is moderate through Broadwater National Park. It was concluded that Koalas occur at very low population densities along Section 8 of the Pacific Highway Upgrade, despite the existence of potentially suitable habitat.

3.2.9 Section 9: Broadwater National Park to Richmond River

Section 9 includes most of the identified Broadwater Koala Population, which also extends into the northern part of Section 8. The approximate distribution of this population in relation to the highway upgrade, is from chainage 137000 to chainage 145000.

One hundred and forty-seven vegetation polygons totalling 85.36 ha (including approximately 51.67 ha of previously cleared vegetation) were assessed within Section 9 (Melaleuca Group 2014). The average HQ score was 4.13 (out of 10; range 3-9, Figure 3-9) for Koala habitat, noting that primary feed trees, including Swamp Mahogany, Forest Red Gum and Tallowwood, were present. The Melaleuca Group (2014) considered that Koalas were highly likely to occur in many areas assessed, and noted Koala scats and climbing marks on trees within several vegetation types, including Swamp Mahogany-Swamp Forest, Grey Gum- Grey Ironbark Open Forest, Forest Red Gum Grassy Open Forest and Brush Box-Tallowwood Shrubby Open Forest. Table 3-3 summarises the location of the scat and Koala records.

Surveys of the Broadwater population were conducted in 2014 and 2015 (Ecosure 2014 and 2015 respectively). These reports are provided in Appendix E and Appendix F respectively. A total of 20 SAT sites were surveyed in 2014 and a further 54 SAT sites were surveyed on 2015. These surveys indicated that the Broadwater Koala Population is located mainly around the perimeter of the Broadwater National Park, especially along the forested fringe and fragmented woodlands outside of the Park. Broadwater National Park is dominated by heathland and, as such, is largely unsuitable for Koalas. The most important areas for Koalas were considered to be between Riley’s Hill and the eastern side of the township of Broadwater.

3.2.10 Section 10: Richmond River to Coolgardie Road

Section 10 includes the Coolgardie-Bagotville Koala Population. The Koala population located in Section 10, extends 13.5 km north of the Richmond River and includes the localities of Bagotville and Coolgardie west of Wardell. More Koalas have been recorded in this Section compared to all other

Sections of the Upgrade. Recent population estimates indicate 196 (± 65,SD) Koalas occur within the area through which Section 10 is located (Phillips 2015).

As part of the Minister’s Conditions of Approval, a population viability analysis (PVA) has been undertaken for this population (Niche 2016). The aim of the PVA was to estimate the likely impact of the proposed highway upgrade in Section 10 on Koala population viability over a 50 year period and investigate the relative benefits of a range of plausible management scenarios that could be implemented by RMS to minimise any potential impacts of the proposed highway upgrade. A more detailed discussion of this population is detailed in the next two sections of this Plan.

The approximate distribution of the population in Section 10, in relation to the Highway Upgrade, is from chainage 146000 (at the Richmond River) to chainage 158500 (in Section 11).

108 mapped vegetation polygons totalling 220.54 ha were assessed along the 13.5 km stretch of Section 10. This included 116.09 ha of previously cleared land. The median Koala HQ score was 5 (average 5, range 3-10; Geolink 2015) (Figure 3-10; Table 4-1). Two recent studies have been undertaken to determine Koala population densities and habitat use within this and the broader area, the information in which has been used to inform this Plan. Ecosure (2014) undertook 30 SAT plots to determine Koala habitat utilisation across the area. Ecosure-Biolink (2015) undertook direct counts (46 transects) and SAT plots (53 primary and 23 supplementary) to determine Koala population estimates and habitat utilisation across the area. Good quality Koala habitat is primarily located within the northern and southern sections of the alignment in this Section, the highest value Koala habitat occurring within the Swamp Sclerophyll Forests to the immediate north of the Richmond River in the south of the Section 10.

3.2.11 Section 11: Coolgardie Road to Ballina bypass

Section 11 is 5.4 km in length and runs north from Coolgardie Road and is proposed to tie in with the Pimlico to Teven project. This section is heavily cleared, consisting predominantly of cane fields. Twenty-nine polygons were mapped, of which 22 contained potential Koala habitat, across an area of 43.28 ha (including 29.61 ha previously cleared) (AMBS 2015). The median habitat quality score was four, with a range of 3-8 and average of 3.65 (AMBS 2015, Figure 3-11). Known Koala records occur within the vegetated areas of this section, in particular within Swamp Sclerophyll Forest (Ecosure 2014). It was concluded that Koalas occur at very low population densities along Section 11 of the Pacific Highway Upgrade, despite the existence of potentially suitable habitat.

3.2.12 Summary

It is evident from the distribution of Koala records in the NSW Wildlife Atlas (BioNet) for the North Coast Bioregion, the results of Koala scat-search plots presented above, and the vegetation community mapping undertaken for this Project, that Koalas could occur in all Sections of the Project and in a range of environments that will be impacted by the Project. The areas with the greatest number of Koala records in relation to the Project occur in the Richmond Valley LGA between Woodburn and the Richmond River including Rileys Hill and Broadwater National Park (Sections 9) and the Ballina LGA particularly around Wardell, Coolgardie and Bagotville (Section 10). These northern populations are considered key populations within the Project area.

Other key Koala populations in the project area have been identified in the western regions of the Clarence Valley LGA (Clarence Valley Council 2010), northern regions of the Coffs Harbour LGA (Coffs Harbour City Council 1999) and to the west of Woodburn in the larger State Forests of the Richmond LGA (Australian Koala Foundation 2008).

3.3 Key populations in the project area

There are more than 14,600 recorded Koala sightings in the NSW Wildlife Atlas for the NSW North Coast Bioregion (data accessed 20 November 2014). These records are spread over all local government areas (LGA) in a wide range of topographies and vegetation types, including in conservation reserves, State Forests and private land. The data indicate that Koalas occur in all project Sections of the highway upgrade area and in a range of vegetation types that will be impacted by the project. Field data collected during the EIS and subsequent SPIR support this assertion. These documents report a total of 160 Koala habitat and faecal assessment plots, and a further 52 Koala faecal-pellet search plots (total 212) being undertaken. Koala faecal pellets were found at sixteen of these plots, with the greatest proportion of plots with pellets occurring in Sections 9 and 10 (Table 3-3).

Three key populations have been identified along the proposed Upgrade. These include: Section 5: Woombah-Iluka population, Section 8 (northern part) and 9: Broadwater population and Section 10: Coolgardie-Bagotville Population.

3.3.1 Section 5: The Woombah- Iluka population

The Woombah Koala population is defined as the animals, and their habitat, contained within a 5 km radius of the intersection between the Pacific Highway and Iluka Road. The Iluka Koala population is located east of the Esk River, more than eight kilometres away, and considered unlikely to be affected directly by the planned upgrading of Sections 5 and 6 the Pacific Highway. Previous surveys for the species within the area including Koala habitat assessments, faecal pellet searches, spotlighliting/call playback searches and direct surveys have revealed little evidence of Koala activity.

Information from all available sources suggests that the Woombah Koala population is present, but that it may be represented by only few individuals. The Comprehensive Koala Plan of Management for the Ashby, Woombah and Iluka localities in the Clarence Valley LGA (draft), September 2010, and updated in March 2015, indicates “The Woombah Koala population is in imminent danger of extinction and it is highly likely that the Iluka Koala population is already extinct. However, recent observations, from a range of sources, indicate that some Koalas are still present in both the Woombah and Iluka areas”.

The area supports large patches of preferred Koala habitat that are currently unoccupied by Koalas and thus the area has the potential to support Koalas should there be any future population increases (Biolink Ecological Consultants 2012). The Iluka Road area is considered to provide an important area of connectivity for Koalas moving between the coast and the Maclean area (GeoLink 2014).

3.3.2 Section 8 (part) and 9: The Broadwater population

The Broadwater Koala population includes the animals, and their habitat, contained within an area 3-5 km either side of an 11.0 km portion of the Pacific Highway Upgrade from Lang Hill (northern part of Section 8) north to the Richmond River (including all of Section 9). These Sections (part 8-9) are one of two areas of the entire Upgrade (along with Section 10) where the greatest numbers of Koala records were encountered in surveys. These two areas were previously considered by the authors of the Highway Upgrade Environmental Impact Statement and Supplementary Biodiversity Assessment (SPIR) to contain “important populations” according to the guidelines for assessment described in the *Interim Koala referral advice for proponents* (DSEWPaC 2012). The Richmond River forms a major barrier to the west and north, restricting the movements of the Broadwater Koala population.

Surveys (Ecosure 2014) indicated that the Broadwater Koala Population is located mainly around the perimeter of the Broadwater National Park, especially along the forested fringe and fragmented woodlands outside of the Park. Broadwater National Park is dominated by heathland and, as such, is largely unsuitable for Koalas. The most important areas for Koalas were considered to be between Riley's Hill and the eastern side of the township of Broadwater, and a number of connectivity structures are proposed throughout the fragmented woodlands along the Highway alignment to permit Koala dispersal. The northern and southern exit points of the Highway at the edges of Broadwater National Park were also regarded as crucial areas requiring connectivity structures to permit Koala movements throughout the area.

3.3.3 Section 10: The Coolgardie-Bagotville population

The Koala population located in Section 10 extends 13.5 km north of the Richmond River and includes the localities of Bagotville and Coolgardie west of Wardell. One-hundred and forty-seven records for the Koala occur within approximately two km of the upgrade alignment within this Section. Recent studies (Ecosure 2014, Ecosure-Biolink 2015 and Biolink 2013) have revealed the relatively high numbers of Koalas within this Section compared to the other Sections and also other areas within the region. As with the Broadwater population, previous assessments have considered that this population may be regarded as an "important population" under the EPBC Act assessment guideline (Phillips and Chang 2013).

The resident populations, predominantly occur in the southern and central portions of the Section. They appear to persist in two large contiguous forest patches associated with the Blackwall Range and areas to the east that are separated predominately by farmland. The considerable number of resident Koala populations in this area coincides with larger areas of intact Koala habitat, as well as a high availability of preferred Koala food trees; including *E. microcorys*, *E. tereticornis*, *E. robusta* and *E. propinqua* (Ecosure 2014).

As mentioned above, the Coolgardie-Bagotville population was the subject of a PVA to determine the potential impacts of the Highway Upgrade on the population. The area nominated as enclosing this population was approximately 8,250 ha. The general landscape context within the study area constitutes a predominantly-cleared, sometimes waterlogged, fertile valley surrounded to the west by mostly tall forested lands on slopes and ridges along the Blackwall Range, and to the east by low slopes covered mostly by drier forests and woodlands with large areas of tall heathland growing on less fertile soils. The valley and lower slopes have been used extensively for grazing and sugar cane production, although significant areas of remnant or regrowth native vegetation still remain, particularly along watercourses. The proposed route of the highway upgrade in Section 10 traverses through the eastern side of the valley and will result in the loss of 34 ha of native vegetation, half of which (17 ha) is recognised as good habitat for Koalas.

Additional Koala surveys using the faecal pellet search (SAT) method were conducted throughout target areas in Sections 5, 7, 9 and 10 (Ecosure 2014). Supplementary sites were also surveyed by targeting known preferred Koala food trees for the presence of scats. Data collected were used to further inform areas of habitat use by Koalas, including two additional sites where a Koala was observed in Section 8 and Section 11 that were not part of the original project scope. Evidence of Koala faecal pellets varied between project Sections, and included one positive site in Section 5 (six sites surveyed), none in Section 7 (8 sites surveyed), one in Section 9 (20 sites surveyed), and six in Section 10 (30 sites surveyed). In addition, Koala habitat use was confirmed at 24 supplementary sites. Five Koalas were confirmed by Ecosure during field surveys (four in Section 9 and one in Section 10), while eight anecdotal sightings were reported by local landholders (one in Section 9 and seven in Section 10),and three by Roads and Maritime Services contractors (one in each in Sections 8, 9 and 10).

Table 3-3. Locations where evidence of Koalas was reported from scat search surveys

Project section	No. of scat-search plots	No. of plots with scats	Location description	Distribution of Koala records
1	30	0	No records of Koala faecal pellets found in Section 1. (NB. One opportunistic record located in Section 1 near the Range Road intersection on the eastern side of the current Pacific Highway (GeoLink 2012).	Only one record from BioNet of the Koala along Section 1 (in Newfoundland State Forest). No evidence of a local population centred near the road corridor.
2	24	1	One plot with Koala faecal pellets in Section 2, located just south of Halfway Creek near Yuraygir State Recreation Area.	Only two records from BioNet of the Koala along Section 2 (both in Yuraygir SCA). No evidence of a local population centred near the road corridor.
3	64	4	Four plots recorded Koala scats in the Brushgrove area. This occurred in three different vegetation types (Scribbly Gum woodland, Turpentine forest and Tallowwood forest).	Many older BioNet records from within the broader landscape, including within nearby State Forests (Bom Bom, Devines, Glenugie SFs). One record from 2012 adjacent to Pine Brush State Forest within 1 km of road corridor.
4	5	0	No records were recorded during field surveys within this section.	Three BioNet records in the broader landscape, all occurring within ~1 km of the road alignment.
5	6	1 of 6 (Ecosure2014) 2 of 13 (EIS/SPIR)	1 plot recorded scats within vegetation to the NW of Iluka Road approximately 150m west chainage 96000 (Ecosure 2014).	Numerous (>100) records in the broader landscape, focused around the townships of Ashby and Iluka. Around 10 records occurring within 1 km of road alignment. One Koala was directly observed in Mororo Creek Nature Reserve. Scats were also found at 4 of 18 sites in the Woombah area (north-east of the Iluka Road intersection) for a study used to inform the Comprehensive Koala Plan of Management for the Ashby, Woombah and Iluka localities in the Clarence Valley LGA (Biolink Consulting Services 2015).
6	18	0	No records of Koala faecal pellets were made during field surveys in this Section.	Nine records occur within 5 km of the road alignment, including recent (2012) records within 1 km of the road alignment.
7	32	1	Koala scats observed at one site near Tabbimoble Swamp Nature Reserve and Doubleduke State Forest.	Four records within 1 km of the road alignment and about 20 within 5 km. None of the records are recent.
8	10	0	No records were recorded during field surveys within this section.	Numerous records within the broader landscape and around 12 records within 5 km of the road alignment. However, none of these records is recent.
9	30	1 of 20 (Ecosure 2014) 5 of 10 (EIS/SPIR) .	Pellets recorded within 5 of 10 sites (EIS and SPIR). Pellets in 1 of 20 plots surveyed by Ecosure 2014 but also recorded in 5 additional supplementary sites.	36 BioNet records within 3-5km of section. No direct observations during scat/habitat and daytime canopy surveys by Ecosure (2014), Melaleuca (2014) and for the EIS/SPIR. Six direct, anecdotal observations were made during the study by Ecosure 2014, including three within close proximity to the road alignment, one in areas of connecting habitat between Riley's Hill and Broadwater, and one recent

Project section	No. of scat-search plots	No. of plots with scats	Location description	Distribution of Koala records
				sighting by a landholder in the northern portion of Section 9. Most important areas for Koalas were considered to be between Riley's Hill and the eastern side of the township of Broadwater (Ecosure 2014). During surveys Ecosure (2015) recorded 8 individuals (including two with back young) during population surveys of 54 sites within the vicinity of the alignment. Koalas were highly likely to occur in many areas assessed, and Melaleuca (2014) noted Koala scats and climbing marks on trees within several vegetation types, including Swamp Mahogany-Swamp Forest, Grey Gum- Grey Ironbark Open Forest, Forest Red Gum Grassy Open Forest and Brush Box-Tallowwood Shrubby Open Forest. 12/28 of sites between the Evans and Richmond Rivers in Richmond Valley LGA showed evidence of Koala activity (Biolink Ecological Consultants 2015), only one Koala directly observed.
10	30	8 of 13 (EIS/SPIR) 6 of 30 (Ecosure 2014) 29 of 53 (Ecosure-Biolink 2015)	EIS/SPIR – One positive SAT site along existing highway south of Coolgardie Road, and six sites between the Richmond River and Old Bagotville Road, including Thurgates Road and Old Bagotville Road. Also in In vegetation to the east of the alignment and in open country to the west of the alignment immediately north of the Richmond River; and to the east and west of the intersection of the alignment with Wardell Rd (Ecosure 2014).	148 BioNet records within approximately 2 km of the alignment. 9 Koalas were sighted/anecdotally recorded during the pre-construction surveys (Ecosure 2014) the majority (6) being within300m of the alignment including 3 within the alignment. The majority of these were located to the north of the Richmond River l including two in the vicinity of Wardell Road. 11 Koalas were observed during direct count surveys of 46 sites within the vicinity of the alignment (Ecosure-Biolink (2015). This survey included 53 SAT plots, 55% of which had scats (1 Koala was observed at one of these sites) and 23 supplementary SAT sites to the east of the alignment.
11	11	0	Anecdotal records of the Koala were reported from landholders during field surveys. Contains a number of stands of Swamp Mahogany, thus some areas contain important Koala habitat.	Approximately 15 BioNet Koala records occur within 2 km of the road alignment, with a random distribution.

Additional Koala surveys, undertaken as a requirement to inform this Plan (Ecosure 2015) included direct surveys for Koalas at 54 sites within Section 9 and the northern portion of Section 8 to encompass the Broadwater population. A total of eight adult Koalas were observed including two with back young. Within Section 10, a total of 11 Koalas were observed during population surveys within this Section (Ecosure-Biolink 2015), which included direct counts at 46 sites. This assessment also found evidence of Koala activity at 55% of primary SAT sites surveyed (total of 53 sites).

Sections 1 and 2 are not considered to support key Koala populations, although the species is present. The initial preferred route studies surveyed 16 scat search sites across Sections 1 and 2 (Ecotone 2007). An additional 32 scat search plots were conducted in Sections 1 and 2 for the EIS (2011) followed by an additional 32 plots surveyed in February 2013. This included plots specifically positioned along Range Road to the east of the project to assess presence of a Koala population. Scat searches were conducted at Range Road as reported in Geolink (2012) and involved a series of plots and random searches between plots. As a result of the accumulated survey effort for Koala across Woolgoolga to Wells Crossing (Sections 1 and 2) and including Range Road, Koala populations in these locations were considered to occur in low densities relative to the amount of habitat available in the locality. There were five records of Koalas within 10 kilometres either side of the project reported in the NSW Wildlife Atlas database between 1992 and 2006. Based on the Wildlife Atlas records and communication with local residents during field surveys, occasional road deaths do occur in the area. This is consistent with only two scats being found despite the level of survey effort.

Sections 3 and 4 are not considered to support key Koala populations, even though the species is present. Sparse BioNet records occur throughout the broader landscape, such as within Bom Bom and Pine Brush State Forests, despite the considerable survey effort that has been undertaken there as part of Forests NSW pre-harvest surveys. A total of four out of 64 faecal pellet search plots completed within Section 3 contained Koala scats and no records occurred from the five plots completed within Section 4. Within Section 4 there are sparse BioNet records.

In Section 5, the Woombah population appears to be represented by only few individuals and little detailed information is available about its distribution and status. The most significant Koala survey effort within 5 km of the Iluka Road intersection was conducted by Phillips and Forsman (2002) and Biolink Ecological Consultants (2012), both of which informed the preparation of the Draft Clarence Valley CKPOM (2010, 2015). These surveys recorded Koala faecal pellets at only two of the19 plots surveyed (separated in time by several years). The RMS surveys described above recorded Koala faecal pellets at one of six plots surveyed, together with an opportunistic record of a live animal on the north-eastern edge of Mororo Creek Nature Reserve. Information from all available sources suggests that the Woombah Koala population is present, but that it may be represented by only few individuals. The Woombah Koala population is likely to extend north into Section 6.

Within Section 6, none of the 18 faecal pellet search plots surveyed contained Koala scats. Nine BioNet Koala records occur within five kilometres of Section 6, suggesting a sparse population that is not considered to be an important Koala population. Within Section 7, one of the 32 faecal pellet search plots surveyed contained Koala scats and approximately 20 BioNet records occur within five kilometres of the Upgrade. None of the surveyed SAT plots within Section 8 contained Koala scats but approximately 12 BioNet Koala records occurred within five kilometres of Section 8. Similarly, none of the three Koala faecal pellet search plots surveyed in Section 11 contained evidence of Koala presence. Koalas are likely to occur at low population densities along Section 11 due to the limited area of suitable habitat (Table 4-1).

Sections 9 and 10 had the highest number of Koala records, scats and direct sightings within the Project area (Table 3-3). These populations have been studied in some detail (see Table 3-3 for summary of results and locations). Due to the relatively high numbers of Koalas occurring within these Sections, as detailed in Section 3.3, the animals within these areas are considered to represent key populations within the Project area. As such, Sections 9 and 10 will be targeted for additional mitigation and management measures to minimise the potential impacts of the Project to these populations.

3.4 Survey adequacy of existing reports informing the Koala Management Plan

Roads and Maritime engaged Dr Rod Kavanagh to conduct a detailed assessment of the adequacy of the surveys of the Koala populations at Coolgardie-Bagotville, Broadwater and Woombah-Iluka informing this KMP. This was conducted to ensure that the Ministers Condition of Approval D9a were met, namely:

- Condition D9 (a) (i) requires that surveys be adequate to determine "the **population status** of the …..Broadwater Koala population".
- Condition D9 (a) (ii) requires that surveys be adequate to determine "**habitat use and movement patterns** of Koala populations within five kilometres of the proposed upgrade, or such area as determined by the independent ecologist;"
- Condition D9 (a) (iii) requires that surveys be adequate to determine "**habitat areas likely to be fragmented** by the SSI;"

The adequacy reviews are provided in Appendix G and summarised below.

3.4.1 Woombah- Iluka population

It was determined that the Ministerial Conditions of Approval for D9 (a) were not technically met for parts (i), (ii) or (iii).

In relation to part (i), the survey effort to date was determined to be inadequate to understand and document details of the status of the Woombah Koala population (i.e. its size, its distribution and trend), other than that the population is very small and sparsely distributed, likely in danger of local extinction from a range of existing and recent factors that are independent of the proposed highway upgrade.

Based on review of the available material regarding the potential impacts of the Upgrade, and consultation with the relevant regulatory authorities (DoE and DP&E, 15 June 2015), it was determined that, there was a low risk that the Woombah- Iluka and Ashby Koala population would be impacted by section 5 of the Woolgoolga to Ballina upgrade project.

Thus, while Condition D9 (a) (i) was not technically met, the review determined that no additional baseline Koala surveys were required for Section 5 for the Woombah- Iluka Koala populations.

It was similarly determined (15 June 2015) in consultation with DoE and DP&E that surveys undertaken to date for Section 5 (Woombah- Iluka area) satisfy MCoA D9(a) ii and (iii). The reasons for this are detailed below.

In relation to part (ii), available information was considered inadequate to understand and document details of habitat use and movement patterns for the Woombah Koala population. For part (iii), the survey effort was also determined to be inadequate to understand and document details of the habitat areas that are likely to be fragmented by the SSI. However, In relation to part (iii), considerable efforts have been made to document and map areas of high quality habitat for Koalas that are proposed for clearing along the highway footprint.

It was determined that the intent of Conditions D9 (a) (ii) and (iii) is primarily to understand where connectivity structures should be placed to minimise impacts of the SSI on the Woombah Koala population. The existing Pacific Highway has already fragmented the habitat of this Koala population into east and west portions, both of which include vegetation types comprised of important food tree species for the Koala. At this location (Section 5), the alignment of the proposed Highway Upgrade sits largely within the existing highway footprint. The forested landscape context within 5 km of the Iluka Road intersection is such that there are obvious locations where connectivity structures and habitat restoration/revegetation should be located to minimise habitat fragmentation and to provide safe passage for Koalas. Recommendations for the placement of connectivity structures to achieve this have been described in the pre-construction survey report by Ecosure (2014).

Thus, while Conditions D9 (a) (ii) and D9 (a) (iii) were not technically met, the regulating agencies decided that sufficient information was available to satisfy these two Conditions, in terms of the locations of connectivity structures required to minimise impacts on the Woombah Koala population.

3.4.2 Broadwater population

It was determined that the Ministerial Conditions of Approval for D9 (a) were not technically met for parts (i), (ii) or (iii).

In relation to part (i), it was determined that survey effort was inadequate to understand and document details of the status of the Broadwater Koala population (i.e. its size, its distribution and trend), other than that the population is small and sparsely distributed.

Consultation and review of this assessment with the regulatory authorities resulted in implementation of additional surveys, to address this. A new baseline survey (fully reviewed and endorsed by Dr Rod Kavanagh and Dr Jonathan Rhodes), was undertaken by Ecosure (2015) covering Section 8 (part) and Section 9 in Spring 2015 and is included in Appendix F.

In relation to part (ii), the survey effort was assessed as inadequate to understand and document details of habitat use and movement patterns for the Broadwater Koala population. For part (iii), the survey effort was also assessed as inadequate to understand and document details of the habitat areas that are likely to be fragmented by the SSI. However, In relation to part (iii), considerable efforts have been made to document and map areas of high quality habitat for Koalas that are proposed for clearing along the highway footprint.

It was determined that the intent of Conditions D9 (a) (ii) and (iii) was primarily to understand where connectivity structures should be placed to minimise impacts of the SSI on the Broadwater Koala population. The existing Pacific Highway has already fragmented the habitat of this Koala population into east and west portions, both of which include vegetation types comprised of important food tree species for the Koala. At this location (Section 9), the alignment of the proposed Highway Upgrade sits partially within the existing highway footprint. The forested landscape context, including the largely heathland-dominated Broadwater National Park and surrounding agricultural matrix, is such that there are obvious locations where connectivity structures and habitat restoration/revegetation should be located to minimise habitat fragmentation and to provide safe passage for Koalas. Recommendations for the placement of connectivity structures to achieve this have been described in the pre-construction survey report by Ecosure 2014.

It was concluded that Conditions D9 (a) (ii) and D9 (a) (iii) were not technically met. However, it was concluded that there was sufficient information available to address the intent of Conditions D9 (a) (ii) and (iii) such that the number and location of connectivity structures required to minimise impacts on the Broadwater Koala population was available. The available information was thus considered sufficient to satisfy these two Conditions.

3.4.3 Section 10: Coolgardie-Bagotville population

In recognition of the importance of the Coolgardie-Bagotville population and the requirement to undertake a population viability analysis (PVA), the Koalas in the Coolgardie-Bagotville area were the subject of a major field study and two laboratory studies (Neaves *et al*. 2015, Norman *et al*. 2015, Phillips *et al*. 2015) to better understand the demographics and genetics of the population and provide the appropriate inputs into the PVA model. These studies were developed to ensure survey adequacy requirements of CoA9 were met.

All population size, distribution, demographic and stochastic inputs to the PVA model, as well as the frequency of likely catastrophic events (i.e. the “baseline” model), were provided by the authors of the local Koala field study, which included details for 50 captured animals (Phillips *et al*. 2015). It is unknown whether the “baseline” demographic parameters, collected from the once-only snapshot sample, are truly representative of the population, and this is an inherent limitation of the PVA for which there are no alternatives. Accordingly, uncertainty around modelled or predicted population estimates must be considered in relation to interpreting or assessing future trends in the Koala population. This Plan includes the provision of long-term population monitoring that will be used to assess actual population trends against the PVA predictions (see Section 8.3 for details).

Under the scenarios modelled, the PVA findings indicated that, due to the relatively low density and declining population, there were not enough Koalas to effectively utilise the new habitat that would be provided if the highway upgrade was constructed. Although there is considerable uncertainty in the PVA, this is the best available information on trends in the population and indicates an ongoing decline. Hence it was determined that management attention needs to focus strongly on measures that will either increase population fecundity, and/or reduce population mortality. Population modelling incorporating reductions in mortality by 4 or 8 young animals per year revealed that efforts to reduce Koala mortality in the region has the potential to substantially improve Koala population viability.

This Koala Management Plan has been developed with the aim of implementing a management strategy that will decrease Koala mortality across the region and increase the viability of the population.

3.5 Key threats

The key threats to Koala populations include:

- Loss of foraging, sheltering and breeding habitat.
- Habitat fragmentation and impacts on habitat connectivity (movement of individual Koalas to different populations and home-ranges allows important genetic exchange which is essential for Koala population viability).
- Vehicle strike (Koala injury or death).
- Domestic dog attacks (Koala injury or death).
- Possible increased prevalence of disease (increased susceptibility to disease due to stress caused by the above mentioned threats) (DEHP 2012 and DSEWPaC 2013).

Drought and incidences of extreme heat are also known to cause very significant mortality, and post-drought recovery may be substantially impaired by a range of other threatening factors (Gordon *et al.* 1988, Seabrook *et al*. 20011, Lunney *et al*. 2012, TSSC 2012).

Koala injuries or death have been reported during the clearing phases of road projects from the removal of habitat trees and have been demonstrated from collisions with vehicles during the operation of these projects (AMBS 2011).

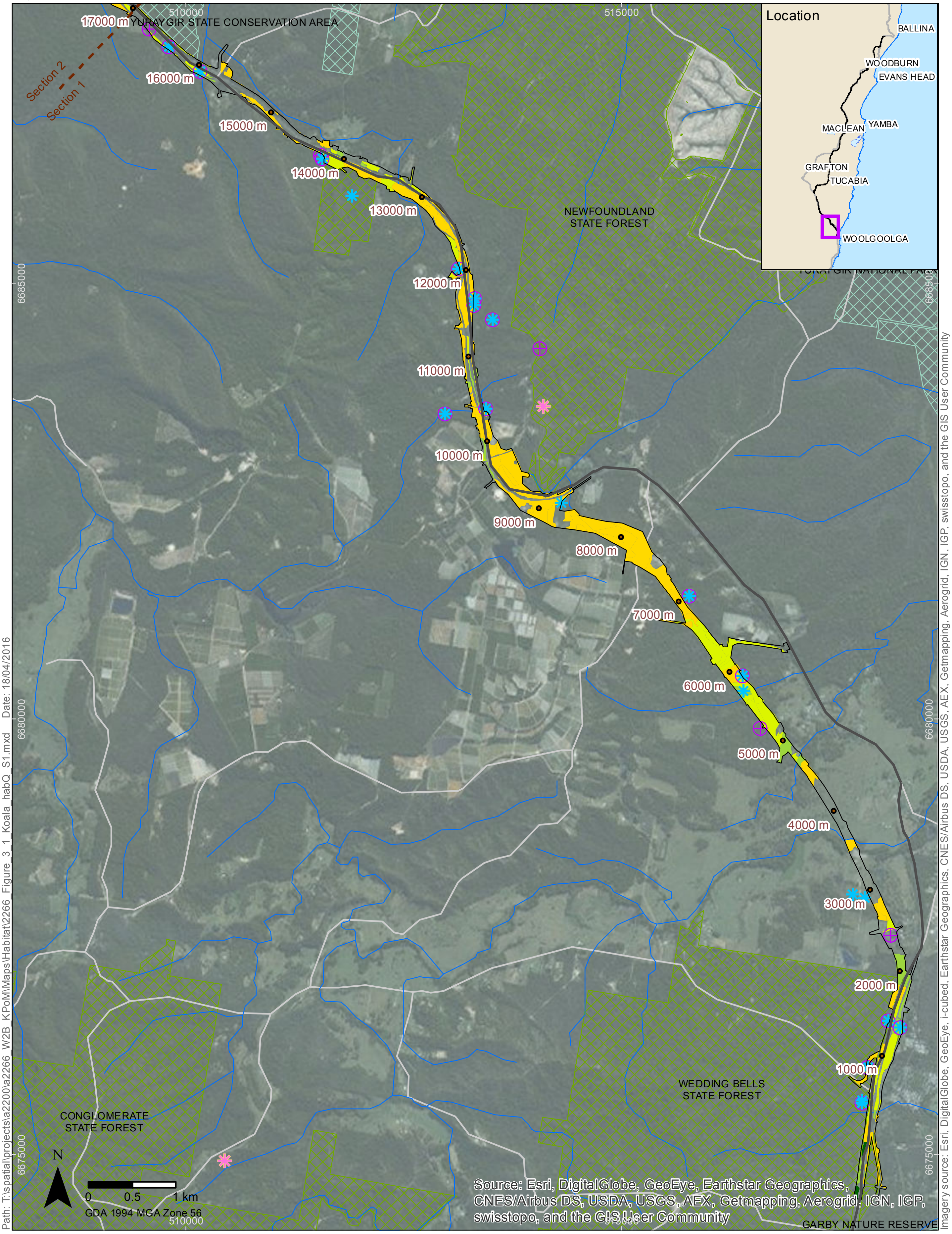
Mortality due to vehicle strike has the potential to significantly affect local Koala populations particularly where individual home-ranges abut or overlap the project corridor (AMBS 2011). These impacts are likely to be most significant in areas where the highway upgrade passes through high quality habitat for Koalas and those areas which are extensively forested. However, the presence of the proposed underpass structures and temporary and permanent fauna exclusion fencing will reduce this risk, including current road-kill events on the existing highway.

Crossing structures (underpasses and overpasses) have been shown to be effective for Koalas provided they are large enough, not too long, and are combined with fencing and revegetation (Taylor and Goldingay 2003, AMBS 2011, RMS unpublished data). However, research is lacking on the extent to which mitigation measures reduce the risk of local extinction, given the overall context of the major linear infrastructure (Taylor and Goldingay 2010, Van der Ree *et al.* 2011). Most Koalas killed by vehicle collisions on the highway are not the local roadside residents but appear to be sub-adults dispersing and perhaps old, weak animals displaced from their former home-ranges away from the highway (Dique *et al.* 2003a, AMBS 2011). Consequently the impact of road mortality may affect populations more widely.

In a radio-tracking study of Koalas on the Pacific Highway at Bonville (AMBS 2011) construction activities in two study areas led directly to only one known death, suggesting that the direct impacts of clearing and construction are relatively minor at a population scale (when appropriate mitigation strategies are in place). Construction activities (in particular habitat removal) indirectly affected individual Koalas, including the mortality of at least one animal through stress, the alteration of home-ranges and behaviour of others, and possibly mortality as a result of home-range adjustments (AMBS 2011).

Habitat restoration using plantings of Koala food trees has been shown to be very successful, with Koalas utilising young plantings within seven years, both as feeding and shelter habitat (Kavanagh and Stanton 2012).

Figure 3-1 Koala records and habitat quality along the proposed highway upgrade (Section 1)



Pacific Highway
Project Boundary
Koala Atlas sightings
Koala habitat assessment plots

Koala scat search plots
No scats

Koala habitat quality values
3
5
6
7

Figure 3-2 Koala records and habitat quality along the proposed highway upgrade (Section 2)

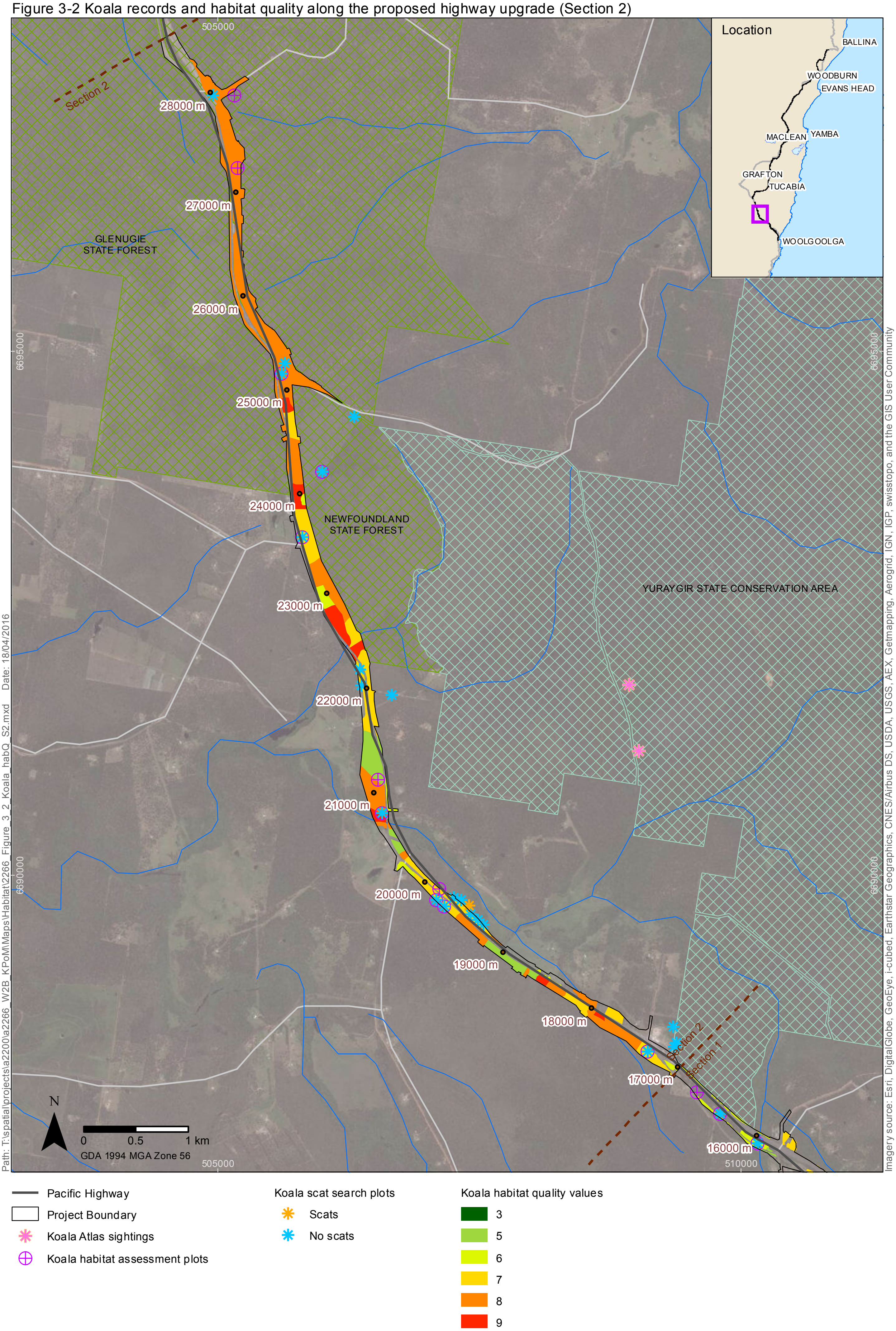
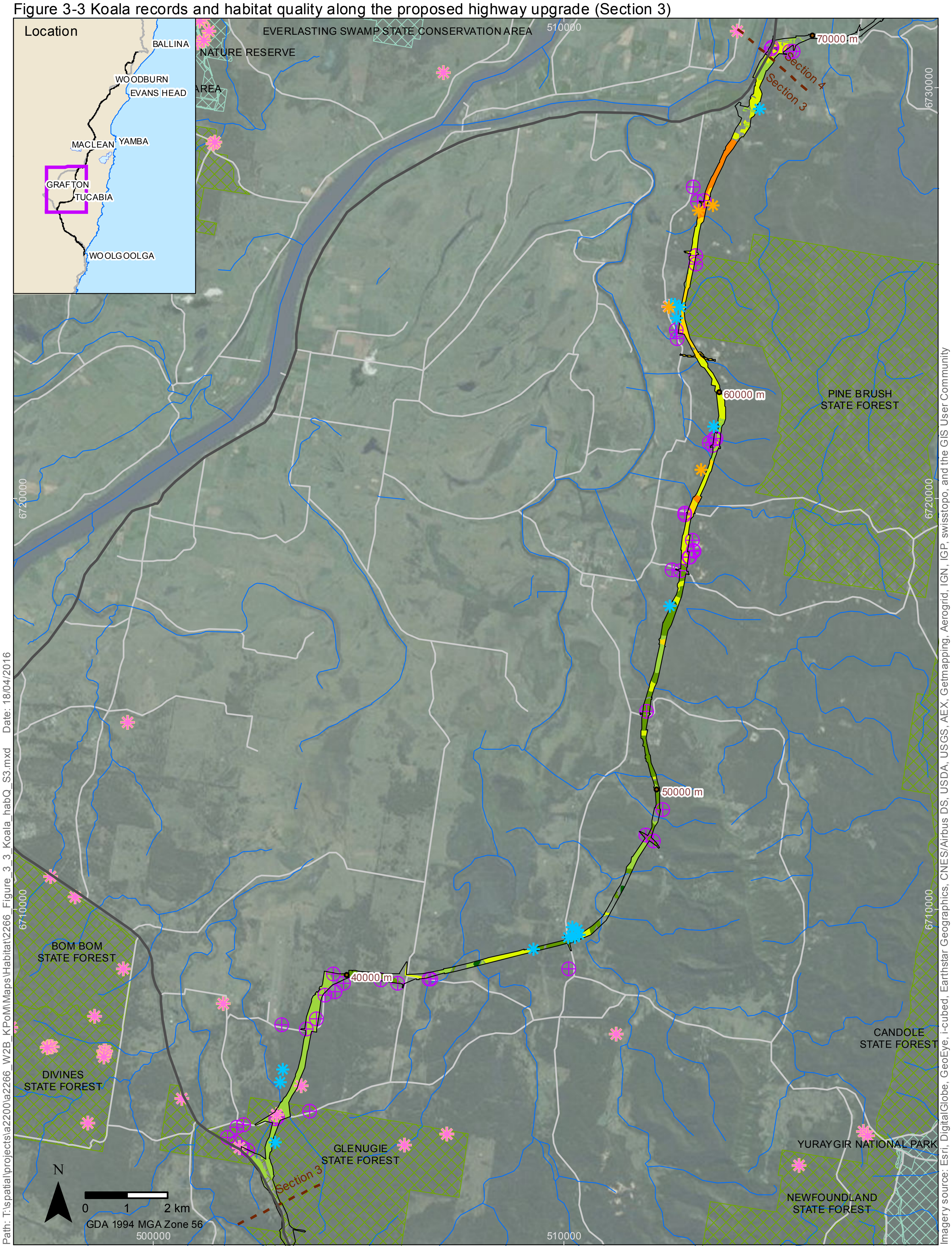


Figure 3-3 Koala records and habitat quality along the proposed highway upgrade (Section 3)



Pacific Highway
Project Boundary
Koala Atlas sightings
Koala habitat assessment plots

Koala scat search plots
Scats
No scats

Koala habitat quality values
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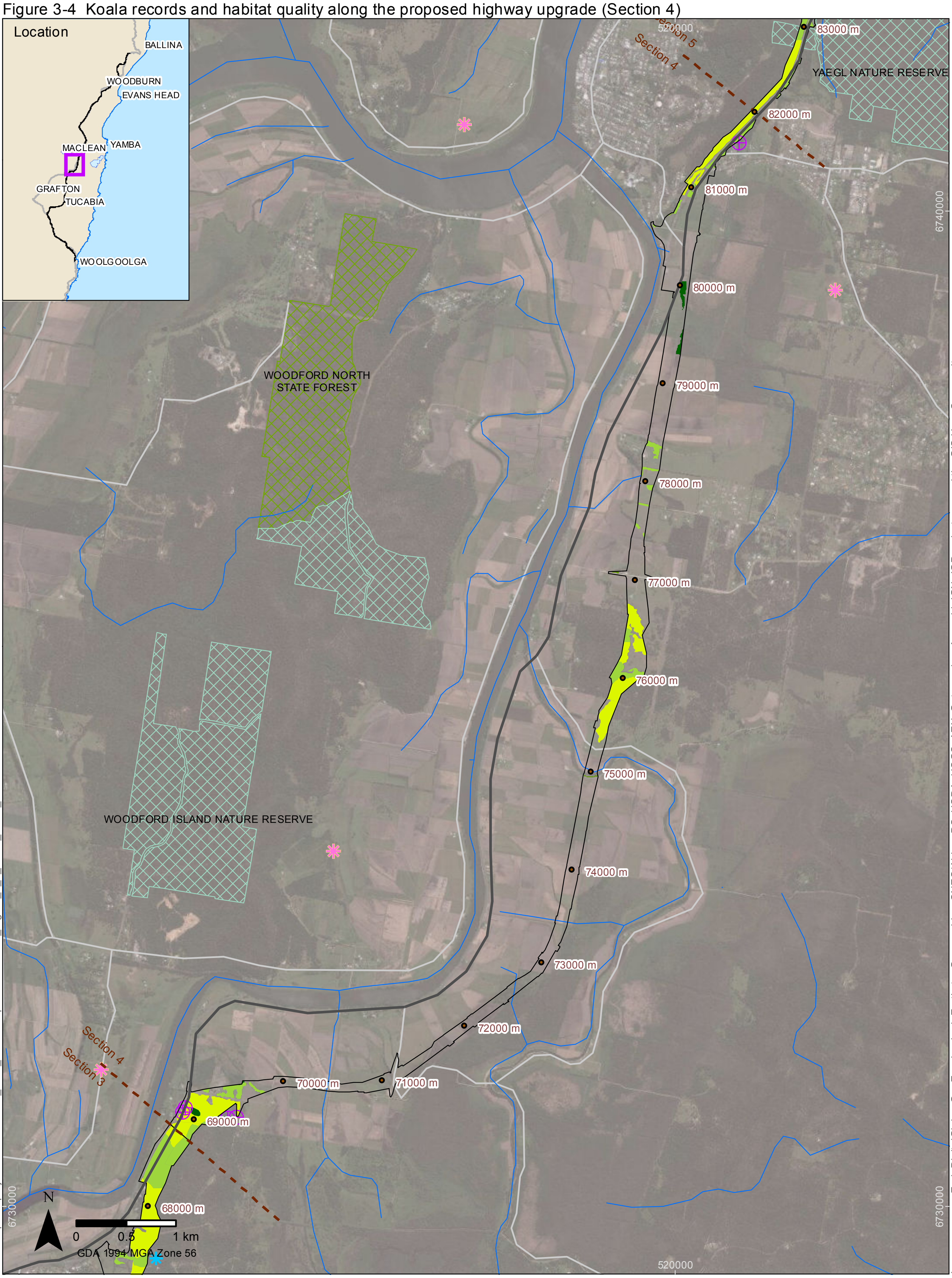
Figure 3-4 Koala records and habitat quality along the proposed highway upgrade (Section 4)



Pacific Highway

Project Boundary

Koala Atlas sightings

Koala habitat assessment plots

Koala scat search plots

No scats

Koala habitat quality values

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Figure 3-5 Koala records and habitat quality along the proposed highway upgrade (Section 5)

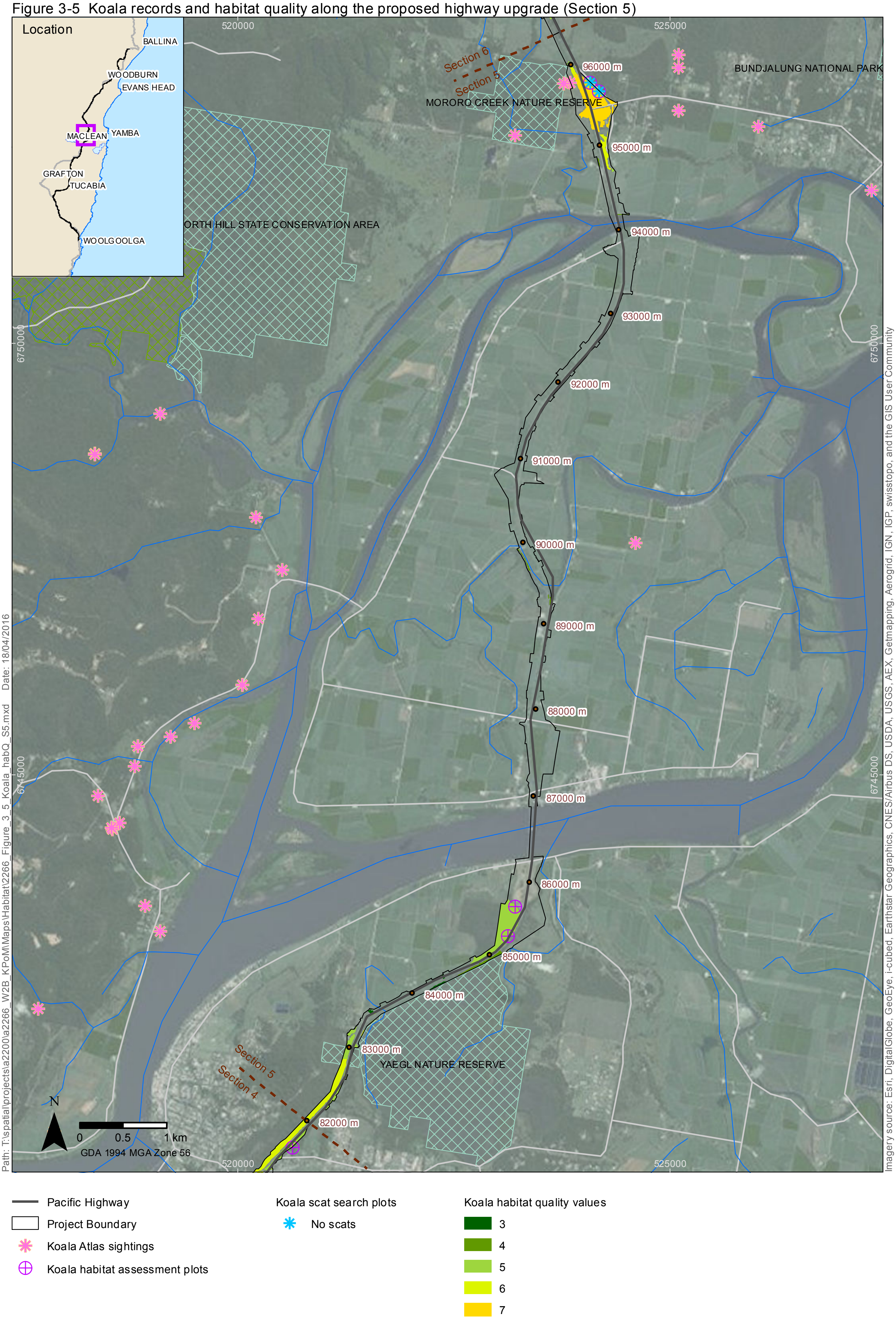


Figure 3-6 Koala records and habitat quality along the proposed highway upgrade (Section 6)

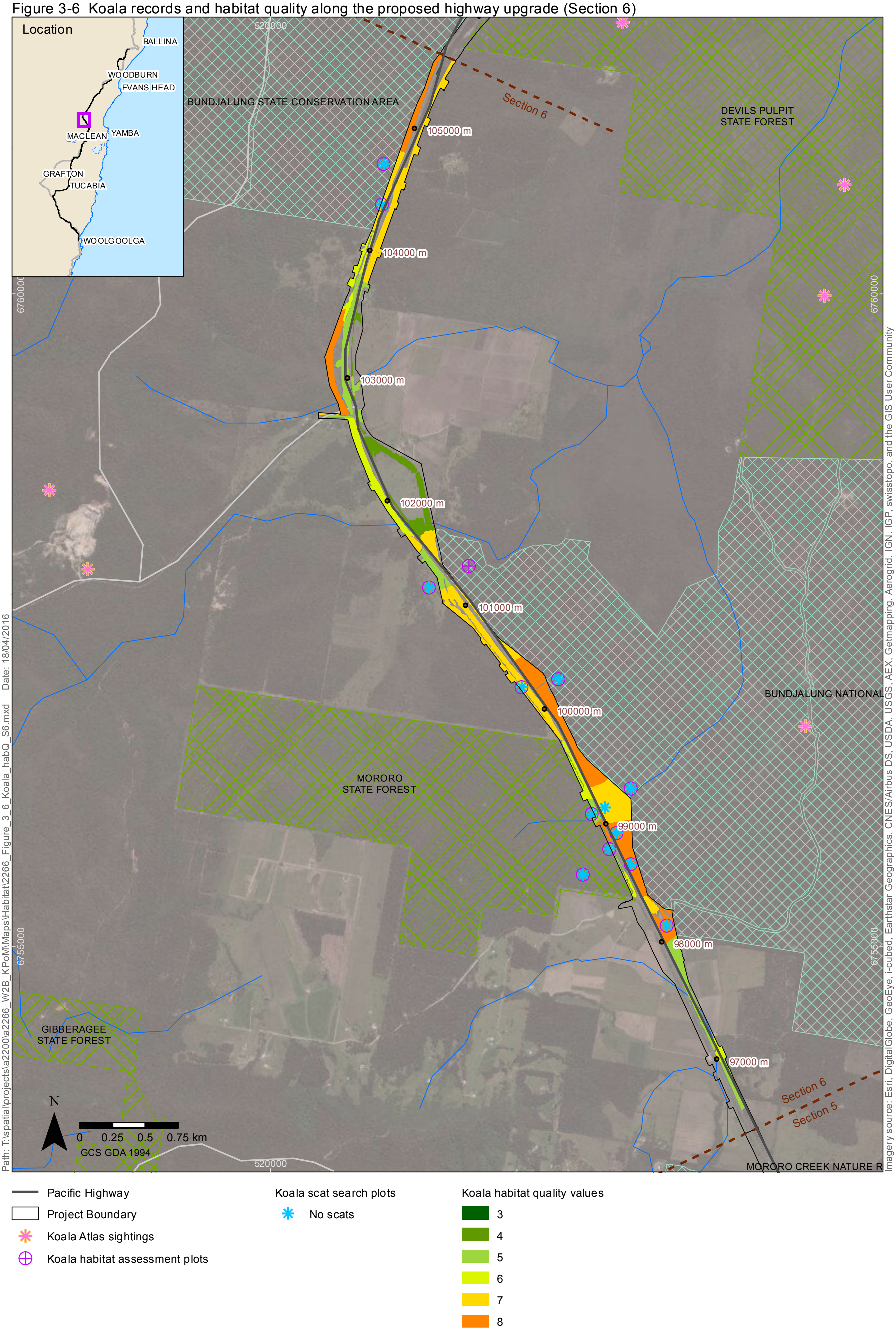
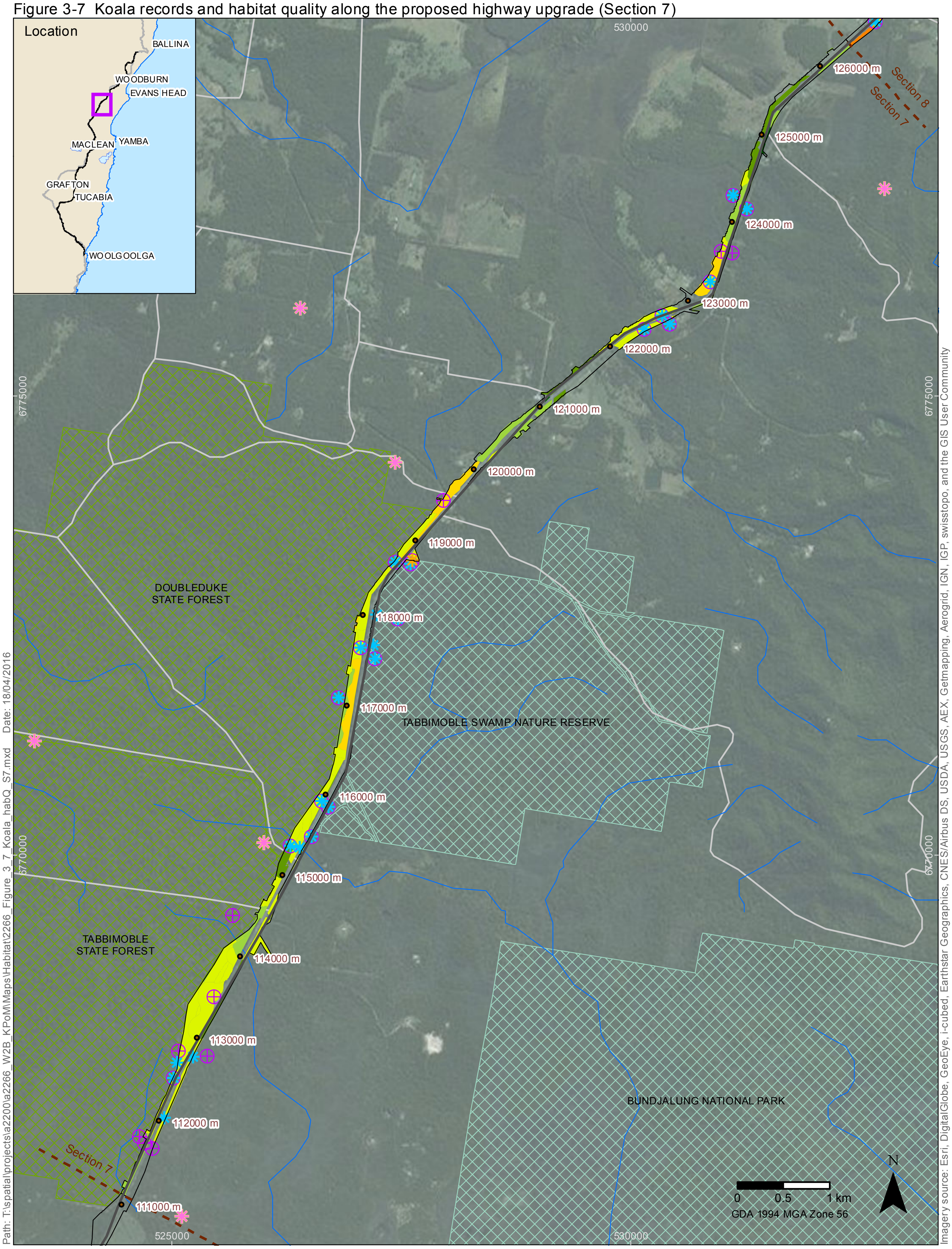


Figure 3-7 Koala records and habitat quality along the proposed highway upgrade (Section 7)



Pacific Highway
Project Boundary
Koala Atlas sightings
Koala habitat assessment plots

Koala scat search plots
Scats
No scats

Koala habitat quality values
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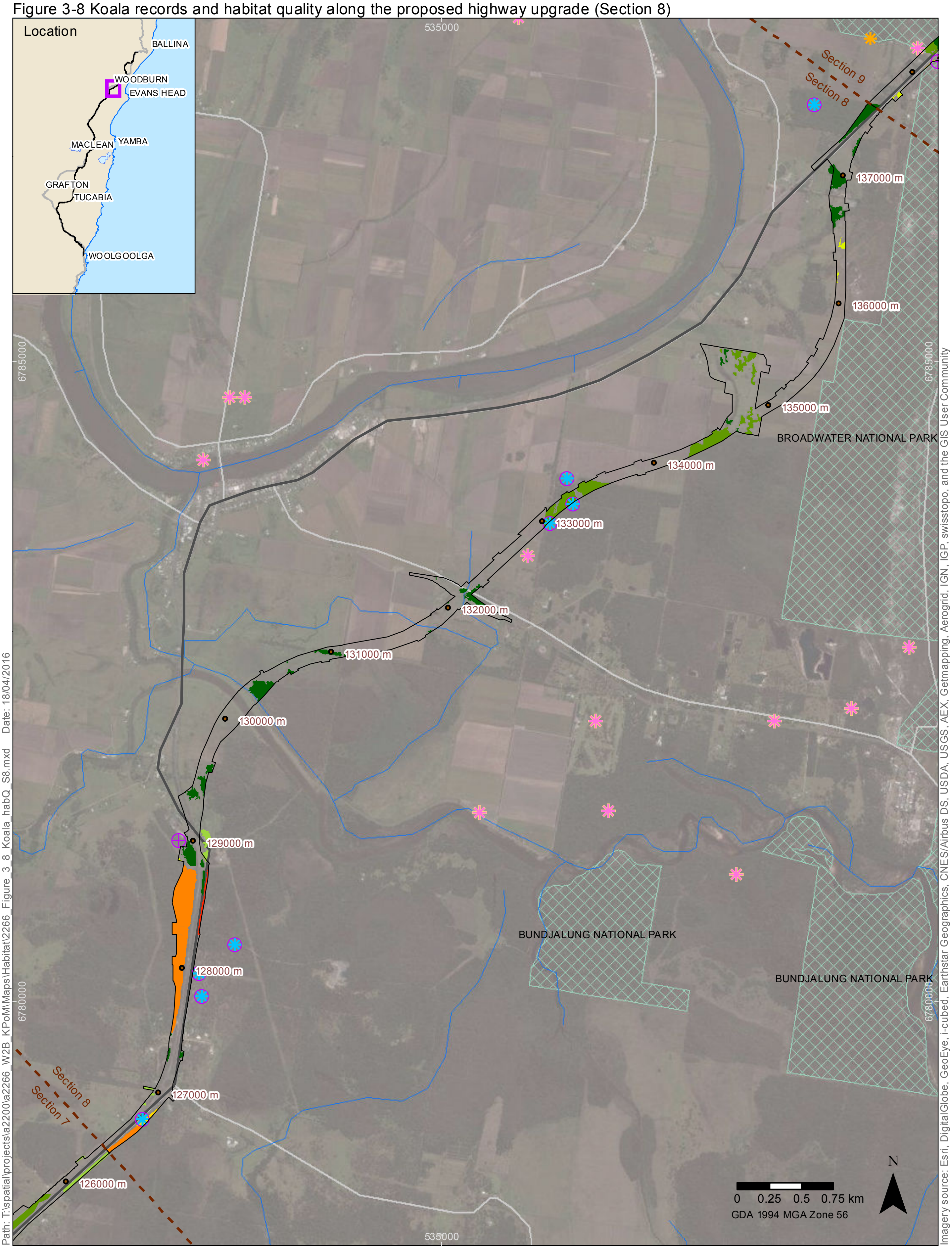
Figure 3-8 Koala records and habitat quality along the proposed highway upgrade (Section 8)



Pacific Highway
Project Boundary
Koala Atlas sightings
Koala habitat assessment plots

Koala scat search plots
Scats
No scats

Koala habitat quality values
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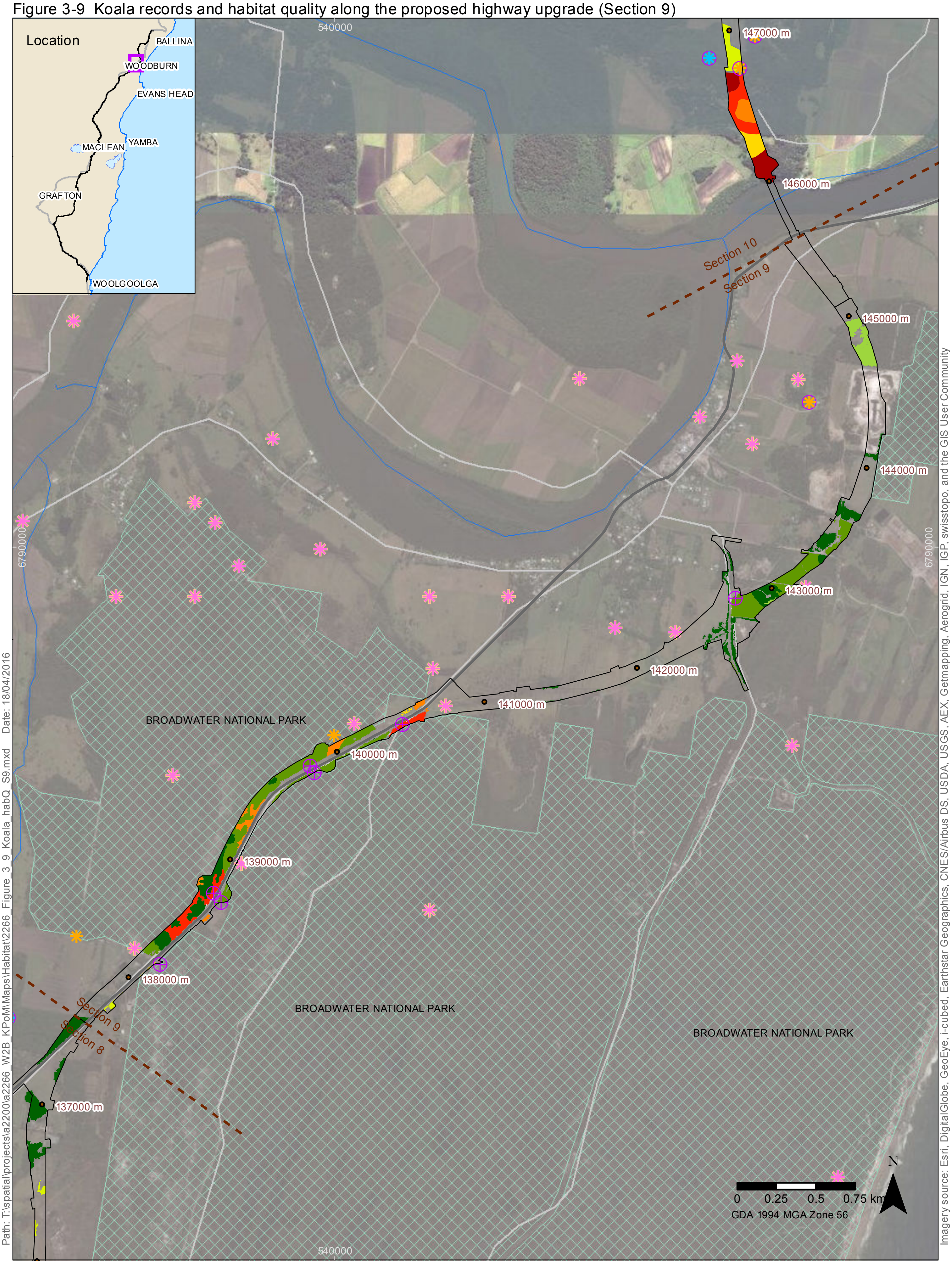
Figure 3-9 Koala records and habitat quality along the proposed highway upgrade (Section 9)



Pacific Highway
Project Boundary
Koala Atlas sightings
Koala habitat assessment plots

Koala scat search plots
Scats
No scats

Koala habitat quality values
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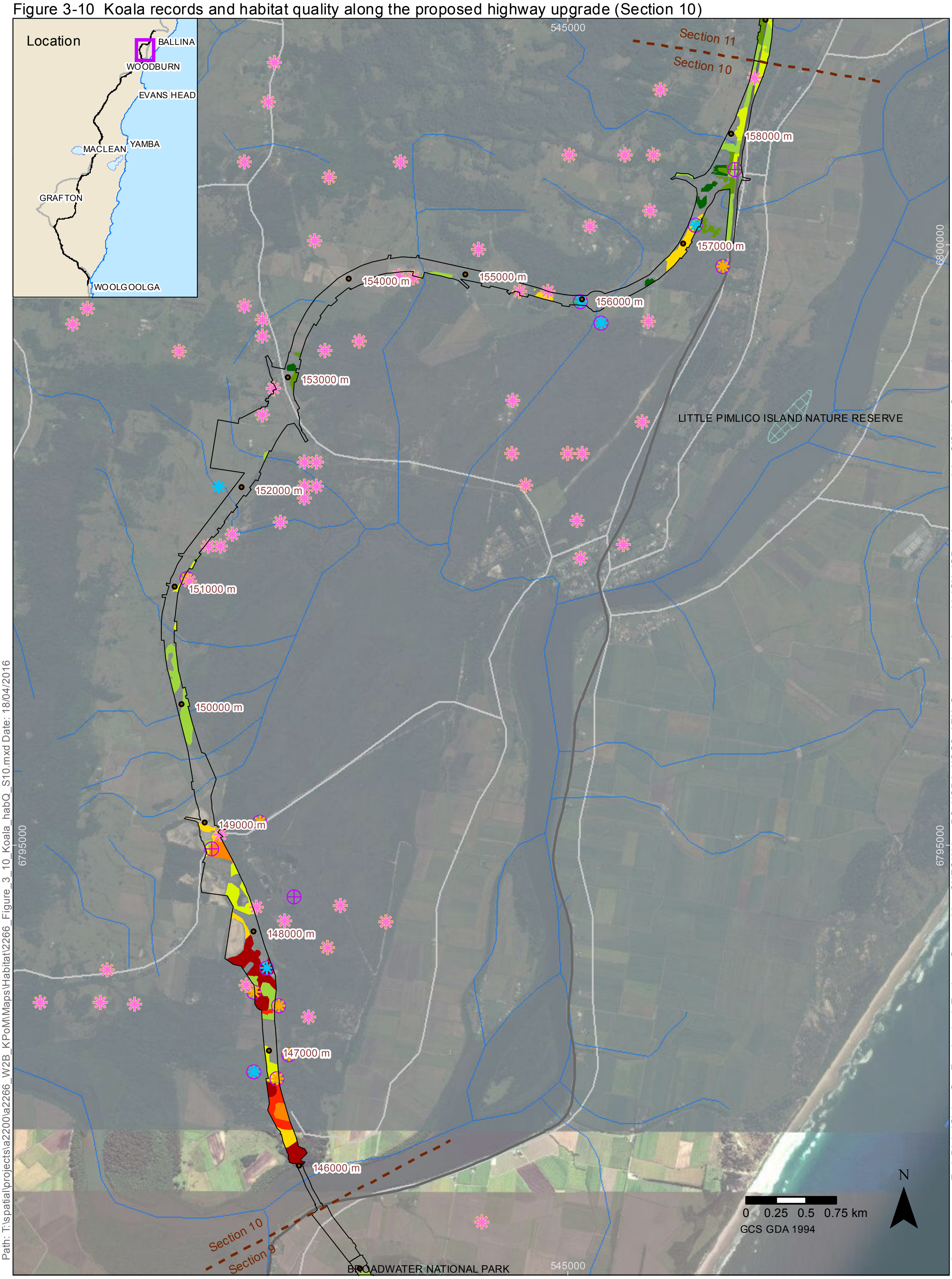
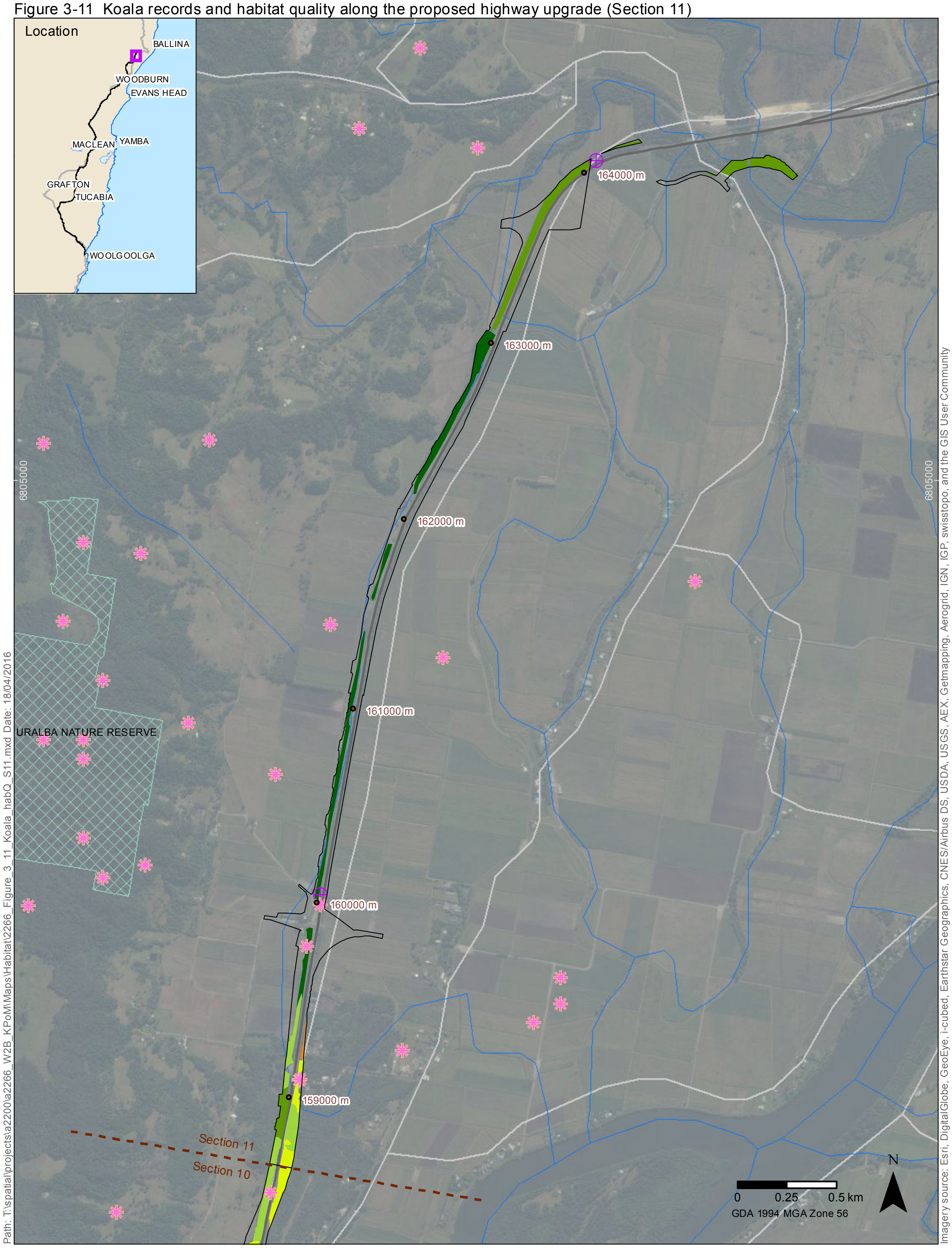
Figure 3-10 Koala records and habitat quality along the proposed highway upgrade (Section 10)



Pacific Highway	Koala scat search plots	Koala habitat quality values		
Project Boundary	Scats	3		7
Koala Atlas sightings	No scats	4		8
Koala habitat assessment plots		5		9
		6		10

Figure 3-11 Koala records and habitat quality along the proposed highway upgrade (Section 11)



Pacific Highway
Project Boundary
Koala Atlas sightings
Koala habitat assessment plots

Koala habitat quality values
3
4
5
6
8

4. Potential impacts and management approach

This chapter provides a brief overview of the potential impacts to Koala populations with reference to the more detailed impact assessment presented in the Section 4.3.2 (pp. 298-300, 306 and 314-315) of the Biodiversity Working Paper (Roads and Maritime 2012) and Section 4.5.6 (pp. 136-155) of the Supplementary Biodiversity Assessment (Roads and Maritime 2013). It also provides an overview of the effectiveness of mitigation measures proposed for this project which have been based on previous experience with Koalas on upgrade projects for the Pacific Highway

4.1 Potential impacts associated with the project

The main potential impacts to Koala populations from the project include:

- Loss of foraging, sheltering and breeding habitat (leading to a reduction in Koala population size).
- Habitat fragmentation and impacts on habitat connectivity (leading to disrupted movements of individual Koalas to different populations and areas of suitable habitat, thus reducing opportunities for genetic exchange and increasing the chances of predation or collision with motor vehicles, both of which are important factors affecting Koala population viability).
- Increased mortality due to vehicle strikes.

The Woolgoolga to Ballina project will directly impact 885 hectares of Koala habitat within the clearing footprint (Sections 1-11). This is based on Koala Habitat Quality Scores ranging from 3-10, and includes 126.85 ha in Section 1, 92.52 ha in Section 2, 306.80 ha in Section 3, 37.90 ha in Section 4, 31.67 ha in Section 5, 69.70 ha in Section 6, 103.15 ha in Section 7, 33.55 ha in Section 8, 23.56 ha in Section 9, 34.96 ha in Section 10 and 13.94 ha in Section 11. (Table 4-1). The Koala habitat score methodology was in accordance with the EPBC Act's Environmental Offset Policy (October 2012) and Offsets Assessment Guide (see Section 3.2of this Plan). The area of Koala habitat to be removed, as estimated using this method, is larger than the 557 ha and 375 ha originally estimated as 'habitat critical to the survival of the Koala' (DSEWPaC 2012) in the EIS and SPIR, respectively. This is because Roads and Maritime Services decided to take a more conservative approach to estimating the area of Koala habitat that would be removed as part of the Project. RMS assumed that all Biometric Vegetation Types that nominally contain Koala food tree species (see Table 3-1), regardless of their actual occurrence on the ground (as required under the definition of 'habitat critical to the survival of the Koala),' would be treated as requiring offsets under the EPBC Act Biodiversity Offsets Policy. The SPIR estimated that 375 ha of primary and secondary 'habitat critical to the survival of Koala' habitat would be cleared throughout the Project footprint. This figure was derived from 160 habitat assessment plots, each 0.1 ha in size and distributed throughout a similar number of vegetation polygons, in which absence of the required percentage composition (30% and 50%) of primary and secondary Koala food trees was interpreted as absence of primary and secondary Koala habitat within the entire vegetation polygon. This methodology was based on Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) (2012) *Interim Koala referral advice for proponents*.

All Biometric Vegetation Types nominally containing primary, secondary and supplementary Koala food tree species will be recognised as requiring offsets. Primary food tree species in these vegetation types include Swamp Mahogany (*Eucalyptus robusta*), Forest Red Gum (*E. tereticornis*), Tallowwood (*E. microcorys*), Cabbage Gum (*E. amplifolia*) and Orange Gum (*E. bancroftii*). Secondary food tree species are represented by Red Mahogany (*E. resinifera*), Small fruited Grey-Gum (*E. propinqua*), Grey Box (*E. moluccana*) and Narrow-leaved Red Gum (*E. seeana*). Supplementary tree species include the stringy-barks (*E. eugenoides and E. tindaliae*).

Table 4-1. Area (ha) of each Biometric Vegetation Type proposed for clearing in relation to Koala habitat score ranking.

Biometric vegetation type	Koala Habitat Quality scores										
	0	2	3	4	5	6	7	8	9	10	Grand total
Section 1											
Cleared	72.86						0.11				72.97
Forest Red Gum - Swamp Box of the Clarence Valley Lowlands of the North Coast						0.26	2.27				2.54
Needlebark Stringybark - Red Bloodwood Heathy Woodland on Sandstones of the Lower Clarence of the North Coast							13.82				13.82
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast	0.03				7.88	3.01	1.18				12.09
Spotted Gum - Grey Ironbark - Pink Bloodwood Open Forest of the Clarence Valley Lowlands of the North Coast	0.33				0.99	3.58	12.94				17.83
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast						5.23	5.69				10.91
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast	0.28		0.60		1.49	5.77	4.26				12.40
Swamp Oak Forest of the Coastal Lowlands of the North Coast	0.95										0.95
Total Section 1	**74.97**		**0.60**		**11.52**	**32.00**	**80.11**				**199.20**
Section 2											
Black Bean - Weeping Lilly Pilly Riparian Rainforest of the North Coast			0.00								0.00
Blackbutt - Tallowwood Dry Grassy Open Forest of the Central Parts North Coast						0.26	0.24				0.50
Blackbutt Grassy Open Forest of the Lower Clarence Valley of the North Coast					3.97						3.97

Biometric vegetation type	Koala Habitat Quality scores										
	0	2	3	4	5	6	7	8	9	10	Grand total
Cleared	37.66										37.66
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast						1.05		4.51			5.56
Needlebark Stringybark - Red Bloodwood Heathy Woodland on Sandstones of the Lower Clarence of the North Coast						1.61	0.63				2.24
Orange Gum (*Eucalyptus bancroftii*) Open Forest of the North Coast								4.84	4.38		9.22
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast					3.34						3.34
Scribbly Gum - Needlebark Stringybark Heathy Open Forest of Coastal Lowlands of the Northern North Coast							6.35				6.35
Scribbly Gum - Red Bloodwood Heathy Open Forest of the Coastal Lowlands of the North Coast							14.12	4.34			18.47
Spotted Gum - Grey Box - Grey Ironbark Dry Open Forest of the Clarence Valley Lowlands of the North Coast								8.61			8.61
Spotted Gum - Grey Ironbark - Pink Bloodwood Open Forest of the Clarence Valley Lowlands of the North Coast							2.10	27.59			29.70
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast							0.09				0.09
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast								2.23	1.87		4.10
Total Section 2	**37.66**		**0.00**		**7.31**	**2.92**	**23.53**	**52.14**	**6.25**		**129.81**
Section 3											
Angophora robur shrubby forest and woodland on sandstones on the north coast					3.69		2.58				6.26
Black Bean - Weeping Lilly Pilly riparian rainforest of the North Coast					0.70						0.70

Biometric vegetation type	Koala Habitat Quality scores										
	0	2	3	4	5	6	7	8	9	10	Grand total
Blackbutt - bloodwood dry heathy open forest on sandstones of the northern North Coast				7.00	5.88						12.88
Cleared	56.72										56.72
Coastal floodplain sedgelands, rushlands, and forblands	0.49		0.84								1.33
Coastal freshwater meadows and forblands of lagoons and wetlands						0.31					0.31
Forest Red Gum - Swamp Box of the Clarence Valley lowlands of the North Coast					0.86	12.94	3.05	1.33			18.18
Narrow-leaved Ironbark dry open forest of the North Coast					5.47						5.47
Paperbark swamp forest of the coastal lowlands of the North Coast					4.72	0.74	6.39				11.84
Pink Bloodwood- Tallowwood moist open forest of the far northern ranges of the North Coast						15.56		15.44			31.00
Scribbly Gum - Needlebark Stringybark heathy open forest of coastal lowlands of the northern North Coast			0.39	28.34	10.45	5.59					44.77
Scribbly Gum - Red Bloodwood heathy open forest of the coastal lowlands of the North Coast			0.62	9.93	5.84						16.40
Spotted Gum - Grey Ironbark - Pink Bloodwood open forest of the Clarence Valley lowlands of the North Coast				15.94	65.27						81.21
Swamp Box swamp forest of the coastal lowlands of the North Coast						1.64	2.15				3.79
Swamp Mahogany swamp forest of the coastal lowlands of the North Coast					0.87	10.79	1.30				12.96
Swamp Oak swamp forest of the coastal lowlands of the North Coast				4.24	4.30	9.02					17.55
Turpentine moist open forest of the coastal hills and ranges of the North Coast						31.09	11.55				42.63
Total Section 3	**57.21**		**1.85**	**65.45**	**108.04**	**87.67**	**27.02**	**16.77**			**364.09**

Biometric vegetation type	Koala Habitat Quality scores										
	0	2	3	4	5	6	7	8	9	10	Grand total
Section 4											
Angophora robur shrubby forest and woodland on sandstones on the north coast					1.13						1.13
Cleared	115.86										
Coastal floodplain sedgelands, rushlands and forblands	2.20										2.20
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal lowlands of the north coast					0.38	0.83					1.21
Forest Red Gum - Swamp Box of the Clarence Valley lowlands				0.05	2.72	10.84					13.61
Grey Gum - Grey Ironbark open forest of the Clarence lowlands of the north coast	0.31			0.10	2.82	14.64					17.87
Paperbark swamp forest of the coastal lowlands	0		1.17								1.17
Spotted Gum - Grey Ironbark open forest at the Clarence lowlands of the north coast					2.72						2.72
Swamp Mahogany swamp forest of coastal lowlands of the north coast						0.51					0.51
Swamp Oak forest of the coastal lowlands of the north coast	5.07										5.07
Total Section 4	**123.45**		**1.17**	**0.15**	**9.77**	**26.81**					**161.35**
Section 5											
Cleared	171.66										171.66
Flooded Gum - Tallowwood - Brush Box moist open forest of the coastal lowlands of the north coast					1.56	4.32					5.88
Forest Red Gum - Swamp Box of the Clarence Valley lowlands				0.32	0.10						0.43

Biometric vegetation type	**Koala Habitat Quality scores**										
	0	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Grand total**
Grey Gum - Grey Ironbark open forest of the Clarence Valley lowlands of the north coast					2.08	2.29	10.52				14.88
Grey Mangrove low closed forest	0.96										0.96
Paperbark swamp forest of the coastal lowlands			0.56	1.20	5.16	0.48					7.40
Swamp Oak forest of the coastal lowlands of the north coast	7.73				3.08						10.81
White Booyong-fig subtropical rainforest of the north coast	0.52										0.52
Total for Section 5	**180.87**		**0.56**	**1.52**	**11.99**	**7.08**	**10.52**				**212.54**
Section 6											
Blackbutt - Bloodwood Dry Heathy Open Forest on Sandstones of the Northern North Coast				0.03	0.12	2.10	2.56	4.32			9.12
Cleared	43.67										43.67
Forest Red Gum - Swamp Box of the Clarence Valley Lowlands of the North Coast				0.27	2.29	2.53	1.03	4.68			10.81
Grey Gum - Grey Ironbark Open Forest of the Clarence Lowlands of the North Coast					2.71	0.39	15.26	9.62			27.97
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast							3.13	1.45			4.58
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast				1.93	4.68	5.19	0.32				12.11
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast					1.76		1.37				3.13
Spotted Gum - Grey Ironbark - Pink Bloodwood Open Forest of the Clarence Valley Lowlands of the North Coast			0.04					0.51			0.55
Tallowwood Dry Grassy Forest of the Far Northern Ranges of the North Coast					1.42						1.42
Total Section 6	**43.67**		**0.04**	**2.22**	**12.97**	**10.21**	**23.67**	**20.58**			**113.37**

Biometric vegetation type	Koala Habitat Quality scores									
	0	2	3	4	5	6	7	8	9	10	Grand total
Section 7											
Blackbutt - Bloodwood Dry Heathy Open Forest on Sandstones of the Northern North Coast					6.80	6.60	3.47				16.87
Cleared	69.19										69.19
Grey Gum - Grey Ironbark Open Forest of the Clarence Lowlands of the North Coast						1.44					1.44
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast				0.81		5.93					6.75
Needlebark Stringybark - Red Bloodwood Heathy Woodland on Sandstones of the Lower Clarence of the North Coast						1.03					1.03
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast					2.14	13.30					15.44
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast			0.53	10.23	11.30	2.32	9.78				34.17
Scribbly Gum - Needlebark Stringybark Heathy Open Forest of Coastal Lowlands of the Northern North Coast						13.92					13.92
Spotted Gum - Grey Ironbark - Pink Bloodwood Open Forest of the Clarence Valley Lowlands of the North Coast						10.03	3.51				13.54
Total Section 7	**69.19**		**0.53**	**11.04**	**20.25**	**54.56**	**16.76**				**172.34**
Section 8											
Angophora paludosa Shrubby Forest and Woodland on Sandstone or Sands of the North Coast								0.61			0.61
Cleared	88.75					0.23					88.98
Forest Red Gum grassy open forest of the coastal ranges of the North Coast			0.89	2.67	0.28	0.05	0.51	10.67			15.07

Biometric vegetation type	Koala Habitat Quality scores										
	0	2	3	4	5	6	7	8	9	10	Grand total
Grey Gum - Grey Ironbark Open Forest of the Clarence Lowlands of the North Coast					0.08				0.48		0.56
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast			3.41	5.34				1.03			9.78
Red Mahogany Open Forest of the Coastal Lowlands of the North Coast								0.48			0.48
Swamp Box Swamp Forest of the Coastal Lowlands of the North Coast			3.05								3.05
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast						0.02					0.02
Swamp Oak Forest of the Coastal Lowlands of the North Coast			3.72	0.03							3.75
Total Section 8	**88.75**		**11.07**	**8.03**	**0.35**	**0.29**	**0.51**	**12.80**	**0.48**		**122.30**
Section 9											
Blackbutt - Bloodwood Dry Heathy Open Forest on Sandstones of the Northern North Coast			0.61		0.60						1.20
Brushbox – Tallowwood Shrubby Open Forest of the Northern Ranges of the North Coast					0.55						0.55
Cleared	51.67										51.67
Coast Cypress Pine Shrubby Open Forest of the North Coast			0.60	0.56	0.88						2.04
Coastal Heath on Sands of the North Coast			6.10	13.70	0.13						19.93
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast			2.82	1.30	0.08			0.25			4.46
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast					0.00	0.20	0.17	1.79	3.35		5.50
Total Section 9	**51.67**		**10.13**	**15.56**	**2.24**	**0.20**	**0.17**	**2.04**	**3.35**		**85.36**

Biometric vegetation type	Koala Habitat Quality scores										
	0	2	3	4	5	6	7	8	9	10	Grand total
Section 10											
Blackbutt – Pink Bloodwood Shrubby Open Forest of the Coastal Lowlands of the North Coast				0.05	2.21	0.14	2.97				5.38
Blackbutt Grassy Open Forest of the lower Clarence Valley of the North Coast						0.23	0.93	0.91		1.53	3.60
Cinnamomum camphora (Camphor Laurel)			1.44								1.44
Cleared	115.02			0.14			0.93				116.09
Mangrove - Grey Mangrove Low Closed Forest of the NSW Coastal Bioregions	0.17										1.44
Narrow-Leaved Red Gum Woodlands of the Lowlands of the North Coast					1.06	2.01	0.70		1.26	3.92	8.94
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast	0.00		0.41	0.88	1.61	2.17			0.25	0.64	5.96
Scribbly Gum - Needlebark Stringybark Heathy Open Forest of Coastal Lowlands of the Northern North Coast					1.98	1.47					3.45
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast					0.63	0.27		1.23			2.12
Tuckeroo – Riberry – Yellow Tulipwood Littoral Rainforest of the North Coast	0.01			0.19	0.89						1.09
White Booyong – Fig Subtropical Rainforest of the North Coast			0.39	0.52	0.47		0.53				1.92
Total Section 10	**115.20**		**2.24**	**1.78**	**8.85**	**6.29**	**6.06**	**2.14**	**1.51**	**6.09**	**150.16**
Section 11											
Cleared	29.30			0.31							29.61
Mangrove - Grey Mangrove Low Closed Forest of the NSW Coastal Bioregions	0.05			0.09							0.13

Biometric vegetation type	Koala Habitat Quality scores										
	0	2	3	4	5	6	7	8	9	10	Grand total
Paperbark Swamp Forest of the Coastal Lowlands of the North Coast			2.35	0.91	0.73	0.63		0.16			4.78
Scribbly Gum - Needlebark Stringybark Heathy Open Forest of Coastal Lowlands of the Northern North Coast					0.68	0.55					1.23
Swamp Mahogany Swamp Forest of the Coastal Lowlands of the North Coast			3.76	2.36	0.52						6.63
Swamp Oak Forest of the Coastal Lowlands of the North Coast				0.89							0.89
Tuckeroo - Riberry - Yellow Tulipwood Littoral Rainforest of the North Coast					0.00						0.00
Total Section 11	**29.34**		**6.10**	**4.56**	**1.93**	**1.18**		**0.16**			**43.28**

Koalas may also be impacted by fragmentation and the barrier effect of the highway. It has been identified that Koalas are regularly struck by cars where high-density populations occur in fragmented urban habitats (Canfield 1987, Dique *et al*. 2003b, Taylor and Goldingay 2010, DSEWPaC 2013). Recent genetic research has identified that major roads can act as a barrier to gene flow for Koalas (Lee *et al.* 2010). Vehicle strike (Koala injury or death) during road construction and operation presents one of the key potential impacts of the Project.

The project will fragment habitat links for Koalas seeking access to preferred habitats either side of the highway, and this is particularly of concern for the key populations located between Bagotville and Wardell and the southern parts of Coolgardie (Section 10 of the project), and also between Broadwater National Park and Rileys Hill (Section 9 of the project). However, any potential barrier effects of the highway upgrade within Sections 1-8 (excluding the Woombah population) and 11 are of less concern due to the very low population density of Koalas inhabiting these areas.

Potential indirect impacts would result from:

- Greater likelihood of local extinction due to small population size as a result of fragmentation.
- Reduced opportunities for effective and safe dispersal due to fragmentation, and potentially reduced breeding success.
- Disease and stress.
- Potential for increased predation risk within and adjacent to fauna underpasses where Koala movements may be concentrated.

The low-density populations of Koalas occurring within most Sections (1-8 and 11) are likely to suffer a reduced level of impact by the Project, compared to other Sections (9 and 10) where this species is more abundant or of greater significance as determined by pre-construction surveys and according to local planning documents. Accordingly, the management response by RMS will differ between Sections.

In an effort to quantify the potential impact on the individual Koalas located within the known hotspots of Section 10 (Wardell Road and Laws Point) the number of food trees present in the locality (area over which Koalas who utilise food trees within the alignment are likely to forage) and those to be removed has been determined (see Figure 6-7). These are shown in Table 4-2 and demonstrate that 23% of the total number of identified food trees present within these areas would be removed for the Project. In general, not all trees within the project boundary will be removed – only those that occur within the proposed construction footprint.

Table 4-2. Number of Koala food trees to be removed within Section 10 Koala 'hot spot' locations.

Location	No. of key food trees present within and directly adjacent to the road corridor. (Dr. S Phillips, unpublished data).	No. of identified trees removed	
		SPIR	Current SMEC Design
Laws Point	70	14	12
Wardell Road	43	17	14

4.2 Detailed design considerations

A number of factors were considered in identifying the key connectivity zones for Koalas and the types of crossing structures likely to be used by this species have been included in the detailed design of the Project. The factors considered in locating and sizing of connectivity structures included:

- Known and potential Koala habitat and connectivity areas.
- Consideration of local Koala population density

- Previous experience from monitoring programs which investigated the effectiveness of structures for Koalas. These experiences included the need to make underpasses as large as possible in profile, but as short as possible in total length (< 50 m).

4.3 Mitigation and monitoring

A number of measures to mitigate and monitor the impact of the project on Koalas during construction and operation for the entire project were suggested in the EIS (Biodiversity Working Paper, Roads and Maritime 2012). In general these measures related to:

- Installation of dedicated and combined connectivity structures, including overpasses and underpasses, in combination with strategic revegetation and fencing to encourage use of these facilities/areas.
- Development of a Koala Fencing Strategy.
- Provision of Koala fauna exclusion fencing, including fencing of escape points and strategic areas of preferred vegetation.
- Additional targeted Koala surveys as part of a comprehensive monitoring program.
- Pre-clearing surveys to identify Koalas within the construction corridor.
- Identification of exclusion zones and fencing to prevent damage to native vegetation and Koala habitat.
- Siting of ancillary facilities to avoid impacts to known and potential Koala habitat.
- Implementation of a dog policy to ensure that no domestic dogs are brought onto the site.
- Induction and training of construction staff to make them aware of Koala habitat requirements, clearing extents and no-go areas.
- A licensed wildlife carer/ecologist would be present on site during all vegetation clearing.

4.4 Effectiveness of mitigation measures

A summary of the proposed Koala-specific mitigation measures for the entire Pacific Highway upgrade, and evaluation of their effectiveness based on past experience with other highway upgrades, is described in Table 4-3.

Table 4-3. Mitigation measures and evaluation of their effectiveness

Issue	Mitigation measure	History of success	Effectiveness rating
Impact to Koala habitat outside the construction zone.	Identification of exclusion zones and limits of clearing. Revegetation of lands adjacent to the corridor post construction.	A standard procedure has been developed by Roads and Maritime and documented in the Biodiversity Guidelines for Construction (RTA 2011). The guidelines were developed in consultation with the NSW Office of Environment and Heritage (OEH) and subsequently by the NSW Environmental Protection Authority (EPA), NSW Department of Primary Industries (DPI) (Fisheries), biodiversity specialists and Roads and Maritime staff including project managers, construction personnel and designers. Consultation was facilitated through a number of workshops carried out in 2009. These procedures have been developed using knowledge gained from a long history of upgrades on the Pacific highway and other road projects in NSW. Temporary fencing around important fauna habitats (exclusion zones) has been used by Roads and Maritime on multiple highway upgrades including the Pacific Highway and Hume Highway for the past 20 years. It has become a standard procedure as part of the Construction Environment Management Plan (CEMP) and is inspected during construction. When combined with standard training of contractors it has become a highly effective measure at avoiding impacts to important habitats adjacent to construction areas. Landscape designs are a standard procedure used on all upgrades and have developed over the last three decades to include the use of locally indigenous plant species and a targeted approach to revegetation where required. This includes the provision of specific keystone species for fauna including Koala feed trees. It is particularly useful at crossing zones, to encourage fauna use of underpass and overpass structures.	High
Potential impacts to Koalas within the project during clearing works.	Pre-clearing and clearing procedures. Installation of temporary barrier fencing during construction including placement of escape points Koala relocation protocol. Managing Koala construction vehicle collisions during construction.	Guide 1: Pre-clearing procedures of the Roads and Maritime Biodiversity Guidelines (RTA 2011) outline the process to be followed prior to clearing works. The objective of this guide is to provide guidance for the pre-clearing process that would be conducted before any clearing takes place to minimise the impact on native flora and fauna. If fauna is within the identified limits of clearing an ecologist would capture and/or remove the fauna that have the potential to be disturbed, injured or killed as a result of clearing activities. Guide 8: Fauna handling would be followed for the capture and release of fauna. Specifically for the Koalas refer to Section 6.3.6 in this plan for a description of the Koala relocation protocol. The use of ecologists and licensed wildlife carers has been used on Pacific Highway projects over the last 10 years to successfully capture and relocate fauna. Temporary exclusion fencing has also been used on all Pacific Highway upgrade over the last 10 years to exclude fauna from the construction works along the highway upgrade.	Moderate – High. Monitor success and implement corrective actions
Domestic dogs brought on site by contractor could lead to dog attack	CEMP to document dog policy.	A prohibition of dog's policy is implemented as a standard procedure part of the CEMP process and has been used on multiple upgrades on the Pacific Highway including the Bonville and Kempsey upgrade where Koalas were important issues. This policy has ensured that no domestic dogs are brought onto the site by construction contractors and is monitored throughout the construction period with consequences for contractors who bring dogs to the site.	High
Potential impact to Koala habitat when siting ancillary facilities.	Locate ancillary facilities and access roads in disturbed and cleared areas.	Roads and Maritime *Stockpile Site Management Procedures* (RTA 2011). The siting of temporary construction related infrastructure is to be sited where possible within existing cleared or disturbed areas. This approach can substantially reduce the overall area of impact to vegetation and fauna habitat, while also reducing the area required to be rehabilitated at the end of construction.	High

Disruption to Koala movements and gene flow. Koala vehicle collisions on the highway.	Fauna crossing structures – underpasses, including refuge poles and furniture Fauna crossing structures – overpasses (land bridges), including refuge poles. Installation of permanent fauna exclusion fencing. Maintenance of fauna exclusion fencing.	Targeted crossing structures for Koalas have been used on multiple projects in Australia with high level of success. Roads and Maritime undertook monitoring of the vegetated median and rope bridge for the Bonville underpass in 2010 (SES 2010). This monitoring found that the underpasses were being used by Koalas, but only rarely during the first few years of the project (AMBS 2011). A review of the usage of fauna passage structures was undertaken for Roads and Maritime in 2009 (Roads and Maritime 2009). This report found that Koalas have been recorded in fauna tunnels and box culverts. Specifically this study found that: • Koalas were using box culverts within the Yelgun to Chinderah and Brunswick Heads sections. • Within the Yelgun to Chinderah section the purpose-built fauna tunnel in the Taree section was also being used. • The culverts successful in attracting Koalas were united by their close proximity to quality vegetation. • The Koala may require time to acclimatise to the presence of the road and the underpass structures (AMBS 2011). Alternatively, it may be necessary for vegetation to regenerate before a Koala is comfortable moving over land. • Koalas were recorded in culverts with and without internal poles and logs. Although the sample sizes were too small to comment on whether culverts with poles were more successful than those without. Permanent fauna exclusion fencing has been used on multiple sections of the Pacific Highway to exclude fauna and direct to crossing points. An investigation of the impact of roads on Koalas was undertaken in 2011 for Roads and Maritime (AMBS 2011). Some of the findings from the study include that: • Most Koalas killed by vehicle collisions on the highway are not the local roadside residents but appear to be sub-adults dispersing and perhaps old, weak animals displaced from their former home-ranges away from the highway. Consequently the impact of road-kill affects a wider section of the population. • The genetic variation in roadside Koalas in the Yelgun to Chinderah and Bonville study areas prior to the upgrades was relatively high and had apparently not been impacted by the long existence of the Pacific Highway • Construction activities in the two study areas directly led to only one known death, suggesting that the direct impacts of clearing and construction are relatively minor at a population scale (when appropriate mitigation strategies are in place). • Floppy-top’ fauna exclusion fencing can be very effective at reducing the rate of road–killed Koalas, but gaps and other weaknesses (including side-roads) have to be eliminated, and fences that end at the forest edge are likely to be not as effective as those that extend beyond the forest. • Underpasses (both constructed culverts and ‘natural’ underpasses such as gullies) can work in providing safe dispersal routes for Koalas to cross the highway. Other studies have recorded Koalas using underpasses in NSW including at the Brunswick Heads bypass, Bulahdelah to Coolongolook section of the Pacific Highway, Taree section of the Pacific Highway upgrade and a culvert near Brunswick Heads (Taylor and Goldingay 2003). • Recommended that clearing activities be undertaken outside the Koala breeding and dispersal period during future road constructions. • Other sources of mortality (e.g. *Chlamydia*) can be much higher in roadside Koalas than road mortality Roads and Maritime routinely conducts maintenance on exclusion fencing along the Pacific Highway both as a standard procedure and in response to a breach in the fence or the discovery of significant numbers of fauna road kills.	Moderate – High, monitor success and implement corrective actions

Increased noise and dust during construction impacting on Koala movements and behaviours.	Dust and noise managed in accordance with procedures in the CEMP	Roads and Maritime have developed standard procedures for dust and noise management on construction sites as part of the CEMP process with a long history of success as reported in auditing reports.	High

4.5 Section 10

As mentioned previously, the population of Koalas within Section 10 was the subject of a PVA. The PVA thoroughly investigated the potential impact of the road on the population, also taking into account implementation of a number of mitigation/management measures. The outcomes of the PVA have been used to guide the management measures contained within this Plan for the animals within this Section and are summarised below.

4.5.1 PVA results

Population projections from the PVA within the Ballina Koala Plan (BKP) showed a gradual decline in the Koala population over 50 years, with or without the proposed highway upgrade. With no road, the model predicted an approximately 41% decline in the population over the first 15 years. This population decline was a result of births not being adequate to offset deaths, regardless of the presence of the highway upgrade. The impact of the road was minimal and estimated to range between no effect and up to a 9.7% decline in the projected population size after 50 years.

It was shown that population projections could be improved substantially through management intervention, including through the provision of supplementary habitat (leading to a 0.5% increase in population size) and by a combination of approaches that result in reduced mortality (by four or eight animals per year, with diminishing benefit over time) and increased fecundity (by 20%), all of which could potentially increase the projected population by 257-404% over 50 years. Management measures aimed at increasing population fecundity, and/or reducing population mortality were identified as having the greatest potential to arrest the current steep decline in this population.

A key mitigation measure of the PVA included reducing the annual mortality of Koalas by an initial four (or up to eight) animals per year. This information was based on long-term road-kill data collected by the Lismore Friends of the Koala, which indicates that an average of 1.23 animals per year are killed on roads within the study area, although annual mortalities of 4-6 animals were considered more likely (Phillips *et al*. 2015). These authors observed six Koala mortalities caused by vehicle-strike during the six months of their field study, and at least 10 mortalities in 2015 (S. Phillips, *pers. comm*. 14/12/2015). Four main road-kill “hot-spots” were identified within the Project study area; the Pacific Highway, the Bruxner Highway, Wardell Road and Old Bagotville Road. The same long-term data set also showed that at least 1.64 Koalas were killed annually by predation by domestic dogs. This information suggested that there may be opportunities for management to reduce the numbers of “avoidable” Koala mortalities by four, or possibly up to eight, animals per year within the study area. These two scenarios of reducing annual mortality by four or eight were included because they represented likely achievable objectives that could be achieved by fencing known road-kill hotspots and by controlling local wild dog numbers. Implementation of management measures to address improving population-level fecundity would prove more challenging.

Figure 4-1 shows the PVA population projections for a number of the modelled scenarios. These scenarios are based on the Ballina Koala Plan and an addendum to the Ballina Koala Plan that was prepared by Dr Kavanagh, the author of the Ballina Koala Plan, at the request of the Department of Environment following submissions made to the Department of Environment by Dr Steve Philips and Dr Phillip Miller (Appendix L).

The six scenarios represented in Figure 4-1 are summarised as follows:

- Scenario 1 – base case – projected population with no road.
- Scenario 2 – projected population with impact from the road with mitigation measures such as connectivity structures, fully fenced highway and koala revegetation, but no additional population

wide mitigation that reduce mortality, and accounting for an initial loss of carrying capacity for five animals.

- Scenario 3 - projected population with impact from the road with mitigation measures such as connectivity structures, fully fenced highway, but no revegetation and no population wide mitigation measures, an initial (and lasting) loss of carrying capacity for 14 animals, and an immediate loss of 14 animals from the population.
- Scenario 4 – projected population with impact from the road with mitigation measures and population wide mitigation measures that result in reduced mortality of four Koalas per year every year.
- Scenario 5 – projected population with impact from the road with mitigation measures and population wide mitigation measures that result in reduced mortality of eight Koalas per year every year.
- Scenario 6 - projected population with impact from the road with mitigation measures such as connectivity structures, fully fenced highway and koala revegetation, population wide mitigation measures that result in a reduced mortality of four Koalas per year initially (Year 0), but where the reduced mortality decreases proportional to population size in subsequent years. Scenario 6 was considered to be the most accurate representation for the model as although it is agreed that the proposed mitigation measures can reduce mortality by at least four animals per year based on the current population size, as the population declines the number of individuals saved per year through the mitigation measures will decline proportional to the population size.

The predicted outcome for the population is approximately the same in each scenario resulting in a Koala population within the study area of approximately 40 animals by the end of 50 years. Scenarios 4, 5 and 6, including various assumptions regarding reducing mortality, and show a marked increase in the projected year 50 population size to at least 65.5 (Scenario 6) compared with scenarios that don’t consider reduced mortality. Scenario 6 is based on a diminishing benefit compared with Scenarios 4 and 5 as it reduces mortality rates proportional to population size. Scenario 4 is based on the same reduction in mortality as Scenario 6 (four individuals a year through reduced road and dog kill), but the number each year is constant, and results in a population of 109 individuals in year 50. Scenario 6 is the counterfactual against which the population counts will be measured, that being that a measure of failure is a population that falls below the lower range estimate from Scenario 6 (195 in Year 5) (see Table 4-4).

These results led to the development of a management framework where RMS has committed to ensuring that no Koala road-kills occur as a result of this Project, and in doing so has committed to a fully-closed (fenced) highway along the corridor, integration of additional and enhanced connectivity structures, and the establishment of 130 ha of new habitat for the Koala adjacent to and within the vicinity of the Upgrade. In addition, the RMS will undertake further work, such as fencing and installation of connectivity structures, at two known Koala hot-spots that occur on other roads that are adjacent to and interact with this Project (i.e. part of Wardell Road in the vicinity of the new highway, and part of the existing Pacific Highway north of Wardell to Coolgardie). The aim of these management measures is to achieve a reduction in Koala mortality in the order of 4-8 animals/year in an effort to arrest population decline as predicted by the PVA models. Scenario 6 is based on reducing mortality by four animals in the first year and then proportionally to population size in future years.

Long-term population monitoring has been included as an integral part of the management of the Koalas within this Section. The selection of specific monitoring objectives and targets was required to enable the success or otherwise of the monitoring and management mitigation measures to be determined. Population projections predicted by Scenario 6 were selected for this purpose. This was based on its consideration of an annual proportional benefit from reducing mortality by an initial four animals/year (which would be the case in a declining population); and it's more conservative estimate of reducing mortality by an initial four, rather than eight animals/year. This Scenario represents the minimum acceptable outcome of the PVA.

Extensive investigations into the type, location and frequency of Koala population monitoring have been undertaken as part of development of this Plan. These included a power analysis to determine the survey effort required to reliably produce population estimates that could detect the projected population declines (see Section 8.3 for details). Initial results indicated that the ability to detect the projected population decline only achieved a reasonable level of confidence (70%) after surveying approximately 50 sites, every six months for 15 years (the ability to reliably detect the projected decline in the population increases over time as data accrues). There was no capacity to increase survey effort above this level. While it is recognised that there are limitations to interpretation of population monitoring data prior to 15 years, it is also considered important to be able to assess (within a known order of magnitude) population changes prior to this time in order to implement adaptive management measures should they be required. As such, it was determined that the PVA population predictions for Scenario 6 at years 5, 10 and 15, and their associated confidence intervals would be used as the goals for population monitoring and management within Section 10 (Table 4-4).

Table 4-4. PVA projected population size at various time intervals for Scenario 6.

Year	Population size (number of Koalas)	Confidence interval (90%)
0	236	236- 236
5	234	195 - 276
10	219	147 – 272
15	207	104 - 262
50	66	24 - 135

Data from the systematic long term population monitoring will be used to determine whether recovery efforts and mitigation measures have been successful in arresting population decline and also assess how the Koala population is trending relative to the PVA predictions (see Section 8.2 for details).

The specific goals for management of Koalas within Section 10 include:

- Zero Koala mortality during construction and operation of the new road.
- Maintenance of habitat connectivity for Koalas across the Upgrade
- Reducing Koala mortality by an initial 4 animals/year and thus arresting population decline such that it is greater than the lower bound of the 90% confidence interval of the PVA Scenario 6 (195 at year 5, 147 at year 10 and 104 at year 15), which equates to a 1.2% decline over five years, 13.7% decline over 10 years and 27.3% decline over 15 years.

The subsequent management and monitoring program detailed within this Plan incorporates these mitigation measures in line with the aim of improving the overall viability of the Koala population by attempting to reduce Koala mortality where possible.

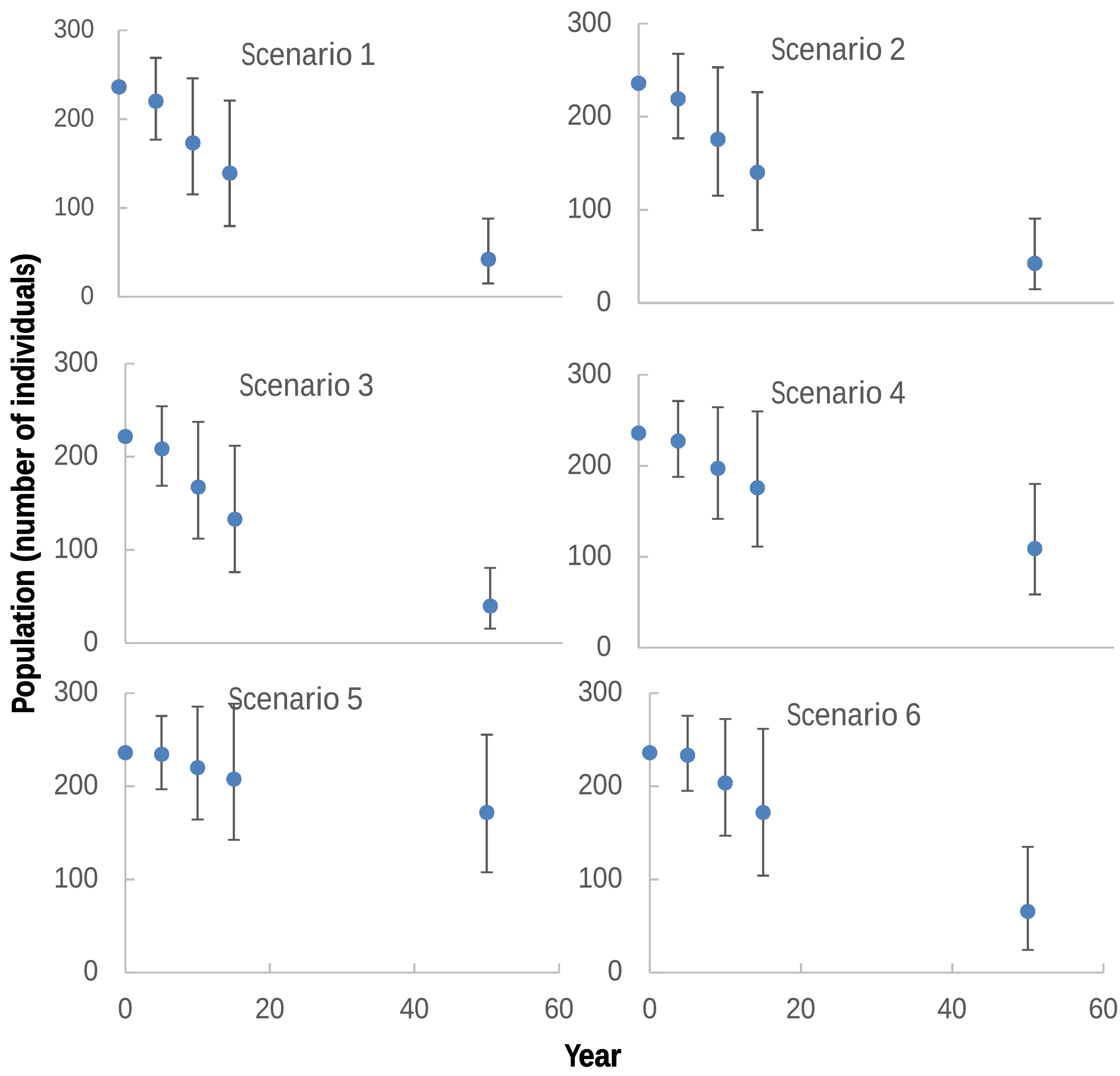


Figure 4-1. PVA population predictions for Scenarios 1-6

Error bars represent 90% confidence intervals. Scenario 6 is that against which population counts will be compared against.

4.6 Adaptive management approach

This management plan follows an adaptive management approach based on the identification of specific goals for management, implementation of management actions, followed by monitoring of the performance of these measures against the goals and identified thresholds. As a final step, the monitoring will evaluate the effectiveness of the management measures using identified thresholds for performance and implementing corrective actions to improve mitigation where required.

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

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

Details of the proposed Koala monitoring program for the entire project are described in Chapter 8 and include:

- Monitoring the use of crossing zones and crossing structures by Koalas during the construction and operational phases.
- Monitoring road-kill and thus the effectiveness of roadside fencing in excluding Koalas from the road corridor and in directing Koalas to crossing zones.
- Monitoring the success and utilisation by Koalas of habitat revegetation works (mainly in Section 10).
- A comprehensive Koala population monitoring program for Sections 8 (part), 9 and 10.

The level of monitoring intensity varies across each Section as a function of differences in animal density and potential impacts of the road. These issues are discussed in detail below.

Monitoring procedures for Koalas in Sections 1-8 and 11 of the highway upgrade are primarily limited to assessments of the effectiveness of the road crossing structures, the effectiveness of fauna exclusion fencing, the frequency and distribution of Koala road kills, and the use of restored (revegetated) habitat by Koalas. Monitoring procedures for Section 9 and 10 include all the above but include additional, long-term population monitoring.

5. Pre-construction management measures

5.1 Potential impacts during pre-construction phase

- Location of infrastructure within ancillary facility sites, including heavy vehicle access, geo-technical investigations, utility adjustments/relocation and property adjustments may impact on Koala habitat, movements, and foraging behaviour.

5.2 Main goals for management

- Koala fencing strategy as required by MCoA D2 Connectivity Strategy be completed prior to the commencement of construction (Note: does not include “floppy top” fencing in Sections 1-4 and Sections 6 (part)-8 and 11).
- Koala floppy top fencing or similar Koala specific fencing to protect the Woombah-Iluka (Section 5), Broadwater (Section 9) and Coolgardie-Bagotville (Section 10) populations.
- No impact to Koala habitat outside designated clearing areas and the project boundary.
- No Koala deaths from contractor domestic dogs on the project.

5.3 Management measures

Details on the site specific mitigation measures for Koalas to be implemented during the pre-construction phase are detailed in the following section and summarised in Table 5-2. Mitigation measures, performance measures and corrective actions - pre-construction.

5.3.1 Fauna fencing

The majority of the Woolgoolga to Ballina Pacific Highway Upgrade will be fenced on both sides to protect wildlife from collisions with motor vehicles. The Fencing Strategy, as required by MCoA D2 Connectivity, has not been finalised but there are a number of fence-types proposed for use along different sections of the road depending on the likelihood of occurrence of fauna species (Table 5-1). Fence types that are most relevant to the protection of Koalas include:

- Koala – Chain-wire floppy-top fence approximately 1.8 m high with galvanised steel posts, wire netting 1.5 m high fence with metal sheeting attached near the top, colourbond fence 1.3m high
- Mammal – Modified rabbit-proof fence 1.2 m high with 800 mm of galvanised steel wire netting and concrete or steel posts
- Emu - Modified rabbit-proof fence 1.5 m high with 1200 mm of galvanised steel wire netting and concrete or steel posts

Each fence type can be modified for Phascogales and Koalas by retro-fitting with smooth galvanised metal sheeting, 600 mm wide, placed near the top of the fence. The general mammal fence is likely to provide a barrier to the occasional Koala that may be encountered within the low density populations that occur along most of the length of the Highway Upgrade. However, if any Koala deaths or injuries are recorded, these fences will be retro-fitted with smooth metal sheeting to prevent any access by Koalas.

Sections 1 and 2

Fauna fencing type and location has been completed as part of the detailed design for Section 1 and Section 2 and is detailed in the Connectivity Strategy for these sections. “Floppy top” Koala fencing is not proposed for use in Section 1 and Section 2 because of the low population density of animals. Instead, a modified rabbit-proof fence will be installed that can be retro-fitted with smooth metal sheeting if any Koala deaths or injuries are recorded. These assessments have been undertaken following consultation with biodiversity specialists in EPA/OEH. The Connectivity Strategy provides detail on fence types and specific locations for fencing, as well as placement of escape points (for instances where fauna become trapped in the road corridor). However, recent research presented at Australian Network of Ecology and Transportation 2014 conference found that these escape points where being used by a variety of fauna groups to access the highway rather than escape from it (Taylor and Goldingay 2014). Further consultation with EPA (December 2014) recommended that “fauna drop downs” rather than “escape poles” be used in Sections 1 and 2, due to the low number of Koala records. The EPA specified that these drop downs be designed with 1200 mm clearance down the front, and that drop downs be placed close to entry nodes and less frequently (at notional 500 m intervals) further away from entry roads. The EPA acknowledged that escape points are a vital design feature of four-lane highways, and that further research is required to improve the efficiency of designs. The current Connectivity Strategy for Section 1 and 2 includes 1200 mm escape drop downs at all dedicated and combined fauna crossing culverts. The Section 2 re-use area will also include fauna drop down structures to allow for fauna to access the underpasses rather than going back across the northbound carriageway.

Details of the fauna fencing locations for Section 1 and Section 2 are shown in the Connectivity Strategy (2014).

Sections 3- 11

Detailed design of fauna fencing types has not yet been completed for Sections 3-11, but the fence-types proposed are listed in Table 5-1. Koala floppy-top fencing is not proposed for use in Sections 3-8 (excluding Woombah-Iluka Koala population area) because of the low population density of animals in these areas. Instead, a range of other fencing types will be employed along the entire length of these Sections (Table 5-1). The southern part of Section 3 (from chainage 35000 – 40000), where a large number of old Koala records occur, will be protected using ‘Phascogale’ fencing (i.e. Mammal fence with 600 mm galvanised steel panel near the top) that will also provide a barrier to Koala movement onto the road. Koala floppy-top fencing will be installed from chainage 94700 - 97200 in Sections 5-6 to protect the Woombah-Iluka population. Floppy-top fencing is also proposed for the Sections 8 (part), 9 (Broadwater), 10 (Coolgardie-Bagotville) and the southern end of Section 11 because of the greater population density of Koalas occurring there.

As described above for Sections 1 and 2, a modified rabbit-proof fence will be installed along many parts of Sections 3-4 and 6-8 and 11 that will be retro-fitted with smooth metal sheeting if any Koala deaths or injuries are recorded. Particular segments along the upgrade will also have fencing that is targeted to limit movements onto the highway by other fauna species (Table 5-1). For example, the 1.5 m high mesh fence proposed for Sections 3 and 4 targeting Emus will also act as a significant barrier for Koalas.

Table 5-1. Indicative locations of fauna fencing in Sections 3-11

Chainage (m)	Fencing type
33800 – 34200	W2G general fauna fence
34200 – 35000	Frog fence
35000 – 35200	Combined mammal/ frog /Phascogale fence

Chainage (m)	Fencing type
35200 – 36100	Mammal /Phascogale fence
36100 – 38250	Combined mammal/ frog /Phascogale fence
38250 – 38300	Combined emu/ mammal/ frog /Phascogale
38300 – 40000	Combined emu/ mammal /Phascogale fence
40000 - 47800	Combined emu / mammal fence
47800 - 52300	Combined emu/ mammal /Phascogale fence
52300 – 53500	Combined emu / mammal fence
53500 - 56300	Combined emu/ mammal /Phascogale fence
56300 - 58000	Combined emu / mammal fence
58000 - 61000	Combined emu/ mammal /Phascogale fence
61000 - 63000	Combined emu / mammal fence
63000 - 64200	Combined emu/ mammal /Phascogale fence
64200 - 65100	Combined emu/ mammal/ frog /Phascogale
65100 - 66700	Combined emu/ mammal /Phascogale fence
66700 - 74350	Combined emu / mammal fence
74350 – 75215	Shark Creek bridge
75125 - 80000	Combined emu/ mammal fence
80000 – 82000	Mammal fence
82000 – 82500	W2G general fauna fence
82500 – 85900	Mammal fence
85900 – 87260	Clarence River bridge
87260 – 89320	Standard highway fencing
89320 – 89415	Serpentine Channel
89415 – 94000	Standard highway fencing
94000 – 94190	Clarence River North Arm
94190 - 94700	Standard highway fencing
94700 – 95200	Koala fencing
95200 – 95800	Combined Koala/ frog fencing
95800 – 97900	Koala fencing
97900 – 98000	Combined Koala / mammal fencing
98000 - 101700	Combined mammal /Phascogale fence
101700 - 101900	Combined mammal /Phascogale fence
101900 - 102000	Phascogale fencing
102000 – 102100	W2G general fauna fencing
102100 – 102600	Frog fencing
102600 – 111000	W2G general fauna fencing
111000 - 111600	Phascogale fencing
111600 – 111800	Mammal / Phascogale fencing
111800 – 112100	Combined mammal/ frog fencing
112100 – 118100	Mammal fencing
118100 – 118600	Mammal Fencing
118600 – 122200	Mammal fencing
122200 - 122600	Mammal / Phascogale fencing
122600 – 123800	Mammal fencing

Chainage (m)	Fencing type
123800 – 124200	Mammal / Phascogale fencing
124200 - 127000	Mammal fencing
127000 - 128400	Mammal / Phascogale fencing
128400 - 129000	Phascogale fencing
129000 – 130100	W2G general fauna fencing
130100 – 130250	Tuckombil Canal
130250 - 134100	W2G general fauna fencing
134100 – 137800	Koala fencing
137800 – 139400	Combined Koala/ mammal fencing
139400 – 139600	Combined Koala/ mammal/ frog fencing
139600 – 139900	Combined Koala/ mammal fencing
139900 – 140100	Combined Koala/ mammal/ frog fencing
140100 – 141000	Combined Koala/ mammal fencing
141000 – 142800	Koala fencing
142800 – 145120	Combined Koala/ mammal fencing
145120 – 146100	Koala fencing
146100 – 148300	Combined Koala/ mammal fencing
148300 – 148750	Combined Koala/ mammal/ frog fencing
148750 – 159700	Combined Koala/ mammal fencing
159700 – 160700	Koala fencing
160700 – 164000	Mammal – western side of alignment
160700 - 164000	Standard highway fencing – Eastern side of alignment

5.3.2 Commence baseline surveys

No baseline surveys for Koala population size and distribution are proposed for Sections 1-8, and 11 due to the low population density of animals in these locations.

Baseline Koala surveys have focused on key Koala populations identified in Sections 8/9 and 10 of the Project and were undertaken by Ecosure (2014) for the Broadwater Population and Ecosure-Biolink for the Bagotsville population (2015). These are provided in Appendix E and Appendix F respectively.

5.3.3 Identify exclusion zones

An exclusion zone is a designated ‘no-go’ area that is clearly identified and appropriately fenced to prevent damage to native vegetation and fauna habitat. This procedure is documented in the CEMP and conducted along the entire construction corridor for all threatened species and endangered ecological communities.

Habitat exclusion zones and limits of clearing will include consideration of Koala habitat. Habitat exclusion zones will be marked out during the on-ground survey of the road corridor and the commencement of construction to ensure that these activities, including vehicles and machinery, do not intrude or remove protected and roadside vegetation in Koala habitat areas.

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

5.3.4 Identify sensitive ancillary areas and access roads

The siting of ancillary areas including stockpiles and construction infrastructure is planned to be located within cleared areas and disturbed vegetation and undertaken in accordance with NSW CoA B73, B74 and B75. This will occur across all ancillary sites for each stage of the project and will be documented in the CEMP. The procedure will avoid direct and indirect impacts to Koala habitat. All clearing will be monitored during the construction phase. Detailed plans will be prepared showing the proposed construction activities and the location of infrastructure prior to commencement of clearing. Development of ancillary facility plans will ensure there is no impact on primary or secondary Koala habitat or vegetated areas.

5.3.5 Dog policy

The CEMP includes a policy that no domestic dogs are to be brought onto the site during pre-construction and construction activities. All project personnel will be inducted as part of the CEMP.

5.4 Performance thresholds and corrective actions

Table 5-2 summarises the pre-construction environmental planning measures for Koalas that will be completed prior to the commencement of construction.

Table 5-2. Mitigation measures, performance measures and corrective actions - pre-construction.

Main goals for mitigation	Proposed mitigation measure	Monitoring/timing frequency	Performance thresholds	Corrective actions if deviation from performance thresholds
Fencing Strategy (as part of the Connectivity Strategy) completed prior to construction commencing.	Detail location of temporary and permanent fencing, encourage use of crossing points and direct Koalas from the road corridor.	Connectivity Strategy to be completed prior to construction commencing.	Connectivity Strategy and associated fencing locations signed off as complete at end of design.	Delay construction until Connectivity Strategy has been completed.
No impact to Koala habitat outside designated clearing areas and the project boundary.	Identification and appropriate fencing/marking of exclusion zones.	Identify clearing limits prior to clearing works. Inspection prior to clearing report in the CEMP to be signed off.	Exclusion fencing signed off at start of clearing.	Do not commence clearing, hold-off work and complete.
No impact to Koala habitat outside designated clearing areas and the project boundary.	Ancillary facilities and access roads to be planned and sited within cleared or disturbed areas within the project boundary and in accordance with NSW CoA B73, B74 and B75.	Ongoing during construction phase. Detailed plans to be prepared showing the proposed location of construction related infrastructure prior to commencement of clearing and construction activities during the construction phase.	Ancillary facility plans ensure there is no impact on primary or secondary Koala habitat and vegetated areas.	Amend locations until all known and potential Koala habitat that is not scheduled for removal is avoided.
No Koala deaths from contractor's domestic dogs on the project.	CEMP to document policy that prohibits dogs being brought onto the construction site.	Ongoing during construction.	No domestic dogs found on site belonging to construction personnel.	Any breach of the policy to be reported to Roads and Maritime and ER, with contractors warned that further breaches would require removal from the project.

6. Construction management measures

6.1 Potential impacts during construction

- Impacts during clearing of vegetation.
- Koalas entering the construction corridor and becoming trapped in the corridor.
- Koala vehicle collisions with construction traffic.
- Disturbance and degradation to adjoining Koala habitat.
- Dust and noise impacting on movements and habitat use.

6.2 Main goals for management

- No injuries to Koalas during clearing of vegetation.
- No injuries to Koalas during construction as a result of any construction related activity including Koala/construction vehicle collisions.
- No damage to Koala habitat within exclusion zones during construction.
- Dust and noise managed in accordance with the CEMP.
- Replanting of Koala habitat adjacent to the road corridor completed as per landscape design.
- Maintenance of habitat connectivity for Koalas across the Upgrade
- Section 10 - reducing Koala mortality by an initial 4 animals/year and thus arresting population decline such that it is statistically slower than the lower bound of the 90% confidence interval of the PVA Scenario 6 (195 at year 5, 147 at year 10 and 104 at year 15), which equates to a 1.2% decline over five years, 13.7% decline over 10 years and 27.3% decline over 15 years.).

6.3 Management measures

6.3.1 Construction work method statements

Construction Work Method Statements are prepared for specific activities to ensure sound environmental practices are implemented and to minimise the risk of environmental incidents or system failures.

Construction Work Method Statements will be prepared to address all construction Koala management requirements during construction in consultation with relevant agencies, Roads and Maritime Services and the relevant project environmental manager prior to the commencement of project activities considered to present risk to the Koala. Construction Work Method Statements will be prepared to ensure that all Koala management measures are implemented.

6.3.2 Construction induction and training

Induction training will be conducted for all contractors and project staff working in areas of known and potential Koala habitat in the project area. This training will identify areas of Koala habitat, crossing zones and key threats to the species. The importance of following the clearing and rehabilitation protocols will be made clear to all project personnel.

6.3.3 Temporary Koala exclusion fencing

Temporary fencing will be erected along either side of the existing highway alignment that is adjacent/parallel to construction and clearing works within the locality of the key populations in Section 5, Section 8 (part), Section 9 and Section 10. This will be done to minimise the risk of Koalas being hit by highway traffic during vegetation clearing works, prior to establishment of permanent fencing along these areas. The fence will be set back on each side of the road corridor by several metres so that if an animal becomes trapped between the fences it will not be on the road edge. Where this is not possible temporary escape structures must be used. The temporary fence should also extend past the northern and southern limits of the construction zone to funnel any Koalas away from the clearing/construction areas. Where there is a gap in the temporary fence for access off the existing highway, a Koala grid will be installed and the temporary fencing will be tied into the grid. The temporary Koala fencing will remain in place for the duration of all clearing works until the permanent Koala exclusion fencing is erected within these areas.

6.3.4 Permanent fauna exclusion fencing

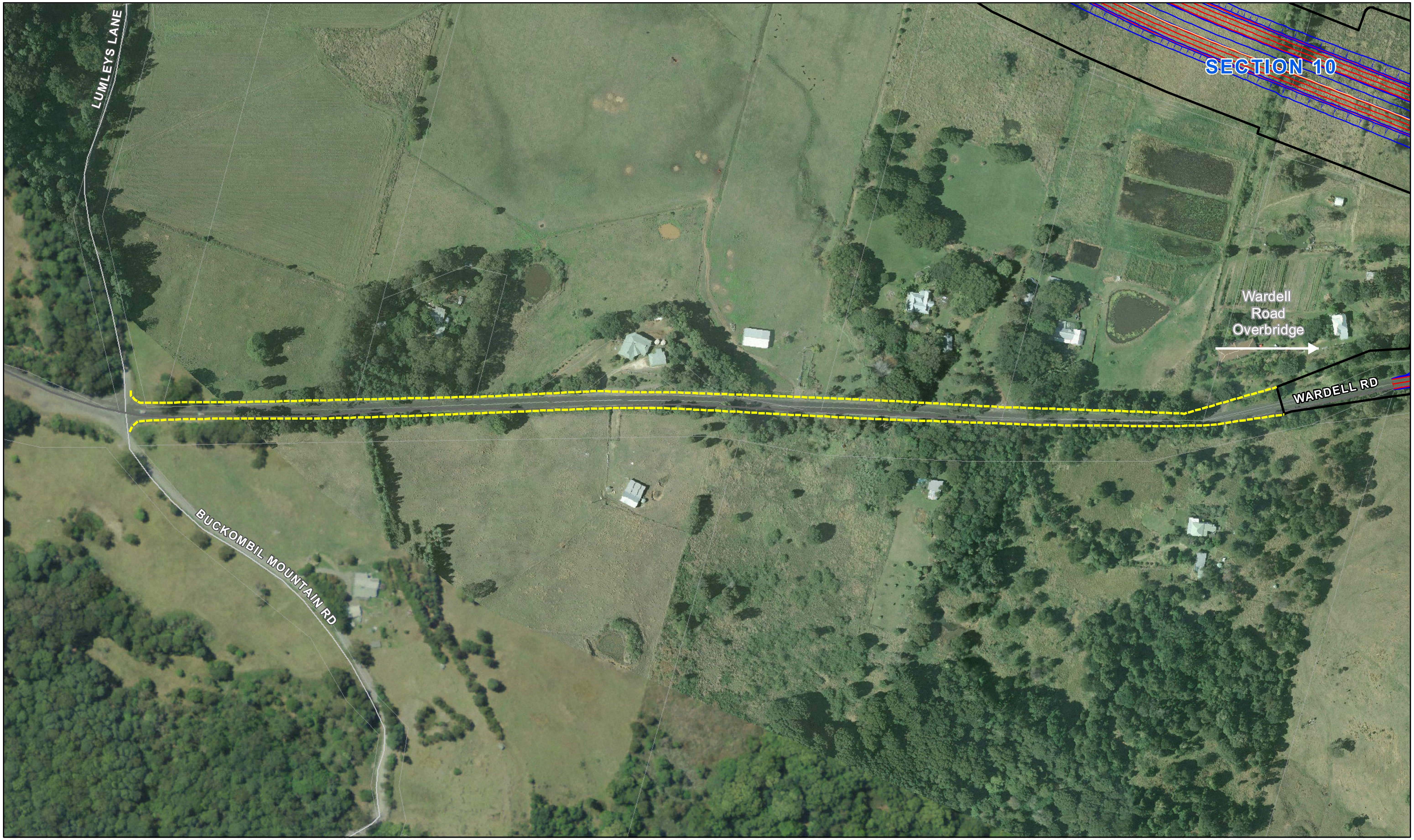
Permanent fauna exclusion fencing, using a range of designs, will be installed along the majority of the length of the Woolgoolga to Ballina Pacific Highway Upgrade (Table 5-1). Sections 1-8 (excluding the Woombah-Iluka Koala population) and 11 have relatively low Koala population densities and, as such, typical floppy-top fencing used for Koalas will not be applied to these Sections. Instead, a modified rabbit proof fence (Mammal fencing; Table 5-1) has been developed which is a minimum 1200 mm high mesh fence pegged into the ground and supported with concrete posts. This fence-type is expected to act as a barrier to deter any occasional Koalas that may encounter it. In developing this fence design, extensive consultation was undertaken with biodiversity specialists from the EPA. If any Koala injuries or road kills occur during the operation of Sections 1-8 and 11, this fence, or parts thereof, will be retro-fitted with 600 mm wide smooth metal sheeting placed near the top of the fence as an additional deterrent to Koalas.

Koala “floppy-top” or similar Koala specific fauna fencing will be installed on both sides of the highway within the three key population areas occupied by the Woombah-Iluka, Broadwater and Coolgardie-Bagotville Koala populations (i.e. Sections 5, 8-9 and 10). Progressive installation of permanent Koala-proof fencing in these areas will connect to the new connectivity structures as they are built.

In addition, permanent Koala fencing will be installed on other roads within Section 10, including on parts of the existing Pacific Highway north of Wardell to Coolgardie interchange and on parts of Wardell Road either side of its crossing with the upgraded highway in Section 10, in accordance with the Ballina Koala Plan. Koala-proof fencing will be installed prior to the commencement of clearing activities adjacent to the existing highway and Wardell Road. The location of permanent Koala fencing to be installed along the existing highway and Wardell Road in shown in Figure 6-1- Figure 6-6.

Fencing along parts of Wardell Rd and the existing highway from Wardell to Coolgardie Interchange, has the potential to create a barrier effect for Koalas and other fauna. Roads and Maritime proposes to build a connectivity structure on either side of the Wardell Rd overpass, as well as an additional connectivity structure approximately 300 metres east of the new alignment along Wardell Road. This connectivity structure, located between the township of Wardell and the upgrade, will be installed in recognition of the need to provide connectivity between the heath habitat on the northern and southern sides of Wardell Road for the Koala and also the threatened Long Nosed Potoroo. The location of the connectivity structure along Wardell Road is shown in Figure 6-2. A connectivity structure already exists on the existing highway south of the Coolgardie interchange (three cell culvert x 16 metres long x 2.2 metres high x 2.8 metres wide) and Roads and Maritime propose to build a connectivity structure on the northern side of the Coolgardie interchange (see location of structure on Figure 6-6).

Figure 6-1. Location of additional permanent Koala fencing - Wardell Road



Transport
Roads & Maritime
Services

PACIFIC HIGHWAY UPGRADE

Woolgoolga to Ballina

Koala Management Plan
Additional Fencing
Wardell Road West

Section 10
Chainage:
145 100 to 158 600

Map 1 of 6

PIR Control Line and 500m Chainages
Additional Koala Proof Fencing Existing Roads

Roads

PrimaryRoad
ArterialRoad
SubArterialRoad
LocalRoad
UrbanServiceLane

EIS / SPIR Project Boundary (Nov 2013)
Cadastre
State Forests
NPWS Reserves

Design Note:
Investigating opportunities for connectivity under the existing roads via existing infrastructure.
Fencing t o be located to minimise clearing and maximise habitat availability.

1:2,500
at A3

0 0.075 0.15
Kilometers

Print Date:	5/05/2016
Author:	SPALDINC

Path: G:\W2B\14_GIS\02_Maps\03_MXD\D00395_0238_FaunaFencingIndicativeS10_DoE_Landscape_v2.mxd

Figure 6-2. Location of additional permanent Koala fencing – Wardell Road

Transport Roads & Maritime Services

NSW GOVERNMENT

PACIFIC HIGHWAY UPGRADE

Woolgoolga to Ballina

Koala Management Plan Additional Fencing Wardell Road East

Section 10 Chainage: 145 100 to 158 600

Map 2 of 6

PIR Control Line and 500m Chainages

Additional Koala Proof Fencing Existing Roads

Roads

PrimaryRoad

ArterialRoad

SubArterialRoad

LocalRoad

UrbanServiceLane

EIS / SPIR Project Boundary (Nov 2013)

Cadastre

State Forests

NPWS Reserves

Design Note:
Investigating opportunities for connectivity under the existing roads via existing infrastructure.
Fencing t o be located to minimise clearing and maximise habitat availability.

1:2,500
at A3

0 0.075 0.15
Kilometers

Print Date:	5/05/2016
Author:	SPALDINC

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Figure 6-3. Location of additional permanent Koala fencing – Wardell Road

Transport Roads & Maritime Services

PACIFIC HIGHWAY UPGRADE

Woolgoolga to Ballina

Koala Management Plan Additional Fencing Wardell Road East

Section 10
Chainage: 145 100 to 158 600

Map 3 of 6

PIR Control Line and 500m Chainages
Additional Koala Proof Fencing Existing Roads

Roads

PrimaryRoad
ArterialRoad
SubArterialRoad
LocalRoad
UrbanServiceLane

EIS / SPIR Project Boundary (Nov 2013)
Cadastre
State Forests
NPWS Reserves

Design Note:
Investigating opportunities for connectivity under the existing roads via existing infrastructure.
Fencing t o be located to minimise clearing and maximise habitat availability.

1:2,500
at A3

0 0.075 0.15
Kilometers

Print Date:	5/05/2016
Author:	SPALDINC

Path: G:\W2B\14_GIS\02_Maps\03_MXD\D00395_0238_FaunaFencingIndicativeS10_DoE_Landscape_v2.mxd

Figure 6-4. Location of additional permanent Koala fencing – existing highway

Transport
Roads & Maritime Services

PACIFIC HIGHWAY UPGRADE

Woolgoolga to Ballina

Koala Management Plan
Additional Fencing
Wardell to Coolgardie Rd

Section 10
Chainage:
145 100 to 158 600

Map 4 of 6

PIR Control Line and 500m Chainages
Additional Koala Proof Fencing Existing Roads

Roads

PrimaryRoad
ArterialRoad
SubArterialRoad
LocalRoad
UrbanServiceLane

EIS / SPIR Project Boundary (Nov 2013)
Cadastre
State Forests
NPWS Reserves

Design Note:
Investigating opportunities for connectivity under the existing roads via existing infrastructure.
Fencing t o be located to minimise clearing and maximise habitat availability.

1:2,500
at A3

0 0.075 0.15
Kilometers

Print Date: 5/05/2016

Author: SPALDINC

Path: G:\W2B\14_GIS\02_Maps\03_MXD\D00395_0238_FaunaFencingIndicativeS10_DoE_Landscape_v2.mxd

Figure 6-5. Location of additional permanent Koala fencing – existing highway

Transport Roads & Maritime Services

NSW GOVERNMENT

PACIFIC HIGHWAY UPGRADE

Woolgoolga to Ballina

Koala Management Plan Additional Fencing Wardell to Coolgardie Rd

Section 10 Chainage: 145 100 to 158 600

Map 5 of 6

- PIR Control Line and 500m Chainages
- Additional Koala Proof Fencing Existing Roads

Roads

- PrimaryRoad
- ArterialRoad
- SubArterialRoad
- LocalRoad
- UrbanServiceLane

- EIS / SPIR Project Boundary (Nov 2013)
- Cadastre
- State Forests
- NPWS Reserves

Design Note:
Investigating opportunities for connectivity under the existing roads via existing infrastructure.
Fencing t o be located to minimise clearing and maximise habitat availability.

1:2,500
at A3

0 0.075 0.15
Kilometers

Print Date: 5/05/2016

Author: SPALDINC

Path: G:\W2B\14_GIS\02_Maps\03_MXD\D00395_0238_FaunaFencingIndicativeS10_DoE_Landscape_v2.mxd

Figure 6-6. Location of additional permanent Koala fencing – existing highway

Transport Roads & Maritime Services

NSW GOVERNMENT

PACIFIC HIGHWAY UPGRADE

Woolgoolga to Ballina

Koala Management Plan
Additional Fencing
Wardell to Coolgardie Rd

Section 10
Chainage:
145 100 to 158 600

Map 6 of 6

PIR Control Line and 500m Chainages

Additional Koala Proof Fencing Existing Roads

Roads

PrimaryRoad

ArterialRoad

SubArterialRoad

LocalRoad

UrbanServiceLane

EIS / SPIR Project Boundary (Nov 2013)

Cadastre

State Forests

NPWS Reserves

Design Note:
Investigating opportunities for connectivity under the existing roads via existing infrastructure.
Fencing t o be located to minimise clearing and maximise habitat availability.

1:2,500
at A3

0 0.075 0.15
Kilometers

Print Date:	5/05/2016
Author:	SPALDINC

Path: G:\W2B\14_GIS\02_Maps\03_MXD\D00395_0238_FaunaFencingIndicativeS10_DoE_Landscape_v2.mxd

6.3.5 Pre-clearing and clearing procedures

Pre-clearing and clearing procedures will be outlined in the CEMP and FFMP, and will be undertaken in accordance with *Biodiversity Guidelines: Protecting and managing biodiversity on RTA Projects* (RTA 2011), in order to minimise impacts on flora and fauna.

Although Sections 1-8 and 11 have low density Koala populations, pre-clearing surveys would be conducted prior to the commencement of any vegetation clearing works to identify Koalas and other fauna within the construction corridor. The pre-clearing process targets all fauna habitat and is a requirement of the CEMP. Searches for signs of Koala activity and Koala presence will form a part of this process. The results of the pre-clearing process will inform planning and procedures for the staged habitat removal process and are documented as part of the FFMP.

The pre-clearing procedures detailed below were informed by the sequential vegetation clearing and requirements for clearing Koala habitat trees in Queensland (EPA 2006), and by subsequent discussions with a range of Koala experts and the NSW EPA.

Clearing procedures will also be informed by the Roads and Maritime unexpected finds procedures (RTA 2011) should a Koala be encountered in the construction corridor at any time during construction.

Clearing Procedure – all Sections

Specifically for Koalas in all Sections, clearing of trees will be undertaken in a way that ensures Koalas living in or near the clearing area have enough time to move out of the site without human intervention. In summary this involves:

- Staged clearing, i.e. sequential thinning or partial removal of trees in progressive stages, to allow Koalas to safely leave the clearing area and relocate to adjacent habitat.
- An ecologist will undertake daylight canopy search surveys of the scheduled clearing area prior to vegetation clearing (i.e. early in the morning prior to the commencement of vegetation clearing activities) to identify trees in which a Koala is present and any adjacent trees with overlapping crowns.
- Suspension of clearing works for a minimum period of 48 hours if a Koala is found within a clearing area to allow the animal to move out of the construction site on its own volition.
- The direction of sequential clearing will be away from threatening processes or hostile environments, i.e. roads. The ecologist is responsible for verifying that sequential clearing has taken place.
- Each tree identified by the ecologist as being a risk to a Koala if felled, will not be felled, damaged or interfered with until the Koala has moved from the clearing site. The ecologist will physically move Koalas if necessary in accordance with Biodiversity Guidelines: Protecting and managing biodiversity on RTA Projects (RTA 2011).
- In the event that a Koala remains in the clearing site for more than 48 hours, it will be captured and relocated by a suitably qualified person to the nearest area of habitat identified as suitable for Koala release and where the individual is at no risk of further harm.

For Section 5, the northern portion of Section 8, Section 9 and Section 10 where the three key Koala populations are located, additional nocturnal spotlighting searches will be undertaken to maximise the likelihood of locating Koalas. These searches will be conducted in the two hours pre-dawn by an experienced ecologist on the day that clearing takes place. This will be followed by the procedure described above (i.e. daylight canopy searches on the morning of proposed clearing). It is considered that the combination of the two survey techniques on the day of clearing will ensure that no Koalas are missed, so that the chance of Koala mortality during clearing works can be minimised.

Section 10 also supports two known Koala 'hot-spot' areas: Laws Point (chainage 146000 – 147000) and Wardell Road (152200 – 153500) (Phillips *et. al.* 2015). Additional pre-clearing and clearing measures will be undertaken within these areas in recognition of the relatively high likelihood that Koalas may be encountered, and in an effort to minimise any potential impacts to the animals located there. These measures are detailed below.

Phased Resource Reduction - Section 10: Koala 'hot-spots'

In addition to the measures set out above, Roads and Maritime Services propose to undertake a staged approach to vegetation clearing, referred to as 'phased resource reduction',

Phased resource reduction involves the gradual reduction of food resources within Koala habitat (by ring-barking and/or collaring trees) to facilitate the safe and voluntary movement of Koalas into adjacent available habitat and avoid indirect deaths (FitzGibbon *et al.* 2013). Indirect deaths are those that may occur as a consequence of factors and/or ecological processes independent of the Project e.g. predation. It operates on the basis that by slowly reducing the availability of Koala food trees, the value of the habitat to resident Koalas will gradually decline. This will allow resident Koalas to vacate the clearing area over a period of time of their own accord, without human intervention, prior to clearing. The phased resource reduction methodology aims to reduce any stress-induced impacts on Koalas associated with clearing activities for the new highway alignment.

Because this strategy has not been adopted elsewhere, including in NSW by RMS, and in order to monitor the potential impacts on the Koalas as a result of this process, an intensive population monitoring program will be undertaken in the vicinity of the 'hot-spots', prior to, during and after clearing to monitor the effect of the works on any resident animals. The proposed phased resource reduction strategy is detailed below and the associated Koala monitoring strategy is detailed in Section 8.2. The monitoring process has been designed to be adaptive such that information gained during monitoring will be fed back into the resource reduction and clearing process.

The protocol involves installing collars on all trees within the proposed clearing footprint. All trees to be collared will be mapped and tagged at the beginning of the process, prior to collars being installed. Trees with hollows will also be mapped and tagged as collaring these trees may prevent fauna utilising them to vacate the tree (see below), Hard plastic, polycarbonate or metal sheeting will be placed as a sleeve (or 'collar') around the lower trunk of all Koala food trees and other significant shelter and resting trees in the clearing footprint area to prevent Koalas from using these resources and discouraging them from re-entering the clearing area. This will allow resident Koalas to vacate the clearing area over a period of time of their own accord, without human intervention, prior to clearing. The location of the Wardell Road and Laws Point Koala 'hot-spots', known food trees and proposed survey areas are shown on Figure 6-7.

In more densely forested areas, such as Laws Point, Koalas may move through the canopy of the trees in order to access collared food-trees. In order to minimise the chance of this occurring, in these areas, a percentage of trees that are identified to aid Koala movement through the canopy onto collared food trees will also be ring-barked to induce de-foliation. Ring-barking will require the complete removal of a section of the bark around the circumference of the tree trunk near ground level. It was suggested that this be trialled to assess the rate of de-foliation and in an effort to stop the Koalas utilising these trees (Sean FitzGibbon *pers. comm.* 10 June 2016). In order to trial this and also assess the rate of de-foliation, it is proposed that approximately 20% of trees within each hot-spot, that form continuous canopy with neighbouring food trees, be ringbarked. A tree will be deemed to be de-foliated once more than 90% of the leaves have fallen, wilted or dead.

The collars will be approximately 60 cm wide and placed between one and two metres off the ground. The distance of the collar from the ground will depend on whether Koalas have been detected utilising the tree or if there are hollows present where other arboreal fauna might be sheltering. If a Koala is in the tree and/or tree hollows are obvious then the collar will be placed lower (approximately one metre from the ground) to allow safe descent from the trees. If there are no obvious hollows or no Koalas detected, the collar will be placed higher (at least 1.7 metres off the ground) to allow animals to climb the tree and gain temporary refuge from terrestrial predators if required. This height has been found to be a sufficient perch height for common fauna, such as reptiles, fleeing approaching predators (Cooper and Blumstein 2015). If a tree is collared that contains a Koala it will be monitored to ensure the Koala has been able to leave the tree of its own accord. If after 48 hours the Koala has not moved from the tree the collar will be removed and not reinstalled until the Koala has moved on.

Trees will be collared sequentially over a period of approximately six weeks prior to commencement of clearing, with the aim of collaring the majority (80%) of Koala food and shelter trees in each of the Laws Point and Wardell Road Koala hot spot locations, within the first four weeks, and the remaining 20% two weeks after that, such that by the end of six weeks all trees will have been collared/ring-barked. This will allow for three weeks prior to clearing occurring for further monitoring of these hot spot areas for koala activity to determine if additional mitigation (such as installation of additional tree collars in the adjacent habitat) is necessary. The proposed phased resource reduction schedule is shown in Table 6-1.

Table 6-1. Proposed phased resource reduction schedule.

Phase	Activity	Timing
1	Tag and map all trees to be collared/ring-barked	Week 1
	Population monitoring	***Weeks 1,2,3***
2	Collar 40% of all trees within Wardell Road and Laws Point 'hot-spots' Ring-bark 20% trees within each 'hot-spot'.	Week 4
	Population monitoring	***Week 5***
3	Collar further 40% of trees within 'hot-spot' areas	Week 6
	Population monitoring	***Week 7***
4	Collar remaining 20% of trees within 'hot-spot' areas	Week 8
	Population monitoring	***Week 10***
5	Clearing commences	Week 11
	Population monitoring	***Weeks 13-16***

The area of the phased resource reduction includes approximately eight hectares within the alignment at Wardell Road and 10 hectares within the alignment at Laws Point. The habitat quality within each section differs in that the section of the alignment at Wardell Road includes relatively poor Koala habitat supporting mainly cleared, open grassland with scattered food trees with a marginal area of low-quality habitat; while the section of the alignment at Laws Point includes relatively high quality habitat with densely forested land supporting relatively more Koala food trees (Figure 3-10 and Figure 6-7). Suitable habitat for Koalas is known to occur adjacent to these areas with 77% of mapped Koala food trees located outside the clearing footprint in the identified Koala hot spot areas (refer to Table 4-2).

Koala fencing will be installed on Wardell Road adjacent to the new alignment prior to tree collaring commencing. Roads and Maritime Service will also work with JALI LALC to undertake predator control targeting wild dogs and foxes in the lead up to tree collaring commencing. These management actions are planned to be undertaken to help avoid indirect impacts to Koalas as they gradually re-establish home ranges as a result of the tree collaring process.

Figure 6-7. Location of food trees and proposed survey transects within the alignment at Laws Point and Wardell Road Koala 'hot-spots'.

Drawn by: RJ Project Manager: AG Project Number: 2622 Date: 23/06/2016

Location of food trees and proposed survey transects within the alignment adjacent to the Section 10 Koala 'hot-spots'

Woolgoolga to Ballina Koala Management Plan

niche Environment and Heritage

FIGURE 6-7

Imagery: (c) LPI 2009 - 2012

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6.3.6 Koala relocation protocol

An ecologist will be present on site prior to and during all vegetation clearing to allow Koalas to safely leave the clearing site and relocate to adjacent habitat without human intervention. In the event that a Koala does not move of its own volition after a period of 48 hours, it will be trapped and re-located. The ‘corflute method’ will be used for trapping Koalas. This typically involves the use of a plastic guard, or similar material (approximately 100 centimetres tall) and, optionally, a cage trap arrangement placed in the fence near the base of the target tree, as shown in Photo 6-1 (AMBS 2011). The tree(s) within the trap are fitted with a collar (50cm wide strip of polycarbonate) approximately one metre off the ground to prevent the Koala going back up the tree(s) once on the ground. The animal is captured once it comes down the tree to find alternate food sources (Koalas usually change trees every day but may sometimes stay in the same tree for longer periods). The Koala enters the trap in an attempt to escape as it is the only opening in the plastic guard.

Photo 6-1. Trap designed to capture Koalas (source AMBS 2011)

Once captured, the Koala’s health will be assessed and details recorded of age, sex, weight, body measurements, and presence of pouch or back young (for females). All healthy animals will be ear tagged, micro-chipped (using a PIT tag) and relocated into adjacent habitat identified for Koala release. Release points will be not more than 100 metres away provided that suitable habitat is present. If an injured Koala is captured, it will be transported to an experienced wildlife veterinarian for treatment. The NSW Code of Practice for Injured, Sick and Orphaned Koalas (OEH, 2011) (refer to Appendix H) will be followed for trapping and relocating Koalas and dealing with any injured Koalas encountered during the clearing procedure.

Direct interactions with Koalas must only be conducted by a suitably qualified and experienced ecologist who holds the necessary capture and handling permits issued by the OEH, or other licensed wildlife carers.

6.3.7 Managing construction vehicle collisions with Koalas

A licensed wildlife carer/ecologist will be present on site during all vegetation clearing and habitat removal activities to redirect Koalas that may be encountered during clearing activities.

Following the clearing works and throughout the remainder of the construction period, any observations of Koalas in the construction corridor will also follow the unexpected threatened species find procedure as detailed in Appendix O of the approved Construction Flora and Flora Management Plan, which have been developed based on the RTA (2011) unexpected threatened species find procedure.

All construction vehicles will be required to comply with the speed limits set out in the CEMP and to remain within the designated construction corridor. The speed limit within the construction zone will range from 10 km/hr – 60 km/hr, depending on construction activities and construction machinery. Speed limits will be reduced to 80 km/hr on the existing Pacific Highway adjacent to highway upgrade works and 40 km/hr on local access roads.

Given the likely increased traffic on local roads during the construction period, Koala awareness signs will be erected on local roads in Koala road-kill hot-spot areas to make motorists aware of the potential for Koalas to cross the road.

6.3.8 Wave 1 early works Mororo cut (borrow) site

The following management section describes the actions required for the Wave 1 early works at the Mororo cut (borrow) site. Construction is expected to commence at the Mororo cutting in February 2016.

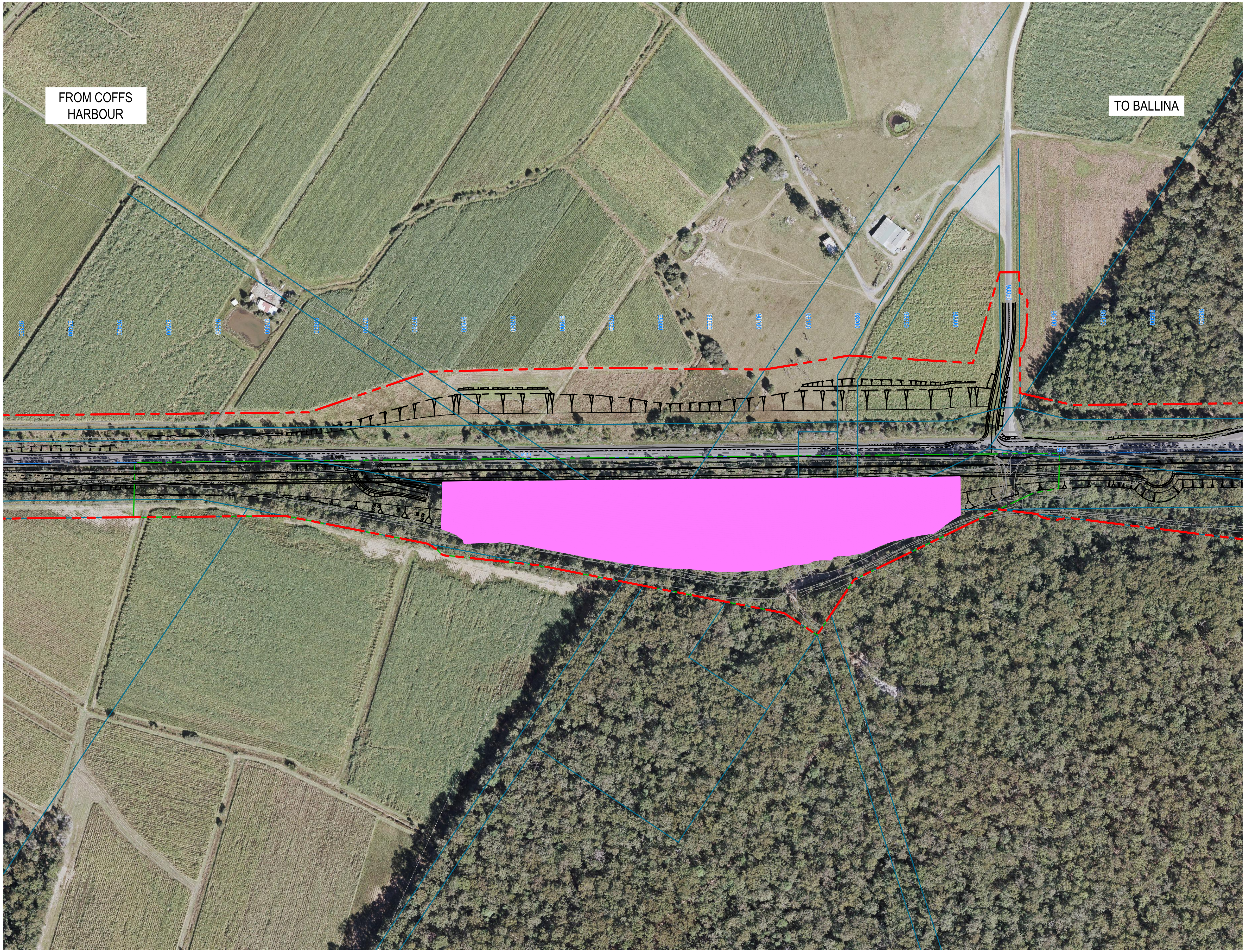
The Woombah-Iluka Koala population is defined as the population that occurs within a five kilometre radius of the Illuka Road/ Pacific Highway interchange and which occurs approximately between chainage 94,000 – 102,000. A material extraction site for the Wave 1 works is proposed within the northern extent of the Woombah-Iluka population at the Mororo cutting between chainage 97,700 and 98,400 (Figure 6-8). The following measures are proposed to minimise any potential impacts on Koalas within the proposed Mororo cut (borrow) site.

The construction at the Mororo cut (borrow) site will involve the removal of approximately 3.55 ha of native vegetation. The clearing of vegetation is to follow the procedure in Section 6.3.5, with the following additional measures:

- Prior to clearing, erect temporary Koala fencing on the eastern side of the existing Pacific Highway for a total length of 1.1km (chainage 97,500 to 98,600), which includes extending fencing 200 metres either side of the cut site. The temporary fencing is to protect any displaced Koalas from road strike as a result of the vegetation clearing process. This fence will be set back on the eastern side of the highway by several metres so that animals crossing the existing highway from the west will not be trapped on the road edge. Where there is a gap in the temporary fence at approximate chainage 97,700 for access off the existing highway, a Koala grid will also be installed and the temporary fencing tied into the grid.
    - Clearing is to follow the two staged clearing process as described in Section 6.3.5, with the addition of nocturnal spotlight searches. Spotlighting is to be done in the two hours pre-dawn on the night prior to the scheduled clearing to provide greater assurance that no animals are present in the area proposed for clearing that day and to ensure that no animals move into the construction site prior to daylight and clearing.
    - An ecologist will also undertake daylight canopy search surveys of the scheduled clearing area prior to vegetation clearing (i.e. in the morning prior to the commencement of vegetation clearing activities) to identify trees in which a Koala is present and any adjacent trees with overlapping crowns.
    - Suspension of clearing works for a minimum period of 48 hours if a Koala is found within a clearing area to allow the animal to move out of the construction site on its own volition.

- The direction of sequential clearing will be away from threatening processes or hostile environments, i.e. roads. The ecologist is responsible for verifying that sequential clearing has taken place.
- Each tree identified by the ecologist as being a risk to a Koala if felled, will not be felled, damaged or interfered with until the Koala has moved from the clearing site.
- In the event that a Koala remains in the clearing site for more than 48 hours, it will be captured and relocated in nearby suitable habitat by an experienced ecologist.

Figure 6-8. Location of the Mororo cut (borrow) site.



PLAN

NOTES

1. FOR GENERAL NOTES REFER TO SHEET EW-00010 AND EW-00011
2. FOR LEGEND REFER TO EW-00013

EARLY WORKS EXCAVATION EXTENTS

UTILITY INFORMATION SHOWN ON THE PLANS DOES NOT DEPICT ANY MORE THAN THE PRESENCE OF A SERVICE, BASED ON AVAILABLE DOCUMENTARY EVIDENCE. THE PRESENCE OF A UTILITY SERVICE, ITS SIZE AND LOCATION SHOULD BE CONFIRMED BY FIELD INSPECTION, PRIOR TO THE COMMENCEMENT OF ROADWORKS AND THE RELEVANT UTILITY PLANS OBTAINED BY DIALLING 1100 OR FAX 1300 652 077 (DIAL BEFORE YOU DIG). CAUTION SHOULD BE EXERCISED WHEN WORKING IN THE VICINITY OF ALL UTILITY SERVICES.

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150mm ON A3 SIZE ORIGINAL

DOCUMENT NUMBER / NAME: W2B-PC01-B-EW-SKT-00004

DESIGN LOT CODE

DESIGN MODEL FILE(S) USED FOR DOCUMENTATION OF THIS DRAWING

EXTERNAL REFERENCE FILES:
RMS-A3-1503-W2B
X-W2B-MORORO-RG-B-TEMPWORKS-PL
X-W2B-MORORO-RG-B-ALIGN-PL
X-W2B-CIV-EX-B-SURVEY-PL
X-W2B-CIV-CD-ALIGN-CTRL-2000-GLOBAL
X-W2B-CIV-RG-B-ALIGN-CTRL-2000
X-W2B-CIV-RG-C-ALIGN-CTRL-2000
X-W2B-CIV-RG-D-ALIGN-CTRL-2000
X-W2B-CIV-RG-A-ALIGN-CTRL-2000
X-W2B-CIV-REF-B-ALIGN-CTRL-2000
X-W2B-CIV-REF-C-ALIGN-CTRL-2000
X-W2B-CIV-REF-D-ALIGN-CTRL-2000
X-W2B-CIV-REF-A-ALIGN-CTRL-2000
X-W2B-CIV-GN-BDY-PL-GLOBAL
X-W2B-CIV-EX-CADAST-PL-GLOBAL
X-W2B-MORORO-RG-B-CLEARING-PL
X-W2B-CIV-EX-AERIAL-GLOBAL-LOW-RES.

REV	DATE	AMENDMENT / REVISION DESCRIPTION	WVR No.	APPROVAL
01	17.10.15	PRELIMINARY DESIGN		

SCALES ON A3 SIZE DRAWING: 0 20 40 60 80 100 SCALE 1:2000m

CO-ORDINATE SYSTEM: MGA ZONE 53
HEIGHT DATUM: A.H.D.

DRAWINGS / DESIGN PREPARED BY: PACIFIC COMPLETE
Ernst & Young Centre, Level 27 680 George Street, Sydney NSW 2000
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PLOT DATE / TIME: 2 October 2015 - 9:57:51 AM
PLOT BY: Saba, Michael

TITLE	NAME	DATE
DRAWN	MICHAEL SABA	17.10.15
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DESIGN	STEVE ELLIS	17.10.15
DESIGN CHECK	DALIA DAKKAN	17.10.15
DESIGN MNGR	MIKE DICKENS	17.10.15
PROJECT MNGR	ANGUS STURROCK	17.10.15

CLIENT: NSW GOVERNMENT Transport Roads & Maritime Services

PREPARED FOR: FOR REVIEW

CLARENCE VALLEY COUNCIL
HW10 - PACIFIC HIGHWAY
MACLEAN TO DEVILS PULPIT
PORTION B
MORORO BORROW SITE
GENERAL OVERVIEW PLAN 1 OF 2

A3

RMS REGISTRATION No.
PART 1

ISSUE STATUS: IFI
EDMS No.
SHEET No.: EW-B-00009
ISSUE

6.3.9 Fauna crossing structures

A number of dedicated and combined fauna/drainage connectivity structures for Sections 1-11 are positioned to maintain existing levels of landscape connectivity for all fauna, including the Koala, and have been developed in close consultation with EPA/OEH and DPI Fisheries. Fauna connectivity structures that are targeted to Koalas, or which may be used by Koalas, are summarised in Table 6-2 below. Note: the numbers and sizes of the connectivity structures listed in this table are subject to revision as part of Connectivity Strategy required under MCoA D2 and DoE Condition of Approval 13.

The locations of these fauna connectivity structures are indicated by the chainages in Table 6-2 and, for Sections 1 and 2, are displayed on maps in Figures 1-1 and 1-2 of the Final Connectivity Strategy (April 2015). It should be noted that many additional under-road structures designed primarily for drainage will also be built in each Section of the highway upgrade and a number of these could also be used by Koalas. Any Targeted Koala structures (identified with a tick in Table 6-2) in the pavement re-use sections shall be built as specified for both carriageways of the upgraded highway.

Approximately 133 combined and dedicated structures that are likely to allow for some dispersal for the Koala are proposed for Sections 1- 11 (Table 6-2). The primary fauna connectivity structures in Sections 1- 11 include:

- Fifty-four bridges with fauna passage beneath, including dry ground retained along river banks
- Forty-four combined drainage / fauna passage culverts in wet areas
- Thirty-five dedicated fauna underpasses for Koalas and other fauna.

Additional fauna crossing structures beyond what was envisaged in the EIS/SPIR will be installed along Section 5, 8, 9 and Section 10 to ensure sufficient connectivity across the highway for these key Koala populations. A total of 39 targeted Koala crossing structures will be installed within Section 8, 9 and 10 including 26 within Section 10 alone (Table 6-2). The number of structures within Section 10 was determined as a function of the PVA such that it was assumed that this number of structures would allow for between 40-100% connectivity for the populations on either side of the road. The crossing structures in Sections 8, 9 and 10 include:

- Fourteen bridges with fauna passage beneath, including dry ground retained along river banks
- Ten combined drainage / fauna passage culverts in wet areas
- Fifteen purpose-built dedicated fauna passage culverts.

Koala proof fencing (e.g. floppy-top, colourbond or chain-link with metal sheeting) along parts of Wardell Rd and the existing highway from Wardell to Coolgardie Interchange, has the potential to create a barrier effect for Koalas. Roads and Maritime proposes to build a connectivity structure on either side of the Wardell Road overpass, as well as a connectivity structure between the township of Wardell and the upgrade to provide connectivity for Koalas and Potoroos within the Wardell Heath shown in Figure 6-1- Figure 6-6. A connectivity structure already exists on the existing highway south of the Coolgardie interchange and Roads and Maritime propose to build a connectivity structure on the northern side of the Coolgardie interchange. Should further opportunities exist along these roads to provide connectivity by retro-fitting existing structures to make them Koala friendly, then this will be investigated.

The dimensions of underpasses that have been shown to facilitate Koala movements (Taylor and Goldingay 2003, AMBS 2011) include:

- Box culvert of three metres height (H) x three metres width (W) – especially for four or greater lane carriageways.
- Box culvert of 2.4 metres (H) x 2.4 metres (W) – as a minimum for a single or dual carriageway (this size may include Koala furniture).
- Preferably, all dedicated underpasses to be less than 50 m in total length.

Fauna furniture will be placed within dedicated Koala underpasses and, where possible, in some combined fauna crossing structures. Fauna furniture includes hard wood horizontal and vertical logs within and outside the culvert to provide a dry passage for Koalas whilst also providing refuge from predators. Previous Koala monitoring on the Pacific Highway in north-east NSW (AMBS 2011) demonstrated that log furniture in underpasses was used by a Koala but not by all animals. This suggests that furniture may facilitate the use of the underpass by some individual Koalas.

Fauna furniture installed at the targeted Koala underpasses will be finalised in the detailed design and adhere to the connectivity guidelines in the EIS which include:

- Horizontal logs placed as high off the ground as possible for Koalas to avoid predators with a minimum space of 600 millimetres between the top of the horizontal log and the structure's roof.
- Horizontal logs supported by vertical logs at regular intervals (approximately every 2-3 metres) along the underpass for Koalas to ascend or descend the Koala furniture as required.
- Logs greater than 200 millimetres in diameter.
- Koala furniture extends beyond the underpass into Koala habitat.
- Where fauna furniture is placed inside a culvert, it is to be constructed on the left or right side of the culvert (not in the middle), to minimise incidence of flooding.

Strategic planting of Koala habitat adjacent to targeted connectivity structures will also be undertaken post-construction, or beforehand if practicable, to improve and maintain connectivity.

Fauna exclusion fencing will be constructed to funnel Koalas to the fauna crossing structures and will be designed with a return at the end to encourage Koalas to move back into habitat and not directly onto the highway. Additional features will be incorporated into the fauna exclusion fencing design, such as fauna drop downs. Permanent Koala fencing will be progressively installed during the construction period, leaving openings at key crossing locations. The project aims to have connectivity structures in key connectivity areas built as soon as possible in the construction program to allow permanent fauna fencing to direct Koalas to these structures.

The monitoring program described in Chapter 8 of this plan will focus on monitoring the effectiveness of crossing structures and exclusion fencing for Koalas. This includes monitoring performance of structures and implementing corrective actions where required.

Table 6-2 Fauna connectivity structures.

Project section	Chainage (m)	Connectivity structure (Cell No x wxhxl*)	Functionality	Targeted Koala Structure
1	2000	3 x 3 x 3 x 45 m	Combined culvert	
1	3600	62 m long	Bridge	
1	4150	300 m long	Bridge	
1	4750	74 m long	Bridge	
1	5660	3 x 3.6 x 1.5 x 25 m	Combined culvert	
1	5660	4 x 3.3 x 1.5 x 35 m	Combined culvert	
1	6170	64 m long	Bridge	
1	6890	1 x 3 x 2.7 x 45 m	Dedicated culvert	
1	7280	1 x 3 x 3 x 80 m	Combined culvert	
1	8470	1 x 3 x 3 x 51 m	Dedicated culvert	
1	8800	1 x 3 x 3 x 50 m	Dedicated culvert	
1	10340	2 x 2.1 x 0.9 x 69 m	Combined culvert	
1	10750	2 x 3 x 3 x 62 m	Combined culvert	
1	11710	1 x 3 x 3 x 57 m	Dedicated culvert	

Project section	Chainage (m)	Connectivity structure (Cell No x wxhxl*)	Functionality	Targeted Koala Structure
1	12420	1 x 3 x 3 x 52 m	Dedicated culvert	
1	12880	1 x 3 x 3 x 54 m	Combined culvert	
1	13310	2 x 3.6 x 3.3 x 27 m	Combined culvert	
1	13310	2 x 3.6 x 3.3 x 66 m	Combined culvert	
1	13800	1 x 3 x 3 x 49 m	Combined culvert	
1	14280	1 x 3 x 3 x 71 m	Combined culvert	
2	17710	1 x 3 x 2.4 x 57 m	Dedicated culvert	
2	18120	2 x 2.7 x 2.1 x 79 m	Combined culvert	
2	19180	1 x 3 x 3 x 59 m	Combined culvert	
2	19880	1 x 3 x 3 x 54 m	Dedicated culvert	
2	20650	4 x 3.6 x 2.7 x 64 m	Combined culvert	
2	20780	57 m long	Bridge	
2	20880	1 x 3 x 3 x 66 m	Combined culvert	
2	21290	1 x 3 x 3 x 47 m	Combined culvert	
2	22400	78 m long	Bridge	
2	23130	1 x 3 x 3 x 22 m	Dedicated culvert	
2	23131	1 x 3 x 3 x 22 m	Dedicated culvert	
2	23750	1 x 3 x 2.7 x 43 m	Dedicated culvert	
2	24570	1 x 3 x 3 x 42 m	Combined culvert	
2	25850	1 x 3 x 3 x 45 m	Dedicated culvert	
2	27420	1 x 3.6 x 3 x 60 m	Combined culvert	
2	29300	1 x 2.4 x 2.4 x 25 m	Dedicated culvert	
2	29360	26 m plus existing	Bridge (Bebo Arch)	
3	35211	2.4x 2.4x 58m.	Combined culvert.	
3	36379	3.6 high x34.5m length	Bridge.	
3	37301	2.4 x 2.4 x 48m	Combined culvert.	
3	39641	3 x 1.2 x22m	Combined culvert.	
3	39671	3x 1.2 x 58m	Combined culvert.	
3	42522	3.6 high x 120m length	Bridge	
3	43102	3.6 high x 370m length	Bridge	
3	43887	3.6 high x 200m length	Bridge	
3	46055	3.6 high x 80m length	Bridge	
3	46325	3.6 high x 90m length	Bridge	
3	46647	3.6 high x 56m length	Bridge	
3	47181	5.2 high x 20m length	Bridge	
3	47643	3.6 high x 60m length	Bridge.	
3	47925	3.6m high x 65m length	Bridge	
3	48742	4.6 high x 29m length	Bridge	
3	49246	3.6 high x 80m length	Bridge.	
3	50280	3.6 high x 45m length	Bridge	

Project section	Chainage (m)	Connectivity structure (Cell No x wxhxl*)	Functionality	Targeted Koala Structure
3	51419	3.6 high x 20m length	Bridge	
3	51854	5.3 high x 55m length	Bridge	
3	52427	3.6 high x 77m length	Bridge	
3	52594	3.6 x 2.1 x 44 m	Combined culvert.	
3	53699	5.5m high x 25.8m length	Bridge	
3	54695	3.6 high x 75m length	Bridge	
3	56885	5.6 high x 29m length	Bridge	
3	57014	5 high x 91m length	Bridge.	
3	58626	5.3 high x 75m length	Bridge	
3	59272	3.6 high x 22.7m length	Bridge	
3	60802	3.6 high x 29m length	Bridge	
3	61033	5.3 high x 31m length	Bridge	
3	64492	3 x 3 x 45 m	Combined culvert.	
3	66190	3 x 3 x 44 m	Dedicated culvert	
4	70455	3.6 high x 28m length	Bridge	
4	74755	3.6 high x 872m length	Bridge.	
4	75565	2.4 x 3.6 x 42 m	Combined culvert.	
4	76450	2.4 x 2.4 x 45m	Combined culvert	
5	83100	4.6 high x 24.9m length	Combined (bridge)	
5	93990	216.6m length	Combined (bridge)	
5	96150	2.4 x 2.4 <40m	Dedicated culvert	√
6	99730	3 x 2.4 x 45 m	Dedicated culvert	
6	100640	2.4 x 1.8 x 62 m	Combined culvert	
6	101100	2.4 x 1.8 x 41 m	Dedicated culvert.	
6	101541	110m length	Bridge	
6	102850	60m length	Bridge	
7	115272	2.77 high x 80m length	Bridge	
7	118500	2.3 high x 20m length	Bridge	

Project section	Chainage (m)	Connectivity structure (Cell No x wxhxl*)	Functionality	Targeted Koala Structure
7	122550	3 x 2.4 x 38.55 m	Combined culvert	
7	123590	3 x 2.4 x 46.985m	Combined culvert	
8	130107	4.48 high x 170m length	Bridge	
8	134600	2.44 high x 40m length	Bridge.	√
8	135575	1.3m height x 15m length	Bridge	
8	136700	Minimum height 2.4m x 20m length	Bridge	√
9	137300	2.4 x 2.4 x <40m length	Dedicated culvert	√
9	138430	1.5 x 1.5m x 64.8m length	Dedicated culvert	
9	139050	4.65m Height x 40m length	Bridge	
9	139440	1.5 x 1.5m x 68.4m length	Dedicated culvert	
9	140520	2.4 x 2.4 x <40m	Dedicated Culvert	√
9	141120	1.87m high x 20m long	Bridge	
9	141890	2.23m high x 20m long	Bridge	
9	142220	2.4 x 2.4 x <40m	Combined Culvert	√
9	142750 (Broadwater Evans Head Rd West))	1.2 x 1.2 x <30m	Dedicated Culvert	√
9	143430	2.4 x 2.4 x <40m	Combined Culvert	√
9	143720	3.6 x 1.2 x <40m	Combined Culvert	
9	144280	3 x 3 x <40m	Dedicated Culvert	√
9	144700	Minimum height 2.4 x 26 m length	Bridge	√
10	146000	Minimum height 2.4	Bridge	√
10	146280	3 x 3 m x <40m	Dedicated culvert	√
10	146390	3 x 3 m x <40m	Combined culvert	√
10	146630	Minimum height 2.4 x 20 m length	Bridge	√
10	146980	Minimum height 2.4 x 15 m length	Bridge	√
10	147100	2.4 x 2.4 m x <40m	Dedicated Culvert	√
10	148592	3 x 3 m x <40m	Combined culvert	√
10	149250	Minimum height 2.4 x 20 m length	Bridge	√
10	150080	Minimum height 2.4 x 20 m length	Bridge	√

Project section	Chainage (m)	Connectivity structure (Cell No x wxhxl*)	Functionality	Targeted Koala Structure
10	150580	2.4 x 2.4 m x <40m	Dedicated Culvert	√
10	150630	Minimum height 2.4 x 20 m length	Bridge	√
10	151196	2.4 x 2.4 m x <40m	Dedicated Culvert	√
10	151825	Minimum height 2.4 x 20 m length	Bridge	√
10	152050	2.4 x 2.4 m x <40m	Dedicated Culvert	√
10	152750 (Wardell Rd)	2.4 x 2.4 m x <40m	Dedicated Culvert	√
10	152970 (Wardell Rd)	2.4 x 2.4 m x <40m	Dedicated Culvert	√
10	153090	3 x 3 m x <40m	Combined culvert	√
10	153620	3 x 3 m x <50m	Combined culvert	√
10	153882	Minimum height 2.4 x 15 m length	Bridge	√
10	154030	Minimum height 2.4 x 20 m length	Bridge	√
10	154770	2.4 x 2.4 m x <40m	Dedicated Culvert	√
10	155280	2.4 x 2.4 m x <40m	Dedicated Culvert	√
10	155920	2.4 x 2.4 m x <40m	Dedicated Culvert	√
10	156300	Minimum height 2.4 x 15 m length	Bridge	√
10	156970	2.4 x 2.4 m x <40m	Combined Culvert	√
10	157250	2.4 x 2.4 m x <40m	Combined Culvert	√
10	157630 (Coolgardie Rd)	3.6 x 2.4 m x <40m	Combined Culvert	√
10	157745	2.4 x 2.4 m x <40m	Combined Culvert	√
10	157900	Minimum height 2.4 x 20 m length	Bridge	√
11	158868	2.4 x 2.4 m x <40m	Dedicated Culvert	√
11	158903	3.6 x 1.8 x 45 m	Combined	
11	158903	3.6 x 1.8 x 25 m	Combined	

NOTE:
1 - * = width x height x length. Note lengths are indicative and there may be minor changes in length as part of detailed design.
2 - Note: the numbers and sizes of the connectivity structures listed in this table are subject to revision and will be detailed in the Connectivity Strategy prepared for Sections 3-11 of the Project.

6.3.10 Habitat revegetation

A landscape design has been prepared for Sections 1 and 2 and includes the use of primary and secondary Koala food trees in those areas that will not cause a road safety traffic hazard. Sections 3-11 will include the same landscape treatments. Areas where specific revegetation is to occur include approaches to fauna connectivity structures and riparian corridors (within the project boundary), which would be directly applicable to Koalas. Methods for topsoiling, seeding and planting will be in accordance with the *Biodiversity Guidelines: Protecting and managing biodiversity on RTA Projects* (RTA 2011).

The landscape design provides due consideration to the landscape requirements around crossing structures by ensuring that the height and density of vegetation does not obscure the structure and provides a clear line of sight, while also providing some cover from predators for fauna approaching and exiting the structure.

Revegetation using primary, secondary and supplementary Koala food trees has been shown to be effective in restoring habitat for Koalas (Kavanagh and Stanton 2012). Revegetation near crossing structures will commence immediately on completion of the construction activity or may commence earlier in the construction period if possible.

A comprehensive re-vegetation strategy has been developed for Section 10 (Niche 2015). This will include the planting of 130 ha of Koala food trees throughout Section 10. A brief summary of the strategy is provided below. Planting of the 130 ha of Koala food trees in Section 10 is expected to commence in spring and/or autumn seasons in 2016/2017.

Details on monitoring the performance of the revegetation, as well as corrective actions to be implemented in instances of change from performance measures, are provided in Chapter 8.

6.3.11 Section 10 Koala re-vegetation strategy

Roads and Maritime) currently owns numerous parcels of land, including approximately 621 ha of forested and cleared land, adjacent to Section 10. These parcels of land were acquired as a result of the Pacific Highway Upgrade, as well as because they provided potential offset habitat for a range of species, including the Koala. Approximately 100 ha will form part of the Highway footprint, leaving approximately 370 ha of retained native forest and 151 ha cleared land. The Minister for Roads and Freight has committed to plant at least 130 ha of Koala habitat – i.e. comprised mainly of primary and secondary Koala food tree species, within these areas. These plantings will be undertaken in two stages; approximately 50% prior to or in the early stages of construction (Spring 2016/Autumn 2017) with the remainder planted when construction of the road has been completed.

A comprehensive revegetation strategy was developed by Niche (2015) as part of the overall strategy to minimise and mitigate the impacts to the Ballina Koala population within Section 10 of the proposed Pacific Highway Upgrade, and is consistent with the NSW Condition of Approval D9(g). The implementation of the revegetation strategy is subject to the necessary approvals being granted by the federal Minister for the Environment for the Ballina Koala Plan.

The revegetation strategy will follow that as described in the *Koala Revegetation Strategy, Section 10, Pacific Highway Upgrade, Woolgoolga to Ballina, NSW* (2015). This is provided in Appendix I and summarised below.

The strategy identifies the goals, the landscape context, areas available for planting, suitable tree species, establishment methods, maintenance regimes and an outline of a suitable monitoring program.

The three main objectives of the revegetation program are: to establish new habitat for Koalas using preferred Koala food tree species to compensate for habitat lost as a result of clearing for the proposed road-works; to improve habitat connectivity within an already fragmented landscape; and thirdly, to guide the movement of Koalas towards the road connectivity structures (e.g. underpasses) that will be provided to ensure the safe passage across the road for dispersing Koalas.

A list of 21 cleared areas ranging in size from 0.4-17.9 ha has been selected (following on-site consultations with RMS, EPA and Koala ecologists from Niche, Ecosure and Biolink) as suitable, available and appropriate for revegetation by planting Koala food tree species. These cleared areas total approximately 151 ha. The strategy identifies areas of high priority for planting prior to road construction, and lower priority to be planted post-construction. Priority 1 areas are needed to facilitate connectivity through the landscape for local “hotspots” or known concentrations of Koalas. The areas that have been identified as Priority 1 will be sufficient to achieve the committed 50% of 130 ha prior to road construction, with the additional Priority 2 areas supplementing the balance of Priority 1 areas for planting that are required to meet the 130 ha commitment after road construction is completed. All properties will be subject to detailed site assessments and agreed offset requirements.

The strategy details tree species and planting locations, site preparation works, planting regimes, maintenance and monitoring. Monitoring will include vegetation and Koala activity monitoring.

6.3.12 Location of ancillary facility sites

Ancillary facility sites (i.e. temporary sites for construction related activities) have been located in cleared land or sites of low ecological value. Locations of plant and equipment will be placed in cleared parts of the site. This will avoid unnecessary clearing of Koala habitat, particularly at locations where Koala food trees and Koala activity have been identified (Roads and Maritime Services 2013).

6.3.13 Minimising dust and noise

Dust and noise impacts will be managed in accordance with the CEMP, including dust suppression measures and construction noise limit measures.

6.4 Performance thresholds and corrective actions

Table 6-3 summarises the operational environmental planning measures for Koalas and corrective actions if the measure reaches the performance threshold.

Table 6-3. Performance indicators and corrective actions – construction.

Main goals for management	Management measure	Monitoring/timing frequency	Performance thresholds	Corrective actions if performance threshold reached
No injuries to Koalas during clearing of vegetation - including Section 10 Koala 'hot-spots' Wardell Rd and Laws Point.	• Documented procedures for clearing and relocating. • Project ecologist to evaluate situation and approach on each occasion. • Implement phased resource reduction as per the management plan for Section 10 Koala 'hot-spots'	• Monitored daily during the clearing works. • Outcome of clearing procedure reported in ER as per the CEMP requirements. • Monitor implementation of phased resource reduction as per monitoring schedule – Section 8.2	Any injury to an individual Koala during clearing works.	Stop clearing works and consult with Koala specialists and/or NPWS. Update procedure for emergency management if a Koala is encountered and convey changes to construction staff via induction and toolbox talks. Consider erection of temporary exclusion fencing if required.
No injuries to Koalas during construction as a result of Koala construction vehicle collisions	• All vehicles to stay within the construction corridor. No vehicles to enter exclusion zones. • Compliance with construction vehicles speed limits designated in the CEMP.	• Reporting of any incidents as, and if, they occur • Monthly fauna incident log to be maintained as per FFMP.	Any injury to an individual Koala during construction activities.	Stop construction activities and review traffic control procedures. Consider erection of temporary fencing if required. Update strategy and speed limit as required and convey changes to construction staff via induction and toolbox talks. Review requirement for additional mitigation measures such as additional Koala fencing.
No damage to Koala habitat within exclusion zones.	• All vehicles to stay within the construction corridor. No vehicles or machinery to enter exclusion zones.	• Monthly inspection of protection zones as part of FFMP.	Any breaches in protection of Koala habitat within exclusion zones.	Supplementary revegetation of disturbed habitat and monitor recovery for period of 12 months.
Dust and noise managed in accordance with the CEMP.	Implement relevant dust and noise procedures from the CEMP.	Measures to be undertaken in response to weather and construction conditions.	Dust and noise control measures outside of acceptable standards as defined in the CEMP.	Increase the frequency of dust and noise measures as appropriate and implement procedures to avoid unnecessary dust and noise events during construction.
Water quality and weeds managed in accordance with the CEMP.	Implement relevant water quality and weed management procedures from the CEMP.	Measures to be undertaken in response to storm events and construction conditions.	Water quality and weed control measures outside of acceptable standards as defined in the CEMP.	Implement additional procedures to control stream siltation, and undertake weed spraying in problem areas during construction.

Replanting of Koala habitat adjacent to the road corridor completed as per the landscape design	• In situations where no fencing is present, and revegetation is required, roadside plantings to avoid Koala food trees to prevent Koalas being attracted to road edges. • Landscape plantings at fauna crossing zones to use Koala habitat trees to encourage use of the crossing zones by the Koala. • Revegetation in areas disturbed during construction to be restored to the original habitat type at each location. Focus at potential habitat locations	Final audit of Landscape design	Non-compliance of landscape plan at end of construction with regard to Koala plantings (refer Chapter 7 and 8 for further details on performance criteria).	Complete plantings where gaps identified
Replanting of 130 ha of Koala habitat within Section 10 as per the Section 10 Koala re-vegetation strategy.	Re-vegetation of 130 ha of cleared/semi-cleared land with Koala food/shelter tree species.	Annual monitoring of new plantings from year 1 for 5 years and/ or until plantings across 90% of plots have an average height of 8 metres (unless otherwise agreed) – as per monitoring strategy Chapter 8 Annual monitoring of at least 60 Koala faecal pellet search plots over all properties beginning year 3 - as per monitoring strategy Chapter 8	Annual density of less than one Koala food/ shelter tube-stock per 20 m^2 across the revegetation site. Trees within 90% of monitoring plots do not have an average height >8 metres after 5 years. Koala scats not recorded across at least 20% of monitoring sites.	Where a density of less than this is observed, conduct supplementary planting across the site. Continue Koala scat monitoring until recorded across at least 20% of monitoring sites (3-10 years).

7. Operational management measures

7.1 Potential impacts during operational phase

- Degradation of exclusion fencing leading to Koala vehicle collisions and road deaths or Koalas becoming trapped within the road corridor.
- Degradation of Koala revegetation areas.
- Wild dogs targeting Koalas at designated crossing zones.
- Koalas not using designated crossing structures where recorded in adjacent habitat.

7.2 Main goals for management

- No Koala deaths or injuries associated with road operations (i.e. vehicular collisions) within the upgrade area after a five year period following commencement of the operational phase.
- Evidence of completed crossings by Koalas at targeted fauna crossing structures.
- Less than 30% mortality of planted Koala feed trees in Koala habitat revegetation areas on Roads and Maritime owned land for a period of five years post-construction.
- Section 10 – reducing Koala mortality by an initial 4 animals/year and thus arresting population decline such that it is statistically slower than the lower bound of the 90% confidence interval of the PVA Scenario 6 (195 at year 5, 147 at year 10 and 104 at year 15), which equates to a 1.2% decline over five years, 13.7% decline over 10 years and 27.3% decline over 15 years..

7.3 Management measures

7.3.1 Maintenance of fauna exclusion fencing and fauna crossings

The Roads and Maritime Services will maintain fauna crossing structures and exclusion fencing as part of the standard maintenance requirements for perpetuity as required. A small vehicle access track adjacent to the fence would facilitate rapid inspection and repair. Fauna fencing will be inspected every six months and maintained as required.

Maintenance of fauna fencing will also be conducted in response to observations and reports of any Koala injuries or road kills in the vicinity of exclusion fencing and structures. The work to be commissioned will include repair of any breaches in the exclusion fence, the slashing of overgrown vegetation that breaches the fence or occurs within 3 m of the fence, and the removal of large debris or vegetation from culverts.

7.3.2 Maintenance of revegetation

Maintenance and monitoring will follow that as outlined in Section 8.6 and detailed in the Section 10 revegetation strategy (Niche 2015).

7.3.3 Predator control

The Ballina Koala Plan (Kavanagh 2016) has identified predation by domestic dogs as likely to be a significant contributor to the high rate of mortality and low rate of breeding success for the Koala population living near Section 10, exacerbating its long-term decline. It is recognised that RMS is a significant landholder in the region and is committed to dog control at a local and regional level. The lead agency for dog control is NSW Local Land Services (LLS). RMS intends to work with LLS/local council/DPI once the KMP is approved to collaborate on landscape level dog control programs where possible. Roads and Maritime will be implementing and funding a dog control program on all of its biodiversity offset properties, including the 130 ha of Koala habitat that will be planted in Section 10.

Wild dogs and other predatory animals have the potential to exploit the channelling function of the fauna exclusion fences by hunting near the entrance to connectivity structures, such as underpasses (Harris *et al*. 2010). Monitoring of predatory animal activity will be conducted as part of the crossing structure monitoring program (refer to Chapter 8). Where monitoring indicates that predators are a threat to Koala movement through the crossing structures, Roads and Maritime Services will engage with the North Coast Local Land Services, NSW National Parks and Wildlife Service (Grafton), and Rural Lands Protection Board (North East) and adjacent landowners to identify and implement strategies to reduce this predation risk. These and other government agencies have an important role to play devising and implementing appropriate strategies to control dog predation on Koalas.

7.3.4 Monitor effectiveness of crossing structures

Monitoring of the targeted Koala connectivity structures (and associated exclusion fencing) will be undertaken to assess their effectiveness to facilitate movement of Koalas across the highway upgrade. Chapter 8 outlines the process that would be used to undertake this monitoring.

7.4 Performance thresholds and corrective actions

Table 7-1 summarises the operational environmental planning measures for Koalas and corrective actions if the performance thresholds for each of the measures are reached.

Table 7-1. Performance indicators and corrective actions – operation.

Main goal	Mitigation / control measure	Monitoring/timing frequency	Performance thresholds	Corrective actions if performance thresholds reached
No Koala deaths or injuries from collisions with vehicles travelling along the new road or associated intersections with minor or feeder roads.	Construction of temporary and permanent fencing in selected locations to encourage the use of designated crossing points and to direct Koalas away from the road corridor. This includes permanent fencing along parts of Wardell Road either side of its crossing with the upgraded highway in Section 10 and also along the existing Pacific Highway north of Wardell to the Coolgardie interchange. Periodic monitoring and maintenance of exclusion fencing for the life-time of the project. Slashing weeds near fences and repair breaches in fence or replace broken fences.	Reporting of any incidents as, and if, they occur. Conduct Koala mortality surveys as per Chapter 8. The program will include inspections of the fence and structures as part of the standard maintenance requirements at the site for the life-time of the project. Monitoring will also be conducted in response to observations and reports of Koala road kills. Monitoring will be conducted for five years initially and the need for further monitoring will be reviewed at the end of this period.	Any injury to an individual Koala from car strikes during operational years 1-5.	Locate and repair faulty exclusion fence within 3 days of Koala death being reported. Review Koala mitigation measures if any Koala has been killed or injured as a result of car strike. Retrofit exclusion fencing, or part there-of, with additional measures to deter Koalas Consider erection of exclusion fencing in areas where none is currently provided. If a Koala is found to have died as a result of the project (within the fenced areas or highway upgrade) then RMS will undertake further investigations into installing additional fencing on other Koala road-kill hotspot areas.
Maintain habitat revegetation areas.	Regular monitoring and reporting on revegetation works and keeping Log Book of Maintenance	Monitor and report on revegetation works at month three, month nine and month twelve following initial establishment of revegetation area. A Log Book of Maintenance shall be prepared. The log book shall report on: • Date of maintenance actions • Results from performance quadrants • Summary of visual inspection • Further soil test information • Any instructions by RMS and response actions from contractor	Greater than 30% mortality of trees at revegetation sites determined from performance quadrants. Weed infestations not controlled.	Review planting regime and methods, and re-plant areas where significant tree mortalities have occurred. Increase maintenance reporting period until revegetation success rate is achieved. Remove and replace dead trees.

No Koala deaths or injuries from wild dog attacks in vicinity of crossing structures in years 1-5.	Conduct ongoing monitoring at crossing zones as per methods in Chapter 8.	Monitor predator presence and predator related Koala kills as part of ongoing crossing structure monitoring program.	Any injury to an individual Koala near crossing zones that are attributed to predator attack (as per methods in Chapter 8).	Engage with stakeholders involved with predator control to identify and implement actions to minimise attacks.
Koalas using designated crossing structures	Monitoring of crossing structures: refer to Chapter 8. Includes connectivity structures adjacent to the upgrade and also between the upgrade and the township of Wardell along Wardell Rd.	As outlined in Chapter 8. Undertake monitoring until such time as the use and effectiveness of mitigation measures can be demonstrated to have been achieved over a minimum of three successive monitoring periods.	No evidence of at least one successful crossing by Koalas of the designated crossing structures within 3 years.	Review and update the monitoring methods, including whether Koalas are present in adjacent habitat. Check exclusion fencing for damage and rectify. Improve habitat condition and connectivity adjacent to crossing structures. Consider whether Koala translocation is warranted within isolated areas of habitat.

8. Monitoring program

Monitoring will be undertaken to determine the effectiveness of mitigation measures implemented in Sections 1-11 of the Pacific Highway Upgrade. The three main mitigation measures requiring monitoring are the effectiveness of Koala-proof fencing along the length of the highway upgrade (Sections 1-11), the effectiveness of Koala connectivity structures along the length of the highway upgrade (Sections 1-11), and the effectiveness of Koala food tree plantings in restoring habitat for Koalas (monitoring focus mainly in Section 10). Coincident with and integral to these programs is the need to monitor trends in overall Koala population size, particularly for the two larger populations along the Pacific Highway upgrade alignment – the Broadwater (Sections 8/9) and the Coolgardie-Bagotville (Section 10) key populations.

The PVA for the Coolgardie-Bagotville key population indicated that this population is projected to decline significantly over the next 50 years (Kavanagh 2016) unless key threatening processes can be controlled. Monitoring of this population is considered important to help determine whether mitigation actions have been effective and management actions are helping to achieve population recovery, or if not, to provide some context as to why not. The Coolgardie-Bagotville (Section 10) population will be monitored against the PVA predictions, but as the Broadwater (Section 9) population has not had PVA completed, it will be monitored against a statistically significant at year 15 compared with year 0.

8.1 Objectives

Monitoring will provide reliable information such that sound conclusions can be drawn in relation to management of the species.

The monitoring objectives for Sections 1-11 of the Pacific Highway Upgrade project include:

- Evaluate the success of mitigation measures against the performance indicators and corrective actions presented in Table 8-4.
- Assess the effectiveness of the fauna crossing structures and fauna exclusion fencing to facilitate movement of Koalas across the upgraded highway. Note that in most areas, except in Sections 9 and 10, and in parts of Sections 5, 6 and 8, Koala “floppy top” exclusion fencing will not be constructed, unless Koala deaths or injuries are observed. However, modified “rabbit-proof” fencing, or other fence types, will be installed along the length of Sections 1-8 and 11 to exclude Koalas and a range of other species (Table 5-1).
- The objective of the Koala population monitoring for Section 9 is to be able to detect whether there is a statistically significant decline at year 15 compared with no decline.

Additional monitoring objectives for Section 10 are to:

- Assess effectiveness of the revegetation program in Section 10 in providing additional habitat for Koalas.
- Monitor the potential impact of tree clearing within the Wardell Road and Laws Point ‘hot spots’ on any resident Koalas.
- Determine whether the population is tracking according the predictions of the PVA (i.e. whether Koala mortality has been reduced by an initial four animals/year thus slowing population decline such that the population is greater than the lower bound of the 90% confidence interval of the PVA Scenario 6 (195 at year 5, 147 at year 10 and 104 at year 15), which equates to an approximate 1.2% decline over five years, 13.7% decline over 10 years and 27.3% decline over 15 years.

The monitoring program may be subject to refinement as a result of the performance of the aforementioned monitoring objectives and assessment against the performance indicators and corrective actions presented in Table 8-4. In order to fulfil these objectives, a number of ecological variables will be monitored, with each variable discussed below.

8.2 Phased resource reduction – Koala monitoring at Wardell Road and Laws Point 'hot-spots'

Monitoring of the Koalas within the known hotspots at Wardell Road and Laws Point will be undertaken in conjunction with the phased resource reduction within these areas. The purpose of the population monitoring is to monitor and assess the impact of the process on any resident Koalas to enable implementation of adaptive clearing procedures such that the goal of zero Koala mortalities in relation to this project is achieved.

The numbers of and resource utilisation by Koalas within the vicinity of the hotspots in relation to the phased resource reduction process will be monitored through regular surveys within the clearing footprint and also adjacent habitat throughout key stages of the process. Surveys will occur before, during and after tree collaring and then again after vegetation clearing. The proposed timing of monitoring in relation to the phased resource reduction schedule is shown in Table 8-1.

Table 8-1. Koala monitoring schedule around Koala 'hot-spot' locations.

Phase	Activity	Timing
1	Tag and map all trees to be collared/ring-barked	Week 1
	Population monitoring	***Weeks 1,2,3***
2	Collar 40% of all trees within Wardell Road and Laws Point 'hot-spots' Ring-bark 20% of trees within each 'hot-spot'.	Week 4
	Population monitoring	***Week 5***
3	Collar further 40% of trees within 'hot-spot' areas	Week 6
	Population monitoring	***Week 7***
4	Collar remaining 20% of trees within 'hot-spot' areas	Week 8
	Population monitoring	***Week 10***
5	Clearing commences	Week 11
	Population monitoring	***Weeks 13-16***

Koala surveys undertaken at Phase 1 will allow for identification of the animals within each area and provide information on the 'baseline' number of Koalas present. Monitoring undertaken after each collaring event and after clearing has commenced will provide information on changes in Koala numbers and resource utilisation that may be attributable to the phased resource reduction process. The regular monitoring of individuals within these two specific areas will allow for implementation of adaptive management of the phased resource reduction process to manage/ mitigate any potential impacts to individual animals.

Surveys will involve diurnal and nocturnal spotlighting surveys along transects that run the length of the alignment within the hotspot areas (see Figure 6-7). Based on the width of the proposed alignment in these areas, this should include at least two transects within the alignment (approximately 50 metres apart) and at least four transects approximately 50 metres either side of the alignment (total of at least 10 transects), as presented in Figure 6-7. The number of transects may need to be increased or decreased depending on the vegetation types present as this will have implications for visibility of the animals (the upgrade alignment at the Laws Point hotspot includes high quality, more densely forested Koala habitat, while the upgrade alignment at the Wardell Road hotspot consists mostly of cleared vegetation). A nocturnal spotlighting survey and a diurnal survey will be undertaken at each location. The location of any Koalas sighted will be recorded with a GPS, and details of the habitat type and tree species in which it was located, and any other relevant information such as behaviour or identifying characteristics will also be recorded. Results of the surveys will be provided to Roads and Maritime in a brief report at the conclusion of each survey, including a map of all recorded Koala locations.

Koala surveys will be undertaken by suitably qualified ecologists/biologists with experience undertaking diurnal and spotlighting surveys for Koalas.

8.3 Koala population monitoring

There is a growing appreciation that the ecological impacts of major linear infrastructure need to be assessed at the landscape scale (Taylor and Goldingay 2010, Van der Ree *et al*. 2011). Many studies (mostly international) have reported the use and effectiveness of wildlife crossing structures (road underpasses and overpasses) and the prevalence of wildlife road mortalities, concluding that most dedicated crossing structures increase the permeability of roads by allowing individual animals to cross more safely (Van der Ree *et al*. 2007, Taylor and Goldingay 2010). However, most studies have been unable to conclude whether “use” of a structure by an individual animal necessarily equates to conservation gain. The important unanswered question is: “Are populations declining in size due to road effects, even though we observe them using the crossing structures?”

The areas with the greatest number of Koala records in relation to the project occur around Wardell, Coolgardie and Bagotville (Section 10) and south of the Richmond River from Rileys Hill to Broadwater National Park (Section 9), both of which are considered to be key populations which could be adversely affected by the Pacific Highway upgrade. In contrast, the low density populations of the Koala occurring in or near Sections 1-8 and 11 of the Upgrade are too sparse to warrant the intensive sampling that would be required to document the broader landscape effects of the Pacific Highway. Instead, population monitoring efforts will be focused in Sections 8/9 and 10 where the Koala is most abundant.

The key aim of the Koala population monitoring is to be able to detect changes in the population that may be used to assess the overall effectiveness of Koala management activities implemented as part of the Highway Upgrade, namely use of connectivity structures, use of the re-vegetation areas and effectiveness of road kill mitigation measures. The information would also be used to assess population changes relative to the PVA predictions in Section 10 only. Two types of population monitoring will be undertaken – long-term systematic, repeated direct surveys for Koalas to provide information on Koala population trends, and periodic collection of Koala faecal pellets which will provide genetic information which may be used to provide an additional estimate of the Koala population size as well the level of genetic exchange occurring across the Upgrade.

8.3.1 Design of population monitoring program

Direct counts

Extensive investigations into the type, location and frequency of Koala population monitoring have been undertaken. Initial investigations involved a power analysis to determine the number of control and impact sites required to reliably detect declines in the populations at Broadwater (Section 8/9) and Coolgardie-Bagotville (Section 10) (Rhodes and Preece 2016).

Power analysis is an important aspect of experimental design. It allows determination of the sample size required to detect an effect of a given size, with a given degree of confidence. This information can then be used to design effective monitoring where there is a known level of confidence around the results. In the case of the current study, it was used to determine the number of sites and surveys that may be required to confidently assess changes in the Koala populations at Coolgardie-Bagotville and Broadwater.

Results indicated that in order to detect a decline over a relatively short time frame (monitoring over a three year period) the sample size required to detect any impact was very high (in the order of 800 sites per year per population) and considered likely to be unrealistic to implement. It was determined that the low ability to detect potential impacts was driven by low Koala densities, high spatial variability in the Koala distribution and the short (three year) monitoring period.

The issue of low Koala densities and high spatial variability in the Koala distribution presented similar difficulties in determining an optimal, practical and feasible monitoring strategy.

The program was subsequently extended to 15 years in order to enable changes in the population to be assessed in line with the PVA predictions. Similarly, the monitoring program was designed such that it would be sensitive enough to detect the quantum of change that is predicted to occur by the results of the PVA – that is, approximately 41% decline in population size over 15 years. A variety of scenarios were modelled to determine the optimal survey frequency/intensity that would be required to adequately detect these changes in the Koala population, with Type 1 and Type 2 errors set equal to each other.

Results of the power analysis indicated that, unsurprisingly, as the number of survey sites, number of surveys undertaken at each site and frequency of surveys increased, so did the power to detect change. Based on 50 survey sites within each of the Bagotville and Broadwater populations, and implementation of diurnal and nocturnal searches, the model indicated that in order to obtain 97% power to detect a 30% change in the population size in 15 years, monthly surveys would be required. The number of survey sites was based roughly on the number of sites surveyed in the previous population surveys; 46 in Section 10 and 54 in Section 9 (Ecosure 2014 and Ecosure-Biolink 2015).

Monthly surveys for 15 years were considered unfeasible. However, it was determined that a minimum of approximately 70% power (or confidence) to detect a 30% decline would be an acceptable outcome (Dr Rod Kavanagh and Dr Jonathan Rhodes, email correspondence 30th March 2016). This would involve a sampling frequency once every six months at each of the 50 sites within the Coolgardie-Bagotville and Broadwater populations. Each site would be surveyed twice on the same day – daytime canopy searches followed by night time spotlighting searches. However, the Koala population is probably too low and too variable to estimate population numbers, and their decline, precisely. These limitations need to be recognised and include the risk of wrongly concluding that declines are faster or greater than the PVA projections or, wrongly concluding that that declines are slower or less than the PVA projections.

For the reasons above, and particularly because the confidence intervals on the estimated population trends are likely to be high, the monitoring strategy will be adaptive such that following each survey, the data will be analysed and an assessment of the power going forward would be undertaken. Based on this, the required survey effort may change (go up or down). Such an adaptive monitoring strategy has been shown to provide better outcomes than fixed strategies (Jonathan Rhodes, *pers. comm*. 1st April 2016). The monitoring program should aim to increase the level of power where possible (e.g. additional sites, additional/alternative techniques) to reduce the monitoring timeframe.

Alternative monitoring methodologies (such as the use of drones) will be explored and implemented for future use if determined appropriate. If more efficient or effective monitoring approaches are identified these will be implemented, in consultation and agreement with the EPA and DoE.

Faecal Pellet (scat) Sampling – population genetics

Genetic analysis of scats allows for the identification of individual animals. It operates as a survey technique by identifying individuals (“individualisation”) and their sexes based on the genetic profiles of the samples. Collection and analysis of scats from across the landscape and over time can be used to determine the distribution and movement of individuals (and their relatives) across the landscape (e.g. Epps *et al.* 2005) as well as estimates of population size (e.g. Janečka *et al.* 2008). Genetic sampling (through DNA analysis of faecal pellets and tissue samples) has been used previously to assess the impact of roads and linear infrastructure on wild animal populations (e.g.Epps *et al*. 2005 and Kuehn *et al.* 2007).

Faecal pellet sampling and scat analysis will be undertaken to provide an additional estimate of Koala population size (according to the capture-mark-recapture technique) and also determine the level of genetic exchange occurring across the Upgrade (i.e. determine if Koalas are moving across/breeding on either side of the Upgrade).

8.3.2 Population monitoring procedures (Section 10 and Section 9)

Direct counts

Survey methods incorporating direct observations of Koalas are considered to be the most appropriate methodology (rather than indirect methods such as scat searches) for determining population numbers and density estimates that can be used to assess changes to the population over time. Survey methodology will follow previous survey methodology (i.e. transect and radial search in 1 ha plots) (see Biolink 2015).

Radial searches will involve searches for Koalas in every tree within a 25 m radius of the centre point of each site (0.196 ha) by three personnel. Transect searches will involve transects approximately 250 m in length and 40 m in width (covering a total area of approximately one ha) to be traversed at each survey site. Three observers equipped with a compass and binoculars, spaced ~20 m apart, walk a fixed bearing searching all trees for Koalas. One observer walks the centre line and one on either side. Where possible, transects are to be oriented north-south (on flat to undulating terrain) or along the contour on steeper terrain), and commenced at 125 m from the centre point, continuing for a further 125 m past the centre.

For any Koalas observed, the GPS co-ordinates, along with the tree species, height of the Koala in the tree, and where possible any other individual Koala characteristics (e.g. sex, age, health status) will be recorded.

Diurnal canopy searches and nocturnal spotlighting searches will be undertaken at each site within each of the Coolgardie-Bagotville and Broadwater population areas. Within each site, the diurnal and nocturnal observations will be undertaken on the same day.

Survey locations will include those previously established and used during the previous population surveys of the Broadwater and Coolgardie-Bagotville populations (Biolink 2015, Ecosure 2015) wherever practicable. This includes 46 sites in Section 10 and 54 sites in Section 9 (see Figure 8-1 and Figure 8-2). Any additional survey locations required for Section 10 will be determined based on the distribution of preferred Koala habitat across the landscape including the 130ha of newly established Koala habitat.

Population monitoring will commence in Spring 2017 to coincide with the beginning of the construction period. The benefits of beginning at this time include the ability to detect any population changes earlier in the life of the project (as power to detect change increases with the number of surveys and data) and it would also provide the opportunity to monitor potential impacts of construction.

For the first 5 years the Koala populations will be monitored twice a year. Surveys would be timed to occur in spring (breeding season, when animals are most active and therefore most easily detected) and then again in autumn. The data would be analysed and reported and power analysis will be run at the end of the each survey reporting period to re-assess population survey requirements including frequency of survey events. Data analysis and interpretation would be undertaken by suitably qualified and experienced personnel.

Population monitoring will be undertaken by suitably qualified and experienced ecologists with experience in Koala survey to maximise the chances of detecting Koalas.

Data analysis will involve the calculation of Koala density based on the number of Koalas counted during transect/radial searches, divided by the combined total search area of all transects/radial searches. This will then be used to estimate trends and statistical equivalence tests will be used to determine if the decline is statistically slower than the lower bound of the 90% confidence interval for Scenario 6 of the PVA for Section 10. For section 9 the trend will be compared against no decline.

Scat sample collection and analysis

It is proposed that Koala faecal pellet sampling will be undertaken periodically (every three years) throughout the 15 years of the population monitoring period. Scats would be collected at each of the population monitoring sites (in conjunction with the six-monthly population surveys) in Section 10 (46 sites) in Year 1, Year 3, Year 5, Year 7, Year 10, Year 12, and Year 14. Scats would be located using the Spot Assessment Technique (SAT), where the base of feed trees a searched for Koala scats. Further opportunity exists to collect scats during monitoring surveys at each of the fauna crossing structures (see Section 8.3). Australian Museum Research Institute estimates at least 200 Koala scats would be required to provide information on 20 individuals. It is unknown whether the proposed sampling intensity would be sufficient to provide this information, however, the first sampling period will be used to estimate the true rate of information that is obtained from scat collections in this population and to inform methodology/sampling effort for Koala scat monitoring in subsequent years.

It is anticipated that DNA be extracted and stored at the end of each collection period. However, DNA analysis of the scats will be conducted at the end of year 1 and then at the end of year 15. The year 1 analysis will provide population estimates and information on the distribution and relatedness of individuals across the study area, but also allow for refinement of collection and storage procedures and amendment of the sampling regime if required. Based on the accumulation of genetic material from four sampling periods, the year 15 assessment will provide a relatively robust estimate of population size (to which the direct population counts can be compared) at each sampling period, and also provide information on Koala breeding and movement across the Upgrade, once offspring between cross-Upgrade individuals have been produced.

The success of extracting high-quality DNA from scats can vary depending on the species. Published data suggests that Koala scats in particular pose some challenges to DNA extraction. Methodologies regarding collection and storage techniques to help maximise genotyping success outlined by Wedrowicz et al. (2013) and other similar studies will be referred to. (e.g.) Specific collection and storage requirements of the scats would be discussed and developed in consultation with the laboratory engaged to do the analysis.

Roads and Maritime will engage suitably qualified experts to advise on the program (including collection and storage procedures and requirements) and undertake the genetic analysis and data analysis. This information will then be integrated with information from the population surveys.

8.3.3 Performance indicators

A key limitation to the development of the monitoring methodology was that, as determined by Rhodes and Preece (2016) and detailed above, it is not feasible to statistically measure Koala population change directly as a result of the Highway relative to control sites due to the prohibitively large sampling effort that would be required to achieve a result with any confidence. However, the monitoring methodology described above is considered to have sufficient power (approximately 70%) to enable trend changes (30% decline over 15 years) in the monitored Koala population to be identified. This will be used to compare against PVA predictions in Section 10 and also inform insights and impacts in combination with data from road kill monitoring, fauna connectivity use and exclusion fence monitoring.

Monitoring information will be used to assess population changes in line with the PVA predictions for scenario 6 (lower bound of 90% confidence intervals) for Section 10 only. The objective of the Koala population monitoring for Section 9 is to be able to detect a statistically significant decline in the population that may be used to assess/inform the overall effectiveness of Koala management activities implemented as part of the Highway Upgrade, namely use of connectivity structures, use of the re-vegetation areas and effectiveness of road kill mitigation measures.

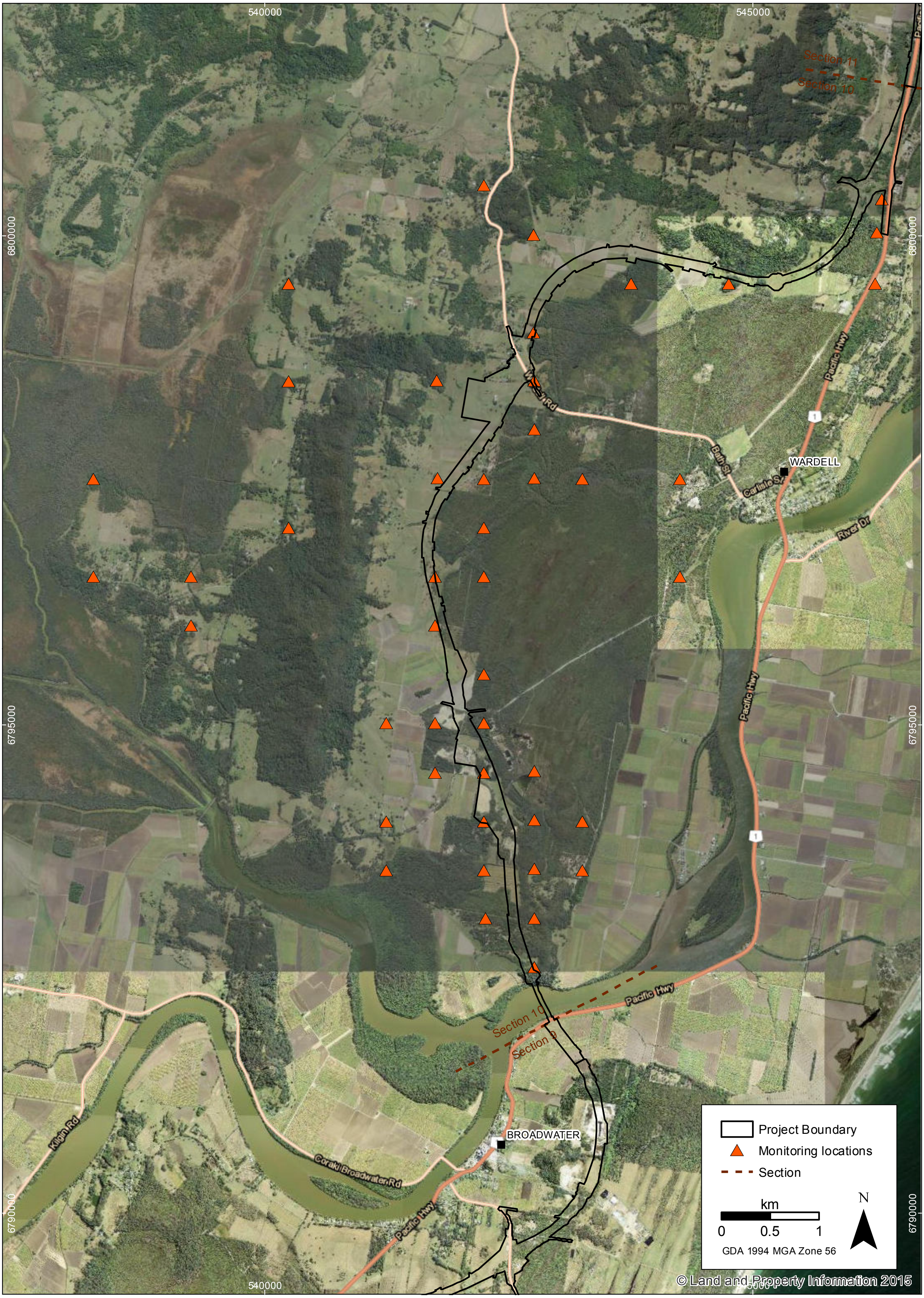
Performance indicated by the population monitoring will be measured by analysis of the data following each survey (to re-assess power of the monitoring program) and a review of population trends, in light of results of other management and mitigation measures, including:

- Evidence of completed crossings by Koalas at targeted fauna crossing structures.
- Koala deaths or injuries due to vehicle strikes in the vicinity of fauna crossing structures.
- Breaches in fauna exclusion fencing or encroachment of shrub or canopy vegetation within two to three metres of fauna exclusion fencing.
- Success of establishment and Koala use of the revegetation areas.
- Road-kill data from local wildlife rehabilitation groups (WIRES, Friends of the Koala).

Should the Section 10 Koala population size decline faster than 17% (lower bound of 90% confidence interval) within the first five years, corrective actions would include identifying the key threatening processes which are continuing to impact on Koala population trends and increase efforts to control these key threatening processes. A complete program review will be undertaken at 5, 10 and 15 years in light of population monitoring data and other monitoring and management outcomes. Should the Broadwater (Section 9) population show a statistically significantly decline by year 15, then corrective actions should also be considered, but given PVA has not been conducted for this population, these actions should only apply to threatening processes that can be attributed to the Project.

To measure and provide for success in achieving the aforementioned objectives, performance indicators and corrective actions have been set and are provided in Table 8-4.

Drawn by: RJ   Project Manager: AG   Project Number: 2622   Date: 03/06/2016



Section 10: Coolgardie-Bagotville population

Woolgoolga to Ballina Koala Management Plan

niche Environment and Heritage

FIGURE 8-1

Path: T:\spatial\projects\a2200\a2266_W2B_KPoM\Maps\RMS_20160511\2266_Figure_81_BagotvilleMonitoring.mxd

Imagery: (c) LPI 2009 - 2012

Drawn by: RJ Project Manager: AG Project Number: 2622 Date: 03/06/2016

Section 8-9: Broadwater population

Woolgoolga to Ballina Koala Management Plan

niche Environment and Heritage

FIGURE 8-2

Path: T:\spatial\projects\a2200\a2266_W2B_KPoM\Maps\RMS_20160511\2266_Figure_82_BroadwaterMonitoring.mxd

Imagery: (c) LPI 2009 - 2012

8.4 Koala activity and fauna crossing structures

Monitoring of the targeted Koala connectivity structures (underpasses and associated exclusion fencing) will be undertaken to assess their effectiveness in facilitating the movement of Koalas across the highway upgrade.

8.4.1 Selection of monitoring locations

Monitoring locations have been pre-selected and include targeted connectivity structures that have been designed for use by the Koala (i.e. dedicated culverts). Motion sensor cameras will be installed at each end of the Koala dedicated underpass structures listed in Table 8-2 to determine whether the connectivity structures provided are effective (i.e. Koalas undertake complete crossings of these structures).

Table 8-2 Fauna connectivity structures targeted for the Koala as detailed in the Connectivity Strategy.

Project section	Chainage (m)	Connectivity structure (Cell No x wxhxl*)	Functionality	Targeted Koala Structure
1	6890	1 x 3 x 2.7 x 45 m	Dedicated culvert	
1	8470	1 x 3 x 3 x 51 m	Dedicated culvert	
1	8800	1 x 3 x 3 x 50 m	Dedicated culvert	
1	11710	1 x 3 x 3 x 57 m	Dedicated culvert	
1	12420	1 x 3 x 3 x 52 m	Dedicated culvert	
2	17710	1 x 3 x 2.4 x 57 m	Dedicated culvert	
2	19880	1 x 3 x 3 x 54 m	Dedicated culvert	
2	23130	1 x 3 x 3 x 22 m	Dedicated culvert	
2	23131	1 x 3 x 3 x 22 m	Dedicated culvert	
2	23750	1 x 3 x 2.7 x 43 m	Dedicated culvert	
2	25850	1 x 3 x 3 x 45 m	Dedicated culvert	
2	29300	1 x 2.4 x 2.4 x 25 m	Dedicated culvert	
3	47181	5.2 high x 20m length	Bridge	
3	66190	3 x 3 x 44 m	Dedicated culvert	
4	75565	3.6 x 2.4 x 42 m	Combined culvert.	
4	76450	2.4 x 2.4 x 455m	Combined culvert	
5	83100	4.6 high x 24.9m length	Combined (bridge)	
5	93990	216.6 x 10.5 m	Combined (bridge)	
5	96150	2.4 x 2.4 <40m	Dedicated	√
6	99730	3x 2.4 x 45 m	Dedicated culvert	
6	101100	1.8 x 2.4 x 41 m	Dedicated culvert.	
6	101541	110m length	Bridge	
7	118500	2.3 high x 20m length	Bridge	
8	134600	2.44 high x 40m length	Bridge.	√

Project section	Chainage (m)	Connectivity structure (Cell No x wxhxl*)	Functionality	Targeted Koala Structure
8	136700	Minimum height 2.4m x 20m length	Bridge	√
9	137300	2.4 x 2.4 x <40mm	Dedicated culvert	√
9	138430	1.5 x 1.5m x 64.8m	Dedicated culvert	
9	139440	1.5 x 1.5m x 68.4m	Dedicated culvert	
9	140520	2.4 x 2.4 x <40m	Dedicated Culvert	√
9	142220	2.4 x 2.4 x <40m	Combined Culvert	√
9	142750 (Broadwater Evans Head Rd West))	1.2 x 1.2 x <30m	Dedicated Culvert	√
9	143430	2.4 x 2.4 x <40m	Combined Culvert	√
9	144280	3 x 3 x <40m	Dedicated Culvert	√
9	144700	Minimum height 2.4 x 26 m length	Bridge	√
10	146000	Minimum height 2.4	Bridge	√
10	146280	3 x 3 m x <40m	Dedicated culvert	√
10	146390	3 x 3 m x <40m	Combined culvert	√
10	146630	Minimum height 2.4 x 20 m length	Bridge	√
10	146980	Minimum height 2.4 x 15 m length	Bridge	√
10	147100	2.4 x 2.4 m x <40m	Dedicated Culvert	√
10	148592	3 x 3 m x <40m	Combined culvert	√
10	149250	Minimum height 2.4 x 20 m length	Bridge	√
10	150080	Minimum height 2.4 x 20 m length	Bridge	√
10	150580	2.4 x 2.4 m x <40m	Dedicated Culvert	√
10	150630	Minimum height 2.4 x 20 m length	Bridge	√
10	151196	2.4 x 2.4 m x <40m	Dedicated Culvert	√
10	151825	Minimum height 2.4 x 20 m length	Bridge	√
10	152050	2.4 x 2.4 m x <40m	Dedicated Culvert	√
10	152750 (Wardell Rd)	2.4 x 2.4 m x <40m	Dedicated Culvert	√
10	152970 (Wardell Rd)	2.4 x 2.4 m x <40m	Dedicated Culvert	√
10	153090	3 x 3 m x <40m	Combined culvert	√

Project section	Chainage (m)	Connectivity structure (Cell No x wxhxl*)	Functionality	Targeted Koala Structure
10	153620	3 x 3 m x <50m	Combined culvert	√
10	153882	Minimum height 2.4 x 15 m length	Bridge	√
10	154030	Minimum height 2.4 x 20 m length	Bridge	√
10	154770	2.4 x 2.4 m x <40m	Dedicated Culvert	√
10	155280	2.4 x 2.4 m x <40m	Dedicated Culvert	√
10	155920	2.4 x 2.4 m x <40m	Dedicated Culvert	√
10	156300	Minimum height 2.4 x 15 m length	Bridge	√
10	156970	2.4 x 2.4 m x <40m	Combined Culvert	√
10	157250	2.4 x 2.4 m x <40m	Combined Culvert	√
10	157630 (Coolgardie Rd)	3.6 x 2.4 m x <40m	Combined Culvert	√
10	157745	2.4 x 2.4 m x <40m	Combined Culvert	√
10	157900	Minimum height 2.4 x 20 m length	Bridge	√
11	158868	2.4 x 2.4 m x <40m	Dedicated Culvert	√

Koala faecal pellet searches and searches for Koala scratches on trees will be conducted in adjacent habitat (within 100 m) to the above connectivity structures and during the period that the underpass structures are being monitored. The purpose of these searches is to determine whether there is any evidence of Koala presence near the connectivity structures at the time they are being monitored.

It is proposed that Koala faecal pellets located during the underpass monitoring in Section 10 (and also during the population monitoring, described in Section 8.2) will be collected for genetic analysis. Information gained from this would support the camera monitoring of the structures already proposed by providing information on:

- Koala use of the structures
- Koala breeding on either side of the road
- sex ratios of the population and
- incidence of inbreeding.

RMS would work with a suitably qualified expert to fully develop the faecal pellet sampling and monitoring program.

8.4.2 Methods, timing, intensity and duration

Monitoring of underpasses will be undertaken using the following techniques:

- Two motion-detecting cameras with infrared flash will be installed either side of the underpasses, facing inwards, and positioned to capture Koala movements on the ground and on fauna furniture. Cameras will operate continuously for at least three months during the monitoring periods (spring/summer). These monitoring periods are scheduled to occur each year for the first three years following completion of the project, after which the need for further monitoring will be reviewed (Table 8-4). The performance of each dedicated Koala crossing structure will be determined by evidence of one or more completed crossings during these monitoring periods (Table 8-4). A standardised camera set up will be used to allow comparison with subsequent monitoring events.

- Faecal pellet and tree-scratch searches within 100 m of each end of dedicated crossing structures, and faecal pellet searches within each dedicated crossing structure, will be undertaken when installing and checking camera batteries (once per month during the monitoring periods). Scat samples will be sent to an appropriately qualified/experienced specialist for identification if necessary. Predator scats will be analysed for Koala hair.
- Exclusion fence monitoring: Survey of the Koala exclusion fence for 250 metres either side of the structure will be conducted to identify and report any breaches and report maintenance requirements.

Genetic analysis of faecal pellets would be undertaken by a suitably qualified expert.

The timing of surveys will be selected to coincide with the breeding season and likely juvenile dispersal period of the Koala (September to February and July to August). Koala movements are expected to be more frequent and extensive during the breeding season and dispersal periods due to expansion of home ranges and movement of juveniles away from natal areas. Therefore, these periods are likely to represent peaks in fauna movement, resulting in higher rates of usage of connectivity structures and thus higher rates of detection.

Fauna crossing structure monitoring will commence six months after installation of connectivity structures (i.e. Veage and Jones 2007). Monitoring will be undertaken annually (in Spring/Summer) for a period of up to three years at which time the success of the structures and requirement for additional monitoring will be reviewed. Sites will be re-surveyed at each monitoring event until structures are proven to be effective in line with the adaptive management approach.

Where monitoring indicates that predators are a threat to Koala movement through the crossing structures, Roads and Maritime Services will engage with the North Coast Local Land Services, NSW National Parks and Wildlife Service (Grafton), and Rural Lands Protection Board (North East) and adjacent landowners to identify and implement strategies to reduce this predation risk.

Should this monitoring determine that structures are not being effective at facilitating road crossings for the Koala, or that fencing is not being effective in directing Koalas to the crossing structures or preventing them from accessing the roadway, additional measures, such as retrofitting or modifying culverts to improve the structural integrity and functionality of the structure will be considered.

8.4.3 Performance indicators and criteria

The objectives of the fauna crossing structures are to provide a safe passage for the movement of wildlife, including Koalas, across the highway and to minimise wildlife mortality due to vehicle strike, specifically to maintain local and regional wildlife corridors, home-ranges and genetic exchange between populations.

Performance of the underpass structures and associated fauna fencing will be measured by achievement of the following possible outcomes:

- Evidence of at least one successful completed crossings by Koalas at targeted fauna crossing structures.
- No Koala deaths or injuries due to vehicle strikes in the vicinity of fauna crossing structures.
- No breaches in fauna exclusion fencing or encroachment of shrub or canopy vegetation within two to three metres of fauna exclusion fencing.

To measure and provide for success in achieving the aforementioned objectives, performance indicators and corrective actions have been set and are provided in Table 8-4.

In line with requirements of CoAD9(j), if the connectivity structures cannot be demonstrated to be successful within one year of their implementation, procedure for the submission of further offsets in accordance with conditions D5 and D6(j), will be provided within one year of these findings. Potential offsets have already been identified within an approved offsets strategy.

8.5 Road mortality monitoring

8.5.1 Selection of monitoring locations

Monitoring of Koala mortalities will be undertaken along the entire length of the project (Sections 1-11), with particular focus at targeted fauna connectivity structures.

Koala deaths or injuries will be reported as, and if, they occur along the length of the highway upgrade. The GPS location of each road kill specimen will be recorded and assessed in relation to the closest fauna crossing structure and/or fauna exclusion fence to evaluate their effectiveness.

8.5.2 Methods, timing, intensity and duration

Road mortality monitoring will occur twice per year for a period of five years (between July-August and October-November) in the operational stage of the program. The method will involve walking transects along the road edge (500 metres in length) along both sides of each dedicated fauna crossing structure and upgraded highway. Transects will also be undertaken in areas that are fenced on Wardell Road and the existing Pacific Highway between Wardell and Coolgardie Interchange. It is noted that Koala road fatalities are likely to be rare events and therefore this survey methodology may not capture all Koala mortalities that occur at these areas. However, the surveys are timed to coincide with the breeding season (spring) when Koala movements are greatest (and thus the chance of getting hit on the road is greatest) and they will also enable assessment of the integrity of the crossing structures and fauna fencing within these areas. At other times of the year, any Koala deaths or injuries along the length of the highway upgrade will be reported as, and if, they occur.

A Project Road Mortality Register will be established which will allow construction personnel to report any Koala road mortalities identified during project works.

Roads and Maritime will also undertake regular communication with local wildlife rehabilitation groups (WIRES, Friends of the Koala) so that any injured or killed Koalas reported by the general public will be brought to the attention of RMS. Any injuries or deaths of Koalas from wildlife care group records will be incorporated into annual reporting for this project.

In Section 10 annual reporting will include review of Koala road-kill mortalities against known data of Koala mortalities in the area (see Table 8-3). It must be noted that there has been no systematic collection of Koala road-kill data across the study area to date. As such there is no comprehensive data set of Koala mortalities along the roads associated with the Upgrade that could be used as a baseline by which to compare the road-kill monitoring for this project.

The current data available (obtained as part of the demographic study to determine inputs into the PVA, Biolink 2015) assessed Koala mortality records across the Ballina LGA from Lismore-based Friends of the Koala call-out records over the past 26 years. The results indicated that an average of 1.23 animals per year are killed on the four roads identified as 'hotspots' within the study area (see Table 8-3), although annual mortalities of 4-6 animals were considered more likely (Biolink 2015). These authors observed six Koala mortalities caused by vehicle-strike during the six months of their field study, and at least 10 mortalities in 2015 (S. Phillips, *pers. comm*. 14/12/2015). It is therefore possible that the averages derived from the long-term roadkill data may actually be lower than the actual number of Koalas killed on the roads within the study area each year. As such, these numbers will be used as a guide only in reference to the efficacy of the road-kill mitigation measures.

Table 8-3. Standardised Koala vehicle-strike data for major roads within the study area. Numbers in brackets represent additional (i.e. non-FoK) records from NSW Wildlife Atlas that have been included in the "n" value being used. The values in the "Average" column were calculated by dividing "n" by the number of years (26) to which the data relate (from Biolink 2015).

Road	n	Average	km	Number of Koala's per km per annum
Pacific Highway	7(3)	0.269	10.5	0.026
Bruxner Highway	8	0.308	5	0.062
Wardell Road	9.5 (5)	0.365	9	0.041
Bagotville Road	7.5	0.288	8.5	0.034

8.5.3 Performance indicators and criteria

Performance of the fauna connectivity structures in preventing Koala road mortalities will be assessed with the aim of achieving zero Koala vehicle strikes.

To measure and provide for success in achieving the aforementioned objectives, performance indicators and corrective actions have been set and are provided in Table 8-4.

8.6 Koala revegetation monitoring

8.6.1 Monitoring

A revegetation strategy has been prepared that identifies the goals, the landscape context, areas available for planting, suitable tree species, establishment methods, maintenance regimes and an outline of a suitable monitoring program (Kavanagh and McLean 2015). The focus of this strategy was to identify at least 130 ha as the priority for planting prior to construction in Section 10.

Annual monitoring is needed to determine the overall success of:

1. the revegetation activities, including whether replanting is required in some areas, and
2. if the planted areas are being used by Koalas.

Monitoring the success of the revegetation should occur across all field sites monitoring one plot per two hectares of revegetation on each occasion. Monitoring should occur at the same month each year, nominally September. Each site should be marked with a star picket and flagging tape and the location should also be recorded with a GPS. Annual monitoring should occur at each site from year 1, where the following variables are recorded within a 50 x 20 m (0.1 ha) quadrat:

- Density of Koala food trees and shelter trees (initial density=approximately 48 trees per quadrat), their average height and number of visible dead stems.
- Presence and dominance of any environmental weeds, including exotic grasses.
- Presence and condition of Acacia cover-crop, if planted.
- One photo taken at the star picket, facing south (on a 180 degree bearing).

Opportunistic observations via a random meander, which may occur while walking between sites, should also be undertaken throughout the revegetation area. These observations should identify if any large infestations of environmental weeds are occurring and their location, if any large-scale plant deaths have occurred and if any other environmental issues are developing, such as sheet or gully erosion. The results of these field surveys should be summarised in an annual report provided within two months of the completion of the field surveys. The monitoring should continue for at least five years, and/ or until plantings across 90% of plots have an average height of eight metres (unless otherwise agreed with the EPA).

At least sixty permanent Koala faecal-pellet search plots (0.1 ha plots) should be established throughout the plantings, with at least six plots located within each revegetation property. These plots can be the same as those established to monitor the success of tree plantings (see above). The plots should also be situated across all topographic positions (i.e. lowlands, mid-slopes and ridges). Each faecal-pellet search plot should be marked with a star picket and flagging tape and the location should also be recorded with a GPS. Annual surveys for Koala use of the revegetation area should begin in year 3 and continue until it is shown that at least 20% of plots (n=12) have evidence of Koala activity in any one year (up to year 10). If after 10 years 20% or more of plots do not show signs of Koala activity then it will be necessary to consider additional adaptive management actions, such as planting additional areas with Koala habitat. The requirement for additional re-planting will be determined in light of the results of all applied monitoring measures. For example, if the population monitoring indicates the population is declining rapidly, then it may be that there are simply not enough Koalas to use the additional habitat. Any additional, adaptive revegetation works would follow the strategy for site selection and planting methodology as outlined in the current re-vegetation strategy.

This work should be done in conjunction with comparable surveys done within existing native forest in Section 10 as part of the overall Koala population monitoring program. Surveys should occur at a similar time each year, notionally September which coincides with the Koala breeding season. An annual report should be prepared which documents the results of the field surveys and their success in relation to the management objective, being the use of the plantations by Koalas. Results should be interpreted in relation to other information from the study area, including comparable Koala “activity” in nearby native forest and trends in the size of the Koala population.

8.6.2 Management responses

Management responses should be guided by the results of the monitoring program. At years one, two and three after planting, supplementary tree plantings should occur where it is observed that greater than 20% mortality of tube-stock or densities of less than one plant per 20 m^2 have resulted. Where woody weeds are present, weeds should be reduced to a density of less than 5% across the revegetation site, while exotic grasses should not be visibly affecting the growth of tube-stock.

After three years, the stand of planted eucalypts should be considered “established” and any further losses should be regarded as part of natural stand thinning due to competition with other planted trees. A stocking rate of 300-400 trees per ha is the expected stand structure of the Koala revegetation program after several decades following plantation establishment.

By year 10 post-establishment, further investigations should be instigated if it is found that Koalas are not using the revegetation areas, or where the threshold of 20% of faecal-pellet search plots has not recorded any evidence of Koala presence. These investigations must consider comparable Koala “activity” levels in nearby native forest, and trends in the size of the Koala population in the study area. Lack of use of the supplementary habitat provided by Koala food tree plantings could occur if the Koala population is in decline due to other factors (e.g. low fecundity, high mortality, limited dispersal opportunities).

8.6.3 Performance criteria

Details of the performance criteria for the provision of 130 ha of new Koala habitat in Section 10 are presented in Table 4 of the Koala Revegetation Strategy (Kavanagh and McLean 2015) and summarised in Table 8-4.

8.7 Evaluation, project review and reporting

Detailed monitoring reports will be prepared outlining the methods and results of the monitoring program.

8.7.1 Responsibility

RMS, through its contractor(s) which are employed to undertake the various aspects of monitoring for the project, will be responsible for the evaluation of the monitoring information collected. Monitoring of Koala use of fauna crossing structures and evidence of Koala presence nearby at the time of monitoring, together with habitat revegetation measures, will be undertaken separately for the project, and the success of these mitigation measures will be considered in the evaluation of impacts on the Koala. The identification of appropriate triggers to undertake corrective actions will be the responsibility of RMS and its contractors, with RMS having the prime responsibility for enforcing any necessary changes as required by this Plan (Table 8-4).

8.7.2 Timing

A brief annual report will be prepared by the contractor(s) for each monitoring project for distribution to the Roads and Maritime, DP&E, EPA and DoE and to document the methods and results from each monitoring period.

A final report would be prepared at the conclusion of the monitoring period. This report will incorporate all the results of the monitoring and recommend any additional measures (if deemed necessary) to facilitate the long term survival of the Koala population in the locality.

8.8 Corrective actions

The Koala monitoring program to be undertaken in all Sections (1-11) will focus on the use of mitigation structures, the success of any habitat restoration and its use by Koalas, and the incidence of Koala injuries and road kill during the project, as well as population-level monitoring of Koalas within Section 9 and Section 10. Any contingency measures to be implemented will be agreed to by the relevant regulatory authorities EPA and DoE prior to being commenced. Performance thresholds for each monitoring activity and corrective actions to be implemented if these are not met, and the party responsible for implementation are listed in Table 8-4.

Observations of Koala presence using faecal pellet-search and tree-scratch searches within 100 m in adjacent habitat during the time of monitoring fauna crossing structures will be used to inform assessments of the effectiveness of these structures. If during the operational phase Koalas are found to be unable or unwilling to use designated crossing structures, and Koalas are known to be present in the vicinity of these structures, provisional options will be developed that could be implemented if research and/or monitoring identify that additional or alternative measures are required.

Depending on the outcome of the monitoring of crossing structures, the following options will be considered in consultation with EPA:

- Maintenance of the existing connectivity measures.
- Modify design of existing measures where feasible and reasonable.
- Consider additional offset measures to improve connectivity elsewhere.

Additionally, should a Koala be found to have died as a result of the project (within the fenced areas or highway upgrade) then RMS will undertake further investigations regarding the installation of additional fencing on other Koala road-kill hotspot areas – including fencing portions of the Bruxner Highway, if determined to be appropriate.

Table 8-4. Performance indicators and corrective actions.

Performance monitoring	Performance threshold	Corrective actions if deviate from performance threshold	Responsibility
Koala population within Koala 'hot-spots' associated with phased resource reduction.	No injury to a Koala as a result of vegetation clearing within the 'hot-spots' of Wardell Rd and Laws Point. Estimated Koala numbers within hotspot areas do not decline less than 30% compared with baseline numbers (i.e. number prior to works).	Clearing activity to cease until cause of death determined and consult with Koala specialists. Response will depend on cause of death/injury. If Koala numbers within hotspot areas decline by >30% then causes to be investigated and corrective actions implemented accordingly (i.e. dog attack = increased predator control; roadkill = increased fencing).	Roads and Maritime responsible for engaging suitably qualified ecologists/specialists to undertake the required Koala surveys, data analysis and reporting.
Koala population trends in Sections 10 and 8/9	Koala population sizes at or above the minimum expected targets including rate of population change/decline at/above the minimum expected target of 195-276 at five years; 147-272 at 10 years and 103-261at 15 years.	Complete program review at 5, 10 and 15 years. Identify the key threatening processes which are continuing to impact on Koala population trends (through monitoring of road-kill, connectivity structure use, and use of re-vegetation areas). Incorporate review of roadkill data from local wildlife rehabilitation groups WIRES, Friends of the Koala. Increase efforts to control these key threatening processes. This may include implementing additional dog control, establishing additional Koala habitat, modifying existing or creating new connectivity structures on adjacent road networks, and/or implementing measures to reduce Koala road-kill.	Roads and Maritime responsible for engaging suitably qualified ecologists/specialists to undertake the required Koala population surveys, data analysis and reporting. Roads and Maritime would share responsibility with other government agencies to control threatening processes.
Road mortality monitoring.	All sections - No injury to an individual Koala as a result of vehicle strike.	Examine fencing for breach or obstruction within 3 days of report and repair. Retrofit exclusion fencing, or part there-of, with additional measures to deter Koalas.	Roads and Maritime maintenance responsible for repairing exclusion fencing.

Performance monitoring	Performance threshold	Corrective actions if deviate from performance threshold	Responsibility
	Section 10 - No Koala road mortality within the fenced areas of the Upgrade, on existing Pacific Highway or Wardell Road.	Section 10 – Roads and Maritime would consider erecting Koala proof fencing on the Bruxner Highway (a known Koala road kill hotspot), in an effort to reduce Koala mortality across the region.	Roads and Maritime responsible for undertaking further investigations into installing additional fencing on other Koala road-kill hotspot areas, including fencing of Bruxner Highway if required.
Fauna crossing structure monitoring	Evidence of at least one completed crossing by Koalas at targeted fauna crossing structures. Evidence of Koala individuals using structures and/or breeding on either side of the highway, via scat analysis. No evidence of high visitation/usage rates by exotic predators.	Review monitoring methods, consider increasing frequency, intensity and duration, to ensure individuals are identified. Check fauna furniture associated with underpass for damage and rectify. Investigate habitat adjoining the underpass. Consider improving habitat condition and connectivity. Check general area, including the underpass itself, for the presence of predators. Seek advice and implement predator control.	Roads and Maritime responsible for engaging suitably qualified ecologists to undertake the monitoring and suitably qualified contractors for the maintenance and engaging with regional stakeholders for pest control.
Fauna exclusion fencing monitoring	No breaches in fauna exclusion fencing.	Check fauna exclusion fencing and fauna crossing structures for damage/blockage and rectify.	Roads and Maritime maintenance responsible for repairing exclusion fencing.
Predator attack near fauna crossing structures	No Koala deaths or injuries due to predator attack in the vicinity of fauna crossing structures	Where monitoring indicates that predators are a threat to Koala movement through the crossing structures, Roads and Maritime Services will engage with the North Coast Local Land Services, NSW National Parks and Wildlife Service (Grafton), and Rural Lands Protection Board (North East) and adjacent landowners to identify and implement strategies to reduce this predation risk.	Roads and Maritime responsible for liaising with relevant agencies and landowners to identify and implement strategies to reduce this predation risk.
Habitat revegetation monitoring	Years 1-3 - annual density of one Koala food/ shelter tube-stock per 20 m^2 across the revegetation site (Years 1-3). Year 5 - trees within 90% of monitoring plots have an average height >8 metres.	Undertake revegetation maintenance, i.e. replanting, replacing, fertiliser treatment, erosion control, weed control where required.	Roads and Maritime responsible for engaging suitably qualified ecologists to undertake the monitoring and suitably qualified contractors for the maintenance of revegetation.
Koala use of food tree plantations	At least 20% of Koala faecal-pellet search plots show evidence of occupancy by Koalas by Year 10 post-establishment.	Investigate whether cultivation practices need to be changed to improve the performance of the planted trees. Investigate whether comparable Koala "activity" levels are similar in nearby native forest. Review trends in the size of the Koala population in Section 10 where the food tree plantings have been established	Roads and Maritime responsible for engaging suitably qualified ecologists to undertake the required Koala surveys to establish whether the usage levels of the food tree plantings are "as expected" based on comparable surveys in nearby native forest.

9. Summary table and implementation schedule

Table 9-1 provides an overall summary of the actions proposed in the above plan. It also identifies the persons responsible for the actions and the estimated timing of the project.

The program schedule will be updated following a review of the approval and project timelines.

Table 9-1 Summary table and implementation schedule of management plan.

No.	Task	Responsibility	Pre-construction	Construction	Operations														
					Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
1. Pre-construction management																			
1.1	Baseline Koala surveys	RMS/Pacific Complete	X																
1.2	Preparation of Koala fencing strategy	RMS/Pacific Complete	X																
1.3	Pre-clearing surveys	Contractor's ecologist	X																
1.4	Identify sensitive ancillary areas and access roads	Contractor and Roads and Maritime	X																
1.5	Dog policy	Contractor and Roads and Maritime	X																
1.6	Phased resource reduction – Section 10 Koala 'hot-spots'	Koala expert/contractor and Roads and Maritime	X																
2. Construction management																			
2.1	Environmental Work Method Statements	Contractor		X															
2.2	Construction induction and training	Contractor		X															
2.3	Temporary fauna exclusion fencing	Contractor		X															
2.4	Permanent fauna exclusion fencing	Contractor		X															
2.5	Pre-clearing and clearing procedures	Contractor		X															
2.6	Managing Koala / vehicle collisions	Contractor's ecologist		X															
2.7	Koala relocation protocol	Contractor's ecologist		X															
2.8	Location of ancillary facilities	Contractor's ecologist, Roads and Maritime		X															

No.	Task	Responsibility	Pre-construction	Construction	Operations														
					Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
2.9	Fauna crossing structures	Roads and Maritime		X															
2.10	Habitat revegetation	Roads and Maritime		X															
3. Operational management																			
3.1	Maintenance of fauna exclusion fencing and fauna crossing structures (ongoing)	Roads and Maritime			X	X	X	X	X										
3.2	Maintenance of revegetation ongoing until revegetation criteria achieved	Roads and Maritime			X	X	X	X	X										
3.3	Predator control dependant on monitoring findings/evidence of predator action on Koala	Roads and Maritime			X	X	X	TBC following year 3 review	TBC following year 3 review										
4. Monitoring program																			
4.1	Selection of population monitoring locations	Ecologist	X																
4.2	Monitoring of Section 10 Koala 'hot-spots'	Ecologist, Roads and Maritime	X	X															
4.3	Fauna crossing structure and exclusion fence monitoring (including faecal pellet genetic analysis) (annually in Spring/summer)	Ecologist, Roads and Maritime			X	X	X	TBC following year 3 review	TBC following year 3 review										
4.4	Road mortality monitoring (bi-annually July/Aug and Oct/Nov))	Ecologist, Roads and Maritime			X	X	X	X	X										
4.5a	Revegetation monitoring (annually) - Plantings (veg plots)	Ecologist, Roads and Maritime			X	X	X	X	X	Until 90% of planting have average height of 8 metres.									

No.	Task	Responsibility	Pre-construction	Construction	Operations														
					Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15
4.5b	Revegetation monitoring (annually) - Koalas (scats)	Ecologist, Roads and Maritime					X	X	X	Until 20% of plots have evidence of Koala activity – or year 10.									
4.6	Koala population monitoring (biannually Spring and Autumn)	Ecologist, Roads and Maritime		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
4.7	Review of population monitoring and implementation of adaptive measures if required.	Roads and Maritime							X					X					X
4.8	Evaluation, project review and reporting	Ecologist, Roads and Maritime	X	X	X	X	X	X	X					X					X

Monitoring methodology may change as new technologies/methods are developed and results of power analysis are known. Reporting frequencies are fixed.

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Appendix A Ballina Koala Plan

Ballina Koala Plan

Koala Population Viability Analysis of the proposed Pacific Highway Upgrade near Wardell, NSW

Prepared for NSW Roads and Maritime Services

January 2016

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Cover photograph: Koala living in Broad-leafed Paperbark and Swamp Mahogany forest; and, the study area, showing the route of the proposed Pacific Highway Upgrade in Section 10, west of Wardell.

Executive summary

Context

The Australian Government Conditions of Approval for Section 10 of the Pacific Highway Upgrade near Wardell in northern NSW require the approval holder to demonstrate that the impacts to the Ballina Koala population as a result of the proposed highway upgrade are acceptable over a 50 year period. A population simulation and threat modelling process (Population Viability Analysis) was the method specified to undertake this assessment. A local Koala ecological and population demographic study, and two genetics studies, were commissioned by the Roads and Maritime Services to provide the parameter estimates needed to run the PVA. A range of mitigation options was also available for assessment.

Aims

To estimate the likely impact of the proposed highway upgrade in Section 10 on Koala population viability over a 50 year period, and over a range of plausible management scenarios.

Methods

The VORTEX (version 10) PVA software program was used to conduct the analyses. All population size, distribution, demographic and stochastic inputs to the model, as well as the frequency of likely catastrophic events, were provided by the authors of the local Koala field study, which included details for 50 captured animals. The genetics studies were used to estimate the minimum numbers of Koalas immigrating into and emigrating from the study area because the distribution of habitat in the region showed that the population was not "closed". These studies were also used to estimate the minimum numbers of animals dispersing, and the extent of inbreeding, within the study area. The impact of the proposed road was assessed by comparing population projections based on differences in the rate of dispersal between two sub-populations as influenced by the proposed connectivity structures. The provision of supplementary habitat for Koalas in the study area was modelled through an increase in the projected carrying capacity of the habitat. Management options were investigated by varying the levels of key population parameters.

Key results

Population projections showed a gradual decline over 50 years, with or without the proposed highway upgrade. The impact of the road was estimated to range between no effect and up to a 9.7% decline in the projected population size after 50 years, depending on the uncertainty associated with estimates of the demographic parameters and assumptions about the effectiveness of the connectivity structures that will be provided. In contrast, population projections could be improved substantially through management intervention, including through the provision of supplementary habitat (0.5%) and by a combination of approaches that result in reduced mortality and increased fecundity (potentially up to 496%).

Conclusions and Management implications

The projected population decline was due to births not being adequate to offset deaths, regardless of the presence of the highway upgrade. Any efforts to increase fecundity and/or reduce mortality in the region will improve population viability.

Significant opportunities exist to reduce Koala mortality by the provision of a range of mitigation structures, including Koala-proof fencing along the proposed highway upgrade and other roads in the area, and other management interventions. Community involvement is needed to control dog predation and to support trials of a new *Chlamydia* vaccine to increase fecundity.

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1. Introduction

1.1 Context

The NSW and Australian Governments are upgrading the Pacific Highway between Woolgoolga-Ballina (155 km) as part of State Significant Infrastructure. This Project is divided into 11 Sections, each of which has been subject to ecological surveys to determine the likely effects of the proposed upgrade on flora and fauna. The Koala in NSW is listed as 'vulnerable' under the Threatened Species Conservation Act 1995 (TSC Act), and also as 'vulnerable' under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). The present study incorporates the results of surveys and other assessments for the Koala in Section 10.

The Koala population located in Section 10, between Bagotville and Coolgardie west of Wardell, has been proposed by Phillips and Chang (2013) as suitable for listing as an "important population" under the EPBC Act. This population is referred to specifically in the draft Comprehensive Koala Plan of Management (2015) for the Ballina Shire Local Government Area and in the Conditions of Approval for the Project.

1.2 Conditions of Approval

On 14 August 2014, the Australian Minister for the Environment approved the Pacific Highway Upgrade from Woolgoolga to Ballina, NSW, subject to conditions, including Conditions 5, 6, 7, 8, 9 and 10 that refer specifically to the Koala.

Condition 5 states: "In order to ensure the long-term viability of the Ballina Koala population, the approval holder must engage a suitably qualified expert to undertake **population viability modelling** of the Ballina Koala population over a time period of no less than 50 years, taking into account the impacts resulting from the road upgrade in Section 10. This modelling should consider the current proposed route and any proposed avoidance or mitigation measures as appropriate".

Condition 7 states: "In addition to the Koala Management Plans(s) required by NSW approval conditions D8 and D9 (approved by the NSW Minister for Planning on 24 June 2014), to ensure that an unacceptable impact will not occur to the Ballina Koala population, the approval holder must submit for the Minister's approval a **Ballina Koala Plan** no less than 3 months prior to the commencement of Section 10. The Minister will only approve the plan and the commencement of Section 10 of the action if the impacts to the Ballina Koala population are demonstrated to be acceptable within the Ballina Koala Plan. The Ballina Koala Plan (this document) must include:

a. The modelling required by Condition 5 and the results of this modelling, and the peer review required by Condition 6;
b. Discussion of the future viability of the Ballina Koala population;
c. In the context of relevant environmental and economic considerations, any additional avoidance, mitigation or offsets, beyond those required by the NSW approval conditions, proposed to minimise the impacts to the Ballina Koala population; and
d. Evidence that any additional avoidance and mitigation measures proposed have been considered in the modelling required in Condition 5.

The approval holder must not commence Section 10 unless the Ballina Koala Plan has been approved by the Minister. The approved Plan must be implemented".

This Ballina Koala Plan is an essential component of the overall strategy to minimise and mitigate the impacts to the Ballina Koala population within Section 10 of the proposed Pacific Highway Upgrade.

1.3 Project objectives

The objectives of this project and report are to satisfy the Australian Government's Conditions of Approval in relation to preparation of the Ballina Koala Plan. This includes the requirement to:

- estimate the likely impact of the proposed highway upgrade in Section 10 on Koala population viability over a 50 year period; and to
- investigate the relative benefits of a range of plausible management scenarios that could be implemented by RMS to minimise any potential impacts of the proposed highway upgrade.

2. The Study Area

2.1 Study area

The Koala population located in Section 10, which extends 13.5 km north of the Richmond River and includes the localities of Bagotville and Coolgardie west of Wardell, is the subject of this study. This population has been proposed by Phillips and Chang (2013) as suitable for listing as an "important population" under the EPBC Act. The area nominated as enclosing this population is approximately 8,250 ha, the boundaries of which are displayed in Figure 1. This population is not considered as "closed" for the purposes of modelling because of the degree of habitat connectivity with surrounding areas (Figure 1).

The general landscape context within the study area is a predominantly-cleared, sometimes waterlogged, fertile valley surrounded to the west by mostly tall forested lands on slopes and ridges along the Blackwall Range, and to the east by low slopes covered mostly by drier forests and woodlands with large areas of tall heathland growing on less fertile soils (Figure 1). The valley and lower slopes have been used extensively for grazing and sugar cane production, although significant areas of remnant or regrowth native vegetation still remain, particularly along watercourses. The proposed route of the highway upgrade in Section 10 traverses through the eastern side of the valley and will result in the loss of a further 34 ha of native vegetation, half of which (17 ha) is recognised as good habitat for Koalas (Table 1).

2.2 Geology

Five main geological types are present in the study area (Figure 2). These geological types are ranked in approximate order of the fertility of the soils derived from them:

- Basalt (Tllb)
- Meta-basalt (Cnx)
- Undifferentiated alluvial deposits/floodplain and swamp deposits (Qa)
- Coarse-grained conglomerates (Rjbwx)
- Dune sand and sand sheets (Qb)

2.3 Vegetation types

A range of remnant or regrowth native vegetation types is present in the study area (Figure 3). The vegetation types likely to be of most importance to Koalas, due to the expected presence of Koala food tree species within them, include:

- Paperbark (depending on the proportion of Swamp Mahogany *Eucalyptus robusta*);
- Lowland Red Gum;
- Wet Flooded Gum – Tallowwood;
- Foothill Grey Gum – Ironbark – Spotted Gum;
- Northern Open Grassy Blackbutt

Other vegetation types present in the study area are less likely to make a significant contribution to Koala habitat but may contribute to Koala dispersal and habitat connectivity in the region.

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Study Area

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FIGURE 1

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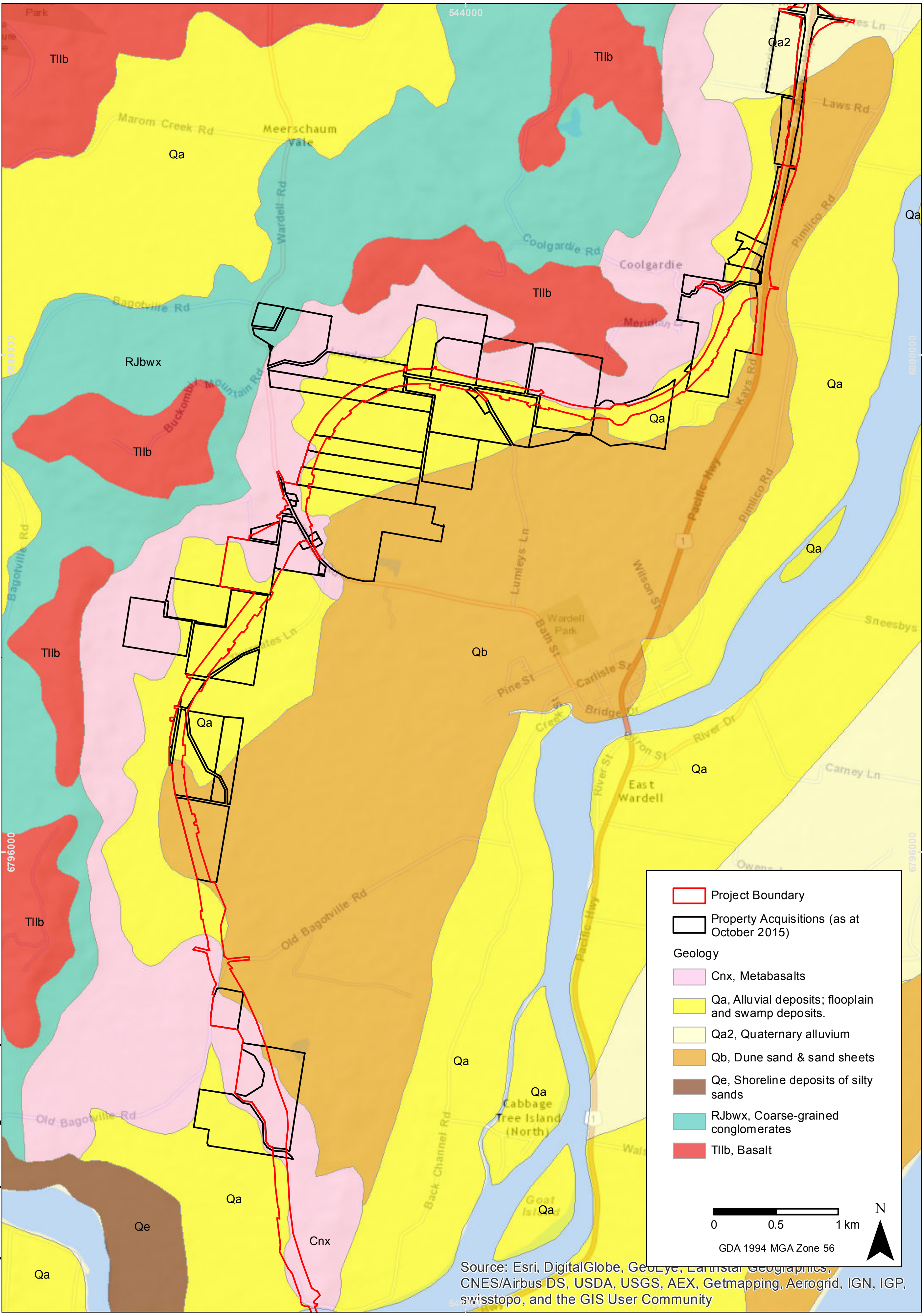

Section 10 - Geology

Environment and Heritage

FIGURE 2

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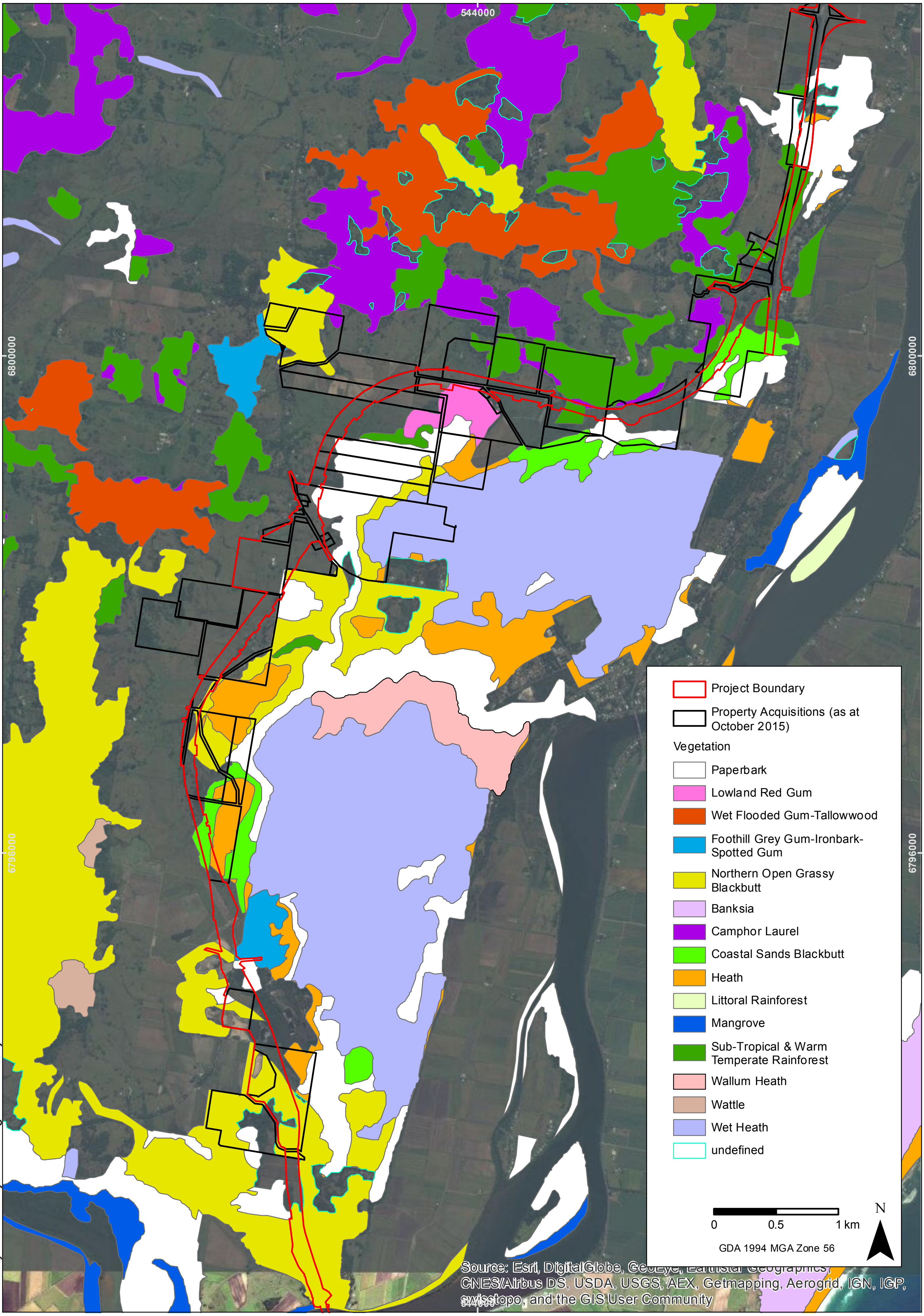

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Section 10 - Vegetation type

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FIGURE 3

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Table 1: Koala habitat quality scores (EPBC Act 1999 Environmental Offsets Policy Calculator) and the areas (ha) of each Biometric Vegetation Type occurring within the clearing "footprint" of Section 10 of the proposed Pacific Highway Upgrade between Bagotville and Coolgardie near Ballina. Source: Pellow and Semeniuk (2015).

Koala Habitat Quality Score **Vegetation Types in Section 10 clearing "footprint"**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
Blackbutt- Pink Bloodwood Shrubby Open Forest					0.05	2.21	0.14	2.97				5.38
Blackbutt Grassy Open For.							0.23	0.93	0.91		1.53	3.60
Cinnamomum camphora				1.44								1.44
Cleared	115.02				0.14			0.93				116.09
Mangrove-Grey Mangrove Low Closed Forest	0.17											0.17
Narrow-leaved Red Gum Woodlands						1.06	2.01	0.70		1.26	3.92	8.94
Paperbark Swamp Forest	0.00			0.41	0.88	1.61	2.17			0.25	0.64	5.96
Scribbly Gum-Needlebark Heathy Open Forest						1.98	1.47					3.45
Swamp Mahogany Swamp Forest						0.63	0.27		1.23			2.12
Tuckeroo-Riberry-Yellow Tulipwood Low Rainforest	0.01				0.19	0.89						1.09
White Booyong-Fig Subtropical Rainforest				0.39	0.52	0.47		0.53				1.92

3. Population Viability Analysis

3.1 Definition and purpose

Conservation problems are almost always multi-faceted, involving not only complex dynamics of biological populations, but also interactions with human populations. Many people need to contribute knowledge, expertise, and ideas in order to achieve the recovery of threatened species. Population viability analysis (PVA) can provide a framework for incorporating the many needed kinds of knowledge into species conservation efforts because PVAs provide a means for assessing the relative contributions of factors that can threaten the persistence of populations (Lacy 1993, Lindenmayer *et al.* 1993). Compared to other alternatives for making conservation decisions, PVA provides a rigorous methodology that can use different types of data, a way to incorporate uncertainties and natural variabilities, and products or predictions that are relevant to conservation goals (Akçakaya and Sjögren-Gulve 2000).

Shaffer (1981) first defined a minimum viable population (MVP) as the size at which a population has a 99% probability of persistence for 1000 years, but it has become more meaningful biologically to consider it to be the size below which a population's fate becomes determined largely by the range of stochastic factors that threaten its existence (Soulé 1987). In simple terms, small populations are more vulnerable to extinction than large populations because unexpected catastrophic events can lead to the death of all individuals, however, even large populations are threatened over time if birth rates are insufficient to offset death rates (Caughley 1994). There is no true consensus on a definition of the term PVA, with previously used definitions ranging from qualitative, verbal processes without models, through to mathematically-sophisticated, spatially-explicit, stochastic simulation models (Reed *et al*. 2002), while numerous practitioners have suggested that the latter definition be used (Ralls *et al.* 2002) and, with the availability of population-modelling software, this has become the most common approach.

The general concept of 'island biogeography' (see Diamond and May 1976) applies to the management of wildlife populations. As wildlife populations become smaller, additional threats to stability and persistence arise, which from a certain point forward, may be difficult to reverse (Lacy 2000b). These problems of small populations usually arise from stochastic processes (Lacy 2000b). Many aspects of population biology are 'sampling processes', such as breeding success, transmission of genetic alleles, survival and dispersal (Lacy 2000b). Uncertainty arises from their outcomes, leading to instability in population dynamics (Lacy 2000b). Demographic stochasticity is the random variation in deterministic factors, such as the numbers of births, deaths and sex ratio in a population, that result from the fates of individuals being outcomes of probability-based events (i.e. reproduction, mortality and sex determination; Shaffer 1981). The function of a PVA model is to assess, over a defined time period, the relative contributions of all deterministic factors and variations in demographic stochasticity towards long-term population persistence. This process can identify those variables which are likely to have the greatest influence on population outcomes, and accordingly which variables should be targeted for management attention should the projected population increase, or decrease, beyond acceptable limits.

3.2 Brief review of PVAs

Simulation-based PVAs (compared to a qualitative PVA) use computer software to model (predict) population trends for a single species, over time. The PVA process relies upon the availability of accurate demographic data for the population being modelled. Common software used for simulation-based PVA includes ALEX (Analysis of the Likelihood of Extinction; Possingham and Davies 1995), RAMAS (Applied Mathematics, NY, USA) and VORTEX (Lacy 1993). These programs have been reviewed and found to be appropriate for a wide range of applications (Lindenmayer *et al*. 1995).

In recent times a number of code-based models have been developed, such as ‘PVAClone’ in the statistical package R, while others have completed PVA analyses using transition matrix models (Edwards *et al*. 2015) and simulation modelling software such as E-Surge (Choquet *et al.* 2009, Hernández-Matías *et al*. 2015). In general PVAs may consider the following types of scenarios (as examples):

- Assess the effectiveness of different control measures for pest animals (Rømer *et al*. 2015).
- Management and recovery of threatened species (Bode and Brennan 2011, Lindenmayer and Possingham 1995, Taylor and Goldingay 2013).
- Competition with introduced species (Glen and Dickman 2013).
- Assessment of the potential success of re-introductions (King *et al*. 2014).
- Future trends in populations, particularly in relation to disturbance regimes (Lunney *et al*. 2007, Lindenmayer and Possingham 1995).

3.3 Strengths and weaknesses of PVAs

Modern applications of PVA are not intended to provide a definitive statement about population size after a specified time period. Instead, the value of this technique is to provide an opportunity for interested parties to assemble relevant information about the status of a population and likely threats to its persistence. The technique is used primarily to evaluate the relative impacts of alternative management scenarios that can be used to inform management actions (Beissinger and Westphal 1998, Coulson *et al*. 2001).

There have been few empirical studies that have attempted to verify the accuracy of PVAs. Brook *et al*. (2000) retrospectively examined the long-term population trends for a range of species based on 21 long term studies in which the actual population sizes were known. They found that the PVA predictions were relatively accurate, with population size estimates not differing substantially between the predicted and observed numbers (Brook *et al*. 2000). However, this level of optimism was criticised by Coulson *et al*. (2001) who cautioned that, while PVAs could be useful for comparing the consequences of different management or conservation strategies, the lack of long-term demographic data and confidence in the future (e.g. impact of catastrophes, habitat availability) would preclude accurate projections of the status of most wild populations. Lindenmayer and McCarthy (2006) used data collected over a seven year period to examine changes in populations of arboreal marsupials in timber production forests. They found that, while many variables were difficult to estimate and contributed to some variation, the overall PVA model was generally consistent with field observations.

One of the biggest influences on the outcome of a PVA is the size of the study area in which populations are being modelled. This is because of the strong relationship between population size and its resilience to the factors which may lead to its extinction; it is well known that smaller populations are much more likely to become extinct than larger populations, all else being equal (Caughley 1994). Thus, when assessing the impact of a development, it is important to ensure that the study area is not so large that most individuals in the population will have no interaction with the proposed development, but not so small that the population is likely to become extinct anyway due to the “small population paradigm” (Caughley 1994).

The main weakness of the PVA process is determining the overall accuracy of the input data (Beissinger and Westphal 1998, Coulson *et al*. 2001). If the input data over or underestimates particular parameters, then the final output will report erroneous results. Any model is only as good as the data which are used, and it is important to be cautious in the interpretation of results (Lindenmayer *et al*. 1995, Beissinger and

Westphal 1998). Often it is recommended to obtain long-term data over many years, in an attempt to calibrate the PVA model (see Lindenmayer and McCarthy 2006).

The strength of the PVA process is it can be used to construct and inform management decisions, to determine if different actions are likely to result in a positive or negative effect on a particular population. The PVA process includes a prediction of population size, thus well designed monitoring programs can be used to test the original predictions from the PVA.

3.4 Examples of the use of PVA

Mammals in Australia

Population viability analysis has been completed for a range of mammal species in Australia, investigating a range of research and management questions. These include the minimum viable area for the Yellow-bellied Glider (*Petaurus australis*; Goldingay and Possingham 1995), the effect of urban fragmentation and the use of connectivity structures for the Squirrel Glider (*Petaurus norfolcensis*; Taylor and Goldingay 2013), and competition between Foxes (*Vulpes vulpes*) and the Spotted-tailed Quoll (*Dasyurus maculatus*; Glen and Dickman 2013). In the Central Highlands of Victoria, several PVAs have been completed for the Leadbeater's Possum (*Gymnobelideus leadbeateri*) in relation to different disturbance regimes (i.e. logging and burning; Lindenmayer *et al.* 1993, Lindenmayer and Possingham 1995, Lindenmayer and Possingham 1996).

The Koala

Three publications, covering PVAs for four Koala populations have been completed (Table 2). These studies have considered both large and small population sizes, ranging from 20 to 800 individuals. Populations considered include the Iluka population, located to the southeast of this study area (Lunney *et al.* 2002), the Port Stephens population (Lunney *et al*. 2007), one population in southeast Queensland and another in Central Queensland (Penn 2000). All of these studies used Vortex to model changes in the Koala populations of those areas.

Three of the four Koala populations examined showed evidence of a significant decline, due primarily to high mortality and sometimes low fecundity. In all modelled scenarios, attempts to reduce mortality had more influence on population viability than any other factor. None of these studies explicitly examined the role of vehicle collisions, although this factor was recognised as one of several that may be contributing to high rates of population mortality. In south-east Queensland, Rhodes *et al*. (2011) reported on the separate effects of an array of threatening processes leading to the decline of a large population of Koalas, and road mortality was a significant factor.

Table 2: Input values for key variables used in previously published PVAs for the Koala.

Variable	Iluka (Lunney *et al.* 2002)	Oakey (SE Queensland; Penn 2000)	Springsure (Central Queensland; Penn 2000)	Port Stephens (Lunney *et al*. 2007)
Initial population size	20	46	20	800
Stable age structure at start	Yes, calculated by Vortex			Yes
Initial population gender structure	13F, 7M			
Maximum age	12	12	12	12
Minimum female breeding age	2	2	2	2
Minimum male breeding age	3	3	3	3
Sex ratio (% male)	55%	57%	53%	53%
% litter size 1	20% (±10%)	57% (±17.85%)	31% (±15.61%)	77% (7%)
% litter size 0	80%	43% (±17.85%)	69% (±15.61%)	33%
% males in breeding pool	50%	50%	50%	100%
Female mortality age 0	32.5% (±3.25%)	32.5% (3.25%)	30% (3%)	40% (4%)
Female mortality age 1	17.3% (±1.73%)	17.27% (1.727%)	15.94% (1.594%)	40 (4%)
Female mortality adult	9.2% (±0.92%)	9.17% (0.917%)	8.47% (0.847%)	23 (2.3%)
Male mortality age 0	20% (±2%)	20% (2%)	20% (2%)	40% (4%)
Male mortality age 1	23% (±2.3%)	22.96% (2.296%)	22.96% (2.296%)	40% (4%)
Male mortality age 2	23% (±2.3%)	22.96% (2.296%)	22.96% (2.296%)	40% (4%)
Male mortality adult	26.4% (±2.64%)	26.36% (2.636%)	26.36% (2.636%)	39% (3.9%)
Density dependence	Nil	Nil	Nil	Nil
Probability of catastrophe	3%	5%	5%	10%
Severity on reproduction	50%	55%	55%	5%
Severity on survival	50%	63%	63%	5%
Inbreeding depression	Nil	Nil	Nil	Nil
Environmental variation, survival and reproduction	Concordant	Concordant	Concordant	Concordant
Carrying capacity (K)	50	70 (7)	60 (6)	2500
Harvest	Nil			Nil
Supplementation	1 male, age 2 per annum	Nil	Nil	Nil

4. Vortex software

4.1 Vortex

VORTEX is an individual-based simulation program that models the effects of mean demographic rates, demographic stochasticity, environmental variation in demographic rates, catastrophes, inbreeding depression, harvest and supplementation, and metapopulation structure on the viability of wildlife populations (Lacy 2000a).

Vortex has been reviewed on many occasions in relation to other computer software packages, but it is important to remember that any computer program necessarily contains a large number of assumptions and simplistically models the behaviour of animals. Thus, the results of viability analyses can only be estimations of the actual dynamics of wild populations. As a result, caution should be used when interpreting and applying the results of any such analyses (Lindenmayer *et al*. 1995).

4.2 Assumptions and limitations

In their simplest form, population viability analyses assume that the population being modelled is a “closed” population (e.g. Penn 2000, Lunney *et al*. 2007), with no immigration in, and no emigration out, however this is rarely the case and Vortex contains the flexibility to take this into account if the information is available. The landscape context in the study area, with its fragmented forests and woodlands set in, or surrounded by an agricultural matrix, is clearly “porous” to Koala movements (Neaves *et al*. 2015, Norman *et al*. 2015) and, therefore, it is important to account for immigration and emigration (this was done in the present study using the “supplementation” and “harvest” features, respectively, of the program).

Vortex requires an assessment of whether inbreeding depression (i.e. the reduction in fitness of offspring produced by inbred mating) is present in the population being modelled and, while this can have a significant effect on results, the information is rarely available for wild populations. Some authors caution not to disregard the influence of inbreeding depression on extinction risk (O’Grady *et al*. 2006) as it may lead to serious overestimates of the survival prospects of threatened taxa, so the presence of inbreeding depression has been assumed for this population.

However, inbreeding may or may not lead to inbreeding depression, as the latter depends on the numbers and types of lethal alleles that are present in the population and whether matings are random in populations of at least moderate size. The Ballina Koala population was reported to have high levels of genetic diversity with very low levels of inbreeding (Neaves *et al*. 2015, Norman *et al*. 2015). Unfortunately, nothing is known about the number of lethal alleles that are present in this population, or the extent to which free-ranging wild populations are likely to be impacted. Again, based on the recommendations of O’Grady *et al*. (2006), we assumed the likely presence of lethal alleles in the population and have accepted the Vortex default value of 6.29 lethal alleles, although a range of values was also considered in this study. Accordingly, in the current study, all scenarios were modelled with inbreeding depression and the presence of lethal alleles. This had the effect of reducing population size projections by approximately 20-40% of those estimated when inbreeding depression and the presence of lethal alleles was switched “off” in the analyses.

Population viability analyses require accurate demographic data and accurate measures of the variability in these data over months and years. Most studies, including this one, take snapshot samples of population demography within usually one year or season, and hope that this information is representative of the population of interest. Of course, the incidence of drought, disease, predation and many other factors can combine to ensure that once-only samples can be unrepresentative, leading to misleading results.

One of the most difficult aspects of PVA using Vortex is to estimate the year-to-year variability associated with the mean values that are calculated for most variables (Beissinger and Westphal 1998). Without large sample sizes and extended periods of data collection, variability is difficult to calculate yet inaccurate measures can have a large effect on results.

PVAs also require an accurate understanding of population size and its distribution. If population size is under or overestimated, an inaccurate model will be produced.

Population dispersal rates and the success of these movements (i.e. percent survival) between sub-populations are crucially important in modelling the effects of a major highway bisecting this population yet, while Koalas have been observed using them, the effectiveness of the proposed connectivity structures is not well known.

4.3 Structure and inputs

Vortex requires data inputs for numerous variables in multiple categories. These inputs are usually means, as well as the variation around these means that is caused by environmental and annual fluctuations. However, environmental and annual variation cannot usually be estimated from short term studies (see above). Instead, most studies, including this one, incorrectly substitute the standard deviation around the mean for one particular year as the best available input for the Environmental Variation (EV) that is associated with each parameter estimate, given that we have no idea of the inter-year variability of these estimates. The principal categories of information requiring inputs in Vortex are:

- Scenario settings
- Inbreeding depression and number of lethal alleles
- Dispersal
- Reproductive system
- Reproductive rates
- Mortality rates
- Catastrophes
- Mate monopolisation
- Initial population size
- Carrying capacity
- Harvest rates
- Supplementation rates
- Genetics

A summary of the key inputs required for Vortex are presented in Table 2 (based on other studies) and Table 3 (this study).

5. Sources of Information for Modelling

5.1 Ecosure/Biolink study

An area of approximately 8250 hectares has been nominated as one encompassing an "important population" of Koalas in the Ballina Local Government Area (Phillips and Chang 2013, Phillips *et al*. 2015), and this was selected as the focal area for this study. The study area is located in the Ballina Local Government Area and is known locally as the Blackwall Range to the west and north of the proposed alignment and as Wardell heath to the east. The eastern and southern boundary of the study area is the Richmond River, with Sugar Cane plantations predominating in the east (Figure 1). Some forest connectivity occurs to the west and north, with rainforest vegetation occurring to the north (Figure 3). The landscape context is porous to Koala movements, with Koalas living adjacent to the study area and elsewhere in the LGA.

Population distribution and habitat occupancy

Within the 8247 ha study area, 2152 hectares was estimated to contain Preferred Koala Habitat (PKH), including 96 hectares of Primary Koala Habitat (Phillips *et al.* 2015; Appendix 1). Mean Koala population densities typical of the vegetation types present in the study area were estimated from existing data collected in the region by Phillips *et al*. (2015). Koala population density was estimated from observations of live animals encountered on 1 ha sampling plots distributed throughout the study area.

Sampling procedure for demographic determinations

A 2.5 km x 2.5 km grid square was applied across the study area, where up to seven Koalas were sampled from any one grid square. When Koalas were encountered, they were captured using either flagging or the fence-trap method. Once on the ground, Koalas were anesthetised, with the animal's gender, weight and body condition score recorded. The reproductive status of captured females was assessed using a four tier system consisting of 1/ no pouch young present, nor evidence of recent lactation; 2/ pouch young present; 3/ back young present; 4/ neither pouch young or back young present, but evidence of recent lactation. Tooth wear classes (after Gordon 1991) were determined, ranging from TWC 2-6.

A total of 40 Koalas was captured using the flagging or fence-trap method, while a further two were captured by hand when they were observed in the open. Another nine Koalas were found deceased in the study area, with three being from dog/fox attack and six as a result of vehicle strike. Koalas sampled were broadly distributed throughout the study area, however, some aggregations did occur in the southern part of the study area. Ocular and urogenital swabs, fur samples and ear tissue were also taken from each captured animal, in order to undergo various pathological and genetic analyses. The results of these data were unavailable at the time of the present study.

Of the 30 female Koalas sampled, 13 showed evidence of reproduction, distributed between Tooth Wear Classes 3-5, resulting in a reproductive rate of 43.33% (SD= 9.2%) which was later updated to 44.83% (SD=9.27) (Phillips *et al.* 2015; Appendix 1). Overall annual mortality was estimated at 9.94% (SD= 8.91%), however this average estimate varied greatly among age classes (Table 3), due to an unusual age-class distribution in the population.

Catastrophes

The likely distribution, frequency and severity of drought and fire on Koala survival and breeding success were reported in Phillips *et al*. (2015).

Table 3: Input values for key variables used in this study (primary source: Phillips et al. 2015).

Variable	Values used in this study
Initial population size	Total 236 individuals (includes estimated number of 0-1 year old males and females, based on fecundity of breeding females – otherwise 196 individuals, 125 females and 71 males) Individuals distributed as 180 west and 56 east of the proposed road upgrade.
Stable age structure at start	No. Local baseline "snapshot" field data used.
Initial population gender structure	0.64F: 0.36M, but 50:50 at birth
Maximum age	10
Minimum female breeding age	2
Maximum female breeding age	8
Minimum male breeding age	4
Sex ratio (% male)	36%
% litter size 1	44.83%
% litter size 0	56.66%
% males in breeding pool	76.47%
Female mortality age 0	19.7% (±11.63%)
Female mortality age 1	19.7% (±11.63%)
Female mortality adult	7% (±4.421%)
Male mortality age 0	19.45% (±11.49%)
Male mortality age 1	19.45% (±11.49%)
Male mortality age 2	30.56% (±18.05%)
Male mortality age 3	4.3% (±2.54%)
Male mortality adult	4 (±2.525%)
Density dependence	Nil (unknown)
Probability of catastrophe over 50 years	Drought 21% Fire 3%
Severity on reproduction	Drought effects restricted to upper slopes (32% of Koala habitat) in the study area. Severity: reduction of reproductive output by 15% in drought years. Fire effects restricted to 10% of the study area. Severity: reduction of reproductive output by 15%.
Severity on survival	Drought causes no additional mortalities. Fire results in 40% mortality of all individuals living within the fire boundary (i.e. 10% of the population).
Inbreeding depression	Modelled with inbreeding depression. Number of lethal alleles set to default 6.29.
Environmental variation, survival and reproduction	Concordant; i.e. good years for reproduction also typically good for adult survival.
Dispersal	Modelled for two sub-populations. Levels set to 3.95 individuals (1.98 each way) per year (see section 5.4), as well as other plausible values (0.792, 4, 8, 10, and 20 individuals each way per year).
Carrying capacity (K)	Population carrying capacity set at 291 (±15) individuals (approximately half of the available habitat remains unutilised). For sub-populations, 222 (±15) individuals distributed in the west and 69 (± 15) in the east. Replanting of 130 ha of new habitat for Koalas was modelled by gradually raising the carrying capacity by three animals per year beginning at year 7 (i.e. to a maximum of 25 and 16 animals for each sub-population) over a 15 year period, after accounting for the potential loss of 5 animals due to habitat clearing during road construction.
Harvest	The effects of mortality due to vehicle strike and dog attack in the study areas are already included in the mortality estimates. However, because of the porous boundaries of the study area, 2.85 individuals (60%M:40%F) (see section 5.5) were permitted to emigrate from the study area each year
Supplementation	Similar to above, 2.85 (60%M:40%F) (see section 5.5) individuals were permitted to immigrate into the study area each year.
Genetic inputs	Initial allele frequencies were entered using a spreadsheet provided by Dr C. Grueber (Sydney University) based on the results of the two genetics studies. 30 neutral loci modelled. Additional loci only included in summary statistics.

5.2 Interpretation and use of parameter estimates

All population size, distribution, demographic and stochastic inputs to the PVA model, as well as the frequency of likely catastrophic events (i.e. the “baseline” model), were provided by the authors of the local Koala field study, which included details for 50 captured animals (Phillips *et al*. 2015; Appendix 1). It is unknown whether the “baseline” demographic parameters, collected from this once-only snapshot sample, are truly representative of the population.

Population demography

The age-class and gender distribution of the Koala population sampled by Phillips *et al.* (2015) contained a number of unexpected results. Firstly, the sex ratio of the sample was highly biased towards females (64%). Secondly, the proportional representation within the population of young females and males in the 2-3 year old age-classes was unusually small, suggesting very high mortality of young Koalas. Thirdly, breeding success per year among adult females was relatively low (44.83%), and was restricted to females occurring within age-classes 3-7 years. For a species with an expected lifespan of approximately 10 years, the observed low breeding success suggests one of the following: that environmental conditions were not favourable to the population during the years prior to sampling; that habitat quality was not as good as expected; that disease may be a factor limiting reproductive output; and, that high mortality could be accounting for the relatively few older-aged, potentially-breeding, animals in the population. The causes of the observed demographic “imbalance” are unknown. However, mortality due to vehicle-strike in the study area appeared to be relatively high and clinical signs of disease appeared to be relatively low (Phillips *et al*. 2015).

Population size

Population estimates provided by Phillips *et al*. (2015) were based on an (unmapped) assessment of the distribution and amount of habitat (i.e. 2152 ha) considered as “preferred” by Koalas in the study area. The results of two surveys, conducted 2 years apart, were pooled to estimate Koala population size occurring within the area of preferred habitat. In the first survey, one Koala was observed in diurnal searches of 42 x 0.2 ha plots (8.4 ha sampled), providing a population density estimate of 0.12 ± 0.05 (SD) Koalas per ha or 259 ± 107 Koalas in the study area. In the second survey, three Koalas were observed in diurnal searches of 46 x 1 ha plots (45.34 ha sampled), providing a population density estimate of 0.066 ± 0.037 (SD) or 142 ± 80 Koalas in the study area. When the results of these two surveys were pooled, Phillips *et al*. (2015) estimated 196 ± 65 (SD) Koalas in the study area which, based on the skewed sex ratios observed in the demographic study (above), translated to a population comprised of 125 females and 71 males.

In the PVA model, we used an initial population size of 236 which included an additional 40 animals that we calculated to form the un-sampled 0-1 year age-class (TWC 1), based on the estimated numbers and breeding success of adult females aged 3-7 years.

Carrying capacity

As indicated above, the amount and distribution of habitat for Koalas in the study area was unmapped, but estimates from previous studies in the region, and elsewhere, were used by Phillips *et al*. (2015) to classify 2,152 ha into four Koala habitat classes (Primary - 96 ha, Secondary A - 578 ha, Secondary B – 808 ha, and Secondary C – 670 ha) with associated Koala population densities (0.63/ha, 0.42/ha, 0.23/ha, and <0.1 Koalas/ha, respectively). This habitat classification was based primarily on the distribution and abundance of three preferred food tree species: Tallowwood (*Eucalyptus microcorys*), Swamp Mahogany (*E. robusta*) and Forest Red Gum (*E. tereticornis*). The estimated population densities were derived from a range of earlier studies by the authors (Phillips *et al*. 2015).

The accuracy of this information, as it applies to the study area, could not be tested. However, the information was used to estimate the carrying capacity of the habitat in the study area as suitable for approximately 556 Koalas (Phillips *et al*. 2015). These authors then considered that such a population density to be unsustainable and reduced their estimate by nearly 50% to a long-term carrying capacity of 291 Koalas (Phillips *et al*. 2015). In the PVA model, carrying capacity was set at 291 Koalas in the study area, but we need to identify the limitations that were involved with this estimate.

A total of 17 ha of good habitat for the Koala is proposed for removal during road construction in Section 10 of the highway upgrade (Table 1). This amounts to the potential loss of habitat for approximately 5 Koalas (17*0.63/2) in the study area, assuming that these animals are unable to re-establish themselves within part of their previous home-ranges. This habit loss was scheduled to occur during clearing for road construction (year 2 of the model).

Roads and Maritime Services has also committed to planting at least 130 ha of new habitat for the Koala (see section 5.3). Using similar calculations to those above, this amounts to the provision of new habitat for approximately 41 Koalas (130*0.63/2). In the PVA model, these were distributed as habitat for 25 new animals on the western side of the road and 16 new animals on the eastern side of the road (i.e. in proportion to proposed areas of planted habitat on both sides of the road). Carrying capacity was scheduled to increase to 327 (222+69-5+41) in yearly increments of three animals, beginning in year 7 (tree plantings were established in year 1), and continuing until year 15 for the western plantings and year 12 for the eastern plantings. Eucalypt plantations comprised mainly of preferred Koala food tree species and aged 6-15 years are rapidly occupied by Koalas if the animals are present nearby (Kavanagh and Stanton 2012, Rhind *et al*. 2014).

In this study, the expected loss of habitat for up to five Koalas and the proposed area of new habitat (revegetation) that will be provided for approximately 41 Koalas were treated in the model as initially reducing (for five years post road construction) then increasing (from seven to 15 years post-plantation establishment) the carrying capacity of the habitat in the study area.

Catastrophic events

Three drought years were identified over the previous 14 years (i.e. frequency of ~ 0.21), but these drought effects were considered by Phillips *et al*. (2015) as likely to affect only ridgeline areas of Koala habitat (i.e. 700/2152 ha) or 32% of Koala habitat in the study area. Estimates of a reduction in breeding success and survival due to drought in 32% of Koala habitat available were 0.85 and 1.0, respectively, of the baseline inputs for these parameters (Phillips *et al*. 2015). Hence, to calculate the average effect of drought across the entire study area (as required for the PVA), there would be no change in breeding success across 68% of the study area (1 x 0.68) but a 0.85 (or 15%) reduction within 32% of the study area (0.85 x 0.32), which, when summed, provided an overall input value of 0.952 (or 4.8%) reduction. There was no predicted reduction in animal survival in areas affected by drought (i.e. no animals died), so the input value for an average reduction in survival due to drought remains as 1.0 (i.e. no change in the parameter estimates).

The probability of a catastrophic fire event was estimated to be once in every 35 years (i.e. at a frequency of ~ 0.03), but this event was considered likely to encompass only 10% of the study area (Phillips *et al*. 2015). Estimates of a reduction in breeding success and survival due to a fire event within 10% of the Koala habitat available were 0.85 and 0.60, respectively, of the baseline inputs for these parameters (Phillips *et* *al*. 2015). So, to calculate the effect of a fire event on average breeding success across the entire study area (as required for the PVA), there would be no change in breeding success across 90% of the study area (1 x 0.9) but a 0.85 (or 15%) reduction within 10% of the study area (0.85 x 0.1), providing an overall input value of 0.985 (or 1.5%) reduction. Similarly, the input value for an average reduction in survival due to a fire event was no change across 90% of the study area (1 x 0.9) but a 0.6 (or 40%) reduction within 10% of the study area (0.60 x 0.1), providing an overall input value of 0.96 (or 4%) reduction.

5.3 Genetics studies

Two studies were conducted to profile the genetic structure and composition of the Ballina Koala population (Neaves *et al*. 2015, Norman *et al*. 2015; Appendices 3 and 2, respectively). These studies measured the levels of genetic diversity in the study area compared to surrounding areas. The Australian Museum study (Neaves *et al*. 2015) obtained tissue samples for 38 Koalas in the study area and compared these using microsatellites with 231 Koala samples from an existing database (Australian Centre for Wildlife Genomics) for four surrounding locations in NSW and south-east Queensland (Port Macquarie, Coffs Harbour, Tyagarah and Coomera). Mitochondrial DNA analyses were also performed for a total of 454 Koalas across the species' distribution to place the population in the study area within a broader context. The Southern Cross University study (Norman *et al*. 2015) analysed tissue samples for 47 Koalas collected within the study area and compared these to samples from 88 Koalas collected from nearby but outside of the study area (42 from west of the study area and south of Lismore, 30 to the north-east of Lismore and 16 from between Lismore and Casino).

Both studies reported that the levels of genetic diversity present within the Ballina Koala population (i.e. within the study area) were comparable to that found at other locations in the region. The levels of genetic variation are within the range reported for populations in northern NSW, central NSW and south-east Queensland but exceed those reported for populations in Victoria. The Australian Museum (AM) study reported no evidence of genetic structuring within the study area, but the Southern Cross University (SCU) study reported that there was genetic differentiation between the northern and southern sub-populations within the study area. This difference was explained by the northern sub-population receiving more immigrants from surrounding areas compared to the southern sub-population which is surrounded on two sides by natural barriers to Koala movement (i.e. the Richmond River and the Tuckean Broadwater). For the purposes of PVA modelling, no genetic sub-structuring was assumed for the population in the study area.

In a regional context, there was evidence for gene flow across the populations sampled in the region, but with some genetic differentiation associated with geographic distance. Both studies found evidence of long-range (up to 20 km) dispersal, although distances of up to 3.5 km were more typical, and animals that were geographically closer to each other were more likely to be closely related. Both studies provided estimates of dispersal (i.e. number of Koalas per generation), both between the study area and surrounding areas and within the study area between areas east and west of the proposed highway. These estimates assumed that dispersal was symmetrical because in most cases it was not possible to determine the direction of dispersal.

Both studies reported that the average level of inbreeding is negligible in the study area. The SCU study provided estimates of the effective number of alleles in the population in the study area, and the AM study provided frequencies for each allele in the population. This information was compiled into a spreadsheet by Dr Catherine Grueber (Sydney University) and used in the PVA modelling to obtain an estimate of the genetic diversity (number of alleles remaining) resulting from each set of scenarios.

5.4 Estimating dispersal

Dispersal occurs at multiple levels, and rates, throughout the study area and it is difficult to estimate these values. Within the study area, one aspect of dispersal (a) is an estimate of the number of animals, per generation, that have successfully contributed to the breeding pool in an adjacent sub-population. This information has been provided by the two studies of genetic diversity in the Ballina Koala population (Neaves *et al*. 2015, Norman *et al*. 2015; Appendices 3 and 2, respectively). These studies estimated that 2.9, or 5 (± 2.2), individuals (mean 3.95), respectively, move from their natal home ranges to their new breeding home ranges across a nominal line coinciding with the location of the proposed road in the study area. These data are based on a Koala generation length of 6.02 years, which was estimated for a free-ranging, *Chlamydia*-positive population in north-eastern New South Wales (Phillips 2000).

Another aspect of dispersal (b) is that which includes all movements that may occur within the Koala population, but which do not necessarily contribute to the breeding pool in an adjacent sub-population (e.g. transient animals, and animals which breed only in one sub-population but whose home-ranges are large enough to overlap parts of two sub-populations). In most years, this form of dispersal is likely to be inconsequential, as the effective rates of dispersal have already been encompassed within estimates for dispersal type (a). However, dispersal type (b) is likely to be density-dependent and so could become very important in certain years through the provision of "population rescue" when a sub-population has been severely depleted by some catastrophe, or if there is a steady decline in the size of an adjacent sub-population. Dispersal type (b) is difficult to parameterise in the model because these population density-dependent relationships are unknown. The relevance of considering this form of dispersal is that, in some years, the rate could be much greater than that normally occurring and the capacity to accommodate this may be affected by the number of connectivity structures provided.

A range of plausible estimates for dispersal were used in the PVA models, beginning with the estimates provided by the two genetic studies (i.e. mean 1.98 animals each way per year). However, because less than half (44.83%) of the females of breeding age actually bred during the year of the local field study (2014-2015), it could be argued that the number of Koala movements through the connectivity structures (if they were present) might be at least twice the numbers for dispersal estimated by the two genetics studies (i.e. more than 4 animals each way per year). Further guidance may be provided by long-term Koala radio-tracking studies elsewhere. For example, 40 (23 males and 17 females) of 195 (20.5%) radio-collared Koalas dispersed in south-east Queensland (Dique *et al*. 2003). Ninety-three percent of these dispersing animals were 20-36 months of age, with the mean straight-line distance between natal and subsequent breeding home ranges measured at 3.5 km for males (range 1.1-9.7 km) and 3.4 km for females (range 0.3-10.6 km). In the Pilliga forests of northern NSW, 6 of 32 (18.8%) radio-collared Koalas were initially captured at one location but moved to establish a new home-range during the 12 month study (Kavanagh *et al.* 2007). These 6 animals were all 2-3 years old (four males and two females). The mean daily (straight-line) movements for all animals in the study was 89 m, but this included the large daily movements (up to 897 m) when young animals were dispersing.

In the PVA modelling, only animals aged 1-4 years (both genders) were permitted to disperse. Dispersal inputs ranged from 1.98 individuals (based on the mean estimate provided by the genetics studies), through to 4, 8, 10 and 20 individuals moving each way per year to encompass a range of potential dispersal scenarios. Dispersal rates were treated as "symmetric" between the two sub-populations, as per the assumptions of the genetics analyses. Dispersal was also modelled as the number of animals dispersing rather than as a percentage of each sub-population because the smaller, eastern sub-population acted as a sink when equal percentages of each sub-population were permitted to disperse. Mortality was assumed to be zero for all dispersing animals.

5.5 Estimating immigration and emigration

The study area boundary (Figure 1) and the surrounding vegetation types were shown by the genetics studies not to constitute a barrier to Koala movements. Accordingly, the “harvest” and “supplementation” features of Vortex were used to account for emigration out of, and immigration into, the study area each year, respectively. As in the previous section (5.4), rates of immigration and emigration can be viewed as dispersal type (a) and dispersal type (b), although it is more difficult to estimate values for these parameters (especially for dispersal type b) because of the large area and perimeter involved. Fortunately, the two recent studies of genetic diversity in the Ballina Koala population (Neaves *et al*. 2015, Norman *et al*. 2015) also compared their results with other Koala populations nearby (Tyagarah and Lismore, respectively).

These studies estimated that 5.7 (± 2.8) Koalas move per year between the study area and the broader Lismore area (Norman *et al*. 2015; Appendix 2), and that 0.8 individuals move per year between the study area and the more distant Tyagarah Koala population (Neaves *et al*. 2015; Appendix 3). Given that the Lismore samples were in closer proximity to the study area (approximately 15 km vs 40 km away), we decided to model immigration and emigration in Vortex using the values of 2.85 and 2.85, respectively (sum=5.7). No estimates of dispersal type (b) could be determined for immigration and emigration, and so only the above values (2.85) were used in modelling immigration and emigration.

5.6 Mitigation options

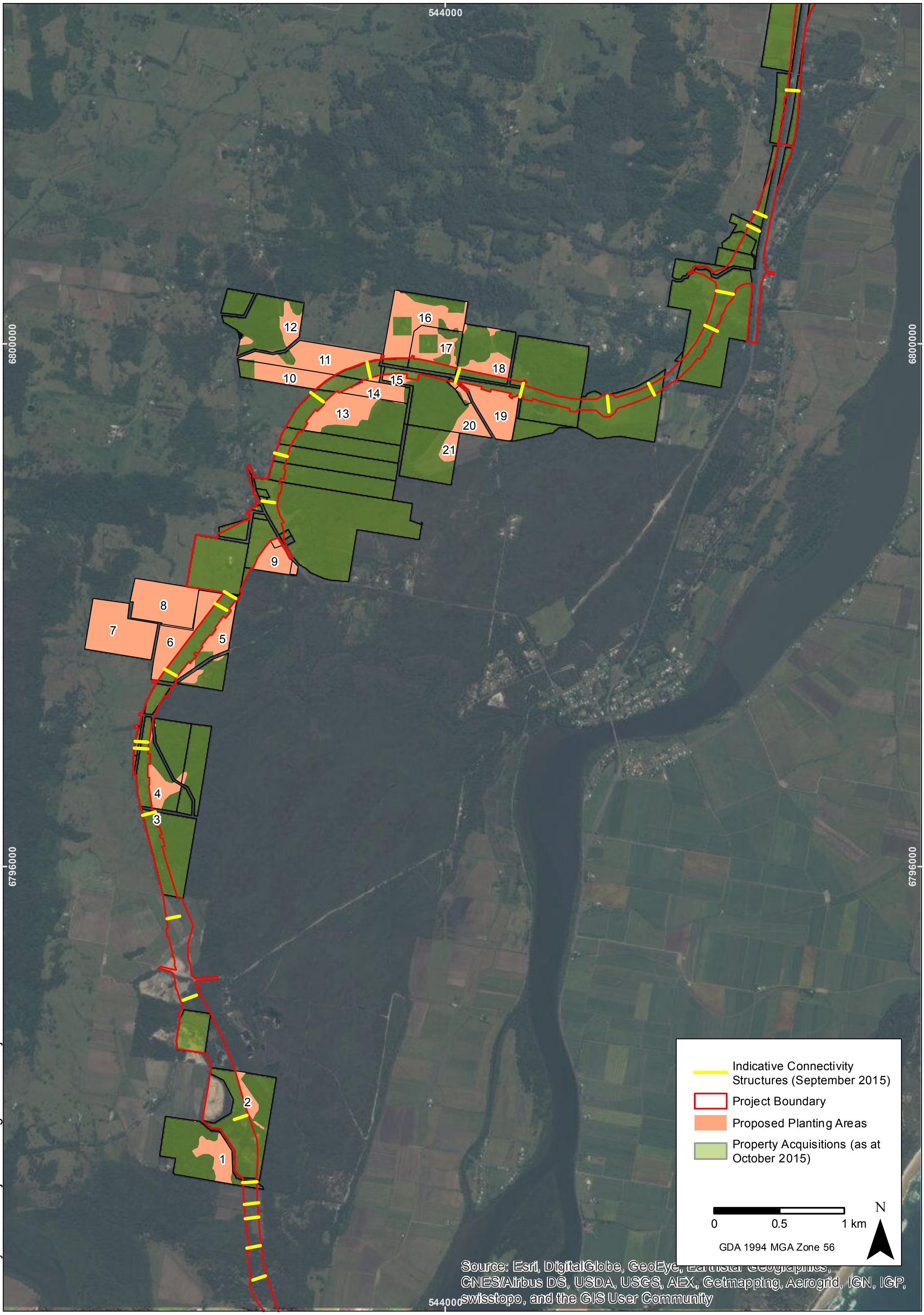
Roads and Maritime Services, in consultation with other agencies and Koala experts, have agreed to build 26 connectivity structures along the 13.5 km of Section 10 of the proposed highway upgrade, all of which are likely to have value in enhancing the dispersal and movements of Koalas in the study area (Figure 4; Appendix 4). This is a significant increase in the numbers and type (i.e. Koala-friendly designs) of these structures compared to those proposed in the EIS/SPIR (2012/2013) (Figure 5; Appendix 4).

On average, it is proposed that there will be approximately 1.9 connectivity structures per km of new road, or about one connectivity structure per 520 m of the road. With Koala home-ranges averaging about 15 ha (i.e. 437 m diameter; Kavanagh *et al.* 2007), this represents nearly one connectivity structure per Koala home-range either side of the proposed highway upgrade in Section 10, providing opportunities for most animals living near the proposed road to cross safely or to disperse.

The highway upgrade along Section 10 will also be fully-fenced, using Koala-proof floppy-top fencing, with the provision of grids near the intersections with other roads, to create a fully closed system to prevent vehicle-strike to Koalas (Appendix 4).

Roads and Maritime Services has acquired at least 621 ha (as at October 2015) of forested and cleared land near the proposed highway upgrade in Section 10, of which 151 ha is available for revegetation. Eucalypt plantations comprised mainly of preferred Koala food tree species are rapidly occupied by Koalas if the animals are present nearby (Kavanagh and Stanton 2012, Rhind *et al*. 2014). The NSW Minister for Roads and Freight has made a commitment to plant at least 130 ha of Koala food trees in the study area, if the proposed upgrade is approved, and a Koala revegetation strategy has been developed (Kavanagh and McLean 2015; Figure 4). This is equivalent to the provision of new habitat for approximately 41 Koalas (see section 5.2). As described in the previous section, this new habitat was incorporated in the model through incremental changes (from years 7-15) in the carrying capacity of the study area.

The proposed new Koala food tree plantations will also enhance dispersal between the western and the eastern sub-populations by focussing Koala movements towards the connectivity structures that will be provided, and will facilitate Koala movements through adjacent areas that are currently cleared farmland.



Section 10 - RMS Proposed Planting Areas

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FIGURE 4

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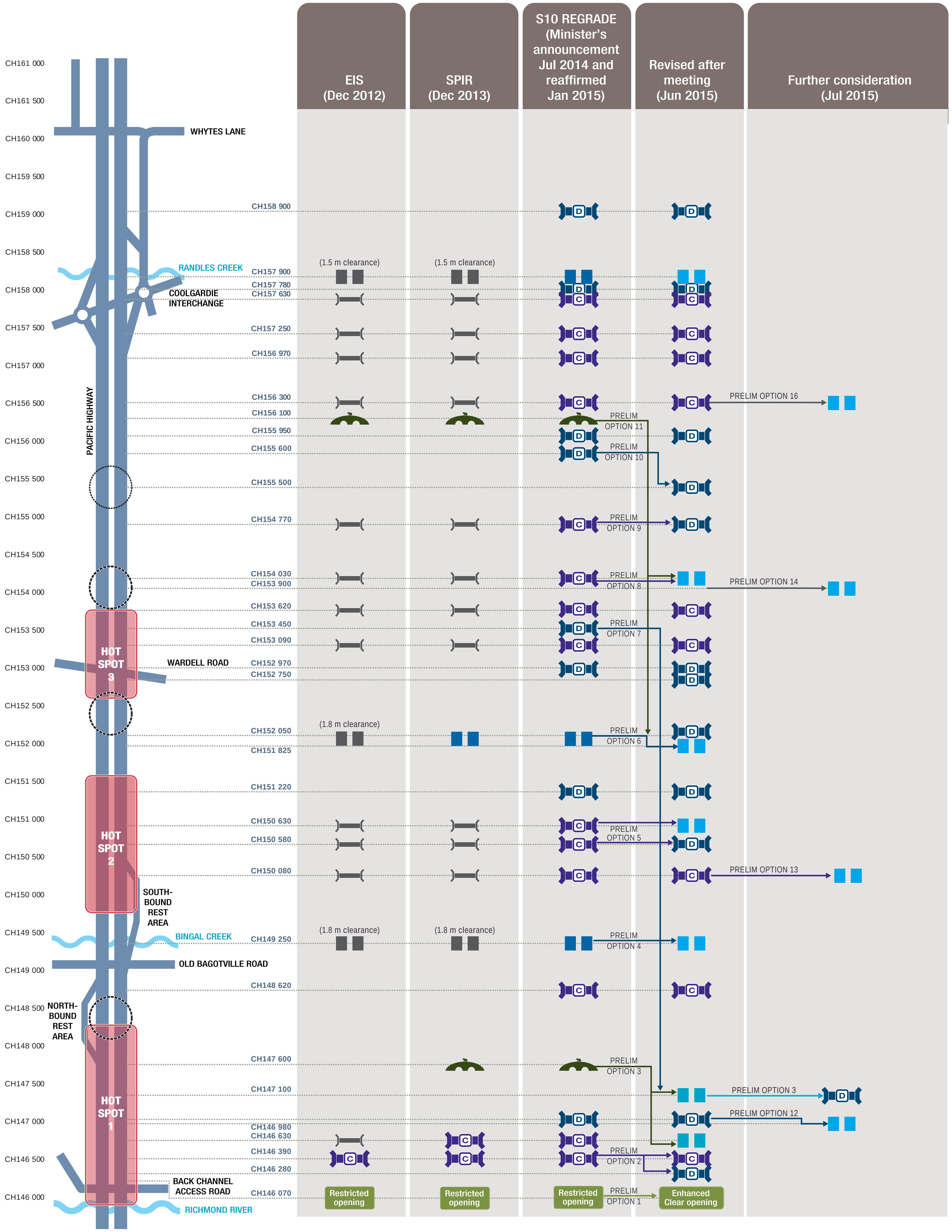
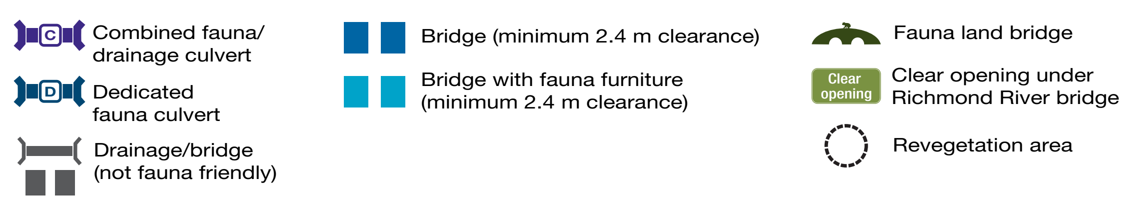
KOALA CONNECTIVITY DEVELOPMENT

Transport Roads & Maritime Services NSW

PACIFIC COMPLETE





Note:
(1) Koala friendly crossing shown have a minimum 2.4 m clearance

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5.7 Road impacts

Road impacts may adversely affect Koala populations through habitat fragmentation and barrier effects, as well as through direct mortality from vehicle strikes. Independent studies have shown that roadkills can be a major source of mortality for Australian wildlife, including Koalas (Taylor and Goldingay 2003, 2004, 2010; Hobday and Minstrell 2008; AMBS 2011). Over a four-year period from 2005-2008, a total of 530 Koalas was presented to veterinary clinics near Port Stephens in NSW, 205 (38.7%) of which had been struck by motor vehicles (D. Hudson, personal communication).

In the Ballina study area, of 109 "call-outs" reported by Lismore Friends of the Koala (data from 1989-2014), 35 (32.2%) Koala deaths were due to vehicle strikes, compared to 22 (20.2%) due to dog attacks, 40 (36.7%) due to disease, and 12 (11.0%) due to natural causes (Phillips *et al*. 2015). These authors reported four locations in the study area as known "hot spots" for Koala mortalities (Pacific Highway, Bruxner Highway, Wardell Road and Bagotville Road; Appendix 5), and observed six road-killed Koalas during their six-month field study (Phillips *et al*. 2015). A recent update reported that at least 10 Koalas were hit by vehicles in the study area during 2015, eight of them within the four hot spots identified (S. Phillips, *pers. comm.* 14/12/2015) (see also section 6.4).

5.8 Koala use of connectivity structures

Crossing structures (underpasses and overpasses) have been shown to be effective for Koalas provided they are large enough in cross-section, not too long (<50 m), and are combined with Koala-proof fencing and revegetation (Taylor and Goldingay 2003, AMBS 2011, RMS unpublished data). However, research is lacking on the extent to which mitigation measures reduce the risk of local extinction, given the overall context of the major linear infrastructure (Taylor and Goldingay 2010, Van der Ree *et al.* 2011). No relationship has yet been established between the numbers of connectivity structures available and the probability that an animal will cross, or the numbers of individual Koalas using them. As indicated above (section 5.4), the number of connectivity structures normally required to satisfy Koala dispersal type (a), may be less than the numbers required to facilitate Koala dispersal type (b) during the period following a catastrophe when sub-population rescue is needed. Accordingly, we modelled dispersal across a continuum of values (0.792, 1.98, 4, 8, 10, 20 animals each way per year) to investigate this possibility. In this PVA, we assumed that all 26 connectivity structures proposed for Section 10 were required to meet the needs of dispersal at each level (1.98, 10 or 20 animals), and that the worst-case scenario for road impact was that connectivity may be reduced to 40% of these levels (0.792, 4 or 8 animals). This worst-case estimate of 40% dispersal was based on each connectivity structure having a "catchment area" of 200 m (i.e. 100 m fencing either side of each connectivity structure), amounting to approximately 40% of the total length of the road.

5.9 Output measures

All PVA scenarios were modelled across a timeframe of 50 years (see section 1.2).

Each model-run in Vortex produced comprehensive output for each sub-population (east and west of the proposed highway upgrade) and for the overall population. These outputs included tables showing the projected number of Koalas remaining after 50 years, the probability of extinction after 50 years, the population growth rate, the number of alleles remaining in the population, and the variability around each of these estimates based on 1000 simulations of each modelled scenario. A wide range of graphical outputs can also be displayed.

6. Modelled Scenarios

6.1 Impact assessment

The impact of the proposed road was assessed by comparing population projections based on differences in the rate of dispersal between two sub-populations as influenced by the proposed connectivity structures. The provision of supplementary habitat for Koalas in the study area was modelled through an increase in the projected carrying capacity of the habitat. Management options were investigated by varying the levels of key population parameters (e.g. fecundity, mortality) in a series of sensitivity tests.

Before any impacts due to the road could be assessed, it was important to untangle any confounding effects that may be caused by splitting the population into two sub-populations. That is, smaller populations are inherently more prone to extinction than larger populations, regardless of any road effects. Accordingly, all modelled scenarios were conducted on the basis of comparisons between two sub-populations in which the level of dispersal was either unconstrained (i.e. the no-road scenario) or constrained (i.e. the presence of the road). For the purposes of assessing the impact of the proposed road, it was assumed (expert workshop discussions, 14 October 2015 organised by NSW Koala Expert Advisory Committee) that the 26 connectivity structures to be provided (section 5.6) would either cater fully for the dispersal needs of the population (i.e. 100% connectivity) – and therefore result in no impact of the road – or, as a worst case scenario, would limit the rate of dispersal to 40% of the numbers of animals attempting to disperse. The worst-case estimate of 40% dispersal was based on each connectivity structure having a "catchment area" of 200 m (i.e. 100 m fencing either side of each connectivity structure), amounting to approximately 40% of the total length of the road. It was also assumed that the proposed road would be fully fenced to prevent any additional Koala mortalities. The "worst-case" impact of the road could therefore be estimated as a percentage by dividing the projected number of animals remaining in the population after 50 years in the 40% connectivity scenario by the numbers remaining after 50 years in the 100% connectivity scenario, and subtracting the result from 100.

The scenarios modelled included the following:

- No habitat supplementation or management interventions, but comparing dispersal rates either unconstrained (100% connectivity) or constrained (40% connectivity) – including sensitivity tests to determine the effects of uncertainty in the estimates of demographic parameters. Note, this scenario is simply provided as a reference point because road construction will require the removal of habitat for some animals.

- No habitat supplementation or management interventions, but comparing dispersal rates either unconstrained (100% connectivity) or constrained (40% connectivity), including the loss of habitat for 5 Koalas during road construction. These scenarios also included sensitivity tests to determine the effects of uncertainty in the estimates of demographic parameters.

- Effect of habitat supplementation for up to 41 Koalas after accounting for the loss of habitat for 5 Koalas. These scenarios also include sensitivity tests for an overall reduction in mortality by 20% across all age-gender classes, increasing population fecundity by 20%, and both reducing mortality by 20% and increasing fecundity by 20%. Note, these variations in fecundity and mortality rate are also provided to indicate the potential for management (unspecified) to affect population outcomes.

- Effect of reducing mortality by either 4 or 8 young animals per year, combined with habitat supplementation.

In each of these scenarios, the PVA models incorporated dispersal estimates ranging from 1.98-20 animals per year moving each way across the proposed road.

6.2 Sensitivity analysis

Sensitivity testing was undertaken to achieve an understanding of the most influential variables in the analysis, and to determine the effects on model results of uncertainty in the estimates of key demographic parameters. The sensitivity test (ST) function in Vortex was used to simultaneously compare a range of inputs for certain parameters, while holding all the rest of the parameters constant. Variables tested in this way were breeding success, female and male mortality rates by age-class, initial population size, carrying capacity and the number of lethal alleles in the population. Subsequently, the effects of uncertainty in the estimates of fecundity, mortality and dispersal on model results were tested by varying these parameters up or down by 20% of their base values (Phillips *et al.* 2015). Inbreeding depression was also assumed to be present for these sensitivity tests.

6.3 Road effects models: role of habitat supplementation

Habitat supplementation for up to 41 Koalas after accounting for the loss of habitat for 5 Koalas was achieved by initially reducing the carrying capacity of the habitat in the study area by five animals for 6 years after clearing for road construction, followed by small increases in carrying capacity each year from 7-15 years after plantation establishment (see section 5.2). These scenarios also included sensitivity tests for an overall reduction in mortality by 20% across all age-gender classes, increasing population fecundity by 20%, and both reducing mortality by 20% and increasing fecundity by 20%. The primary reason for including these scenarios was to assess the effects of uncertainty in these parameter values, but they also provide an indication of the potential for management (unspecified) to affect population outcomes (e.g. by reducing Koala mortality through fencing on other local roads, controlling dog predation, and by increasing Koala fecundity by limiting the frequency and severity of disease in the population through the application of a *Chlamydia* vaccine, or both).

6.4 Road effects models: applying management to control mortality

Long-term data collected by the Lismore Friends of the Koala group for the numbers and locations of Koalas killed by vehicles on roads in the study area averaged 1.23 animals per year, although annual mortalities of 4-6 animals were considered more likely (Phillips *et al*. 2015). These authors observed six Koala mortalities caused by vehicle-strike during the six months of their field study, and at least 10 mortalities in 2015 (S. Phillips, *pers. comm*. 14/12/2015). Four main road-kill "hot-spots" were identified (Appendix 5). The same long-term data set also showed that at least 1.64 Koalas were killed annually by predation by domestic dogs. This information suggests that there may be opportunities for management to reduce the numbers of "avoidable" Koala mortalities by up to four or possibly eight animals per year in the study area. These two scenarios are included because they represent achievable objectives for management because reducing mortality by 4 or 8 animals could occur by fencing known road-kill hotspots, and by controlling local dog predation.

Reducing Koala mortality by either 4 or 8 animals in the study area due to management control was modelled by eliminating "harvest" (emigration) from the study area (i.e. 2.85 animals per year) and adding the balance (either 1.15 or 5.15 animals per year, respectively) to the existing level of 2.85 for "supplementation" (immigration). This reduction in mortality was applied at the rate of 40% for young females (1-3 years old) and 60% for young males (1-4 years old) because of the greater propensity for males to be killed by cars (Phillips *et al*. 2015).

7. Results

7.1 Deterministic population growth rate

All scenarios modelled, with or without the proposed highway upgrade, showed a gradual decline in this population of Koalas. Deterministic projections of population growth (i.e. in the absence of catastrophes and other unplanned stochastic events) were negative. This is, in 2014-2015, the birth rate was insufficient to offset the death rate in this population. The exponential rate of increase for the population was r=-0.0049, the annual rate of change was λ=0.9951, and the per-generation rate of change or “net replacement rate” was R_0=0.8092. The population was found likely to persist for at least 50 years under most scenarios, but at much reduced numbers (Figure 6; Tables 4-5).

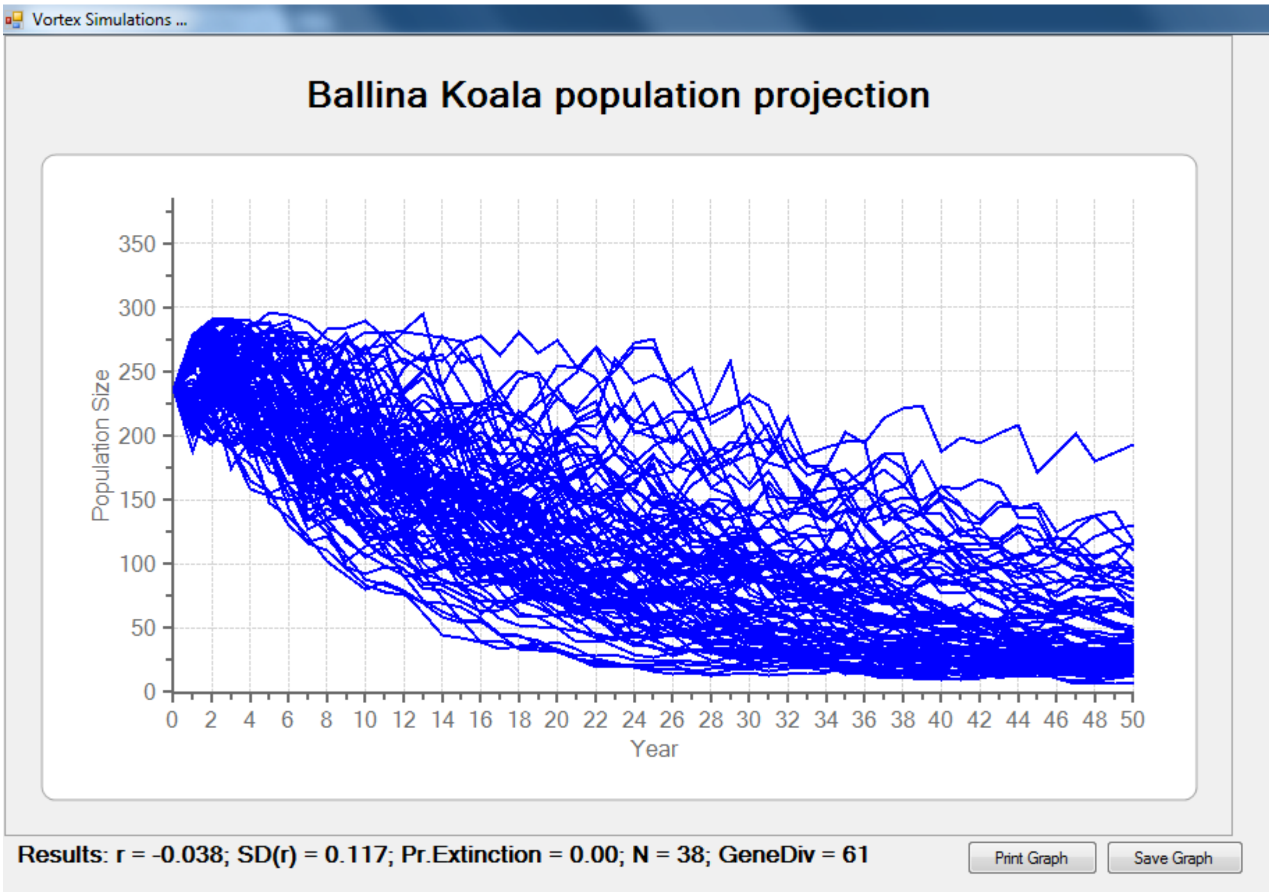


Figure 6: Projected Koala population decline in the study area over 50 years, in the absence of the proposed highway (results of 1000 simulations). The projection incorporates the likelihood of drought and fire in the study area, together with a small allowance (2.85 individuals per year) for both immigration and emigration. The projection also assumes the presence of inbreeding in the population

Assumptions about the presence of inbreeding depression in the population had a significant effect on the results. Including inbreeding depression and the presence of lethal alleles in all models had the effect of reducing population size projections by approximately 20-40% of those estimated when inbreeding depression and the presence of lethal alleles was switched “off” in the analyses. The genetics studies by Neaves *et al*. (2015) and Norman *et al*. (2015) both reported very low levels of inbreeding in the Ballina Koala population but, to be conservative, we presented our final PVA results with the assumption that inbreeding depression was present in the population.

7.2 Sensitivity tests – identifying the most influential variables

Sensitivity tests were applied within Vortex to investigate the influence of parameter estimates for key population variables. There will always be uncertainty surrounding the results of “snapshot” estimates derived from short-term field studies because these estimates vary from one year to another but, in the absence of long-term population data, the real question is - for which variables are these errors likely to have a significant impact on the results? Conversely, which variables are most likely to influence population viability outcomes if they can be controlled or manipulated by management?

Sensitivity tests showed that breeding success (population fecundity; Figure 7) and female mortality rates for both juveniles and adults (Figure 8) were highly influential in the results of the PVA (i.e. in projected population sizes). This means that any errors in the estimation of these two variables are likely to have a significant effect on the results, and also that efforts to manipulate these variables through management are likely to have a beneficial effect on population viability. In contrast, sensitivity tests for other variables, including male mortality rates for juveniles, sub-adults and adults (Figure 9), initial population size (Figure 10), habitat carrying capacity (Figure 11), and the number of lethal alleles in the population (Figure 12), showed that management attempts to vary these parameters would be unlikely to have a large effect on the results, and, of course, that errors in the initial estimates for these parameters are unlikely to be of major concern for the analysis.

The importance of birth rates (breeding success) being adequate to cover death rates (mortality) in this population is clearly shown in Figure 10 where population size is projected to decline rapidly. However, it should be noted that the declines observed in year 1 for initial population sizes of 500 and 400 animals were due to carrying capacity remaining capped at 291 individuals in the model. Management efforts to improve breeding success and/or to reduce mortality would be highly beneficial for this population. It is likely that by reducing mortality of females in particular (Figures 8 and 9), that breeding success in the population would also increase.

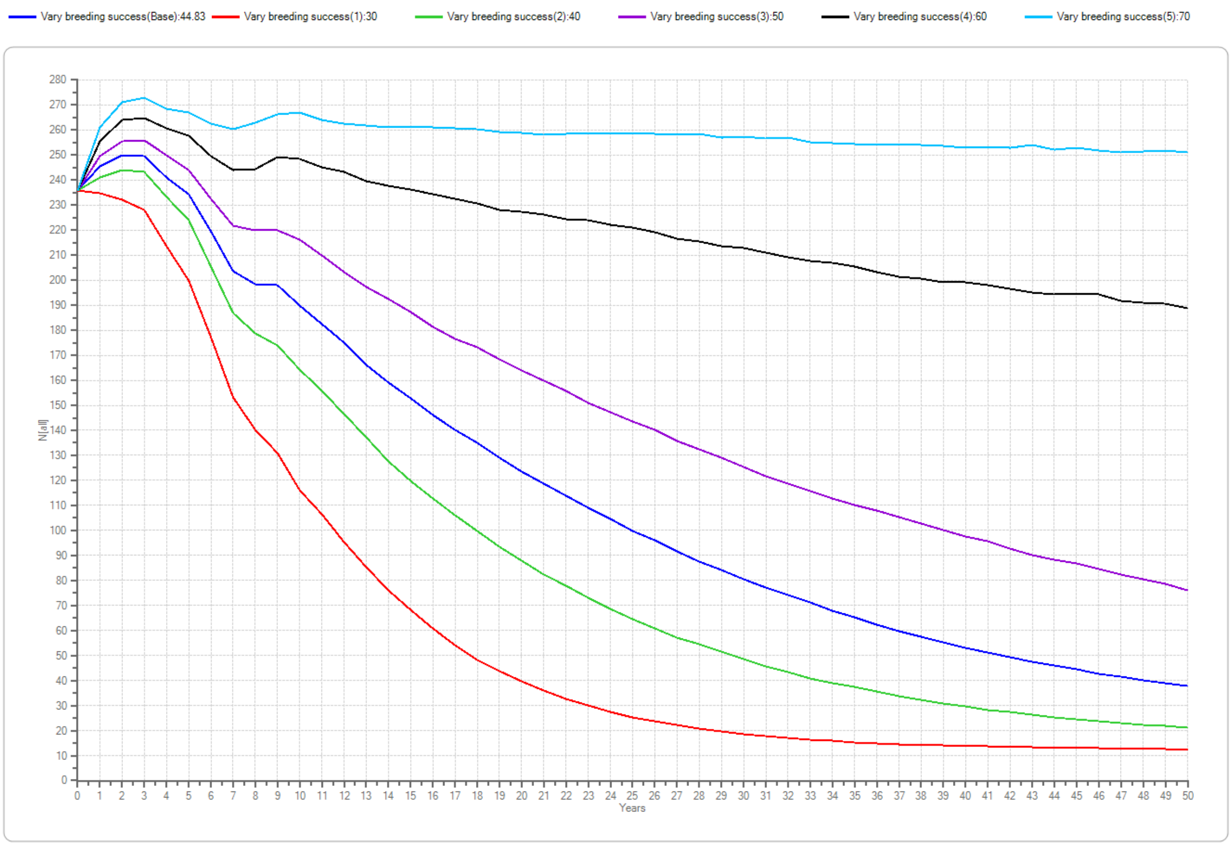
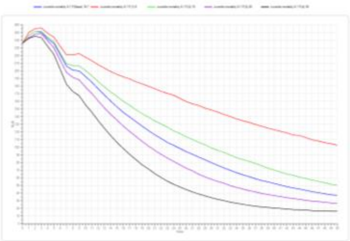
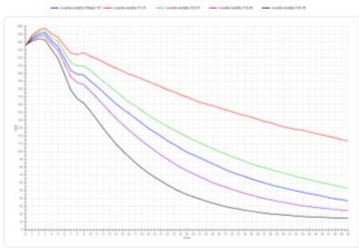


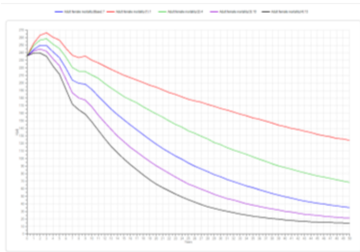
Figure 7: Sensitivity tests showing the effect of varying breeding success from 30% (red line) to 70% (turquoise line) on Koala population size after 50 years. The blue line (44.83%) shows the baseline estimate used in this study



(a) Juvenile females (0-1 years)

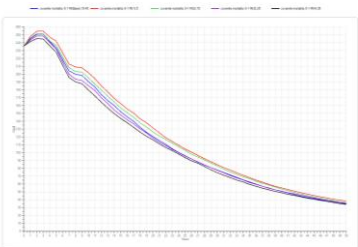


(b) Sub-adult females (1-2 years)

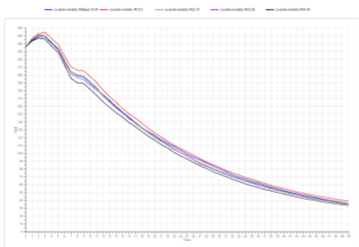


(c) Adult females (3+ years)

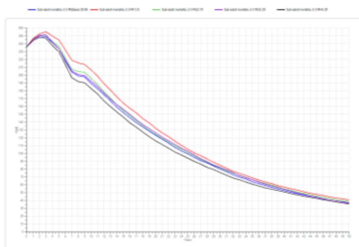
Figure 8: Sensitivity tests showing the effect of varying female mortality in age-classes 0-1 and 1-2 years from 5% (red line) to 35% (black line) on Koala population size after 50 years. For adult females, the range was from 1% (red line) to 13% (black line). In each case (a-c), the blue line shows the baseline estimates used in this study.



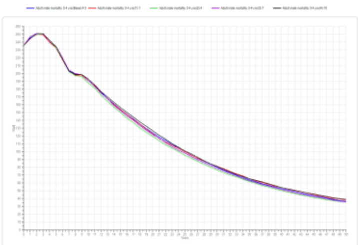
(a) Juvenile males (0-1 years)



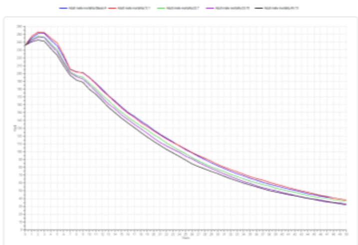
(b) Juvenile males (1-2 years)



(c) Sub-adult males (2-3 years



(d) Adult males (3-4 years)



(e) Adult males (4+ years)

Figure 9: Sensitivity tests showing the effect of varying male mortality in age-classes 0-1, 1-2, and 2-3 years from 5% (red line) to 35% (black line) on Koala population size after 50 years. For adult males, the range was from 1% (red line) to 10% (black line). In each case (a-e), the blue line shows the baseline estimates used in this study

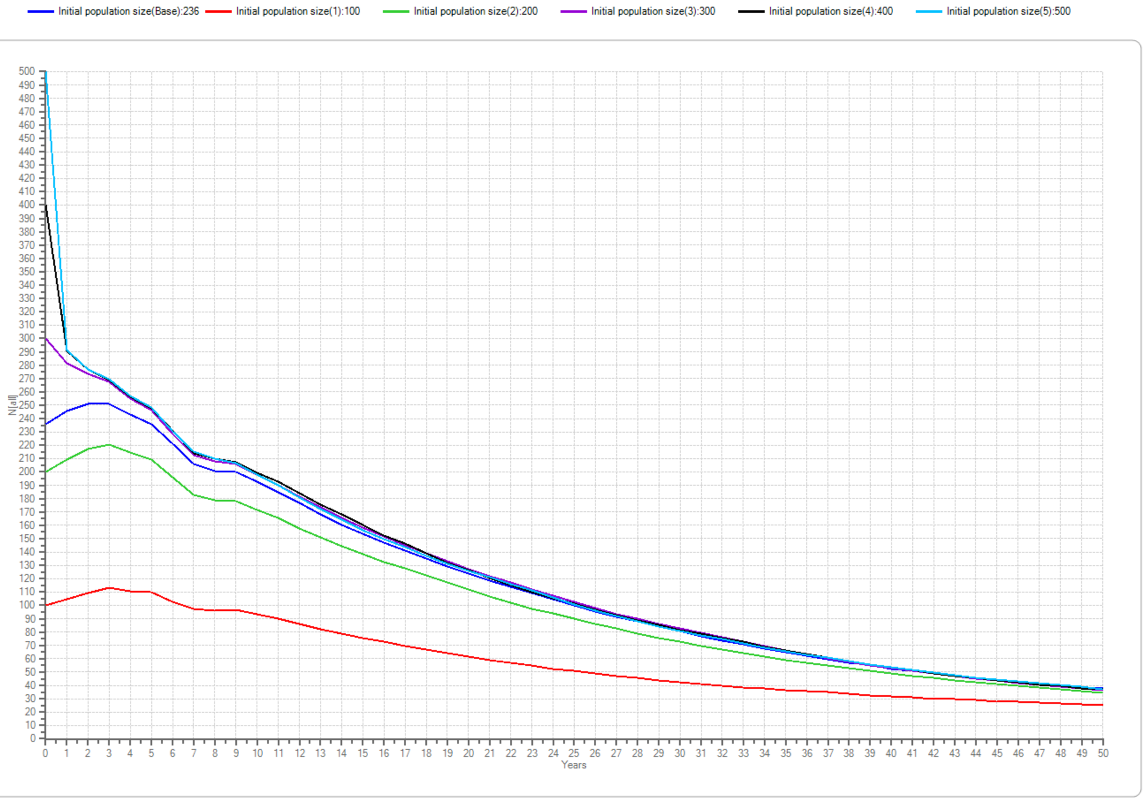


Figure 10: Sensitivity tests showing the effect of varying initial population size from 100 (red line) to 500 (turquoise line) on Koala population size after 50 years. The blue line shows the baseline estimate (236) used in this study. Note the effect of the cap on carrying capacity (291) in these simulations

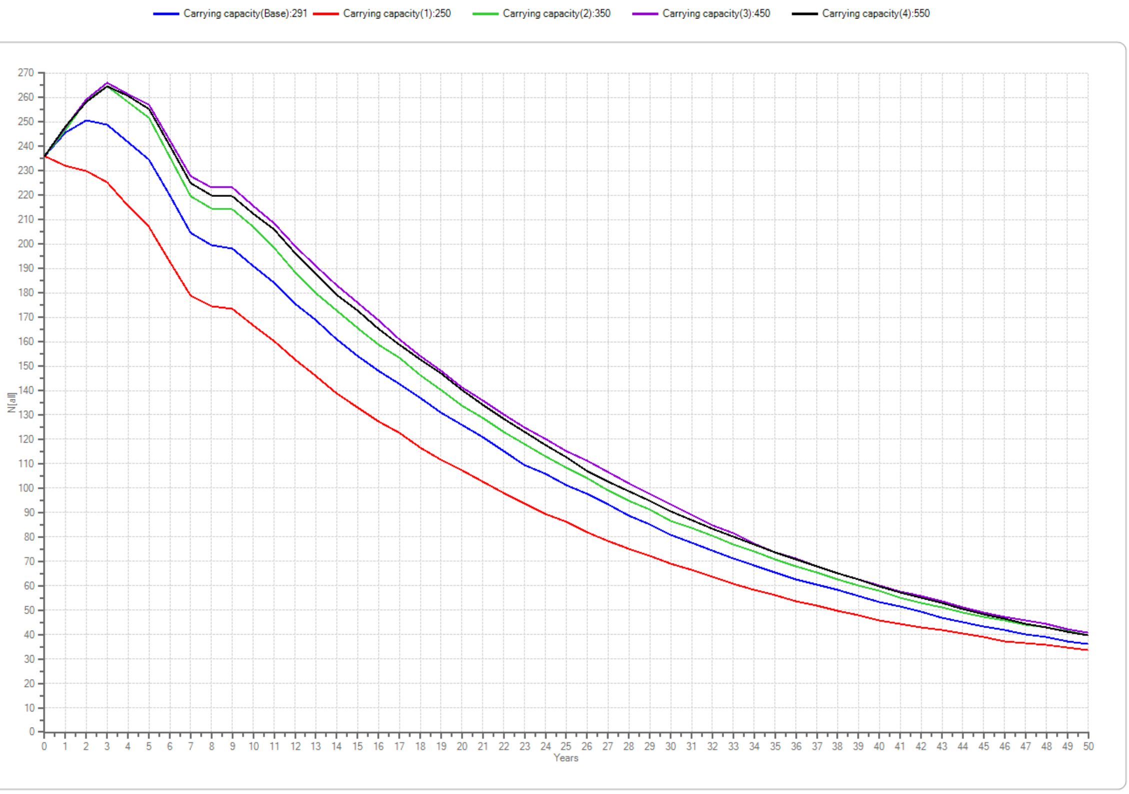


Figure 11: Sensitivity tests showing the effect of varying carrying capacity of the habitat from 250 (red line) to 550 animals (black line) on Koala population size after 50 years. The blue line shows the baseline estimate (291) used in this study

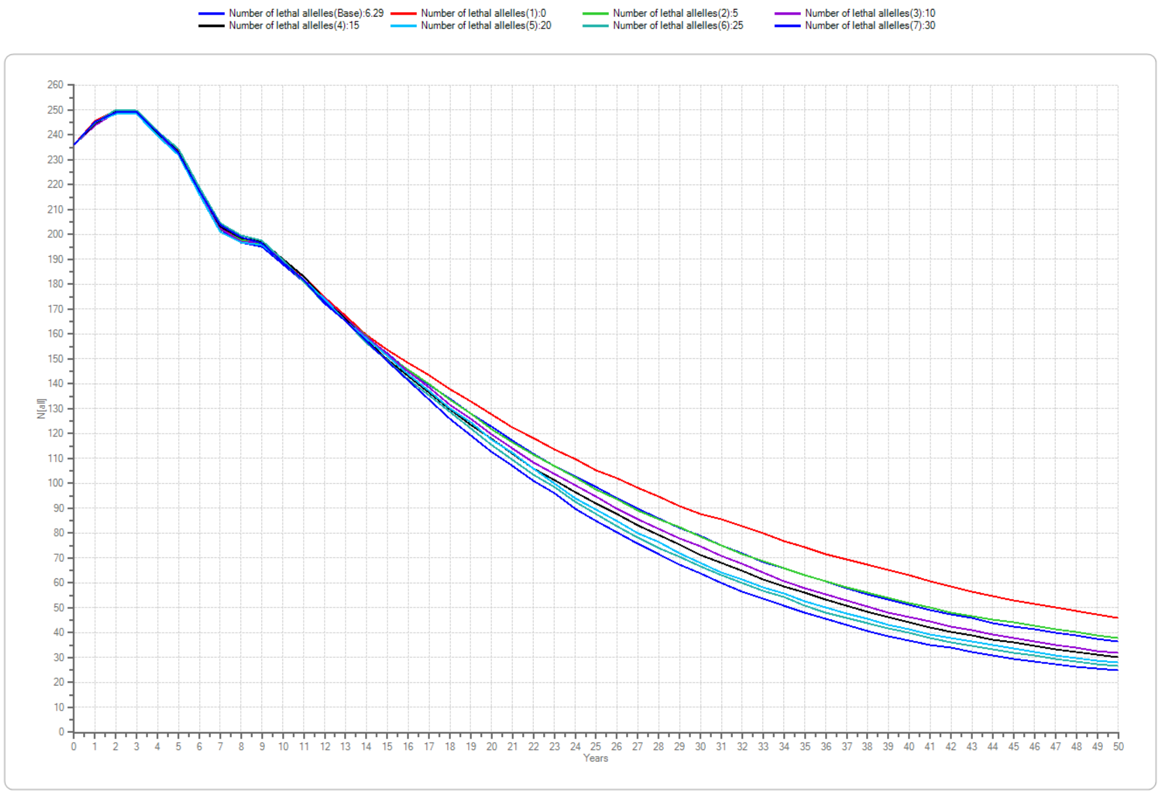


Figure 12: Sensitivity tests showing the effect of varying the number of lethal alleles in the population from 0 (red line) to 30 (lower blue line) on Koala population size after 50 years. The blue line near upper-middle shows the baseline "default" estimate (6.29) used in this study

7.3 Effects of the proposed road – varying dispersal and connectivity

Three primary considerations need to be dealt with before the effects of the proposed road can be estimated. Firstly, it is important to untangle any confounding effects that may be caused by splitting the population into two sub-populations. This is because Vortex could calculate the probability of extinction for two sub-populations as greater than that for a single population of the same size, although this was not observed. Secondly, dispersal rates and the directions of animal movement between each sub-population are difficult to estimate, and these factors are likely to vary from one year to another depending on population density and population size. The minimum rate of dispersal in the study area was identified by the two genetics studies as approximately 3.95 animals (i.e. 1.98 each way) per year (section 5.4), although dispersal rates of up to 40 animals (i.e. 20 each way) were also modelled. Without further information, it was assumed (as did the genetics studies) that dispersal was symmetric (equal numbers of animals dispersing from west to east, and from east to west). Thirdly, relationships between dispersal rates and the numbers (or type) of connectivity structures provided are not well established. For the purposes of assessing the impact of the proposed road, it was assumed that the 26 connectivity structures to be provided (section 5.6) would either cater fully for the dispersal needs of the population (i.e. 100% connectivity) – and therefore result in no impact of the road – or, as a worst case scenario, would limit the rate of dispersal to 40% of the numbers of animals attempting to disperse. This result could also be interpreted as the likely outcome if only 40% of the planned connectivity structures were provided. The impact of the road would therefore be estimated as a percentage by dividing the projected number of animals remaining in the population after 50 years in the 40% connectivity scenario by the numbers remaining after 50 years in the 100% connectivity scenario, and subtracting the result from 100.

For analysis, the population was treated as two sub-populations divided by the location of the proposed road, but with full dispersal and connectivity between them to the extent indicated by the genetics results. A similar projected population decline was observed (Figure 13) to that shown in Figure 6.

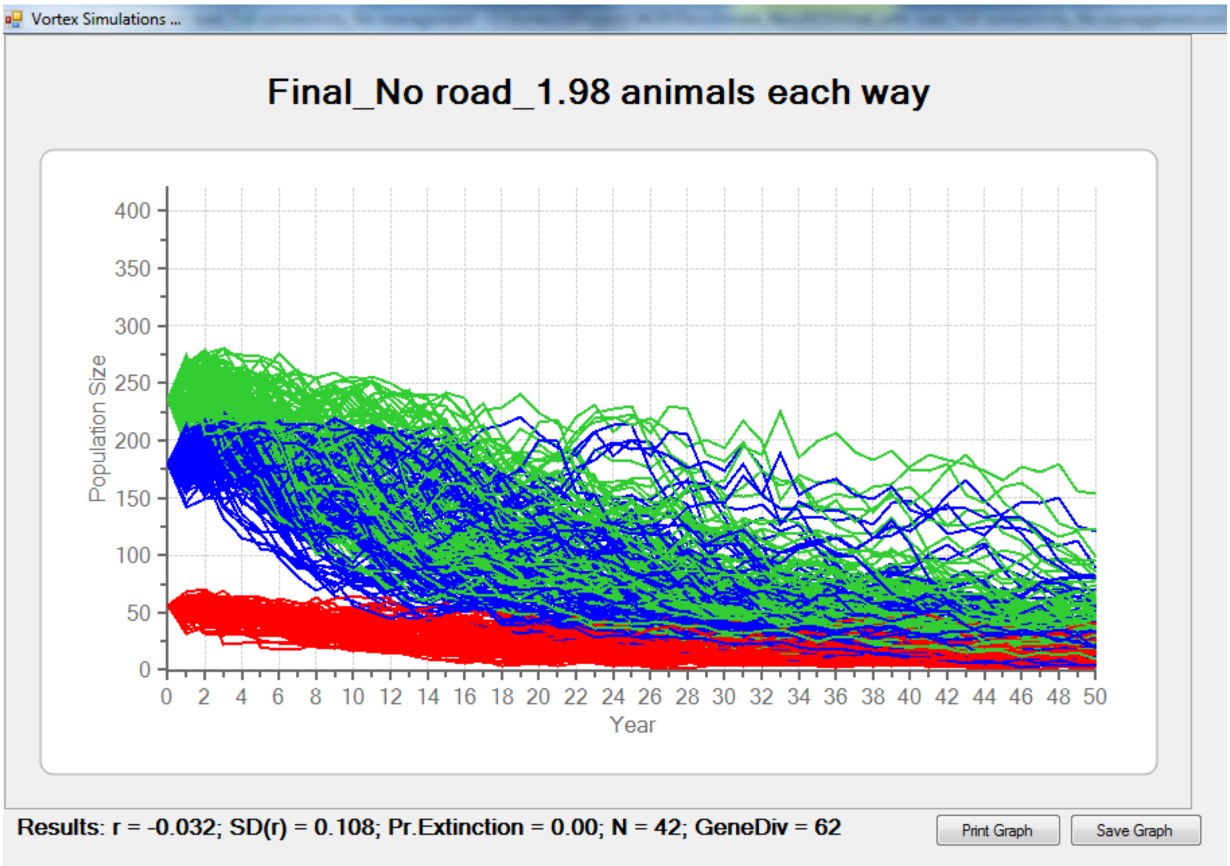


Figure 13: Projected Koala population decline over 50 years, without the proposed highway. Parameter estimates and model settings as for Figure 6, except that two sub-populations are modelled with 1.98 animals dispersing each way, per year, between them. The smaller, eastern sub-population is indicated in red, the larger western sub-population in blue, and the total population in green

The results showed that, at the minimum levels of dispersal estimated to occur in the study area (1.98 animals moving each way per year), there was virtually no impact of the road on projected Koala population size after 50 years when reduced dispersal and connectivity was assumed (i.e. 100–[42.1/42.3*100] = -0.5%) (Table 4). If 10 animals were dispersing each way per year, there could be a 4% impact on the population if the connectivity structures limited dispersal to only 40% of this number (i.e. 100-[41.7/43.4*100] = -3.9%) (Table 4). Similarly, the impact of the road could increase to 8% if 20 animals were dispersing each way per year (i.e. 100-[43.0/46.8*100] = -8.1%) (Table 4).

Under all scenarios, with and without the road, the projected Koala population size in the study area declined substantially over the 50 year time frame (Table 4). However, varying levels of dispersal, and varying levels of connectivity, had relatively minor impacts on projected Koala population size. The final number of alleles estimated within the Koala population under each of the above scenarios ranged from 4.81-4.96.

Note, that these scenarios do not include the initial loss of habitat for 5 Koalas, or the provision of 130 ha of new Koala habitat; these are included in the following section (Section 7.4).

It should be understood that the data reported in the following series of tables are the results of simulations (i.e. probability based on 1000 runs analysed for each scenario using different values for each parameter depending on its range of variability) and so can vary slightly each time that a scenario is run using the same data inputs.

Table 4: Impacts of the proposed road on the Ballina Koala population near Wardell under a range of dispersal scenarios, not including initial habitat loss due to clearing for road construction

All scenarios include the same demographic inputs, the same likelihood of two types of catastrophes, and 2.85 animals emigrating out of, and 2.85 animals immigrating into, the study area. Data inputs from Neaves *et al*. (2015), Norman *et al*. (2015) and Phillips *et al*. (2015). Assumes the presence of inbreeding depression and lethal alleles.

P(E), probability of extinction; N, estimated number of individuals present after 50 years.

Scenarios	Population P(E)	Population N	Western sub-Pop P(E)	Western sub-Pop N	Eastern sub-Pop P(E)	Eastern sub-Pop N
Single population	0.00	37.7	na	na	na	na
Two sub-populations, with dispersal 0 animals each way per year (zero connectivity)	0.00	38.2	0.00	23.6	0.01	14.8
Two sub-populations, with dispersal 1.98 animals each way per year (100% connectivity) **<u>i.e. BASIC NO-ROAD SCENARIO</u>**	0.00	42.3	0.00	27.4	0.02	15.3
Two sub-populations, with dispersal 0.792 animals each way per year (i.e. 40% connectivity)	0.00	42.1	0.00	27.0	0.01	15.4
Two sub-populations, with dispersal 10 animals each way per year (100% connectivity)	0.00	43.4	0.00	33.5	0.14	11.2
Two sub-populations, with dispersal 4 animals each way per year (i.e. 40% connectivity)	0.00	41.7	0.00	27.9	0.03	14.2
Two sub-populations, with dispersal 20 animals each way per year (100% connectivity)	0.00	46.8	0.00	41.6	0.34	7.3
Two sub-populations, with dispersal 8 animals each way per year (i.e. 40% connectivity)	0.00	43.0	0.00	31.7	0.09	12.2

7.4 Effects of the proposed road – initial habitat loss and revegetation

The provision of new habitat for up to 41 Koalas, following the loss of habitat for five animals during road construction, made little difference to the projected outcomes for the population; only fractional improvements were indicated by the modelling (Table 5). The same relativities between dispersal rates and connectivity in terms of projected population outcomes (Table 4) were observed when carrying capacity was raised to account for the planting of supplementary habitat (Table 5). This was because the deterministic decline in this Koala population ensured that there were not enough animals present to utilise the new habitat provided. The final number of alleles estimated within the Koala population under each of the above scenarios ranged from 4.86-4.94.

Table 5: Impacts of the proposed road on the Ballina Koala population near Wardell with revegetation and after accounting for initial habitat loss

All scenarios include the same demographic inputs, the same likelihood of two types of catastrophes, 2.85 animals emigrating out of, and 2.85 animals immigrating into, the study area, and changes to habitat carrying capacity to model the effects of losing habitat for five Koalas during road construction followed by the provision of new habitat for up to 41 Koalas. Data inputs from Neaves *et al*. (2015), Norman *et al*. (2015) and Phillips *et al*. (2015). Assumes the presence of inbreeding depression and lethal alleles.

P(E), probability of extinction; N, estimated number of individuals present after 50 years.

Scenarios	Population P(E)	Population N	Western sub-Pop P(E)	Western sub-Pop N	Eastern sub-Pop P(E)	Eastern sub-Pop N
Two sub-populations, with revegetation: dispersal 0 animals each way per year (zero connectivity)	0.00	39.4	0.00	24.8	0.02	14.8
Two sub-populations, with revegetation: dispersal 1.98 animals each way per year (100% connectivity) **i.e. WITH-ROAD SCENARIO, assuming no loss of connectivity**	0.00	42.5	0.01	27.3	0.02	15.5
Two sub-populations, with revegetation: dispersal 0.792 animals each way per year (i.e. 40% connectivity) **i.e. WITH-ROAD SCENARIO, assuming reduced connectivity**	0.00	42.0	0.01	26.8	0.01	15.5
Two sub-populations, with revegetation: dispersal 10 animals each way per year (100% connectivity)	0.00	43.8	0.00	33.7	0.14	11.4
Two sub-populations, with revegetation: dispersal 4 animals each way per year (i.e. 40%	0.00	42.5	0.00	27.4	0.02	15.4

connectivity)						
Two sub-populations, with revegetation: dispersal 20 animals each way per year (100% connectivity)	0.00	47.8	0.00	42.5	0.34	7.4
Two sub-populations, with revegetation: dispersal 8 animals each way per year (i.e. 40% connectivity)	0.00	43.5	0.00	31.9	0.08	12.4

7.5 Effects of the proposed road - mortality reduced by 20 percent

A reduction in mortality by 20% across all age-gender classes each year would have a marked effect in improving Koala population viability (Table 6). If this reduced level of mortality could be achieved through local management efforts (e.g. comprehensive fencing arrangements on other roads in the study area), the Ballina Koala population is likely to remain viable in the long term, whether the highway upgrade is present or not. The range of estimates modelled for dispersal showed this variable to have only modest effects (<10%) on projected population size (Table 6). The final number of alleles estimated within the Koala population ranged from 5.14-5.18 for the models presented in Table 6.

The exponential rate of increase for the population when mortality is reduced each year by 20% was $r=0.0220$, the annual rate of change was $\lambda=1.0223$, and the per-generation rate of change or "net replacement rate" was $R_0=0.9277$.

Table 6: Impacts of the proposed road on the Ballina Koala population near Wardell when mortality is reduced by 20% across all age-gender classes

All scenarios include the same demographic inputs, the same likelihood of two types of catastrophes, 2.85 animals emigrating out of, and 2.85 animals immigrating into, the study area, and changes to habitat carrying capacity to model the effects of losing habitat for five Koalas during road construction followed by the provision of new habitat for up to 41 Koalas. Data inputs from Neaves *et al*. (2015), Norman *et al*. (2015) and Phillips *et al*. (2015). Assumes the presence of inbreeding depression and lethal alleles.

P(E), probability of extinction; N, estimated number of individuals present after 50 years.

Scenarios	Population P(E)	Population N	Western sub-Pop P(E)	Western sub-Pop N	Eastern sub-Pop P(E)	Eastern sub-Pop N
Two sub-populations, with revegetation: dispersal 1.98 animals each way per year, and mortality reduced by 20%	0.00	90.8	0.00	66.2	0.00	24.7
Two sub-populations, with revegetation: dispersal 4 animals each way per year, and mortality reduced by 20%	0.00	97.4	0.00	72.5	0.01	25.0
Two sub-populations, with revegetation: dispersal 10 animals each way per year, and mortality reduced by 20%	0.00	98.5	0.00	75.2	0.02	23.8
Two sub-populations, with revegetation: dispersal 20 animals each way per year, and mortality reduced by 20%	0.00	100.2	0.00	81.2	0.07	20.4

7.6 Effects of the proposed road – fecundity increased by 20 percent

A 20% increase in fecundity of breeding-age females would significantly improve the long-term prospects for this population (Table 7). Increasing population fecundity by 20% would have a greater effect (almost 20%) on population viability than reducing population mortality by 20%. If this increase in fecundity could be achieved through local management efforts (e.g. in part by reducing mortality and thereby increasing the numbers of breeding females, or by vaccinating a proportion of the population for *Chlamydia*), the Koala population is likely to remain viable under all scenarios, whether the highway upgrade is present or not. The range of estimates modelled for dispersal showed this variable to have only modest effects (~<1%) on projected population size (Table 7). The final number of alleles estimated within the Koala population ranged from 5.15-5.18 for the models presented in Table 7.

The exponential rate of increase for the population when fecundity is increased each year by 20% was r=0.0287, the annual rate of change was λ=1.0291, and the per-generation rate of change or "net replacement rate" was R_0=0.9711.

Table 7: Impacts of the proposed road on the Ballina Koala population near Wardell when fecundity is increased by 20%

All scenarios include the same demographic inputs, the same likelihood of two types of catastrophes, 2.85 animals emigrating out of, and 2.85 animals immigrating into, the study area, and changes to habitat carrying capacity to model the effects of losing habitat for five Koalas during road construction followed by the provision of new habitat for up to 41 Koalas. Data inputs from Neaves *et al*. (2015), Norman *et al*. (2015) and Phillips *et al*. (2015). Assumes the presence of inbreeding depression and lethal alleles.

P(E), probability of extinction; N, estimated number of individuals present after 50 years.

Scenarios	Population P(E)	Population N	Western sub-Pop P(E)	Western sub-Pop N	Eastern sub-Pop P(E)	Eastern sub-Pop N
Two sub-populations, with revegetation: dispersal 1.98 animals each way per year, and fecundity increased by 20%	0.00	112.8	0.00	87.0	0.01	25.9
Two sub-populations, with revegetation: dispersal 4 animals each way per year, and fecundity increased by 20%	0.00	112.8	0.00	85.3	0.01	27.6
Two sub-populations, with revegetation: dispersal 10 animals each way per year, and fecundity increased by 20%	0.00	113.0	0.00	87.8	0.01	25.5
Two sub-populations, with revegetation: dispersal 20 animals each way per year, and fecundity increased by 20%	0.00	114.5	0.00	91.9	0.06	23.8

7.7 Effects of the proposed road – increasing fecundity by 20% and reducing mortality by 20%

A 20% increase in annual fecundity of breeding-age females, combined with an overall 20% reduction in mortality across all age-gender classes each year, was projected to have a major beneficial effect on long-term viability of this Koala population (Table 8). Indeed, population projections showed that, if these two actions could be achieved, the combined effects of these two actions would result in population increases of approximately 186% and 231%, respectively, above those projected to result from either increasing fecundity or reducing mortality alone (Table 8). The projected population gains were also nearly five times greater (494%) than scenarios where neither fecundity nor mortality was manipulated (Tables 4, 5 and 8).

The deterministic rate of growth for the Ballina Koala population would be firmly in the positive if both management objectives (increasing fecundity and reducing mortality) could be achieved. In this scenario, the exponential rate of increase for the population was $r=0.0561$, the annual rate of change was $\lambda=1.0577$, and the per-generation rate of change or "net replacement rate" was $R_0=1.1133$.

The range of estimates modelled for dispersal again showed this variable to have little influence in the outcomes of the population projections (Table 8). The final number of alleles estimated within the Koala population ranged from 5.34-5.35 for the models presented in Table 8.

Table 8: Impacts of the proposed road on the Ballina Koala population near Wardell when fecundity is increased by 20% and mortality is reduced by 20%.

All scenarios include the same demographic inputs, the same likelihood of two types of catastrophes, 2.85 animals emigrating out of, and 2.85 animals immigrating into, the study area, and changes to habitat carrying capacity to model the effects of losing habitat for five Koalas during road construction followed by the provision of new habitat for up to 41 Koalas. Data inputs from Neaves *et al*. (2015), Norman *et al*. (2015) and Phillips *et al*. (2015). Assumes the presence of inbreeding depression and lethal alleles.

P(E), probability of extinction; N, estimated number of individuals present after 50 years.

Scenarios	Population P(E)	Population N	Western sub-Pop P(E)	Western sub-Pop N	Eastern sub-Pop P(E)	Eastern sub-Pop N
Two sub-populations, with revegetation: dispersal 1.98 animals each way per year, with fecundity increased by 20% and mortality reduced by 20%	0.00	209.9	0.00	167.6	0.00	42.3
Two sub-populations, with revegetation: dispersal 4 animals each way per year, with fecundity increased by 20% and mortality reduced by 20%	0.00	212.6	0.00	169.3	0.00	43.3
Two sub-populations, with revegetation: dispersal 10 animals each way per year, with fecundity increased by 20% and mortality reduced by 20%	0.00	212.9	0.00	169.5	0.00	43.4
Two sub-populations, with revegetation: dispersal 20 animals each way per year, with fecundity increased by 20% and mortality reduced by 20%	0.00	212.8	0.00	170.7	0.00	42.2

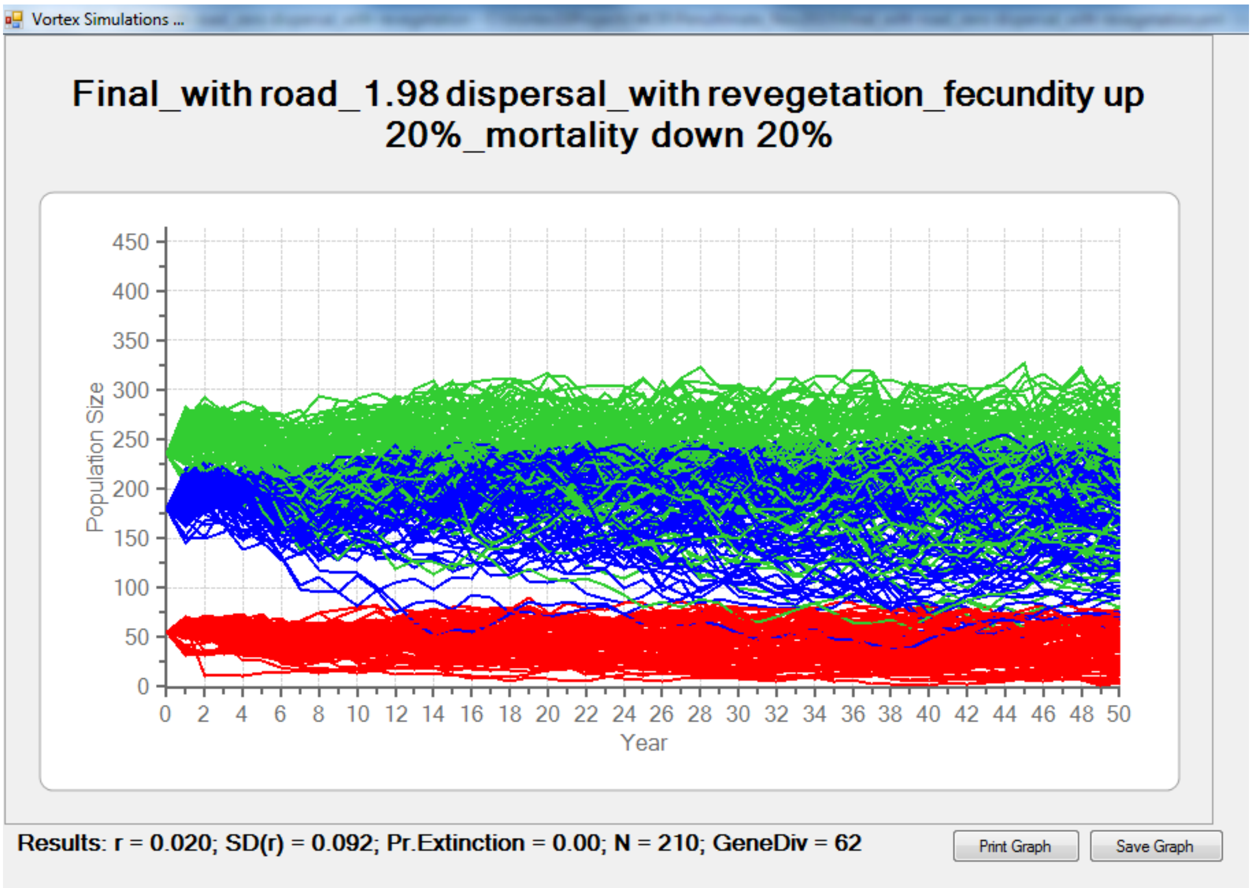


Figure 14: Stable Koala population projections over 50 years, with the proposed highway, when fecundity is increased by 20% each year and mortality is reduced by 20% each year across all age-gender classes. Other parameter estimates and model settings as for Figure 13, except that carrying capacity has been adjusted to reflect the steady increase in habitat availability that should result from new Koala food tree plantings in the study area. The smaller, eastern sub-population is indicated in red, the larger western sub-population in blue, and the total population in green.

7.8 Effects of the proposed road - using management to control mortality

Koala population viability in the study area was greatly enhanced by reducing mortality by eight young (<4 years) animals (5 males and 3 females) per year (Table 9; Figure 15). Under this scenario, the population was projected to decline very slowly, but still comprising approximately 170 animals after 50 years.

The easier target of reducing mortality by four young (<4 years) animals (2.5 males and 1.5 females) per year also had significant benefits to long-term Koala population viability with approximately 109 animals remaining after 50 years (Table 9; Figure 16).

These results suggest that management intervention to reduce Koala mortality due to vehicle strikes (e.g. fencing along the proposed road and other local roads within recognised hot spots), and local dog predation, have the potential to improve the prospects for this Koala population, compared to the current situation. It is unknown whether funding would be available without the road to undertake these important management actions (e.g. fencing).

Table 9: Impacts of the proposed road on the Ballina Koala population near Wardell when mortality is reduced by either 4 or 8 young animals per year

All scenarios include the same demographic inputs, the same likelihood of two types of catastrophes, 2.85 animals emigrating out of, and 2.85 animals immigrating into, the study area, and changes to habitat carrying capacity to model the effects of losing habitat for five Koalas during road construction followed by the provision of new habitat for up to 41 Koalas. Data inputs from Neaves *et al*. (2015), Norman *et al*. (2015) and Phillips *et al*. (2015). Assumes the presence of inbreeding depression and lethal alleles.

P(E), probability of extinction; N, estimated number of individuals present after 50 years.

Scenarios	Population P(E)	Population N	Western sub-Pop P(E)	Western sub-Pop N	Eastern sub-Pop P(E)	Eastern sub-Pop N
Two sub-populations, with revegetation: dispersal 1.98 animals each way per year, with mortality reduced by 4 animals per year.	0.00	108.9	0.00	66.3	0.00	42.6
Two sub-populations, with revegetation: dispersal 1.98 animals each way per year, with mortality reduced by 8 animals per year.	0.00	170.7	0.00	112.0	0.00	58.6

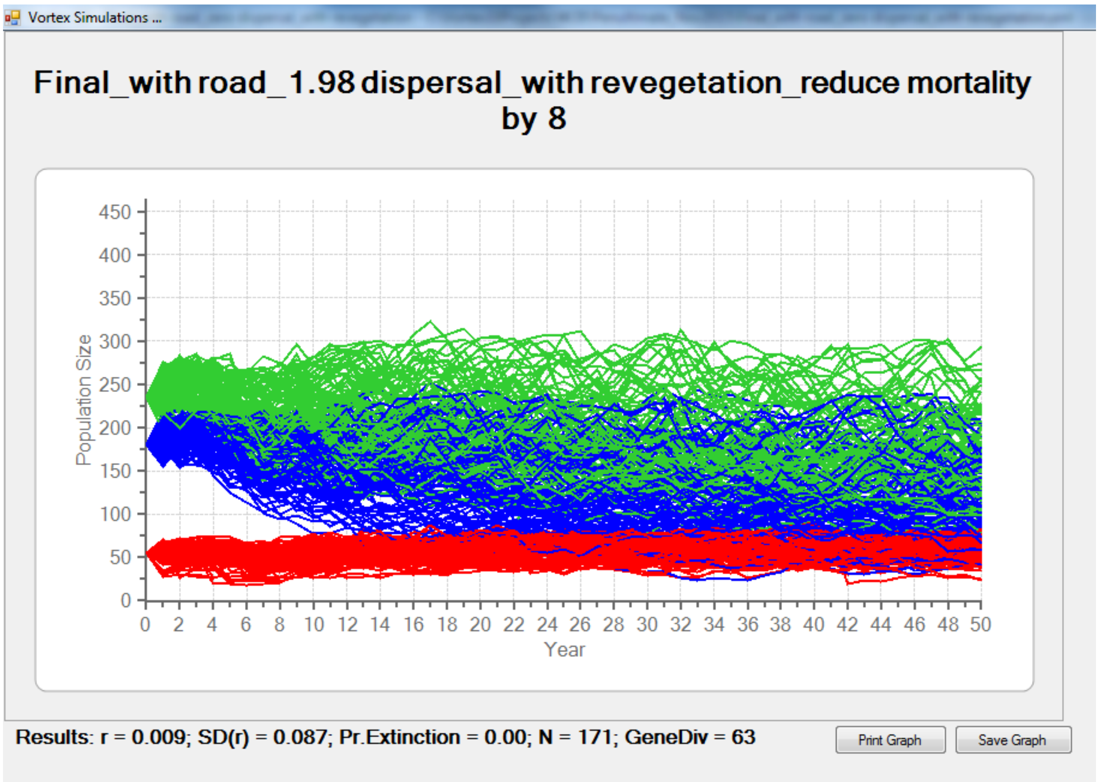


Figure 15: Koala population projections over 50 years, with the proposed highway, when mortality is reduced by 8 young animals per year through management intervention. Other parameter estimates and model settings as for Figure 14

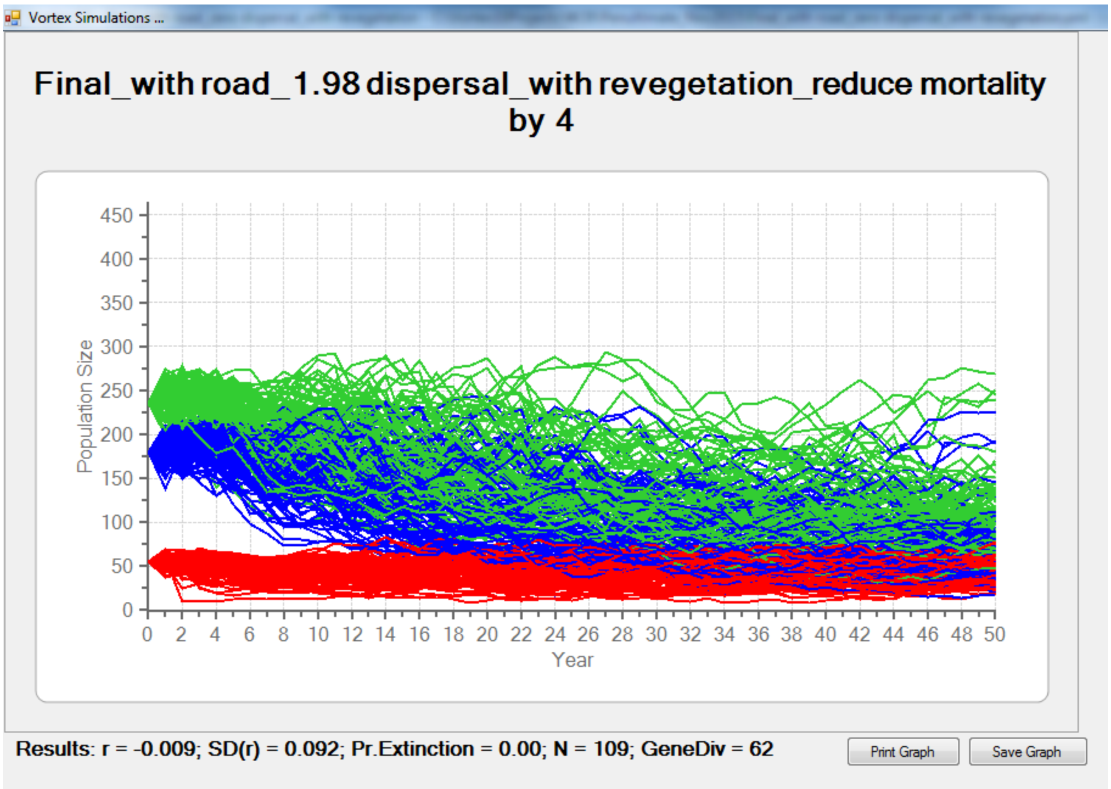


Figure 16: Koala population projections over 50 years, with the proposed highway, when mortality is reduced by 4 young animals per year through management intervention. Other parameter estimates and model settings as for Figure 14. The smaller, eastern sub-population is indicated in red, the larger western sub-population in blue, and the total population in green.

7.9 Effects of the proposed road – summary of impacts

The proposed road has the potential to cause a small adverse impact, reducing the projected population size over 50 years by 0-9.7%, depending on the rate of dispersal and assumptions about the effectiveness of the connectivity structures that will be provided (Table 10). Overall, dispersal rates did not have a major influence on the results (Tables 4-9).

The robustness of these findings was investigated using sensitivity tests of the impact of the proposed highway upgrade in relation to uncertainty in the estimates of demographic parameters (Table 10). These tests also included the impact of losing habitat for five Koalas following road construction. The sensitivity tests were performed by modelling an "optimistic" scenario (in which both mortality was reduced and fecundity was increased) and a "pessimistic" scenario (in which both mortality was increased and fecundity was reduced) for three different rates of dispersal.

These results (Table 10) showed that:

- Dispersal rate made little difference to the results (i.e. whether 100% is set at 1.98, or 10 or 20 animals dispersing each way per year).
- The impact of the road (i.e. the worst case scenario which modelled 40% of each of the above rates of dispersal) ranged between -0.5 to -9.4%, averaging -4.1%, across all scenarios.
- When the potential loss of habitat for 5 Koalas was taken into account, the impact ranged between -0.7—9.7%, averaging -4.8% across all scenarios.

Table 10: Sensitivity tests of the impact of the proposed highway upgrade in relation to uncertainty in the estimates of demographic parameters

Scenarios represent variations on the standard parameter estimates for population fecundity and mortality (Phillips *et al*. 2015) and dispersal (Neaves *et al*. 2015, Norman *et al*. 2015), and they also incorporate the potential loss of habitat for five Koalas following road construction.The road impact (%) is calculated from the modelled population projections resulting from each scenario, where "no road" represents 100% dispersal (i.e. 100% connectivity) and "with road" represents a "worst-case" reduction to 40% dispersal (i.e. 40% connectivity). Assumes the road is fully fenced to prevent additional mortality.

Scenarios / Impact assessments	Population projection (N) No road (100% dispersal)	Population projection (N) With road (40% dispersal "worst case")	Impact (%)
Dispersal = 1.98 animals each way/year			
No change in base rates (Table 4)	42.3	42.1	-0.5
- Including loss of habitat for 5 Koalas	42.3	42.0	-0.7
Optimistic: mortality reduced by 20% and fecundity increased by 20%	186.9	181.5	-2.9
- Including loss of habitat for 5 Koalas	186.9	180.1	-3.6
Pessimistic: mortality increased by 20% and fecundity decreased by 20%	19.5	19.2	-1.5
- Including loss of habitat for 5 Koalas	19.5	19.4	-0.3
Dispersal = 10 animals each way/year			
No change in base rates (Table 4)	43.4	41.7	-3.9
- Including loss of habitat for 5 Koalas	43.4	40.7	-6.2
Optimistic: mortality reduced by 20% and fecundity increased by 20%	187.3	186.3	-0.5
- Including loss of habitat for 5 Koalas	187.3	181.4	-3.1
Pessimistic: mortality increased by 20% and fecundity decreased by 20%	21.5	19.6	-8.7
- Including loss of habitat for 5 Koalas	21.5	19.4	-9.7
Dispersal = 20 animals each way/year			
No change in base rates (Table 4)	46.8	43.0	-8.1
- Including loss of habitat for 5 Koalas	46.8	42.3	-9.7
Optimistic: mortality reduced by 20% and fecundity increased by 20%	186.6	184.4	-1.1
- Including loss of habitat for 5 Koalas	186.6	185.0	-0.8
Pessimistic: mortality increased by 20% and fecundity decreased by 20%	22.3	20.2	-9.4
- Including loss of habitat for 5 Koalas	22.3	20.2	-9.2

7.10 Effects of the proposed road – summary of potential management responses

Management to reduce the incidence of vehicle strikes, dog predation, and potentially disease are required to improve the long-term viability of this population. The potential small adverse effects of the proposed road (section 7.9) could be reversed by the enormous potential to improve population projections through management intervention (Table 11). The form that these management interventions could take include:

- the provision of supplementary habitat after accounting for the loss of habitat for up to five Koalas resulting in a slight increase in projected population size (+0.5%)
- the provision of additional Koala-proof fencing along known road-kill hotspots in the study area, together with local dog control, so that Koala mortality is reduced by up to 4 or 8 animals per year resulting, with habitat supplementation, in large increases in projected population size (257%-404%), and
- improvements in the health of the population, potentially through the application of a new vaccine to counteract the effects of *Chlamydia* and so raise population fecundity resulting, with habitat supplementation, in a large increase in projected population size (267%) if breeding success could be raised by 20%.

Other combinations of these approaches could result in significant increases to the projected size of the population if mortality can be reduced and fecundity can be increased simultaneously (Table 11).

Table 11: Summary of the impacts of the proposed highway upgrade in relation to potential management interventions

Scenarios represent variations on the standard parameter estimates for population fecundity and mortality (Phillips *et al*. 2015). They also incorporate the potential loss of habitat for five Koalas following road construction, and the provision of supplementary habitat for up to 41 Koalas by year 15. Management interventions also include full fencing along the proposed new road, with the potential to fence other roads (road-kill hotspots) in the study area.

The road impact (%) is calculated from the modelled population projections resulting from each scenario, where “no road” represents 100% dispersal (i.e. 100% connectivity) and “with road” represents a “worst-case” reduction to 40% dispersal (i.e. 40% connectivity).

Scenarios / Impact assessments	Population projection (N) No road (100% dispersal)	Population projection (N) With road (40% dispersal “worst case”) plus management intervention	Impact (%)
Dispersal = 1.98 animals each way/year			
Effect of habitat supplementation, including the loss of habitat for 5 Koalas (Table 4 and Table 5)	42.3	42.5	+0.5
As above, but reducing mortality by 20% (Table 4 and Table 6)	42.3	90.8	+215
As above, but increasing fecundity by 20% (Table 4 and Table 7)	42.3	112.8	+267
As above, but reducing mortality by 20% and increasing fecundity by 20% (Table 4 and Table 8)	42.3	209.9	+496
Dispersal = 1.98 animals each way/year			
Effect of habitat supplementation, including the loss of habitat for 5 Koalas, with reducing mortality by either 4 or 8 young animals per year (Table 4 and Table 9)	42.3 42.3	108.9 (4) 170.7 (8)	+257 +404

7.11 Changes in genetic diversity

This section presents a summary of the number of alleles remaining within the Koala population under the range of modelling scenarios reported in sections 7.3-7.7. The scenarios reported in each section were conducted under a range of dispersal rates, and this accounts for the range in results. Projected population size was strongly correlated with the levels of genetic diversity in the population. Higher rates of dispersal in each scenario resulted in higher estimates of the number of alleles remaining in the population.

The effect of doubling the rate of dispersal from 1.98 to 4 individuals each way per year, to incorporate the effects of breeding rate being only 44.83%, resulted in a small increase in the number of final alleles in the population (4.89 to 4.90) even though the projected population size remained the same (i.e. 42.5 animals) (Table 5).

Table 12: Summary of the changes in genetic diversity resulting from the scenarios reported in sections 7.3-7.7

Scenarios	Number of alleles remaining
1. Impact of the road under a range of dispersal scenarios, but not including the initial loss of habitat for five Koalas due to clearing for road construction and the provision of 130 ha of new Koala habitat.	4.81-4.96
2. Impact of the road under a range of dispersal scenarios, including the initial loss of habitat for five Koalas due to clearing for road construction as well as the provision of 130 ha of new Koala habitat	4.86-4.94
As for 2. above, but with mortality reduced overall by 20%	5.14-5.18
As for 2. above, but with fecundity increased by 20%	5.15-5.18
As for 2. above, but with both mortality reduced overall by 20% and fecundity increased by 20%.	5.34-5.35

8. Discussion

The projected population decline observed in all modelled scenarios is due to births not being adequate to offset deaths, regardless of any effects of inbreeding, the presence of the highway upgrade, or any of a range of mitigation efforts (i.e. Koala-proof fencing, connectivity structures, provision of new habitat) that might be implemented by RMS. This view was confirmed in email communications (18^{th} and 30th September 2015) between Dr Rod Kavanagh and Dr Bob Lacy (the author of the Vortex software). Dr Lacy stated "If these birth and death rates are correct, and if they continue to pertain to the local population, then it could only be sustained if there is a continual inflow of Koalas from other, healthier populations".

The primary issue is with the estimates of population demography, not with the presence of the road or the proposed mitigation efforts. It is unknown whether the demographic parameters, collected from a once-only snapshot sample, are truly representative of the population. Under the scenarios modelled, there are simply not enough Koalas to effectively utilise the new habitat that would be provided if the highway upgrade was constructed. The demographic estimates used in the models may well be correct but, if so, management attention needs to be focused strongly on measures that will either increase population fecundity, and/or reduce population mortality. As the models incorporating reductions in mortality by 4 or 8 young animals per year have shown, any efforts to reduce Koala mortality in the region will improve Koala population viability. This response is likely to occur primarily by increasing the numbers of breeding females in the population. Indeed, management interventions that result in an increase in fecundity by 20% are likely to be more effective in reversing the downward trend in this population than reducing mortality by the same amount, but if these measures can be combined, the population was projected to increase five-fold over current trends.

Dispersal was difficult to model initially for several reasons, although these problems were subsequently overcome. Firstly, dispersal is largely dependent on population density, although we have no clear understanding of these relationships. This issue was overcome using a range of plausible estimates derived from the genetics reports (Neaves *et al*. 2015, Norman *et al*. 2015) and from other field studies (Dique *et al.* 2003, Kavanagh *et al.* 2007). Secondly, initial attempts to model dispersal were expressed as percentage of the population, rather than as the number of animals dispersing. The application of dispersal as an equal percentage of each sub-population was problematic because the western sub-population was more than three times larger than the eastern sub-population. This effectively propped up the smaller sub-population (which was operating as a population sink by receiving three times as many individuals) at the expense of the larger sub-population. However, sensible comparisons were achieved when dispersal was treated symmetrically between the two sub-populations and expressed as the numbers of individuals dispersing per year. Thirdly, the impact of the road effectively rested upon comparisons between the rate of dispersal through the connectivity structures that are proposed, yet little published information is available about of these relationships. Assumptions about the effectiveness of the 26 connectivity structures (approximately one every 500 m along the proposed road) ranged from enabling 100% dispersal to a 'worst case' of only 40% dispersal. However, overall, dispersal rates did not have a major influence on the results.

Inbreeding was found to occur at very low levels in the population (Neaves *et al*. 2015, Norman *et al*. 2015), yet we took the conservative approach in our PVA modelling of assuming that inbreeding depression could present (O'Grady *et al*. 2006). This had the effect of reducing population projections by approximately 20-40% (unpublished preliminary results). The levels of genetic diversity in the population were strongly correlated with projected population size and the rate of dispersal. Therefore, any management interventions that serve to increase these two parameters are likely to result in improved genetic diversity within the population.

The proposed Pacific Highway Upgrade, by itself, is unlikely to contribute adversely to the viability of the Koala population near Wardell; the population is already in steady decline due to other factors (low breeding success, high mortality) and connectivity between the two sub-populations is not a big driver of population size. In the context of this steadily declining population, the proposed supply of 130 ha of new habitat for the Koala was unable to be fully exploited, but this could be reversed through management interventions to increase population size. Significant opportunities and benefits exist to reduce Koala mortality and thereby to assist an increase in fecundity as part of this Project. This could occur through the provision of a range of mitigation actions, including Koala-proof fencing along the proposed highway upgrade and at known Koala road-kill hotspots on other roads in the area. Similarly, efforts to limit the presumed incidence of disease in this population, if this had the effect of raising fecundity, would be highly beneficial to overall viability of the population.

8.1 Conclusions

The Conditions of Consent for this Project require that "the impacts to the Ballina Koala population are demonstrated to be acceptable within the Ballina Koala Plan". No definition of "acceptable impact" has been provided, but in this study we have interpreted this to mean "no impact". If by "no impact" we assume "no worse" than the status quo (i.e. no new road), then this study has shown that the proposed highway upgrade near Wardell (Section 10) could cause a reduction of between 0-9.7% in projected population size over the next 50 years. However, this small impact on the Ballina Koala population could be compensated for by the provision of Koala-proof fencing in the study area and by the establishment of 130 ha of supplementary new habitat. Indeed, the management responsibilities, actions and resources associated with this infrastructure have the potential to arrest the current steep decline in this population.

This study has shown that the Ballina Koala population is in desperate need of assistance because of its high mortality and low breeding success which will inevitably lead to its extinction if not addressed. Modest and achievable reductions in Koala mortality will improve the current unbalanced population structure and ensure that more females are available to increase population fecundity. Further work to investigate and reduce the incidence of disease in this population may be warranted if this has the effect of increasing fecundity.

All of the proposed connectivity structures and mitigation activities will benefit this population of Koalas, although some of them may not be fully utilised until the population decline is reversed.

8.2 Management Implications

Recovery of the Ballina Koala population is a responsibility for the whole community. The RMS has clear obligations to ensure that no Koala road-kills occur as a result of this Project, and indeed this organisation has committed to a fully-closed highway fencing system along the corridor, additional and enhanced connectivity structures, and the establishment of a minimum of 130 ha of new habitat for the Koala. In addition, the RMS is willing to undertake further work, such as fencing, at two known Koala hot-spots that occur on other roads in association with this Project (i.e. part of Wardell Road in the vicinity of the new highway, and part of the existing Pacific Highway north of Wardell to Coolgardie). The value of these additional measures, even if mortality could be reduced by just four animals per year, was clearly shown in the PVA modelling.

However, there are other road-kill hot spots, and other threats to this Koala population, that need to be addressed. The Bruxner Highway (a State road) and Bagotville Road (a Council road), each have significant Koala road-kill hotspots that require attention by the relevant authorities. Predation by domestic dogs is also likely to be a significant threat to Koalas in the study area and should be controlled. The local community and other government agencies have an important role to play in devising and implementing appropriate strategies to control dog predation on Koalas. This work could be done in conjunction with the management of a number of the offset properties adjacent to Section 10 that have been purchased by RMS on which predator control programs will be implemented. Koala mortality needs to be reduced by at least four to eight young animals per year to slow the rate of decline in this population.

The role of disease in potentially limiting population fecundity needs to be explored and understood. We know that disease is present in this population, but we do not know its true incidence and whether it is adversely affecting breeding success. Recent trials have shown that a newly-developed vaccine has the potential to protect wild Koalas from *Chlamydia* infections and to improve reproductive success in females (Waugh *et al*. 2015). Research funding is required to make the necessary assessments, and to consider whether medical intervention is required or indeed appropriate. Local community support may be the best way to obtain the research funds required.

Finally, regular and systematic long-term monitoring of the Koala population in the study area is required to determine whether recovery efforts and mitigation activities have been successful, and also to assess the accuracy of the PVA projections. RMS is responsible for initiating and funding such a monitoring program after road construction, as per the conditions of approval, but broader community involvement is required to maintain this program and to extend it in both space and time.

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Appendix B Expert review: Associate Professor Robert Close CV

Rob Close
Mammalogist / Associate Professor

Australian museum CONSULTING

Qualifications

Ph.D., Macquarie University, 1977

B.Sc. (Hons), University of Adelaide, 1972

Employment History

1996 – present University of Western Sydney – Associate Professor, School of Biomedical and Health Sciences

1994 – 1996 University of Western Sydney – Senior Lecturer, School of Business and Technology

Professional Experience

My principal field of interest is marsupial biology which includes cytogenetics, formation of new species, hybridisation of existing species, fertility of hybrids, and ecology. My original Ph D research was on the cytogenetics of bandicoots which led to post-doctoral studies of the taxonomy and distribution of this group of marsupials. My main area of research then became rock wallabies (Petrogale) and I have been studying this group since 1976. Since that time, my colleagues and I dramatically changed the taxonomy of the group including the naming of four new species and the discovery of three of them. We also plotted, for the first time, the distributions of many of the species. The research showed that there was some hybridisation occurring at the borders between some of the distributions.

I have conducted a study of koalas in the Campbelltown region since 1990 that has included supervision of graduated PhD student, Steven Ward on his ecological study of koalas in Sydney's South and graduated MSc student Grace Hey for her study of identifying individual koalas from their faecal DNA. We now have 120 animals in the region with individually coloured ear-tags including 8 radio-tracked females. The Campbelltown study has largely been ecological and genetic but has become a community-associated research program, with feedback from the community leading to increased sightings of koalas. I am on 24h call via a pager, the number for which is posted on koala road signs which Campbelltown Council has erected in the LGA. Since October 1995, we have published a weekly column in the Macarthur Advertiser principally describing our koala research, which is important in maintaining the community interaction on which the project depends. The project has developed a momentum that is time consuming and on-going but rewarding in terms of interaction with the University and the community, as well as providing long-term family data for koalas that include four generations of koalas.

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Appendix C Expert review: Comments and recommendations, and responses by Roads and Maritime Services

The following table summarises the recommendations of the independent expert reviewer and identifies how each of the recommendations have been addressed. Recommendations have been addressed in one of three ways:

- Adopted - plan updated.
- Adopted - plan to be updated prior to implementation.
- To be reviewed - recommendation to be reviewed further by Roads and Maritime prior to implementation.

Table. Summary of recommendations from the expert review and how addressed in this plan

ID No.	Comment / Recommendation	How recommendations have been addressed
KMP1	Reconsider which sections of the Upgrade require focus. Would like to see a map on which all the various Koala sightings are marked as well as the inclusion of vegetation maps so that potential dispersal routes can be visualised.	Adopted- plan updated. See figures 2.1a, 2.2a,
KMP2	Reconsider suitability of methods for gathering base-line data. It will be very difficult to monitor changes, particularly in low density areas for Koalas using the SAT technique	Adopted- plan to be updated, See section 8. monitoring program
KMP3	Reconsider methods for monitoring road kill data (more frequent)	Adopted- plan updated. See section 8.4 Road Kill Monitoring
KMP4	Reconsider methods of catching and treating Koalas located in the clearing areas Ear tagging of captured / relocated individuals is extremely worthwhile	Adopted – plan updated. See Section 6.3.6 Koala Relocation Protocol
KMP5	Captured Koalas should go to the vet rather that the vet goes to the Koala.	Adopted- plan updated. See section 6.3.6 Koala Relocation Protocol
KMP6	Examine side-road fencing	Adopted – plan updated. See section 8.6
KMP7	Consider the approaches to the crossing structure	Adopted- plan updated. See section 6.3.9 habitat revegetation.

Appendix D Agency reviews: Comments and requirements, and responses by Roads and Maritime Services

Department of the Environment review of Koala Management Plan: Sections 1 and 2

February 2015

Requirements of the Conditions	Comment:	Response by RMS
General:	Currently, this Plan is intended to cover Sections 1 and 2 of the proposal only. However, as a lot of the content covers the remainder of the action, there is contradicting information between what is proposed for the broader proposal, and what is proposed specifically for sections 1 and 2. This makes the plan difficult to comply with and implement. For example, Table 5.1 refers to temporary fence monitoring to be undertaken, when it is stated in the plan that no temporary fencing will be installed for sections 1 and 2. The same problem occurs for references to population monitoring, which based on this plan is not proposed for sections 1 and 2. Another example is where section 7.1 refers to the objective of determining the extent to which the highway creates a barrier for the Koala, while the plan currently does not provide any mechanism to meet this objective in sections 1 and 2. Furthermore, it is unclear where reference is made to the project, whether this means the whole upgrade or the projects in section 1 and 2. The Department recommends that the format be addressed to amend this as we understand that approval of this plan would be sought prior to it being updated to address the remaining sections.	The format and content of the report has been addressed throughout to clarify that this plan is referring principally to highway upgrades along Section 1 and Section 2. In a number of areas, where it was considered useful to include a broader context, reference has been given to the entire project. Table 5-1 (re-labelled as 5-2) has been revised to deal with temporary fencing. Table 7-1 has been revised to deal with monitoring objectives of Section 1 and section 2.
General	The Department notes and concurs with the EPAs comments on the Plan.	Noted refer to responses below.
General	Key sections of the document, and mitigation measures proposed within, are currently worded as recommendations. The Department recommends that this wording be strengthened to clear commitments by RMS.	Word such as “would” have been replaced by “will”, etc. throughout the document.

General	There seems to be confusion in the plan between performance thresholds and triggers for corrective actions. Performance thresholds are thresholds that are trying to be met and for which deviation from these thresholds would result in corrective actions being implemented (as is written in the headings of tables within the document). On the other hand triggers for corrective actions are negative outcomes which would trigger corrective actions. Currently the majority of the actions/statements under the performance measures heading are actually triggers for corrective actions. Therefore, as currently written, deviation from these measures, which would trigger corrective actions, would in effect result in corrective actions being implemented when the desired outcome is being achieved. The actions under the heading or the terminology used in the heading needs to be amended to address this inconsistency.	The column headings for “Performance thresholds” in Tables 4-1, 5-2 and 6-2 have been altered. The language used to describe performance thresholds has been changed to remove inconsistencies in terminology. Alterations to language have also been inserted in 7-2 under “performance indicator”.

D9 (a) demonstration that adequate surveys have been undertaken to assess the impacts of the SSI with reference to the Mitigation Framework developed under condition D1, including baseline data collected from surveys, undertaken by a suitably qualified and experienced ecologist on threatened species and ecological communities within all habitat areas to be cleared of vegetation for the SSI, that are likely to contain these species and that are likely to be adversely impacted by the SSI (as determined by a suitably qualified expert). The data shall address the densities, distribution, habitat use and movement patterns of these species;	Currently, no reference is made to the Mitigation Framework in the Plan. While there is a brief reference to additional surveys undertaken, further information is required to demonstrate the adequacy of these surveys, as required by this condition (noting the expert comment that SAT surveys are not sufficient to determine population density). Furthermore, the baseline data from the surveys and the detail of the location and methodology of the surveys needs to be provided. Currently, the plan appears to still rely heavily of NSW Wildlife Atlas records, and not on evidence based on surveys undertaken. This may be as a result of the plan being updated in parts for section 1 and 2, but not in other parts (see general comment above). Further information, including the details of surveys undertaken should be included as a part of this plan. The data provided for sections 1 and 2 does not address all the requirements of the condition (distribution and movement patterns). The Department notes that the low density of Koalas in this area may is likely to be the reason for this and requests that this be clarified.	New reference to the Biodiversity Mitigation Framework has been inserted in part 1.2. The population density of Koalas in Section 1 and Section 2 is considered to be too low using any survey method to achieve cost-effective and accurate assessments of Koala density. This is the reason why baseline surveys are not being undertaken in Section 1 and Section 2, because such low population densities will be difficult to monitor and any changes that may occur cannot be determined statistically from the data that would be collected. Additional information about Koala surveys undertaken, and the results of these surveys in Section 1 and Section 2, has been presented in part 2.2 of this Plan.

		The low density of Koalas in Section 1 and Section 2 is the reason why detailed studies of Koala distribution and movement patterns have not been undertaken in these Sections.
(b) identification of potential impacts on each species;	The Department recommends that this plan needs to contain all the detailed impact assessment for the Koala for sections 1 and 2, including the amount of habitat to be cleared (for example, this is required on page 25) The Department also notes that reference is made to the interim EPBC Act guidelines for the species and not the current guidelines, a draft of which was made available for public comment in late 2013. These are available at http://www.environment.gov.au/biodiversity/threatened/publications/epbc-act-referral-guidelines-vulnerable-Koala Please confirm that these guidelines have been considered in determining the quantum of habitat critical to the survival of the species likely to be impacted by the action. Page 41, 6.1 impacts from operation phase – please add road kill as an impact. This is currently presented as a result of degradation of fauna fencing only, when it can easily occur in unfenced areas or areas where there are gaps in the fence, or where inappropriate fencing is used.	The total amount of Koala habitat that is to be cleared for the entire Project has been amended upwards to 782 ha. This is indicated in part 3.1 of this Plan. A Table showing the breakdown by Sections (including Section 1 and Section2) is presented in Table 3-1.

		The new (2014) guidelines were consulted, but were not considered to change the results of the now, more conservative, estimates of Koala habitat that will be removed (782 ha across the entire Project). The EPBC Biodiversity Offset Policy, in conjunction with the nominal tree species composition of NSW Biometric Vegetation Types, were used as the basis for calculating areas of habitat critical for the survival of the Koala (see part 3.1 of this Plan). Amendments have been made to Table 6-1 (re-labelled 6-2) to include Koala deaths and injuries as a possible impact.

(c) details of and demonstrated effectiveness of the proposed avoidance and mitigation and management measures to be implemented for each threatened species including measures to at least maintain habitat values of habitat areas compared to baseline data and maintain connectivity for the relevant species;	Specific measures, as proposed for section 1 and 2, based on surveys undertaken in these areas are required. For example, please provide further information regarding the locations proposed for revegetation and the location of proposed fencing. Reference to a fencing strategy is made on page 31, however the strategy is currently not included. Please attach the strategy to the plan or provide a reference as to which plan the document is attached to, and a discussion of the key outcomes to be addressed in the strategy. Insufficient baseline data is currently presented to meet this requirement. A discussion is also required as to how habitat values will be at least maintained. In section 4.3.3, it is stated that the results of pre-clearance surveys would inform procedures for staged clearing. Please provide further information about how this would occur.	Strategic plantings will be undertaken adjacent to connectivity structures to improve connectivity. Plantings will be endemic species which will include Koala food trees. The fencing strategy is included in the connectivity strategy for Sections 1 and 2 please refer to this document. As above, no baseline surveys undertaken because of low densities and expert review comment. A new paragraph has been inserted into part 4.3.3.to state: Pre-clearing surveys include a 2-staged process for habitat trees and any trees that contain fauna. If a Koala is found, clearing will stop and the area left for 24hrs to allow the Koala to relocate. If the Koala is still present after 24hrs, the Koala will be trapped and relocated. A Koala spotter will also be present during clearing operations.

	Please identify the basis for selecting exclusion zones and their proposed locations.	Exclusion zones are those that include Biometric Vegetation Types containing Koala food tree species that are located outside the construction footprint.
	Location of ancillary facilities page 39 – please define 'low ecological value'.	A suitably qualified ecologist will use his/her professional judgement to identify land as being of 'low ecological value' based on a site inspection and ecological assessment report,

(d) an adaptive monitoring program to assess the use of the mitigation measures identified in conditions B10 and D2. The monitoring program shall nominate appropriate and justified monitoring periods, performance parameters and criteria against which effectiveness of the mitigation measures will be measured and include operational road kill and fauna crossing surveys to assess the use of fauna crossings and exclusion fencing implemented as part of the SSI;	D2 connectivity strategy – The Department notes that the location of the proposed crossings can only be confirmed once the strategy has been approved and that these must be informed by the further survey undertaken since the EIS/PIR (e.g. page 37). This is currently not addressed in the plan. Further justification of the monitoring periods proposed is required to address the requirement of this condition. For example, in Table 5.1 a monthly inspection of fencing is proposed, and in section 7.4.2 biannual road kill monitoring is proposed. Further justification is required to demonstrate that this is sufficient. Section 5.3.4 – please provide further detail as to the retrofitting of fencing, specifically how the location and extent would be determined, and what amount of Koala road kill, over what period of time would need to occur to trigger this corrective action.	No further surveys have been undertaken for Koalas in Section 1 and 2 for reasons explained above. The connectivity strategy identifies connectivity structures that will facilitate the movement of fauna including the Koala. The connectivity strategy has been closely developed in consultation with EPA Table 5-2 (previously 5-1) refers to daily inspections for Koala deaths and injuries during the clearing phase, and monthly inspections immediately after clearing. Part 7.4.2 refers to bi-annual road-kill monitoring during the operational phase of the Project. The timing of monitoring of effectiveness of mitigation structures is set to co-incide with periods of peak movements of Koalas (dispersal of sub-adults and movement of adults during the breeding season).

		Retro-fitting of Koala exclusion fencing in Section 1 and Section 2 is dependent on records of Koala deaths or injuries in these Sections of the highway upgrade. One Koala mortality is sufficient to trigger an investigation to determine whether this course of action is required.
(e) monitoring methodology for threatened flora and fauna adjacent to the SSI footprint,	The Department notes that population monitoring is not proposed based on the density of Koalas in sections 1 and 2. The plan needs to be updated to include the survey data that supports this statement. Once these are included and this is demonstrated, the Department would agree with the proposal to remove population monitoring requirements for these sections.	Additional information about Koala surveys undertaken, and the results of these surveys in Section 1 and Section 2, has been presented in part 2.2 of this Plan.
(f) goals and performance indicators to measure the success of mitigation measures, which shall be specific, measurable, achievable, realistic and timely (SMART), and be compared against baseline data;	Goals and performance indicators do not currently meet this requirement and need to be updated to be more specific, measurable, achievable, realistic and timely (see for example table 5.1, 6.1 and 7.2 and the specific examples below). Section 6.2 page 41 – main goals for management are defined as: zero or reduce rate of reported Koala deaths - For this goal to be achievable, baseline data needs to be provided against which it will be measured; Targeted crossing found to be “used by Koalas” – this should be further defined i.e. Koalas are found to be making a full crossing; “Successful” revegetation also should be defined and can only be achieved when the vegetation is self-sustaining, not for a period of five years post construction Table 5.1 Exclusion zones: The Department suggests adding performance thresholds of damage to vegetation within exclusion zones, not just vehicle breaches; for the proposed replanting of Koala habitat outlined in this table, the thresholds need to include survival rates to be achieved and within what timeframes they will be achieved.	Goals and performance indicators have been revised to better reflect SMART criteria. Goal re-defined to clarify as “No Koala deaths or injuries” (baseline data unnecessary). Goal re-defined as “Evidence of completed crossings by Koalas at targeted fauna crossing structures

	Table 7.2 – in the vicinity needs to be further defined to clarify what distance this is referring to	Goal re-defined as “Less than 30% mortality of planted Koala feed trees in Koala habitat revegetation areas on Roads and Maritime owned land for a period of five years post-construction” is a reasonable metric to assume revegetated area will continue to survive and become self-sustaining. (i.e. additional evidence of flowering/ /seeding/ germination is unrealistic). Exclusion zones are normally defined as the boundary of the approved clearing footprint. These areas will be marked with temporary flagging tape or temporary fencing. Any breaches by vehicles or equipment will be reported. Performance thresholds for tree planting of habitat for Koalas will be set at less than 30% mortality of planted trees. The term “vicinity” has been deleted and the performance indicator revised.

(g) methodology for the ongoing monitoring of road kill, the species densities, distribution, habitat use and movement patterns, and the use of fauna crossings during construction and operation of the SSI, including the proposed timing, and duration of that monitoring;	7.4.1 Please amend incorrect references to sections of the proposal in this section. 7.4.2 please provide further justification of the frequency of the proposed monitoring	Edits made as required. Ad-hoc observations of Koala deaths or injuries may occur, and will be reported, at any time throughout the project, However, more formal monitoring, involving searching on foot for any evidence of road-killed animals, will be confined to two sampling periods per year. This constraint is applied because it is necessary to restrict traffic flows along the highway to enable this monitoring work to be done.
(h) provision for the assessment of monitoring data to identify changes to habitat usage and whether this can be attributed to the SSI;	n/a based on low density of individuals	Not applicable within Section 1 and Section 2 because of the very low population density of Koalas that occur in this area.

(i) details of contingency measures that would be implemented in the event of changes to habitat usage patterns, entities, distribution, and movement patterns attributable to the construction or operation of the SSI, based on adequate baseline data;	No baseline data is currently presented to address this requirement The Department recommends that the corrective actions in this table be strengthened. For example: • Retrofitting of rabbit proof fence with smooth metal sheeting is proposed on page 34 – further information is required regarding what level of road kill would trigger this action, and the location and extent of fencing that would be installed, and a clear commitment to implement this action if required. • Table 5.1 Proposes a corrective action to review Koala measures if more than one Koala is reported as killed (or injured) as a result of road strike – please clarify over which period this would be measured. • Table 5.1 Retrofitting of fencing is proposed as a corrective action – within what timeframe would this occur from when a Koala road strike is reported? • The Department requests that a corrective action be included that ensures that for sections 1 and 2, where temporary exclusion fencing is not proposed, that it be installed should Koalas be recorded, injured or killed in the clearing footprint • Section 6.3.1 Fencing monitoring– how often will this occur? How will it be undertaken? In what timeframe would fencing be repaired once a breach is reported? • Table 5.1 The Department recommends that “adding additional exclusion fencing in unfenced areas” is added as a corrective action; identify and *implement* actions is added to the corrective action proposed for mortality from dog attacks.	Not applicable within Section 1 and Section 2 because of the very low population density of Koalas that occur in this area. Clear commitment has been made to consider the need to retro-fit fencing to provide further deterrence to Koalas. Table 5-2 refers only to the construction period, however, this corrective action applies for up to five years during the operational period (Table 6-2). Action to locate and repair a faulty exclusion fence (if present) will be undertaken within 3 days of Koala death being reported. Retro-fitting, if required, will be undertaken in consultation with suitably qualified ecologists. Corrective actions will include the provision of exclusion fencing where there is none if Koala deaths or injuries are recorded.

		Periodic monitoring and maintenance of exclusion fencing will be undertaken for the life-time of the project. Edits made to Table 6-2 regarding exclusion fencing and corrective actions for mortality from dog attacks.
(j) mechanisms for the monitoring, review and amendment of these plans;	Requirement met	
(k) provision for ongoing monitoring during operation of the SSI (for operation/ongoing impacts) until such time as the use and effectiveness of mitigation measures can be demonstrated to have been achieved over a minimum of three successive monitoring periods, unless otherwise agreed by the Secretary in consultation with the EPA, DPI (Fisheries) and DoE; and	The commitment to undertake monitoring until such time as the use and effectiveness of mitigation measures can be demonstrated to have been achieved over a minimum of three successive monitoring periods for the monitoring proposed for mitigation measures must be included in this plan. (for example road kill monitoring in table 6.1)	This commitment is stated in Table 6-2.

(l) provision for annual reporting of monitoring results to the Secretary and the EPA, DPI (Fisheries) and DoE, or as otherwise agreed by those agencies.	Requirement met	
In developing the Plans, the Applicant shall demonstrate to the satisfaction of the Secretary and DoE, how the public authorities and expert reviewer recommendations provided for each draft plan in the documents listed in condition A2(c) have been addressed, including detailed justification of any variance from the recommendations of the expert reviewer of the management plans, including analysis of potential risk to the threatened species.	The Department notes the expert's comment that the SAT technique is recommended as being unsuitable to determine population densities. Please discuss how this has been addressed.	The key thing to note is that the SAT technique is not designed to provide a measure of Koala population density. The SAT technique is an **"indirect"** method which can provide estimates of relative use by Koalas of different areas or vegetation types. Other **"direct"** survey methods are required to estimate Koala population density. These direct survey methods are not effective or cost-efficient when Koala population densities are very low, as in the case of Section 1 and Section 2.

NSW Environmental Protection Authority review of Koala Management Plan: Sections 1 and 2 December 2014

Comment:	Response by RMS
Section 4.3.1 - EPA recommends using fauna drop downs rather than escape poles in sections 1 & 2 due to the low number of Koala records. Drop downs need to be designed with 1200mm clearance down the front. Place drop downs close to entry nodes and less frequently further away from entry roads, arbitrarily every 500m. The EPA welcomes the opportunity to consider alternative escape mechanism designs. The EPA believes escape mechanisms are a vital design feature of 4 lane highways however further research and experiment is necessary to improve the efficacy of designs.	New text has been inserted in part 4.3.1 to reflect this requirement.
Sections 5.3.4 – EPA supports the decision not to provide temporary Koala exclusion fencing during construction and operation. However as discussed in this section and in Table 6-1 any Koala road accidents/ kill should trigger analysis of potential Koala movement areas and the subsequent need for retrofitted metal sheeting.	The Table has been updated to reflect this requirement.
Section 5.3.8 - EPA recommends that all Koala furniture is a minimum of 200mm diameter. Also the EPA would prefer the installation of horizontal logs rather than planks.	New text has been inserted in part 5.3.8 to reflect this requirement.

NSW Department of Planning and Environment review of Koala Management Plan: Sections 1 and 2

January 2015

Comment:	Response by RMS
The plan needs to more clearly demonstrate what surveys have been undertaken for W2G (condition D8(a)). Some detail is required on each of the key points in D8(a) (e.g. density, habitat use and movement patterns).	Additional information about Koala surveys undertaken, and the results of these surveys in Section 1 and Section 2, has been presented in part 2.2 of this Plan.
For D8(a), it is also necessary to link to the Mitigation Framework. Could you let me know the status of the framework for W2G?	New reference to the Biodiversity Mitigation Framework has been inserted in part 1.2.
Information about how the expert review comments have been reviewed and incorporated into the plan should also be provided.	Provided in Appendix B of this Plan.

Department of the Environment review of Koala Management Plan: Sections 1 and 2

Additional comments - April 2015

Condition No	Condition requirement	Section/ Page Reference of the document/Plan	Department Comment Date – 14/4/2015	RMS Response Date – 28/4/2015
8	Develop a Koala management plan as per NSW condition 8 and 9 for each relevant stage	This plan	This plan has been prepared to address mainly section 1 and section 2 of the project which is from Woolgoolga to Halfway Creek	
General		Table 3-1 and page 17	**Response required** The figures provided for total clearing of vegetation within sections 1 and 2 (section 3.1) do not appear to correspond with those provided in Table 3-1.	Table 3-1 displays the correct information, following merging of the vegetation polygons used by different consultants and constraining analysis to the areas proposed for clearing as part of the highway upgrade footprint. The text on p. 17 has been updated to correspond to the information presented in Table 3-1.
8	Plan must minimise impacts to Koala to the satisfaction of the Minister	Sections 4, 5 & 6	See below.	
	Management – pre construction	Section 1.3	**Response required** Tables 4-1 should include a column on responsibility/responsibly party	Table 8-1 lists the responsible parties for each stage of the Koala Management Plan, including pre-construction works.

	Management-construction	Section 5 Section 5.3.7	clearing procedures, relocation protocol are discussed satisfactorily. **Response required** Please ensure that this plan designates the speed limit for construction vehicles within the construction corridor, as this plan will need to be implemented by the Contractor as part of the CEMP for sections 1 & 2. The expert review raised the issue of side roads joining the main highway as a major hazard which can funnel Koalas on to the highway and suggested fencing side roads in conjunction with permanent fencing on the adjacent highway or removing vegetation from around the road entrance. It would appear that the applicability or otherwise of this recommendation, and if applicable appropriate mitigation measures to sections 1 and 2 have not been included.	The designated speed limit will vary between different construction activities and construction machinery. The Traffic Management Plan will identify speed limits for each construction activity. The speed limit within the construction zone will range from approximately 10km/hr – 60km/hr. Speed limits will be reduced to 80km/hr on the existing Pacific Highway and 40km/hr on local access roads. Koala floppy top fencing is not proposed on Section 1 and 2 because of the low population densities. For instances where fauna become trapped in the road corridor the connectivity strategy for Section 1 and 2 includes escape drop downs to allow fauna to exit the construction corridor. The issue of side roads funnelling Koalas onto the highway will be further considered for the populations referred to in MCoA D9. RMS is currently looking into solutions to resolve this issue (e.g. Koala “roller grids”). RMS is also required to meet MCoA D9 (d) (vii) “provide passage for Koalas under or over the existing highway and service roads or local roads (servicing over 100 vehicles per day)”.
	Management construction	Table 5-2	**Response required** It is unclear why the measure provided under main goal for management (performance objective) and the	Performance measures in Table 5-2 amended to:

			performance threshold (trigger) is the same. If there are no injuries to a Koala this should not trigger corrective action. The trigger should be any injury to a Koala individual. Please include a column on responsible party for monitoring and taking corrective action.	“Any injury to an individual Koala during clearing works”. Also: “Any injury to an individual Koala during construction activities”. Table 8-1 lists the responsible parties for each stage of the Koala Management Plan, including construction activities.
	Management construction		**Response required** Should include weed management and water quality management in table 5-2 Please confirm that general fauna fence (F1) referred to in Table 54 of the connectivity strategy provides for Koalas as described in section 5.3.4 of the Koala Management plan.	Table 5-2 amended to include references to weed management and water quality management

				Section 1 and Section 2 have relatively low Koala population densities and, as such, typical floppy top fencing used for Koalas will not be applied to these sections. Instead, a modified rabbit proof fence has been developed which is minimum 1200 mm high mesh fence pegged into the ground and secured with concrete posts. Although this fence is not targeting Koalas, it will act as a barrier for Koalas. In developing this fence design, extensive consultation was undertaken with biodiversity specialists from the EPA. If Koala accidents or road kills occur during the operation of Section 1 and 2, this fence, or parts thereof, will be retro-fitted with smooth metal sheeting as an additional deterrent to Koalas.
	Management – Operation	Section 6.3 Table 6.3.2	**Response required** Frequency of maintenance inspections of fauna exclusion fencing will need to be specified. Table 6.3.2 needs to include a column on responsible party.	Section 6.3.1 has been amended to indicate that fauna exclusion fencing will be inspected and maintained every six months, or in response to any Koala injuries or death. Table 8-1 lists the responsible parties for each stage of the Koala Management Plan, including maintenance activities.
	Responsibilities for implementation of the plan	Section 1.3, Chapter 8	Construction contractor and ecologist engaged will be responsible during construction phase. RMS will be responsible for operational phase.	Table 8-1 lists the responsible parties for each stage of the Koala Management Plan.

			Please see comments above for inclusion in to the relevant Tables **Response required** It is important to delineate responsibilities as per previous comments given the split of responsibilities.	
NSW D8(a)	Demonstration of adequate surveys	Sections2.2, 2.2.1, 2.2.2 and figures 2.1 a & 2,2a	The level of surveys undertaken for sections 1 & 2 appears reasonable.	
		5.3.8 & Table 5-1	Table 5-1provides a list of key Koala connectivity structures and their locations for sections 1 & 2 and includes 6 bridges and 18 culverts. These have been developed in consultation with NSW EPA/OEH and DPI (Fisheries). This will need to be updated with the information provided in the Connectivity strategy (final connectivity structures).	Table 5-1 has been updated to include the relevant information provided in Table 5 of the Final Connectivity Strategy (April 2015). One additional bridge (64 m) over a tributary of Corindi Creek at chainage 6170has been included in Table 5-1. Additional changes to the text of the Plan have been made in part 5.3.8.
NSW D8(d)	Monitoring program to assess the use of mitigation measures- include monitoring periods, performance parameters and criteria against which effectiveness will be measured.	Section 7	**Response required** Please confirm if Table 7-1 indicates locations of under passes where motion cameras will be located on either end of each culvert. Section 7.3.2 states motion detection cameras will operate continuously during the monitoring period (spring/summer). Please specify the monitoring duration. Duration is given as until structures are proven to be effective. This will need to be defined in terms of how many successful crossings over what period of time.	Text has been added in part 7.3.1 to clarify that: “Motion sensor cameras will be installed at each end of the Koala dedicated underpass structures listed in Table 7-1 to determine whether Koalas are prepared to undertake complete crossings of these structures”. Additional text also includes: “Koala faecal pellet searches and searches for Koala scratches on trees will be

			Ideally x number of years following the construction of structures and following operation of the highway.	conducted in adjacent habitat (within 100 m) to the above connectivity structures and during the period that the underpass structures are being monitored. The purpose of these searches is to determine whether there is any evidence of Koala presence near the connectivity structures at the time they are being monitored.” Section 7.3.2 has been amended to read “Cameras will operate continuously for at least three months during the monitoring periods (spring/summer). These monitoring periods are scheduled to occur each year for the first three years following completion of the project, after which the need for further monitoring will be reviewed (Table 8-1). The performance of each dedicated Koala crossing structure will be determined by evidence of one or more completed crossings during these monitoring periods (Table 7-2).
NSW D8(e)	Monitoring methodology	Section 7	Motion cameras, remote cameras, digital photography, SAT assessment are proposed. **Response required** For SAT and remote camera monitoring of adjacent habitat – please provide a definition in terms of distance for adjacent areas	Text in 7.3.2 has been amended to clarify distance (100 m) and timing (monthly) over which Koala faecal pellet searches and Koala tree-scratch searches will be undertaken either side of dedicated fauna crossing structures that are being monitored with remote cameras.

NSW D8(f)	Goals and performance indicators		See previous comment under condition 8	Amendments made to performance indicators in Tables 6-1 and 7-2.
D8(g)	Methodology for ongoing monitoring of road kill, species densities, distribution, habitat use and movement and use of fauna crossings Timing and duration of monitoring	7.3.2	See previous comment under D8(d)	Amendments made within part 7.3.2 to clarify monitoring methodology. Further information in Tables 7-2 and 8-1. Scat-search and tree-scratch searches will be undertaken within 100 m in habitat adjacent to each dedicated crossing structure. Methodology is clarified in 7.3.2. The purpose of these search plots is to identify whether Koalas have recently been in proximity to the dedicated fauna crossing structures which are being monitored.
D8(h)	Provision for assessment of monitoring data to identify changes attributable to the project	7.3.2, 7.6	No comment	
D8(i)	Details of contingency measures in the event of changes to habitat usage patterns, distribution and movement patterns attributable to the project	7.6		Text amended in 7.6 to read “Observations of Koala presence using faecal pellet-search and tree-scratch track searches within 100 m in adjacent habitat during the time of monitoring fauna crossing structures will be used in assessments of the effectiveness of these structures.”

D8(j)	Mechanism for monitoring, review, and amendment of the plans	7.5	Not addressed under section 7.5	7.5 amended to include the following new text: “The responsibility for identifying appropriate triggers to undertake corrective actions, if needed, will be shared between RMS and its consulting ecologists, with RMS having the prime responsibility for enforcing any necessary changes as required by this Plan (Table 8-1).”
D8(k)	Provision for ongoing monitoring during operation until the success of mitigation measures are demonstrated	7.3.1 & 7.4.2	Has not been satisfactorily addressed under section 7.3.1 or section 7.4.2. se comment under D8(d)	Table 8-1 outlines the implementation schedule for monitoring activities in this Plan. Text has been amended in 7.3.1 and 7.4.2 to clarify these issues.
D8(l)	Annual reporting of monitoring results	7.5	No comment	

Department of the Environment review of Koala Management Plan: Sections 1-8 (excluding Woombah population), and 11 (version 3)

Comments - September 2015

Condition No	Condition requirement	Plan Reference	Department Comment Date – 15/09/2015	Proponent Response Date - November 2015
General Comments		2.2.5 – 2.2.6	Section 5: Maclean to Iluka Road states that further discussions of this population will be deferred until Update 3 (version 4) of this Koala Management Plan as the Iluka /Woombah population is present from chainage 94000 to 102000. Figures 2-5 and 2-6 show that the areas between these chainages are predominately in section 6. **Queries** Will further discussion of this population be included for section 6 in the updated version since this population spans both sections 5 and 6? Will the updated version (version 4) be provided for approval before works will begin for sections 5 and 6? Under EPBC approval Condition 8, the relevant stage cannot commence until the KMP for that stage is approved. The information for stages 5 and 6, including the Woombah population, is required in order to approve this KMP for those stages.	Further information will be included in Update 3 (Version 4) about the populations between chainage 94000 to 102000. Construction will not commence within chainage 94000 to 102000 until version 4 is approved.
		Figures 2-1 – 2-11	No information for connectivity structures has been proposed in this plan. The titles for these figures indicate that connectivity information is detailed. **ACTION** Please consider revising the title of these figures.	The titles of all figures (1-8, 11) have been revised to remove reference to connectivity structures.

EPBC 8	The **approval holder** must develop a Koala Management Plan(s) pursuant to the requirements of **NSW approval conditions** D8 and D9 for each **relevant stage(s)**. The Koala Management Plan must minimise impacts to the Koala to the satisfaction of the **Minister** and must be submitted to the **Minister** for approval.		This plan has been submitted as a requirement under NSW approval condition D8 as the plan covers sections 1-8 (section 1-2 previously approved – 11/5/2015) and section 11. MCoA D9 is not required for these sections as it is not within Koala populations at Coolgardie/Bagotville, Broadwater and Woombah/Iluka. Version 4.0 to the KMP will incorporate these populations for MCoA D9.	No action required
NSW MCoA D8	The Applicant shall prepare and implement Threatened Species Management Plans to detail how impacts of the SSI will be minimised and managed specifically for each species identified as significantly impacted.			Actions underway
a)	demonstration that adequate surveys have been undertaken to assess the impacts of the SSI with reference to the Mitigation Framework developed under condition D1, including baseline data collected from surveys	Ch 2	Figures 2-1 to 2-11 have been provided to the Department separately to the Koala Management Plan. Figure 2-3 shows two Koala scat search plots where scats were located. Table 2-3 indicates that 'four plots recorded Koala scats in the Bushgrove area. This occurred in three different vegetation types.' At least 17 Koala Atlas sightings have been recorded at the southern region of section 3 on both the Bom Bom and Glenugie state forest sides (Figure 2-3). Table 2-3 states 'Four BioNet records in the broader landscape, with other records outside of the broader landscape'.	This was a plotting overlay issue which has now been rectified and the Figure redrawn. Text edited in Table 2-3 to indicate many older records present in southern part of Section 3

			Section 2.2.3 Section 3: Glenugie to Tyndale states that ‘BioNet records of the Koala for this section are sparse compared to other locations’ and ‘Koalas occur at very low population densities along Section 3 of the Pacific Highway Upgrade’. The historic records as shown in figure 2-3 indicate a high density of Koala activity in the southern region of this section, particularly relative to other sections of the project as outlined in this plan. **ACTION** Please consider the use of floppy top fencing in the southern portion of section 3 due to the higher level of historic Koala records in the area. There are multiple types of fencing described, please consider descriptions of fencing as an appendix to this document. Section 4.3.2, states that ‘no baseline surveys for Koala population size and distribution are proposed for Sections 1-8 (see 3.6 above for the Woombah/Iluka Koala population), and 11 due to the low population density of animals in these locations.’ Under NSW MCoA D9, RMS must prepare and implement a KMP to demonstrate the ongoing survival of populations at Coolgardie/Bagotville, Broadwater and Woombah/Iluka and include detailed assessment of the impacts to the Koala populations based on survey results. **ACTION** Please include the provision for baseline surveys for the Woombah/Iluka Koala population.	Text modified in Section 2.2.3 to indicate that most of the mapped records are more than 10 years old. Most of the records of Koalas in the southern portion of Section 3 are old (> 10 years). Recent surveys suggest that Koala population density is very low in these areas. However, in this section, from chainage 35000-40000, it is proposed to erect “Phascogale fencing”, which is Mammal fencing with 600 mm wide galvanised steel panel near the top that should provide a barrier to Koala movement onto the road. A description of the fencing types that are most relevant to protection of the Koala is now provided in section 4.3.1, and their locations are provided in Table 4-1 which has been updated. A meeting between RMS, DoE and DP&E on 15 June 2015 confirmed that no additional Koala baseline surveys are required for Section 5 for the

				Woombah/Iluka Koala population. The proposed monitoring design and methods for the Broadwater and Coolgardie/ Bagotville populations will be presented in Update 3 (Version 4) of this Management Plan
b)	identification of potential impacts on each species;	2.4	A discussion of key threats has been provided in Section 2.4 and includes any of the key threats associated with Koala population decline. Section 3.1 provides an overview of those potential impacts to Koala populations associated with the project. Based on field surveys, a total of 885 ha of Koala Habitat will be directly impacted on, within the clearing footprint. **ACTION** Please consider including increased predator attacks around fauna road crossing structures as a potential impact associated with the project.	This is addressed in section 6.3.3
c)	details of and demonstrated effectiveness of the proposed avoidance and mitigation and management measures to be implemented...... including measures to at least maintain habitat values of habitat areas compared to baseline data and maintain connectivity.	3	Table 3-2 outlines mitigation measures and an evaluation of their effectiveness as demonstrated by other, previous roads projects in NSW. The Koala relocation protocol (Section 5.3.6) has been provided as mitigating the effects of impacts on individuals due to clearing works. A revegetation strategy and connectivity strategy are being developed to outline these mitigation and management measures under both the EPBC and NSW CoAs. Table 7-1 outlines the location and detail of the fauna connectivity structures.	No action required
d)	An adaptive monitoring program to assess the use of	7	Section 7.2 states that due to the presence of low density populations in sections 1-8 and 11, population monitoring efforts	A meeting between RMS, DoE and DP&E on 15 June 2015

	the mitigation measures....... The monitoring program shall nominate appropriate and justified monitoring periods, performance parameters and criteria against which effectiveness of the mitigation measures will be measured and include operational road kill and fauna crossing surveys to assess the use of fauna crossings and exclusion fencing		will be focused in later stages and in other sections where the Koala is more abundant. **ACTION** Please include the provision for Koala population monitoring for the Woombah/Iluka Koala population. Methods, timing, intensity and duration of monitoring of fauna underpasses are provided in section 7.3.2. The timing of monitoring will coincide with peak movement periods; breeding season and juvenile dispersal periods. Fauna crossing structures will be monitored 6 months after installation and will continue annually until structures are proven to be effective.	confirmed that no additional Koala baseline surveys are required for Section 5 for the Woombah/Iluka Koala population.
e)	monitoring methodology	7	Section 7.3.3 provides performance indicators and performance criteria for success of the fauna underpasses and associated fencing. **ACTION** Please consider including the following as a performance indicator and provide corrective actions and responsibility in Table 7-2: No Koala deaths or injuries due to predator attack in the vicinity of fauna crossing structures. Section 7.6 states that: “Further monitoring/assessment will be undertaken if a decline of Koala population numbers is identified as being attributable to the construction and operation of the project.” **ACTION** Please outline how the decline in population numbers will be identified in sections 1-8 and 11. Road Mortality monitoring has been provided in section 7.4, with an aim of achieving zero Koala vehicle strikes.	
f)	goals and performance indicators to measure the success of mitigation measures, which shall be specific, measurable, achievable, realistic and timely (SMART), and be compared against baseline data	7		In section 6.3.3 it states the following: “Where monitoring indicates that predators are a threat to Koala movement through the crossing structures, Roads and Maritime Services will engage with the North Coast Local Land Services, NSW National Parks and Wildlife Service (Grafton), and Rural Lands Protection Board (North East) and adjacent landowners to identify and implement strategies to reduce this predation risk”. This has been included as a performance indicator in Table 7.2.

			QUERY Please provide information regarding how Koala mortalities will be reported during the operational phase of the project. Will there be liaison with local wildlife care and rescue organisations in order to accurately report mortalities?	In Section 7.6, sentences referring to population monitoring and responses to population decline have been removed because this is relevant to Sections 9 and 10 only. Road kill monitoring will occur as per section 7.4 during the operation for up to 5 years in operation. A new point has been added to section 7.4.2 stating "Regular communication will occur with local wildlife rehabilitation groups (WIRES, Friends of the Koala) so that any injured or killed Koalas would be brought to the attention of RMS. Any injuries or deaths of Koalas from wildlife care group records would be incorporated into annual reporting for this project."
g)	methodology for the ongoing monitoring of road kill, the species densities, distribution, habitat use and movement patterns, and the use of fauna crossings during construction and operation,	7		

	including the proposed timing, and duration of that monitoring			
h)	provision for the assessment of monitoring data to identify changes to habitat usage and whether this can be attributed to the project	7	Section 7.2 includes the following statement in reference to important populations (Wardell, Coolgardie and Bagotville; section 10 population, and south of the Richmond River from Rileys Hill to Broadwater National Park; section 9 population. “The low density populations of the Koala occurring in or near Sections 1-8 and 11 of the Upgrade are too sparse to warrant the intensive sampling that would be required to document the broader landscape effects of the Pacific Highway. Instead, population monitoring efforts will be focused in later Stages and in other Sections where the Koala is more abundant. **ACTION** Please include the provision for the assessment of monitoring data to identify changes to habitat usage for the Woombah/Iluka Koala population. **ACTION** Where appropriate, please provide contingency measures that would be implemented in the event of changes to habitat usage patterns, entities, distribution and movement patterns attributable to the construction or operation.	
i)	details of contingency measures that would be implemented in the event of changes to habitat usage patterns, entities, distribution, and movement patterns attributable to the construction or operation, based on adequate baseline data	7		A meeting between RMS, DoE and DP&E on 15 June 2015 confirmed that no additional Koala baseline surveys are required for Section 5 for the Woombah/Iluka Koala population. These issues, as they relate to the Koala populations in Sections 8/9 and 10, will be addressed in Update 3 (Version 4).
j)	mechanisms for the monitoring, review and amendment of these plans	1.3	**ACTION** Please include under Plan Updates that EPBC Project Approval Condition 8 requires the approval holder to develop a Koala Management Plan(s) pursuant to the requirements of NSW approval conditions D8 and D9 for each relevant stage. The Plan must minimise impacts to the Koala to the satisfaction of the Minister and must be submitted to the Minister for approval.	These two paragraphs have been inserted in section 1.3 under “Plan updates”.

			The relevant stage cannot commence until the KMP for that stage is approved by the Minister. And Condition 23 states that if the approval holder wishes to carry out any activity otherwise than in accordance with this plan, the approval holder must submit to the Department for the Minister's written approval, a revised version of this plan. The varied activity shall not commence until the Minister has approved the revised plan or agreement in writing.	
k)	provision for ongoing monitoring during operation, until such time as the use and effectiveness of mitigation measures can be demonstrated to have been achieved over a minimum of three successive monitoring periods		As above, please provide information regarding how Koala mortalities will be reported during the operational phase of the project. Will there be liaison with local wildlife care and rescue organisations in order to accurately report mortalities?	The method for monitoring Koala mortalities is described in section 7.4.2. Also, as indicated above, a new point has been added to section 7.4.2 stating "Regular communication will occur with local wildlife rehabilitation groups (WIRES, Friends of the Koala) so that any injured or killed Koalas would be brought to the attention of RMS. Any injuries or deaths of Koalas from wildlife care group records would be incorporated into annual reporting for this project."
l)	Provision for annual reporting of monitoring results to the Secretary and the EPA, DPI (Fisheries) and DoE, or as otherwise agreed by those agencies.	8	Table 8.1-4 outlines that annual reporting of monitoring results will occur and will be provided by ecologists and RMS.	
	In developing the Plans, the Applicant shall demonstrate to the satisfaction of the		Section 11, Appendix B provides the Expert Review comments of Professor Robert Close and how the recommendations have been addressed. All comments have led to a plan update.	

	Secretary and DoE, how the public authorities and expert reviewer recommendations provided for each draft plan in the documents listed in condition A2(c) have been addressed, including detailed justification of any variance from the recommendations of the expert reviewer of the management plans, including analysis of potential risk to the threatened species.		It is not clear if this review includes the update to include sections 3-8 and 11 or if this review was provided on Version 2.0 for sections 1-2. **ACTION** Please clarify which version of the plan was reviewed.	Professor Rob Close reviewed Version 1 of the Plan only which was included as part of the SPIR

NSW Environmental Protection Authority review of Koala Management Plan: Sections 1-8 (excluding Woombah population), and 11 (version 3) Comments – September 2015

Reference	EPA Comments	RMS Response
General	• References to OEH need to be replaced by EPA where appropriate (e.g. table 1.1) • There are numerous typo's throughout the document	Amended throughout
3.1 potential impacts associated with the project	The stated 885ha of impacted Koala habitat is seemingly incongruous with the stated section values. The total Koala habitat clearing of the sections included in this plan (all except sections 9 and 10) total 816.08ha. This indicates that only approx. 70ha of Koala habitat is to be cleared in sections 9 and 10? Please confirm this is the case.	That is correct – there is approximately 34 ha of Koala habitat that will be cleared in each of Sections 9 and 10.
3.1	Potential indirect impacts listed include vehicle strike. Vehicle strike appears more as a direct impact of upgrade construction.	In this context, refers to unmitigated or unintended impacts.
Table 3-2 Mitigation measures	A recommendation listed in this table is that clearing be undertaken outside of the breeding and dispersal seasons. Is this to be considered going forward, particularly in sections 9 and 10?	This was a recommendation from the AMBS study. This is not practical for Sections 9 and 10 to meet the current program. Some clearing would be required within the breeding season and will need to be managed accordingly. The clearing procedures RMS has developed are very successful in not harming fauna, including Koalas.
Table 4-1	The EPA suggests including a descriptive text for each type of fencing listed in this table. There are numerous 'types' of fencing and some confusion as to what they all are.	Section 4.3.1 has been updated to describe main fence types relevant to the Koala. Table 4-1 has also been updated.

5.3.3 (and 5.3.7)	What are the triggers to temporary fencing in the sections relating to this plan? The EPA supports the use of well-defined triggers, for example any Koala presence within project footprint be the trigger for temporary fencing.	Text in section 5.3.3 amended to read: "if a Koala is sighted before clearing within the highway footprint area, this will trigger action to erect temporary fencing to prevent this animal or other nearby animals from re-entering the area.
5.3.5	Koala specific, staged and sequential clearing. What are the triggers for these protocols relevant to this plan/sections 1-8 and 11. Is this to be standard in sections 9 and 10?	This is a standard clearing process for all RMS projects and will be the same for Section 9 and 10. Section 5.3.5 amended to include spotlighting as part of the pre-clearing protocol, and to indicate that temporary fencing will be erected at sites where a Koala is found within the clearing footprint and returned to adjacent habitat to prevent its re-entry into the construction zone. Further information on the clearing process will be included in the next update to the Plan (Version 4)
5.3.8	Fauna furniture is to be placed in both combined and dedicated fauna crossing structures, not only in dedicated structures as you have stated. Combined structures are not necessarily less relevant to fauna, just in an area that has a shared drainage need. Watercourses are often natural pathways for many fauna taxa. The usage of these structures is dependent upon linkages to habitat and adequate revegetation adjacent to the structures. In recognition of this the EPA supports a focus on achieving an effective linkage from structure to adjacent habitat as effectively and quickly as possible. In acknowledgement of this important feature the EPA encourages a more robust focus on this, in this and subsequent KMP.	Section 5.3.8 amended to read: "Fauna furniture will be placed within dedicated Koala underpasses and, where possible, in some combined fauna crossing structures".

	The EPA encourages that 2.4m high culverts have a maximum length of 40m and 3.3m high box culverts have a maximum of 50m length. These are benchmarks the EPA has endeavoured to see adopted on all RMS projects and are part of the MCoA (D9) for the omitted sections of this plan (sections 9 and 10).	RMS has adopted this for the specific Koala populations in MCoA D9 which are not relevant to this Koala Management Plan for Sections 1-8 and 11. Culverts longer than 40 m are required to be 3 m high rather than 3.3 m.
Section 7 Monitoring General	The EPA recognises the validity of the goals proposed for the monitoring program. These are primarily focussed upon the integrity of exclusion fencing and usage of connectivity structures. There are no measures included (or possible) to determine any population changes generally, or related specifically to construction, so any reference to actions resulting from observations of population declines etc should be removed from this plan as redundant (see 7.6). Obviously this is an integral feature of the future version incorporating sections 9 and 10, so will be a prominent feature then (as discussed in 7.2).	In Section 7.6, sentences referring to population monitoring and responses to population decline have been removed.
7.4.2	As well as the listed formal and informal methods to capture road kill data, is there opportunity to enlist public reporting of Koala roadkill, e.g. on RMS website or other. Every opportunity to capture road kill data should be taken, i.e. involving RMS staff where possible. Road kill provides an important trigger to repair fence, upgrade fence, or add to fence if not already there. In addition it supplements Koala population data in an area of documented low density.	A new point has been added to section 7.4.2 stating "Regular communication will occur with local wildlife rehabilitation groups (WIRES, Friends of the Koala) so that any injured or killed Koalas would be brought to the attention of RMS. Any injuries or deaths of Koalas from wildlife care group records would be incorporated into annual reporting for this project."
7.5.1 Responsibility.	Stated in this section is: " the responsibility for identifying appropriate triggers to undertake corrective actions, if needed, will be shared between RMS and its ecologists,…" The EPA have do not support this approach, as the triggers for corrective actions are at the heart of the monitoring program and EPA involvement in their selection is implicit in the MCoA (D8). Table 7-2 is general in detail, with specific triggers not included.	Section 7.5.1 amended to include clarification that monitoring is the responsibility of RMS. "RMS, through its contractor(s) which are employed to undertake the various aspects of monitoring for the project, will be responsible for the evaluation of the monitoring information collected. The last sentence in this section amended to read:

	The lack of background population data and associated low population in these sections of upgrade necessitate the need for hard, well defined triggers to corrective actions. Some examples follow: • What number of predators sighted in structures trigger the need for corrective actions • Stated in 7.3.2 is the examination of predator scats for Koala hair as a technique for detecting Koala presence near structures. In addition the EPA suggests this as an additional trigger for predator control. • What level of Koala presence, as represented by adjacent survey, coupled with a lack of Koala transit in the connectivity structure will constitute a trigger for further corrective actions? In light of these concerns the EPA is not satisfied that this section of the plan is adequate and seeks to be involved in the selection of the specifics of the monitoring criteria and triggers for corrective actions that are alluded to in this plan.	"The identification of appropriate triggers to undertake corrective actions will be the responsibility of RMS and its contractors, with RMS having the prime responsibility for enforcing any necessary changes as required by this Plan (Table 8-1)." Table 7-2 does provide specific triggers for actions. For example: "Any injury to an individual Koalas as a results of a vehicle strike…" "No breaches in fauna exclusion fencing…" "No Koala deaths…" Etc.
Table 8-1	Point 1.1 baseline Koala surveys and 1.2 Preparation of Contractor fencing strategy are stated as Contractor ecologist's responsibility whereas they are RMS responsibility. Is the terminology RMS strictly accurate here (and throughout document) where do Pacific Complete fit into this picture?	Point 1.1 and 1.2 amended to state that responsibility for these two actions is RMS/Pacific Complete. Pacific Complete will be responsible for construction requirements however RMS will be responsible for any post construction monitoring.

NSW Department of Planning and Environment review of Koala Management Plan: Sections 1-8 (excluding Woombah population), and 11 (version 3)

Comments - September 2015

Document		**Woolgoolga to Ballina Pacific Highway Upgrade Koala Management Plan**	
Version No.		Version 3.0 August 2015	
Agency Name		Department of Planning & Environment	
Date		9 September 2015	
Item	**Condition No/Report Reference**	**Department's Comment**	**RMS Response**
1.	Acronyms and abbreviations	• CMS – is the Construction Method Statement the same as an Environmental Work Method Statement (EWMS)? If so the same terminology should be used in all the management plans. • the project – the project is the area to which this management plan applies – sections 1 to 8 and 11 (excluding the Woombah Koala population).	CMS updated to EWMS in Acronyms and Table 8-1 The Project re-defined in Acronyms
2.	Section 1.4	Expert review – has Professor Jonathon Rhodes reviewed this Plan (version 3.0)? Please provide details of comments made and RMS response. Agency review – update to version 3.0 and consultation with agencies.	Independent review not required for MCoA D8. Only required for MCoA D9 for the specific Koala populations around Iluka/Woombah, Broadwater and Coolgardie/Bagotville, which is the next update to the Plan (Version 4).

3.	Section 2.2.3 and Table 2-3	It is concluded that Koalas occur at very low population densities in section 3. However, Figure 2-3 shows concentration of Koala Atlas sightings in the State Forests to the east and west of the project to the north of the Glenugie upgrade. Based on these records can the conclusion be made that Koalas exist at low densities in this area? Compared to other sections of the project this area has a relatively large number of recorded sightings. There would appear to be an east-west corridor along the State Forests which the project traverses.	Section 2.2.3 has been amended to read: "Many older (> 10 years) and few recent Bionet records of the Koala occur along the southern parts of Section 3, particularly within nearby Glenugie, Bom Bom and Devines State Forests which maintain good connectivity. Much of the northern part of this Section has been cleared for agriculture, with minimal vegetation connectivity between the east and the west. However, Pine Brush State Forest occurs in the east which maintains good north-south connectivity to larger tracts of native vegetation. It was concluded that Koalas now occur at low population densities along Section 3 of the Pacific Highway Upgrade, despite the existence of potentially suitable habitat." Text in Table 2-3 has also been revised.
4.	Section 3.5	Are Koalas in the east – west corridor in section 3 to the north of Glenugie likely to have reduced level of impact. Based on existing records there appears to be a concentration of Koalas in the state forests and good connectivity in this area is required to facilitate Koala movements.	Reduced impact in the sense that Koala population density is much less than in other sections (e.g. 9 and 10). Most of the Koala records in Section 3 are more than 10 years old. Many connectivity structures are proposed in Section 3 (see Table 5-1), including large bridges designed for Emus that can be used by Koalas

5.	Section 4.3.1	<u>Sections 3-8 and 11</u> The type of fencing in section 3 to the north of Genugie should be reviewed in light of large number of existing Koala sightings to the east and west of the highway alignment. In particular review the provision of floppy top Koala fencing in this area.	The fence proposed in this area is the general Mammal / Phascogale fauna fence with concrete posts (Table 4-1). Between chainages 35000 – 40000, this fence will have 600 mm wide galvanised metal sheeting fitted which will act as a significant barrier to Koalas.
6.	Table 4-1	The location of fauna fencing may need to be updated to be consistent with the Connectivity Strategy (CoA D2) for sections 3-11.	Noted
7.	Table 5-1	The table may require updating to be consistent with the Connectivity Strategy (CoA D2) for sections 3-11.	Noted
8.	Section 5.3.9	Is the detail of the landscape design for revegetation areas to be provided in the Urban Design and Landscape Plan required by CoA D20? The Plan should provide details of key landscaping and revegetation features.	Correct

NSW Department of Planning and Environment review of Koala Management Plan: Sections 3-8, and 11, including Mororo Cut Site

December 2015

Comment:	Response by RMS
The Management Plan should discuss impacts (if any) on proposed fauna crossing structures (in particular those targeting Koalas) to the north and south of the Mororo cutting).	The cutting extends 400 m north and south of the proposed extraction site therefore no fauna crossing structures are within cut areas.
Will the clearing of vegetation for the Mororo cutting affect north-south fauna movements?	Clearing of any vegetation for construction of the highway has the potential to affect fauna movements. Significant amounts of vegetation remain to North/East of the site including the Bundjalung National Park. No additional clearing is proposed beyond the approved project boundary.
Will permanent Koala fencing be installed following completion of the works?	Yes permanent fauna fencing will be progressively installed as part of the main construction works.
How will the site be rehabilitated/landscaped? Will Koala food tree species be planted as part of the landscaping of the site?	The rehabilitation and landscaping of the site will be subject to the Urban Design and Landscape Plan. Landscaping will aim to include endemic species which is most likely to include Koala food trees.
The Wave 1 CEMP (and sub-Plans) will need to be updated and approval sought from the Secretary to include the additional scope of the project, being the extraction of road material from the Mororo cutting, prior to the work commencing.	Noted, the CEMP will be updated accordingly to the additional scope of works.

NSW Environmental Protection Authority review of Koala Management Plan: Sections 3-8, and 11, including Mororo Cut Site December 2015

Comment:	Response by RMS
Further to our discussion with RMS, the EPA clarifies and amends our response to the proposed changes to the KMP update 2 in the following:	
• The EPA notes the reference to adhere to the clearing protocols detailed in the KMP for targeted Koala areas.	Correct
• With regard to the proposed fencing, the EPA advises that as the fencing is not proposed to be mirrored on the western side of the highway that the temporary fence either; 1) be adequately set back from the highway (by several metres), or 2) that the installation of escape mechanisms/drop-downs will be necessary. This stems from the possibility of animals crossing the existing highway from the west and being trapped on the road edge by the temporary fence. This situation has been observed to occur on other projects and needs to be addressed.	New Section 5.3.8 describes the proposed fencing arrangements at the Mororo cut (borrow) site. Prior to clearing, temporary Koala fencing will be erected on the eastern side of the existing Pacific Highway for a total length of 1.1km (chainage 97,500 to 98,600), which includes extending fencing 200 metres either side of the cut site. The temporary fencing is to protect any displaced Koalas from road strike as a result of the vegetation clearing process. This fence will be set back on the eastern side of the highway by several metres so that animals crossing the existing highway from the west will not be trapped on the road edge.
• The EPA seeks confirmation that the temporary fence will be 'floppy top' and adequately maintained.	RMS confirms that the temporary fence will be floppy top.

Department of the Environment review of Koala Management Plan: Sections 1-8, and 11, including Mororo Cut Site

Comments - December 2015

Comment:	Response by RMS
According to the Koala Management Plan (KMP), Version 3.0, the Woolgoolga to Ballina Project (2012/6394) will directly impact on 885 hectares of Koala habitat (Section 1-11). The additional information provided on 11 December 2015 states that the construction at the Mororo cut site will involve the removal of approximately 3.55 hectares of native vegetation. Is this impact additional to the 885 hectares outlined in section 3.1 of the version 3.0 KMP? Will this 3.55 hectare impact require offsets under the EPBC Act Biodiversity Offsets Policy?	No, this work is part of the approved project. No additional impacts on native vegetation are proposed. As above

Department of the Environment review of Koala Management Plan: Sections 1-11 (version 4.1)

Comments – 2 June 2016

Condition 8.	Department Notes/Comments	Approval Holder Comments
Section 4.1	**Action Item:** As per the Ballina Koala Plan (BKP) Addendum, could you include a table which lists the number of koala food trees that will be impacted In particular by the highway, Laws Point, Jali Land and Wardell Road. The BKP Addendum lists the number of trees that will be impacted, and it would be good to see this detail in the Koala Management Plan as well. In previous conversations with RMS officers, it has been indicated that sections of the route can be slightly 'tweaked' to reduce the number of vegetation impacted.	Through the detailed design process the alignment has had minor tweaks. This has resulted in a slight reduction in impact on Koala food trees around the Laws point area. Approximately 23% of the identified food trees will be removed for the road alignment. Table 4.2 lists the number of Koala food trees that will be impacted by the highway, at Laws Point and Wardell Road, as provided in the BKP addendum, now included in Section 4.1 of the KMP.
All of Section 5.0 6.3.4	Question: Can you clarify that the entire fencing (permanent fencing, temporary fencing or both) for section 10 will be installed prior to construction? If so, what level of clearing will need to take place in order to erect the fencing? Will relocation of koalas need to occur before the fencing is installed? (so they are not fenced within the alignment) What is the typical length for a clearing zone, and what length will the fencing extend past the point of clearing? The Department has concerns that koala will still be able to get in the clearing zones. **Action Item:** Could a diagram be included in the plan that shows exactly where the additional fencing will be?	Koala fencing will be installed on both sides of the highway within the three key population areas occupied by the Woombah-Iluka, Broadwater and Coolgardie-Bagotville Koala populations (i.e. Sections 5, 8-9 and 10). This fencing will not be installed prior to construction. Progressive installation of permanent Koala proof fencing in these areas will connect to the new connectivity structures as they are built. Temporary fencing will be erected along either side of the existing highway alignment that is adjacent/parallel to construction works and where clearing will occur within the locality of the key populations in Section 5, Section 8 (part), Section 9 and Section 10.This will be done to minimise the risk of Koalas being hit by highway traffic during vegetation clearing works. In addition, Koala fencing will be installed on other roads within Section 10, including on parts of the existing Pacific Highway north of Wardell to Coolgardie interchange and on parts of Wardell Road either side its crossing with the upgraded highway in Section 10, in accordance with the Ballina Koala Plan. This fencing will run parallel to these roads and installed prior to the commencement of mainline clearing for the road alignment. Figures showing the location of this fencing now provided in Section 6.

	In addition to the connectivity structures being placed adjacent to the proposed alignment, is there progress on developing connectivity structures on other sections of Wardell Road? The Department is concerned about the connectivity from the south – crossing over Wardell Road towards the North. In particular, the northern section of Wardell Road already has a barrier to the eastern side (old Pacific Highway). Where will the fencing on Wardell Road be placed? Next to the road, or behind residential properties? The Department supports the fencing proposed for the new alignment, however the details of fencing for Wardell Road and surrounding roads, including the old pacific highway, is lacking details.	The exact location of the fence in relation to the properties is still under investigation. Roads and Maritime will be consulting with landowners with the intention to install koala grids on drive ways and self-closing gates for pedestrian access where appropriate. Fauna escape structures will also be installed along the fence to allow koala to escape, if they become trapped within the fence. Pre-clearing surveys for Koalas will be undertaken prior any vegetation clearing, including for temporary and permanent fencing. RMS no longer propose to adopt the extended re-location program within Section 10, but rather leave the animals in situ and undertake a phased resource reduction ' approach. This would include progressively collaring of all habitat (feed and shelter) trees within the alignment prior to clearing to encourage resident animals to progressively move away from the area of their own accord, in conjunction with population monitoring in the vicinity of the sites, prior to, during and after clearing to monitor the effect of the works on any resident animals. Relevant details are included in Section 6.3.5. Roads and Maritime proposes to build a Connectivity structure on either side of the Wardell Rd overpass. A connectivity structure already exists on the existing highway south of the Coolgardie interchange and Roads and Maritime propose to build a connectivity structure on the northern side of the Coolgardie interchange. Roads and Maritime also propose to build an additional connectivity structure on Wardell Road, between the highway alignment and Wardell to provide connectivity within the Wardell Heath for Koalas and Potoroos. This is also shown on the Figures in Section 6. Further details on connectivity structures will be included in the Connectivity Strategy required by NSW CoA D1 and DoE Condition 13.

6.3.6 (Relocation Program)	**General Comments and questions:** The Department is concerned about the close proximity from where koalas will be removed, to proposed receiver sites. The Department has reviewed the Oxley highway relocation program and the success with a number of the measures. However this plan does not provide the same level of detail as the Oxley Highway plan. This KMP proposes more risk with close proximity of release with no detail on how the risk will be managed. Where are the receiver sites for the relocation (the plan does not provide a specific location) and are they adequate to accommodate large groups of new koalas? The Department notes that the receiver sites have not been assessed yet, so if these sites are not adequate for the relocation, are there additional sites that could be used? The plan will also need to provide justification for the proposed sites and why they are most suitable for relocation. There is frequent reference to “suitable” unoccupied habitat into which koalas will be relocated. The Department isn’t in a position to be confident in what constitutes as koala habitat unless there’s actually a koala in it. So the KMP should refer to *potential* suitable habitat and then act accordingly. The reasons why some vacant ‘suitable habitats aren’t be utilised. The Department is of the view that some koalas would need to be utilising a proposed area for relocation to ensure it is suitable. The Department believes there is a risk of fencing koalas in to a new area with what *looks* like good food trees but that really aren’t. This needs to have an adaptive element to say that they will monitor the animals for clear evidence that they are feeding, with an option to provide supplementary food if not.	All noted. Extended re-location program including capture and radio-tracking no longer proposed. Based on new information regarding the actual number of food trees to be removed within the alignment in Section 10 (only 12 of 70 within the Laws Point area and 14 of 43 within the Wardell Road area) it is understood that far fewer feed trees will be removed as a result of the proposal than previously indicated (45% of feed trees within the Laws Point area and 95% of feed trees within the Wardell Road area, S Phillips unpublished data). As such, given the risks to the animals associated with intervention (stress, sickness and mortality), it has been determined that it would be better not to intervene to move the animals, but rather leave the animals in situ and undertake a ‘soft clearing’ approach. This would include collaring of all habitat (feed and shelter) trees within the alignment prior to clearing to encourage resident animals to move away from the area of their own accord, in conjunction with population monitoring in the vicinity of the sites, prior to, during and after clearing to monitor the effect of the works on any resident animals. Relevant details are included in Section 6.3.5. Noted. Re-location no longer proposed. Noted. Re-location no longer proposed.

	If additional information and/or a greater level of certainty can't be provided, then the Department would consider that a number of the affected koalas could be lost. This outcome is not acceptable given the Ballina Koala Plan assures there will be no impact as a result from the highway construction. Given a relocation of this nature has not been attempted before; the Department would need a greater level of comfort that the receiver site is suitable, and the monitoring would provide additional level of comfort. The monitoring program alone for this relocation needs to be more robust. The tracking of these animals and the information collected will need to ensure that these koalas aren't going to be significantly impacted, and proof that the koalas are re establishing new home ranges. Will the koalas be closely monitored in their new environment to ensure they are feeding? And if not, whether supplementary feed will be provided. If the koalas are feeding in the new environment, then we could be more confident that they will be ok. Will the koalas be GPS tracked? What measures will be put in place if a radio tracked koala/s moves away from the site and dies as a result? The plan states that movements of all animals relocated in this program will be monitored for up to one year (the expected life of the radio-transmitter batteries) to determine whether each animal is healthy and has established a new home range. However the in the plan there is no indication of any response if they're found *not* to be healthy or have established a new home range. What adaptive measures will be put in place? Ideally, there should be some compulsion to make those data available to the Department and publicly available from the project website so that it can inform decisions on subsequent developments. Is it possible to provide more clarity in the plan regarding the 'release points'? Section 6.3.6 states that release points will be no longer than 100m away, however in reference to Attachment H; there is information that suggests koalas could be relocated up to 10km away from their original site.	Noted. Re-location no longer proposed. Noted. Re-location no longer proposed. Noted. Re-location no longer proposed. The Koalas come down the tree of their own accord when looking to move trees for food (usually daily) but may sometimes stay in the trees longer. The Koalas are unable to re-climb the tree as collars are attached to the tree to prevent this. The Koala enters the trap in an attempt to escape as it is the only opening in the plastic guard. Detail has been added in Section 6.3.6.

	At a minimum, the Department requests that all risks are detailed in a risk assessment. All the risks identified with this relocation program would need to documented with the relevant mitigation measures. Could the permanent fencing be put in place after the koalas are relocated, and before construction? The “corflute” method doesn’t detail the process in which the koala is brought to ground level. It is difficult to presume that a koala will come down and then not simply re-climb the tree once it sees it has no option. This is not a problem, but should be provided for the sake of completeness/transparency. In line with the Department’s policy statement on translocation of threatened species, unless it can be shown that there is a high degree of certainty that a translocation will be successful in contributing to the long term conservation of the species or community, a proposal for translocation associated with an action will be unlikely to be approved. Until this relocation strategy is supported by the relevant state agency, (OEH, EPA and DPE) the Department will not approve this plan. The Department will also need to consult on a more refined version of this plan to ensure every risk has been thought out.	Noted. Re-location no longer proposed.
8.0	**Monitoring program** The Department would like to see the plan amended to include baseline figures of current mortalities in the surrounding area (based on Dr Phillips surveys) and records of koala road strikes to create a starting figure by which the following years of monitoring look to decrease that figure. For example on average, in 2015 it was estimated that there were around 10 koala mortalities. Once the fencing is erected on surrounding roads, could this data be looked at again to see if a reduction in mortalities has been achieved? Is annual rate of mortality easily accessed from Friends of the koala or council?	Noted. Have included number, locations, and rates of vehicle-strike at known hotspots as identified in Koala demographic study for PVA by Biolink 2015. This information will be used in annual reporting to see if numbers have gone up/down and thus assess efficacy of fencing mitigation measures. Section 8.4.2. See above.

Table 7.2	The Department would support any strategy that presents a current/average number of koala mortalities to be used as a starting level of mortalities and one of the main objectives of the KMP is to reduce that number after fencing has been put in place. This potential reduction should be consistent every year for the life of the monitoring program. The reason is that the Department needs to see a reduction in the rate of current road strikes within the subject area. If there is any other way to prove that 4 – 8 koalas will actually be saved, then please provide that information. The performance indicators is this table sets out the main goals and measures, however it is unclear how the separate measures specific to section is managed. Is it possible to create a separate table of Performance Indicators and corrective actions for those measures that are critical for the Section 10, and the measures that are linked to the BKP?	The reduction in road mortality of 4-8 individuals is very difficult to monitor directly, although the Plan will require data collected by Friends of the Koala and WIRES to be analysed to estimate Koala deaths on surrounding roads to the Project compared with current roadkill numbers. The current road mortalities on Wardell Road and Pacific Hwy have been estimated based on roadkill data from Lismore Friends of the Koala. In addition to the roadkill data, the PVA scenario against which population estimates will be compared takes into consideration mortality of 4 koalas per year, so if the population estimate is equal to or above that predicted by the PVA then the mitigation measures will be assumed to have been effective. Noted. This Table relates to main goals, performance indicators/measures and corrective actions for the duration of *operation* of the upgrade. As identified in Table 7.2 – this is largely dependant on outcomes of the detailed monitoring program, described in Section 8. Have included words to clarify this.
Section 8.2.1	The plan does not clearly distinguish the additional monitoring to be undertaken under section 10. The Department understands the rationale behind the power analysis and the level of monitoring that is feasible over the 15 year period. However there are some elements such as the relocation program that will need more monitoring to ensure success. Is it possible for this section to delineate between the necessary monitoring with specific of the management measures such as the relocation program?	Additional monitoring to be undertaken within Section 10 is described in Section 8.2 – Monitoring. Note relocation program no longer proposed.
Section 8.3.2	Will the fencing, population monitoring, revegetation monitoring be done at the same time?	Monitoring of road mortality, fencing, underpasses and the population will co-incide in Spring, although each of these activities will be monitored for different time periods and some bi-annually. Details of timing of each monitoring activity provided in Section 8.2, 8.3, 8.4 and 8.5 and summarised in Table 9-1.

	The monitoring of connectivity structure usage, i.e. analysis and revision of motion sensor cameras will be done twice per year in conjunction with other population monitoring?	Connectivity structure monitoring will occur in Spring/summer annually. Population monitoring will occur bi-annually in Spring and also Autumn (see Table 9-1).
Section 8.4	The Department supports the need for genetics testing of faecal pellets to inform future gene flow of the population. Could the plan provide more details on how this will be carried out, and provide information on how the results will be evaluated? Also the KMP needs to provide a commitment to providing the results to the Department for consideration.	Genetic testing of faecal pellets has been included in conjunction with the population monitoring to support monitoring of Koala use of the connectivity structures and also provide additional estimates of population size. Faecal pellets will be collected during the 6 monthly population surveys across the study area and analysed at year 1 and then also at year 10 to determine population estimates but also breeding and movement across the road. Details are included in Section 8.2.2
		RMS will include road mortality monitoring along the additional areas to be fenced – Wardell Road and the existing Highway. These results will be included in an annual report as stated in Section 8.4.2.
Section 8.5	Road mortality monitoring – the Department requests that monitoring of surrounding roads, such as Wardell road be included in the plan. Also how will the results be presented for future reference?	Removed reference to 'sampling' for clarification.
Table 8.2		Adaptive management response will depend on review of other monitoring data. Clarification included in Section 8.5.
	It is unclear the delineation between revegetation monitoring periods and sampling periods.	
	This section of the plan states that if reveg areas do not contain koalas within 20% of the plots (by year 10 of the monitoring program) then adaptive management actions such as additional plating would need to be considered. The Department would request the potential adaptive measures be expanded and more detail provided.	Section 8.2.2 has been updated to provide more detail on survey methodology (derived from previous surveys, Ecosure 2015). Figures of survey locations also provided. Population assessments will be carried out every 6 months starting Spring 2017 to co-incide with the beginning of the construction period; to provide population estimates prior to operation of the road. The PVA has been re-run to determine approximate population numbers at years 5, 10 and 15 to enable assessment of changes to the population prior to Year 15. It must be noted that to **accurately** detect population declines prior to 15 years would require an unfeasible sampling intensity (monthly) due to the relatively small population size. The predicted population sizes generated by the PVA are guidelines only.

Table 9.1	The Department supports the need for evaluating future population trends, as per this table. The Department would request firm timing as to when population assessments will be carried out and expansion of how the work will be undertaken. The Department understands the requirement to undertake population assessments to enable population trends should be carried out 3-5 years into the project. The Department supports this layout to inform future management actions. Could this table be expanded to capture all monitoring years up to year 15? Noting there are some management activities that state ‘up to year 15’. Some measures such as population trend analysis, genetics testing of faecal pellets have not been included.	Table 9.1 has been expanded to include management actions/monitoring up to Yr15.

NSW Environment Protection Authority review of Koala Management Plan: Sections 1-11 (version 4.1)

Comments – 26 May 2016

Report Reference	EPA Comments	Response
General	This Management Plan is attendant upon approval of the Ballina Koala Plan, and the following EPA comments are on this draft document only, and may need to be revised if/when the BKP is approved as the content of that document approval may have ramifications on the content contained in this one (KMP vers 4).	Noted.
General	There are several sections contained within this current KMP (vers 4) that the EPA considers as underdeveloped, requiring further research and expert expansion to reach the standard essential for implementation as a management plan. This reflects primarily the unique management challenges relating to the federally significant Koala population in section 10 (and to a lesser extent sections 9,8 and 5). Management necessities associated with this population and the more comprehensive ministerial conditions of approval attached to it has required the expansion of management into a less traditional arena, outside the road corridor and into a regional context. The EPA is specifically referring to the relocation proposal (section 6.3.8) and the monitoring strategy (chapter 8). Specific issues relating to these sections are addressed below. The EPA supports the substantial refinement of these sections, potentially involving referral to/development of a separate document, or sub-plan of management (for e.g. for the proposed relocation strategy).	See below for responses.
3.4.1. (Adequacy of Survey for the) Iluka/Woombah population	It was agreed by DoE and DP&E on15 June 2015 to cease any further baseline population studies on the Iluka/Woombah koala population. In short this was, in part, based on the recognition that satisfactory information was available to inform the nature and placement of connectivity structures. Attendant upon this was a RMS commitment that this funding (for further survey work) was better diverted to ensuring that good connectivity was achieved for this recovering population. Currently there is only one structure available for Koalas in this area.	A new connectivity structure (2.4m x 2.4m x <40m RCBC) has been included into the design at chainage 96020 to provide for koala connectivity.

Report Reference	EPA Comments	Response
	The EPA would like assurance that discussions continue regarding the potential utilisation/enhancement of other available incidental structures in this area (e.g. Mororo creek and other structures as identified in the field) for koalas specifically, and other fauna generally, as crossing structures.	Roads and Maritime will continue to consult with EPA in regards to incidental connectivity structures in the vicinity of the Iluka Interchange. Although some incidental structures are available, the length, height and flood immunity of these structures may not be ideal for koalas. The site is constrained with available fill height, Iluka interchange, Banana Rd etc.
6.2 Main goals for management	Amend second dot point to read: No injuries to koalas during construction as a result of any construction related activity (which includes vehicular collision)	Amended accordingly.
6.3.4 Permanent Koala Exclusion Fencing (and 6.3.9)	The EPA supports the extension of koala exclusion fencing onto road kill hot spot areas (Wardell Rd, existing highway) but remains concerned about connectivity, particularly across Wardell Road. There are 2 structures currently proposed through Wardell Rd adjacent to the new alignment which is noted. However, the remainder of Wardell Road, from the upgrade to the township currently offers no connectivity options. This relates to Koalas but also to other fauna, most notably Potoroo in the heath areas north and south of Wardell Road. **The EPA cannot support this (essential) fencing of Wardell road until connectivity for koala and Potoroo are further addressed in the span between Wardell and the upgrade**.	RMS recognises the need for a connectivity structure between the township of Wardell and the upgrade to provide connectivity within the heath areas north and south of Wardell Road for the Koala and Potoroo. As such, RMS are including provisions for development of such a connectivity structure and the location of this structure is included in the management plan. Further details on connectivity structures will be included in the Connectivity Strategy required under NSW CoA D2.
6.3.8 relocation /translocation	The EPA has the following concerns and reservations relating to the proposed relocation/translocation proposal for section 10: The proposed relocation is an unprecedented action that has no previous history of experience to draw on. The suggested relocation of animals 1-1.5km away from their contemporary sites differs significantly in concept from translocation experiences such as the Oxley highway project quoted in the management plan.	Noted.

Report Reference	EPA Comments	Response
	The proposal is in a concept/ raw state only, with many unaddressed risks and a lack of necessary information. There is no detailed information regarding the number of animals involved, with home ranges directly compromised by the construction, as well as any details regarding the receival sites, including inherent dangers and habitat quality, patch isolation etc. In addition the actions and risks associated with the relocation process itself aren't adequately detailed and addressed. The EPA does not consider what is contained in the current MP regarding the proposed relocation of what seems may be up to 20 koalas (?) as adequate to provide definitive comment on. At the moment there is no evidence provided that expert opinion supports the notion that the risk to koalas is lesser under the proposed relocation than simply following standard procedure of relocating adjacent to the upgrade. The survival of these resident animals in these hot-spot cells is integral to satisfying RMS commitments, MCoA and PVA parameters. As such the EPA recognises the need to provide robust management of these 2 hot spot areas, however the EPA believes that not enough detail is presented and not enough work, involving species experts, has been done to determine the most robust approach to successfully ensure the persistence of these koalas, **and is unable to support the proposed relocation procedure in section 10 at this time**.	Based on new information regarding the actual number of food trees to be removed within the alignment (only 12 of 70 within the Laws Point area and 14 of 43 within the Wardell Road area) it is understood that far fewer feed trees will be removed as a result of the proposal than previously indicated (45% of feed trees within the Laws Point area and 95% of feed trees within the Wardell Road area, S Phillips unpublished data). As such, given the risks to the animals associated with intervention (stress, sickness and mortality), it has been determined that it would be better not to intervene to move the animals, but rather leave the animals in situ and undertake a phased resource reduction approach. This would include progressively collaring of all habitat (feed and shelter) trees within the alignment prior to clearing to encourage resident animals to progressively move away from the area of their own accord, in conjunction with population monitoring in the vicinity of the sites, prior to, during and after clearing to monitor the effect of the works on any resident animals. Relevant details are included in Section 6.3.5.
6.3.9 Fauna crossing structures	The following statement from the KMP relates to connectivity structures in section 10:	Noted and re-worded accordingly.

Report Reference	EPA Comments	Response
	"Based on the population modelling requirements in the PVA this number was considered sufficient to allow for the movement/dispersal of Koalas throughout Section 10 " This statement is ambiguous and should be removed or altered. It is suggesting that the PVA supports the number of structures as adequate, which is not true. The adequacy of the connectivity structures (number of and function) was an assumption inputted into the PVA and not a conclusion of the PVA. The assumption was that this number of structures is likely to provide some measure of connectivity ranging between 40% and 80% (as discussed in the Oct 2015 PVA workshop). The PVA actually assumed it as between 40-100% connectivity, which was done for other reasons, but the important point is that this figure of 26 structures is an assumption not a (mitigation) conclusion of the PVA as suggested in the KMP text.	
General discussion regarding stated goals throughout the KMP.	The following commentary relates to 2 goals repeatedly stated throughout different sections of the text, both of which have emerged from the PVA conclusions. 1) Reduction in mortality of 4-8- animals/year. 2) Zero koala mortality due to construction activity in the pre-, construction and operational phases. Comments relating to these goals follow below:	See below.

Report Reference	EPA Comments	Response
	1) The reduction of mortality by 4-8 koalas is a significant and important goal that is intertwined with the PVA conclusions and MCoA. How will this be monitored? In addition, are the actions proposed in the KMP adequate to deliver this reduction in mortality? Are the current road mortalities on Wardell road and Pacific highway this high annually?, Because this and a restricted dog control program are the only avenues provided to achieve this over the entire population area. RMS need to provide some evidence supporting the possibility of achieving this reduction in mortality and the method this will be monitored and demonstrated.	The reduction in road mortality of 4-8 individuals is very difficult to monitor directly, although the Plan will require data collected by Friends of the Koala and WIRES to be analysed to estimate Koala deaths on surrounding roads to the Project compared with current roadkill numbers. The current road mortalities on Wardell Road and Pacific Hwy have been estimated based on roadkill data from Lismore Friends of the Koala. In addition to the roadkill data, the PVA scenario against which population estimates will be compared takes into consideration mortality of 4 koalas per year, so if the population estimate is equal to or above that predicted then the mitigation measures will be assumed to have been effective.
	2) Zero koala mortality is essential if the goal of 4-8 less mortalities a year (as above) are to be achieved as well as a raft of other commitments. If zero mortality is not achieved the EPA suggests this will trigger actions above those suggested as corrective actions in tables 7-2, etc in the plan, and these need to be explored more fully in the context of the PVA, and further mitigation actions.	Noted. If a Koala is found to have died as a result of the project (zero mortality not achieved) then RMS will undertake further investigations into additional mitigation measures (depending on the causes of mortality) including installing additional fencing on other Koala hotspot areas, including koala-proof fencing portions of the Bruxner Highway if required. This additional corrective action has been included in Table 8.2 and Section 8.7.
7.3.3 Predator Control	The EPA support the development of a landscape based approach to predator control to be built onto what occurs on RMS offset properties and revegetation lands. This may be as a co-ordinator or seed money for LLS/local council/DPI involvement. To achieve the target of a 4-8 reduction in koala mortality per annum as stated will necessarily involve an ongoing reduction in dog kills, in addition to side road fencing as proposed.	The lead agency for dog control is NSW Local Land Services.

Report Reference	EPA Comments	Response
		It is recognised that RMS is a significant landholder in the region and is committed to dog control at a local and regional level. RMS is intends to work with LLS/local council/DPI once the KMP is approved to collaborate on landscape level dog control programs where possible.
Chapter 8 Monitoring	These comments relate to koala population monitoring in sections 8-9 and 10: 15 years is too long a time frame before some kind of review regarding the fate of these populations must occur. The EPA supports the long term monitoring as proposed, and recognises that it will be necessary and very valuable. However there should be a review conducted within a 5 year time frame; which by collating all facets of the monitoring (culverts/road mortality/population etc as well as any available non RMS/ council KPOM data) will be able to inform as to the trajectory of the local Ballina and Broadwater koala populations. Associated with this will be the need to build in triggers for corrective actions, as per MCoA. It is important to note that the amount of population data collected by the 5 year mark will be approximately 10 times the amount that went into the PVA, that forms the basis of this KMP version 4 and any federal approval, and should be adequate to provide the basis for review.	The monitoring program has been amended to allow for review of Koala population estimates at 5, 10 and 15 years. It must be noted that the power (confidence) in our ability to detect change in the population at these earlier time intervals is lower than at 15 years, however, the projected population estimates and associated confidence intervals may be used as a guide to assess changes in the population relative to the PVA redictions. As indicated, all facets of the monitoring (roadkill, use of crossing structures and re-veg areas) will be reviewed at this time also to inform the results of the population assessment. Details on this process are described in Section 8.2 and Table 8.2

Report Reference	EPA Comments	Response
General	The EPA notes the absence of regional collaboration in the development and proposed implementation of this KMP as it relates to the important koala population in section 10. Due to the unique and comprehensive nature of the proposed actions and mitigations contained in this plan the EPA encourages inclusion and input from Ballina council at least. There is a Ballina Shire Koala Management Strategy that may provide a source of supplementary information and possible avenues of mitigation actions. As the proposed mitigation efforts necessarily exceed the usual road based focus in section 10, to facilitate a regional affect on the Koala population, it seems remiss not to involve regional managers to ensure successful outcomes are achieved. In addition the proposed side road fencing on Wardell Road at least will involve council management in the long term?	As noted above, once the KMP is approved, RMS intends to consult with Local Council regarding Koala management issues including dog control and implementation of additional fencing/signage/mitigation strategies on local council owned land/roads if required.

NSW Department of Planning and Environment review of Koala Management Plan: Sections 1-11 (version 4.1)

Comments – 27 May 2016

Document	**Woolgoolga to Ballina Pacific Highway Upgrade Koala Management Plan Sections 3-11**
Version No.	Version 4.0 April 2016
Agency Name	Department of Planning & Environment
Date	27 May 2016

Item	Condition No/Report Reference	Department's Comment	RMS Response
9.	Chapter 2.1	Add information about Stage 2 following paragraph 4. Does not have to be detailed – relevant sections/portions.	Information about Stage 2 now included in Section 2.1.
10	Chapter 2.2	Paragraphs 3 and 4 refer to "important population" in the guidelines for assessments in the Commonwealth's Interim Koala Referral Advice. What is an important population as described in the referral advice. Paragraph 5 states the DoE significant impact guidelines include generic assessment criteria that refer to important populations. It goes on to state that important populations has not been used in the koala referral guidelines. Please clarify paragraphs 3-4 and 5 in relation to important populations.	DoE has general assessment guidelines for all threatened species (Significant Impact Guidelines 1.1 http://www.environment.gov.au/system/files/resources/42f84df4-720b-4dcf-b262-48679a3aba58/files/nes-guidelines_1.pdf) and specific guidelines for certain species such as the koala . https://www.environment.gov.au/system/files/resources/dc2ae592-ff25-4e2c-ada3-843e4dea1dae/files/koala-referral-guidelines.pdf Where specific guidelines exist they provide more detailed guidance on DoE assessment requirements.

			The general assessment guidelines include reference to considering whether proposal will impact on an important population of a species. For vulnerable species, "an 'important population' is a population that is necessary for a species' long-term survival and recovery. This may include populations identified as such in recovery plans, and/or that are: • key source populations either for breeding or dispersal • populations that are necessary for maintaining genetic diversity, and/or • populations that are near the limit of the species range." In June 2012, DoE released interim koala referral guidelines. https://www.environment.gov.au/resource/interim-koala-referral-advice-proponents These guidelines required that "If you identify a koala population in your study area, you need to determine whether it is an important population. Until important populations can be adequately identified through consultation with koala experts, apply the criteria for an important population of a species outlined in Significant impact guidelines 1.1:" These were relevant guidelines that applied when the EIS assessments were undertaken.

			In revising its referral guidelines for koala in 2014, https://www.environment.gov.au/biodiversity/threatened/publications/epbc-act-referral-guidelines-vulnerable-koala DoE have moved away from the requirement to identify "important populations" noting that "The Department's Significant Impact Guidelines 1.1 include a number of generic significant impact assessment criteria that refer to 'important populations'. The concept of 'important populations' has not been used in these koala referral guidelines. Sufficient information was not available at the time of writing to adequately identify and separate the nature of any important populations throughout the range of the listed species. The guidelines now focus on habitat assessment and field survey and consideration of the severity of impacts and the likely success of mitigation as main consideration in determining significance of impacts. The KMP text has been drafted to reflect these current DoE referral guidelines.
11	Table 2-1	The approval requirement for CoAD8 (a) is addressed in Chapter 3 of the KMP not Chapter 2.	Amended accordingly
12	Chapter 2.3.1	The third paragraph states the responsibilities of implementation of the KMP are summarise din Chapter 8. Chapter 8 describes the monitoring program and does not mention implementation of the KMP.	Amended accordingly – implementation summarised in Chapter 9.
13	Chapter 2.3.2	Figure 2-1 illustrates the process followed for updating of the KMP. It is recommended that the Figure also show the process for updating of KMP Version 4.0 following monitoring of sections 9 and 10 populations and triggering of corrective actions, if required.	Process for updating KMP version 4 following 5 year review of population monitoring data included. Figure 2-1.

14	Chapters 3.2.1 to 3.2.11	These chapters describe by project section the potential koala habitat identified through vegetation assessments, the habitat quality, connectivity and survey effort and potential for suitable habitat. The information includes total area of mapped vegetation, including area already cleared. Please provide information on the area of vegetation that was assessed: • Is the vegetation assessed within the project boundary? • Vegetation already cleared – is this vegetation cleared for early works (utility adjustments, soft soil treatment, emu fencing). The description for section 10 (Chapter 3.2.10) states 220.54 ha of vegetation was assessed, which includes 116.09 ha of previously cleared land (more than half the total area of vegetation assessed). Please clarify this statement as construction in section 10 cannot commence until the KMP is approved. Cleared areas are also listed in Table 4-1.	Yes, the vegetation assessed was within the project boundary as stated in the first paragraph of Section 3.2 “The distribution of potential habitat for the Koala **throughout the footprint area of the Pacific Highway upgrade between Woolgoolga and Ballina** was assessed by means of vegetation assessments etc…” ‘Vegetation already cleared’ relates to land that was cleared (for grazing or other purposes) prior to the project. Have replaced ‘already cleared’ with ‘previously cleared’ to provide clarification. Have also added definition of ‘cleared land’ into Section 3.2
15	Chapter 3.4.2	Paragraph 5 – the project in section 9 includes an alignment along the existing footprint through Broadwater National Park and a greenfields alignment bypassing to the east of Broadwater to the Richmond River. The upgrade in section 9 is not largely within the existing highway footprint.	Agreed. Replaced “largely” with “partially”.

16	Chapter 4.1	Paragraph 2 states the koala habitat score methodology is in accordance with the EPBC Environmental offsets policy and offsets assessment guide in Part 2.2 of the Plan. Chapter 2.2 of the KMP does not make reference to the koala habitat score methodology.	Agreed. It is referred to in Section 3.2 – amended accordingly.
17	Table 4-2	Exclusion fencing is proposed along Wardell Road and the existing highway. The KMP must consider property access and include measures to restrict koala movements through property access (driveways, gates, etc.).	Roads and Maritime will be consulting with landowners with the intention to install koala grids on drive ways and self-closing gates for pedestrian access where appropriate. Fauna escape structures will also be installed along the fence to allow koala to escape, if they become trapped within the fence.
18	Chapter 4.5	This chapter specifically refers to the section 10 Koala population. This chapter should discuss the mitigation measures for sections 5 and 8-9, the other key populations, and other sections with low density Koala populations.	It was considered that a separate chapter was required to provide the background and results of the PVA for the Koalas in Section 10 as this required the development of specific and substantial management measures within that Section, that were not applicable to the other 'key population' sections. Additional mitigation measures for the other key populations (Section 5, 8-9) are detailed within Sections 5.3, 6.3 and 7.3.
19	Chapter 5.1	Does pre-construction include geotechnical investigation and utility adjustments/relocation and property access relocation? Potential impacts including vehicle movements through vegetated areas, establishment of access tracks and pads, vegetation clearing and construction noise. These activities must be discussed in Chapter 5	Have included geotechnical investigation, utility adjustments/relocation and property access adjustments within potential impacts. Also included discussion on vegetation clearing (associated with access tracks and ancillary areas) in Section 5.3.4. Detailed information on impacts and mitigation measures to meet goals detailed in Table 5.2. Management of dust and noise also addressed in Section 6 and summarised in Table 6.2.

20	Chapter 6.3.3	Temporary fencing must be provided along both sides of Wardell Road adjacent/parallel to construction works, in addition to the existing highway. It is proposed to keep the temporary fencing in place for three months following clearing. Should the temporary fencing along these roads be kept for the duration of construction or until permanent fencing is erected along Wardell Road and the existing highway.	Permanent fencing will be installed on parts of Wardell Rd and existing highway prior to construction. Where works are undertaken adjacent/parallel to these roads temporary fencing will be required and will be in place until permanent fencing can be constructed.
21	Chapter 6	The timing of Koala relocation and commencement of clearing is unclear. In section 10, in particular, the length of time between capture and relocation of Koalas and commencement of clearing for both the temporary/permanent fence and mainline clearing is not specified. Is mainline clearing expected to commence soon after the exclusion fencing has been erected? Details of the hold points after Koala relocation, erection of fauna fencing, Koala surveys of the alignment prior to mainline clearing should be provided.	Based on new information regarding the actual number of food trees to be removed within the alignment (only 12 of 70 within the Laws Point area and 14 of 43 within the Wardell Road area) it is understood that far fewer feed trees will be removed as a result of the proposal than previously indicated (45% of feed trees within the Laws Point area and 95% of feed trees within the Wardell Road area, S Phillips unpublished data). As such, given the risks to the animals associated with intervention (stress, sickness and mortality) it has been determined that it would be better not to intervene to move the animals, but rather leave the animals in situ and undertake a phased resource reduction approach. This would include collaring of all habitat (feed and shelter) trees within the alignment to encourage resident animals to move away from the area of their own accord, in conjunction with population monitoring in the vicinity of the sites, prior to, during and after clearing to determine and monitor the effect of the works on any resident animals. Relevant details are now included in Section 6.3.5.
22	Chapter 6.3.6	Koalas once relocated will be kept as a group. Food trees will be fenced to prevent animals returning to their place of capture. Will one Koala be placed in a group of food trees or will several be placed in an enclosure and free to move around and interact within the enclosure? Is 2-3 weeks sufficient time for animals to adapt to the new habitat prior to the removal of fences?	Re-location of animals within Section 10 no longer proposed. See above.

		The Department considers that further discussion and justification of the relocation strategy is require, in particular its objectives, methodology, appropriateness and success. The need for the relocation program should be assessed against the permanent fencing of the construction corridor and the relocation of Koalas within the alignment to outside the fence should be considered.	
23	Chapter 6.3.12	Ancillary facility sites (including Lumleys Lane borrow site) and associated access roads must be fenced with Koala proof fencing.	Lumleys Lane borrow site will be accessed off Wardell Road, which will have permanent Koala-proof fencing. No further Koala proof fencing is proposed around the ancillary sites given they are sited in cleared/disturbed areas and there is considered to be a low likelihood of Koalas entering these areas. Additionally, all personnel will be inducted regarding no-go zones and restricted to speed limits as per the CEMP (Table 6.2).
24	Table 6-2	Add capture and relocation of Koalas in temporary enclosure as a management measure.	No longer relevant.
25	Table 7-2	Add provision of fauna fencing along Wardell Road and the existing Pacific Highway and connectivity structures along Wardell Road as mitigation measures. The Department supports this measure however, details of the proposed connectivity structures must be provided and whether other roads such as Old Bagotville Road should also be fenced.	Information added to Table 7.2. Roads and Maritime proposes to build a Connectivity structure on either side of the Wardell Rd overpass. A connectivity structure already exists on the existing highway south of the Coolgardie interchange and Roads and Maritime propose to build a connectivity structure on the northern side of the Coolgardie interchange. Roads and Maritime also propose to build an additional connectivity structure on Wardell Road, between the highway alignment and Wardell to provide connectivity within the Wardell Heath for Koalas and Potoroos. Details of location of connectivity structures on Wardell Rd and existing highway provided in Section 6.3.9.

			RMS do not propose to fence Old Bagotville Road at this stage but will work with Local Council regarding further opportunities to mitigate potential impacts to Koalas within this area e.g. establishment of vehicle activated messaging signs indicating presence of Koalas in the area and potential speed restrictions.
26	Chapter 8.2	The Department supports monitoring over an extended period to determine changes to the Broadwater and Bagotville/Coolgardie Koala populations. It is proposed that 6-monthly surveys would be undertaken, however more frequent (monthly) monitoring should be considered if Koala deaths through vehicle strike or predation become apparent/increase to determine if additional mitigation measures are required. Review after 15 years is considered to be too long a timeframe to implement corrective actions. Further details of the population monitoring methodology must be provided, including the methodology to determine population numbers/density.	The monitoring program has been amended to allow for review of Koala population estimates at 5, 10 and 15 years. Monitoring of roadkill, use of crossing structures and re-veg areas will provide information within a much shorter time frame that may trigger the need for further mitigative actions. The population estimates will be reviewed in light of the results of the monitoring of the roadkill, crossing structures and re-veg areas. If a Koala is found to have died as a result of the project then RMS will undertake further investigations into additional mitigation measures (depending on the causes of mortality) including installing additional fencing on other Koala hotspot areas, such as the Bruxner Highway if required. This additional corrective action has been included in Table 8.2 and Section 8.7. Further information regarding population survey methodology has been included in Section 8.2.2.

NSW Department of Planning and Environment review of Koala Management Plan: Sections 1-11 (version 4.3)

Comments – 21 July 2016

Document		**Woolgoolga to Ballina Pacific Highway Upgrade Koala Management Plan Sections 3-11**	
Version No.		Version 4.3 July 2016	
Agency Name		Department of Planning & Environment	
Date		21 July 2016	
Item	**Condition No/Report Reference**	**Department's Comment**	**RMS Response**
1.	Section 2.1	Detailed design of Stage 2 is underway and opportunities to re-use existing sections of the existing Pacific Highway is being explored. This would involve the re-use of the existing highway for the northbound or southbound carriageway of the upgraded highway. Sections under investigation include section 5 (CH88900 to CH96400) and section 6 (CH96400 to CH 105400). A key Koala culvert is proposed in section 5 at CH 96150. The KMP is silent on the provision of fauna crossing structures in sections of the highway to be re-used for the upgraded highway. It is acknowledged that the provision of fauna connectivity in Stage 2 would be subject to the final structures identified in the Connectivity Strategy required under condition D2. Notwithstanding, the Department seeks a commitment in the KMP that the provision of key Koala crossings (and other structures that provide connectivity for Koalas) in the re-use sections shall built as specified in Table 6-2, subject to the Connectivity Strategy, for both carriageways of the upgraded highway.	RMS can confirm that the culvert at Ch96150 is not within the re-use section. This culvert will be a new build with a new pavement construction. A commitment has been included in section 6.3.9 that any Targeted Koala Structures (identified with ticks in table 6-2) in the pavement re-use sections, shall be built as specified in Table 6-2, for both carriageways of the upgraded highway.

2.	Table 2-1	CoA D9(d)(vii) requires passages for Koalas under/over the existing highway (where the existing highway forms part of the SSI) to be provided and for service/local roads servicing over 100 vehicles per day. This requirement would apply to the re-use sections of the existing highway. The requirement for koala passage on local roads with over 100 vehicles per day would apply to Old Bagoville Road, identified as a hot spot for Koala mortality (see Chapter 4.5 Section 10 PVA results). No provision of Koala fencing or connectivity structures are proposed for Old Bagotville Road which is identified as a hot spot for Koala road mortality. The Department considers that this requirement has not been adequately addressed in the KMP.	In the Ballina Koala Plan, RMS has committed to undertake further work, such as fencing and installation of connectivity structures, at two known Koala hot-spots that occur on other roads that are adjacent to and interact with this Project (i.e. part of Wardell Road in the vicinity of the new highway, and part of the existing Pacific Highway north of Wardell to Coolgardie). The aim of these management measures is to achieve a reduction in Koala mortality in the order of 4-8 animals/year in an effort to arrest population decline as predicted by the PVA models. The annual average traffic count for Old Bagotville Road is approximately 100 vehicles per day or less. No additional fencing or connectivity structures are proposed for Old Bagotville Road.
3.	Table 2-1	CoA D9(e) specifies additional mitigation requirements should monitoring indicate the mitigation measures are ineffective. The KMP states that this requirement is addressed in Section 6.3.9. The Department does not consider that this requirement has been addressed in Chapter 6.3.9. Further information is required specifically addressing the requirement for additional structures at 500 metre intervals.	Through the development of the Plan, the connectivity structures have been determined in consultation with species experts and government agencies. These structures are considered to be appropriate for koala connectivity and therefore RMS does not propose to include additional structures every 500 metres.
4.	Chapter 4.1	This chapter discusses potential impacts, including the Koala hotspots in Section 10 (Wardell Road and Laws Point). Cross reference should be made to Figure 6-7 which shows the location of these two hotspots.	Chapter 4.1 updated to include cross-reference to Figure 6-7
5.	Table 4-3	Incorrect cross reference to Section 5.3.6 which should read Section 6.3.6.	Cross-reference updated to Section 6.3.6

6.	Chapter 4.5	The last paragraph on page 4-64 refers to Figure 4-1 (PVA population projections) and various scenarios (6 in total) that were modelled. This paragraph, currently is hard to understand and does not enlighten the reader as to the information that is being conveyed. The paragraph/Figure 4-1 needs to explain the 6 scenarios, how the population in 50 years (40 to 109) was calculated, and the selection of scenario 6 as the benchmark/goal for population monitoring.	The paragraph has been updated to include dot points for each scenario that describe the assumptions of each.
7.	Chapter 4.5	The specific goals for management of Koalas in section 10 are specified on page 4-66, including (3rd dot point) reducing Koala mortality by 4/year in terms of PVA scenario 6, which equates to 1.2% decline over 5 years, 13.7% over 10 years and 27.3% over 15 years. This goal also applies to construction (Chapter 6.2, 7th dot point), operation (Chapter 7.2, 4th dot point) and monitoring (Chapter 8.1, 3rd dot point of additional monitoring objectives for section 10). However, the relative decline specified for the latter two goals is different to the decline specified in Section 4.5. The discrepancy in the percentages quoted must be explained.	Percentages are correct on page 4-66 3rd dot point and section 8.1 3rd dot point. The 7th dot point in section 6.2 and 4th dot point in section 7.2 have been updated with the correct percentages.
8.	Chapter 6.3.4	It is stated a connectivity structure exists in the existing highway south of the Coolgardie interchange. The dimensions of this structure should be provided and the structure shown in the relevant figure (6-4, 6-5 or 6-6).	Figure 6-6 has been updated to indicate location. Section 6.3.4 has been updated to include the dimensions of the structure.
9.	Chapter 6.3.5	Table 6-1 shows the different phases of the proposed Phased Resource Reduction program with trees being collared over a period of 6 weeks prior to clearing. Ring barking of trees would also be undertaken during this period. Several matters are raised with this proposal: 1. Is 6 weeks sufficient period for ring barked trees to lose their foliage? 2. Are the trees that will be collared or ring barked the key food trees identified in Table 4-2?	All koala food trees and other koala shelter trees will be collared. As a trial 20% of the trees that already have collars on them will be ring barked to induce de-foliation. It was suggested that this be trialled to assess the rate of de-foliation and in an effort to stop the Koalas utilising these trees (Sean FitzGibbon *pers. comm.* 10 June 2016).

10	Chapter 6.3.7	Reference is made to the RTA's 2011 unexpected threatened species find procedure. The relevant procedure should be the unexpected find procedure in Appendix O of the approved Construction Flora and Fauna Management Plan. If the KMP's procedure is different then justification must be provided why the CFFMP is not relevant to the KMP.	The unexpected threatened species find procedure in the FFMP has been developed from the RTA's 2011 unexpected threatened species find procedure and are essentially the same procedure. This section has been updated in the KMP to refer to unexpected find procedure in Appendix O of the approved Construction Flora and Fauna Management Plan.
11	Chapter 6.3.9	The final connectivity structures are discussed in this chapter. However the KMP does not provide measures to allow Koalas (and other fauna) to cross the alignment during its construction. Temporary/permanent fauna exclusion fencing is to be provided for the full length of the upgrade. It is understood that connectivity structures are to be constructed early in the construction period to allow unimpeded fauna connectivity during the construction of the upgrade. The KMP is silent on measures to allow fauna connectivity during construction. The Department recommends that measures similar to those provided for the Coastal Emu during construction are implemented for the KMP. Exclusion fencing is erected during construction hours and removed when no construction is occurring (eg. nights, Sundays and public holidays).	As noted in Appendix D response to DoE comments June 2016:Koala fencing will be installed on both sides of the highway within the three key population areas occupied by the Woombah-Iluka, Broadwater and Coolgardie- Bagotville Koala populations (i.e. Sections 5, 8-9 and 10).This fencing will not be installed prior to construction. This will also provide the opportunity for dispersing koalas to move across the construction corridor during out of hours/night time. However, temporary and/or permanent koala fencing will be installed where the new works are adjacent to the existing Pacific Highway prior to clearing commencing. This will be done to minimise the risk of Koalas being hit by highway traffic during vegetation clearing works.

			Progressive installation of permanent Koala proof fencing on the new alignment in the three key koala population areas will connect to the new connectivity structures as they are built. Bridges in connectivity areas will be built as soon as possible in the construction to allow permanent fauna fencing to direct koalas to these structures. In addition, Koala fencing will be installed on other roads within Section 10, including on parts of the existing Pacific Highway north of Wardell to Coolgardie interchange and on parts of Wardell Road either side its crossing with the upgraded highway in Section 10, in accordance with the Ballina Koala Plan. This fencing will run parallel to these roads and installed prior to the commencement of mainline clearing for the road alignment. With regard to early construction of connectivity structures, a constructability review by Pacific Complete has indicated building the connectivity structures early requires significant access works, enabling works, clearing and earthworks similar to mainline construction works. In terms of early installation of temporary koala fencing within construction corridor, numerous construction access points are required into the construction corridor throughput the day which creates openings in the temporary fence and could potentially create issues for fauna trapped in the construction corridor.

			It was recognised that the risk to koalas within the construction corridor is low because koalas prefer to keep their distance from the construction activity at least during the day. History on Pacific Highway projects show that koala deaths within corridor have not been an issue. However, as per the Ballina Koala Plan, it is important that fencing of adjacent local roads and existing Pacific Highway between Wardell and Coolgardie is undertaken prior to clearing commencing to minimise road strike.
12	Chapter 8.3.2	The Department considers that population monitoring and scat sample collection should be undertaken in Section 5 for the Woombah Koala population, in addition to connectivity structure monitoring. This will provide evidence of the status of the Woombah population over the 15 year period. Population monitoring is scheduled to commence in Spring 2017. The Department considers that the commencement of monitoring should commence soon after approval of the KMP to provide baseline information for the existing populations.	As noted in section 3.4.1: Based on review of the available material regarding the potential impacts of the Upgrade, and consultation with the relevant regulatory authorities (DoE and DP&E, 15 June 2015), it was determined that, there was a low risk that the Woombah- Iluka and Ashby Koala population would be impacted by section 5 of the Woolgoolga to Ballina upgrade project. The review determined that no additional baseline Koala surveys were required for Section 5 for the Woombah- Iluka Koala populations. RMS does not propose to undertake and further population monitoring for the Woombah- Iluka population. As noted in section 8.4.1, RMS propose to undertake connectivity structure monitoring for the Koala structure located at chainage 96150 in Section 5. Koala faecal searches and searches for koala scratches on trees will also be undertaken in adjacent habitat (within 100m) of the connectivity structure.

Department of the Environment review of Koala Management Plan: Sections 1-11 (version 4.3)

Comments – 27 July 2016

Condition 8.	Department Notes/Comments	Approval Holder Comments
General comment	The Department understands that fencing of local roads such as Wardell Road and the existing Pacific Highway will occur before main line clearing of section 10 commences. This is aimed to reduce any risk of koalas moving away and being killed on surrounding local roads. The Department has consulted with EPA and DPE regarding the possibility for additional fencing on Old Bagotville Road. However the Department understands there are a number of issues with this request. Please provide any information that details the constraints of this exercise. The Department notes this area has very low traffic activity; however any measures to avoid road strikes in this area would be welcomed. Is there a possibility to work with council for signage, i.e. reduced speed limits, or koala signage?	Traffic volumes on Old Bagotville Rd adjacent to the project are very low<100 vehicles per day and do not warrant permanent fencing. Also important to note that fencing itself can have impacts in restricting ecological movements. However, to help avoid road strikes in this area during construction RMS will examine the feasibility of installing temporary fencing prior to mainline clearing taking into consideration public safety and clearing of native vegetation. This will be confirmed as part of the Connectivity Strategy in Section 10 required to be approved prior to construction commencing.
General comment	After consultation with the EPA, the Department notes the reasons why temporary fencing will not be erected during construction of section 10. Could the plan be updated to include these benefits of connectivity being maintained (during both construction and the phased resource reduction) and the measures in place that will ensure that when clearing is resumed at the beginning of each day that koalas that may have moved into the alignment will be safely moved on? (If this has been overlooked, please point out the relevant section that details this). The Department notes the process for capturing any koalas that will not move from a tree on its own accord, however the Department still has remaining concerns that koalas may be confused and stay close by to the clearing zones (especially near hot spots). Is this information captured in the monitoring section?	Refer previous response to DP&E comments. In terms of koalas staying close to clearing zone. The pre-clearing procedures outlined in the KMP(refer to Sections 6.3.6 and 6.3.7) address this concern ie RMS will still be undertaking pre-clearing surveys using experienced ecologists to ensure no koalas are harmed during clearing operations. The monitoring of the phased resource reduction program will also provide additional information on the numbers and proximity of Koalas adjacent to the alignment near the 'hot spots'.

Section 4.5	The information regarding the PVA and the predictions of population size will be estimated and monitored every 5 years (5, 10 and 15). While the Department accepts the power analysis and what is an appropriate (and feasible) amount of monitoring during the first 15 year period, is there a risk that any great decline between each 5 year intervals will be too long to detect any sharp declines? So how will the other monitoring events (detailed in Table 9-1) between each of these 5 year intervals detect any steep decline in the population?	Population monitoring will occur every year, twice a year and will be reported yearly. Large changes between individual years will be able to be detected through this method of monitoring. Specific performance targets every 5 years were selected as the statistical power of the results are more meaningful (i.e. more data to allow detection of statistically significant changes).
Chapter 4.5	After discussions with EPA and DPE, they are unclear what the 6 PVA scenarios referenced in the revised KMP and don't fully understand how the PVA ties in to the KMP, specifically for Section 10. Could RMS include more background on each of the 6 scenarios, i.e. Steve Phillips predictions, P Miller input and how the proposed scenario was developed? The Department understands the details, however for people who have not read the PVA may struggle to understand this section.	Refer previous response to DP&E. Section 4.5 has been updated to include dot points for each scenario that describe the assumptions of each.
Chapter 8.5	Are there any trigger points for road fatality monitoring? Whilst the Department accepts the monitoring proposed within the subject area/ habitat is robust – however once the highway is operational, and all fencing has been constructed, could there be additional monitoring of fences and fauna crossings within the first year? Just to clarify, the KMP proposes 6 monthly monitoring of fencing in the first year and every year after.	Through ongoing maintenance regime there will be capacity to detect koala road kills. RMS road crews drive the Pacific Highway on weekly basis and will record and notify Pacific Highway Office of any Koala road kills which would trigger need to review fencing and undertake inspection maintenance.
Chapter 8	Please ensure that any annual road kills are monitored in comparison to previous mortality data collected.	Section 8.5.2 already states that road kill data needs to compared to data collected prior to operation of the road to detect any changes in road kill numbers, although it does note that there are issues with doing this as the data has not been collected systematically.

Table 9-1	This table provides a good breakdown for each type of monitoring event over a period of 15 years. Although do these monitoring events represent 1 single monitoring event for that year? In most cases for example in the Operational Management Section of this table, the maintenance of fauna and exclusion fencing and crossing structures has an ‘X’ marked for year 1 of operation. Is it fair to say there should be 2 X to represent 6 monthly monitoring? 2 monitoring events for that year (happy to chat if this isn’t clear). This is just to be clear when monitoring events occur and the frequency (some monitoring events in this table actually do state ‘bi-annually, ‘on going’ etc, however some monitoring events are unclear in their frequency.	The table is intended as a summary of the monitoring plan, but does state the frequency of each monitoring procedure in the “Task” column, where relevant. Details of the timing and methodology for each monitoring procedure are provided in Section 8.

Appendix E Koala Pre-construction Surveys - Ecosure Report (2014)

Woolgoolga to Ballina Koala Preconstruction Surveys

Final Report
October 2014

ROADS AND MARITIME SERVICES

ecology / vegetation / wildlife / aquatic ecology / GIS

Executive summary

The Woolgoolga to Ballina Pacific Highway upgrade will result in a four-lane divided road extending approximately 155 kilometres which is divided into 11 sections. This upgrade will extend from north of Woolgoolga at the northern extent of the current Sapphire to Woolgoolga Pacific Highway upgrade, to south of Ballina at the southern extent of the recently completed Ballina bypass. Preconstruction koala surveys were required in project Sections 9 and 10 and at single sites in Sections 5 and 7. These surveys were necessary to confirm koala presence and activity, and identify connectivity hotspots critical for guiding mitigation measures such as connectivity strategies. Additionally, targeted surveys were important to confirm suitable locations for monitoring, including during construction and operation to determine the effectiveness of such mitigation measures.

The focal species of this project, the koala (*Phascolarctos cinereus*), is a folivorous arboreal marsupial largely restricted to forests containing their preferred food tree species. These preferred food trees species predominately comprise species of the genus *Eucalyptus* as a primary source, while other genera such as *Corymbia*, *Lophostemon* and *Melaleuca* may also be incorporated into the diet. In Queensland, New South Wales and the Australian Capital Territory, the koala is listed as vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999*. It is well documented that the key threats to koalas throughout its range are road mortality, habitat loss, dog attack and disease. Roads pose significant threat to koala populations due to habitat loss and fragmentation, as well as the high vulnerability of koalas to death from vehicle collisions. Koalas are also considered susceptible to low genetic diversity, and in a recent study of koalas in south-east Queensland, roads were found to be a key barrier to genetic flow. The impacts of roads may be reduced by implementing appropriate mitigation measures; however this will only be achievable with robust datasets illustrating koala habitat use and movements, as well as a good understanding of proven management measures.

Within the proposed road alignment, Section 10 will be traversing an area identified in the Ballina Shire Council koala habitat and population assessment report, and the Roads and Maritime Services Submissions/Preferred Infrastructure Report, as supporting an important koala population for *Environment Protection and Biodiversity Conservation Act 1999* purposes. There is evidence that some of this area has been sustaining resident koala populations for at least the last six consecutive koala generations (i.e. 35 – 40 years), with occasional records back to the 1900s. The area is also likely to have sustained the ancestral source population for both the Lismore Local Government Area to the west and the coastal lowland areas of the Byron Local Government Area to the north. The status of remaining populations inhabiting the Section 10 area remains uncertain. As with the majority of koala populations along the east coast, koalas in the Section 10 face threats to their long-term persistence from road mortality, habitat loss, dog attack and disease.

High density koala populations are known to exist in Section 9 in areas south of the Richmond River from Riley's Hill to Broadwater National Park. There is less known about koalas in Section 7; however knowledge of the area's fire history suggests a low probability of any large populations being present in the immediate vicinity. Specifically for Section 7, koala records are widespread throughout the Tabbimoble area from Bundjalung National Park and several state forests to the west. However, a lack of high density koala records near the project corridor suggests the area is unlikely to support an important population. Conversely, for Section 5 it is now known that three important sub-populations exist nearby at Iluka, Woombah and Ashby. It is also evident that the Iluka population is recovering, and that the northern bank of Clarence, comprising the Section 5 study area, is identified as the most likely link between this recovering population and that in the Woombah and Ashby areas. It is therefore important that potential structures at the Iluka interchange be considered to assist in recovery of koalas in the area.

Koala surveys involved a regularised grid-based application of the Spot Assessment Technique at 500 metre intervals throughout target areas in Sections 5, 7, 9 and 10. Supplementary sites were also surveyed by targeting known preferred koala food trees for the presence of scats. Data collected were used to further inform areas of habitat use by koalas, including two additional sites in Sections 8 and 11 that were not part of the original project scope. Evidence of koala activity varied between project sections, and included one positive site in Section 5, none in Section 7, one in Section 9, and six in Section 10. In addition, koala habitat use was confirmed at 24 supplementary sites. Five koalas were confirmed by Ecosure during field surveys, while eight anecdotal sightings were reported by local landholders and three by Roads and Maritime Services contractors.

Survey results indicate that a small resident aggregation of koalas is likely to be present in Section 5. Despite this, the lack of koala activity in all but one site indicates that koalas using this area are likely to be transient individuals dispersing between nearby important populations and/or due to a declining or low resident population. This pinch point in connectivity is considered critical to offer koala populations the best chance of long-term persistence in the area because it provides a link between a known recovering population at Iluka, and the Woombah and Ashby areas. The abundance of preferred koala food trees in the Section 5 study area also suggests that with appropriate management, this area could support a viable resident population, as well as serve as a critical dispersal corridor. Connectivity structures and exclusion fencing at the Iluka interchange will be essential to assist in recovery of the immediate and broader area.

Despite historical records, field surveys found no evidence of koalas in Section 7. This is likely due to the area's fire history, which suggests a low probability of any resident populations being present in the immediate vicinity. Considering the high availability of contiguous koala habitat throughout Section 7, koalas may still be present, albeit very infrequently. Management actions, such as structures and fencing will still be important in the area, but more so for other fauna species currently occupying contiguous forest areas surrounding the proposed road alignment.

A recent koala record prompted further surveys in fragmented habitat in Section 8. Consequently, supplementary sites indicate that this area is regularly used by koalas and that it is likely to be a critical pinch-point in the link between known koala populations to the north at Rileys Hill and Broadwater, and those to the south around Doonbah. This is particularly critical given the unsuitable coastal heathland habitat to the east in the

Broadwater National Park, and cleared agricultural land and the Richmond River further to the west. The current location of the road alignment means that habitat will remain on both sides. Suitable habitat that will remain on the eastern side of the proposed road alignment will be largely restricted to the fringes of the Broadwater National Park, and is likely to provide very poor connectivity to the south. Conversely, while habitat on the western side of the proposed alignment is highly fragmented and contains area of cleared farmland, this area is likely to provide the primary link into contiguous habitat in Doonbah. This highlights the importance of providing safe connectivity to afford koala's access to sufficient food trees on both sides of the road, and suitable connectivity through the broader landscape.

In the southern portion of Section 9, field surveys indicate that habitat in the Broadwater National Park is dominated by heathland, and as such is largely unsuitable for koalas. Despite this, koalas were recorded in both the northern and southern extents of this area, directly adjacent to the Pacific Highway. It is clear that these pinch-points are critical for the dispersal of koalas throughout the landscape. The northern most location provides a link between known koala populations in Rileys Hill and habitat to the east of Broadwater, while the southern location provides the only link Rileys Hill and known koala populations to the south around Doonbah. Ensuring connectivity through these pinch-points will be essential in maintaining koala persistence in the region.

Survey results for the northern portion of Section 9, coupled with landholder observations, indicate that koalas use fragmented patches of koala habitat to the east of the Broadwater township. Although field surveys indicate that this area is unlikely to support a large resident population, it is considered a critical extension for dispersal and supplementary food provisions from areas to the west surrounding Rileys Hill. Owing to the fragmented nature of potential koala habitat through the area, it will be important for dispersal to maintain connectivity on either side of the proposed road alignment, as well as affording safe crossover via regular connectivity structures.

Section 10 currently contains a number of distinct resident koala aggregations, particularly in the southern and central portions. Current resident populations exist in two distinct large forest patches that are separated for the most part by farmland, which is the location of the proposed road alignment. Resident koala aggregations in these areas coincide with larger areas of intact potential koala habitat, as well as a high availability of preferred food trees. Survey results indicate that the proposed road alignment will bisect critical linkages between these resident koala aggregations. Given previous study findings in the 2013 Ballina Shire Council koala habitat and population assessment, and new survey results from this project, it is clear that to offer koala populations the best chance at long-term persistence in Section 10 will hinge upon maintaining connectivity through the landscape, and mitigation measures such as appropriately designed exclusion fencing to ensure there is no increase in vehicle collision mortalities.

Supplementary field survey results and landholder observations indicate that koalas regularly use the area just north of Section 10 (southern extent of Section 11), which is dominated by *Eucalyptus robusta*. Considering the stretch of poor quality habitat in the northern extent of Section 10, and known koala aggregations to the west in Coolgardie, this area is likely to form an important habitat extension for koalas in the region. In order to maintain available koala habitat in this area, connectivity structure/s will be important. In addition, extending exclusion fencing from Section 10 to areas dominated by agricultural land use just north of this area will assist to limit road mortalities.

Overall, survey results indicate that the distribution and abundance of koalas varies between project sections. As a result, the likely impact of the proposed road alignment on each project section should be treated in isolation. Therefore, the need to maintain connectivity and incorporate road mitigation measures should be considered on a section by section basis. One constant requirement in all sections is the need for monitoring, which will be important to determine the status of koala populations and the effectiveness of mitigation measures during construction and operation. Ultimately, koala populations will have the best chance of long-term persistence if these recommended road management measures are implemented and used effectively. A summary of the results of this study and subsequent recommendations are provided in the Table below.

Koala presence confirmed[1]	Connectivity area reference no.[2]	Roads and Maritime chainage reference	Connectivity structure/s	Koala habitat revegetation/restoration	Exclusion fencing	Monitoring[3]
Section 5						
✓	1	95300 – 96000	✓	✓	✓	✓ a,b
✕	2	96600 - 96800	✓	✕	✓	✕
Section 7						
✕	3	117500 – 118800	✓	✕	✓	✓ b
Section 8						
NA	4	134200 – 135000	✓	✓	✓	✓ a[4],b
✓	5	135900 – 137000	✓	✓	✓	✓ a[4],b
Section 9						
✓	6	137300 – 138100	✓	✓	✓	✓ a,b
✓	7	140100 – 140600	✓	✕	✓	✓ a,b
✓	8	143100 - 143500	✓	✓	✓	✓ a,b
✓	9	142000 – 142300	✓	✓	✓	✓ a,b
✓	10	144600- 145000	✓	✓	✓	✓ a,b
Section 10						
✓	11	146400 – 146900	✓	✕	✓	✓ a,b,c
✓	12	147200 – 147900	✓	✓	✓	✓ a,b,c
✓	13	148200 – 149100	✓	✓	✓	✓ a,b,c
✕	14	150000 – 150600	✓	✕	✓	✓ a,b,c
✓	15	151000 – 152100	✓	✓	✓	✓ a,b,c
✓	16	153000 – 153500	✓	✕	✓	✓ a,b,c
✕	17	153800 – 154300	✓	✓	✓	✓ a,b,c
✕	18	154500 – 155600	✓	✓	✓	✓ a,b,c
✕	19	155900 – 157400	✓	✓	✓	✓ a,b,c
Section 11						
✓	20	159000 – 159300	✓	✕	✓	✓ a[4],b,c

[1] Koala's confirmed either directly or indirectly within close proximity of connectivity structure during Ecosure surveys.

[2] Refer to Figures 5a-f and Table 12 for detailed information and locations of connectivity areas.

[3] Recommended monitoring type: (a) koala grid-based SAT surveys; (b) remote sensing cameras at connectivity structures; (c) health checks and satellite tracking pre, during, and post construction.

[4] No grid-based SAT surveys were conducted for Section 8 as this area was additional to the original project scope. As part of ongoing koala surveys it is recommended that the survey grid for Section 9 is extended to include Section 8 for ongoing monitoring. Section 11 could be monitored by extending the survey grid for Section 10.

Acknowledgements

We wish to thank Roads and Maritime Services for enabling us input into the scope of the study based on our Alternate Tender.

We would like to gratefully acknowledge Dr Steve Phillips (Biolink) for his initial technical and planning support in developing the survey design for the project, and the Ballina Shire Council for allowing the use of the prior survey data for areas of the project.

We would also like to thank all of the local landholders in the study area who provided access to their properties, as well as shared with us any additional koala records and/or information.

Acronyms and abbreviations

DBH	Diameter at breast height
EIS	Environmental Impact Statement
GPS	Global positioning system
Ha	Hectares
Km	Kilometres
LGA	Local Government Area
M	Metres
MCP	Minimum convex polygon
NSW	New South Wales
PKFT	Preferred koala food tree
QLD	Queensland
RG-bSAT	Regularised grid-based Spot Assessment Technique
SAT	Spot Assessment Technique
SPIR	Submissions/Preferred Infrastructure Report
UTM	Universal Transverse Mercator

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Introduction

1.1 Project background

The Woolgoolga to Ballina Pacific Highway upgrade will result in a four-lane divided road extending approximately 155 kilometres. This upgrade will extend from north of Woolgoolga at the northern extent of the Sapphire to Woolgoolga Pacific Highway upgrade, to south of Ballina at the southern extent of the Ballina bypass. Preconstruction koala surveys were required by Roads and Maritime Services (Roads and Maritime) for the entirety of project Sections 9 and 10 and target portions in Section 5 and 7. Targeted surveys in these project areas were required to confirm koala presence and activity, and to identify connectivity hotspots critical for guiding mitigation measures such as connectivity strategies. Additionally, targeted surveys were important to confirm suitable locations for monitoring, including during construction and operation to determine the effectiveness of such mitigation measures.

Recent koala surveys undertaken for the Environmental Impact Statement (EIS) (Roads and Maritime 2012) and Submissions/Preferred Infrastructure Report (SPIR) (Roads and Maritime 2013a) identified Sections 9 and 10 and single sites in Sections 5 as areas recording the greatest koala density (i.e. koala scats). The project alignment bisects preferred koala habitat, with the likely outcome being that these koala populations become isolated without mitigation measures. Connectivity structures will be important for maintaining movement in these areas, and where the proposed alignment follows the existing Pacific Highway, connectivity will be improved. The declining koala population in the study area is already subject to the continued impacts of habitat loss, vehicle strike and dog attack. Determining the best locations to retain connectivity for the koala must be paramount.

Section 10 will be traversing an area identified by a previous report as supporting an important koala population for *Environment Protection and Biodiversity Conservation Act 1999* (EPBC) purposes (Biolink 2013; Roads and Maritime 2013a). Specific areas in Section 10 where high density koala populations occur are around Wardell to Coolgardie and Bagotville (Roads and Maritime 2013a). The presence of resident koala populations either side of the proposed Stage 10 alignment has been confirmed by Biolink (2013). The resolution of this assessment was coarse (1000 metre and 500 metre sampling intervals) but is recent enough (2012/13) to inform relevant components of this current road project. The status of remaining populations inhabiting the Section 10 area remains uncertain, however, as with the majority of koala populations along the east coast, koalas in this area face threats to its population including road mortality, habitat loss, dog attack and disease. Section 10 of this project has previously been identified in Biolink (2013) as having potential for a significant impact on koala populations.

High density koala populations are known to exist in Section 9 in areas south of the Richmond River from Riley's Hill to Broadwater National Park (Roads and Maritime 2013a). There is less known about Section 7; however knowledge of the area's fire history suggests a low probability of any large populations being present in the immediate vicinity. Koala records are widespread throughout the Tabbimoble area from Bundjalung National Park and several state forests to the west. However, a lack of high density koala records near the project corridor suggests the area is unlikely to hold an important population (Roads and Maritime 2013b). Conversely, for Section 5, it is now known that three important sub-populations exist nearby at Iluka, Woombah and Ashby (CVC 2010). It is also evident that the Iluka population is recovering, and that the northern bank of Clarence is identified as the most likely link between this recovering population and that in the Woombah and Ashby areas (Phillips & Hopkins 2012).

1.2 The koala (*Phascolarctos cinereus*)

The koala (*Phascolarctos cinereus*) is an iconic Australian marsupial and as such has been the focus of nationwide survey effort (Phillips 1990), including state-wide surveys in New South Wales (NSW) and Queensland (QLD) (Kikkawa & Walter 1968; Gall 1978; Reed, Lunney & Walker 1990; Patterson 1996; Lunney et al. 2009). Analyses of historical koala records are increasingly being used to inform planning outcomes at the Local Government Area (LGA) level (Lunney et al. 1998; Biolink 2007; Phillips & Hopkins 2009; Ecosure 2013). In QLD, NSW and the Australian Capital Territory the koala was recently listed as vulnerable under the EPBC Act (Australian Government 2012).

The koala is a folivorous arboreal marsupial restricted to forests which contain their preferred food tree species (Lee & Martin 1988). Koalas exhibit strong preferences between individual trees species, with species of the genus *Eucalyptus* consumed as a primary source of food, while other genera such as *Corymbia*, *Lophostemon* and *Melaleuca* may also be incorporated into the diet as supplementary browse and/or utilised for other purposes (Lee & Martin 1988; Hindell & Lee 1990; Phillips 1990; Phillips, Callaghan & Thompson 2000; Phillips & Callaghan 2000). Specifically, the forest red gum (*Eucalyptus tereticornis*), swamp mahogany (*E. robusta*) and tallowwood (*E. microcorys)* and grey gum (*E. propinqua*) are recognised as preferred koala food trees (PKFTs) throughout the study area (Biolink 2013). Due to their highly specialised diet, food availability is thought to be a key determinant of high koala habitat quality (Moore & Foley 2000). High nutrient soils affecting palatability of the leaves (Reed et al. 1988), forest area and landscape configuration are also considered to be involved in the overall desirability of koala habitat (McAlpine et al. 2006).

Koalas are solitary animals with a highly defined social structure at the local aggregation level, with juveniles dispersing at around 18 to 36 months to ensure that a healthy social and mating system and food availability is sustained (Dique et al. 2004). Home range reflects the resource ability for required food, shelter and space for successful reproduction; hence an abundance of healthy large food and shelter trees would allow koalas to have smaller home ranges than would an area with fewer resources (Callaghan et al. 2011). Generally, the breeding and dispersal seasons for koalas are spring and summer (Martin & Handasyde 1999).

It is well documented that the key threats to koalas throughout its range are road mortality, habitat loss, dog attack and disease. Roads pose a significant threat to koala populations due to habitat loss and fragmentation, as well the high vulnerability of koalas to death from vehicle collisions (Canfield 1987; Backhouse & Crouch 1990; Kraschnefski, 1999; Dique et al. 2003; DECC 2008; Preece 2009). Koalas are also considered susceptible to low genetic diversity which may be exacerbated by road barriers (DECC 2008; AMBS 2011). In a recent study in south-east QLD, roads were found to be a key barrier to genetic flow in the koala population (Dudaniec et al. 2013). Ultimately, the impacts of roads may be reduced by implementing appropriate mitigation measures, which primarily include connectivity structures and exclusion fencing. Nonetheless, appropriate mitigation measures will only be achievable with robust datasets illustrating koala habitat use and movement corridors, as well as a good understanding of proven management measures. Recent investigations by Polak et al. (2014) also indicate that achieving very good road mitigation outcomes for koalas will be expensive and that a reduced investment in mitigation measures will likely result in a population decline which can be quite significant, especially in small populations.

1.3 Scope of works

The initial project scope proposed targeted surveys in Sections 5, 7, 9 and 10 to form a preconstruction baseline, and to identify connectivity hotspots critical for guiding mitigation measures such as connectivity strategies. Targeted surveys were also used to confirm suitable locations for monitoring, including during construction and operation to determine the effectiveness of such mitigation measures. As per Roads and Maritime's request, an area containing a recent koala record in the northern portion of Section 8 was assessed to determine if any connectivity structures or mitigation measure would be required. In addition, an area in the southern portion of Section 11 was surveyed for any evidence of koalas to identify potential nearby connectivity hotpots or monitoring locations that may be missed by only surveying to the extent of Section 10. The final scope of works for each project section included:

Sections 5

- Targeted koala surveys to assess koala presence and activity, and to develop (where possible) a population distribution model.
- Identifying critical linkage areas across the proposed footprint on the basis of existing vegetation cover, and the presence of any resident and/or nearby koala populations and likely movement patterns.
- Forming a preconstruction baseline and providing recommendations for connectivity strategies; including optimising the location of proposed structures with a view to maximising opportunities for utilisation.
- Confirming any suitable locations for monitoring.

Section 7

- Targeted koala surveys to assess koala presence and activity, and to develop (where possible) a population distribution model.
- Identifying critical linkage areas across the proposed footprint on the basis of existing vegetation cover and proximity of resident koala populations and likely movement patterns.

- Evaluating the potential utility and efficacy of proposed fauna structures.
- Forming a preconstruction baseline and providing recommendations for connectivity strategies; including optimising the location of proposed structures, deleting proposed structures considered to be located in sub-optimal locations, and adding structures with a view to maximising opportunities for utilisation.
- Confirming any suitable locations for monitoring.

Section 8

- Targeted searches of known PKFTs in an area of recent koala sightings (as requested by Roads and Maritime), with the aim to confirm presence and identify additional areas for connectivity and mitigation strategies.
- Confirming any suitable locations for monitoring.

Section 9

- Targeted koala surveys to assess koala presence and activity, and to develop (where possible) a population distribution model.
- Identifying critical linkage areas across the proposed footprint on the basis of existing vegetation cover and proximity of resident koala populations and likely movement patterns.
- Evaluating the potential utility and efficacy of proposed fauna structures.
- Forming a preconstruction baseline and providing recommendations for connectivity strategies; including optimising the location of proposed structures, deleting proposed structures considered to be located in sub-optimal locations, and adding structures with a view to maximising opportunities for utilisation.
- Confirming any suitable locations for monitoring.

Section 10

- Improving the resolution of existing survey data (Biolink 2013) by augmenting it with finer-scale field survey sites at 500 metre and 250 metre intervals as required within the project alignment.
- Combining koala distribution and abundance from this current project with data collected for Ballina Shire Council (Biolink 2013) to develop a population distribution model.
- Identifying critical linkage areas across the proposed footprint on the basis of existing vegetation cover and proximity of resident koala populations and likely movement patterns.
- Evaluating the potential utility and efficacy of proposed fauna structures.
- Forming a preconstruction baseline and providing recommendations for connectivity strategies; including optimising the location of proposed structures, deleting proposed structures considered to be located in sub-optimal locations, and adding structures with a view to maximising opportunities for utilisation.

- Confirming any suitable locations for monitoring.

Section 11

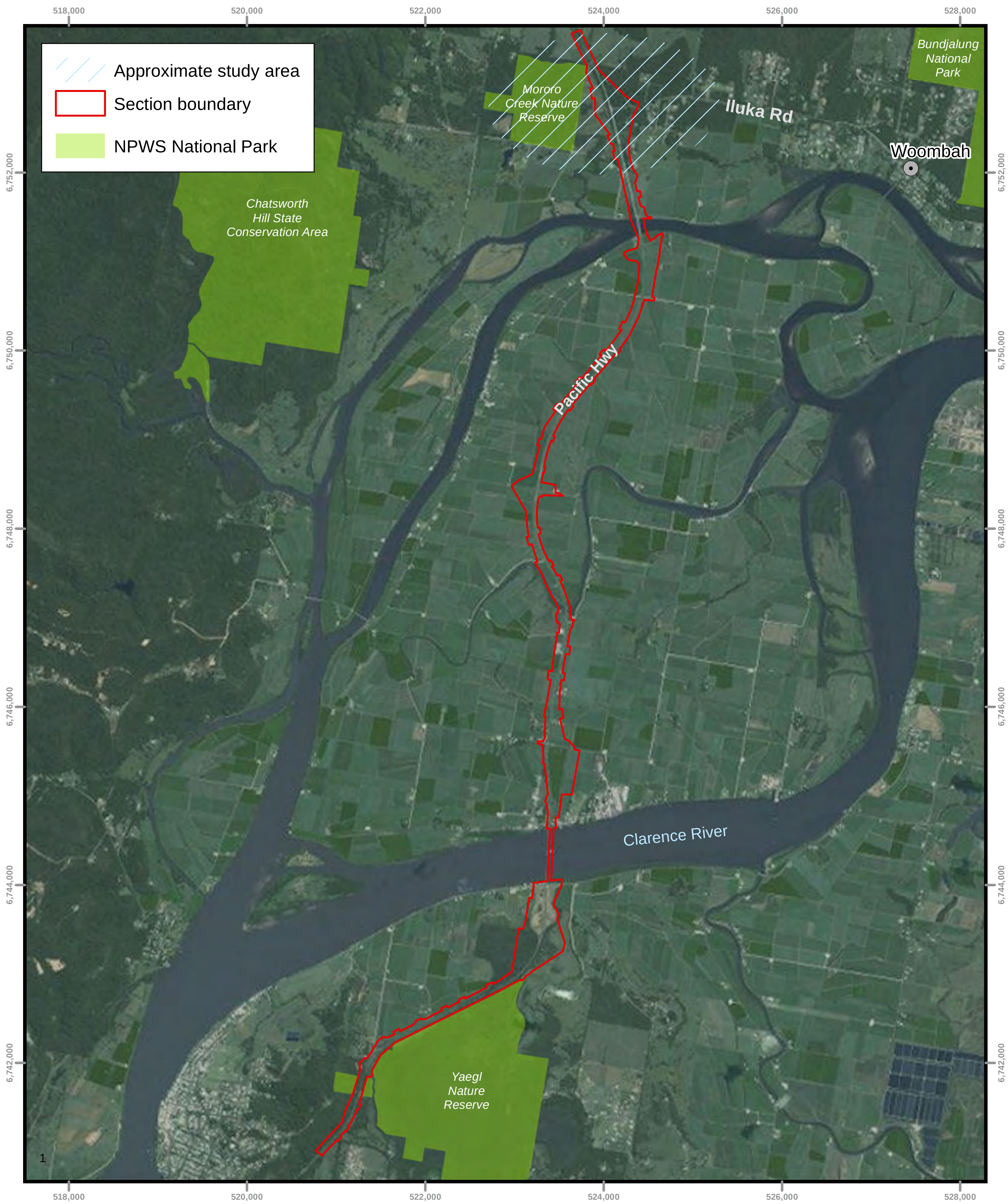
- Targeted searches of PKFTs in an area of Section 11, with the aim to confirm presence and identify additional areas for connectivity and mitigation strategies
- Confirming any suitable locations for monitoring.

2 Methods

2.1 Study area

The study area is split up into six targeted project sections listed south to north: 5, 7, 8, 9, 10 and 11 (Figures 1(a) – 1(e)).

- The study area for Section 5 is a fragmented landscape centred on the Pacific Highway and Iluka Road interchange (Figure 1a). This area connects contiguous koala habitat in the north, east and west. To the south the area is bordered by cleared farmland and the Clarence River.
- The Section 7 study area is located between the Tabbimoble nature reserve to the east and Doubleduke State Forest to the west, and is centred on the Pacific Highway approximately 3 kilometres south of New Italy (Figure 1b).
- The Section 8 study area comprises fragmented habitat and scattered PKFTs which provide a stepping-stone link between contiguous forest to the north-north-west (connecting to Rileys Hill), and habitat to the south (connecting to Doonbah) (Figure 1c).
- The northern portion of the Section 9 study area is located between the Richmond River and the township of Broadwater, fragmented and coastal habitat which extends to the coast, and the Broadwater National park. The southern portion of the study area bisects the Broadwater National Park (Figure 1d).
- The study area for Section 10 comprises an area located between Coolgardie in the north, Wardell and the Pacific Highway in the east, the Richmond River in the south, and cleared farmland extending to the Blackwall Ranges in the west (Figure 1e). Contiguous patches of preferred koala habitat are present throughout the study area.
- The study area surveyed for Section 11 is located approximately 500 metres north of Section 10, directly adjacent to the Pacific Highway. This area is the northern most extent of vegetation before a large stretch of agricultural farmland (Figure 1e).



ecosure

Document
GW116_MP_Fig1_SiteLocation

Job Number: GW116

Approved Project Manager	GB	02/10/2014

R1	MD	GB	ISSUED TO CLIENT	02/10/2014
R0	MD	DB	ISSUED TO CLIENT	04/07/2014
REV	BY	CHK	DESCRIPTION	DATE

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Scale: 1:56,000 when printed at A4

Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Units: Metre

Data Sources:
- NSW Roads and Maritime Services
- NSW National Parks and Wildlife Service
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- Image Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

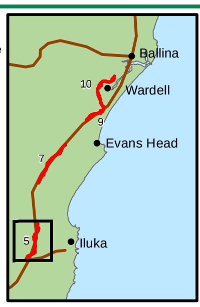

Figure 1(a): Study area and proposed road alignment for Section 5

Roads and Maritime Services

Pre-construction koala surveys

Woolgoolga to Ballina, NSW

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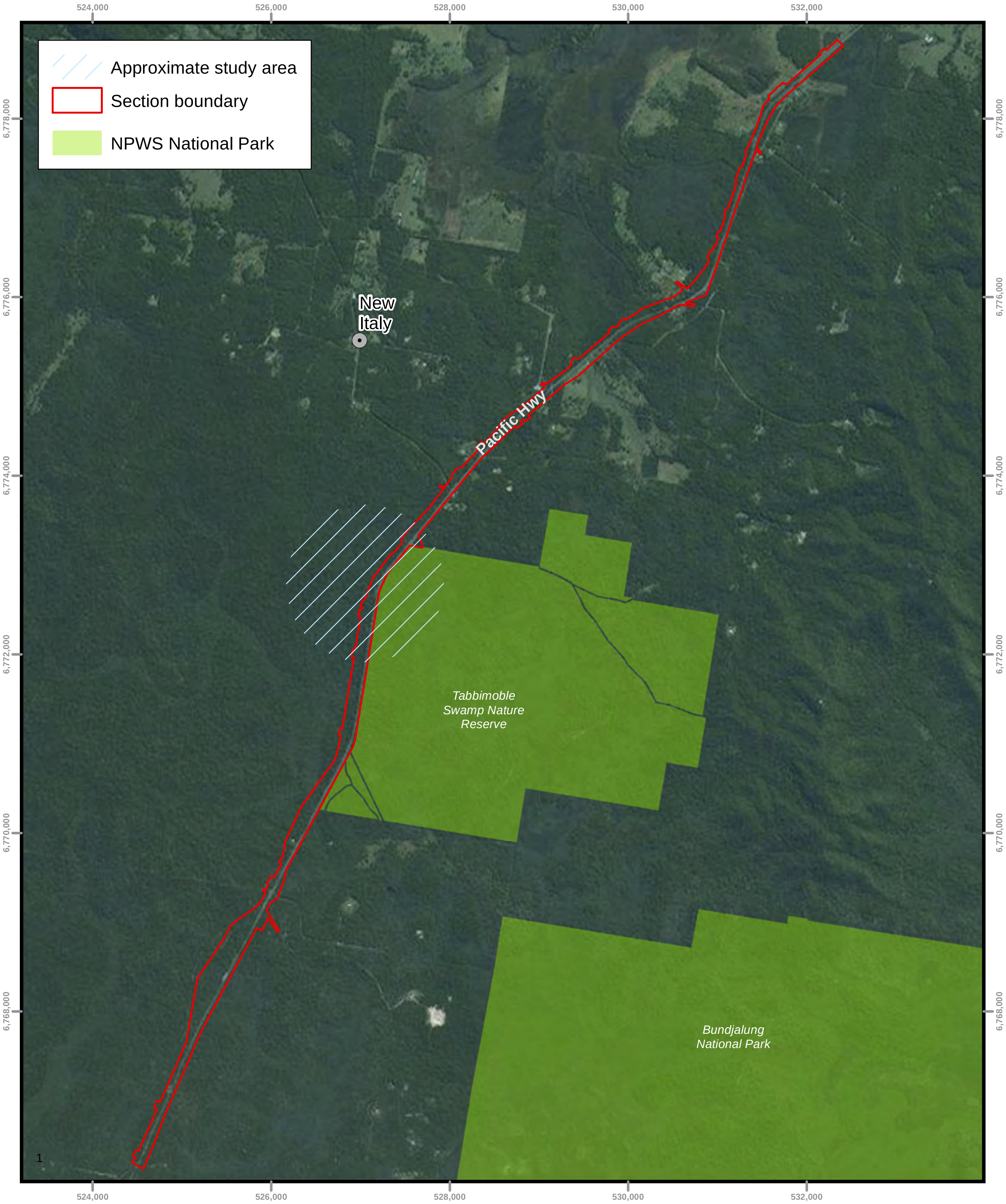

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R0	MD	DB	ISSUED TO CLIENT	04/07/2014
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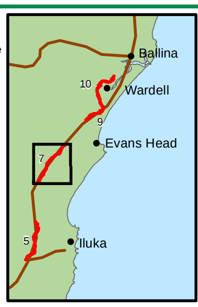

Figure 1(b): Study area and proposed road alignment for Section 7

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Pre-construction koala surveys

Woolgoolga to Ballina, NSW

A4

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Document
GW116_MP_Fig1_SiteLocation

Job Number: GW116

REV	BY	CHK	DESCRIPTION	DATE
Approved Project Manager		GB		02/10/2014
R1	MD	GB	ISSUED TO CLIENT	02/10/2014
R0	MD	DB	ISSUED TO CLIENT	04/07/2014

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Metres

Scale: 1:56,000 when printed at A4

Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Units: Metre

Data Sources:
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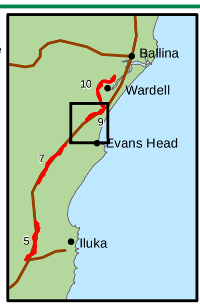

Figure 1(c): Study area and proposed road alignment for Section 8

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GW116_MP_Fig1_SiteLocation

Job Number: GW116

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R1	MD	GB	ISSUED TO CLIENT	02/10/2014
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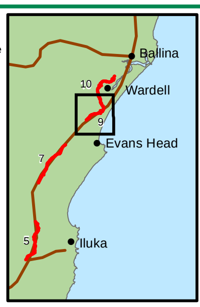

Figure 1(d): Study area and proposed road alignment for Section 9

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Woolgoolga to Ballina, NSW

A4

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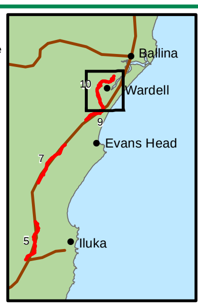

Figure 1(e): Study area and proposed road alignment for Section 10 and 11

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Pre-construction koala surveys

Woolgoolga to Ballina, NSW

A4

2.2 Site selection

Survey sites for Spot Assessment Technique (SAT) sampling were confirmed using the regularised grid-based SAT sampling technique described by Phillips et al. (submitted). This is an unbiased survey technique whereby regularly spaced grid cell intersection points are used to sample for koala activity in areas of otherwise suitable habitat (i.e. areas of forest/woodland containing *Eucalyptus* spp).

Only Sections 5, 7, 9 and 10 were overlain with a 500 metre x 500 metre grid for detail SAT surveys. Previous data were used to assess Section 10; these data were provided by Ballina Shire Council (Biolink 2013). The resolution of surveys conducted for Ballina Shire Council were coarse (1000 metre and 500 metre sampling intervals), but recent enough (2012/13) to inform relevant components of the survey methodology and results of this current project.

The following numbers of primary SAT sites were identified for each section whereupon the centre of a grid cell occurred within an identified area of potential koala habitat (Figures 2a – 2e). A 250 metre default grid was created to allow for finer scale sampling when koala habitat use was confirmed at a primary site.

- *Section 5* – 10 SAT sites (Figure 2a)
- *Section 7* – nine SAT sites (Figure 2b)
- *Section 9* – 21 SAT sites (Figure 2c)
- *Section 10* – 35 SAT sites (Figures 2d-e).

Universal Transverse Mercator (UTM) coordinates for these locations were programmed into a Garmin GPS60 handheld receiver navigating on a GDA94 datum. In the field, a level of flexibility (5% of sampling scale) was allowed when determining the position of the centre point of the site, in order to enable the repositioning of a site into an area determined to be most suitable for sampling (from a koala habitat perspective).

2.2.1.1 Supplementary survey sites

Supplementary sites were chosen specifically for their likelihood of supporting koalas, and were opportunistically chosen on transit between primary SAT sites and comprised of (i) multiple PKFTs, or (ii) single PKFTs. Sites were surveyed by targeting known PKFTs for the presence of scats. Sites Data collected were used to further inform areas of habitat use by koalas. Only supplementary sites were used to survey Sections 8 and 11. Data on koala habitat use in these areas were collected to determine if any connectivity structures or mitigation measures were likely to be required.

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Job Number: GW116

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R0	MD	GB	ISSUED TO CLIENT	04/07/2014
REV	BY	CHK	DESCRIPTION	DATE

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Metres

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Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Units: Metre

Chainages

Section boundary

Primary site

Default site

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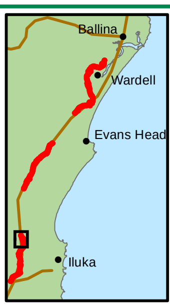

Figure 2(a): Location of sites in Section 5 surveyed using the Spot Assessment Technique (Phillips and Callaghan 2011)

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Pre-construction koala surveys

Woolgoolga to Ballina, NSW

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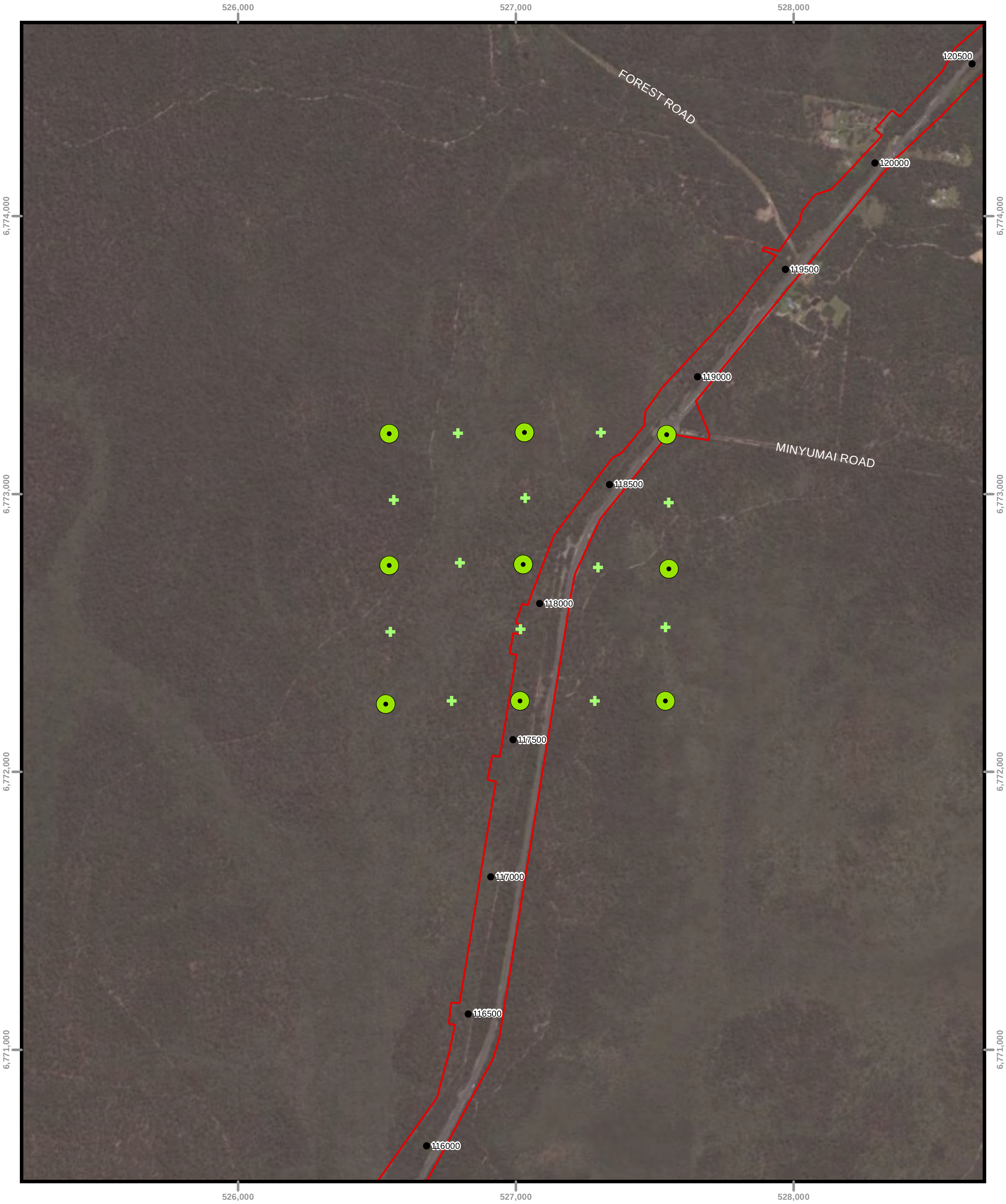

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Job Number: GW116

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R0	MD	GB	ISSUED TO CLIENT	04/07/2014
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Projection: Transverse Mercator
Datum: GDA 1994
Units: Metre

Chainages
Section boundary
Primary site
Default site

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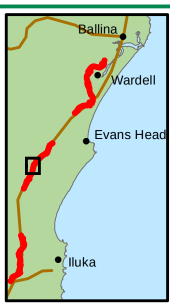

Figure 2(b): Location of sites in Section 7 surveyed using the Spot Assessment Technique (Phillips and Callaghan 2011)

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Woolgoolga to Ballina, NSW

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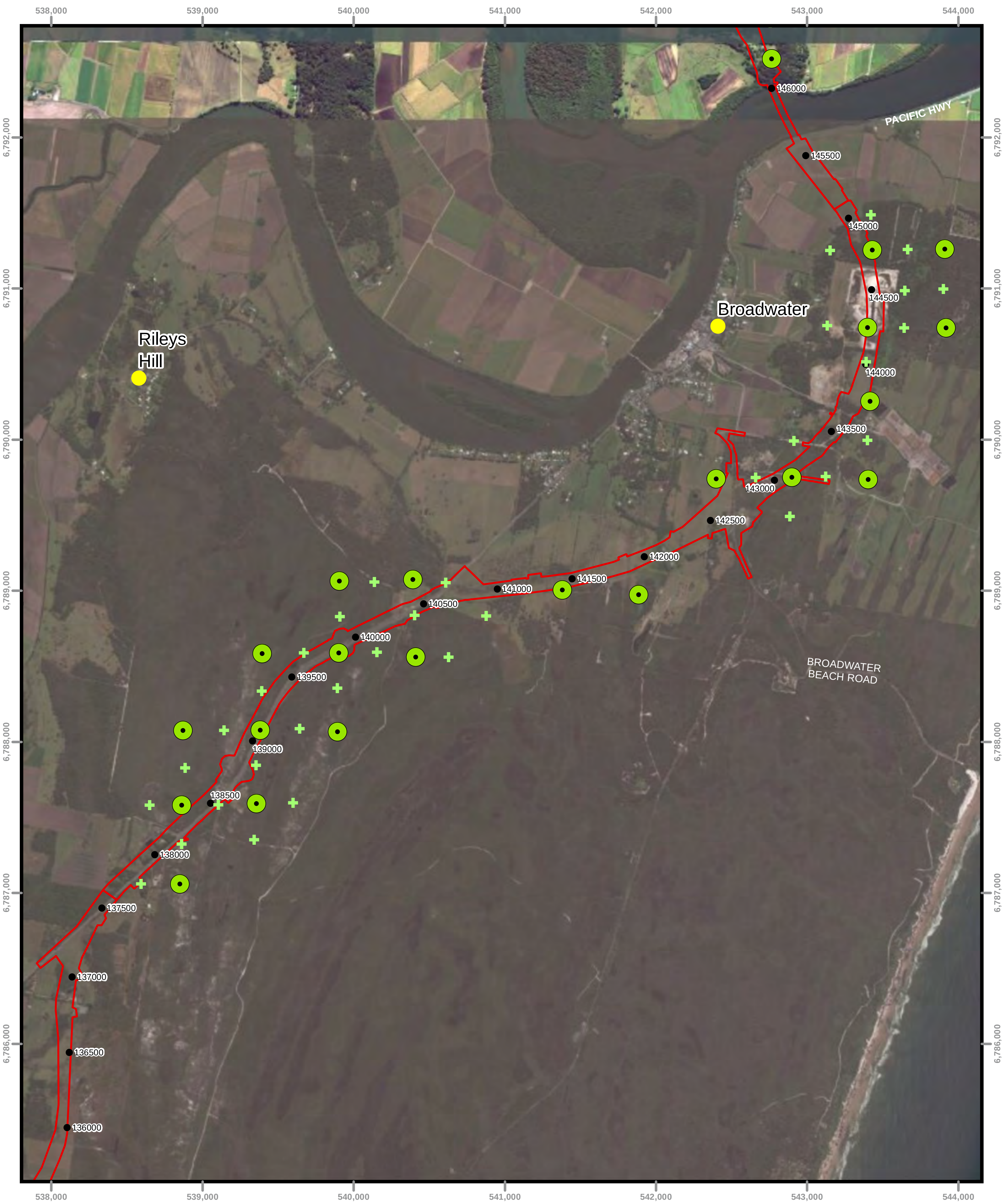

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Job Number: GW116

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Projection: Transverse Mercator
Datum: GDA 1994
Units: Metre

- Chainages
- Section boundary
- Primary site
- Default site

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Figure 2(c): Location of sites in Section 9 surveyed using the Spot Assessment Technique (Phillips and Callaghan 2011)

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Pre-construction koala surveys

Woolgoolga to Ballina, NSW

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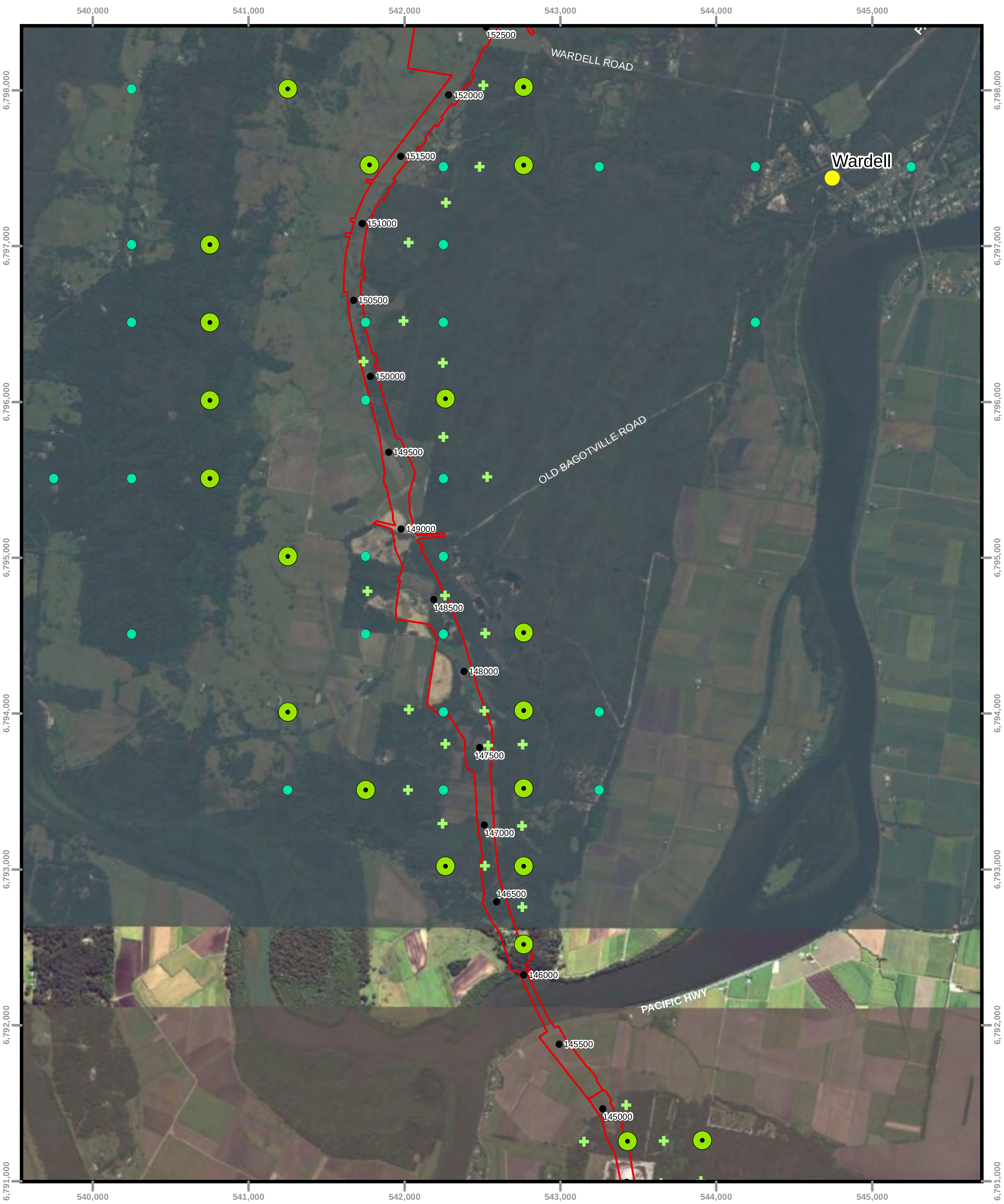

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Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Units: Metre

- Chainages
- Section boundary
- Primary site
- Default site
- Previous SAT site

Data Sources:
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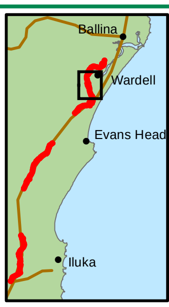

Figure 2(d): Location of sites in Section 10(i) surveyed using the Spot Assessment Technique (Phillips and Callaghan 2011)

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Woolgoolga to Ballina, NSW

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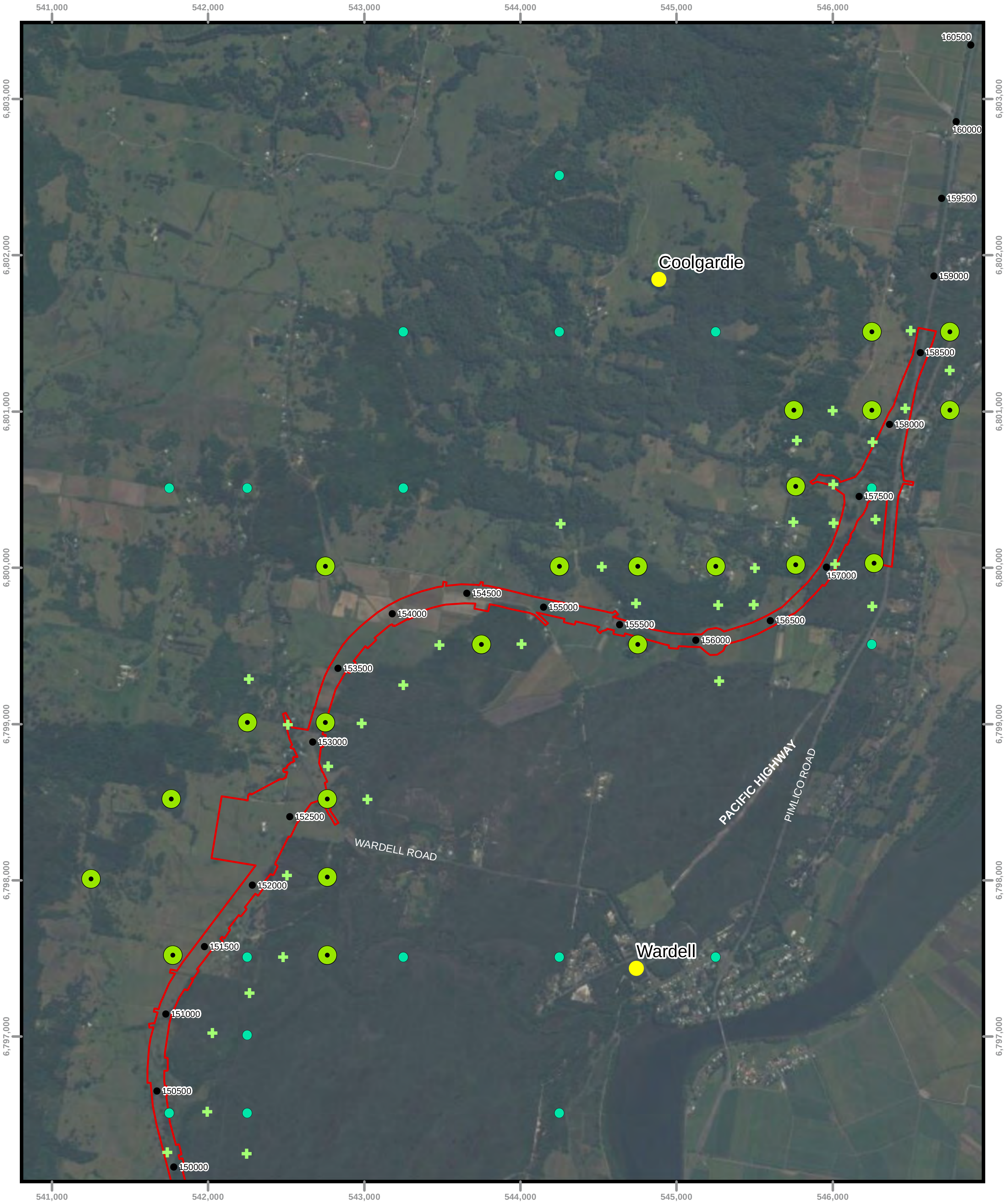

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Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Units: Metre

Chainages
Section boundary
Primary site
Default site
Previous SAT site

Data Sources:
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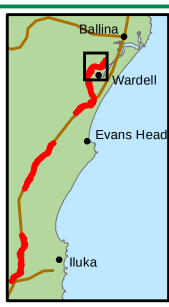


Figure 2(e): Location of sites in Section 10(ii) & 11 surveyed using the Spot Assessment Technique (Phillips and Callaghan 2011)

Roads and Maritime Services

Pre-construction koala surveys

Woolgoolga to Ballina, NSW

A4

2.3 Spot Assessment Technique (SAT)

Koala presence and activity levels were determined using SAT sampling (Phillips & Callaghan 2011). A central tree with a diameter at breast height (DBH) >100 millimetres was selected and its location recorded using a handheld GPS device. Using this tree as a survey site centre point, the 29 closest trees over 100 millimetres DBH were recorded. The DBH and the species of each tree were noted.

Koala faecal pellet surveys were undertaken by a field team of three team members (one lead and two support personnel). Two team members searched at the base of each of the 30 survey trees within each site using the 1 metre search protocol of Phillips and Callaghan (2011) to determine the extent of tree use and associated activity of koalas. The survey also incorporated a search for koalas in every tree within a 25 metre radius of the centre tree (0.196 hectares) as well as opportunistic observations of koalas. If a koala was sighted, the koala field lead would assess those characteristics specified in Table 1.

Table 1 Koala variables recorded for all koala sightings during field surveys

Variable	Measure
Sex	Male, female, indeterminate
Age	Pouch young, back young, dependent, immature, adult, indeterminate
Health status	Any overt signs of Chlamydiosis
Behaviour	Resting, vocalising, moving (arboreal), moving (terrestrial)

2.4 Koala activity

The results of field sampling are interpreted herein in terms of 'active sites' and 'koala activity'. An active site is thus defined as any site within which one or more koala faecal pellets were recorded beneath a tree during sampling. The koala activity level for a given site is calculated as the percentage of trees within that scored positive for the presence of koala faecal pellets (see below).

$$\text{Activity level (\%)} = \frac{\text{Number of trees surveyed}}{\text{Number of trees with faecal pellets}} \text{ X } 100$$

2.4.1 Occupancy rate

A current occupancy rate estimate for each section within the study area was determined by dividing the number of active sites by the total number of sites assessed. This estimate is a coarse indication of the likely habitat occupancy of koalas in the area.

2.5 Population modelling

Koala activity data from the field sites were analysed using thin plate splining techniques in order to interpolate activity patterns (Phillips, Hopkins & Warnken submitted). This process ultimately produces an activity contour model which delineates areas occupied by resident koala populations; when interpreted with regard to the activity thresholds of Phillips and Callaghan (2011), the process invariably encapsulates areas occupied by approximately 85% of current koala records and 100% of breeding female koalas (Phillips, Hopkins & Warnken submitted) (Table 2). Similar to Biolink (2013), both the East Coast (low) and East Coast (med-high) activity category thresholds were applied for the purposes of interpreting koala activity.

Table 2 Categorisation of koala activity based on use of mean activity level ± 99% confidence intervals for each area/population density category relative to the project. Activity levels in the Medium (normal) and High use range indicates occupancy by resident koala populations (Phillips and Callaghan 2011).

Activity category	Low use	Medium (normal) use	High use
Area (koala density)			
East Coast (low)	<10.00%	>10.00% but <12.59%	>12.59%
East Coast (med-high)	<22.52%	>22.52% but <32.84%	>32.84%

Null (zero activity) sites were also incorporated into the modelling process in order to effectively delineate distributional and/or dispersal barriers such as the major rivers and/or roads.

2.6 Koala habitat categories

A coarse estimate of koala habitat availability (%) throughout the landscape was determined using SAT sites containing potential koala habitat (i.e. areas of forest/woodland containing *Eucalyptus* spp) compared to the number of SAT sites void of any potential koala habitat.

Koala habitat category for each SAT site was determined using the classification outlined in Biolink (2013) (Table 3). PKFTs used for this process included *E. tereticornis*, *E. microcorys, E. propinqua* and *E. robusta*, which have all been consistently recognised in northern NSW as PKFTs (Biolink 2013). As highlighted in Biolink (2013), "*the terms 'Primary', and 'Secondary' koala food tree species as used in the following definitions are based on the mathematical models and associated definitions of Phillips (2000b) and are thus consistent with terminology used in the approved Recovery Plan for the Koala (DECC 2008)".*

Table 3 Criteria for classifying koala habitat quality for each SAT site based on the abundance of PKFTs. Criteria and descriptions from Biolink (2013)

Habitat category	Habitat description
Preferred koala habitat	
Primary	Areas of forest and/or woodland wherein primary food tree species comprise the dominant or co-dominant (i.e. ≥ 50%) overstorey tree species.
Secondary (Class A)	Areas of forest and/or woodland wherein primary food tree species are present but not dominant or co-dominant and usually (but not always) growing in association with one or more secondary food tree species.
Secondary (Class B)	Areas of forest and/or woodland wherein primary food tree species are absent, habitat containing secondary and/or supplementary food tree species only.
Other habitat	
Other	Areas of forest and/or woodland wherein koala food trees are absent
Unknown	Areas for which insufficient information regarding community composition is available

2.7 Landholder liaison

During field surveys, information on koala sightings and directional movement was collated based on discussions with local landowners and information provided by Roads and Maritime from other contractors. This information was used in conjunction with other field data to identify locations for crossing structures.

3 Results

Field surveys were conducted by ecologists between 17 - 21 March and 7 - 16 April 2014. There were a number of SAT sites that could not be surveyed due to access restrictions (e.g. landholder permission, extreme weediness etc.). The total numbers of SAT sites surveyed are outlined below and are illustrated in Figures 4a-f:

- Sections 5 - six of 10 SAT sites were surveyed.
- Sections 7 - eight of the nine SAT were surveyed.
- Sections 9 – 20 of the 21 SAT sites were surveyed.
- Sections 10 – 30 of the 35 SAT sites were surveyed.

3.1 Koala sightings

Five koalas were observed in the targeted project sections during Ecosure's field surveys. An additional 11 anecdotal koalas observations were recorded during the survey period and the preceding six months. These latter records arose from local landowner and Roads and Maritime contractor sightings.

3.1.1 Field surveys

Five koalas were observed during field surveys (Table 4). These included:

- Three koalas in Section 9. Two were recorded on the northern (Figures 3c & 4d) and southern (Figures 3d & 4d) extents of the current Pacific Highway in the Broadwater National Park. The third was recorded to the west of Broadwater within close proximity to the proposed road alignment (Figures 3e & 4d).
- One koala recorded in connecting habitat between Riley's Hill and Broadwater in an area to the west of Section 9 (Figures 3b & 4d).
- One koala in Section 10, which was recorded in a primary SAT site above a dog[1] that was displaying an aggressive behaviour (Figure 3a & 4f).

No overt signs of Chlamydiosis were evident; however all assessments were conducted using binoculars and the accuracy of this diagnosis is considered unreliable.

3.1.2 Landowners

Eight anecdotal observations of koalas were provided by landowners for during the survey period and from the preceding six months. These included seven throughout Section 10 and one in the northern extent of Section 9 (Table 5 and Figures 4d-f).

[1] The tenants (and dog) had vacated this property between the February and May 2014 surveys.

3.1.3 Roads and Maritime Services contractors

During the survey period, three anecdotal observations of koalas were provided by Roads and Maritime contractors (Table 5). These included:

- One koala recorded in Section 9, on the edge of the current Pacific Highway in the northern extent of Broadwater National Park (same location as one recorded during Ecosure surveys[2]) (Figure 4d)
- One koala was recorded in Section 10, located on Thurgates Lane (off Wardell Rd) (Figure 4f)
- One koala was recorded in the northern extent of Section 8. This record resulted in additional targeted surveys (Figure 4d).

[2] It is likely that these records are of the same individual, however this could not be confirmed

Table 4 Individual characteristics of each koala observed by Ecosure staff during field surveys. Koala sex, age and condition were determined using binoculars only. Koala record number provided in Figures 4d-f

Koala record	Location description	GPS	Project Section	Date	Approx. distance to road alignment	Sex	Age	Condition	Behaviour	Tree species
1	Wardell road approx. 300 m north of Thurgates road intersection	542819 E 6798569 N	10	12/2/2014	50 m	NA	Adult	Good	Resting	*Eucalyptus tereticornis*
2	450 m west of Evans Head – Broadwater Road and	542123 E 6789198 N	9	10/4/2014	50 m	NA	Adult	Good	Resting	*E. dunnii*
3	Rileys Hill road (1.5 km west/north-west of Broadwater Koala Conservation Park)	539692 E 6790350 N	9	8/4/2014	2 km NW	M	Adult	Good	Resting, eating	*E. tereticornis*
4*	Pacific Highway, northern end of Broadwater National Park	540571 E 6788925 N	9	8/4/2014 & 9/4/2014	Within alignment	F	Adult	Good	Resting	*E. robusta*
5	Pacific Highway southern end of Broadwater National Park	538800 E 6787308 N	9	9/4/2014	Within alignment	M	Adult	Good	Resting	*E. robusta*

*NOTE: likely to be the same individual as that recorded by Roads and Maritime contractors in this location; however this could not be confirmed (Table 5).

Table 5 Location descriptions of koalas observed by landholders and Roads and Maritime contractors. All observations were reported during the current project timeframe (not all specific dates were provided and koalas were not confirmed on site). Koala sex, age and condition not determined. Koala record number provided in Figures 4d-f.

Koala record	Location description	GPS	Project Section	Approx. distance to road alignment
Landholder				
1	Pacific Highway (approx. 500 m north of Section 10)	546862 E 6801934 N	11	<100 m
2	Approx. 500 m north of Coolgardie Road and 500 m west of Pacific Highway	545897 E 6801008 N	10	300 m
3	Wardell Road	542508 E 6799252 N	10	200 m
4	Northern portion of the Blackwall Range	541448 E 6798537 N	10	600 m
5	South-eastern portion of the Blackwall Range (Approx 1 km west of the road alignment)	540809 E 6795505 N	10	1 km
6	500 m east of Old Bagotville Road	542424 E 6794083 N	10	Within alignment
7	Approx. 700 m south-east of koala record 11	542899 E 6793553 N	10	300 m
8	Southern tip of Section 10 vegetation. Approx. 100 m north of Richmond River	542708 E 6792482 N	10	Within alignment
9	Directly north of Pine Tree Road (east of Broadwater)	542982 E 6790955 N	9	300 m
Roads and Maritime contractor				
1	Thurgates Lane (off Wardell road)	542780 E 6797926 N	10	200 m
2	Pacific Highway, northern end of Broadwater National Park (edge of dump)	540384 E 6789051 N	9	Within alignment
3	Private property (approx. 650 m south-east of current Pacific Highway)	538161 E 6785883 N	8	50 m

*NOTE: likely to be the same individual as that recorded by Ecosure in this location; however this could not be confirmed (Table 4).

Figure 3a Koala record 5 (Evans Head – Broadwater Road), observed on 10 April 2014

Figure 3b Koala record 2 (Rileys Hill Road), observed on 8 April 2014

Figure 3c Koala record 3 (Broadwater National Park north), observed on 8 April 2014

Figure 3d Koala record 3 (Broadwater National Park south), observed on 8 April 2014

Figure 3e Koala record 5 (Evans Head – Broadwater Road), observed on 10 April 2014

Figure 3 Koalas observed by Ecosure during field surveys

3.2 Koala activity

Evidence of koala activity (i.e. koala faecal pellets recorded beneath at least one tree within the site) varied between project sections. The Figure references for distribution of koala activity in Sections 5, 7, 9 and 10 as determined by spatial modelling is listed below.

- *Section 5* - Evidence of koala habitat use was confirmed at one SAT site in Section 5, providing an estimated occupancy rate of 16.6%. The activity level at this site was medium; indicating a resident koala population is likely to present in the area (Figure 4a).
- *Section 7*- No koala activity was recorded at any SAT site in Section 7 (Figure 4b).
- *Section 9* - In Section 9, evidence of koala activity was confirmed at one SAT site, providing an estimated occupancy rate of 5%. Activity level at this site was low, indicating transient habitat use by one or more koalas through the area (Figure 4d).
- *Section 10* - Koala activity was confirmed in Section 10 at six SAT sites, including one high, one medium, and four low activity sites. The presence of high and medium activity sites in the area indicates resident koala populations are present (Figures 4e-f). Low activity sites that were recorded sporadically throughout the study area are consistent with indications of transient habitat use by one or more koalas. The estimated occupancy rate in Section 10 is 20%.

3.3 Supplementary sites

Evidence of koala habitat use (i.e. koala faecal pellets recorded) was recorded at 24 supplementary sites (Table 6). These included sites confirming koala presence in Sections 8 and 11.

Table 6 Project section and number of supplementary sites containing evidence of koala habitat use. Includes two additional areas not originally identified for sampling. Specific locations of supplementary sites are provided in Figures 4a-f.

Project section	Number of sites with evidence of koala habitat use
Section 8	8
Section 9	5
Section 10	10
Section 11	1

3.4 Koala habitat availability and quality

An assessment of koala habitat availability and quality was determined only for sections surveyed using detailed SAT methodology (i.e. Sections 5, 7, 9 and 10).

3.4.1 Section 5

Of the seven sites surveyed, six contained potential koala habitat providing a coarse estimate of 86% of available koala habitat in the survey area. Five sites also contained

PKFTs (Primary and Secondary Class A habitat). The only site containing evidence of koala habitat use in Section 5 contained PKFTs (Secondary Class A habitat). The availability of each habitat category in Section 5 is summarised in Table 7.

Table 7 Habitat categories present in Section 5 according to the presence and abundance of PKFTs at SAT survey sites (Biolink 2013). Four sites that were not surveyed have been included in these data as 'Unknown habitat'.

Habitat quality	No. SAT sites	No. site containing pellets
Primary habitat	1	-
Secondary (Class A) habitat	3	1
Secondary (Class B) habitat	1	-
Other habitat	1	-
Unknown habitat	3	-

3.4.2 Section 7

Seven of the eight surveyed sites contained potential koala habitat, providing a coarse estimate of 88% of available koala habitat in the survey area.

Two of the eight SAT sites (25%) contained PKFTs (Secondary Class A habitat only). The availability of each habitat category in Section 7 is summarised in Table 8.

Table 8 Habitat categories present in Section 7 according to the presence and abundance of PKFTs at SAT survey sites (Biolink 2013). One site that was not surveyed has been included in these data as 'Unknown habitat'.

Habitat quality	No. SAT sites	No. site containing pellets
Primary habitat	0	-
Secondary (Class A) habitat	2	-
Secondary (Class B) habitat	5	-
Other habitat	1	-
Unknown habitat	1	-

3.4.3 Section 9

Of the 20 sites surveyed, four contained potential koala habitat resulting in a coarse estimate of 20% of available koala habitat in areas surrounding the proposed road alignment.

Only three of the 20 SAT sites (15%) contained PKFTs (Secondary Class A habitat only). One of these three sites comprised the only positive record of koala habitat use in Section 9. The availability of each habitat category in Section 9 is summarised in Table 9.

Table 9 Habitat categories present in Section 9 according to the presence and abundance of PKFTs at SAT sites (Biolink 2013). One site that was not surveyed has been included in these data as ‘Unknown habitat’.

Habitat quality	No. SAT sites	No. site containing pellets
Primary habitat	0	-
Secondary (Class A) habitat	3	1
Secondary (Class B) habitat	1	-
Other habitat	15	-
Unknown habitat	1	-

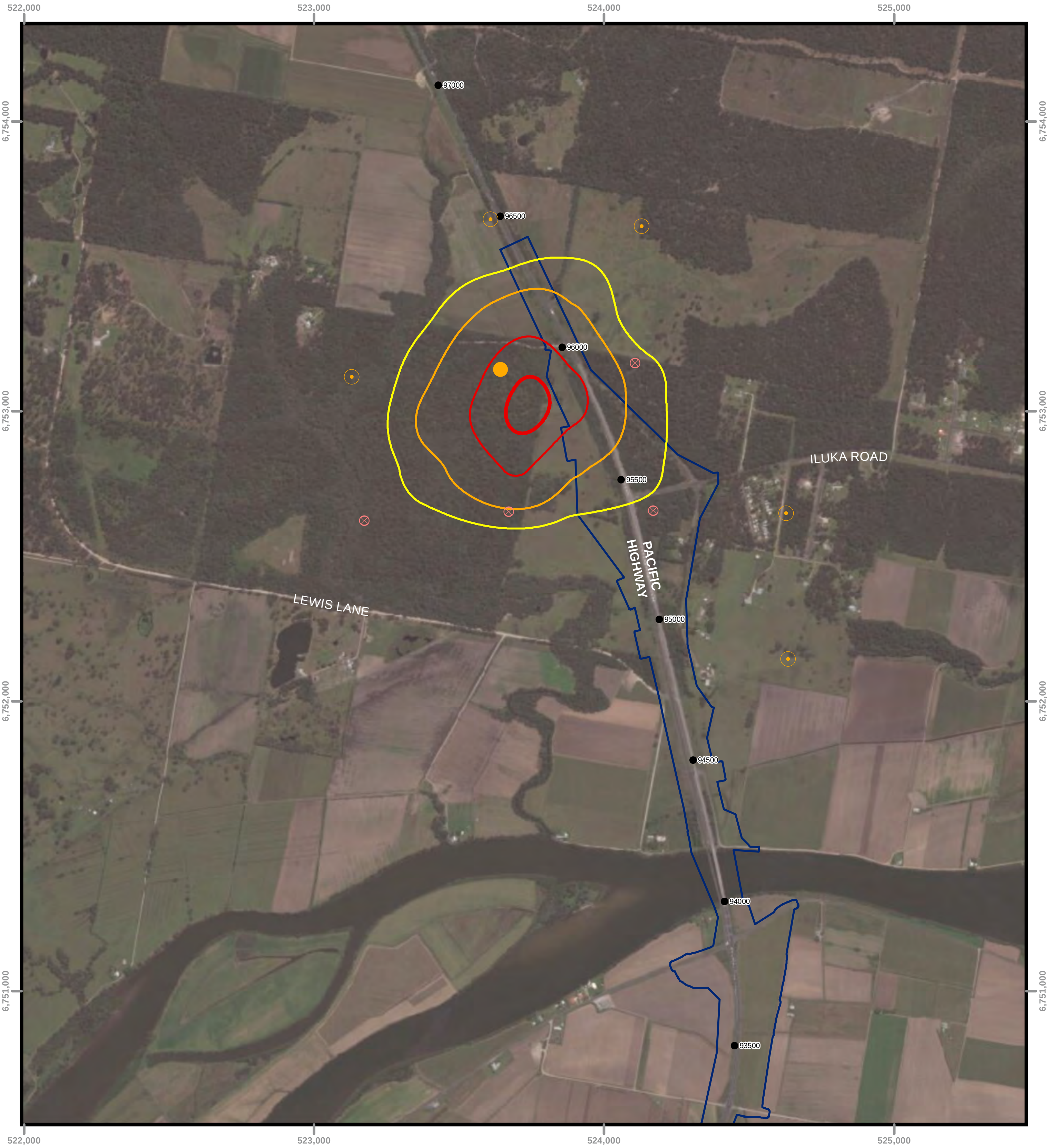
3.4.4 Section 10

Of the 30 sites surveyed, 14 sites contained potential koala habitat, resulting in a coarse estimate of 47% of available koala habitat in areas surrounding the proposed road alignment.

Seven of the 30 SAT sites (23%) contained PKFTs (Primary and Secondary Class A habitat). Of the six sites found to contain evidence of koala habitat use, four were found at SAT sites containing PKFTs. The availability of each habitat category in Section 10 is summarised in Table 10.

Table 10 Habitat categories present in Section 10 according to the presence and abundance of PKFTs at SAT survey sites (Biolink 2013). Five sites not surveyed have been included in these data as ‘Unknown habitat’.

Habitat quality	No. SAT sites	No. site containing pellets
Primary habitat	4	3
Secondary (Class A) habitat	3	1
Secondary (Class B) habitat	7	2
Other habitat	16	
Unknown habitat	5	-



- Chainages
- Section boundary

SAT survey records
- Positive
- Negative
- No access

Activity contour
- 3%
- 10%
- 23%
- 33%

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Document
GW116_MP_Fig4_Results

Job Number: GW116

Approved Project Manager	GB			03/10/2014
R1	MD	GB	ISSUED TO CLIENT	03/10/2014
R0	MD	GB	ISSUED TO CLIENT	04/07/2014
REV	BY	CHK	DESCRIPTION	DATE

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Metres

Scale: 1:18,000 when printed at A4

Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Units: Metre

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- Image Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

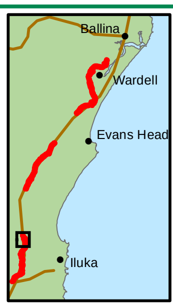

Figure 4(a): Survey results and activity contours for Section 5

Roads and Maritime Services

Pre-construction koala surveys

Woolgoolga to Ballina, NSW

A4

Chainages
Section boundary

SAT survey records

Negative

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Coordinate System: GDA 1994 MGA Zone 56
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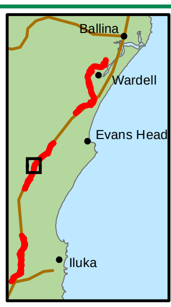

Figure 4(b): Survey results and activity contours for Section 7

Roads and Maritime Services

Pre-construction koala surveys

Woolgoolga to Ballina, NSW

A4

● Chainages
Section boundary

SAT survey records
Negative

Koala records
Koala sighting
Koala sighting (RMS)
Positive supplementary site

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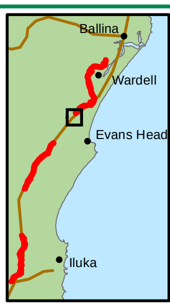

Figure 4(c): Survey results and activity contours for Section 8

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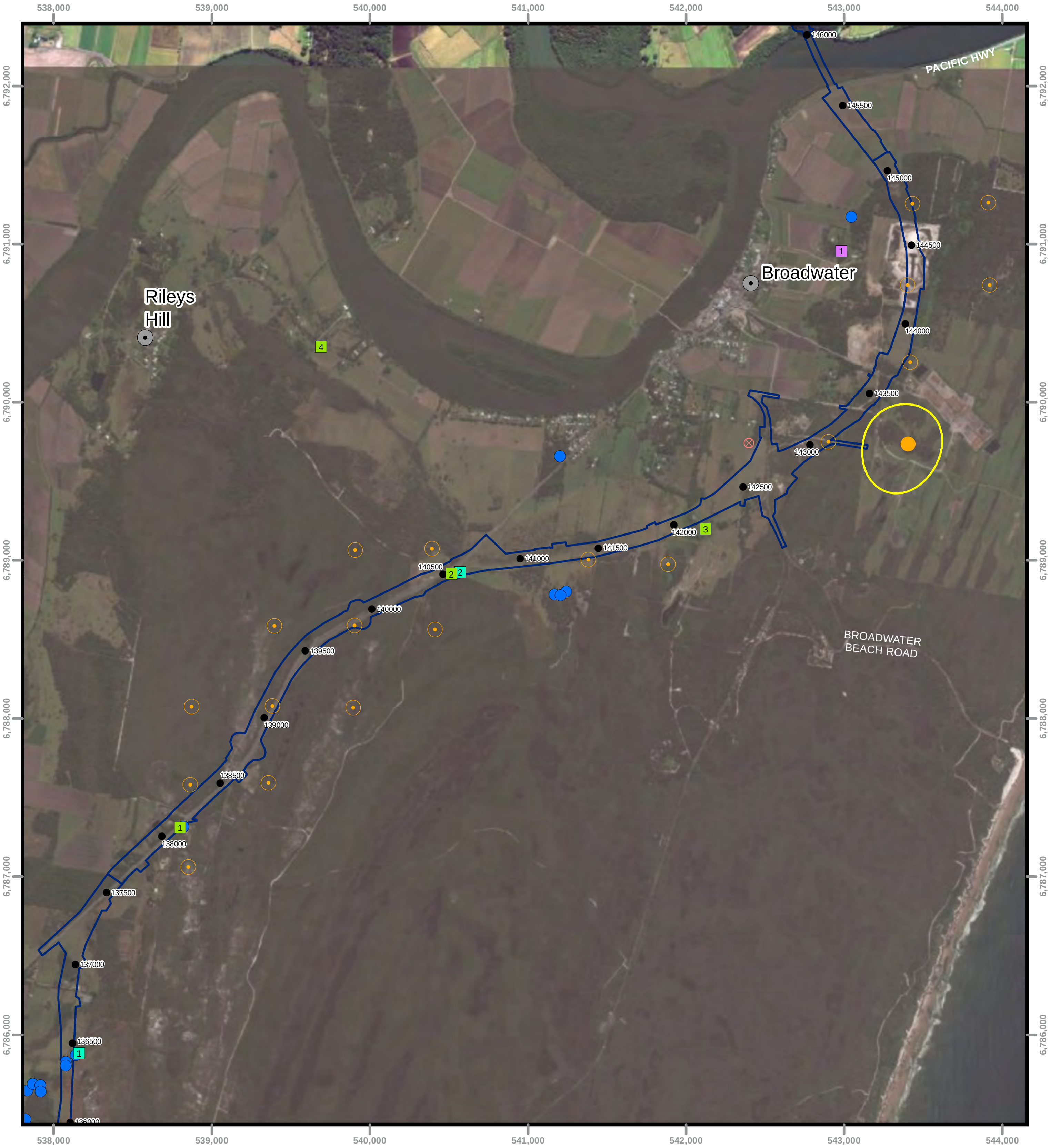
Pre-construction koala surveys

Woolgoolga to Ballina, NSW

A4



Chainages

Section boundary

SAT survey records

Positive

Negative

No access

Koala records

Koala sighting

Koala sighting (RMS)

Koala sighting (landholder)

Positive supplementary site

Activity contour

3%

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Document

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Coordinate System: GDA 1994 MGA Zone 56
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Datum: GDA 1994
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Ballina
Wardell
Evans Head
Iluka

Figure 4(d): Survey results and activity contours for Section 9

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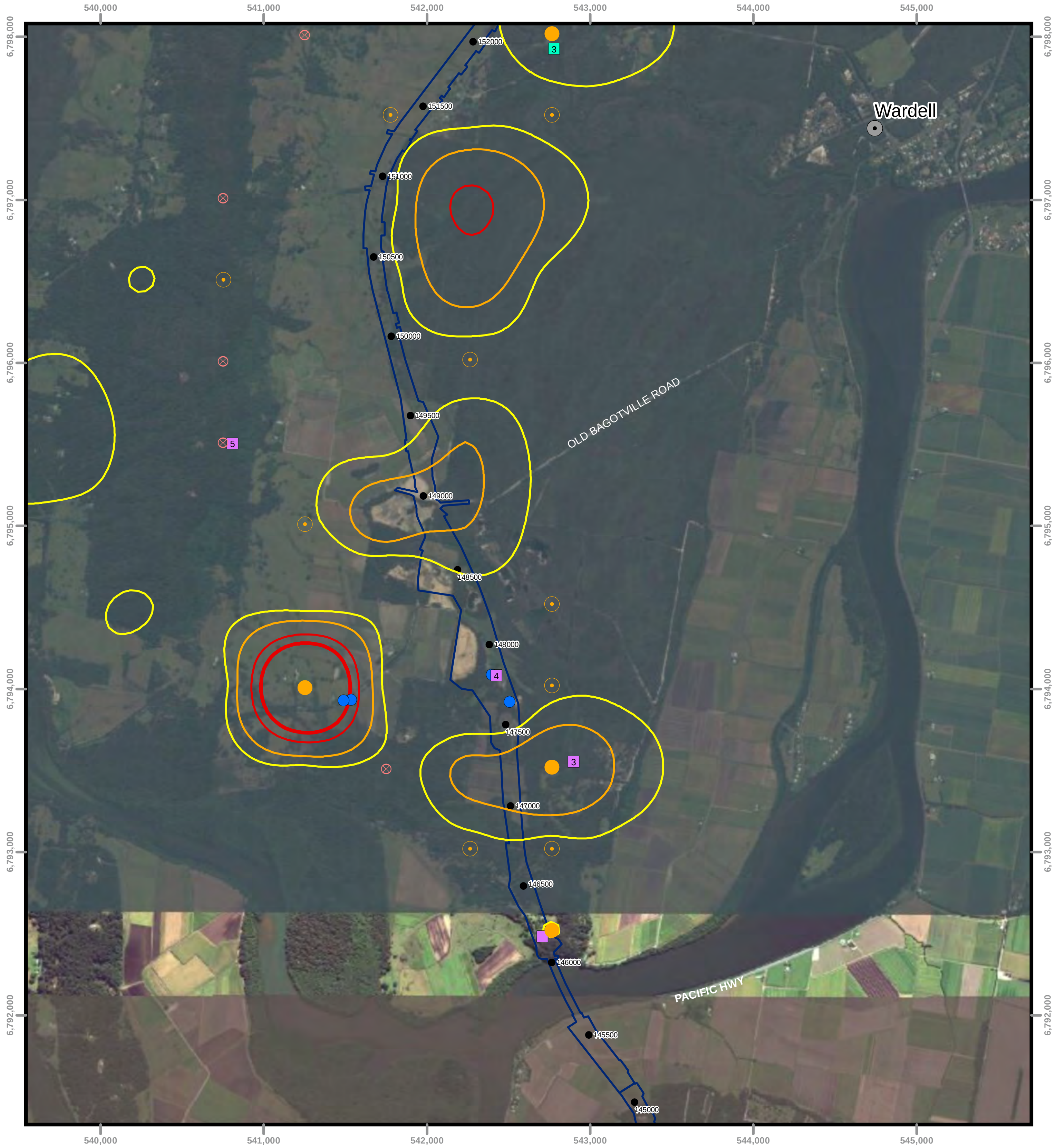
Pre-construction koala surveys

Woolgoolga to Ballina, NSW

A4



● Chainages
▭ Section boundary

SAT survey records
- Positive
- Negative
- No access

Koala records
- Koala sighting (RMS)
- Koala sighting (landholder)
- Positive supplementary site

Activity contour
- 3%
- 10%
- 23%
- 33%

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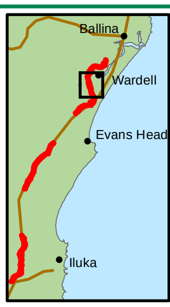


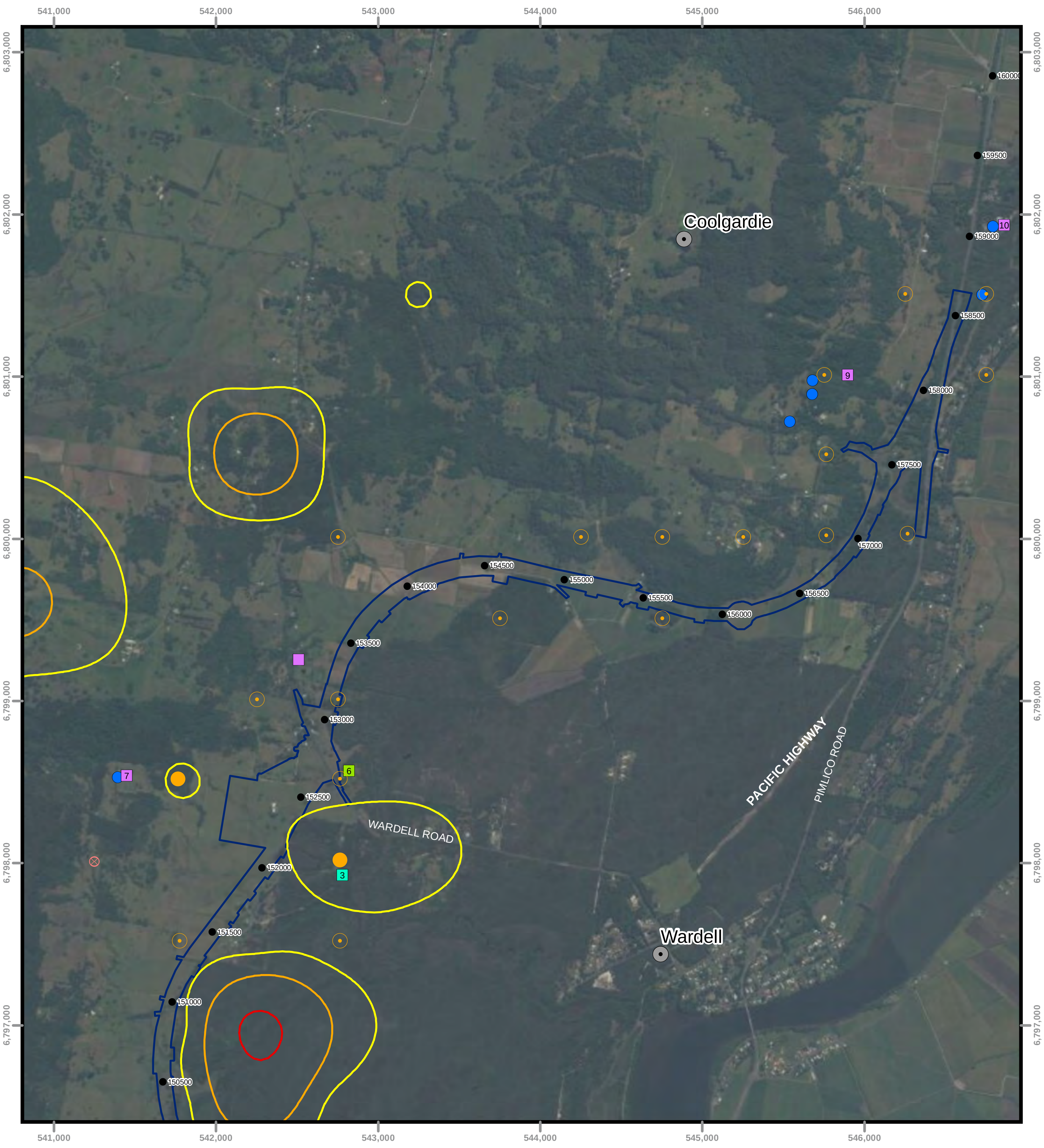
Figure 4(e): Survey results and activity contours for Section 10 (i)

Roads and Maritime Services

Pre-construction koala surveys

Woolgoolga to Ballina, NSW

A4



- Chainages
- Section boundary

SAT survey records
- Positive
- Negative
- No access

Koala records
- Koala sighting
- Koala sighting (RMS)
- Koala sighting (landholder)
- Positive supplementary site

Activity contour
- 3%
- 10%
- 23%

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GW116_MP_Fig4_Results

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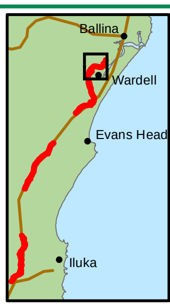

Figure 4(f): Survey results and activity contours for Section 10 (ii) & 11

Roads and Maritime Services

Pre-construction koala surveys

Woolgoolga to Ballina, NSW

A4

4 Key findings

Survey results indicate that the distribution and abundance of koalas varies between project sections. As a result, the likely impact of the proposed road alignment on each project section should be treated in isolation. The need to maintain connectivity and incorporate road mitigation measures (e.g. fencing) should also be considered on a section by section basis. Ultimately, koala populations will have the best chance of long-term persistence if these recommended road management measures are implemented and used effectively. Monitoring will also be crucial to assess the status of koala populations and to inform the effectiveness of mitigation measures.

4.1 Section 5

Survey results indicate that a small resident aggregation of koalas is likely to be present in this section. Further to this, the study area contains high quality koala habitat, with an estimate of up to 86% of this habitat containing PKFTs. This highlights the availability of preferred koala habitat in the study area. Despite this, the absence of koala activity in all but one site, and a relatively low estimated occupancy rate of 16.6%, indicates that any koalas in this area are likely to be transient individuals dispersing between nearby important populations (e.g. Illuka, Woombah and Ashby) (CVC 2010) and/or due to a declining or low resident population. As a result, there is currently an elevated risk to mortality due to vehicle collisions on the unmanaged Pacific Highway and Iluka road. This pinch point in connectivity is considered critical for the long-term persistence of koalas in the study area, and also for koalas dispersing through the broader landscape (Figure 5a). The latter is particularly important because it is now known that the Iluka population to the east is recovering, and that the northern bank of Clarence (i.e. study area) is identified as the most likely link between this recovering population at Iluka and that in the Ashby area to the west (Phillips & Hopkins 2012). It is therefore important that connectivity structures and exclusion fencing at the Iluka interchange be implemented to assist in recovery of the immediate and broader area. These mitigation measures would ultimately improve connectivity and reduce mortality rates. In order to assess the effectiveness of mitigation measures, ongoing koala surveys and monitoring at connectivity structures (e.g. remote sensing cameras) will provide information on koala use and structure effectiveness (*see Section 5 – Discussion and recommendations*).

4.2 Section 7

Historically, koalas are known to be widespread throughout the Tabbimoble area from Bundjalung National Park and several state forests to the west (e.g. Tabbimoble State Forest and Doubleduke State Forest). However, a lack of activity in the study area suggests it is unlikely to support a resident population. This is further supported by the knowledge of the area's fire history, which suggests a low probability of any large populations being present in the immediate vicinity (Steve Phillips pers. comm. 2014).

Considering the high availability of contiguous koala habitat (including PKFTs) throughout the study area, koalas may occupy the study area in some form, albeit very infrequently. While the proposed road upgrade is unlikely to impact on any resident koala populations, implementing mitigation measures such as connectivity structures and exclusion fencing will ensure that any dispersing or recolonising individuals are not at a greater risk of mortality. These management actions will also be particularly important for other fauna species (e.g. wallabies, kangaroos, gliders, possums etc.) likely to be occupying contiguous forest areas surrounding the proposed road alignment. No further koala surveys are required in this area; however monitoring at connectivity structures will be important to assess their effectiveness and to provide information on fauna species' use (*see Section 5 – Discussion and recommendations*).

4.3 Section 8

The study area in Section 8 is predominately farmland containing fragmented native vegetation and scattered PKFTs, and is fringed by the Broadwater National Park that is dominated by coastal heathland. A recent anecdotal koala record (Roads and Maritime contractor) and positive supplementary sites in the study area indicate that this area is frequently used by koalas. As a result, this area is likely to be a pinch-point in the link between known koala populations to the north at Rileys Hill and Broadwater, and those to the south around Doonbah (Figure 5b). However, the extent of koala dispersal in the area is yet to be confirmed. Given the fragmented and scattered nature of the vegetation that will remain on either side of the proposed alignment, it is recommended that potential connectivity is maintained across and adjacent to the proposed road alignment.

It is considered likely that koala's using this area move in a north-south direction and cross the proposed road alignment at connectivity area 5 (Figure 5b). Surrounding Roads and Maritime owned land affords the opportunity for revegetation, which would increase the availability of suitable koala habitat in this area. It is recommended that connectivity structures and exclusion fencing, in conjunction with targeted koala habitat revegetation, be implemented in this area to facilitate continued koalas movement through the landscape, as well as enable access to available habitat on either side of the proposed road alignment. This will be important because koalas are considered vulnerable to low genetic diversity (DECC 2008), and as a result maintaining connectivity between populations at Rileys Hill and Doonbah will be critical for dispersing juvenile males, and overall to maintain genetic flow and prevent genetic bottlenecking.

Areas in the southern portion of Section 8 (e.g. Lang Hill and fringes of Broadwater National Park) were not surveyed during the current project, and it is recommended that surveys are conducted to inform the likely importance of this area for koala movement. Nonetheless, habitat is proposed to be cleared on Lang Hill to provide critical material for the project. Consequently, potential connectivity into Doonbah will be removed for a period of time from the west of the proposed alignment. Currently, Roads and Maritime own areas within the project boundary, and areas subject to excavation materials will be revegetated; however there will be a time-lag associated with this. While connectivity area 4 may facilitate infrequent movement in the short-term, this structure is likely to be more important for long-term mitigation following construction (Figure 6c). Despite this, mitigation measures and targeted restoration should be strongly considered on the eastern side of the proposed road alignment to facilitate and maintain connectivity into Doonbah. In its current state, connectivity in this area is likely to be limited, and is largely restricted to the fringes of the Broadwater National Park. Further assessments are required to confirm the availability of suitable koala habitat in this area, and to identify surrounding areas that are required for restoration to ensure connectivity is maintained.

Ongoing SAT surveys should be established and follow a regularised-grid design (similar to that used in other sections of this project) so that sites can be re-visited over time. Baseline data of koala presence now exists; however additional surveys in the southern portion of Section 8 (e.g. surrounding Lang Hill) are required. Ongoing koala surveys and monitoring at connectivity structures will allow Roads and Maritime to monitor the effectiveness of mitigation measures.

4.4 Section 9

The study area for Section 9 will be split and discussed in two areas: (Area 1) areas where the current Pacific Highway bisects the Broadwater National Park; and (Area 2) areas within close proximity to the township of Broadwater.

Area 1 - Broadwater National Park

The proposed road alignment in Area 1 of Section 9 follows the existing Pacific Highway which bisects the Broadwater National Park. For the most part, field survey results indicate that the Broadwater National Park is dominated by coastal heathlands, and as such is largely unsuitable for koalas. Despite this, two important connectivity pinch-points for koalas are evident (Figure 5c). Specifically, these include the northern and southern extents of where the Pacific Highway traverses the Broadwater National Park. Both locations contain a number of *E. robusta* (a PKFT) and koalas were recorded in both locations during field surveys (i.e. by Ecosure and Roads and Maritime contractors). These pinch-points are considered critical for the dispersal of koalas throughout the broader landscape. The northern most location provides a link between known populations in Rileys Hill and habitat to the east of Broadwater (discussed above) (Figure 5c), while the southern location provides the only suitable link for known koala populations between Rileys Hill to the north and Doonbah in the south (discussed for Section 8) (Figures 5b & 5c). Ensuring safe connectivity through these pinch-points will be essential to maintain koala persistence in the region, as will mitigating any increases to road collision mortalities. Ongoing koala surveys and monitoring of connectivity structures both areas will inform any changes in koala use and the effectiveness of structures. Due to the lack of suitable habitat, no further koala surveys would be required in the central portions of the Broadwater National Park.

Area 2 - Broadwater township

The proposed road alignment traverses areas to the east of the Broadwater township. Survey results, coupled with landholder observations, indicate that koalas use fragmented patches of potential koala habitat throughout this area. Although field surveys indicate that

Area 2 is unlikely to currently support a large resident population, it is considered a critical extension for dispersal and supplementary food provisions from known koala populations west at Rileys Hill. Area 2 is the northern most extent of koala habitat for koalas south of the Richmond River. Owing to the fragmented nature of potential koala habitat through Area 2, it will be important for dispersal and day-to-day movement to maintain connectivity on either side of the proposed road alignment (including connectivity across interchange roads at connectivity areas 8a and 8b – Figure 6d), as well as affording crossover via regular connectivity structures (Figure 5c). The current position of the road alignment through available habitat means that exclusion fencing for its entirety will be crucial to ensure road fatalities are not increased. In order to assess the effectiveness of mitigation measures, ongoing koala surveys and monitoring at connectivity structures will be important.

4.5 Section 10

Survey results support recent findings by Biolink (2013) and Roads and Maritime (2013a) that the proposed road alignment in Section 10 will be traversing an area likely to be supporting an important koala population as defined under the EPBC Act. Section 10 currently contains distinct resident koala populations, particularly in the southern and central portions of the study area. Current resident populations persist in two large contiguous forest patches associated with the Blackwall Range and areas to the east that are separated predominately by farmland. The considerable number of resident koala populations in this area coincides with larger areas of intact koala habitat, as well as a high availability of PKFTs; including *E. microcorys, E. tereticornis, E. robusta and E. propinqua.* It was recently demonstrated in Biolink (2013) that this area has been sustaining resident koala populations for at least the last six consecutive koala generations (i.e. 35 – 40 years), with isolated records back to the 1900s. In addition, this area is also considered likely to have sustained the ancestral source population for both the Lismore LGA to the west, and the coastal lowland areas of the Byron LGA to the north (Biolink 2013). The proposed road alignment is highly likely to bisect resident populations, and therefore potentially displace a considerable number of koalas. Revegetation and/or restoration will be essential to replace lost koala habitat in these areas, as will detailed monitoring plans to ensure koalas are safely and effectively relocated prior to clearing and construction phases. Preconstruction implementation of exclusion fencing and connectivity structures will be particularly important in this area to maintain natural movements and eliminate any elevations to mortality rates.

Survey results indicate that the proposed road alignment will bisect critical linkages between the aforementioned resident koala populations in Section 10. These linkages are highlighted in the southern extent of the study area (i.e. south of Old Bagotville Road) and in central portions around Wardell Road (Figures 5d & 5e). Notwithstanding this, there are also numerous locations in-between that contain sufficient scattered trees to afford potential koala movement across cleared farmland between contiguous forest patches (Figures 5d & 5e). By combining previous findings by Biolink (2013), with new survey results from this study, it is clear that the long-term persistence of koalas in Section 10 will hinge upon maintaining connectivity through the landscape and effective mitigation measures such as appropriately designed exclusions fencing to ensure there are no elevations in vehicle collision mortalities.

Ongoing koala surveys and monitoring of connectivity structures will be essential to assess the effectiveness of mitigation measures and the status of koala populations in Section 10. Considering the importance of this area for koalas, a tracking program would be beneficial to understand koala health and movement before, during, and after construction phases.

4.6 Section 11

Field survey results and landholder observations indicate that koalas regularly use this area, which is dominated by PKFTs (primarily *E. robusta*). Considering the stretch of poor quality habitat in the northern extent of Section 10, and known koala aggregations to the west in Coolgardie, this area is likely to form an important habitat extension in the region. This is the northern most available habitat for approximately five kilometres to the east of the proposed road alignment. Considering survey data suggests that koalas currently cross the Pacific Highway (Figure 5e), structure/s in this area will subsequently improve connectivity and will ensure safe movement and the continued use of available koala habitat. In addition, extending exclusion fencing from Section 10 to areas dominated by agricultural land use just north of this study area will minimise the likely impact of vehicle collisions on koalas.

- Chainages
- Section boundary
- 1 Recommended connectivity area and reference number
- Recommended restoration/revegetation subject to property acquisition and biodiversity offset opportunities

Koala movement

- Potential: based on available vegetation connecting suitable koala habitat
- Predicted: based on field survey results, preferred koala habitat and/or landholder liason

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Document

GW116_MP_Fig5_KoalaMovement

Job Number: GW116

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R0	MD	GB	ISSUED TO CLIENT	04/07/2014
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Metres

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Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
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Data Sources:
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- Ecosure Pty Ltd, 2014
- Image Source: Esri, DigitalGlobe, GeoEye, i-cubed, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Note: Arrows indicate potential koala use areas not exact koala movement pathways

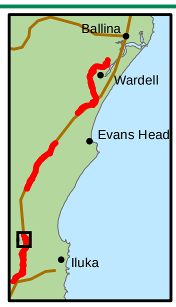

Figure 5 (a) Predicted koala movement for Section 5

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Woolgoolga to Ballina, NSW

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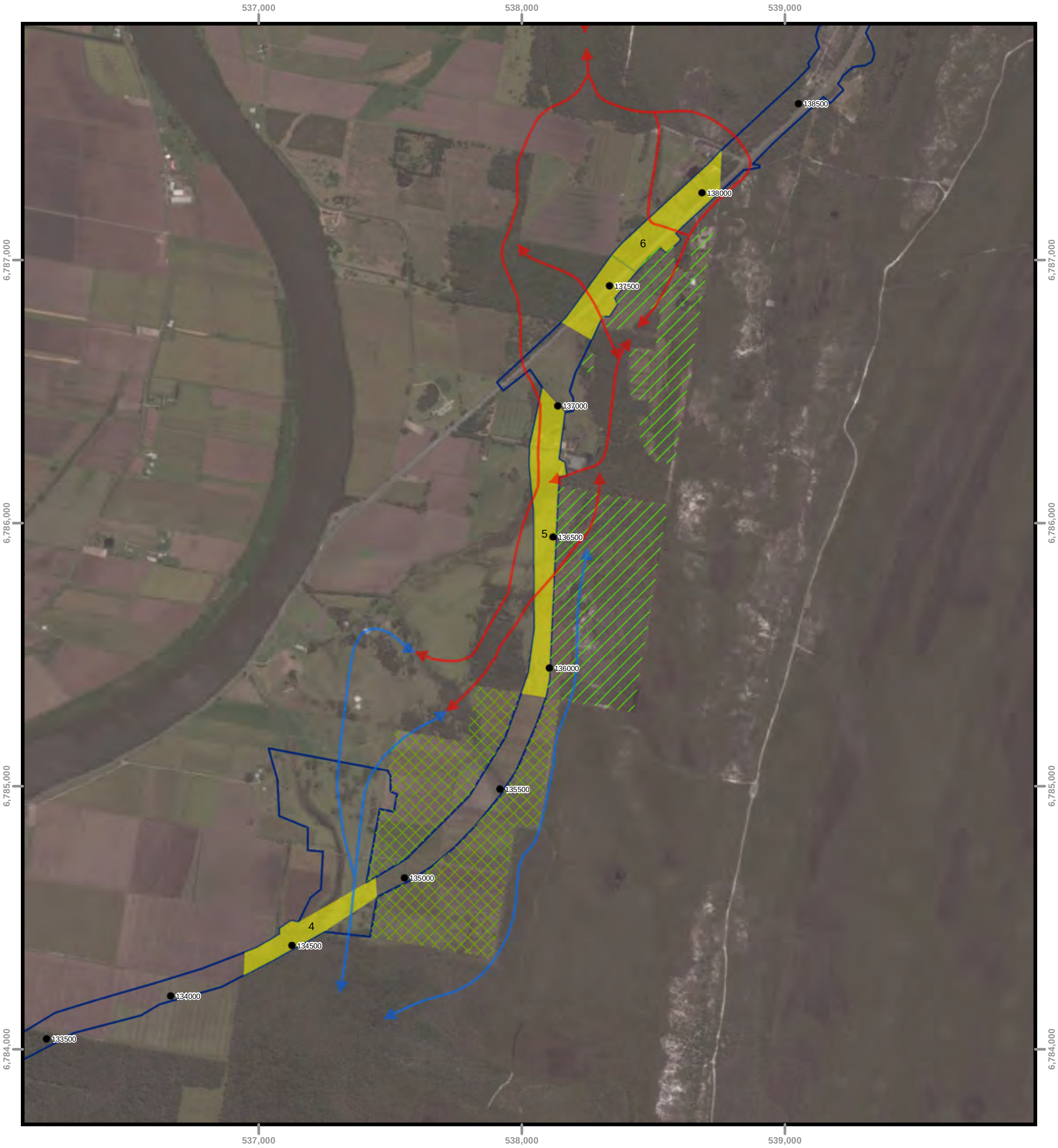

- Chainages
- Section boundary
- 1 Recommended connectivity area and reference number
- Recommended restoration/revegetation subject to property acquisition and biodiversity offset opportunities
- Consider restoration/revegetation, subject to property acquisition

Koala movement

- Potential: based on available vegetation connecting suitable koala habitat
- Predicted: based on field survey results, preferred koala habitat and/or landholder liason

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GW116_MP_Fig5_KoalaMovement

Job Number: GW116

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Note: Arrows indicate potential koala use areas not exact koala movement pathways

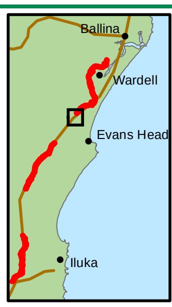

Figure 5 (b) Predicted koala movement for Section 8

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Pre-construction koala surveys

Woolgoolga to Ballina, NSW

A4

- Chainages
- Section boundary
- 1 Recommended connectivity area and reference number
- Recommended restoration/revegetation subject to property acquisition and biodiversity offset opportunities

Koala movement

- Potential: based on available vegetation connecting suitable koala habitat
- Predicted: based on field survey results, preferred koala habitat and/or landholder liason

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GW116_MP_Fig5_KoalaMovement

Job Number: GW116

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Note: Arrows indicate potential koala use areas not exact koala movement pathways

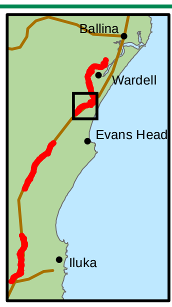


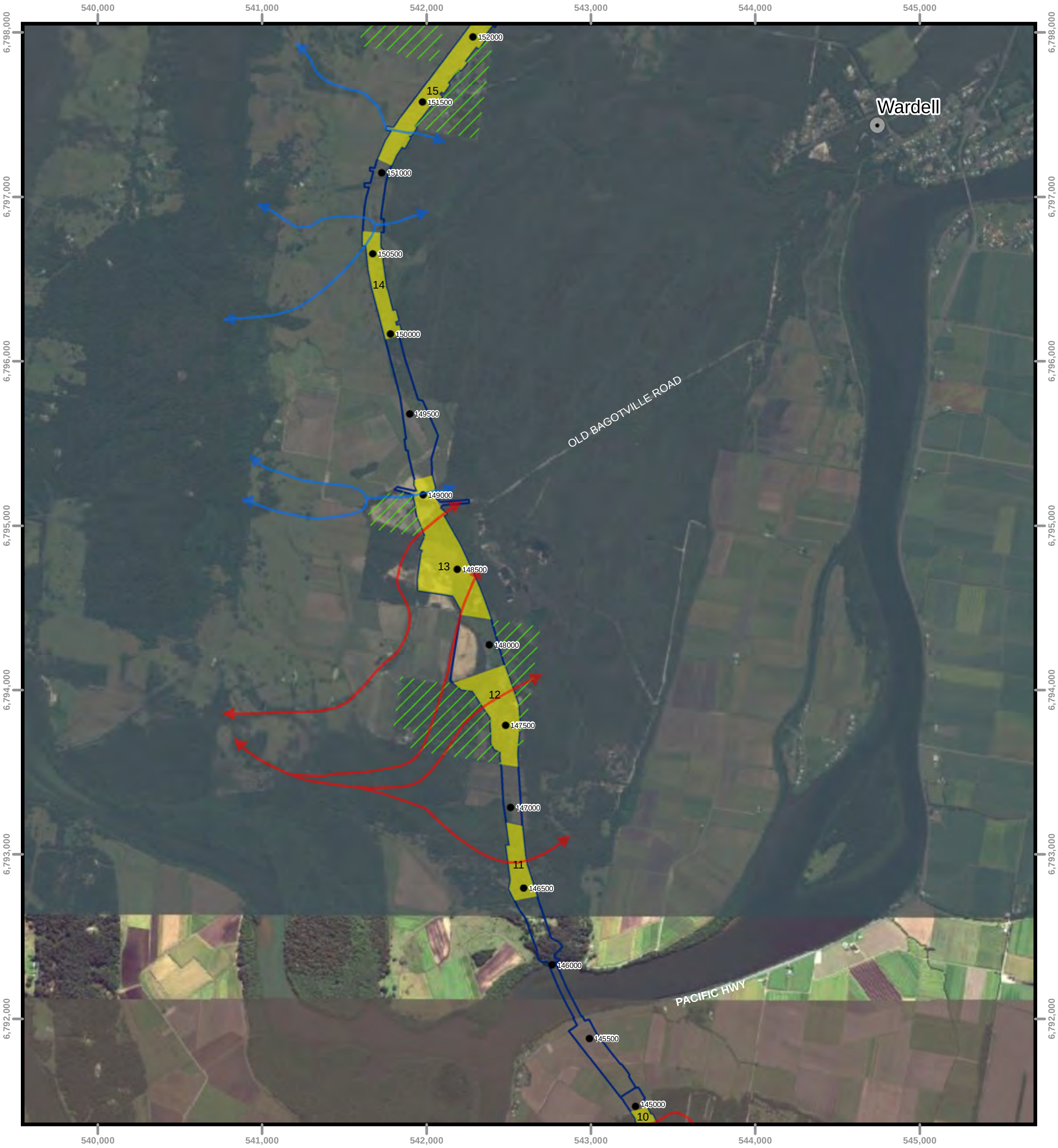
Figure 5 (c) Predicted koala movement for Section 9

Roads and Maritime Services

Pre-construction koala surveys

Woolgoolga to Ballina, NSW

A4



- Chainages
- Section boundary
- 1 Recommended connectivity area and reference number
- Recommended restoration/revegetation subject to property acquisition and biodiversity offset opportunities

Koala movement

- Potential: based on available vegetation connecting suitable koala habitat
- Predicted: based on field survey results, preferred koala habitat and/or landholder liason

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GW116_MP_Fig5_KoalaMovement

Job Number: GW116

Approved Project Manager		GB	03/10/2014
R1	MD	GB	ISSUED TO CLIENT	03/10/2014
R0	MD	GB	ISSUED TO CLIENT	04/07/2014
REV	BY	CHK	DESCRIPTION	DATE

0 125 250 500

Metres

Scale: 1:32,000 when printed at A4

Coordinate System: GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Units: Metre

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Note: Arrows indicate potential koala use areas not exact koala movement pathways

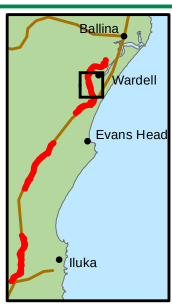


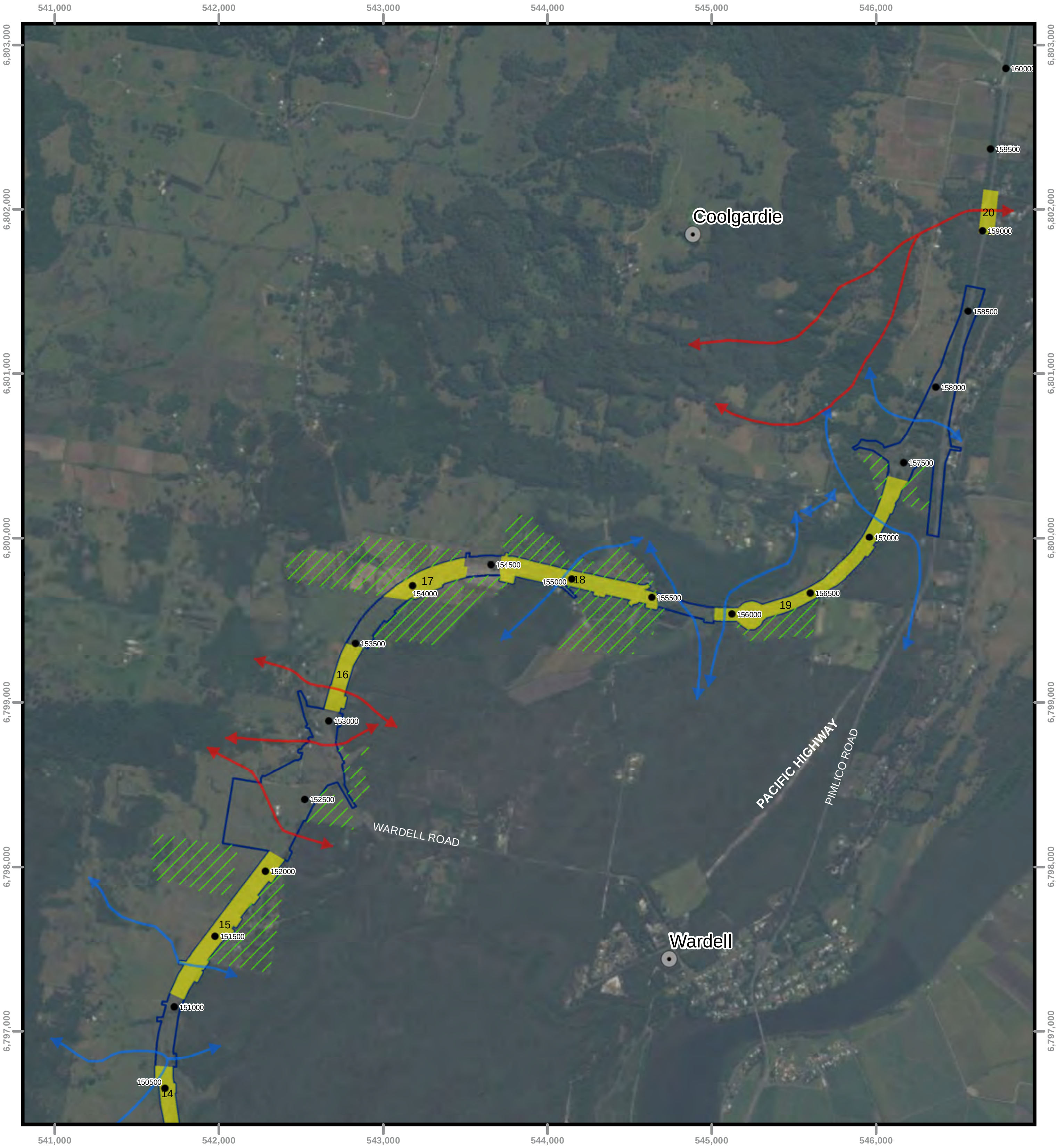
Figure 5 (d) Predicted koala movement for Section 10(i)

Roads and Maritime Services

Pre-construction koala surveys

Woolgoolga to Ballina, NSW

A4



Chainages

Section boundary

1 Recommended connectivity area and reference number

Recommended restoration/revegetation subject to property acquisition and biodiversity offset opportunities

Koala movement

Potential: based on available vegetation connecting suitable koala habitat

Predicted: based on field survey results, preferred koala habitat and/or landholder liason

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GW116_MP_Fig5_KoalaMovement

Job Number: GW116

Approved Project Manager		GB		03/10/2014
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0 125 250 500

Metres

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Note: Arrows indicate potential koala use areas not exact koala movement pathways

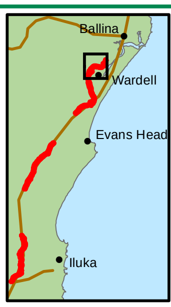


Figure 5 (e) Predicted koala movement for Section 10(ii) & 11

Roads and Maritime Services

Pre-construction koala surveys

Woolgoolga to Ballina, NSW

A4

5 Discussion and recommendations

Based on Ecosure's analysis of field data and provision of additional data from Roads and Maritime and local landowners, the following recommendations have been made with the aim to offer koala populations in the region the best chance of long-term persistence.

5.1 Connectivity structures

Maintaining functional connectivity through unimpeded movement and dispersal is essential to reduce in-breeding and maintain genetic flow, along with providing accessibility to additional resources (Taylor & Goldingay 2010; Brearley 2011). Artificial structures are becoming increasingly important management tools to maintain safe connectivity across roads and other linear infrastructure. Data on the use of connectivity structures by koalas is currently in its infancy; however there are some studies available that provide an indication of their likely effectiveness. Specifically in NSW, these studies include:

- Twelve successful koala crossings out of 31 structure uses in Bonville since 1999 (AMBS 2011).
- The use of underpasses by four koalas along the Brunswick Heads bypass (AMBS 2000).
- The use of underpasses by two koalas along the Bulahdelah to Coolongolook section of the Pacific Highway upgrade (AMBS 2001).
- The use of underpass by two koalas along the Taree section of the Pacific Highway upgrade (AMBS 2002).
- The use of a 2.4 metres x 1.2 metres culvert by two koalas near Brunswick Heads (Taylor & Goldingay 2003).

The evidence above indicates that culverts are used more frequently by koalas than land bridges. There are several possible explanations for this disparity; however the most general and probable explanation is the relative infancy and less frequent application of land bridges as a mitigation measure coupled with the time lags involved in establishing vegetation on new bridges and subsequent limited monitoring datasets (AMBS 2011). It is considered likely that koalas will use land bridges to cross roads; however their effectiveness will be determined by early planning and effective revegetation.

Beben (2012) indicated that the effectiveness of structures will be determined by considering a number of factors during the design stage to overcome common errors in width, height, angle etc. Specifically for koalas, recommended guidelines for crossing structures have been outlined in detail in EHP (2012) and are provided in Table 11.

Table 11 Recommended guidelines for koala crossing structures. Information sourced from EHP (2012). Recommendations on the use of exclusion fencing have been provided in section 5.3.

Structure type	Recommended guidelines
Underpasses	1. The underpass must be an appropriate dimension for the width of the road to allow natural night time light filtration into the structure: a. Underpasses that exceed 20 m in length have been found to be less effective than those that are less than 20 m, deterring koala use due to lack of natural light. New or upgraded roads requiring culverts to allow koala movement should be designed as split carriageways to avoid lengthy underpasses. b. The dimension of underpasses should be: ▪ Box culvert of 3m (H) x 3 m (W) – especially for four lanes or more; ▪ Box culvert of 1.5 m (H) x 1.5 m (W) as a minimum for a single or dual carriageway (this size may include koala furniture). 2. 'Koala furniture' is placed in the crossing structure to facilitate koala movement: a. Horizontal logs are placed as high off the ground as possible for koalas to avoid predators with a minimum space of 600 mm between the top of the horizontal log and the structure's roof; and b. Horizontal logs are supported by vertical logs at regular intervals (approximately 5 m) along the underpass for koalas to ascend or descend the koala furniture as required; and c. Logs are greater or equal to 150 mm in diameter, or horizontal planks are greater or equal to 150 mm in width; and d. Koala furniture extends beyond the underpass into koala habitat. 3. Underpass floors are designed to remain dry at all times except in significant rain events where the structure quickly dries out, or ledges or koala furniture are incorporated in the underpass to provide a dry path for movement. 4. Vegetation is retained up to the entrance/exit of the underpass but does not obstruct the access to the structure or the view to habitat beyond the underpass by animals entering the structure. 5. Koala exclusion fencing is used to funnel koalas to the underpass.
Overpasses	1. The overpass is as wide as possible, with a minimum width of 60 cm to comfortably accommodate the crossing of koalas. 2. The overpass is built with rigid or semi rigid materials that do not have a large degree of flexibility that a koala would find unstable traversing. 3. Vegetation or refuge poles are incorporated if the overpass (particularly if this is a land bridge) is accessible by predators. 4. Koala exclusion fencing is incorporated to funnel koalas to the crossing structure.
Additional requirements	1. Crossing structures are placed at regular intervals along sections of road adjacent to koala habitat or habitat linkages, at a maximum distance of one structure every 2 km; and 2. Sited where koala exclusion fencing of adequate length (a minimum of 150 m) on either side of crossing structure can be incorporated into the design; and 3. Designed with fencing that has a return at the completion of the koala exclusion fencing to encourage koalas back into habitat and not directly onto the road; and 4. Additional features, such as escape poles, koala gates or other designs, are used on the road side of the koala exclusion fencing to allow koalas trapped in the road corridor to exit to habitat. 5. Vegetated habitat linkages are retained or established by securing habitat on either side of the road.

5.2 Koala habitat restoration

Implementing habitat restoration (including revegetation) as part of the road management actions will be important to maintain or increase available koala habitat and connectivity throughout the landscape. Both actions will be essential to offer koala populations the best chance of survival, particularly in areas where the proposed road alignment bisects known koala populations and either removes available habitat or presents a barrier to dispersal. Ultimately, it has been found that the chances of koalas being present in an area declines rapidly as the percentage of koala habitat or overall forest cover falls below 60-70% of the landscape (McAlpine et al. 2005; 2006; 2007). In addition, there is also some evidence of critical patch size requirements for koalas, with koalas more likely to be absent from patches less than 50 ha in size (McAlpine et al. 2007), highlighting the need to replace and indeed enhance, any removed habitat in known koala areas (e.g. Section 10).

Areas offering the potential for koala habitat restoration have been highlighted in Figures 5a-f and are discussed in association with connectivity structures in Table 12. These areas are based on land that is owned by Roads and Maritime or currently in negotiation for purchase[3]. These areas will contribute towards two key outcomes for koala conservation throughout the area. These include:

- *An increase and/or enhancement in habitat availability* – Revegetation and/or restoration is highly recommended (where possible) to supplement habitat lost during road clearing, and to result in a net gain in habitat availability for koalas in the region.
- *An increase and/or enhancement in habitat connectivity* - These areas are essential in maintaining or increasing connectivity through the landscape, particularly in conjunction with recommended structures. In areas completely devoid of vegetation (e.g. no scattered trees), structures should not be implemented to avoid leading koalas into cleared landscapes unless targeted revegetation is possible to provide connectivity. Where able, it is highly recommended that land is revegetated and/or restored to facilitate continued koala connectivity in areas currently used naturally, or to increase connectivity in areas that currently retain little natural value (e.g. cleared farmland and/or agricultural areas).

It is recommended that a detailed restoration plan is developed preconstruction to guide early works and long-term maintenance, and ensure maximum success rates. It will be important to begin restoration works at the earliest possible stage (preconstruction) to afford koalas ‘usable’ habitat in the fastest possible timeframe.

[3] Revegetation/restoration areas are only provided as a ‘best case’ recommendation, and these may be subject to property acquisition and biodiversity offset opportunities to preserve the land in perpetuity.

The key findings of this study have identified the need to facilitate connectivity in 20 pinch point areas (Figures 6a-f). A detailed discussion of each area is provided in Table 12. It should be noted that connectivity structures are already planned by Roads and Maritime at a number of the locations recommended below.

Table 12 Proposed connectivity structure/s and sites for koala habitat restoration (figure and area reference numbers provided for Figures 6a-f). Current information includes results and findings from this survey (Ecosure), and takes into account Roads and Maritime land ownership for proposed revegetation/restoration opportunities.

Figure number	Recommended connectivity area reference no. & Roads and Maritime chainage reference	Connectivity structure/s	Koala habitat revegetation/ restoration	Survey information	Discussion & recommendation/s
Section 5					
6a	1 (95300–96000)	✓	✓	· Evidence of koala habitat use was recorded directly to the west of this area · PKFTs dominate much of the habitat throughout the landscape · Koala activity data indicates that koalas persist in this area.	This area is considered critical for koala movement throughout the landscape. It is likely that this area supports a threatened koala population, as indicated by the activity spatial modelling data. It is recommended that connectivity structures be implemented in this area to maintain movement of any remaining koalas in the region (Figure 5a), and provide an opportunity for population recovery through decreased mortality threats, and increased connectivity and habitat. It is also recommended that RMS owned land directly to the west be considered for revegetation to increase the amount of available koala habitat in the immediate vicinity.
6a	2 (96600-96800)	✓	×	· No evidence of habitat use was recorded at SAT sites · PKFTs are present throughout this area.	This area is likely to support a natural linkage for koalas, albeit infrequent. Without the ability to revegetate surrounding land (e.g. privately owned land), it is recommended that connectivity structure be considered for this area; however structures in connectivity area 1 will provide the best outcome.
Section 7					
6b	3 (117500–118800)	✓	×	· No evidence of habitat use was recorded at SAT sites · PKFTs are present throughout this area.	Although it is likely that koalas are either absent or in very low numbers in this area, it is recommended that structures be considered to maximize potential use by koalas and other fauna.

Figure number	Recommended connectivity area reference no. & Roads and Maritime chainage reference	Connectivity structure/s	Koala habitat revegetation/ restoration	Survey information	Discussion & recommendation/s
Section 8					
6c	4 (134200–135000)	✓	✓	· No surveys conducted · High resolution aerial imagery assessment	Based on high resolution mapping, this area is considered likely to be a critical pinch-point in the link between known koala populations to the north at Rileys Hill and Broadwater (Figure 5b), and those to the south around Doonbah. However, koala dispersal in the area is yet to be confirmed. It is recommended that surveys are conducted to inform the likely importance of this area for koala movement. Habitat will be cleared on Lang Hill for critical material for the project. As a result, potential connectivity into Doonbah will be removed for a period of time from the west of the proposed alignment. Currently, Roads and Maritime own areas within the project boundary, and areas subject to excavation materials will be revegetated; however there will be a time-lag associated with this. While connectivity area 4 may facilitate infrequent movement in the short-term, this structure is more important for long-term mitigation following construction. As a result, habitat restoration should be considered on the eastern side of the proposed road alignment to facilitate and maintain connectivity into Doonbah. In its current state, connectivity in this area is largely restricted to the fringes of the Broadwater National Park and further assessments are required to confirm the availability of suitable koala habitat, and to identify the areas that are required for revegetation to ensure connectivity is maintained.
6c	5 (135900–137000)	✓	✓	· A koala was observed in this area during recent surveys (Roads and Maritime) · Supplementary sites confirm koala habitat use within, and in the immediate vicinity on either side of the proposed road alignment	The proposed alignment will run in a north-south direction through this area, and given the fragmented and scattered nature of the vegetation that will remain of either side of the road alignment, it is highly recommended that potential connectivity is maintained. The majority of land surrounding connectivity area 5 is cleared for farmland. Despite this, the presence of scattered PKFTs and the recent koala record indicates that this area is frequently used by koalas. It is considered likely that koala's using this area move in a north-south direction and cross the proposed road alignment at connectivity area 6 (Figure 5b). Surrounding Roads and Maritime

Figure number	Recommended connectivity area reference no. & Roads and Maritime chainage reference	Connectivity structure/s	Koala habitat revegetation/ restoration	Survey information	Discussion & recommendation/s
					owned land affords the opportunity for revegetation, which would increase the availability of suitable koala habitat in this area. It is highly recommended that connectivity structures, in conjunction with targeted koala habitat revegetation, be implemented in this area to facilitate continued koalas movement through the landscape, as well as enable access to available habitat on either side of the proposed road alignment.
Section 9					
6d	6 (137300–138100)	✓	✓	· A koala was observed directly to the north of this area during recent surveys · This area contains a narrow strip of *E. robusta* (PKFT) on the eastern side of the road alignment · Supplementary sites confirmed koala habitat use approx. 5 km to the south of this area · The Broadwater National Park to the north contains no PKFTs.	The majority of habitat surrounding this area is unsuitable for koalas (e.g. coastal heathlands). Despite this, the presence of scattered PKFTs and the recent koala record indicates that this area is another pinch point for north-south koala movement throughout the region (Figure 5b & 5c). This is particularly important because of the known persistence of koalas in Riley's Hill to the north-west, the available linking habitat to the west of the Broadwater National Park, and the confirmed koala habitat use to the south of the area (Figure 5b & 5c). Surrounding Roads and Maritime owned land affords the opportunity for considerable revegetation and/or restoration, which would increase the availability of habitat significantly in this area. It is highly recommended that connectivity structures be implemented in this area to maintain this movement through the region, as well as in conjunction with targeted koala habitat revegetation.
6d	7 (140100–140600)	✓	×	· Koalas were observed in this area on two occasions (Roads and Maritime and Ecosure) · Supplementary sites confirmed koala habitat use approx. 1 km to the north-eat and to the west of this area · This area contains *E. robusta* (PKFT)	Discussions with caretakers from the Broadwater Koala Conservation Park (approx. 1 km north-east), indicated that this area is the southern extent of regular road fatalities before the BNP habitat begins. As a result, this area is considered critical as a pinch point to the east-west movement of koalas through the landscape (Figure 5c). It is recommended that connectivity structures be implemented here to eliminate current road fatalities and also to facilitate continued movement of koalas.

Figure number	Recommended connectivity area reference no. & Roads and Maritime chainage reference	Connectivity structure/s	Koala habitat revegetation/ restoration	Survey information	Discussion & recommendation/s
				· The Broadwater National Park to the south contains no PKFTs.	
6d	8 + 8a & 8b (143100-143500) 9 (142000–142300)	✓	✓	· Evidence of koala habitat use was determined at a SAT site directly to the east of connectivity area 9 · A koala was recorded at connectivity area 8, and landholder information indicates they are regularly observed in this area · Supplementary sites confirmed koala habitat use approx. 1.5 km to the west of connectivity area 8.	Both areas currently support scattered PKFTs and fragmented linkages through the landscape. Both areas are considered important for koala movement throughout the region. It is recommended that connectivity structures be implemented in these areas to afford safe koala movement between available habitats, and also to provide connectivity within close proximity of the interchange with Evans Head-Broadwater Road. It is also important to ensure that the distance between connectivity structures are not too great (e.g. between connectivity areas 7 and 10). It is recommended that interchange roads are fenced to prevent koalas entering the proposed road (discussed below). Despite this, it is critical to facilitate koala movement along the road alignment to retain access to habitat in the north-east. Ideally, crossing structures would be installed to allow safe passing of Broadwater-Evans Head road (connectivity areas 8a & 8b), as well as revegetation to enhance available habitat. If appropriate fencing design is implemented, this should eliminate koalas getting on to the road, while still ensuring individuals can disperse safely through the area.
6d	10 (144600-145000)	✓	✓	· No evidence of habitat use was recorded at SAT sites · Evidence of koala habitat use was found in a supplementary site directly to the east (<200 m) · A koala was recently recorded approximately 500 m to the south-west of this area	This area provides the northern most point of habitat for koalas in Section 9, and they are regularly observed in this area by landholders. Habitat to the west of the area contains limited KFTs; however there are scattered patches of PKFTs present. Connectivity structures are highly recommended in this area to allow continued east-west movement for koalas across the new road alignment.
Section 10					
6e	11 (146400–146900)	✓	×	· Evidence of koala habitat use was determined at SAT sites and supplementary sites.	These areas are considered critical for koala persistence and movement throughout the landscape. A resident koala population is present within this area and extends to the west and north-west.

Figure number	Recommended connectivity area reference no. & Roads and Maritime chainage reference	Connectivity structure/s	Koala habitat revegetation/ restoration	Survey information	Discussion & recommendation/s
	12 (147200–147900)	✓	✓	· Two koalas have recently been observed in the areas (both by landholders) · Koala habitat quality is considered high throughout this area, containing a high density of PKFTs	Natural habitat connectivity is considered to be high, as is habitat quality. Only one small section between connectivity areas 11 and 12 is unlikely to be important for koala east-west movement, and this area affords no current opportunities for future revegetation (e.g. privately owned land). In order to maintain continual koala movement through the landscape, it is recommended that connectivity structures be implemented in both areas 11 and 12. In addition, structures will also be important in conjunction with revegetation and/or restoration on Roads and Maritime land directly adjacent to connectivity area 12.
6e	13 (148200–149100)	✓	✓	· No evidence of koala habitat use was found in the immediate vicinity of this area · Koalas are known to persist in habitat within this area · Evidence supporting resident koala population is present for areas to the south (<1 km)	This area is considered important for koalas. Evidence of frequent use of this area is shown using koala activity contours. The nearby quarry affords an opportunity to increase available habitat. It is recommended that connectivity structures be implemented in this area to facilitate continued movement of koalas.
6e	14 (150000–150600)	✓	×	· Evidence of koala habitat use was recorded to the north-east and north-west · Koalas are known to persist in habitat directly adjacent to the north-east of the area · The landscape to the west of this area is predominately cleared farmland; however scattered trees are likely to support natural east-west linkages.	This area is likely to support infrequent east-west movement through the landscape. There are no opportunities for revegetation on land to the west (i.e. privately owned). It is recommended that a small number of connectivity structures be considered for this area to maintain any current koala movement and also ensure the distance between structures (in areas 13 and 15) are not too large.
6e	15 (151000–152100)	✓	✓	· Evidence of koala habitat use was recorded to the north-east and north-west.	This area is considered important for koala east-west movement through the landscape. While current movement is likely to be infrequent, surrounding Roads and Maritime owned land affords the

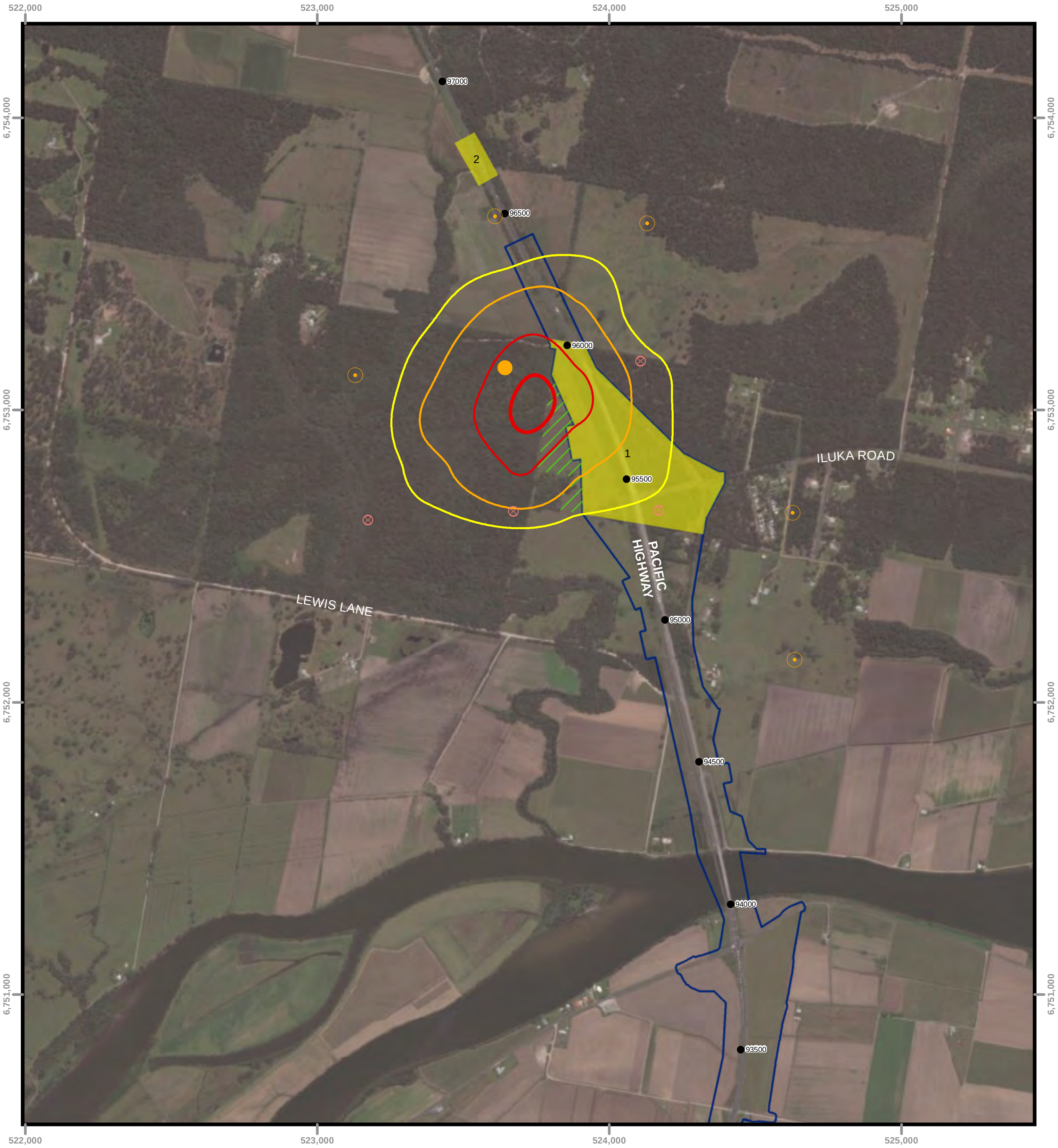
Figure number	Recommended connectivity area reference no. & Roads and Maritime chainage reference	Connectivity structure/s	Koala habitat revegetation/ restoration	Survey information	Discussion & recommendation/s
				· Koalas are known to persist in habitat directly adjacent to the east of the area · The landscape to the west of this area is predominately cleared farmland; however scattered trees are likely to support natural east-west linkages.	opportunity for considerable revegetation. This revegetation would increase the connectivity of known resident koalas in populations to the east and the west. This would also increase habitat availability throughout the landscape. It is recommended that connectivity structures are implemented in this area to facilitate increased movement of koalas through the landscape.
6f	16 (153000–153500)	✓	×	· No evidence of koala habitat use was found in the immediate vicinity of this area; however access was difficult in some locations · Koala were recently recorded in two locations within 500 m of the area (Ecosure, and landholder) · Koalas are known to persist in habitat to the west and south of the area · PKFTs are present throughout the surrounding areas.	This area is considered critical for koala east-west movement through the landscape. It is recommended that connectivity structures be implemented in this area to facilitate movement of koalas through the landscape.
6f	17 (153800–154300)	✓	✓	· No evidence of koala habitat use was found in the immediate vicinity of this area · Land directly adjacent to the road alignment is typically cleared · A recent koala record (landholder) is present approx. 500 m to 1 km south of the area · Koalas are known to persist within 500 m of this area.	While it is considered unlikely that this area forms an important natural linkage in its current form, an opportunity is present for considerable bushland revegetation on Roads and Maritime land. This revegetation would link current habitat and also increase habitat availability and connectivity in the area. It is recommended that structures are considered for this area in conjunction with revegetation.
6f	18 (154500–155600)	✓	✓	· No evidence of koala habitat use was found in the immediate vicinity	This area should be considered for connectivity structures due to the presence of contiguous habitat and scattered patches containing

Figure number	Recommended connectivity area reference no. & Roads and Maritime chainage reference	Connectivity structure/s	Koala habitat revegetation/ restoration	Survey information	Discussion & recommendation/s
				of this area · Koala habitat quality is typically poor (e.g. rainforest, weeds); however a few small patches on PKFTs exist to the east and west of the road alignment.	PKFTs. This area also affords the opportunity for revegetation/restoration on Roads and Maritime land to increase habitat availability and connectivity.
6f	19 (155900–157400)	✓	✓	· No evidence of koala habitat use was found in the immediate vicinity of this area · Koala habitat quality is typically poor (e.g. rainforest, weeds); however a few small patches on PKFTs exist to the east and west of the road alignment · A koala was observed approx. 500 m to 1 km to the north of this area · Supplementary surveys also found evidence of recent koala habitat use approx. 500 m to 1 km to the north of this area.	This area should be considered for connectivity structures due to the contiguous habitat present through the area. While the majority of this habitat is considered poor for koalas, the area does provide sufficient patches of PKFTs to suggest occasional use. Furthermore, historical and local records indicate that koalas are occasionally present in this area. At this stage, a fauna land bridge is proposed in this area. A fauna land bridge is considered unsuitable, and instead it is recommended that this is replaced by underpasses, and the cost saving be allocated towards structures in more suitable locations and revegetation efforts to enhance available habitat.
Section 11					
	20 (159000–159300)	✓	×	· Supplementary surveys found evidence of recent koala habitat use · Area contains primary koala food tree, (PKFT) swamp mahogany (*E. robusta*). · Area directly to the south contains poor quality koala habitat (e.g. no PKFTs), and are unlikely to be used on a regular basis	This area supports a natural linkage for koalas, although in its current state traverses the Pacific Highway. Owing to the lack of habitat and opportunities for revegetation/restoration directly to the south, it is important to maintain connectivity in this area. Subsequently, it is recommended that structure/s be included in this area to improve connectivity and reduce risks of mortality for koalas through the landscape.

Figure number	Recommended connectivity area reference no. & Roads and Maritime chainage reference	Connectivity structure/s	Koala habitat revegetation/ restoration	Survey information	Discussion & recommendation/s
				· No opportunities currently exist directly to the south that afford revegetation/restoration (e.g. Roads and Maritime owned land)	

NOTE: Recommendations for revegetation/restoration are provided as a 'best case' scenario and that the ability to implement these will be subject to property acquisition and biodiversity offset opportunities to preserve the land in perpetuity.

PKFTs = known preferred koala food trees (*Eucalyptus robusta, E. tereticornis, E. propinqua* and/or *E. microcorys*)



- Chainages
- Section boundary
- 1 Recommended connectivity area and reference number
- Recommended restoration/revegetation subject to property acquisition and biodiversity offset opportunities

SAT survey records

- Positive
- Negative
- No access

Activity contour

- 3%
- 10%
- 23%
- 33%

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Document
GW116_MP_Fig6_Structures

Job Number: GW116

Approved Project Manager		GB		09/10/2014
R2	MD	GB	UPDATED STRUCTURES	09/10/2014
R1	MD	GB	ISSUED TO CLIENT	03/10/2014
R0	MD	GB	ISSUED TO CLIENT	04/07/2014
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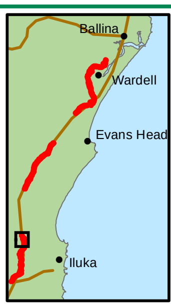

Figure 6(a): Proposed connectivity structures and revegetation/restoration areas for Section 5

Roads and Maritime Services

Pre-construction koala surveys

Woolgoolga to Ballina, NSW

A4

● Chainages

Section boundary

1 Recommended connectivity area and reference number

SAT survey records

Negative

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GW116_MP_Fig6_Structures

Job Number: GW116

Approved Project Manager		GB		09/10/2014
R2	MD	GB	UPDATED STRUCTURES	09/10/2014
R1	MD	GB	ISSUED TO CLIENT	03/10/2014
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REV	BY	CHK	DESCRIPTION	DATE

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Metres

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Coordinate System: GDA 1994 MGA Zone 56
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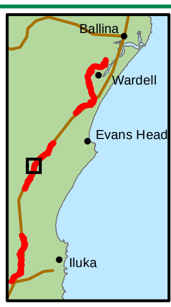

Figure 6(b): Proposed connectivity structures and revegetation/restoration areas for Section 7

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Pre-construction koala surveys

Woolgoolga to Ballina, NSW

A4

- Chainages
- Section boundary
- 1 Recommended connectivity area and reference number
- Recommended restoration/revegetation subject to property acquisition and biodiversity offset opportunities
- Consider restoration/revegetation, subject to property acquisition

SAT survey records

- Negative

Koala records

- Koala sighting
- Koala sighting (RMS)
- Positive supplementary site

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Job Number: GW116

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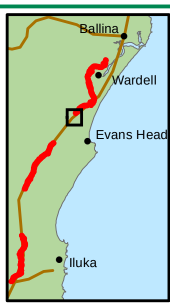

Figure 6(c): Proposed connectivity structures and revegetation/restoration areas for Section 8

Roads and Maritime Services

Pre-construction koala surveys

Woolgoolga to Ballina, NSW

A4

- Chainages
- Section boundary
- 1 Recommended connectivity area and reference number
- Recommended restoration/revegetation subject to property acquisition and biodiversity offset opportunities

SAT survey records
- Positive
- Negative
- No access

Koala records
- Koala sighting
- Koala sighting (RMS)
- Koala sighting (landholder)
- Positive supplementary site

Activity contour
- 3%

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Job Number: GW116

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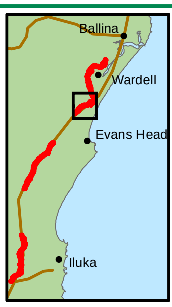

Figure 6(d): Proposed connectivity structures and revegetation/restoration areas for Section 9

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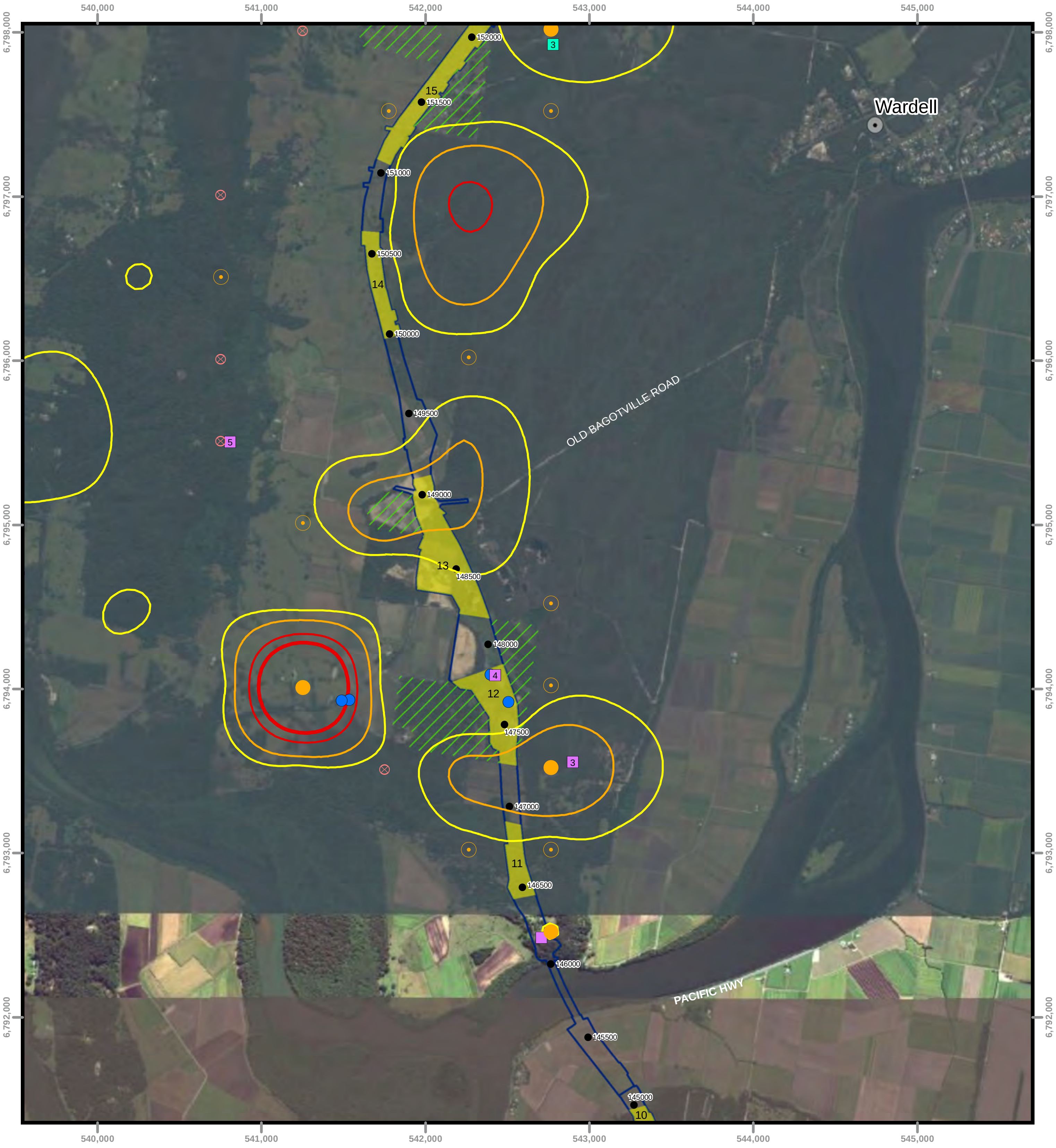
Pre-construction koala surveys

Woolgoolga to Ballina, NSW

A4



- Chainages
- Section boundary
- 1 Recommended connectivity area and reference number
- Recommended restoration/revegetation subject to property acquisition and biodiversity offset opportunities

SAT survey records
- Positive
- Negative
- No access

Koala records
- Koala sighting (RMS)
- Koala sighting (landholder)
- Positive supplementary site

Activity contour
- 3%
- 10%
- 23%
- 33%

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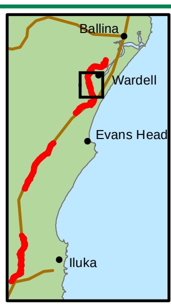

Figure 6(e): Proposed connectivity structures and revegetation/restoration areas for Section 10(i)

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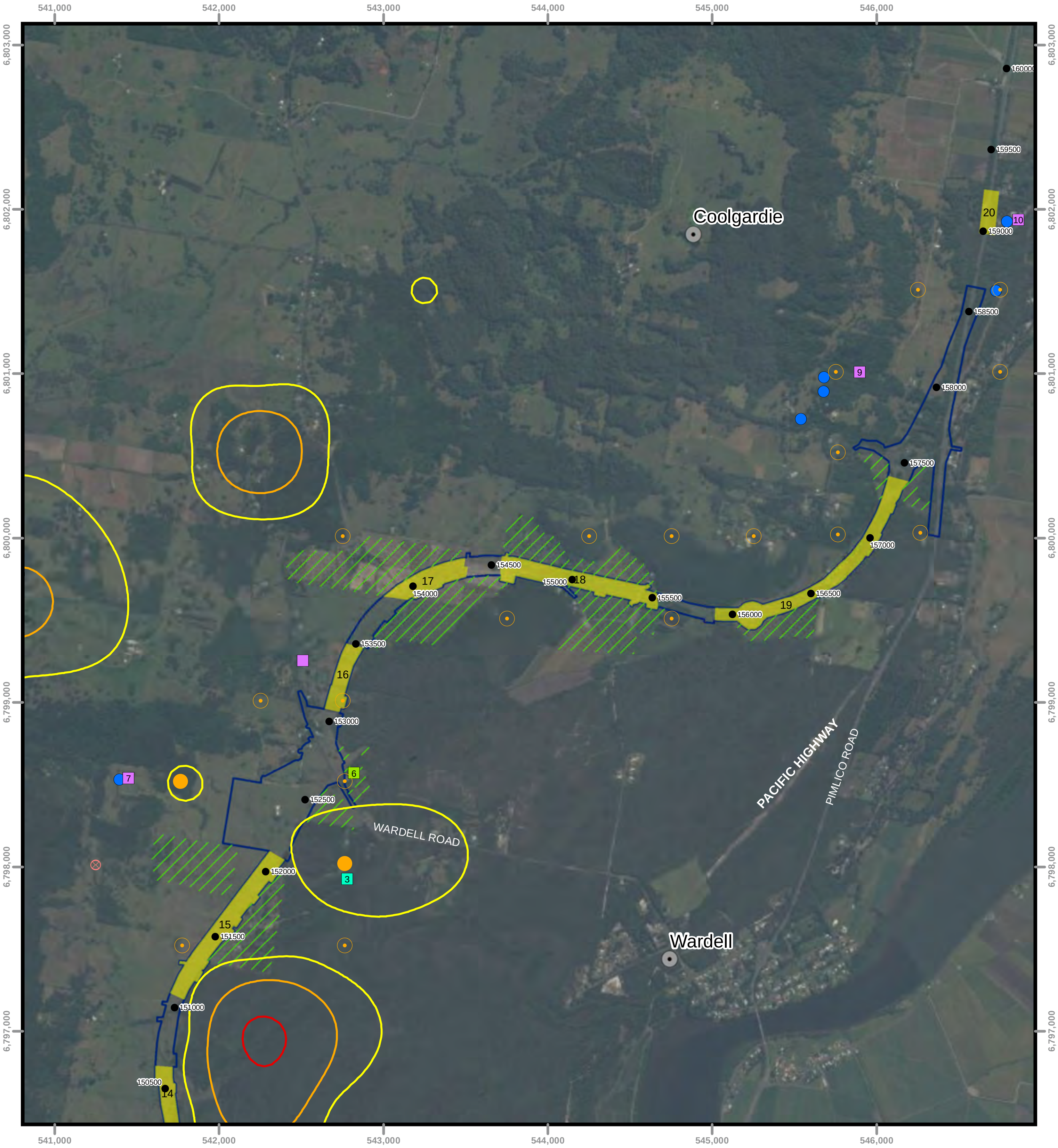
Pre-construction koala surveys

Woolgoolga to Ballina, NSW

A4



- Chainages
- Section boundary
- 1 Recommended connectivity area and reference number
- Recommended restoration/revegetation subject to property acquisition and biodiversity offset opportunities

SAT survey records
- Positive
- Negative
- No access

Koala records
- Koala sighting
- Koala sighting (RMS)
- Koala sighting (landholder)
- Positive supplementary site

Activity contour
- 3%
- 10%
- 23%

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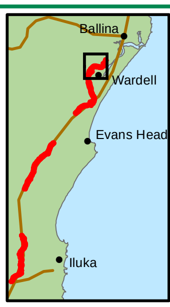

Figure 6(f): Proposed connectivity structures and revegetation/restoration areas for Section 10(ii) & 11

Roads and Maritime Services

Pre-construction koala surveys

Woolgoolga to Ballina, NSW

A4

5.3 Exclusion fencing

In a general sense, appropriately designed wildlife exclusion fencing should be installed in all areas where: (a) there are connectivity structures present, and (b) where vegetation abuts the proposed road alignment. Appropriately designed wildlife exclusion fencing in these areas will be essential to maintain koala persistence. Not only does fencing provide a directional push towards safe crossing structures, it also prevents arguably the most critical impact of roads on wildlife: elevated mortality rates from vehicle collisions (Rhodes et al. 2014). There have been a number of studies that provide insight into the likely impact of the proposed road alignment on koala mortality. While AMBS (2012) provide a suggestion for habituation to roads, they also show overwhelming evidence for mortality of koala near roads, with 65 known koala deaths in the study area between 2000 and 2010. There have been numerous studies along the east coast of Australia that have shown the devastating impact of vehicle collisions on koalas. A study on the Koala Coast (QLD) reported more than 300 koala vehicle collisions annually with over 80% resulting in death (Kraschnefski 1999; Dique et al. 2003). Additionally, an assessment by Preece (2009) found that vehicle collisions were the single largest cause of koala death in south-east QLD, being responsible for 35% of mortalities. In NSW, records at the Port Macquarie Koala Hospital (NSW) indicate more that 30% of the koalas that died in care had been involved in vehicles collisions (Canfield, 1987), while on Phillip Island in Victoria, road mortality has accounted for more than 60% of total mortality (Backhouse & Crouch 1990).

Even if the notion is true that *dispersing koalas are at a greater risk*, the introduction of a ‘new’ motorway will elevate mortality rates due to a lack of familiarity. This is particularly true for areas in Sections 8, 9 and 10, where there are currently no major roads. However, with the exception of Section 7 where koalas are likely to be absent or very infrequent, all other study areas currently located on the Pacific Highway (e.g. Section 5, the southern portion of Section 9, and the northern portion of Section 10) are still considered to present a very high risk of elevated mortality with the road upgrade. An example of the potential risk posed by a new road is illustrated by Jones (2000), who demonstrated that the extinction of a population of eastern quolls (*Dasyurus viverrinus*) in Tasmania could be attributed to an increase in vehicle collision mortalities due to a new road upgrade and subsequent higher vehicle speeds.

Early establishment of fencing will ultimately be essential to guide and maintain effective use of connectivity structures by koalas and other fauna, but most importantly will minimise any potential elevation to vehicle collision mortality rates. Despite this, there are a number of factors that must be considered to ensure exclusion fencing is successful for koalas. These include a combination of timing, design and maintenance, and extent.

5.3.1 Timing

AMBS (2012) highlighted a clear disparity between the effectiveness of temporary and permanent exclusion fencing during construction. In this study, temporary exclusion fencing during construction was found to have numerous weak spots and on the whole was ineffective in preventing koala road collisions. As a result, seven koalas were killed during this phase. Conversely, only one koala was killed due to a vehicle collision once permanent fencing has been erected. It is recommended that the following strategies be implemented by Roads and Maritime for the current project:

1. Confirm the detailed design and implementation plan for all permanent exclusion fencing prior to construction.
2. Permanent exclusion fencing must be implemented early in the construction phase, or ideally prior to any construction.
3. Permanent exclusion fencing must be in place before koala breeding and dispersal periods.

5.3.2 Design and maintenance

Appropriately designed and implemented exclusion fencing is the only mitigation measure that can all but eliminate the impact of vehicle collision mortality on koala. The most appropriate koala exclusion fencing comprises three primary designs (EHP 2012).

1. Fence is unclimbable (e.g. brick, metal sheeting etc.).
2. Fence is chain wire with a floppy top that falls in the direction of the vegetation (i.e. area koala will be climbing from) (Figure 7).
3. Fence is climbable but comprises smooth sheeting or perspex of at least 600 millimetres in width on the top of the fence (including posts and supports) (Figure 8).

For the current road project it is likely that the latter two designs would be the most appropriate.

Figure 7 Floppy wire koala exclusion fence design (picture from EHP 2012).

Figure 8 Koala exclusion fencing showing climbable materials with unclimbable metal sheet along the top (picture from EHP 2012)

In addition to fence type, there are a number of design characteristics and vegetation maintenance actions that must be considered to ensure fencing is effective. All characteristics outlined below are provided in detail in EHP (2012).

Design characteristics

- All bracing and/or supports must be on the roadside of the fence to eliminate access by koalas.
- The top of the fence (e.g. floppy wire or unclimbable sheet) must be at least 1.5 metres from the ground. This will prevent koalas from jumping up and gripping the top of the fencing.
- Where the ground in uneven or undulating, fencing must extend to ground level.

Vegetation maintenance

Maintenance of all adjacent vegetation is essential to prevent opportunities for koalas to climb over the fence. This includes (i) removing all trees and shrubs from within 3 metres of the fence, (ii) keeping adjacent canopies of trees trimmed to remove links over the fence, and (iii) removing fallen branches and any vines growing on the fence. Maintaining vegetation adjacent to the exclusion fencing is critical to achieving maximum effectiveness. During a study conducted at Bonville (AMBS 2012), one radio-collared koala successfully scaled an exclusion fence by using an adjacent tree fern. This highlights the importance for strict vegetation buffers and regular maintenance along all exclusion fences.

5.3.3 Extent

AMBS (2012) highlighted a potential issue with gaps in exclusion fences at locations like road intersections, whereby koalas were recorded moving along fence lines and were subsequently killed on the road just past the fence edge. These findings have implications for the effective design and extent of exclusion fencing. AMBS (2012) provided some vital insights that must be considered when guiding the development of fencing for this project. It should be noted that at this stage fencing can only be achieved within the approved project boundary. In some instances (e.g. interchanges), 'best practice' fencing recommendations may extend beyond the project boundary. It is recommended that further discussions are conducted to negotiate the extension of these fences on local council roads, or with adjacent land holders. These include:

- Fences should extend well beyond the edge of forested habitats so that koalas cannot easily turn onto the road when they reach the end of the fence.
- Where fences cannot extend beyond the forested edge they should have return ends that run along the edge of the habitat away from the road.
- Side roads should have return edges to turn koalas back into the forest and away from the road.
- Where possible, side roads should have gates with signage indicating the importance of their purpose.

- Connectivity structures should be frequently located to give koalas easier or ‘earlier’ options to get through the fence before reaching its ends.

Areas requiring consideration of the aforementioned guidelines are discussed in Table 13.

Table 13 Fencing extents recommended at key interchanges within the proposed road alignment (figure and area reference numbers provided for Figures 9a-h).

Project Section	Figure No.	Intersection and/or side road	Discussion & recommendations
5	9a	Iluka Road	High quality koala habitat abuts the Iluka Road interchange. This area is considered critical for road mitigation to allow continued dispersal and population recovery. It is highly recommended that exclusion fencing be installed along Iluka Road (as far as possible) to prevent koalas entering the Pacific Highway and to prevent increases to vehicle collision mortalities. Fences should have return edges to turn koalas back into the forest and away from the road.
8	9b	Pacific Highway	The proposed road alignment veers south away from the current Pacific Highway in the northern portion of Section 8. It is recommended that exclusion fencing be installed along the current Pacific Motorway to the Rileys Hill Road interchange in order to exceed forested habitat.
9	9c	Pacific Highway	The proposed road alignment veers east away from the current Pacific Highway in order to bypass Broadwater township. It is recommended that exclusion fencing be installed along the current Pacific Motorway into cleared areas containing no forested habitat.
9	9d	Pacific Highway	The proposed road alignment intersects with Evans Head-Broadwater Road in an area containing koala habitat, and not far from a recent koala record. In order to reduce any elevated road mortalities it is recommended that exclusion fencing continue along Evans Head-Broadwater Road. Specifically, this includes: · fencing to the north is recommended to exceed forest habitat (approx. 400 m) · to the south fencing should extend into coastal heathlands habitat that is unsuitable for koalas (approx. 200 m). As per Table 12, it is recommended that connectivity structures be implemented within close proximity of this interchange to provide koalas with earlier and safer avenues across the fence. Connectivity structures will also be essential to facilitate safe movement across Evans Head-Broadwater Road to maintain dispersal through the area (Figure 5b).
10	9e	Old Bagotville Road	The proposed road alignment intersects with Old Bagotville Road in an area identified as containing a resident koala population. This area is considered to be a critical natural linkage and hot spot for koalas throughout the landscape. In order to reduce any elevated road mortalities it is recommended that exclusion fencing be implemented along Old Bagotville Road away from the proposed road alignment. Specifically this includes: · Fencing to the west/south-west is only required to exceed forest habitat (approx. 200 m), and must be installed on the road side of the current PKFTs fringing Old Bagotville Road. This will ensure koala movement is directed to the outside of the fence. · To the east, fencing should extend into coastal heathlands habitat that is unsuitable for koalas (approx. 500 m), and should have return edges to turn koalas back into the forest and away from the road If possible, gates with signage indicating the importance of their purpose should be considered for Coolgardie Road.

Project Section	Figure No.	Intersection and/or side road	Discussion & recommendations
			As per Table 12 it is recommended that numerous connectivity structures be implemented within close proximity of this interchange to provide koalas with earlier and safer avenues across the fence. Structures should also be considered on Wardell Road within close proximity of the proposed road alignment. This is particularly important in this area as it currently supports resident koalas.
10	9f	Wardell Road	The proposed road alignment intersects with Wardell Road in an area within close proximity to an identified resident koala population and recent koala records. This area is considered an important natural linkage for koalas through the landscape, and as a result, in addition to maintaining connectivity, reducing elevated road mortalities will be critical. Where possible, exclusion fencing is recommended along Wardell Road from the interchange, and should have return edges to turn koalas back into the forest and away from the road. If possible, gates with signage indicating the importance of their purpose should be considered for Wardell Road. As per Table 12 it is recommended that numerous connectivity structures be implemented within close proximity of this interchange to provide koalas with earlier and safer avenues across the fence. Structures should also be considered on Wardell Road within close proximity of the proposed road alignment.
10	9g	Lumleys Lane	Exclusion fencing is recommended on Lumleys Lane (approx. 200 m) where it heads south from the proposed road alignment. Fencing is only required to exceed forested habitat areas. While field surveys indicated that this area does not currently support resident koala aggregations, it is considered likely that koalas disperse through this area infrequently. In addition, Roads and Maritime owned land in this area provides opportunities to increase its use by koalas in the future.
10	9h	Pacific Highway	Where the proposed road alignment rejoins the current Pacific Highway it is recommended that exclusion fencing is also installed heading south along the Pacific Highway. As per Table 12 it is recommended that connectivity structures be implemented just south of this interchange to provide koalas access to the west from this habitat bottleneck.
10	9h	Coolgardie Road	Koalas are known to occur in areas immediately to the west of the Coolgardie Road interchange. This area is an important linkage for koalas through the landscape, and as a result it will be important to extend exclusion fencing west along Coolgardie Road. Fences should be positioned on the road side of fringing vegetation, and should have return edges to turn koalas back into the forest and away from the road. If possible, gates with signage indicating the importance of their purpose should be considered for Coolgardie Road.

NOTE: At this stage fencing can only be achieved within the approved project boundary. In some instances (e.g. interchanges), 'best practise' fencing recommendations may extend beyond the project boundary. It is recommended that further discussions are conducted to negotiate the extension of these fences on local council roads.

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Document
GW116_MP_Fig9_Fencing

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Metres

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Recommended exclusions fencing

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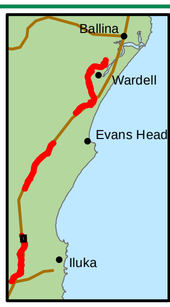

Figure 9(a): Recommended exclusions fencing for key road interchanges in Section 5 (Iluka Road)

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Woolgoolga to Ballina, NSW

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Projection: Transverse Mercator
Datum: GDA 1994
Units: Metre

Recommended exclusions fencing

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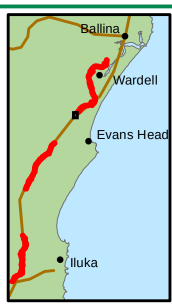

Figure 9(b): Recommended exclusions fencing for key road interchanges in Section 8 (Pacific Highway)

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Pre-construction koala surveys

Woolgoolga to Ballina, NSW

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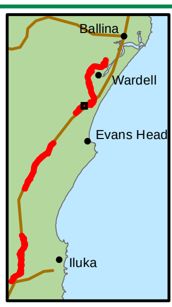

Figure 9(c): Recommended exclusions fencing for key road interchanges in Section 9 (Pacific Highway)

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Pre-construction koala surveys

Woolgoolga to Ballina, NSW

Recommended exclusions fencing

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Metres

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Recommended exclusions fencing

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Figure 9(d): Recommended exclusions fencing for key road interchanges in Section 9 (Pacific Highway)

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Woolgoolga to Ballina, NSW

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Recommended exclusions fencing

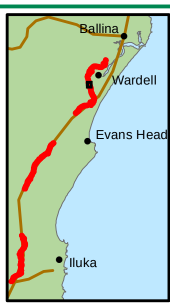

Figure 9(e): Recommended exclusions fencing for key road interchanges in Section 10 (Old Bagotville Road)

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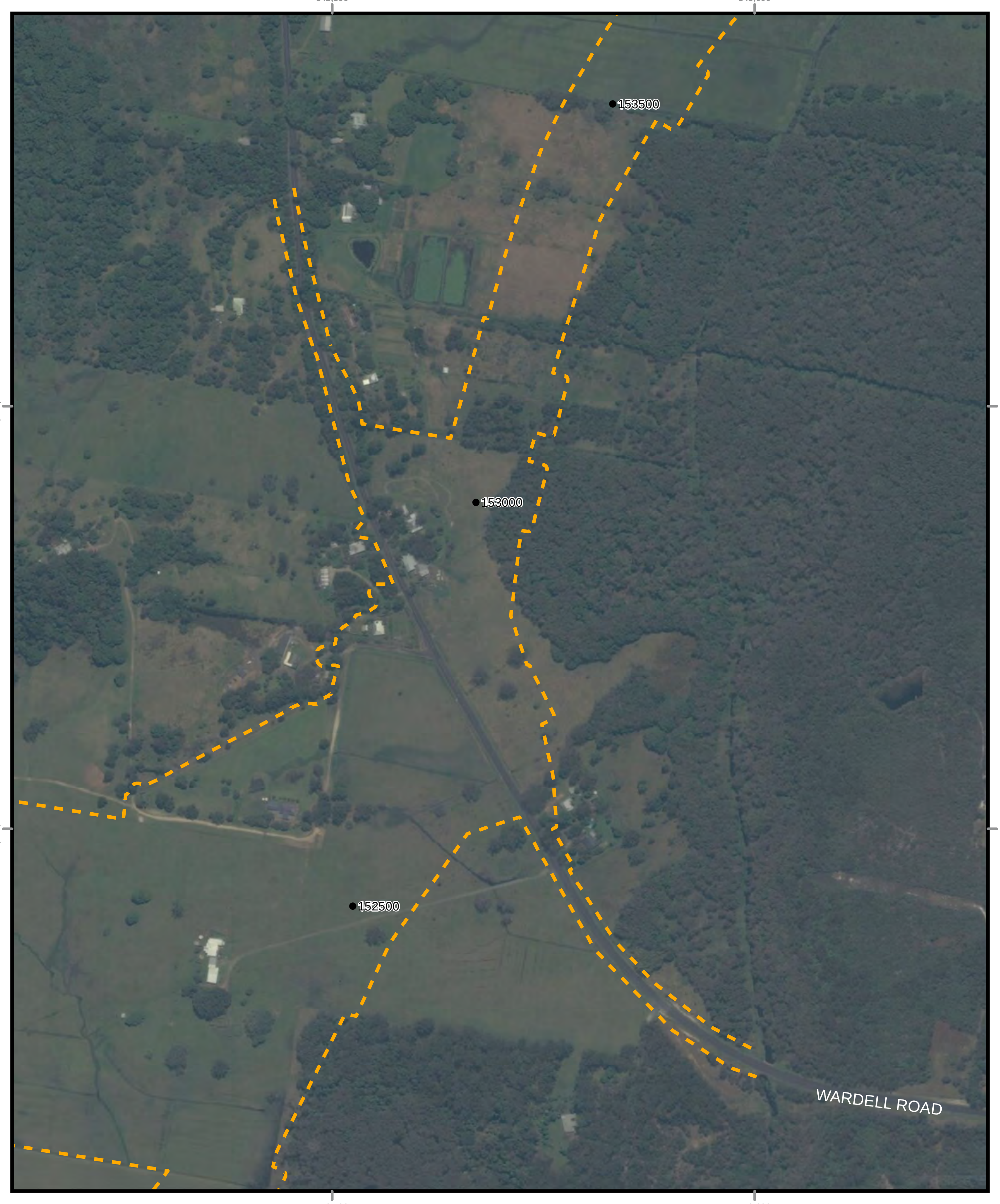

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GW116_MP_Fig9_Fencing

Job Number: GW116

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Metres

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Coordinate System:
GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
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Recommended exclusions fencing

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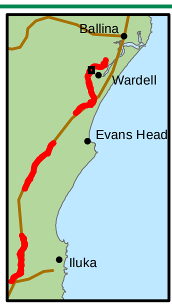


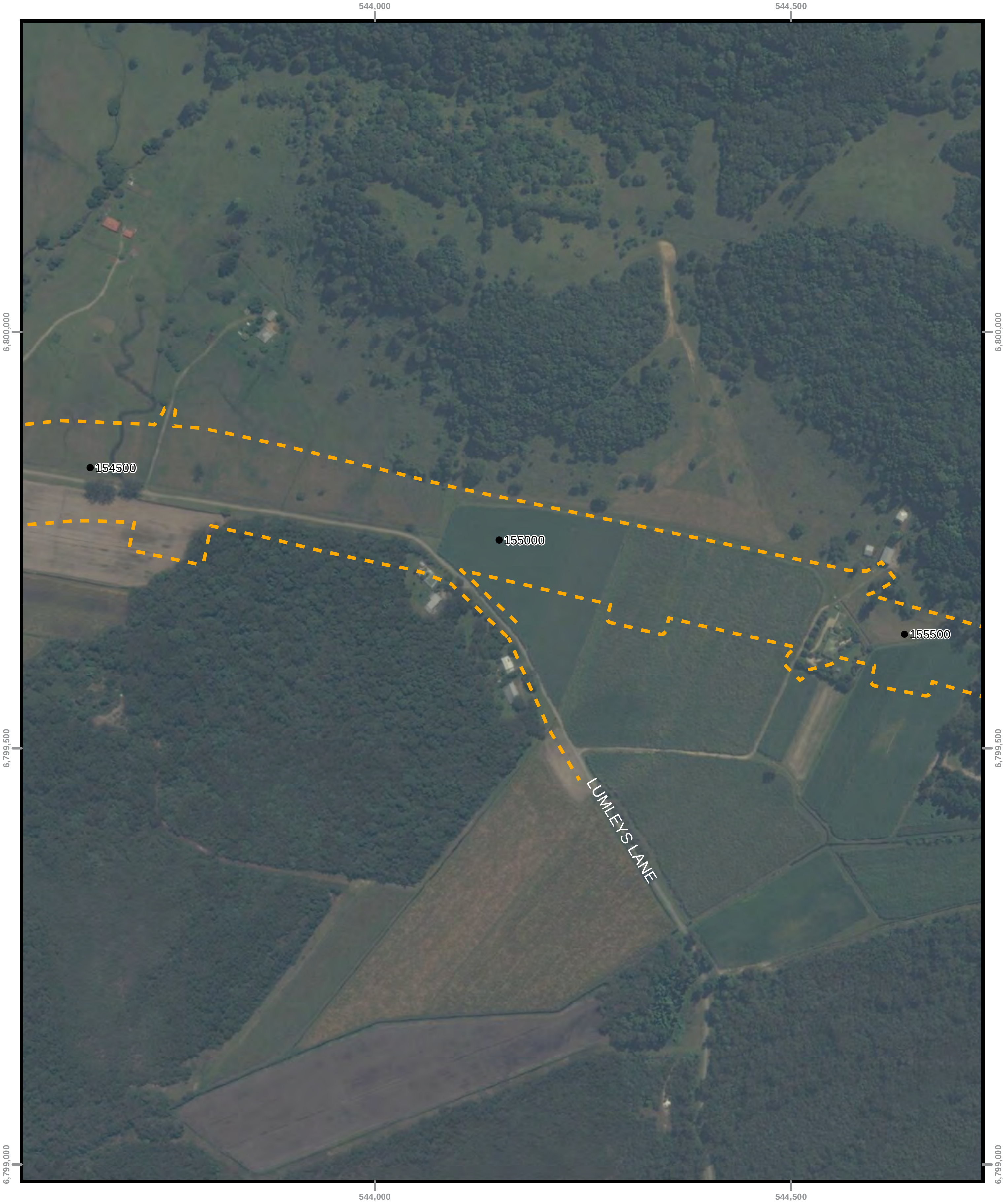
Figure 9(f): Recommended exclusions fencing for key road interchanges in Section 10 (Wardell Road)

Roads and Maritime Services

Pre-construction koala surveys

Woolgoolga to Ballina, NSW

A4



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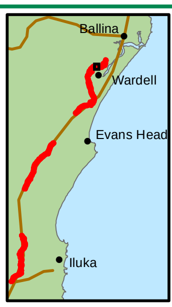

Figure 9(g): Recommended exclusions fencing for key road interchanges in Section 10 (Lumleys Lane)

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Pre-construction koala surveys

Woolgoolga to Ballina, NSW

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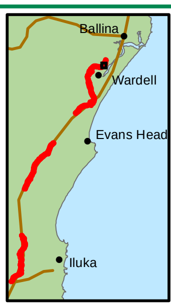

Figure 9(h): Recommended exclusions fencing for key road interchanges in Section 10 (Pacific Highway)

Roads and Maritime Services

Pre-construction koala surveys

Woolgoolga to Ballina, NSW

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5.4 Monitoring

In order to assess the effectiveness of mitigation measures and monitor the status of koala populations, ongoing koala surveys will be important. It is recommended that a detailed monitoring plan be established. Where applicable, surveys should follow the same regularised-grid to that used during this project, and if possible should be extended to incorporate additional habitat areas. By using the same survey design and replicating sites, surveys will monitor for any changes in koala activity and population status, and provide indications of lasting impacts associated with the new/upgraded road.

In addition, it is also important to monitor connectivity structures (e.g. remote sensing cameras) in order to assess the use and effectiveness of mitigation measures. The following general monitoring recommendations have been made for each section based on survey results and the presence of recommended connectivity structures.

5.4.1 Section 5

Ongoing koala surveys are recommended for this area to monitor for koala presence and potential population recovery. Surveys should be predominately focused around connectivity structure 1, and should expand on the regularised-grid used for this project to include habitat further to the east and west. Monitoring at connectivity structures will also provide information on koala presence and use, and the effectiveness of mitigation measures.

5.4.2 Section 7

No further koala surveys are required in this area; however, monitoring at connectivity structures will be important to provide information on fauna species' use and structure effectiveness.

5.4.3 Section 8

This area was targeted for supplementary surveys as it was not part of the original scope of this project. Supplementary surveys provide baseline evidence of koala use of the area and it is recommended that a regularised-grid (similar to that used in other sections of this project) is used for ongoing monitoring so that sites can be re-visited over time. Similar to other sections, monitoring at connectivity structures is also recommended.

5.4.4 Section 9

Ongoing koala surveys and monitoring of connectivity structures throughout the northern portions of Section 9 (Area 1) is recommended. This is particularly important because this area is likely to provide supplementary habitat for koalas dispersing from populations to the west, and although this habitat is fragmented, it is important for the long-term persistence of koalas in the region. Connectivity structures should also be monitoring to inform any changes in koala use and the effectiveness of mitigation measures.

Ongoing koala surveys are also recommended in the northern and southern extents of the Broadwater National Park, which are focused around critical connectivity pinch-points. Monitoring of connectivity structures should also be conducted. Due to the lack of suitable habitat, no further koala surveys would be required in the central portions of the Broadwater National Park.

5.4.5 Section 10

In order to assess the success of mitigation measures, ongoing koala surveys are recommended for the entirety of Section 10. These surveys should follow the regularised-grid to that used for this project and developed from Biolink (2013). Monitoring at connectivity structures is recommended to provide information on koala use and the effectiveness of mitigation measures.

Considering the importance of this area for koalas, a koala tracking program is recommended to understand koala health and movement before, during, and after construction phases. This program is discussed in greater detail below in *report section 5.5*.

5.4.6 Section 11

Ongoing koala surveys using the regularised-grid from Section 10 should be extended to include the area. Monitoring at connectivity structure/s is also recommended.

5.5 Monitoring koala movements

It is recommended that a monitoring program be implemented to understand koala movement before, during, and after construction phases in areas between Wardell, Blackwall Range and Coolgardie (Section 10). This program will provide further assessment on the effectiveness of mitigation measures.

While the most appropriate monitoring method can be determined at a later date; it should be developed taking into account the desired outcome of the program and the accepted impact on the koala. If the required outcomes are to determine movement at a landscape-level, then a non-invasive program may be preferable (e.g. fine scale SAT sampling and gene mapping). This method would follow the ongoing SAT monitoring grid (see *report section 5.4*), and would also provide detailed information on the status of koala populations. Alternatively, if precise koala movement data is required at a patch-level to monitoring the success of mitigation measures, then radio-tracking may be the preferred program. An example program employing radio-tracking as the primary method would require the capture of koalas (number to be discussed prior to project) in known critical areas of the project extent and would include the following:

- Detailed health check (and treatment) by experienced koala veterinarians equipped with a mobile field veterinary unit.
- Attachment of radio-tracking collars.

- Tracking of koalas that would continue until battery power is nearing its end, at which point batteries could be replaced, or a new koala could be captured and tracked.
- Detailed necropsy examination of each deceased koala during the project. This is important to determine the potential influence of construction on the mortality rates in the population, and also to ensure correct diagnosis is made (e.g. attributed simply to natural predation or disease). The latter will be essential for Roads and Maritime to address any speculation about koala death. This program will be particularly important in areas where resident koalas will be displaced by clearing, and will provide an understanding of preconstruction movement patterns between Wardell, Blackwall Range and Coolgardie, and to determine how construction and operations affect movement patterns. This will also give indication of mortalities affecting the koala in the larger population and help inform detail design of connectivity structures. Specifically, this is important for Roads and Maritime to determine the following:
- Current natural movements and home-ranges of koalas in areas within and near the proposed road alignment. This information could also guide the potential success of revegetation and/or restoration projects in adjacent habitats.
- The health of koalas (including disease prevalence) existing throughout the region.
- Identification of koalas that may be directly impacted on during habitat clearing stages.
- Any impacts on natural koala movement and home-ranges before, during and after construction phases.
- Any increase in mortality rates, and their causes, before, during and after construction.
- If koalas are using connectivity structures (e.g. do they return to normal movement patterns), or showing avoidance of the new road. This information will be essential for Roads and Maritime to highlight the success of connectivity structures.

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Revision History

Revision No.	Revision date	Details	Prepared by	Reviewed by	Approved by
00	04/07/2014	Koala preconstruction surveys report - Draft	Emily Hatfield Scientist Grant Brearley Senior Ecologist	Beth Kramer Senior Environmental Scientist	Phil Shaw, Managing Director
01	27/08/2014	Koala preconstruction surveys report - Final	Grant Brearley Senior Ecologist	Elvira Lanham Senior Ecologist	Phil Shaw, Managing Director
02	09/10/2014	Koala preconstruction surveys report - Final_R2	Grant Brearley Senior Ecologist	Phil Shaw, Managing Director	

Distribution List

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Appendix F Broadwater Koala Population Survey - Ecosure Report (2015)

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Broadwater Koala Population Survey

Woolgoolga to Ballina Pacific Highway Upgrade: Sections 8 and 9

November 2015

Final Report

ROADS AND MARITIME SERVICES

ecology / vegetation / wildlife / aquatic ecology / GIS

Executive summary

As part of the Federal Environment Ministers approval of the Woolgoolga to Ballina Pacific Highway upgrade in June 2014, a number of additional conditions were applied. One of these conditions included a need for further work to be undertaken on koala populations inhabiting the Broadwater area (Section 9) of the upgrade.

Baseline koala population estimates are required to compare to data from subsequent monitoring events which will provide information on the local koala population over time. This information can also be used to infer any trends pre- and post- road construction on population size.

To obtain baseline data on the Broadwater koala population a 350 metre x 350 metre survey grid was overlain on the study area which identified 62 survey sites containing potential koala habitat.

Following access restrictions, 54 field sites were surveyed using two techniques: (1) 25 metre radial searches, and (2) transect searches. As a result, a total area of 10.58 hectares for radial searches and 50.15 hectares for transect surveys were searched.

Eight adult koalas were recorded during surveys, with two females carrying back young. One of these koalas was observed while transiting between survey sites. The resulting population estimates derived using both techniques did not differ significantly from each other, and provide a baseline population estimate of approximately 150 – 230 koalas in the study area.

Acknowledgements

This study would not have been possible without the support of landowners who generously allowed access to their properties and/or provided information about local koalas.

We would also like to acknowledge National Parks and Wildlife for permission and access to National Park estates and associated tracks.

Glossary, acronyms and abbreviations

GPS	Global positioning system
Ha	Hectares
m	Metres
SD	Standard Deviation
W2B upgrade	Woolgoolga to Ballina Pacific Highway upgrade

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1 Introduction

In May 2012, the koala was listed as a threatened species throughout Queensland, New South Wales and the Australian Capital Territory under the Commonwealth Government's *Environment Protection and Biodiversity Conservation Act 1999*. In NSW, koalas are listed as a vulnerable species under the *Threatened Species Conservation Act 1995*.

The Woolgoolga to Ballina Pacific Highway upgrade (W2B upgrade) was approved by the NSW Government in June 2014. In August 2014, the Federal Environment Minister similarly approved the W2B upgrade, albeit with a number of additional conditions including a need for further work to be undertaken on koala populations inhabiting the area.

1.1 Objective

To obtain baseline data on the Broadwater koala population (Section 9 and northern parts of Section 8). These additional surveys are required to comply with the Minister's Condition of Approval D9 (a) for the W2B upgrade.

The data can then be used to compare to data from subsequent monitoring events which will provide information on the local koala population over time. This information can also be used to infer any trends pre- and post- road construction on population size.

1.2 The study area

The focal area for this survey will be areas surrounding the Broadwater township (Section 9), including west to Rileys Hill, and south through the Broadwater National Park to an area known as Lang's Hill (northern portion of Section 8)[1] (Figure 1).

[1] herein referred to as the study area

Figure 1: Study area for the Broadwater koala population study

Roads and Maritime Services

Broadwater koala population surveys

W2B Project boundary (sections 8 & 9)

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Revision: 1
Author: MED
Date: 10/11/2015

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Metres

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Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

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2 Methods

2.1 Site selection

Although a number of targeted koala surveys have been conducted in this area over the past 18 months (Ecosure 2014; Biolink 2015[2]), a seperate assessment was undertaken to provide an un-biased indication of population density. The survey design used a more refined grid than previous surveys (i.e. 350 m x 350 m), and comprised 62 potential sites covering all potentially relevant vegetation types (Figures 2 and 3). The benefit of a more refined grid is that it provides higher resolution and stronger confidence around the population estimates.

An indicative study boundary was established around the survey grid in order to identify areas containing potential koala habitat that were the primary target for the survey (Figure 2 and Table 1). For the most part, this excluded coastal heathlands and rainforest vegetation communities that contain no suitable koala habitat; however, in areas where mapping indicates the potential presence of koala food trees (e.g. swamp mahogany *Eucalyptus robusta*), these sites were left in.

Table 1 Survey site representation in vegetation communities across the study area (Figure 3). The predicted number of survey sites based on vegetation community extent is also shown to highlight the accuracy of the grid design.

Vegetation community[3]	Extent in study area (ha)	Number of proposed survey sites (Figure 2)	Number of sites surveyed (Figure 4)	Predicted no. survey sites based on vegetation community extent*
Unidentified vegetation	38.68	0	0	1
Banksia	67.67	3	2	2
Coast cypress pine	15.96	1	1	1
Coastal complex	3.98	2	2	0
Coastal flooded gum	1.15	0	0	0
Coastal mallee	1.14	0	0	0
Coastal pink bloodwood	1.98	0	0	0
Coastal sands blackbutt	44.80	4	4	1
Coastal swamp box	13.48	1	1	0
Hardwood plantations	31.96	2	2	1
Heath	208.73	7	7	7
Heathy scribbly gum	24.89	3	3	1
Littoral rainforest	0.18	0	0	0
Lowland rainforest on floodplain	2.65	0	0	0
Lowlands scribbly gum	57.64	2	2	2
Paperbark	322.70	16	11	11

[2] The exact reference of this survey is unknown; however it relates to the Richmond Valley Council koala surveys (*Steve Phillips pers. comm*.).

[3] Vegetation community mapping was provided by Dr Rod Kavanagh at Niche Environment and Heritage. The exact reference of this mapping could not be obtained prior to sending this document. If this is required it can be sourced.

Vegetation community[3]	Extent in study area (ha)	Number of proposed survey sites (Figure 2)	Number of sites surveyed (Figure 4)	Predicted no. survey sites based on vegetation community extent*
Red mahogany	13.02	1	1	0
Sedgeland/Rushland	10.87	0	0	0
Sub-tropical & warm temperate rainforest	1.21	0	0	0
Swamp	0.41	0	0	0
Swamp mahogany	27.41	2	2	1
Wallum heath	134.40	3	3	4
Wet heath	171.42	7	7	6
Unmapped vegetation	428.38	8	6	14
Total	**1624.70 ha**	**62**	**54**	**54**

*Based on number of sites surveyed and not proposed survey sites

2.2 Survey timing

Surveys were conducted over a two week period from the 5th – 16th October 2015, which coincided with the koala breeding season (August to January). Weather conditions for the survey period was fine and sunny with no rain during the day.

2.3 Field survey

Two direct count methods (radial searches and transect searches) were used to determine population density and size in the study area. A field team comprising three members experienced in the aforementioned techniques conducted the surveys at each survey point (Figure 2).

If a koala was located, the GPS co-ordinates were recorded, along with the tree species, height of the koala in the tree, and where possible any other individual characteristics where recorded (e.g. sex, age, health status).

The following searches enabled an area-based koala density estimates to be derived, and subsequently estimates of population size in the focal area.

1. Radial searches

Searches for koalas were conducted in every tree within a 25 m radius of the centre point of each site (0.196 ha) by three personnel.

2. Transect searches

Transects approximately 250 m in length and 40 m in width (covering a total area of approximately one ha) were traversed at each survey site. Three observers equipped with a compass and binoculars, spaced ~20 m apart, walked a fixed bearing searching all trees for koalas. One observer walked the centre line and one on either side.

Where possible based on the presence of habitat and landholder access, transects were oriented north-south (on flat to undulating terrain) or along the contour (on steeper terrain), and commenced at 125 m from the centre point, continuing for a further 125 m past the centre.

2.4 Koala density/population

Koala density and subsequent population estimate was calculated for both techniques discussed above.

The number of koalas counted during transect/radial searches was divided by the combined total search area of all transects/radial searches. Density data was then extrapolated across the total area of potential koala habitat (1,624.70 ha) mapped within the study boundary (Figure 3) in order to derive a population estimate.

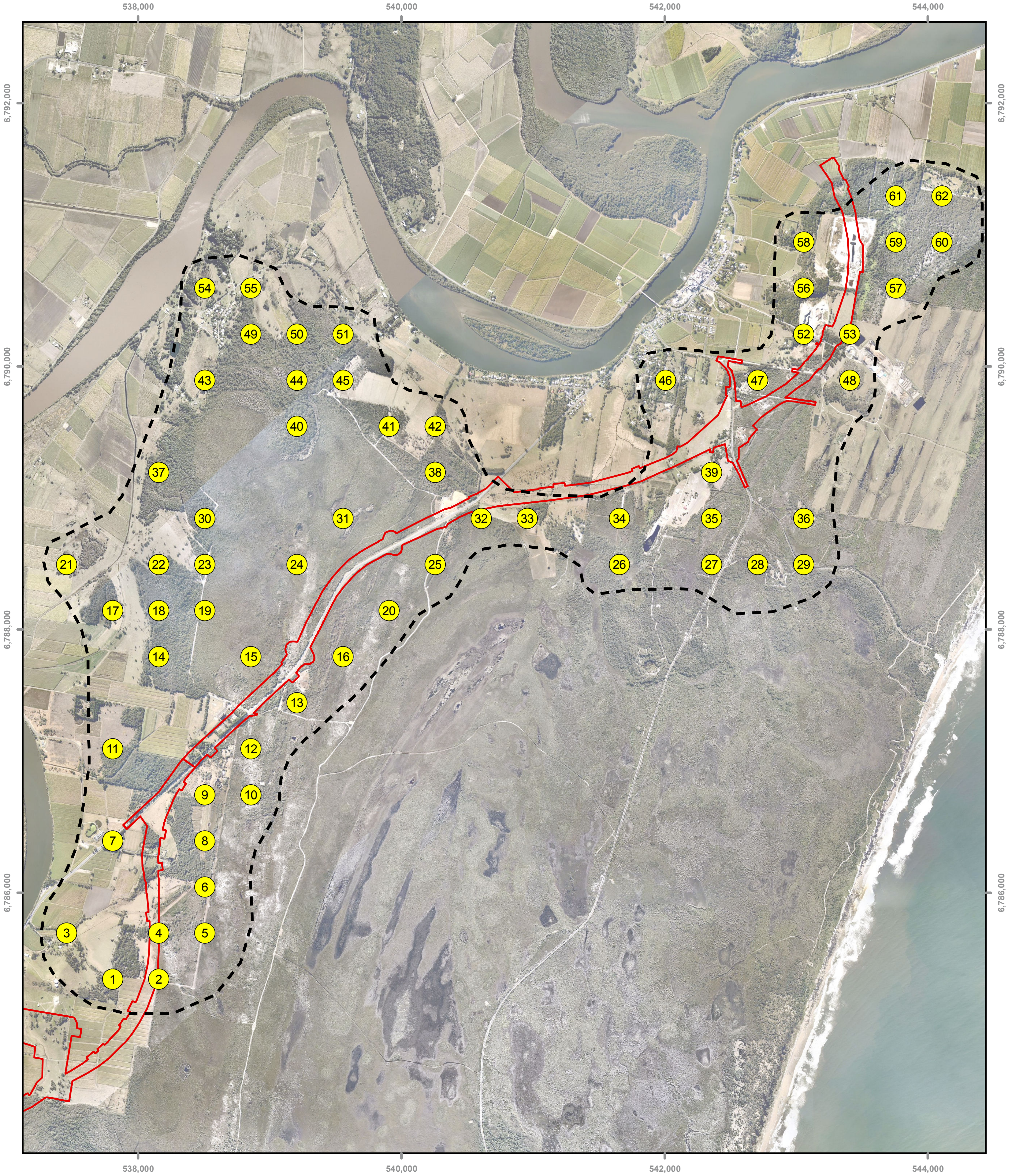

Figure 2: Location of 62 field sites planned for transect and 25 m radial searches

Roads and Maritime Services

Broadwater koala population surveys

Indicative study boundary

Planned survey site

W2B Project boundary

ecosure

Job number: GW116v14
Revision: 0
Author: MED
Date: 28/10/2015

0 250 500 1,000
Metres

GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

Data Sources: Roads and Maritime Services; © Ecosure Pty Ltd, 2015; Aerial Image: Nearmap, 2014

GW116_v14_MP_Fig2_PlannedSites
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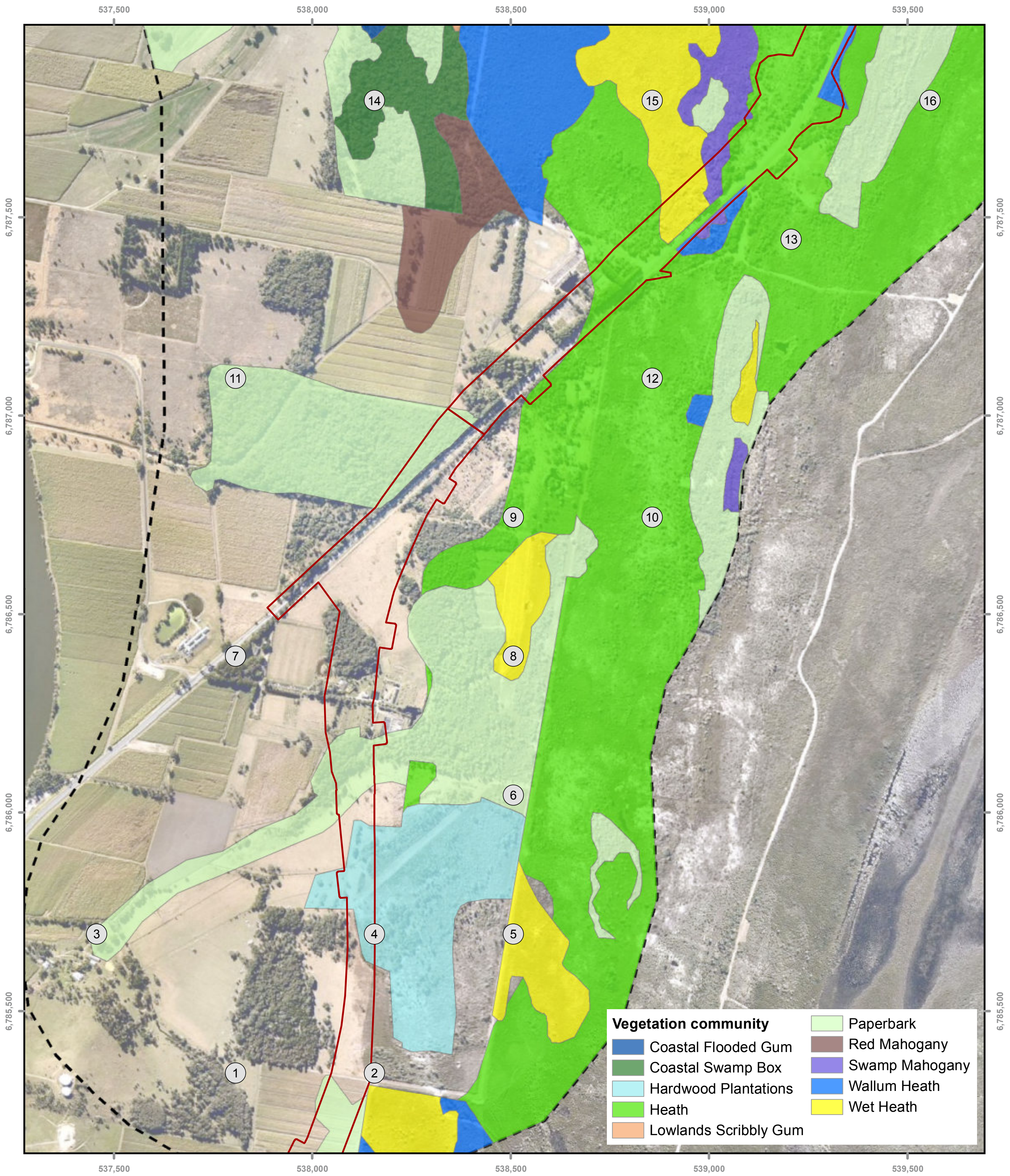


Figure 3: Location of planned survey sites and associated vegetation communities across the study area

Roads and Maritime Services

Broadwater koala population surveys

Indicative study boundary

Planned survey site

W2B Project boundary

Page 1 of 5

ecosure

Job number: GW116v14
Revision: 0
Author: MED
Date: 10/11/2015

0 100 200 400 Metres

GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

Data Sources: Vegetation Mapping - Niche Environment and Hertigage (Rod Kavanagh); Roads and Maritime Services; © Ecosure Pty Ltd, 2015; Aerial Image: Nearmap, 2014

GW116_v14_MP_Fig3_Vegetation
A5

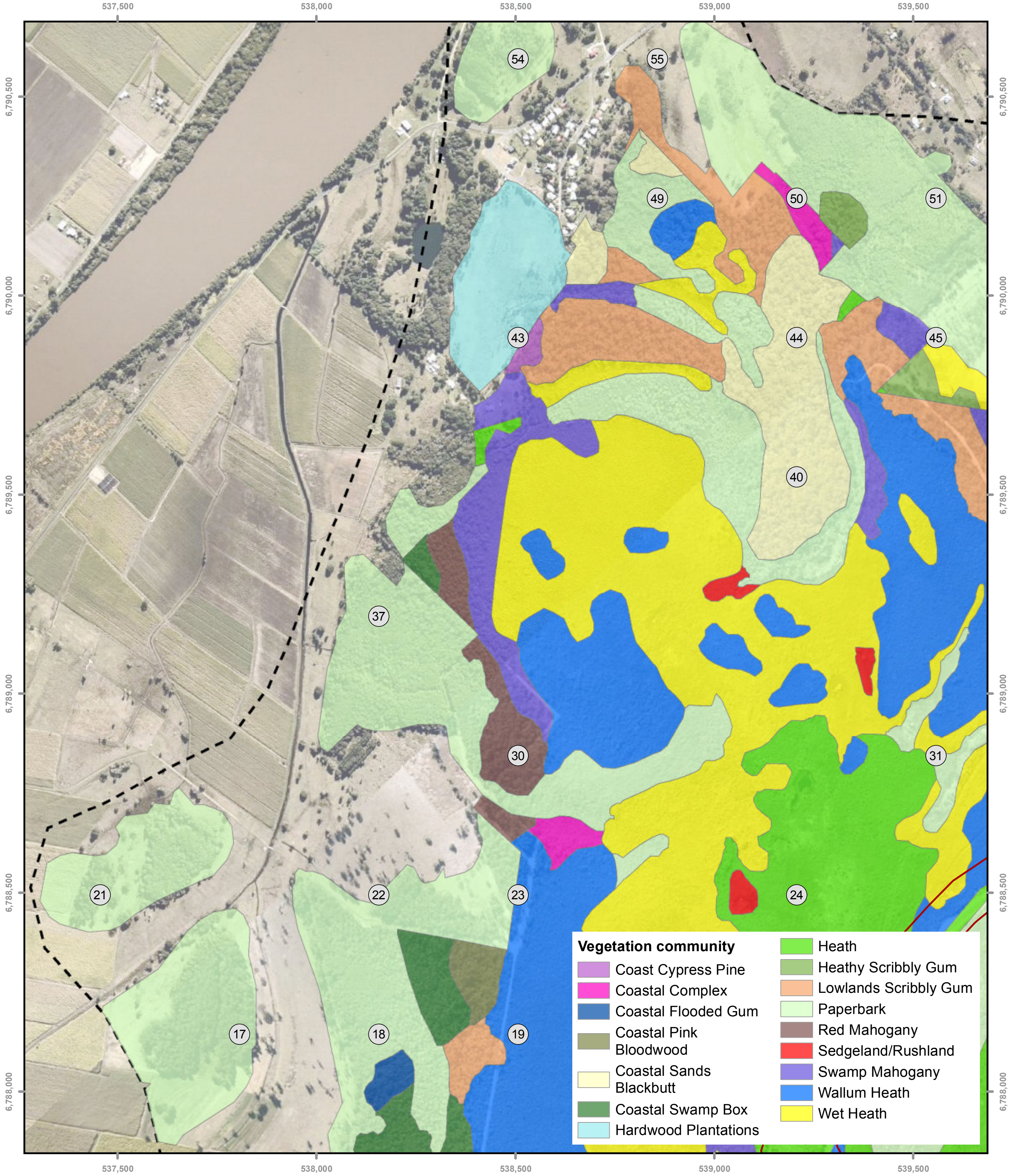


Figure 3: Location of planned survey sites and associated vegetation communities across the study area

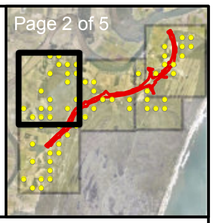
Roads and Maritime Services

Broadwater koala population surveys

Indicative study boundary

Planned survey site

W2B Project boundary



ecosure

Job number: GW116v14
Revision: 0
Author: MED
Date: 10/11/2015

0 100 200 400
Metres

GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

Data Sources: Vegetation Mapping - Niche Environment and Hertigage (Rod Kavanagh); Roads and Maritime Services; © Ecosure Pty Ltd, 2015; Aerial Image: Nearmap, 2014

GW116_v14_MP_Fig3_Vegetation
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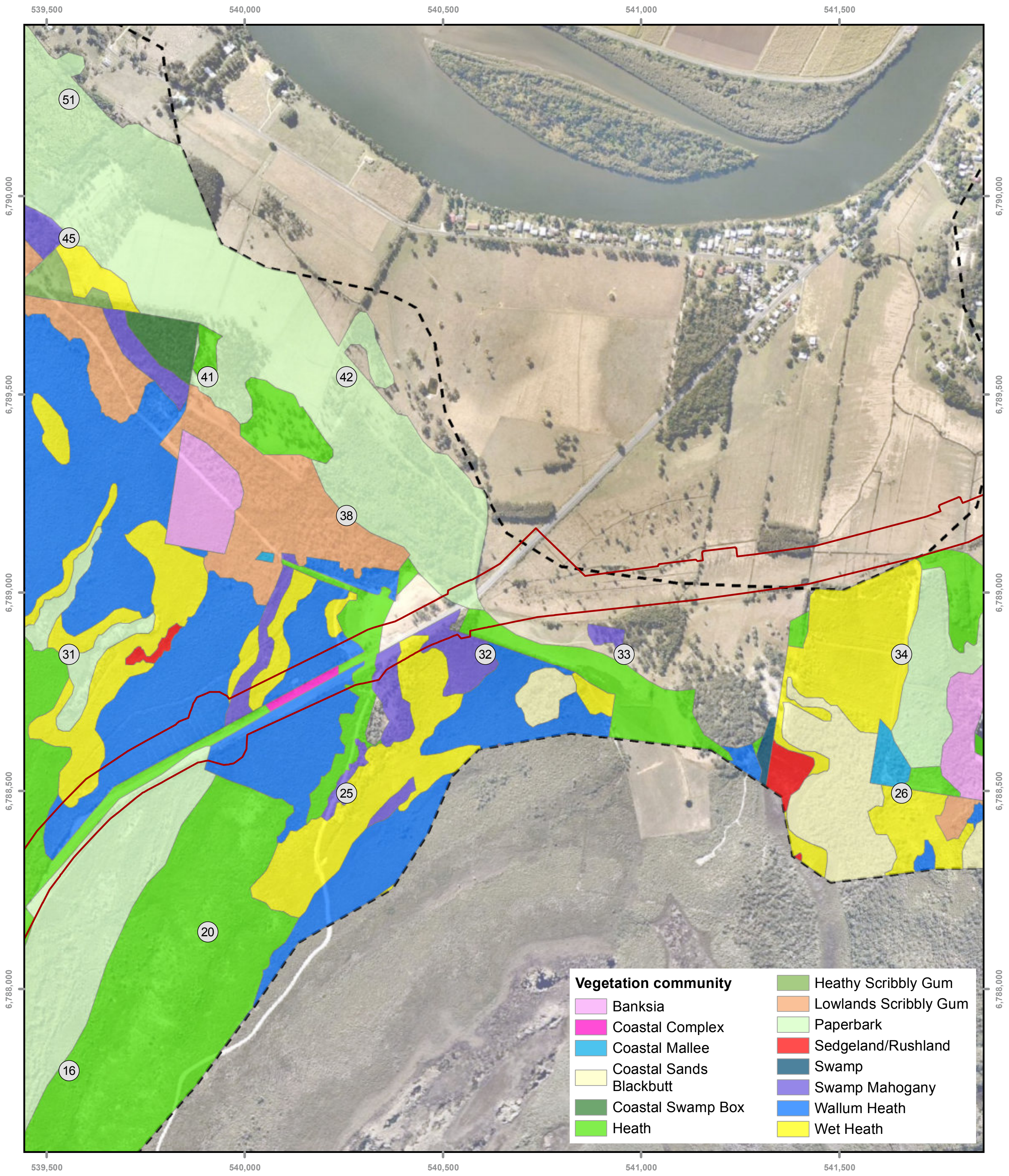


Figure 3: Location of planned survey sites and associated vegetation communities across the study area

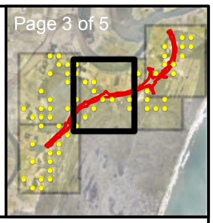
Roads and Maritime Services

Broadwater koala population surveys

Indicative study boundary

Planned survey site

W2B Project boundary



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Job number: GW116v14
Revision: 0
Author: MED
Date: 10/11/2015

0 100 200 400
Metres

GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

Data Sources: Vegetation Mapping - Niche Environment and Hertiggage (Rod Kavanagh); Roads and Maritime Services; © Ecosure Pty Ltd, 2015; Aerial Image: Nearmap, 2014

GW116_v14_MP_Fig3_Vegetation
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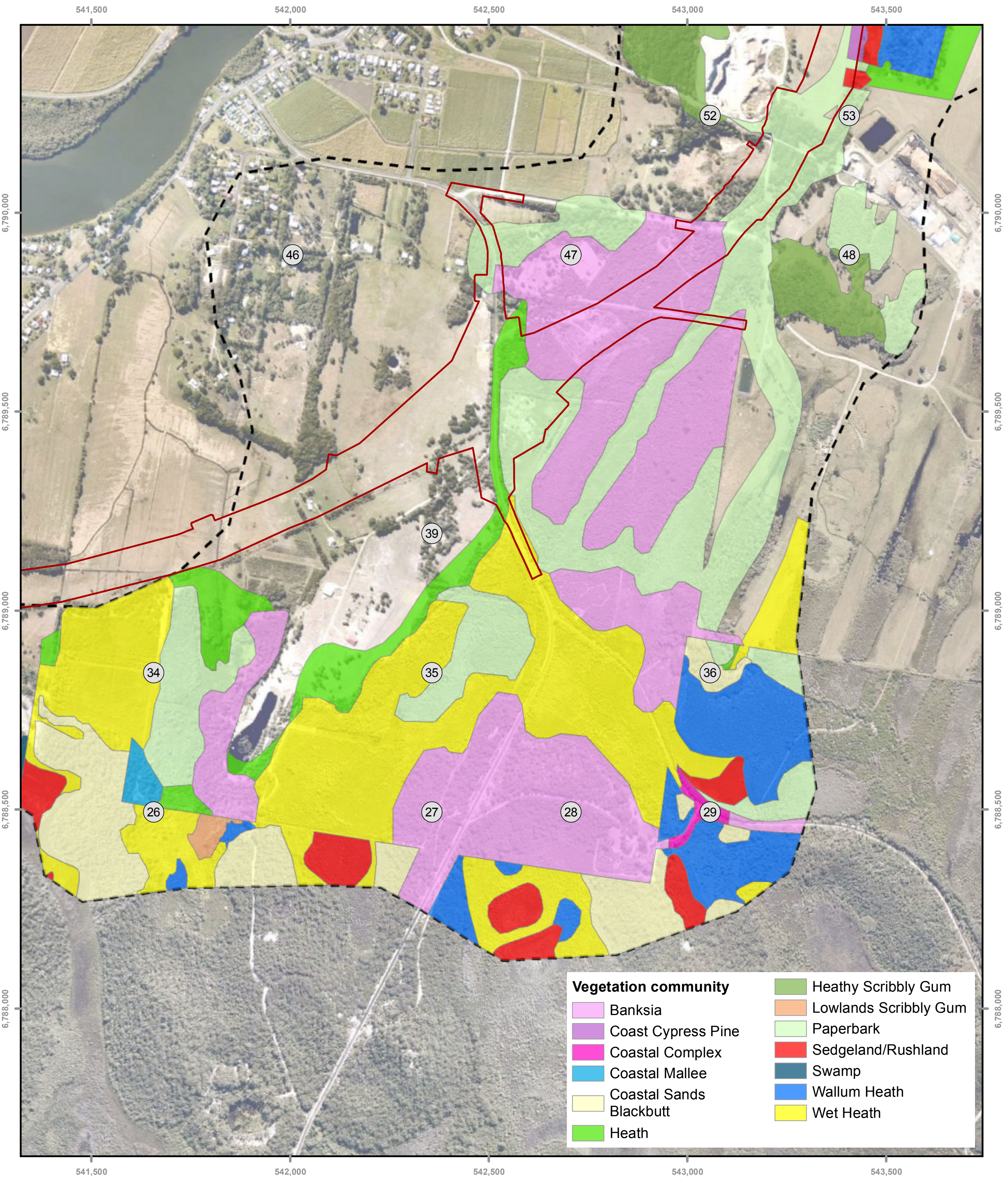

Figure 3: Location of planned survey sites and associated vegetation communities across the study area

Roads and Maritime Services

Broadwater koala population surveys

Indicative study boundary

Planned survey site

W2B Project boundary

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Job number: GW116v14
Revision: 0
Author: MED
Date: 10/11/2015

0 100 200 400
Metres

GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

Data Sources: Vegetation Mapping - Niche Environment and Hertigage (Rod Kavanagh); Roads and Maritime Services; © Ecosure Pty Ltd, 2015; Aerial Image: Nearmap, 2014

GW116_v14_MP_Fig3_Vegetation
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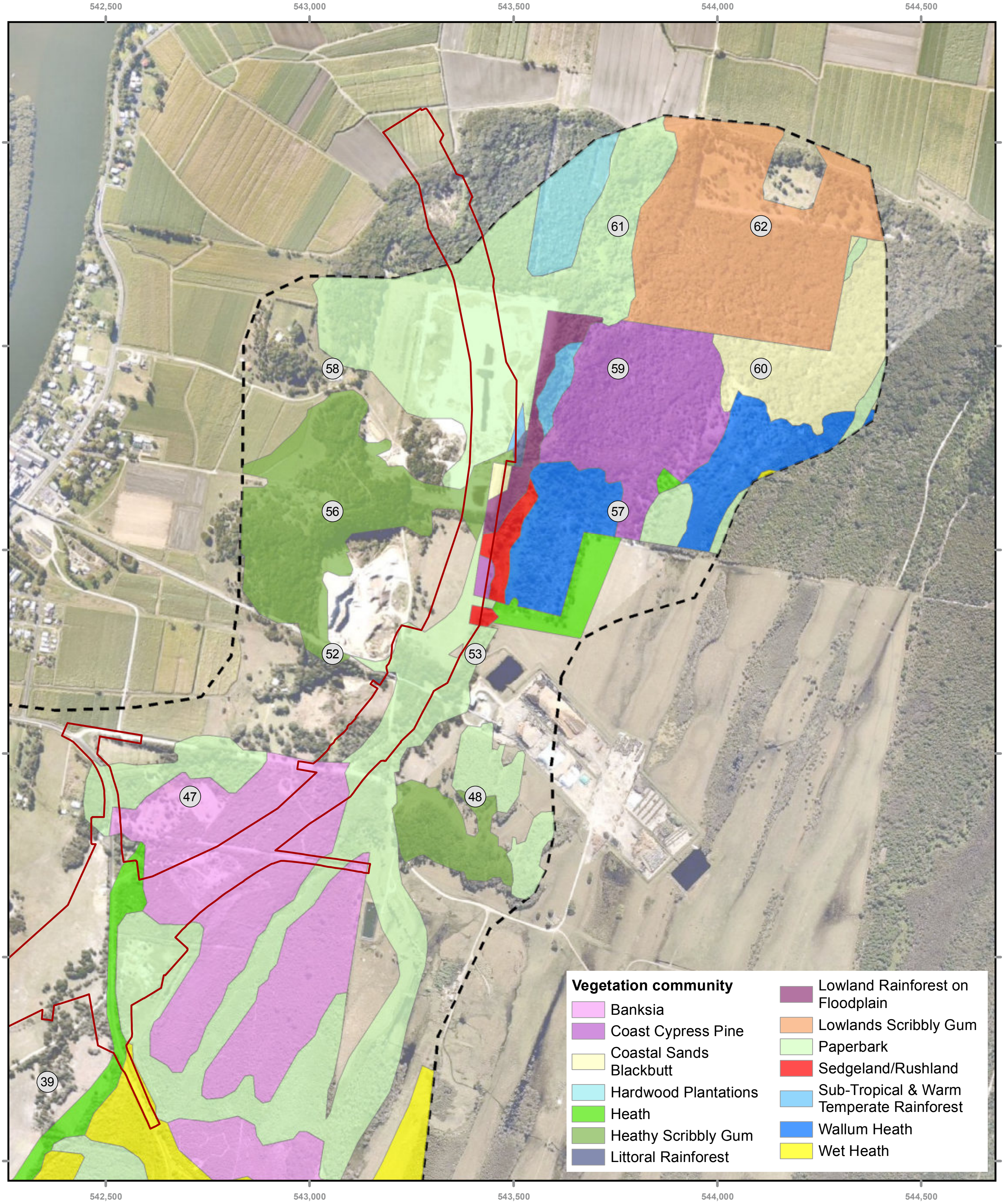

Figure 3: Location of planned survey sites and associated vegetation communities across the study area

Roads and Maritime Services

Broadwater koala population surveys

Indicative study boundary

Planned survey site

W2B Project boundary

Page 5 of 5

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Job number: GW116v14
Revision: 0
Author: MED
Date: 10/11/2015

0 100 200 400
Metres

GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

Data Sources: Vegetation Mapping - Niche Environment and Hertigage (Rod Kavanagh); Roads and Maritime Services; © Ecosure Pty Ltd, 2015; Aerial Image: Nearmap, 2014

GW116_v14_MP_Fig3_Vegetation
A5

3 Results

3.1 Survey effort

Fifty-four field sites were surveyed between 5 October and 14 October 2015 covering a total search area of 50.15 ha for transect surveys and 10.58 ha for radial searches. Eight of the 62 targeted sites could not be accessed due to landholder permissions (Figure 4).

3.2 Koala sightings

Eight adult koalas were recorded during surveys, with two females carrying back young (Table 2). One of these koalas was observed while transiting between survey sites. The location of koala sightings are illustrated in Figure 4.

Table 2 Individual characteristics of each koala observed by during field surveys. Koala sex, condition and additional information were determined using binoculars only.

Koala record*	Survey type	Sex	Condition	Behaviour	Tree species	Vegetation community/s#	Additional information
1	Transect	Male	Good	Resting	*Acacia sp.*	Heath (unmapped *E. robusta* in transect)	Older animal with ripped ears. Possibly previous alpha male.
2	Transect	Female	Good	Resting	*E. robusta*	Swamp mahogany	Back young present
3	Transect	Female	Good	Resting	*E. robusta*	Lowlands scribbly gum/Paperbark	Young koala likely to be recently independent.
4	Transect	Unknown	Unknown	Resting	*E. robusta*	Swamp mahogany	High in tree amongst vines. No sex or condition could be determined
5	Transect & radial	Male	Good	Resting	*E. robusta*	Wallum heath/Swamp mahogany	N/A
6	Transect	Male	Good	Resting	*E. robusta*	Lowlands scribbly gum	N/A
7	N/A	Female	Good	Resting	*Angophora floribunda*	Paperbark	Not observed on a transect or within a radial search Possible pouch young, not able to be confirmed
8	Transect	Female	Good	Resting	*E. microcorys*	Paperbark	Back young present

*Reference number for Figure 4

3.3 Koala density/population estimate

Based on the presence of one koala within the 10.58 ha covered by the radial searches, koala density was estimated at 0.09 ± 0.08 (95% SD) koalas $^{ha-1}$. When this density estimate was extrapolated across the 1,624.70 ha of potential koala habitat within the study area, a population estimate of 154 ± 128 (95% SD) koalas resulted.

Based on the presence of seven koalas within the 50.15 ha covered by the transect searches, koala density was estimated at 0.14 ± 0.19 (95% SD) koalas $^{ha-1}$. When this density estimate was extrapolated across the 1,624 ha of potential koala habitat within the study area, a population estimate of 227 ± 152 (95% SD) koalas resulted.

Table 3 provides summary data and results for each survey technique.

Despite the trend towards a higher density/population estimate when using the transect searches, estimates derived using both techniques broadly overlap and do not differ significantly from each other (p = 0.89071).

Table 3 Summary table for koala density and population estimates based on radial and transect surveys.

Component	**Radial search method**	**Strip transect method**
No. sites	54 sites	54 transects
Total area surveyed	53 x 0.196 ha = 10.58 ha	50.15 ha
Koalas recorded	1*	7
Density estimate	0.09 ± 0..08	0.14 ± 0.19
Potential koala habitat	1,624.70 ha	1,624.70 ha
Population estimate	153.51 ± 127.89	226.78 ± 151.53
Population estimate (lower level)	25.56	75.20
Population estimate (upper level)	281.45	378.38

*Koala recorded for both radial and transect searches

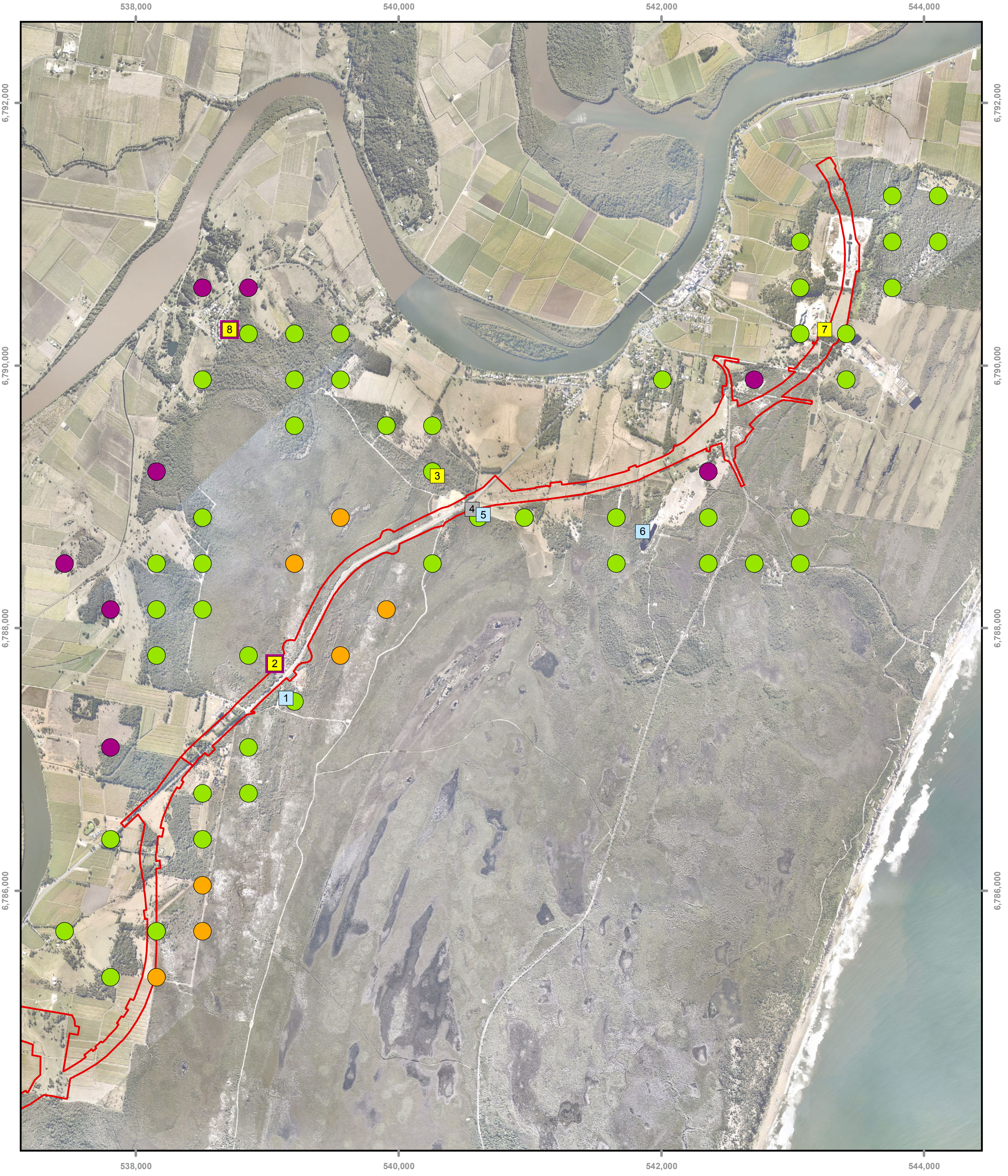

Figure 4: Location of surveyed and not surveyed sites, and location of koala sightings

Roads and Maritime Services

Broadwater koala population surveys

W2B Project boundary

Koala record with ID

- Female
- Female with back young
- Male
- Unknown

Survey location

- Surveyed
- No suitable habitat
- No access

ecosure

Job number: GW116v14
Revision: 0
Author: MED
Date: 28/10/2015

0 250 500 1,000
Metres

GDA 1994 MGA Zone 56
Projection: Transverse Mercator
Datum: GDA 1994
Units: Meter

GW116_v14_MP_Fig4_SurveyedSites
A5

4 Key outcomes

Direct counts of koala numbers were undertaken in 54 transects and radial survey sites uniformly distributed across the study area. Eight adult koalas (plus two back young) were sighted, seven of which were recorded during transect or radial searches.

Transect searches covered an area of 50.15 ha and provided a density estimate of 0.14 koalas $^{ha-1}$, with a corresponding baseline population estimate for the study area of 227 koalas.

Radial searched covered an area of 10.58 ha and provided a density estimate of 0.09 koalas $^{ha-1}$, with a corresponding baseline population estimate for the study area of 154 koalas.

Population estimates derived using both transect and radial search techniques do not differ significantly from each other, and therefore provide a baseline population estimate of approximately 150 – 230 (25 – 378 at 95%) koalas in the study area.

The similar population estimates derived from both techniques indicate a good level of agreement, and are considered suitable for the purpose of the project. It is acknowledged however that this accuracy may have limitations. Increasing confidence around the estimates would require repeat surveys over a short period of time.

References

Ecosure (2014), Woolgoolga to Ballina koala preconstruction surveys - final report, Report to Roads and Maritime Services, West Burleigh.

Hindell, MA & Lee, AK 1990, ‘Tree preferences of the koala’, in Lee AK, Handasyde KA and Sanson GD (eds.), Biology of the Koala, Surrey Beatty and Sons, Sydney, Australia, pp. 117-121.

Lee, AK & Martin, R 1988, The koala: a natural history, Kensington, New South Wales, New South Wales University Press.

Phillips, B 1990. Koalas: the Little Australians We'd All Hate to Lose, Canberra, Australian National Parks and Wildlife Service.

Phillips, S & Callaghan, J 2000, ‘Tree species preferences of koalas (*Phascolarctos cinereus*) in the Campbelltown area south-west of Sydney, New South Wales’, Wildlife Research, vol. 27, pp. 509-516.

Appendix 1 Transect data

Site No.[1]	Orientation	Length (m)	Search area (ha)	Vegetation community[1]	No. koalas	Additional details
1	NS	240	0.96	Unmapped vegetation	-	
2	EW	175	0.7	Unmapped vegetation	-	
3	NE-SW	250	0.5	Paperbark	-	
4	EW	250	1	Hardwood plantations	-	
5	NS	250	1	Wet heath	-	
6	NS	250	1	Paperbark	-	
7	NS	249	0.996	Unmapped vegetation	-	
8	EW	208	0.832	Wet heath	-	
9	NS	250	1	Heath	-	
10	NS	250	1	Heath	-	
11	-	-	-	Paperbark	-	No access
12	NS	250	1	Heath	-	
13	EW	250	1	Heath	1	Male koala with ripped ears, good condition in Acacia.
14	NS	250	1	Coastal swamp box	-	
15	EW	250	1	Wet heath	1	Female with back young in *E. robusta*
16	NS	250	1	Heath	-	
17	-	-	-	Paperbark	-	No access
18	NS	250	1	Paperbark	-	
19	NS	241	0.964	Wallum heath	-	
20	NS	250	1	Heath	-	
21	-	-	-	Paperbark	-	No access
22	EW	250	1	Paperbark	-	Unknown in *E. microcorys*
23	NS	243	0.972	Wallum heath	-	
24	NS	250	1	Heath	-	Female with back young in *E. robusta*
25	NS	232	0.928	Swamp mahogany	-	
26	EW	250	1	Wet heath	-	
27	NS	250	1	Banksia	-	
28	EW	206	0.824	Banksia	-	
29	EW	248	0.992	Coastal complex	-	
30	NS	249	0.996	Red mahogany	-	
31	NE-SW	250	1	Paperbark		
32	EW	157	0.628	Swamp mahogany	2	Two koalas - one unknown, one male both in *E. robusta* One koala recorded in radial search

Site No.[1]	Orientation	Length (m)	Search area (ha)	Vegetation community[1]	No. koalas	Additional details
33	NS	133	0.532	Unmapped vegetation	-	
34	EW	250	1	Wet heath	1	Male resting near bee hives
35	NE-SW	75	0.3	Wet heath	-	
36	NS	249	0.996	Coastal sands blackbutt	-	
37	-	-	-	Paperbark	-	No access
38	EW	250	1	Lowlands scribbly gum	1	Young koala in *E. robusta.* Likely to be recently independent.
39	-	-	-	Unmapped vegetation	-	No access
40	NS	250	1	Coastal sands blackbutt	-	
41	NS	220	0.88	Paperbark	-	
42	NS	248	0.992	Paperbark	-	
43	NE-SW	250	1	Hardwood plantations	-	
44	NS	239	0.956	Coastal sands blackbutt	-	
45	NS	230	0.92	Wet heath	-	
46	EW	240	0.96	Unmapped vegetation	-	
47	-	-	-	Banksia	-	No access
48	EW	250	1	Heath scribbly gum	-	
49	EW	245	0.98	Paperbark	1	Female with back young in *E. microcorys*
50	SE-NW	231	0.924	Coastal complex	-	
51	NW - SE	250	1	Paperbark	-	
52	EW	213	0.852	Heath scribbly gum	-	Female koala observed approximately 200 m northeast of the site[2]
53	NE-SW	250	1	Paperbark	-	Female koala observed approximately 150 m west of the site[2]
54	-	-	-	Paperbark	-	No access
55	-	-	-	Unmapped vegetation	-	No access
56	Contour	175	0.7	Heath scribbly gum	-	Female koala observed approximately 300 m southeast of the site[2]
57	NS	235	0.94	Wallum heath	-	
58	NS	239	0.956	Unmapped vegetation	-	
59	NS	244	0.976	Coast cypress pine	-	
60	NS	250	1	Coastal sands blackbutt	-	
61	NS	248	0.992	Paperbark	-	
62	EW	250	1	Lowlands scribbly gum	-	

[1]See Figure 2 for survey site locations and Figure 3 for vegetation communities

[2]This is the same koala recorded outside of the transect and radial searches

Revision History

Revision No.	Revision date	Details	Prepared by	Reviewed by	Approved by
00	13/11/2015	Broadwater koala population survey	Emily Hatfield, Ecologist	Grant Brearley, Senior Ecologist	Jeff McKee, Principal Research Scientist

Distribution List

Copy #	Date	Type	Issued to	Name
1	13/11/2015	Electronic	Roads and Maritime Services	Simon Wilson
2	13/11/2015	Electronic	Ecosure	Administration

Citation: Ecosure (2015), Broadwater koala population survey, Final report to Roads and Maritime Services, Publication Location – Burleigh Heads

Report compiled by Ecosure Pty Ltd

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GW116v14-RE.Broadwater koala population surveyFINAL

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Appendix G Adequacy Reviews

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21 August 2015

Mr Scott Lawrence / Mr Simon Wilson,
Roads and Maritime Services
21 Prince Street,
GRAFTON, NSW 2460

Dear Scott and Simon,

Re: Survey adequacy (MCoA D9a) – Woombah/Iluka Koala population

On 24 June 2014, the NSW Government approved the upgrading of the Pacific Highway between Woolgoolga and Ballina as State Significant Infrastructure, subject to a number of conditions. One of those conditions (Ministers Condition of Approval D9a) requires that an assessment be made of the adequacy of existing surveys for the Koala populations at Coolgardie/Bagotville, Broadwater and Woombah/Iluka.

This memo addresses those concerns for the Koala population at Woombah/Iluka.

Clarification was sought about the intent of Commonwealth and State planning and consent authorities in relation to CoA D9 (a) (i). This and other relevant matters were discussed at a meeting of NSW Roads and Maritime Services, NSW Department of Planning and Environment and Australian Department of the Environment on 15 June 2015. Extracts of relevant decisions made at that meeting are provided in the following assessment.

Yours sincerely

Dr Rod Kavanagh
Principal Research Ecologist

Niche Environment and Heritage

Woombah/Iluka Koala population

MCoA D9a

Condition D9, in part, states:

"D9. As part of the Threatened Species Management Plans required under condition D8, the Applicant shall prepare and implement a Koala Management Plan to demonstrate the ongoing survival of the Koala populations at Coolgardie/Bagotville, Broadwater and Woombah/Iluka. The Plan shall be prepared by a suitably qualified and experienced species expert and shall include, but not necessarily be limited to:

(a) results of detailed surveys to determine:

(i) the **population status** of the Coolgardie/Bagotville, Broadwater and Woombah/Iluka Koala populations;

(ii) **habitat use and movement patterns** of Koala populations within five kilometres of the proposed upgrade, or such area as determined by the independent ecologist; and

(iii) **habitat areas likely to be fragmented** by the SSI;

including the results of SPOT assessment and radio tracking.

The results and adequacy of surveys shall be verified by an independent suitably qualified and experienced ecologist with appropriate qualifications and experience in Koala and road ecology. Where appropriate, the Applicant may vary the required area of survey specified under condition D9(a)(ii) to the satisfaction of the independent ecologist; …"

Survey objectives and Procedures

NSW Roads and Maritime Services has commissioned a range of ecological surveys for the Koala and other threatened species within the conditionally-approved Pacific Highway Upgrade between Woolgoolga and Ballina. The broad objectives of this work, in relation to the Koala (see Table 2-15, EIS/Biodiversity Working Paper), are to:

- "Establish that a Koala population occurs in the study area"; and,
- Gather adequate information on the characteristics of the Koala populations and the quality of potential habitat within the study area.

In particular, RMS needs to be able to adequately assess the impacts of the Project so that appropriate management and mitigation/offset measures can be developed. More specifically, RMS wants to know the most appropriate locations for installing under-road or over-road connectivity structures to ensure that Koala populations are not fragmented by the Highway Upgrade. RMS also wants to know where significant populations of the Koala occur so that the Highway Upgrade in these areas can be appropriately fenced to eliminate any road-kills that may occur as a result of the Project.

A range of survey techniques has been employed, principally diurnal faecal pellet search plots, but also nocturnal spotlighting and call-playback surveys at some locations (Tables 2-10, 2-11 and 2-15, EIS). Koala habitat assessment plots were generally co-located with faecal pellet search plots. All vegetation polygons proposed for clearing within the footprint area of the Highway Upgrade have been assessed in terms of their likely contributions to Koala habitat.

<u>Woombah Koala population (Sections 5 and 6): Surveys undertaken and Results</u>

The Woombah Koala population is defined here as the animals, and their habitat, contained within a 5 km radius of the intersection between the Pacific Highway and Iluka Road. The Iluka Koala population is located east of the Esk River, more than eight kilometres away, and unlikely to be affected directly by the planned upgrading of Sections 5 and 6 the Pacific Highway.

Five primary sources of information were reviewed for this assessment:

1. *NSW Wildlife Atlas (BioNet) records within a 5 km radius of the intersection between Pacific Highway and Iluka Road.*

   Six Koala records are displayed in Fig. 2-5 of the Draft Koala Management Plan (Version 1, October 2013) and Figs. 5.24 and 5.25 from Appendix J (SPIR) within approximately five kilometres of this intersection. These records were all on the most populated, eastern, side of the Pacific Highway near the village of Woombah.

   A check of BioNet records (accessed 1 May 2015) showed **nine records in the same area**: 3 west of the Highway in, or adjacent to, Mororo Creek Nature Reserve, 5 in or near the village of Woombah (including one record of faecal pellets, presumably from a Koala observed nearby on the same day), and 1 old record (1992) to the north in Bundjalung NP (previously Mororo State Forest). The three records west of the highway were all recent (Dec. 2012, Jan. 2013). The remaining records near Woombah were made in 1986, 2001, 2006 and 2008.

2. *EIS (Biodiversity assessment working paper) and SPIR (Supplementary biodiversity assessment)*

   It is difficult to separate the various contributions made by each of these two documents because the survey efforts expended in each, and the results obtained, have been presented either cumulatively as maps, in the case of spotlighting and call-playback results (see email from Chris Thomson SKM/Jacobs on 27 April 2015), or in a combined spreadsheet documenting the results of habitat assessment plots and faecal pellet search plots. The survey effort for Koalas within 5 km of the Iluka Road intersection between 2005-2012 consisted of **13 Koala habitat assessment plots** and **13 Koala faecal pellet search plots** (12 plots were used for both purposes), **one spotlighting/call playback site** (in 2005), and **two spotlighting sites** in 2012 (Figs 2-5 and 2-6 of the draft Koala Management Plan, version 1, October 2013; and Tables 2-10, 2-11 and 2-15 and Appendix N of the Biodiversity Assessment Working Paper, November 2012). Koala faecal pellets were found at **two sites** (one east and one west of the Iluka Road intersection) following these surveys, and **one Koala was directly observed in Mororo Creek Nature Reserve** during the surveys (Figs 3-48 and 3-49 of the Biodiversity Assessment; Table 5-8 Appendix J SPIR).

3. Comprehensive Koala Plan of Management for the Ashby, Woombah and Iluka localities in the Clarence Valley LGA (draft), September 2010, and updated in March 2015. Also, reports by Phillips and Forsman (2002) and Biolink Ecological Consultants (2012).

   The two drafts of this CKPOM were informed largely by independent surveys (i.e. not commissioned as part of the Pacific Highway Upgrade project) that were conducted by Phillips and Forsman (2002) and Biolink Ecological Consultants (2012) in the Woombah area (north-east of the Iluka Road intersection). In 2002, Phillips and Forsman established 18 faecal pellet search sites on a 500 m grid, recording **Koala faecal pellets at only four of these sites** – all were regarded as "low use" sites. All four of these sites were located within 1.5 km of the Iluka Road intersection. In 2011, these authors (Biolink Ecological Consultants) revisited the same 18 sites, recording **Koala faecal pellets at only one of these sites** (this was a different site, also scored as "low use").

   Both 2010 and 2015 versions of the draft CKPOM (in "Summary") state: "**The Woombah koala population is in imminent danger of extinction and it is highly likely that the Iluka koala population is already extinct**." However, recent observations, from a range of sources, indicate that some Koalas are still present in both the Woombah and Iluka areas. It is thought that these animals have come from adjacent public lands (Bundjalung National Park and nearby State Forests) that were not covered by this CKPOM.

   Biolink Ecological Consultants (2012) concluded: "there clearly remains the **potential for increases in koala populations** in the Ashby, Woombah and Iluka areas generally, due to **large areas of preferred koala habitat that are currently unoccupied by resident koala populations**."

4. Ecosure Pre-construction surveys

   In Sections 5/6, within 5 km of the Iluka Road intersection, Ecosure established 10 Koala faecal pellet search plots, each 500 m apart, but surveyed only six of these plots (in March-April 2014). They recorded **Koala faecal pellets at only 1 of these 6 plots**. "Medium activity" was noted at this plot. A daylight search of the tree canopy was also conducted within 25 m radius of these six plots, but **no Koalas were observed**.

   Potential Koala habitat, as defined by the presence of preferred Koala food trees, was observed at all six of these sites.

5. Koala habitat-quality site-rankings

   In 2014, GeoLink undertook vegetation assessments within Sections 4 and 5. They did not specifically look for Koalas, and **did not find any**. However, they scored the vegetation polygons present across these two Sections in terms of their likely quality as habitat for Koalas. On average, they ranked a total of 75.5 ha within seven Biometric Vegetation Types as 4 (out of 10; range 2-6.7) for Koala habitat, noting that primary feed trees, including Forest Red Gum and Tallowwood, were present.

   GeoLink concluded that **"the Iluka Road area provides an important area of connectivity for Koalas moving between the coast and the Maclean area".**

Adequacy of surveys

- Condition D9 (a) (i) requires that surveys be adequate to determine “the **population status** of the …..Woombah/Iluka Koala populations”.

The most significant Koala survey effort within 5 km of the Iluka Road intersection was conducted independently of this Project (Phillips and Forsman 2002, Biolink Ecological Consultants 2012). Surveys commissioned by RMS within 5 km of the Iluka Road intersection were limited in scope and intensity. Aside from two “positive” Koala faecal assessment plots from a total of 19 plots surveyed (separated in time by several years), and one Koala observed directly, the RMS surveys provided limited understanding of Koala population status. Information from all available sources suggests that the Woombah Koala population is present, but that it may be represented by only few individuals.

The information collected to date is insufficient to estimate the population size of the Woombah population, and the status of this population is likely to be at risk of extinction – a view which is reflected in the draft CKPOM (2010, 2015). Given the apparently low numbers of animals present, it may not be economically feasible to accurately determine the size of this population.

The Iluka Koala population, which is also very small and likely to be at risk of extinction (draft CKPOM 2010, 2015) is located east of the Esk River, more than eight kilometres away, and unlikely to be affected directly by the planned upgrading of Sections 5 and 6 the Pacific Highway.

- Condition D9 (a) (ii) requires that surveys be adequate to determine “**habitat use and movement patterns** of Koala populations within five kilometres of the proposed upgrade, or such area as determined by the independent ecologist;”

Existing information is inadequate to determine details of Koala habitat use and movement patterns. However, several vegetation types including Primary Koala Food Tree species are known to occur in the area, and Ecosure (2014) has used this information to map the locations of areas likely to be most important (Fig. 5a) for Koala movement. One area in particular (approximately 0-500 m north of the Iluka Road intersection [chainage 95500-96000]) has been identified as a “pinch point” where connectivity structures need to be built and associated revegetation/habitat restoration areas should be established.

- Condition D9 (a) (iii) requires that surveys be adequate to determine “**habitat areas likely to be fragmented** by the SSI;”

The existing Pacific Highway has already fragmented the habitat of the Woombah Koala population into east and west portions, with occasional Koala road-kills likely to occur along this stretch of the Highway. Currently, there are no connectivity structures present. The proposed widening of the road presents an opportunity to install fencing and connectivity structures that should reduce Koala road-kills in this area and potentially reduce fragmentation of the Woombah Koala population and its habitat.

As indicated above, the forested landscape context within 5 km of the Iluka Road intersection is such that there are obvious locations where connectivity structures and habitat restoration/revegetation should be implemented to minimise habitat fragmentation and provide safe passage for Koalas. Primary Koala Food Tree species are known to be represented within the different vegetation types that are present in or near these areas. Unfortunately, only one connectivity structure (dedicated culvert 2.4 x 2.4 x 38 m long, near chainage 96200) is proposed to be built in the most strategic location (meeting of 31 July 2015 with Roads and Maritime Services, Pacific Complete, NSW National Parks and Wildlife Service, NSW Environmental Protection Authority, Ecosure and Niche Environment and Heritage) due to the large footprint of required infrastructure at the nearby Iluka Road interchange.

Summary and Recommendations

1. The Woombah Koala population appears to be very small and sparsely distributed, and in danger of local extinction from a range of existing and recent factors that are independent of the proposed highway upgrade. However, the survey effort to date has not been adequate to understand details of the population size, its distribution and trend. The reliance on indirect survey methods (faecal pellet search plots), sparsely implemented, precludes thorough assessment of the status of the Woombah Koala population. This method, at best (i.e. when large numbers of sites are surveyed), can only provide a coarse index of relative abundance. Otherwise (when few sites are surveyed), the only conclusion permissible is that the species is present if pellets are found. The current survey effort is inadequate to provide a baseline for the status of the Woombah Koala population, and for future monitoring of trends in this population.

   Clarity is needed about the intent of Commonwealth and State planning and consent authorities in relation to CoA D9 (a) (i). It could be argued that it is not the responsibility of NSW Roads and Maritime Services to fund the level of sampling intensity that would be required to rigorously address the population status of the Woombah Koala population.

2. The Iluka Koala population is unlikely to be affected directly by the planned upgrading of Sections 5 and 6 the Pacific Highway. This population is also very small and likely to be at risk of extinction but, since it is located more than eight kilometres away from the planned upgrade, and east of the Esk River, it is difficult to see why this population has been included as a matter of concern for this Project.

3. Radio-tracking has not been employed as a survey or research tool in this Project. Given the apparently small, sparse, nature of the Woombah Koala population, any information so derived from radio-tracking would be limited to very small sample sizes and the search effort to find suitable animals for tracking could be large. Given the degree of habitat fragmentation in the area, it is doubtful whether detailed information about the movements of one or two individuals would greatly improve efforts to protect and conserve this population beyond that which is already apparent based on the distribution of habitat for this species.

Conclusions

The Ministerial Conditions of Approval for D9 (a) have not technically been met for parts (i), (ii) or (iii).

In relation to part (i), it cannot be said that the survey effort to date has been adequate to understand and document details of the status of the Woombah Koala population (i.e. its size, its distribution and trend), other than that the population is very small and sparsely distributed. If, as the Condition states: “the Applicant shall prepare and implement a Koala Management Plan **to demonstrate the ongoing survival of the Koala populations** at Coolgardie/Bagotville, Broadwater and Woombah/Iluka”, then further work is needed to provide a baseline for the status of the Woombah Koala population, and for future monitoring of trends in this population.

Clarification was sought about the intent of Commonwealth and State planning and consent authorities in relation to CoA D9 (a) (i). This and other relevant matters were discussed on 15 June 2015 at a meeting of NSW Roads and Maritime Services, NSW Department of Planning and Environment and Australian Department of the Environment. Extracts of relevant decisions made at that meeting are provided below.

- "DoE and DP&E (RW/KJ/MY/MS) Based on the available information to date, there is a low risk that the Iluka/Woombah and Ashby Koala population would be impacted by section 5 of the Woolgoolga to Ballina upgrade project.
- DoE and DP&E (RW/KJ/MY/MS) confirmed that **no additional baseline koala base line surveys are required for Section 5 for the Iluka/Woombah Koala populations**".

<u>Thus, while Condition D9 (a) (i) has not been met, the regulating agencies have decided that no further survey effort is required</u>.

In relation to part (ii), the survey effort to date has been inadequate to understand and document details of habitat use and movement patterns for the Woombah Koala population. For part (iii), the survey effort has also been inadequate to understand and document details of the habitat areas that are likely to be fragmented by the SSI. However, In relation to part (iii), considerable efforts have been made to document and map areas of high quality habitat for Koalas that are proposed for clearing along the highway footprint.

In my opinion, the intent of Conditions D9 (a) (ii) and (iii) is primarily to understand where connectivity structures should be placed to minimise impacts of the SSI on the Woombah Koala population. The existing Pacific Highway has already fragmented the habitat of this Koala population into east and west portions, both of which include vegetation types comprised of important food tree species for the Koala. At this location (Section 5), the alignment of the proposed Highway Upgrade sits largely within the existing highway footprint. The forested landscape context within 5 km of the Iluka Road intersection is such that there are obvious locations where connectivity structures and habitat restoration/revegetation should be located to minimise habitat fragmentation and to provide safe passage for Koalas. Recommendations for the placement of connectivity structures to achieve this have been described in the pre-construction survey report by Ecosure.

The relevant decision of the meeting of 15 June 2015 stated that:

- DoE and DP&E (RW/KJ/MY**) agree with findings of Dr Rod Kavanagh that surveys undertaken to date for Section 5 (Iluka/ Woombah area) satisfy MCoA D9(a)ii and (iii)**

<u>Thus, while Conditions D9 (a) (ii) and D9 (a) (iii) have not technically been met, the regulating agencies have decided that sufficient information is available to satisfy these two Conditions, in terms of the locations of connectivity structures required to minimise impacts on the Woombah Koala population.</u>

Rod Kavanagh

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21 August 2015

Mr Scott Lawrence / Mr Simon Wilson,
Roads and Maritime Services
21 Prince Street,
GRAFTON, NSW 2460

Dear Scott and Simon,

Re: Survey adequacy (MCoA D9a) – Broadwater population

On 24 June 2014, the NSW Government approved the upgrading of the Pacific Highway between Woolgoolga and Ballina as State Significant Infrastructure, subject to a number of conditions. One of those conditions (Ministers Condition of Approval D9a) requires that an assessment be made of the adequacy of existing surveys for the Koala populations at Coolgardie/Bagotville, Broadwater and Woombah/Iluka.

This memo addresses those concerns for the Koala population at Broadwater.

Clarification was sought about the intent of Commonwealth and State planning and consent authorities in relation to CoA D9 (a) (i). This and other relevant matters were discussed at a meeting of NSW Roads and Maritime Services, NSW Department of Planning and Environment and Australian Department of the Environment on 15 June 2015. Extracts of relevant decisions made at that meeting are provided in the following assessment.

Yours sincerely

Dr Rod Kavanagh
Principal Research Ecologist

Niche Environment and Heritage

Broadwater Koala population

<u>MCoA D9a</u>

Condition D9, in part, states:

"D9. As part of the Threatened Species Management Plans required under condition D8, the Applicant shall prepare and implement a Koala Management Plan to demonstrate the ongoing survival of the Koala populations at Coolgardie/Bagotville, Broadwater and Woombah/Iluka. The Plan shall be prepared by a suitably qualified and experienced species expert and shall include, but not necessarily be limited to:

(a) results of detailed surveys to determine:

(i) the **population status** of the Coolgardie/Bagotville, Broadwater and Woombah/Iluka Koala populations;

(ii) **habitat use and movement patterns** of Koala populations within five kilometres of the proposed upgrade, or such area as determined by the independent ecologist; and

(iii) **habitat areas likely to be fragmented** by the SSI;

including the results of SPOT assessment and radio tracking.

The results and adequacy of surveys shall be verified by an independent suitably qualified and experienced ecologist with appropriate qualifications and experience in Koala and road ecology. Where appropriate, the Applicant may vary the required area of survey specified under condition D9(a)(ii) to the satisfaction of the independent ecologist; …"

<u>Survey objectives and Procedures</u>

NSW Roads and Maritime Services has commissioned a range of ecological surveys for the Koala and other threatened species within the conditionally-approved Pacific Highway Upgrade between Woolgoolga and Ballina. The broad objectives of this work, in relation to the Koala (see Table 2-15, EIS/Biodiversity Working Paper), are to:

- "Establish that a Koala population occurs in the study area"; and,
- Gather adequate information on the characteristics of the Koala populations and the quality of potential habitat within the study area.

In particular, RMS needs to be able to adequately assess the impacts of the Project so that appropriate management and mitigation/offset measures can be developed. More specifically, RMS wants to know the most appropriate locations for installing under-road or over-road connectivity structures to ensure that Koala populations are not fragmented by the Highway Upgrade. RMS also wants to know where significant populations of the Koala occur so that the Highway Upgrade in these areas can be appropriately fenced to eliminate any road-kills that may occur as a result of the Project.

A range of survey techniques has been employed, principally diurnal faecal pellet search plots, but also nocturnal spotlighting and call-playback surveys at some locations (Tables 2-10, 2-11 and 2-15, EIS). Koala habitat assessment plots were generally co-located with faecal-pellet search plots. All vegetation polygons proposed for clearing within the footprint area of the Highway Upgrade have been assessed in terms of their likely contributions to Koala habitat.

<u>Broadwater Koala population (Section 9): Surveys undertaken and Results</u>

The Broadwater Koala population is defined here as the animals, and their habitat, contained within an area 3-5 km either side of an 11.0 km portion of the Pacific Highway Upgrade from Lang Hill (northern part of Section 8) north to the Richmond River (including all of Section 9). These Sections (part 8-9) are one of two areas of the entire Upgrade (along with Section 10) where the greatest numbers of Koala records were encountered in surveys. These two areas were considered by the authors of the Highway Upgrade Environmental Impact Statement and Supplementary Biodiversity Assessment (SPIR) to contain "important populations" according to the guidelines for assessment described in the *Interim Koala referral advice for proponents* (DSEWPaC 2012). The Richmond River forms a major barrier to the west and north, restricting the movements of the Broadwater Koala population.

Five primary sources of information were reviewed for this assessment:

1. *NSW Wildlife Atlas (BioNet) records within 3-5 km of (part) Section 8 and Section 9 of the Pacific HighwayUpgrade.*

   Twenty-eight Koala records (~15 in Broadwater National Park) are displayed in Figs. 2-8 and 2-9 of the Draft Koala Management Plan (Version 1, October 2013). Most of these records were distributed around the edges of the Broadwater National Park or occurred on adjacent private lands, with concentrations near the town of Broadwater and Riley's Hill.

   A check of BioNet records (accessed 4 August 2015) showed approximately **thirty-six records in the same area**: several additional records were made near Riley's Hill and on the northern edge of Broadwater National Park.

2. *EIS (Biodiversity assessment working paper) and SPIR (Supplementary biodiversity assessment*

   It is difficult to separate the various contributions made by each of these two documents because the survey efforts expended in each, and the results obtained, have been presented either cumulatively as maps, in the case of spotlighting and call-playback results (see email from Chris Thomson SKM/Jacobs on 27 April 2015), or in a combined spreadsheet documenting the results of habitat assessment plots and faecal pellet search plots. The survey effort for Koalas along the 11.0 km Sections (part) 8 and 9 of the Highway Upgrade between 2006-2007 consisted of **9 Koala habitat assessment plots** and **10 Koala faecal-pellet search plots** (8 plots were used for both purposes), **four spotlighting/call playback sites** (in 2005) (Figs. 2-8 and 2-9 of the draft Koala Management Plan, version 1, October 2013; and Tables 2-10, 2-11 and 2-15 and Appendix N of the Biodiversity Assessment Working Paper, November 2012). Koala faecal pellets were recorded at **four (or five?) sites only**. N**o direct observations of the Koalas** were reported during these surveys (Figs 3-48 and 3-49 of the Biodiversity Assessment; Table 5-8 Appendix J SPIR).

3. Ecosure Pre-construction surveys

   In Section 9, Ecosure (2014) established 20 Koala faecal-pellet search plots, each 500 m apart, and surveyed them in March-April 2014 (none were established in Section 8). The method also included daylight searching for the presence of Koalas within 0.2 ha plots centred on the faecal search plots. They recorded **Koala faecal pellets at only 1 of these 20 plots**. “Low activity” was noted at this plot. Good habitat (i.e. presence of primary and secondary Koala food tree species) was noted at four of these sites. Koala faecal pellets were also observed at five supplementary search plots in Section 9 and at eight supplementary search plots in Section 8. **No Koalas were observed during daylight searches** of the tree canopy at the 20 faecal-pellet search plots. Five direct, but anecdotal, observations were made of Koalas during the study, including three within close proximity to the road alignment, one in areas of connecting habitat between Riley’s Hill and Broadwater, and one recent sighting by a landholder in the northern portion of Section 9.

   The surveys indicated that the Broadwater Koala Population is located mainly around the perimeter of the Broadwater National Park, especially along the forested fringe and fragmented woodlands outside of the Park. Broadwater National Park is dominated by heathland and, as such, is largely unsuitable for Koalas. The most important areas for Koalas were considered to be between Riley’s Hill and the eastern side of the township of Broadwater, and a number of connectivity structures were proposed throughout the fragmented woodlands along the Highway alignment to permit Koala dispersal. The northern and southern exit points of the Highway at the edges of Broadwater National Park were also regarded as crucial areas requiring connectivity structures to permit Koala movements throughout the area.

4. Koala habitat-quality site-rankings

   In 2014, the Melaleuca Group undertook vegetation assessments within Sections 8 and 9. They did not specifically look for Koalas, and **did not find any**. However, they scored the 147 vegetation polygons present across these two Sections in terms of their likely quality as habitat for Koalas. On average, they ranked a total of 73.3 ha within twelve Biometric Vegetation Types as 4.13 (out of 10; range 3-9) for Koala habitat, noting that primary feed trees, including Swamp Mahogany, Forest Red Gum and Tallowwood, were present.

   The Melaleuca Group (2014) considered that Koalas were highly likely to occur in many areas assessed, and noted Koala scats and climbing marks on trees within several vegetation types, including Swamp Mahogany-Swamp Forest, Grey Gum- Grey Ironbark Open Forest, Forest Red Gum Grassy Open Forest and Brush Box-Tallowwood Shrubby Open Forest.

5. Koala Habitat and Population Assessment: Draft report to Richmond Valley LGA (Biolink Ecological Consultants, June 2015).

   Key findings of this draft report include the following:

   - The 768 historical records of the Koala in the Richmond Valley LGA show that this species has a history of occupation extending back more than a century. The population in this area appears to have declined by one-third between 1996-2013.

- Major source populations occur around the townships of Broadwater- Riley's Hill and Evans Head – Doonbah, as well as around the township of Coraki.

- A total of 58 sites were searched in the LGA for the presence of Koala faecal pellets. A subset of 12/28 of these sites between the Evans and Richmond Rivers showed evidence of Koala activity, implying that over 40% of available habitat was being utilised by Koalas. However, only one Koala was directly observed during these surveys.

- Excluding National Park estate, the population density of Koalas within the LGA was estimated at ~ 0.18 Koalas ha-1, or approximately 287 koalas.

- Data from 4,640 trees searched indicated that Swamp Mahogany (*Eucalyptus robusta*), Tallowwood (*E. microcorys*) and Forest Red Gum (*E. tereticornis*) were the tree species most preferred by Koalas, followed by a suite of secondary species including Grey Gum (*E. propinqua*) and Grey Box (*E. moluccana*).

- Preferred Koala Habitat was estimated to be 73,361 ha within the RVLGA.

- Threats to the continued viability of Koala populations inhabiting the RVLGA include fire, selective logging of preferred koala food trees on public and private lands, urban expansion, vehicle-strike and domestic dog attack.

- At least two "Important Populations" as defined for purposes of the Federal Government's Environmental Protection and Biodiversity Conservation Act 1999, were considered to occur within the LGA: one in the coastal areas between the Richmond and Evans Rivers, and the other in the Rappville area.

<u>Adequacy of surveys</u>

- Condition D9 (a) (i) requires that surveys be adequate to determine "the **population status** of the …..Broadwater Koala population".

The Broadwater Koala population appears to be larger, and better known, than the Woombah Koala population, but this observation is made principally on the basis of the larger numbers of records (fourfold) in the NSW Wildlife Atlas (BioNet) and the larger number of animals detected, albeit mostly opportunistically, during the survey period (5:1). However, the relative survey effort between the two populations yielded similar results, suggesting that low Koala population densities occurred in both areas. For example, ~30 Koala faecal pellet search plots were surveyed at Broadwater, with pellets recorded at ~5 plots, compared to ~55 plots surveyed at Woombah where pellets were recorded at ~7 plots.

The information collected to date is insufficient to estimate the population size of the Broadwater population. This is, in part, because most of the sampling effort expended to date has been focussed near the Highway, and in particular along the road alignment within Broadwater National Park, yet most of the Koala population appears to be located near the edges of the National Park and among the more fragmented forests and woodlands outside of the Park. The Highway Upgrade is planned to traverse these fragmented areas, but only few survey sites have been located there. Secondly, there appear to be concentrations of animals living 1-3 kilometres away from the road alignment (e.g. Riley's Hill) which have not been surveyed.

- Condition D9 (a) (ii) requires that surveys be adequate to determine "**habitat use and movement patterns** of Koala populations within five kilometres of the proposed upgrade, or such area as determined by the independent ecologist;"

Existing information is inadequate to determine details of Koala habitat use and movement patterns. However, several vegetation types including Primary Koala Food Tree species are known to occur in the area, and Ecosure (2014) has used this information, together with the forested landscape context, to map the locations of areas likely to be most important (Fig. 5c) for Koala movement. Two locations in particular, one at the northern exit from Broadwater National Park and one at the southern exit from the Park (chainage 140100-140600 and 137300-138100, respectively) were identified as crucial "pinch points" where connectivity structures need to be built and associated revegetation/habitat restoration areas should be established to minimise habitat fragmentation and provide safe passage for Koalas. Ecosure (2014) also identified three other locations where connectivity structures should be established, along with associated revegetation/habitat restoration areas (chainage 142000-142300, 143100-143500 and 144600-145000). Connectivity structures are proposed to be built in these strategic areas. Four "Koala-friendly" connectivity structures are proposed in the northern part of Section 8, while another 12 structures are proposed for Section 9 (meeting of 31 July 2015 with Roads and Maritime Services, Pacific Complete, NSW National Parks and Wildlife Service, NSW Environmental Protection Authority, Ecosure and Niche Environment and Heritage).

- Condition D9 (a) (iii) requires that surveys be adequate to determine "**habitat areas likely to be fragmented** by the SSI;"

The existing Pacific Highway has already fragmented the habitat of the Broadwater Koala population into east and west portions, particularly within the National Park. Furthermore, the new road alignment will traverse existing fragmented forests and woodlands located outside of the National Park, and these areas are occupied by Koalas. Koala road-kills are likely to occur at any point along Sections 8 (part) and 9 of the Highway Upgrade. The proposed widening and re-alignment of the road presents an opportunity to install fencing and connectivity structures that should reduce Koala road-kills in this area, and the proposed plans to revegetate strategic areas near the highway (Fig. 5c, Ecosure 2014; meeting of 31 July 2015 referred to above) should serve to reduce fragmentation of the Broadwater Koala population and its habitat.

<u>Summary and Recommendations</u>

1. The Broadwater Koala population appears to be small or, possibly, moderate in size with a significant proportion of individuals distributed around the perimeter of Broadwater National Park or in the fragmented forests and woodlands occurring outside of the National Park. There appears to be a number of "clusters" of animals occurring outside of the Park (e.g. at Riley's Hill and near the township of Broadwater), although the status of the Koala population within any of these areas is unknown. The vegetation occurring in the centre of Broadwater National Park near the road alignment appears to be largely unsuitable as habitat for Koalas, although some dispersal may occur through these areas.

The survey effort to date has not been adequate to understand details of the population size, its distribution and trend. The reliance on indirect survey methods (faecal-pellet search plots), sparsely implemented, precludes thorough assessment of the status of the Broadwater Koala population. This method, at best (i.e. when large numbers of sites are surveyed), can only provide a coarse index of relative abundance. Otherwise (when few sites are surveyed), the only conclusion permissible is that the species is present if pellets are found. The current survey effort is inadequate to provide a baseline for the status of the Broadwater Koala population, and for future monitoring of trends in this population.

Clarity is needed about the intent of Commonwealth and State planning and consent authorities in relation to CoA D9 (a) (i).

2. Radio-tracking has not been employed as a survey or research tool in this Project, however, in my opinion, this technique has not been required to address the relevant MCoA. Given the apparently small, sparse, nature of the Broadwater Koala population, any information so derived from radio-tracking would be limited to very small sample sizes and the search effort to find suitable animals for tracking could be large. Furthermore, given the degree of habitat fragmentation in the area, it is doubtful whether detailed information about the movements of a few individuals would greatly improve efforts to protect and conserve this population beyond that which is already apparent based on the distribution of habitat for this species.

Conclusions

The Ministerial Conditions of Approval for D9 (a) have not technically been met for parts (i), (ii) or (iii).

In relation to part (i), it cannot be said that the survey effort to date has been adequate to understand and document details of the status of the Broadwater Koala population (i.e. its size, its distribution and trend), other than that the population is small and sparsely distributed. If, as the Condition states: "the Applicant shall prepare and implement a Koala Management Plan **to demonstrate the ongoing survival of the Koala populations** at Coolgardie/Bagotville, Broadwater and Woombah/Iluka", then further work is needed to provide a baseline for the status of the Broadwater Koala population, and for future monitoring of trends in this population.

Clarification was sought about the intent of Commonwealth and State planning and consent authorities in relation to CoA D9 (a) (i). This and other relevant matters were discussed on 15 June 2015 at a meeting of NSW Roads and Maritime Services, NSW Department of Planning and Environment and Australian Department of the Environment. Extracts of relevant decisions made at that meeting are provided below.

- "DoE and DP&E (RW/KJ/MY/MS); confirmed that **additional baseline surveys are likely to be required for the Broadwater Koala population in Section 8/9**.
- Roads &Maritime (BH/SL) **agreed to progress methodology for additional base line surveys in Section 8/9**. To address the relevant approval conditions the baseline methodology would be reviewed by Dr Kavanagh and Dr Rhodes prior to commencing field work. The additional baseline survey work anticipated to occur within the 2015 koala breeding season".

Subsequently, a proposal to satisfy the requirements for additional Koala surveys in Section 8 (part) and Section 9 (the Broadwater Koala population) was prepared by Ecosure (28 July 2015; see attached document). This proposal described a survey design (based on 62 sites, stratified by vegetation type) and methodology (based on direct counts of Koalas on fixed plots) which should serve as a suitable basis for monitoring changes in the size and distribution of the Broadwater Koala population over time. The proposed new baseline surveys will be initiated in spring 2015.

This new baseline survey for the Broadwater Koala population, and other Koala population monitoring programs associated with the Project (e.g. Section 10), require the establishment of "**external control sites**" which are monitored concurrently to determine whether any changes in Sections 8 (part), 9 and 10 are due to the Highway Upgrade or some other factor (e.g. drought). The numbers and locations of these external control sites have not yet been considered and implemented.

Thus, because Condition D9 (a) (i) has not been met, the regulating agencies have decided that further survey effort is required. A new baseline survey covering Section 8 (part) and Section 9 has been designed and will be implemented in spring 2015.

In relation to part (ii), the survey effort to date has been inadequate to understand and document details of habitat use and movement patterns for the Broadwater Koala population. For part (iii), the survey effort has also been inadequate to understand and document details of the habitat areas that are likely to be fragmented by the SSI. However, In relation to part (iii), considerable efforts have been made to document and map areas of high quality habitat for Koalas that are proposed for clearing along the highway footprint.

In my opinion, the intent of Conditions D9 (a) (ii) and (iii) is primarily to understand where connectivity structures should be placed to minimise impacts of the SSI on the Broadwater Koala population. The existing Pacific Highway has already fragmented the habitat of this Koala population into east and west portions, both of which include vegetation types comprised of important food tree species for the Koala. At this location (Section 9), the alignment of the proposed Highway Upgrade sits largely within the existing highway footprint. The forested landscape context, including the largely heathland-dominated Broadwater National Park and surrounding agricultural matrix, is such that there are obvious locations where connectivity structures and habitat restoration/revegetation should be located to minimise habitat fragmentation and to provide safe passage for Koalas. Recommendations for the placement of connectivity structures to achieve this have been described in the pre-construction survey report by Ecosure.

The meeting of 15 June 2015 between RMS, DP&E and DoE did not make any decision about the adequacy of surveys undertaken to date for Sections 8 (part) and 9 and whether they satisfied MCoA D9(a) (ii) and (iii).

Thus, while Conditions D9 (a) (ii) and D9 (a) (iii) have not technically not been met, the implications for regulating agencies and the RMS are clear, in terms of the required numbers and locations of connectivity structures to minimise impacts on the Broadwater Koala population, because sufficient information is available to satisfy these two Conditions.

Rod Kavanagh

Appendix H NSW Code of Practice for Injured, Sick or Orphaned Koalas

Office of Environment & Heritage

Code of Practice for Injured, Sick and Orphaned Koalas

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Report pollution and environmental incidents
Environment Line: 131 555 (NSW only) or info@environment.nsw.gov.au
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Preface

The Code of Practice for Injured, Sick and Orphaned Koalas (the Code) is intended for anyone authorised by the Office of Environment and Heritage (OEH) to rehabilitate and release koalas (*Phascolarctos cinereus*). It has been developed to protect the welfare of koalas in care and for the conservation of wild koala populations. The Code contains both standards and guidelines for the care of koalas and is designed to be read in conjunction with the *Code of Practice for Injured, Sick and Orphaned Protected Fauna* (OEH 2011).

Koalas are listed as vulnerable under the *Threatened Species Conservation Act 1995*. The koala population in the Pittwater Local Government Area and in the Hawks Nest and Tea Gardens areas are listed as endangered.

Both the *NSW Recovery Plan for the Koala* (DECC 2008) and the *National Koala Conservation and Management Strategy 2009–2014* (Australian Government 2009) have high welfare standards for koalas in care as a key objective. The Code is intended to contribute to this objective.

Compliance with the Code does not remove the need to abide by the requirements of the *Prevention of Cruelty to Animals Act 1979* and any other laws and regulations, for example, the *Local Government Act 1993.*

Compliance with the standards in the Code is a condition of licences issued (under Section 120 of the *National Parks and Wildlife Act 1974* (NPW Act)), to rehabilitate and release sick, injured and orphaned protected fauna. Failure to comply with a licence condition is an offence under the Section 133 of the NPW Act and may result in a Penalty Infringement Notice being issued or the commencement of a prosecution.

The Code has been prepared by OEH in consultation with Friends of the Koala, Koalas In Care, Native Animal Trust Fund, WIRES, Hunter Koala Preservation Society and the Koala Preservation Society NSW. It is also supported by the NSW Animal Welfare Advisory Council within the Department of Primary Industries.

The Code is neither a complete manual on animal husbandry, nor a static document. It will be revised as necessary to take into account new knowledge of animal physiology and behaviour, technological advances, developments in standards of animal welfare and changing community attitudes and expectations about the humane treatment of koalas. OEH will consult with licence holders regarding potential changes to the Code and give written notice when the Code is superseded.

Contents

1. Introduction

This Code sets the standards for the care and housing of koalas that are incapable of fending for themselves in their natural habitat. It comprises both enforceable provisions and guidelines. Enforceable provisions are identified by the word 'standards' and these **must** be followed.

2. Interpretations and definitions

2.1. Interpretations

Objectives

Objectives are the intended outcome(s) for each section of the Code.

Standards

Standards describe the mandatory specific actions needed to achieve acceptable animal welfare levels. These are the minimum standards that must be met. They are identified in the text by the heading 'Standards' and use the word 'must'.

Guidelines

Guidelines describe the agreed best practice, following consideration of scientific information and accumulated experience. They also reflect society's values and expectations regarding the care of animals. A guideline usually indicates a higher level of care than the minimum standard, except where the standard is best practice.

Guidelines will be particularly appropriate where it is desirable to promote or encourage better care for animals than is provided by the minimum standards. Guidelines are also appropriate where it is difficult to determine an assessable standard. Guidelines are identified in the text by the heading 'Guidelines' and use the word 'should'.

Notes

Where appropriate, notes describe practical procedures to achieve the minimum standards and guidelines. They may also refer to relevant legislation.

2.2. Definitions

In this Code:

- ***Fauna rehabilitator*** means someone who is either authorised by a fauna rehabilitation group or zoological park or is individually licensed by OEH to rehabilitate and release protected fauna.
- ***Fauna rehabilitation*** means the temporary care of injured, sick or orphaned fauna with the aim of successfully releasing it back into its natural habitat.
- ***Fauna rehabilitation group*** means an incorporated group that is licensed by OEH to rehabilitate and release protected fauna.

- ***Park*** means a national park, historic site, state conservation area, regional park, nature reserve, karst conservation reserve or Aboriginal area, or any land acquired by the Minister under Part 11 of the NPW Act.

3. Case assessment

Refer to Section 4 of the *Code of Practice for Injured, Sick and Orphaned Protected Fauna* (OEH 2011).

4. Rescue

Objective

To conduct a koala rescue so as to minimise further stress and injury to the animal.

4.1. Standards

4.1.1 Prior to a rescue attempt, the rescuer must assess the risks to the koala from environmental hazards and from capture.

4.1.2. Rescuers must employ the correct rescue equipment for the condition and location of the koala and be trained in its use.

4.1.3. The following methods must not be used to capture a koala:

- noosing with a rope that tightens
- shaking the tree
- cutting the tree down.

4.1.4. The rescue attempt must be suspended if the koala is exhibiting signs of stress (e.g. crying or panting).

4.1.5. If the koala is a suspected orphan, the surrounding area must be searched for the mother. If the mother is found and is healthy, attempts must be made to reunite it with its young.

4.1.6. If the koala is an injured female with signs of having a pouch young (e.g. swollen teat), the surrounding area must be searched for the young.

4.1.7. Rescuers must not move a healthy, independent koala unless it is at immediate risk of injury (e.g. on a road). Such relocations will involve moving the koala a safe distance from the hazard and placing it in a climbable tree.

4.1.8. If multiple koalas are rescued (e.g. on a fire ground), the containers the koalas are placed in must be labelled with the capture location.

4.2. Guidelines

4.2.1. The rescue of a koala should not be attempted unless at least two trained personnel are involved.

4.2.2. If the koala has not been captured after being pursued for 10 minutes, the rescue attempt should be suspended to allow the koala to recover.

4.2.3. Rescuers should take steps to protect the koala from additional stressors such as onlookers, loud noises, other animals and extremes of temperature during rescue.

4.2.4. A koala should be picked up from behind using a towel or blanket and held firmly by the wrists/forearms.

Notes

A canvas bag, blanket or towel is suitable for catching a koala on the ground.

A long pole with flagging at one end is suitable for encouraging a koala that is close to the ground to move down.

A hoop net is suitable for catching a koala in a difficult location.

A ground trap is suitable for a koala that is too high to flag

Covering a koala's eyes with a towel, blanket or bag will often assist with calming it down.

Researchers are responsible for the welfare of the koalas covered by their animal research authority. It may be useful for researchers to establish a relationship with local rehabilitation groups should such an animal require rescue.

5. Transport

Objective

To minimise further stress and injury to a koala during transport. This section applies to all movement of the koala including from the point-of-rescue to a veterinary surgery and between rehabilitation facilities.

5.1. Standards

5.1.1. The transport method and container size must be appropriate for the size and condition of the koala. For example:

- an orphaned pouch young requires an artificial pouch that is secured within a container (e.g. cage, box or basket). Artificial heat (e.g. a hot water bottle) may also be required
- an adult or sub-adult requires a padded container.

5.1.2. The container must be designed, set-up and secured to prevent injuries to the koala. Hessian sacks must not be used as the koala's claws can become entangled and threads can be inhaled.

5.1.3. The container must be designed to prevent the koala from escaping.

5.1.4. The koala must be placed upright in the container.

5.1.5. The container must be kept at a temperature which is appropriate for the age and condition of the koala. For example:

- a range of 20–25^{o}C is appropriate for an adult in most circumstances
- a range of 28–32^{o}C is appropriate for an unfurred pouch young.

5.1.6. The container must be ventilated so air can circulate around the koala.

5.1.7. The container must minimise light, noise and vibrations and prevent contact with young children and pets.

5.1.8. The koala must not be transported in the back of uncovered utility vehicles, car boots that are separate from the main cabin or on the rescuer’s lap.

5.1.9. The container must be constructed from material that can be easily cleaned and disinfected.

5.2. Guidelines

5.2.1. A container used for transporting an adult or sub-adult koala should contain something for the koala to hold on to (e.g. a rolled up towel).

5.2.2. An adult koala should be transported with fresh eucalyptus leaves to assist with calming it.

5.2.3. Koala transport should be the sole purpose of the trip and undertaken in the shortest possible time.

6. Euthanasia

6.1. When to euthanase

Objective

To end a koala’s life in situations where death is imminent, or recovery is impossible, or the likelihood of successful reintegration into the wild population is remote, or the animal poses an unacceptable health risk to wild animals.

6.1.1. Standards

6.1.1.1. A koala must be euthanased without exception when:

- death is imminent or highly likely regardless of the treatment provided, or
- it is suffering from chronic, un-relievable pain or distress, or
- it is carrying (or suspected to be carrying) an incurable disease that may pose a health risk to wild animals, or
- it is permanently unable to consume leaf unaided due to an injured jaw or missing/worn teeth.

6.1.1.2. A koala must be euthanased (unless OEH has granted permission to hold it in permanent care) when:

- there is no suitable release location, or
- its ability to reproduce is lost due to an injury, disease or procedure, or
- it is permanently incapable of climbing trees due to a missing or injured claws, digits, limb, pelvis or back bone, or

- it is permanently vision-impaired, hearing-impaired, or anosmic (can't smell) such that it is unable to survive in its natural habitat, or
- its ability to handle branches is permanently impaired due to a missing or injured digits, or
- its advanced age renders it unable to survive in its natural habitat.

In certain exceptional circumstances, OEH may grant permission to hold such animals in permanent care. See the *Rehabilitation of Protected Fauna Policy* (DECCW 2010) for details.

Notes

A koala with a late-stage Chlamydia infection is extremely difficult to cure and poses a health risk to wild koalas.

The age of a koala can be determined through examining pre-molar and molar wear using a tooth-wear chart. For an example see Figure 8.4 in Vogelnest and Woods (2008).

6.2. How to euthanase

Refer to Section 7.2 of the *Code of Practice for Injured, Sick and Orphaned Protected Fauna,* (OEH2011).

6.3. Disposal of carcasses and animal waste

Objective

To dispose of waste so that the risks of disease transmission are minimised.

6.3.1. Standards

6.3.1.1. Carcasses and organic waste suspected of disease contamination or that have been exposed to chemicals (e.g. barbiturates) must either be incinerated or buried at a depth that will prevent scavengers from reaching them.

6.3.1.2. A koala that has died from disease or chemical means (e.g. barbiturate overdose) must not be fed to other fauna.

6.3.2. Guidelines

6.3.2.1. A deceased koala should undergo a necropsy if the cause of death is uncertain.

7. Care procedures

7.1. Monitoring

Objective

To check the health of a koala undergoing rehabilitation so that issues can be promptly identified and managed. The type and frequency of monitoring will vary with the type of injury or illness and required treatment.

7.1.1. Standards

7.1.1.1. A dependent koala (i.e. pouch young) or a koala in intensive care must be monitored repeatedly during the day and weighed at least twice per week.

7.1.1.2. An independent juvenile koala or a koala in intermediate care must be monitored at least once per day and weighed at least once per week.

7.1.1.3. A koala being prepared for release must be monitored at least every few days to determine if it is physically and behaviourally ready for release (See Section 11 Suitability for Release).

7.1.1.4. Rehabilitators must regularly monitor the temperature within an enclosure that contains thermal support, to ensure that temperatures, appropriate to the animals' condition, are maintained (e.g. blankets, hot water bottles and electric heat mats).

7.1.2. Guidelines

7.1.2.1. On admission, a koala should be checked for:

- bleeding, puncture wounds or matted wet-looking fur
- bone fractures
- rapid breathing or elevated heart rate
- dilated pupils or erratic eye movements
- enlarged lymph nodes
- pale or blue mucous membranes
- cold extremities
- ticks
- discharge from the eyes, nostrils, mouth or cloaca
- odd smells.

7.1.2.2. Monitoring a koala should entail:

- manually assessing body condition and demeanour
- checking for signs of injury, disease and parasites
- assessing hydration using the 'pinch test'
- determining how much leaf has been consumed
- noting the quantity and quality of scats and urine
- looking for indications of activity.

7.2. Controlling disease transmission between animals

Refer to Section 8.2 of the *Code of Practice for Injured, Sick and Orphaned Protected Fauna* (OEH2011).

8. Husbandry

8.1. Food and water

Objectives

To ensure that the koala has a feeding and watering regime that encourages rapid recovery, supports growth if it is a juvenile and assists with the maintenance of foraging behaviour necessary for survival in the wild.

8.1.1. Standards

8.1.1.1. Clean, fresh drinking water must be available at all times and changed daily, except in the case of dependent young (See Section 9.1.1.7).

8.1.1.2. Water containers must be designed and positioned so as to avoid spillage and contamination and must be appropriate for the size, age and mobility of the koala.

8.1.1.3. Fresh leaves must be available for the koala to eat at all times and replaced daily, except in the case of dependent young. Leaves may be harvested every few days and stored prior to use.

8.1.1.4. Stored leaves must not be accessible to pets, pests and wild animals and must be protected from contamination and nutritional and moisture loss (i.e. stored in containers of fresh water for a maximum of three days).

8.1.1.5. Leaves from at least two different eucalyptus species must be offered to the koala each day. At least one of these species must be a preferred eucalyptus species sourced from the area in which the koala was found.

8.1.1.6. Branches must be placed in holders that contain clean water. The water must be emptied and re-filled as necessary to keep the leaf hydrated.

9.1.1.7. A hand-reared koala must be fed a milk formula that is appropriate for its stage of development.

8.1.2. Guidelines

8.1.2.1. Leaves from non-eucalyptus food trees that are sourced from the area in which the koala was found should be offered as a supplement.

8.1.2.2. Milk supplements should be offered to an adult koala in the intensive and intermediate care stages.

8.1.2.3. Contaminant-free dirt and bark should be offered to a koala in the intermediate and pre-release stages.

8.1.2.4. The choice of eucalyptus species offered to a koala should be varied every few days.

8.1.2.5. Leaves should be sprayed with water before being offered to a koala.

8.1.2.6. Both young and mature leaves should be offered to a koala.

8.1.2.7. Leaves should not be collected from the side of a major road as they are likely to be contaminated.

8.1.2.8. Leaves should not be dragged across the ground as they may become contaminated.

8.1.2.9. If multiple koalas are kept within the same enclosure, branches should be placed in different locations so that all koalas can feed simultaneously.

8.2. Hygiene

Refer to Section 9.2 of the *Code of Practice for Injured, Sick and Orphaned Protected Fauna* (OEH2011).

9. Housing

9.1. General requirements

Refer to Section 10 of the *Code of Practice for Injured, Sick and Orphaned Protected Fauna* (OEH2011).

9.2. Intensive care housing

Objectives

To reduce activity for a short period of time in order to facilitate frequent monitoring, treatment, feeding and re-hydration. It is suitable for severely injured or diseased adults and orphaned pouch young.

9.2.1. Standards

9.2.1.1. Intensive care housing must provide sufficient space for the koala to sit upright and to stretch its body and limbs, but not enough space to crawl around.

9.2.1.2. Intensive care housing must contain a prop for the koala to hold on to (e.g. a shortened branch with a fork for an adult and a stuffed toy for a juvenile).

9.2.1.3. Intensive care housing must provide a constant temperature appropriate to the age and nature of the illness or injury.

9.2.1.4. The temperature in intensive care housing must be regularly monitored using a thermometer and electrical heat sources must be regulated by a thermostat.

9.2.1.5. A koala in intensive care housing must experience a light-dark cycle that replicates outside conditions.

9.2.1.6. Intensive care housing must be designed and/or positioned so that visual and auditory stimuli are reduced (e.g. by covering the animal with a towel and placing it in a quiet room).

9.2.1.7. Intensive care housing must be adequately ventilated without allowing excessive drafts.

9.2.1.8. Substrate used in intensive care housing must be replaced daily.

9.2.2. Guidelines

9.2.2.1. Intensive care enclosures should have floor dimensions of at least 0.7 m long by 0.7 m wide.

9.3. Intermediate care housing

Objectives

To provide a mobile koala with enough space to allow some physical activity while enabling it to be readily caught for monitoring or treatment.

9.3.1. Standards

9.3.1.1. Intermediate care housing must provide sufficient space for the koala to move about freely whilst being conveniently sized for capture.

9.3.1.2. Intermediate care housing must contain at least one branch with a fork and one horizontal pole.

9.3.1.3. A koala in intermediate care housing must experience a light-dark cycle that replicates outside conditions. This may be achieved by using a well-lit room or constructing an enclosure in a sheltered area outside.

9.3.2. Guidelines

9.3.2.1. Intermediate care enclosures should have floor dimensions of at least 2 m long by 1 m wide.

9.4. Pre-release housing

Objectives

To give the koala the opportunity to regain its physical condition, acclimatise to current weather conditions and practise natural behaviour. At this stage of rehabilitation, interactions between the koala and humans will be greatly reduced.

9.4.1. Standards

9.4.1.1. Pre-release housing must provide sufficient space for the koala to move about freely, express a range of natural behaviours and withdraw from undue conflict with co-housed koalas.

9.4.1.2. Pre-release housing must provide areas where the koala can gain exposure to prevailing weather conditions and locations where it can shelter.

9.4.1.3. Pre-release housing must contain habitat that enables the koala to perform a range of natural behaviour. A koala requires at least two tree forks to allow climbing.

9.4.1.4. Pre-release housing must be designed and/or positioned so that exposure to humans is kept to the minimum required for monitoring, feeding and cleaning.

9.4.2. Guidelines

9.4.2.1. Pre-release enclosures should have floor dimensions of at least 4 m long by 3 m wide and provide at least 3 metres of usable vertical space.

9.4.2.2. Pre-release enclosures should contain a variety of natural branches oriented both vertically and horizontally. Branches should have different thicknesses and textures.

9.4.2.3. Leaves should be positioned in such as way as to encourage exercise.

9.4.2.4. Pre-release enclosure walls should be smooth, at least 1.5 m high and at least 2 m from the nearest branch to prevent escape.

10. Suitability for release

Objectives

To ensure that the koala is physically fit and possesses the appropriate survival skills prior to its release. Preparations for a koala's release will start at the time of rescue and continue throughout the rehabilitation process.

10.1. Standards

10.1.1. A koala must not be released until it is physically ready. This status has been achieved when:

- it has recovered from any injury and/or disease (e.g. climbs normally)
- its weight is within the appropriate range for that age (koalas are normally independent at 18 months of age weighing 3.5–4 kg)
- its body score is 3 (fair) or better as determined by scapula, cranial and limb musculature examination
- it has appropriate fitness levels as determined by observation
- its pelage is adequate for survival in its natural habitat (i.e. fur covering the entire body)
- it has acclimatised to prevailing climatic conditions.

10.1.2. A koala must not be released until it is behaviourally ready. This status has been achieved when:

- it can recognise and consume eucalyptus leaves unaided
- it can recognise and successfully avoid predators (including pets)
- it is not attracted to humans (i.e. not humanised) or to sights, sounds or smells that are specific to captivity (i.e. not imprinted)
- it can climb effectively.

10.1.3. A koala's readiness for release must be confirmed by either a veterinarian or experienced fauna rehabilitator.

11. Release considerations

11.1. Timing of release

Objectives

To ensure that a koala is released as soon as it is ready and at a time that minimises stress and maximises their chances of survival in their natural habitat.

11.1.1. Standards

11.1.1.1. Once a koala is deemed ready for release, it must be released as soon as conditions are suitable (see 11.1.1.2).

11.1.1.2. A koala must be released when weather conditions encourage high activity levels. Release during extremes of temperature and storms must be avoided.

11.2. Release site selection

Objectives

To ensure that the wild koala population and natural environment are not negatively impacted by the release of the koala. The welfare of the rehabilitated koala after release is a secondary consideration.

11.2.1. Standards

11.2.1.1. If the exact location where the koala was found is known and it is a suitable environment for release, it must be released there.

A suitable environment for release is one that:

- contains appropriate habitat and an adequate number of food trees
- is occupied by other koalas
- does not place the koala at a high risk of injury (e.g. a suburban park surrounded by busy roads).

11.2.1.2. If the exact location where the koala was found is known but it is an unsuitable environment for release, the koala must be released in a suitable environment as near as possible to this location, without transporting it across a physical boundary that it would not normally cross (e.g. a river) or further than it would normally move (10 km for adults; 30 km for hand-reared sub-adults).

If there is no suitable environment within 10 km (adults) or 30 km (hand-reared sub-adults) of the rescue location, the koala must not be released.

11.2.1.3. If only the general location where the koala was found is known and it contains or adjoins a suitable environment for release, the koala must be released there without potentially transporting it across a physical boundary that it would not normally cross, or further than 10 km (adults) or 30 km (hand-reared sub-adults). If the general location where the koala was found is wider than 10 km (adults) or 30 km (hand-reared sub-adults) at its widest point, the koala must not be released.

11.2.1.4. If there is no information about where the koala was found, it must not be released.

11.2.1.5. A koala can only be released in a park if:

- it was originally found in that location
- the release has written consent from the relevant National Parks and Wildlife Area Manager (issued under section 9 of the National Parks and Wildlife Regulations 2009)
- the release complies with the relevant OEH policies on translocation and environmental integrity.

These conditions also apply to the release of a koala in a location where it might reasonably be expected to immediately enter a park (e.g. on a property adjoining a park).

11.2.2. Guidelines

11.2.2.1. A koala should be released in an area that is connected to other suitable koala habitat.

11.2.2.2. If a koala is going to be released in a different area from where it was found, rehabilitators should first survey the area for resident koalas. A sub-adult koala should not be released into the home range of an adult koala.

Note

Rehabilitators who wish to release a rehabilitated or hand-reared koala further than 10 km (adults) or 30 km (hand-reared sub-adults) from where they were found require a translocation approval issued by OEH (under section 132c of the NPW Act).

11.3. Release techniques

Objectives

The use of release techniques that facilitate successful reintegration into the wild population. The collection of information regarding the fate of rehabilitated koalas after release so that the relative merits of different rehabilitation and release techniques can be compared.

11.3.1. Standards

11.3.1.1. Rehabilitators must arrange for the koala to be ear-tagged prior to release (numbered swivel sheep tags are appropriate).

11.3.2. Guidelines

11.3.2.1. A hand-reared koala should be soft released. This can involve putting the koala into a food tree that is surrounded by a temporary fence. After a few days the fence can be removed.

11.3.2.2 A hand-reared koala should be released with a similarly aged koala with which it has been housed.

11.3.2.3. Rehabilitators should not release multiple adult koalas at a single location, as increased competition is likely to have a detrimental effect on the existing koala population.

Appendix I Section 10 Koala Revegetation Strategy

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Environment and Heritage

Koala revegetation strategy

Section 10, Pacific Highway Upgrade, Woolgoolga to Ballina NSW

Prepared for Roads and Maritime Services

August 2015

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Cover photograph: Young (7 years old) *Eucalyptus camaldulensis* plantation near Spring Ridge on the Liverpool Plains, NSW. Trees in this planting were used by a Koala for feeding at night and resting during the day.

Executive summary

Roads and Maritime Services (RMS) currently (October 2015) owns 621 ha of land adjacent to Section 10 (near Wardell) of the Pacific Highway Upgrade between Woolgoolga and Ballina. Approximately 100 ha will form part of the highway footprint, leaving approximately 370 ha of retained native forest and 151 ha which is cleared. This land has been purchased for the proposed Pacific Highway Upgrade in the area, with a portion of it potentially available for biodiversity offsets and to mitigate impacts on a range of species, including the Koala. The NSW Minister for Roads and Freight has committed to plant at least 130 ha of new habitat for the Koala – i.e. comprised mainly of primary and secondary Koala food tree species. These plantings will be undertaken in two stages; approximately 50% will be planted prior to road construction (Autumn/Spring 2016) with the remainder planted when construction of the road has been completed. The implementation of this revegetation strategy is subject to the necessary approvals being granted by the Australian Minister for the Environment for the commencement of Section 10, which depends on the Ballina Koala Plan demonstrating the acceptability of impacts to the Ballina Koala population.

Niche Environment and Heritage (Niche) has been engaged by RMS to prepare a revegetation strategy that identifies the goals, the landscape context, areas available for planting, suitable tree species, establishment methods, maintenance regimes and an outline of a suitable monitoring program. The focus of this strategy is to identify at least 65 ha as the first priority for planting prior to construction, but all suitable areas for revegetation (i.e. at least 130 ha) have been considered.

The three main objectives of this revegetation program are: to establish new habitat for Koalas using preferred Koala food tree species to compensate for habitat lost as a result of clearing for the proposed road-works; to improve habitat connectivity within this fragmented landscape; and thirdly, to guide the movement of Koalas towards the road connectivity structures (e.g. underpasses) that will be provided to ensure the safe passage of dispersing Koalas.

Recent studies have shown that Koalas will utilise young (4-7 year old) eucalypt plantations for foraging at night provided some old trees are present nearby to provide diurnal shelter. Also, that older plantings (7-20 years old) are capable of providing both food and diurnal shelter. Eucalypt plantations comprised mainly of preferred Koala food tree species are rapidly occupied by Koalas if the animals are present nearby.

The locations of approximately 151 ha of cleared land that should be considered for planting within Section 10 of the Pacific Highway Upgrade are identified and mapped. These properties will be subject to detailed site assessments and agreed offset requirements. Further properties may become available as the acquisition process and offset program continues.

Guidelines are presented for site preparation and establishment, planting season, planting density, maintenance regime, as well as monitoring, evaluation and reporting requirements to ensure the success of these revegetation works and to document their acceptance by Koalas.

It is recommended that Roads and Maritime Services order the preparation of tube-stock for planting of the following species and numbers of each: *Eucalyptus robusta* (15,000), *Melaleuca quinquenervia* (5,000), *Eucalyptus tereticornis* (15,000), *Eucalyptus seeana* (5,000), *Eucalyptus resinifera* (5,000), *Eucalyptus grandis* (5,000), *Eucalyptus saligna* (5,000), *Eucalyptus microcorys* (15,000), *Eucalyptus propinqua* (10,000), *Allocasuarina torulosa* (5,000), *Acacia irrorata* (3,500) and *Acacia fimbriata* (3,000).

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1. Introduction

On 14 August 2014, the Australian Minister for the Environment approved the Pacific Highway Upgrade from Woolgoolga to Ballina, NSW, subject to conditions, including Conditions 5, 6, 7, 8, 9 and 10 that refer specifically to the Koala. Condition 7 states, in part: "In addition to the Koala Management Plans(s) required by NSW approval conditions D8 and D9 (approved by the NSW Minister for Planning on 24 June 2014), to ensure that an unacceptable impact will not occur to the Ballina Koala population, the approval holder must submit for the Minister's approval a Ballina Koala Plan no less than 3 months prior to the commencement of Section 10. The Minister will only approve the plan and the commencement of Section 10 of the action if the impacts to the Ballina Koala population are demonstrated to be acceptable within the Ballina Koala Plan". This revegetation strategy is part of the overall strategy to minimise and mitigate the impacts to the Ballina Koala population within Section 10 of the proposed Pacific Highway Upgrade, and is consistent with the NSW Condition of Approval D9(g). The implementation of this revegetation strategy is subject to the necessary approvals being granted by the federal Minister for the Environment for the Ballina Koala Plan.

Roads and Maritime Services (RMS) currently (October 2015) owns 621 ha of land adjacent to Section 10 (near Wardell) of the Pacific Highway Upgrade between Woolgoolga and Ballina. Approximately 100 ha will form part of the highway footprint, leaving approximately 370 ha of retained native forest and 151 ha which is cleared. This land has been purchased for the proposed Pacific Highway Upgrade in the area, with a portion of it potentially available for biodiversity offsets and to mitigate impacts on a range of species, including the Koala. The NSW Minister for Roads and Freight has committed to plant at least 130 ha of new habitat for the Koala – i.e. comprised mainly of primary and secondary Koala food tree species. These plantings will be undertaken in two stages; approximately 50% will be planted prior to road construction (Autumn/Spring 2016) with the remainder planted when construction of the road has been completed.

Niche Environment and Heritage (Niche) has been engaged by RMS to prepare a revegetation strategy that identifies the goals, the landscape context, areas available for planting, suitable tree species, establishment methods, maintenance regimes and an outline of a suitable monitoring program. The focus of this strategy is to identify at least 65 ha as the first priority for planting prior to construction, but all suitable areas for revegetation (i.e. at least 130 ha) have been considered.

1.1 Aim of the Revegetation Strategy

The aim of this Koala revegetation strategy is to identify the following:

- The objectives of the revegetation program;
- Site description and landscape context;
- Which areas should be considered for planting ;
- Suitable tree species;
- Site preparation;
- Planting method, planting density, numbers of tube-stock required, and maintenance regime;
- Measures of success for both revegetation and its use by Koalas;

1.2 Objectives of the Revegetation Program

The main objectives of the revegetation/habitat restoration program, using preferred Koala food tree species, are to:

- establish new habitat for Koalas in the study area to compensate for habitat lost as a result of clearing for the proposed road-works;
- improve habitat connectivity within this fragmented landscape; and,
- guide the movement of Koalas towards the road connectivity structures (e.g. underpasses) that will be provided to ensure the safe passage of dispersing Koalas.

This strategy provides a description of the means by which these objectives will be accomplished. An annual monitoring program is provided to assess the overall success of the revegetation activities, including whether replanting is required in some areas, and also whether the planted areas are being used by Koalas.

1.3 Role of *Eucalyptus* plantations in conserving Koalas

Loss of habitat, due mainly to clearing for urban and agricultural development, is regarded as the major threat to the Koala in NSW and Queensland and the primary factor responsible for declining populations in those States (NRMMC 2009). An important Action (1.05) arising from the National Koala Conservation and Management Strategy 2009-2014 is to “revegetate habitat to facilitate natural dispersal and reduce fragmentation effects”.

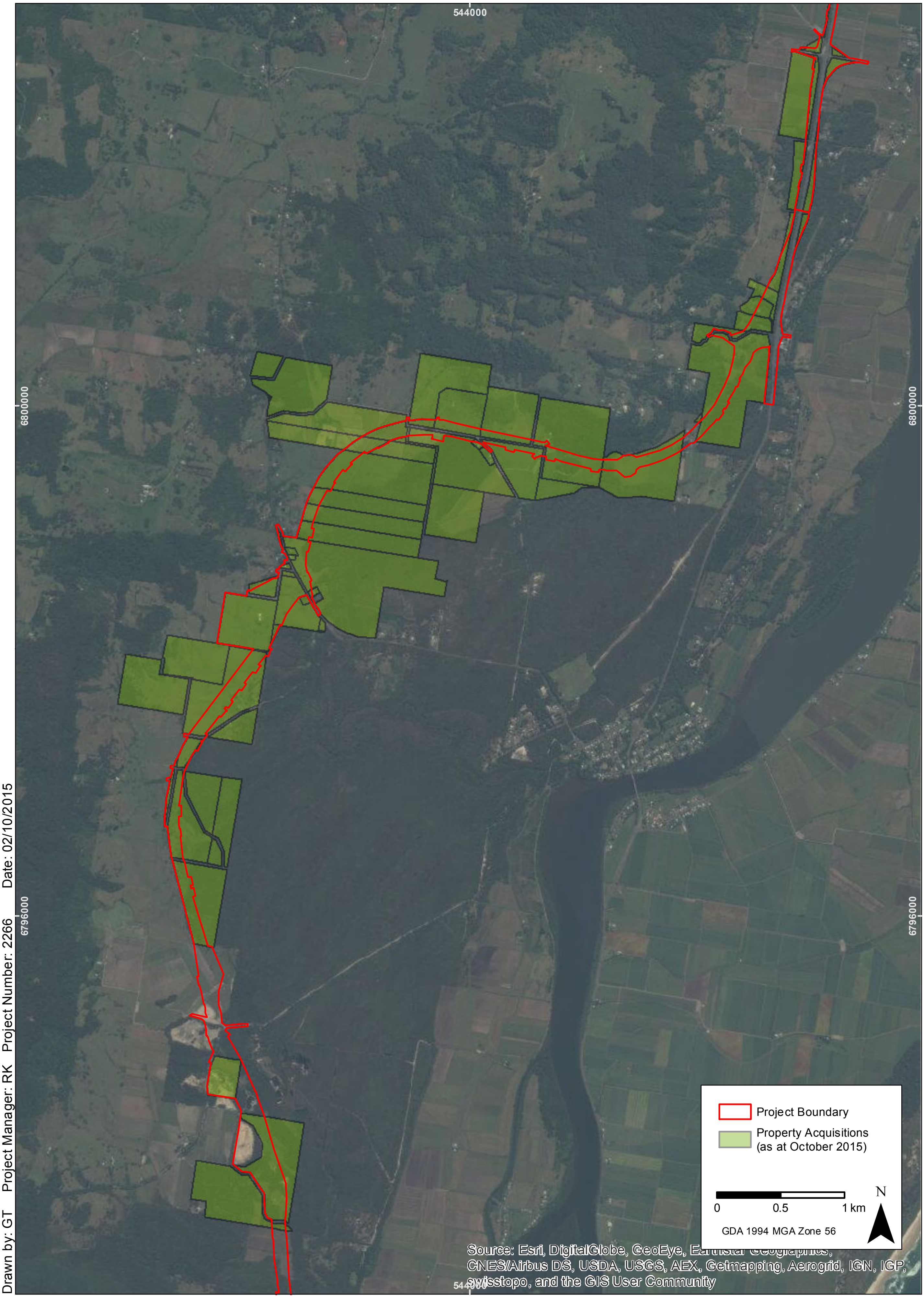
Until recently, there had been little understanding of the acceptance of young eucalypt plantations by Koalas and the age at which they are colonised. We now know that Koalas will utilise young (4-7 year old) eucalypt plantations for foraging if some old trees are present nearby to provide diurnal shelter, and that older plantations (7-20 years old) are capable of providing both food and diurnal shelter for Koalas (Woodward *et al*. 2008, Kavanagh and Stanton 2012, Crowther *et al*. 2014). Eucalypt plantations comprised mainly of preferred Koala food tree species are rapidly occupied by Koalas if they are present nearby (Kavanagh and Stanton 2012).

1.4 Site description and landscape context

A range of properties has been acquired by RMS along Section 10 of the highway alignment of the Woolgoolga to Ballina Pacific Highway upgrade (Fig. 1). These properties consist of varying combinations of cleared land used for grazing or sugar cane production and areas of remnant or regrowth native vegetation. In general, the vegetation occurring on the lower slopes and flats is predominantly cleared, whereas the upper slopes and ridges along the Blackall Range are still forested.

Five main geological types are present in the study area (Fig. 2). These geological types are ranked in approximate order of the fertility of the soils derived from them:

- Basalt (Tllb)
- Meta-basalt (Cnx)
- Undifferentiated alluvial deposits/floodplain and swamp deposits (Qa)
- Coarse-grained conglomerates (Rjbwx)
- Dune sand and sand sheets (Qb)



Section 10 - RMS Property Acquisitions

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FIGURE 1

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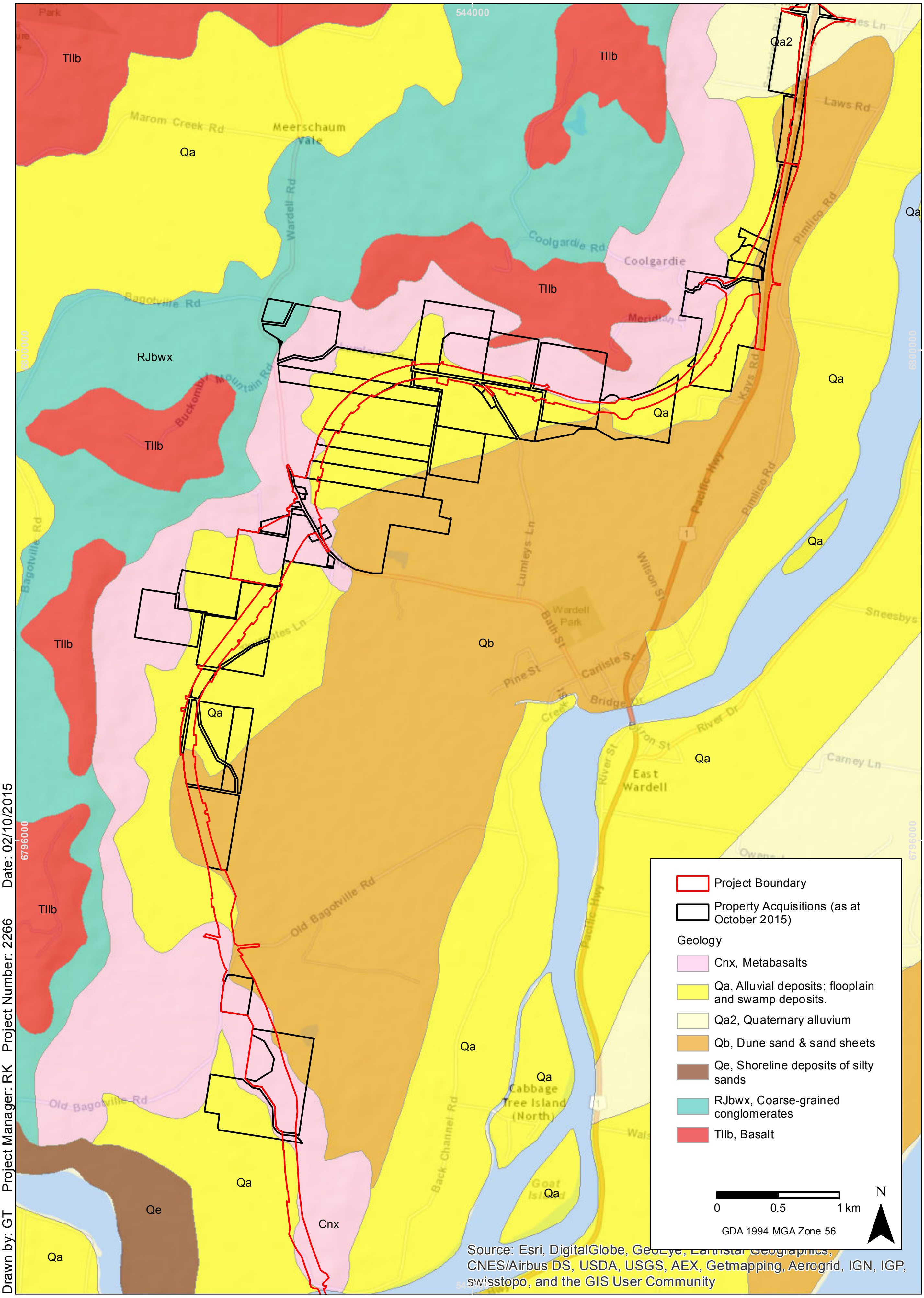

Section 10 - Geology

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FIGURE 2

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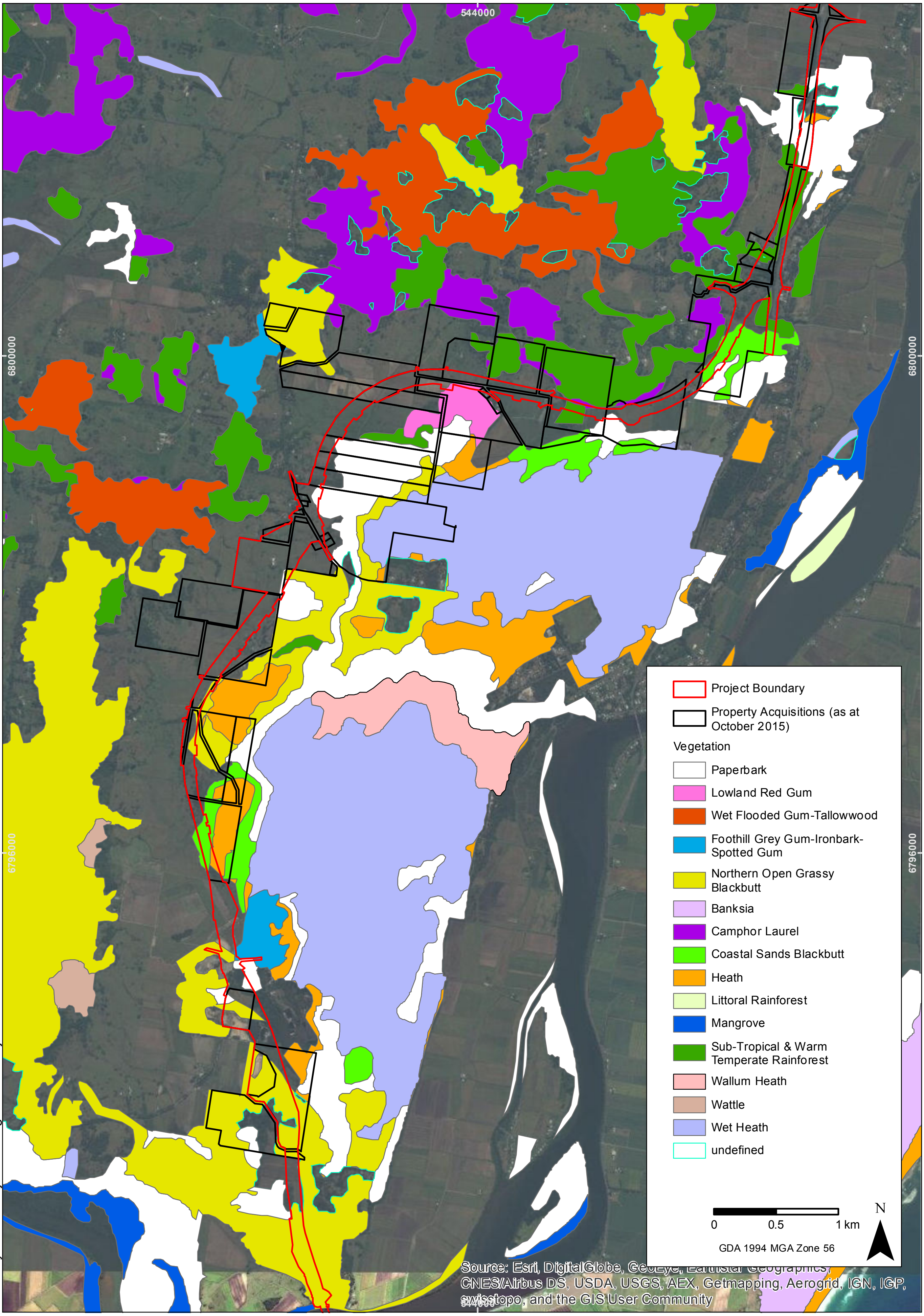
A range of remnant or regrowth native vegetation types is present in the study area (Fig.3). The vegetation types likely to be of most importance to Koalas, due to the expected presence of Koala food tree species within them, include:

- Paperbark (includes Swamp Mahogany *Eucalyptus robusta* and Red Mahogany *E. resinifera*);
- Lowland Red Gum (includes Forest Red Gum *E. tereticornis* and Narrow-leaved Red Gum *E. seeana*);
- Wet Flooded Gum – Tallowwood (includes *E. microcorys* and *E. resinifera*);
- Foothill Grey Gum – Ironbark – Spotted Gum (includes Small-fruited Grey Gum *E. propinqua* and *E. tereticornis*),
- Northern Open Grassy Blackbutt (includes *E. microcorys* and *E. propinqua*)

Details of the ecology of these and other tree species, including their status as Koala food trees, are described in Section 2.3 and Table 2.

Other vegetation types present in the study area are less likely to make a significant contribution to Koala habitat but may contribute to Koala dispersal and habitat connectivity in the region.



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Section 10 - Vegetation type

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FIGURE 3

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2. The planting program

2.1 Which areas should be planted

The distribution of properties that have been acquired by RMS (as at October 2015) and which are available to either enhance connectivity in the landscape for Koalas, or to provide new habitat for Koalas, is shown in Fig. 1. Priority areas for re-vegetation in the study area have been identified using reference to the properties numbered in the file: D00395_0081_PropertyAcquisitionStatus_v20.pdf. These properties often include multiple lots on the same title, not all of which contain cleared land available for planting. Furthermore, not all of the cleared lands available on these properties are proposed for planting. Additional properties may become available as the acquisition process and offset program continues.

A list of 21 cleared areas ranging in size from 0.4-17.9 ha has been selected (following on-site consultations with RMS, EPA and Koala ecologists from Niche, Ecosure and Biolink) as suitable, available and appropriate for revegetation by planting Koala food tree species (Table 1). These cleared areas total approximately 151 ha and are displayed in Fig. 4. A preliminary division of these areas into high priority (1; totalling 107 ha) for planting prior to road construction, and lower priority (2; totalling 44 ha) to be planted post-construction, is provided in Table 1. Priority 1 areas are needed to facilitate connectivity through the landscape for local “hotspots” or known concentrations of Koalas. The areas that have been identified as priority 1 will be sufficient to achieve the committed 50% of 130 ha prior to road construction, with the additional priority 2 areas supplementing the balance of priority 1 areas for planting that are required to meet the 130 ha commitment after road construction is completed. All properties will be subject to detailed site assessments and agreed offset requirements.

The proportions of each tree species which should be planted in each patch are indicated in Table 1. See Part 2.2 for the common names of these tree species, and for brief notes about their ecology.

Initial priority should be given to establishing blocks of new habitat on the lower slopes and flats within the study area, but utilising the opportunities available to also improve connectivity with existing native forest and woodland on mid slopes and upper slopes. Existing areas of Swamp Mahogany-Paperbark forest, and/or Forest Red Gum/Narrow-leaved Red Gum forest should be targeted for augmentation using eucalypt plantings. These areas are likely to contain the highest quality habitat for Koalas, and plantings adjacent to these areas will provide valuable *in situ* habitat as well as guiding Koalas towards planned connectivity structures or other habitat linkages in the study area.

The most rapid uptake of new plantings by Koalas will occur where some older (or remnant) trees are still present or retained within the plantings. This is because Koalas prefer to use larger trees for diurnal shelter, whereas they are willing to feed at night in very young planted trees. Therefore, plantings should encompass existing large trees.

2.2 Proximity to connectivity structures

Up to 27 connectivity structures have been proposed (as at September 2015) to facilitate the movement of Koalas and other fauna from one side of the highway to the other. As far as possible, areas proposed for planting have been located to enhance the effectiveness of these connectivity structures and other broader landscape linkages, as well as to provide supplementary new habitat for Koalas (Figure 4).

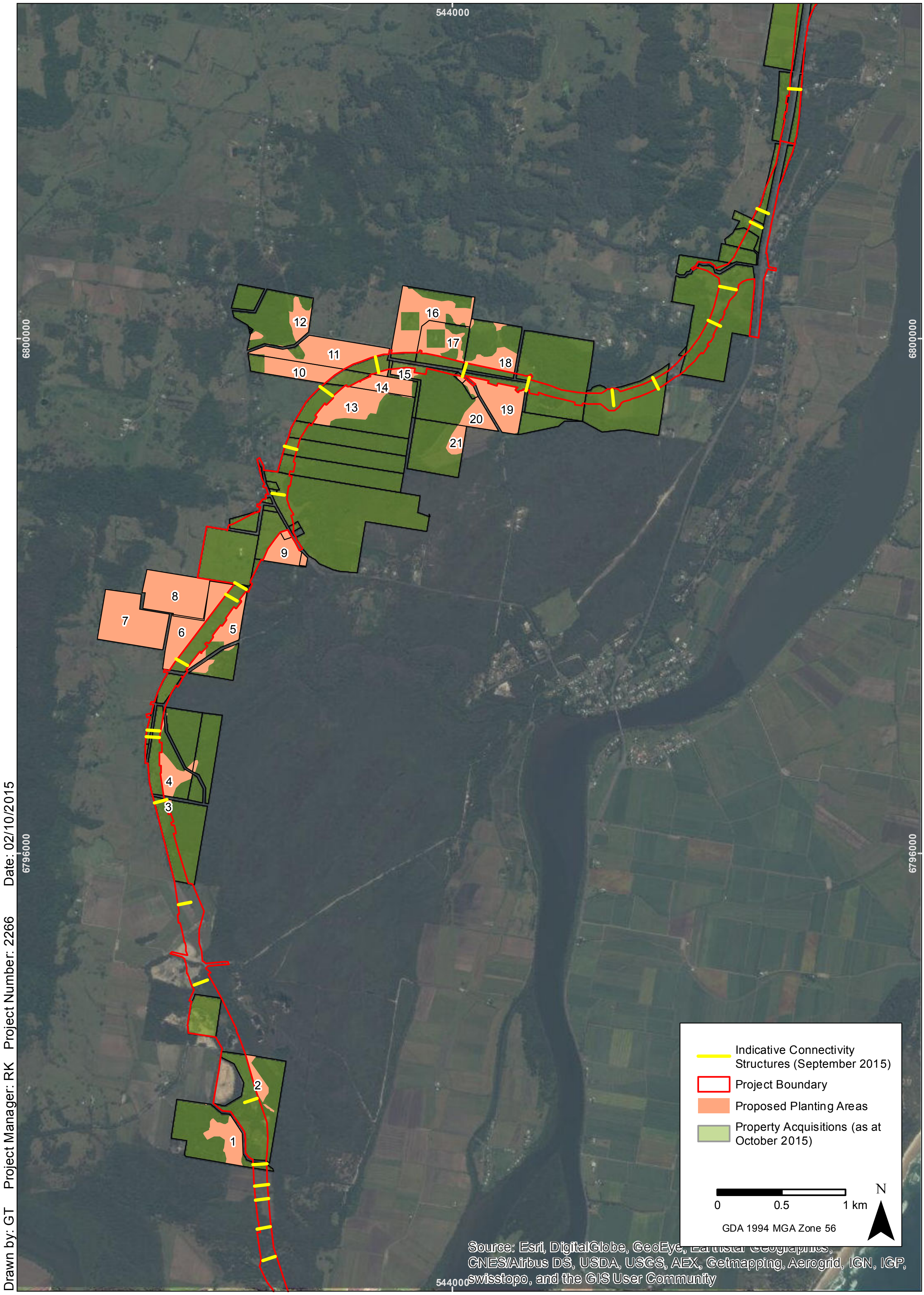
Table 1. Patches of cleared land that are available and which should be considered for planting.

See Fig. 4 for locations of each patch.

Patch number	Area (ha)	Tree species to be planted (composition %)	Priority for planting in 2016
1	6.1	*E. robusta* (30), *M. quinquenervia* (5), *E. resinifera* (10), *E. tereticornis* (20), *E. microcorys* (15), *E. propinqua* (5), *A. torulosa* (5), *E. saligna* (5), *E. grandis* (5)	1
2	2.5	*E. robusta* (30), *M. quinquenervia* (5), *E. resinifera* (10), *E. tereticornis* (20), *E. seeana* (10), *E. microcorys* (15), *E. saligna* (5), *E. grandis* (5)	1
3	0.4	*E. robusta* (70), *M. quinquenervia* (10), *E. resinifera* (5), *E. tereticornis* (5), *E. microcorys* (5), *E. grandis* (5)	1
4	5.0	*E. robusta* (70), *M. quinquenervia* (10), *E. resinifera* (5), *E. tereticornis* (5), *E. microcorys* (5), *E. grandis* (5)	1
5	6.4	*E. robusta* (70), *M. quinquenervia* (10), *E. resinifera* (5), *E. tereticornis* (5), *E. microcorys* (5), *E. grandis* (5)	1
6	10.0	*E. robusta* (70), *M. quinquenervia* (10), *E. resinifera* (5), *E. tereticornis* (5), *E. microcorys* (5), *E. grandis* (5)	1
7	17.9	*E. robusta* (5), *M. quinquenervia* (2), *E. resinifera* (3), *E. tereticornis* (20), *E. microcorys* (35), *E. propinqua* (15), *A. torulosa* (10), *E. saligna* (10), [*Ac. irrorata* + *Ac. fimbriata*]	1
8	15.6	*E. robusta* (10), *M. quinquenervia* (5), *E. resinifera* (5), *E. tereticornis* (20), *E. microcorys* (30), *E. propinqua* (10), *A. torulosa* (10), *E. saligna* (5), *E. grandis* (5), [*Ac. irrorata* + *Ac. fimbriata*]	1
9	5.6	*E. robusta* (5), *M. quinquenervia* (2), *E. resinifera* (3), *E. tereticornis* (20), *E. microcorys* (35), *E. propinqua* (15), *A. torulosa* (10), *E. saligna* (10), [*Ac. irrorata* + *Ac. fimbriata*]	1
10	7.0	*E. robusta* (10), *M. quinquenervia* (5), *E. resinifera* (5), *E. tereticornis* (20), *E. microcorys* (30), *E. propinqua* (10), *A. torulosa* (10), *E. saligna* (5), *E. grandis* (5), [*Ac. irrorata* + *Ac. fimbriata*]	1

11	13.9	*E. robusta* (10), *M. quinquenervia* (5), *E. resinifera* (5), *E. tereticornis* (20), *E. microcorys* (30), *E. propinqua* (10), *A. torulosa* (10), *E. saligna* (5), *E. grandis* (5), [*Ac. irrorata* + *Ac. fimbriata*]	1
12	4.3	*E. tereticornis* (20), *E. microcorys* (35), *E. propinqua* (20), *A. torulosa* (10), *E. saligna* (15), [*Ac. irrorata* + *Ac. fimbriata*]	2
13	10.0	*E. robusta* (30), *M. quinquenervia* (5), *E. resinifera* (10), *E. tereticornis* (20), *E. seeana* (10), *E. microcorys* (15), *E. saligna* (5), *E. grandis* (5)	1
14	5.1	*E. robusta* (30), *M. quinquenervia* (5), *E. resinifera* (10), *E. tereticornis* (20), *E. seeana* (10), *E. microcorys* (15), *E. saligna* (5), *E. grandis* (5)	1
15	1.6	*E. robusta* (30), *M. quinquenervia* (5), *E. resinifera* (10), *E. tereticornis* (20), *E. seeana* (10), *E. microcorys* (15), *E. saligna* (5), *E. grandis* (5)	1
16	13.1	*E. robusta* (15), *M. quinquenervia* (5), *E. resinifera* (5), *E. tereticornis* (20), *E. microcorys* (30), *E. propinqua* (10), *A. torulosa* (5), *E. saligna* (5), *E. grandis* (5), [*Ac. irrorata* + *Ac. fimbriata*]	2
17	5.1	*E. robusta* (15), *M. quinquenervia* (5), *E. resinifera* (5), *E. tereticornis* (20), *E. microcorys* (30), *E. propinqua* (10), *A. torulosa* (5), *E. saligna* (5), *E. grandis* (5), [*Ac. irrorata* + *Ac. fimbriata*]	2
18	4.8	*E. robusta* (30), *M. quinquenervia* (5), *E. resinifera* (5), *E. tereticornis* (20), *E. seeana* (5), *E. microcorys* (15), *E. saligna* (10), *E. grandis* (10)	2
19	10.1	*E. robusta* (30), *M. quinquenervia* (5), *E. resinifera* (5), *E. tereticornis* (20), *E. seeana* (5), *E. microcorys* (15), *E. saligna* (10), *E. grandis* (10)	2
20	4.8	*E. robusta* (30), *M. quinquenervia* (5), *E. resinifera* (5), *E. tereticornis* (20), *E. seeana* (5), *E. microcorys* (15), *E. saligna* (10), *E. grandis* (10)	2

21	2.4	*E. robusta* (30), *M. quinquenervia* (5), *E. resinifera* (5), *E. tereticornis* (20), *E. seeana* (5), *E. microcorys* (15), *E. saligna* (10), *E. grandis* (10)	2
Total	151.5		



Section 10 - RMS Proposed Planting Areas

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FIGURE 4

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2.3 Species for use in revegetation plantings

A combination of primary and secondary Koala food trees, together with some shelter trees, is suggested for use in revegetation areas. Different tree species are better suited to growing on some soil types, drainage conditions and topographical positions than others. Optimal growth and survival of young planted trees will result if trees are planted in the most appropriate places in accordance with their ecology.

The intention is to plant Swamp Mahogany (*Eucalyptus robusta*) and Broad-leaved Paperbark (*Melaleuca quinquenervia*) on lower slopes and flats. These two tree species are particularly suited to poorly-drained, and seasonally-inundated, boggy areas. Forest Red Gum (*Eucalyptus tereticornis*), Small-leaved Red Gum (*Eucalyptus seeana*) and Red Mahogany (*Eucalyptus resinifera*) are best planted on lower slopes on fertile soils. Tallowwood (*Eucalyptus microcorys*), Small-fruited Grey Gum (*Eucalyptus propinqua*) and Forest Oak (*Allocasuarina torulosa*) are best planted on mid-upper slopes. While not listed as primary or secondary Koala food trees (DECC 2008), Koalas are known to feed extensively on Forest Oak (*Allocasuarina torulosa*), Flooded Gum (*Eucalyptus grandis*) and Sydney Blue Gum (*Eucalyptus saligna*) (Smith 2004, Miller 2015). The last two species are best suited to planting on lower and mid-upper slopes, respectively.

A 'cover crop' of fast growing Acacias should also be planted among the eucalypts within a selection of the areas planned for revegetation. These areas should include any with drier, rocky or sandy soils growing on mid-upper slopes in the study area. The purpose of the Acacia species is to develop microbial (nitrogen-fixing) communities within the soil through symbiont mycorrhiza (Duponnois and Plenchette 2003). Mycorrhiza have been shown to increase the growth rate of *Eucalyptus* species (Chen *et al*. 2000) and may be depleted within disturbed environments (Johnsson *et al*. 1999). The intention is that a large proportion of these wattles will die-off within 10 years, providing a self-thinning mechanism within the eucalypt plantings. Suitable species for planting as a cover crop include *Acacia irrorata* and *Acacia fimbriata*, both of which have a wide natural distribution including north-eastern NSW.

Details on the general ecology and the locations for planting each species are presented in Table 2.

Table 2: Description of recommended tree species and locations for planting.

Tree species	General description	Where the species should be planted.
Swamp Mahogany- *Eucalyptus robusta*	A medium tree, found in waterlogged soils in swamp sclerophyll forest. A primary Koala food tree and often used as a Koala shelter tree.	Boggy areas.
Broad-leaved Paperbark- *Melaleuca quinquenervia*	A medium tree, found in waterlogged soils in swamp sclerophyll forest. Used as both secondary browse by Koalas and as a shelter tree.	Boggy areas.
Forest Red Gum- *Eucalyptus tereticornis*	A medium to large tree, often growing on floodplains and other fertile alluvial flats. Primary Koala food tree.	Lower slopes on fertile soils.
Narrow-leaved Red Gum – *Eucalyptus seeana*	Narrow-leaved Red Gum is more abundant locally than Forest Red Gum, and should also be planted. Secondary Koala food tree.	Lower slopes on fertile soils.
Red Mahogany- *Eucalyptus resinifera*	A medium to large tree, often found growing along riparian areas and on midslopes in wet sclerophyll forests. Secondary Koala food tree.	Lower slopes on fertile soils.
Flooded Gum- *Eucalyptus grandis*	A large tree, found in wet sclerophyll forest and often in swamp sclerophyll forest. Used as secondary browse by Koalas.	Lower slopes.
Sydney Blue Gum- *Eucalyptus saligna*	A large tree, found in wet sclerophyll forest that is often used as secondary browse by Koalas.	Mid slopes.
Tallowwood- *Eucalyptus microcorys*	A medium to large tree, found in wet sclerophyll forest and rainforest. A primary Koala food tree.	Mid slopes
Small-fruited Grey Gum- *Eucalyptus propinqua*	A medium to large tree, found on upper slopes in wet sclerophyll forest and on midslopes in dry sclerophyll forest. A secondary Koala food tree.	Mid-upper slopes.
Forest Oak- *Allocasuarina torulosa*	A small to medium sized tree, found throughout grassy dry and wet sclerophyll forest. Used as both secondary browse by Koalas and as a shelter tree.	Mid-upper slopes.
Acacia irrorata	A shrub to approximately six metres in height, a coloniser following disturbance: suitable for planting in damp places. <u>To be used as a cover crop.</u>	All areas.
Acacia fimbriata	A shrub to approximately six metres in height, a coloniser following disturbance: suitable for planting in drier places. <u>To be used as a cover crop.</u>	Mid and upper slopes.

2.4 Site preparation and establishment

General principles for planting trees for wildlife include: maintaining native vegetation as intact as possible; tree planting should augment existing native vegetation; plantings should target creek lines and gullies; planted patches should be as large as possible (>5-10 ha); plant corridors to connect larger patches of native vegetation; leave fallen trees and branches, and standing remnant trees; avoid stock grazing for the first 10 years after planting; and consider planting at a range of tree spacings (Johnson *et al*. 2009a).

Successful forestry plantings established on farmland in the Liverpool Plains region of NSW (Johnson *et al*. 2009b) were deep-ripped along contours to a depth of 60 cm using bulldozers of Caterpillar D6-D7 size. Mounding to about 30 cm high was carried out using a 2 or 4 disc mound plough and a profiler to give a shallow depression along the mid-line to help retain water. Mounding was essential for planting in boggy ground. All sites received one or two herbicide applications 1-3 months following soil preparations (i.e. 3-6 months before planting). Herbicides were also applied after planting to control weed outbreaks. Seedlings were hand-planted using a spade, and fertiliser (50g of DAP) was applied at the time of planting. Plants were watered at the time of planting, with additional watering during the following summer if required. No mulching was provided. Failed seedlings were re-planted after annual inspections over the following two years.

A meta-analysis study by Graham *et al.* (2009) considered the results of 46 studies with regard to different site preparation techniques on the establishment of seedlings on farms. They considered factors such as soil cultivation, pre and post planting weed suppression, mulch and irrigation. They found that weed control before and after planting significantly increased seedling survival, however, weed control before planting with no follow up weeding did not. It was also found that pre-planting weed control, combined with the application of mulch, also significantly increased the survival of seedlings (Graham *et al*. 2009). Soil cultivation, and soil cultivation combined with the application of fertiliser, significantly increased the survival of seedlings, however fertiliser application without soil cultivation did not (Graham *et al.* 2009). Irrigation did not increase seedling survival rates, even when used in combination with weed control (Graham *et al*. 2009). The results of this meta-analysis study have been used to inform the recommendations below.

All sites, except those in boggy areas, should be deep-ripped and mounded prior to planting. Site preparations should be undertaken at least 3 months prior to planting, with one or two herbicide applications as required, the first before ripping and the other 1-3 months before planting. Care should be taken to avoid herbicide spray getting into the drainage system, such that 20 m exclusion buffers are maintained either side of drainage lines or around perpetually boggy ground. Planting can and should occur in wet and boggy areas, although these sites will require local mounding for planted tube-stock. Slow-release fertiliser should be added to the hole dug for each tube-stock at the time of planting.

It is recommended that any plants that are likely to compete with the plantings are managed prior to the planting of the tube-stock. In areas with dense pasture grasses, such as Rhodes Grass (*Chloris gayana*) or Kikuyu (*Pennisetum clandestinum*), these grasses should be slashed and sprayed with a residual herbicide prior to tube-stock establishment. This may require multiple herbicide applications to achieve satisfactory knock down. Where possible, organic mulch should be applied, however due to the scale of the project, this may not be feasible at all locations. Instead mulch should be placed on areas with the greatest potential for erosion, such as any steeper slopes or via a spot application, consisting of 0.5 m radius of mulch around each plant to assist in water retention and weed suppression.

Organic mulch sourced from adjacent road clearing may be used provided it is sourced from native vegetation and not weeds (e.g. Camphor Laurel, Cocos Palm). Mulch from an unknown origin may contain weed seeds and/ or propagules which could become established within the revegetation area and so should not be used.

In areas where environmental weeds occur, such as Lantana (*Lantana camera*) and Camphor Laurel (*Cinnamomum camphora*), these weeds must be controlled prior to the establishment of tube-stock, using recognised bush regeneration techniques (i.e. cut and paint and/ or basal bark herbicide applications).

2.5 Planting season, planting density and maintenance regime

Seedlings should be grown within 50 x 50 x 125 mm 'forestry tubes' from locally sourced seed (i.e. be of 'local provenance'). The seed should be collected, as far as possible, from within Section 10 of the Highway Upgrade as the traits within these plants will be best suited to local conditions. Seedlings need to be ordered approximately 12 months in advance of planting.

Plantation establishment is normally carried out in autumn and spring in eastern Australia, with autumn being less risky (Walsh *et al*. 2005). It is recommended that plantation establishment be scheduled for autumn 2016 and, if required, also in spring 2016, and that careful attention be given to soil moisture levels and to weather forecasts in the week prior to planting.

Commercial forestry plantings are normally established at the rate of 800-1000 trees per ha at 4 m row spacing with 2.5 m between trees (Walsh *et al*. 2005), reducing to approximately 75-150 trees per ha 60-80 years later as a final crop of sawlogs (Johnson *et al*. 2009c). However, this reduction requires considerable intervention in the form of multiple thinning operations to achieve the best commercial outcome, which is not a consideration in this project. A stocking rate of 300-400 trees per ha after 10 years post-establishment is an acceptable, and expected, objective in this project (Walsh *et al*. 2008).

It is recommended that Koala food and shelter tree species be planted at a density of 625 plants/ha (i.e. one plant every 16 m^2 or one plant every 4 m). In selected areas (e.g. in patches 7, 8, 10, 11, 12, 16 and 17), short-lived Acacia cover-crop species may be considered for planting in addition to, or alternate with, Koala food trees and shelter trees. As discussed above, the intention here is to augment soil nutrient status, if soils are dry, rocky or sandy, and to provide a mechanism for self-thinning of densely-planted eucalypt tree plantations. More open stands of eucalypt trees after 10 years of age are likely to promote the development of larger-diameter, more vigorously-growing, trees that should benefit Koalas.

Watering should occur at establishment and, for the next three years, at least fortnightly in months when below average rainfall is recorded, such as during local drought conditions.

Herbicide applications are required twice, both 1-3 months and 3-6 months before planting. Follow-up weeding is also important to guarantee the success of revegetation activities. Annual or biannual maintenance weeding should occur throughout the planting area, which includes ensuring that all major environmental weeds that have the potential to outcompete the plantings and dominant areas of exotic grasses are controlled. The management and frequency of these activities is to be at the discretion of a qualified bushland regeneration contractor but should include the removal of all 'woody weeds' (e.g. Lantana, Camphor Laurel) and the management of pasture grasses near the base of tube-stock, through either herbicide or mechanical control measures. This management regime should continue for at least three years after establishment. After three years, the young eucalypt trees should be taller than most weedy competitors and hence unlikely to require further weed control.

2.6 Other management issues

Fencing is required around all planted areas to reduce the likelihood of browsing and trampling by livestock. The fencing is required for at least 10 years until the trees become large enough to withstand livestock and should be inspected regularly to ensure that no breaches have occurred. Young plantings are quite vulnerable to fire and so fire must be excluded for the first 10 years after establishment. This includes any prescribed fuel-reduction burns. During plantation establishment and maintenance works, care should be taken to keep machinery out of drainage lines to ensure that erosion does not occur. Erosion protection might also be provided through the use of mulch, sediment fencing and soil contour banks.

The management regime assumes an initial planting density of 650 plants per hectare, with 5% replacement of Koala food/ shelter tree tube-stock annually for three years if required due to losses. Replacement of Acacia cover-crop species is not proposed. After three years, the stand of planted eucalypts should be considered "established" and any further losses should be regarded as part of natural stand thinning due to competition with other planted trees. A stocking rate of 300-400 trees per ha is the expected stand structure of the Koala revegetation program after several decades following plantation establishment.

2.7 Number of plants required

An indication of the numbers of tube-stock that should be acquired by RMS for the planting program is provided in Table 3.

Table 3: Numbers of tube-stock required for the planting program.

Tree species	Number of tube-stock
Swamp Mahogany *Eucalyptus robusta*	15,000
Broad-leaved Paperbark *Melaleuca quinquenervia*	5,000
Forest Red Gum *Eucalyptus tereticornis*	15,000
Narrow-leaved Red Gum *Eucalyptus seeana*	5,000
Red Mahogany *Eucalyptus resinifera*	5,000
Flooded Gum *Eucalyptus grandis*	5,000
Sydney Blue Gum *Eucalyptus saligna*	5,000
Tallowwood *Eucalyptus microcorys*	15,000
Small-fruited Grey Gum *Eucalyptus propinqua*	10,000
Forest Oak *Allocasuarina torulosa*	5,000
Acacia irrorata	3,500
Acacia fimbriata	3,000

3. Monitoring, evaluation and reporting

3.1 Monitoring

Annual monitoring is needed to determine the overall success of the revegetation activities, including whether replanting is required in some areas, and also if the planted areas are being used by Koalas.

Monitoring the success of the revegetation activities (Table 4) should occur across all field sites (as well as simultaneously in adjacent remnant forest), with a sampling intensity of one plot per two hectares of revegetation. Sampling should occur at the same month each year, nominally September. Each site should be marked with a star picket and flagging tape and the location should also be recorded with a GPS. Annual monitoring should occur at each site from year 1, where the following variables are recorded within a 50 x 20 m (0.1 ha) quadrat:

- Density of Koala food trees and shelter trees (initial density=approximately 48 trees per quadrat), their average height and number of visible dead stems.
- Presence and dominance of any environmental weeds, including exotic grasses.
- Presence and condition of Acacia cover-crop, if planted.
- One photo taken at the star picket, facing south (on a 180 degree bearing).

Opportunistic observations via a random meander, which may occur while walking between sites, should also be undertaken throughout the revegetation area. These observations should identify if any large infestations of environmental weeds are occurring and their location, if any large-scale plant deaths have occurred and if any other environmental issues are developing, such as sheet or gully erosion. The results of these field surveys should be summarised in an annual report provided within two months of the completion of the field surveys. The monitoring should continue for at least five years, and/ or until plantings across 90% of plots have an average height of eight metres (unless otherwise agreed with the EPA).

At least sixty permanent Koala faecal-pellet search plots (0.1 ha plots) should be established throughout the plantings, with at least six plots located within each revegetation property. These plots can be the same as those established to monitor the success of tree plantings (see above). The plots should also be situated across all topographic positions (i.e. lowlands, mid-slopes and ridges). Each faecal-pellet search plot should be marked with a star picket and flagging tape and the location should also be recorded with a GPS. Annual surveys for Koala use of the revegetation area should begin in year 3 and continue until it is shown that at least 20% of plots (n=12) have evidence of Koala activity in any one year (Table 4). In comparison, Phillips and Chang (2013) recorded Koala faecal pellets at 18 of 56 (32%) search plots of a similar size that were located in native forest in, or near, the study area. Furthermore, Phillips *et al*. (2015) recorded evidence of Koala activity (i.e. Koala faecal pellets recorded beneath at least one tree within a given site) at 29 of 53 (55%) search plots in the forests and heathlands in the east of the study area. The data from Phillips and Chang (2013) and Phillips *et al*. (2015) were based on 30 trees inspected per plot, compared to initial stocking levels of approximately 48 trees per quadrat that would be searched in the current project.

This work should be done in conjunction with comparable surveys done within existing native forest in the study area as part of the Ballina Koala Management Plan. Surveys should occur at a similar time each year, notionally September which coincides with the Koala breeding season. An annual report should be prepared which documents the results of the field surveys and their success in relation to the management objective, being the use of the plantations by Koalas. Results should be interpreted in relation to other information from the study area, including comparable Koala “activity” in nearby native forest and trends in the size of the Koala population.

3.2 Management responses

Management responses should be guided by the results of the monitoring program. At years one, two and three after planting, supplementary tree plantings should occur where it is observed that greater than 20% mortality of tube-stock or densities of less than one plant per 20 m^2 have resulted. Where woody weeds are present, weeds should be reduced to a density of less than 5% across the revegetation site, while exotic grasses should not be visibly affecting the growth of tube-stock.

After three years, the stand of planted eucalypts should be considered “established” and any further losses should be regarded as part of natural stand thinning due to competition with other planted trees. A stocking rate of 300-400 trees per ha is the expected stand structure of the Koala revegetation program after several decades following plantation establishment.

By year 10 post-establishment, further investigations should be instigated if it is found that Koalas are not using the revegetation areas, or where the threshold of 20% of faecal-pellet search plots has not recorded any evidence of Koala presence. These investigations must consider comparable Koala “activity” levels in nearby native forest, and trends in the size of the Koala population in the study area. Lack of use of the supplementary habitat provided by Koala food tree plantings could occur if the Koala population is in decline due to other factors (e.g. low fecundity, high mortality, limited dispersal opportunities).

Table 4: Performance criteria

Performance target	Management action	Time frame	Party responsible for meeting target
Initial density of one Koala food/ shelter tree per 16 m^2 (625 per hectare) across all revegetation sites.	Plant 81,250 Koala food tree/ shelter tree tube-stock across 130 hectares.	Year 1	RMS
Supplementary cover-crop of Acacia species as considered relevant across all revegetation sites.	Plant up to 50 stems per ha, if this measure is likely to improve soil fertility or, due to their short lifespan, assist with self-thinning of the planted eucalypt stand. Up to 6,500 Acacias across 130 hectares.	Year 1	RMS
Annual density of one Koala food/ shelter tube-stock per 20 m^2 across the revegetation site.	Where a density of less than this is observed, conduct supplementary planting across the site.	Years 1-3	RMS
Woody weed density less than 5% across the revegetation site.	Where infestations of woody weeds occur, initiate removal.	Years 1-5	RMS
Exotic grasses not disrupting the growth of tube-stock (i.e. not within the drip zone of the plant).	Undertake spraying and/ or mechanical removal.	Years 1-3	RMS
Trees within 90% of monitoring plots have an average height >8 metres after 5 years.	Conclude vegetation monitoring program and associated planting and weed management.	Year 5	RMS
Koala scats recorded across at least 20% of monitoring sites.	Conclude Koala monitoring program.	Years 3-10	RMS

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Appendix J Guidelines and conditions for Koala Care in NSW

GUIDELINES AND CONDITIONS
FOR
KOALA CARE
IN NEW SOUTH WALES

June 1997

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1. INTRODUCTION

1.1 Standards for the care of koalas

Many reasons have been identified for caring for koalas, including the need to maintain the health and integrity of local populations, the personal satisfaction of rehabilitating and returning a koala to the wild, a moral responsibility for care, an emotional involvement, a commitment to community quality of life and spirit, and the public expectation of government responsibility for both the welfare of individual koalas and for ensuring the long-term survival of koala populations in the wild.

Koalas may require assistance as a result of disorientation through loss or fragmentation of their habitat, disease, injury (often associated with traffic or dog attack), death of a mother with dependent young, bushfire, or the necessity to relocate a koala away from a highly dangerous location. Koala welfare incorporates issues such as rescue, care, hand raising, rehabilitation and release. It is desirable that every temporarily disadvantaged wild animal is given the best available care to maximise its chances of successful return to the wild. In the case of a high profile and vulnerable species like the koala, it is vital to set and maintain the highest standard of care. The koala is listed as a Vulnerable species in New South Wales under the *Threatened Species Conservation Act 1995.* These conditions and guidelines have been prepared to assist in the recovery of this species.

From a welfare viewpoint, the primary aim of wildlife rehabilitation is to return each individual to the wild population with maximum chances of survival. The length of time a koala is held, the means by which it is held and the place of release are crucial factors. Beyond these principles, there are many points that need to be addressed so that there is consistency among individuals and among groups. This document draws together the considerable experience of koala care that exists in the community and frames the conditions of care in the context of this skill and understanding.

1.2 Legislation and policy

The koala is a protected species under the *National Parks and Wildlife Act 1974* and it is an offence to harm a protected species and the definition of “harm” in the legislation (in addition to its normal meaning) includes hunt, shoot, poison, net, snare, spear, pursue, capture, trap, injure or kill. The legislation also imposes restrictions on holding protected fauna, including for the purpose of rehabilitating an animal which is incapable of fending for itself. When a person comes into possession of a sick, injured or orphaned protected species, such as a koala, but has not been licensed to rescue, hold and rehabilitate protected fauna by the National Parks and Wildlife Service, or a licensed wildlife rehabilitation organisation, they are legally required to notify the Director-General of the National Parks and Wildlife Service in writing within seven (7) days and to comply with any direction given. In the case of a koala, in every situation, directions will be given that it immediately be passed to a skilled licensed/authorised koala carer.

Since the mid-1980s the New South Wales National Parks and Wildlife Service has supported the establishment of specialist wildlife rehabilitation organisations. These train their members in the skills of animal care and wildlife rehabilitation, authorise appropriately trained and skilled members who have the necessary facilities and other resources to care for particular groups or species of animals and then supervise and monitor their activities. These groups also ensure that their members are kept up-to-date with advances in wildlife rehabilitation techniques and encourage peer liaison. There are now over 20 such organisations in NSW and some have regional branches. It is only in a very rare situation, and generally only in a region which does not have a licensed rehabilitation organisation, that the Service will licence an individual to care for sick, injured or orphaned native animals.

These conditions and guidelines refer to the care of koalas by carer groups for the purpose of rehabilitation to the wild, rather than for captive management in zoos or fauna parks. Also they were not written to be binding on researchers, who are subject to the *Animal Research Act 1985*, but where those aspects of research protocols require care and handling of koalas these guidelines may be utilised. to fulfil those requirements. This will particularly apply when a researcher and a carer group are working co-operatively.

These conditions and guidelines are consistent with the Australian and New Zealand Environment and Conservation Council (ANZECC) 1996 *Draft National Koala Conservation Strategy* and contribute to fulfilling Objective 5: ‘To manage captive, sick or injured koalas and orphaned wild koalas to ensure consistent and high standards of care’. Thus, although parts of this document carry conditions that are binding in New South Wales, it has also been prepared to assist koala carers, other interested parties and the relevant authorities in other states. In doing so, it has provided a worked example of the welfare aspect of wildlife management, a need made explicit by Objective 5 of the *Draft National Koala Conservation Strategy.*

This document has been prepared in two parts: 1) guidelines, and 2) formal conditions for koala care in New South Wales. Both parts have been prepared in conjunction with carers, veterinarians, Service officers and other interested parties through an extended period of negotiation, including workshops, discussions and a wide circulation of drafts for critical comment. The acknowledgments section lists the participants in this process.

Part 1) The guidelines, which outline the concerns, points of interest and importance for koala care. They were prepared to assist carer groups in their detailed response to comply with the conditions when seeking accreditation.

Part 2) *The formal conditions for koala care in New South Wales are presented in italics at the end of each section*. Accreditation is a formal requirement under the *National Parks and Wildlife Act 1974* and is administered through the Field Services Division of the National Parks and Wildlife Service. These are the conditions that need to be met by carer groups prior to, or to preserve, accreditation.

Each of the following topics is dealt with in two parts. The first contains the guidelines, which are in a normal typeface; the other part, which is in italics, states the condition that must be satisfied to obtain or maintain accreditation as a koala care group in New South Wales.

2. REQUIREMENTS FOR CARERS

Everyone who cares for koalas must be appropriately skilled and have appropriate facilities, access to reliable sources of a variety of recognised koala food tree species and an ability to collect it.

2.1 Training

- Training for new carers should cover all aspects of the care that they will be expected to undertake, and may consist of one or all of the following options:
    a) Carers course/workshop;
    b) Apprentice System (one-on-one training with an accredited carer or fauna park);
    c) Experience in koala hospital situation in districts where this is possible;
    d) Voluntary work in fauna parks or zoos where this is possible.
- Training should cover all aspects of handling, observation, restraint, treatment and tree identification and leaf collection.
- Training should include an assessment of competence and be appropriately recorded.

Conditions: New carers must be trained by an accredited carer or group.

2.2 Licensing

Carers and carer groups in NSW require licences from the NPWS (Wildlife Licensing Unit, NPWS, PO Box 1967, Hurstville NSW 2220) Phone (02) 9585-6481, FAX (02) 9585-6401.

Conditions: New carers must be registered in a licensed group. The group must provide a detailed training program and a list of all registered carers as requirements to gain or continue to hold a licence.

2.3 Accreditation

- An independent Accreditation Committee will be established by the National Parks and Wildlife Service to undertake the accreditation of organisations and in the case of appropriate groups, their regional branches. (Only in special cases will individuals, not part of a group, receive accreditation.) This Committee will comprise at least a Service officer, a carer and a veterinarian.
- Koalas will not be permitted to be held by groups or individuals who have not been accredited to care for koalas. An accreditation system will be established to ensure that each carer group and individual carers are accredited as having the expertise and facilities etc, to provide excellent care for koalas.
- An accredited group/branch will be required to establish its own Accreditation Committee to review the credentials of each of its own carers.

- Koalas will be permitted to be cared for only by accredited carers. Each accreditation committee will establish grievance procedures and undertake grievance resolution.
- Trained and accredited wildlife rescuers may rescue a koala and transport to a vet or accredited carer, or hold temporarily.

Conditions: An independent Accreditation Committee, established by the National Parks and Wildlife Service, and consisting of at least a carer, veterinarian and a Service officer, will undertake the accreditation of organisations applying for accreditation. A carer group is to set up an accreditation committee, keeping all appropriate records (such as minutes and correspondence). The formal procedures for accreditation need to be listed by each committee and this must be used in the accreditation of each carer or carer group.

2.4 Facilities

- Homecare specific requirements - facilities must be available for: intensive care, intermediate care and rehabilitation.
- Individual carers need not have all facilities, but all should be available within a care group.
- Facilities are to be checked for suitability by the co-ordinator in the accredited care group.
- If possible, a carer is to have no dogs or cats and the facilities must be in a quiet area. If they are owned by the carer, then they should never have contact with koalas which are in care.

Conditions: All facilities for each stage of care must be available within a group. A detailed list of facilities must be prepared as part of the accreditation process. Each carer must have their facilities checked for suitability by the group co-ordinator and a record kept.

3. LIAISON WITH VETERINARIANS

- Carers should advise vets that they are an accredited carer and offer assistance.
- Common experience and practice shows that an authorised or experienced person is often required to restrain and feed the koala while in veterinary care.
- Carers should be respected for their expertise, but should not tell vets what to do. Rather, they should advise on the best practice, including medication and restraining.
- When koalas are taken directly to the vet, by the public (including police, RTA and council workers), the vet should notify the carer group in the area.
- The carer group has a responsibility to disseminate current information on koala care and a list of experienced vets in koala care to all vets in the area.
- Vets should not hold koalas in care if there are appropriate care facilities available in the carer group.
- Within veterinary facilities, koalas should be in isolation and vets should not hold koalas in pet kennel areas.
- Carers must respect veterinary advice on euthanasia of koalas, but retain the right for a second opinion from another vet.

- Vets instructions relating to medication should be adhered to.
- No animal medication, human medication, ointment or herb should be administered to a koala in care unless it has been approved by a vet.

Conditions: Carers must advise the vets in the area of their existence, what information is available and the best procedures for koala care. Carers must respect the vet's professional rights and responsibilities.

4. RESCUE

- Members of the public who find a sick, injured, orphaned or otherwise distressed koala should note its location and condition and contact the local koala care group or the National Parks and Wildlife Service as soon as possible. Members of the public should not attempt to capture or transport the animal.
- The carer group should attend ASAP with proper catching gear, restraining and transport equipment.
- Carer groups should ensure that all vets, RTA, RSPCA, police and firefighting in the area have the contact numbers of the group.

4.1. Criteria to rescue

- Sick, injured and orphaned wild koalas which are unable to fend for themselves should be rescued.
- Extreme care should be taken when rescuing orphans that the mother is not nearby.
- Juvenile koalas with weights estimated in excess of 3 kg should not be rescued on the grounds of being orphaned.
- Wild koalas should not be handled or moved unless considered absolutely necessary. An example of a dangerous situation would be a koala on a median strip on a highway.
- If a koala is in an unusual place but appears healthy and in no immediate danger it should be left alone and its location reported to the carer group or the National Parks and Wildlife Service.
- Koalas in a research program are the responsibility of the researcher under the *Animal Research Act 1985*. Contact can be made with the researchers to discuss their project or liaise with the researcher via the NPWS District Manager. Research koalas may not be rescued unless by prior arrangement with the researcher. It is in the interests of the researcher to notify the local carers of the program and to discuss contacts and actions should an animal in the program be found sick or injured or in a dangerous situation. If a carer, or anyone, considers that the welfare of a koala in a research program is being neglected, they should contact the researcher and discuss options for change. If that proves unsatisfactory, the concerned person should then contact the chair or secretary of the Animal Care and Ethics Committee (ACEC) that gave the authority to the researcher.

Conditions: Only koalas which have a poor chance of survival from obvious signs of injury or disease, or that are orphaned, or that are in a dangerous location, may be *rescued. No koala known to be covered by an Animal Research Authority may be rescued without consent of the researcher.*

4.2. Catching and retrieving injured animals

- Always assess the danger to the rescuer.
- Ask bystanders to stand back and remain quiet. Rescuers must be assertive but not aggressive to onlookers. Rescuers should explain what is happening with the animal.
- Use a blanket or cloth bag to wrap the animal - first place it over the head when catching so the risk of biting to the rescuer is minimised.
- Pick the koala up from behind. A koala can be picked up safely from behind by the lower forearms. Alternatively, bring the koala to the ground and hold it on the ground and ease into an appropriate catching bag. Do not pick up from the front by the ribcage or wrists.
- Put in a carrybox or similar properly-secured container.
- Prop animal up with towels into sitting position.
- Avoid unnecessary handling and avoid loud noise, dogs and unnecessary photos.
- Be conscious of possible injuries, such as fractures, when handling injured animals.
- If attending a road accident at night, rescuers should wear bright-coloured clothing to reduce the risk of being hit by other vehicles, or use a reflective sign.

Conditions: Procedures for catching and retrieving koalas must be specified by the carer groups in seeking accreditation. Procedures should include methods of catching, holding and securing for transportation. Koalas may only be handled by an authorised person.

4.3. Transport

- The koala must be restrained in containers for transport. Suitable containers include garbage bins with plenty of large holes for ventilation and air circulation; two clothes baskets tied together; or custom-made koala boxes.
- In emergency situations, hessian bags are suitable but not preferred- a light canvas bag or large pillowcase is adequate. Do not use hessian bags to contain koalas unless there is no alternative as they can damage claws and shed fibres that can be inhaled. Do not transport koalas suffering burns in canvas bags.
- Koalas are not to be transported on the body of carers.
- The koala should be kept dark, quiet, and warm (15-25 degrees Celsius).
- Do not transport the koala in the boot , or with dogs in the vehicle, or with the radio on.
- Be conscious of the time factor - act quickly and get the animal to a vet or carer by the most direct route.
- If possible, transport the koala with leaves picked from the area. The smell may relieve some stress.
- Do not leave koalas in any container for a long period.
- Ensure that the koala and container are out of direct sunlight when being transported.

- Koalas should not be moved from home care unless for treatment or to an external location within the home care premises or for the purposes of pre-release or release to the wild.

Conditions: Each koala care group is to establish detailed criteria under which koalas are to be transported.

5. CRITERIA FOR ENTERING CARE OR FOR EUTHANASIA

- The following questions should be asked:
  - a) Should the koala be released immediately?
  - b) Is it able to be rehabilitated?
  - c) Is euthanasia the best welfare option?
- The decision on the fate of the koala is to be made by the carer and a vet and/or koala coordinator.
- In deciding, a note is to be taken of the animal's past history if its identification is known (eg. by microchip or eartag).
- Reasons for euthanasia include:
  - a) No chance of a normal life, eg. loss of tongue, limb;
  - b) Signs of extreme pain and stress;
  - c) Serious and multiple wounds eg. from dog bites which usually become infected.
- Euthanasia to be performed by a vet.
- If a fire victim, burns on paws are not always evident for a couple of days, so the animal should be held for later assessment.

Conditions: The decision to take a koala into care or to euthanase is to be made by the carer and a veterinarian and/or group co-ordinator. The carer group must review each decision to assist in refining the decision making process. A record of the reasons for decision must be kept on a standard record form.

6. CARE

There are three stages in the care of koalas:

1. First 12 hours - may be temporary care following rescue;
2. Next 48 hours - koalas are considered wild in care;
3. Long-term care (greater than 48 hours) - koalas are considered captive;

The conditions for long-term care require a substantial commitment of resources, time and record keeping. The only reason for long-term care is that the koala is likely to improve in health and be rehabilitated to the wild.

Conditions: Detailed specifications, record sheets, inspection procedures and care protocol need to be formally established for koalas in long-term care as a requirement for accreditation.

6.1 Assessment

- The initial assessment of the koala needs to be thorough but should be performed with as little disturbance as possible.
- Check the pouch to see if a joey is attached to the teat. If so, do not anaesthetise the mother.
- Koalas should be assessed for wounds, fractures (including jaw area), ticks, swollen lymph glands, anaemia (check colour of gums) as well as more obvious signs such as wet bottom and conjunctivitis.
- Koalas should be weighed. Normal body weights vary across the koala's range. Carers should be aware of the normal body weights for different ages and sex of the koalas in their area.
- *Chlamydia* status can be checked by the clinical presence of conjunctivitis and wet bottom. Clearview test kits may help.
- Dehydration can be critical in sick animals. Hydration status can be assessed by changes in skin tone. In normal condition, the skin over the scapula (shoulder blade) area should slide freely and, when pinched, skin on the top of the head, between the ears, should snap quickly back to place. Dry rough skin on the paws and nose is a sign of dehydration.
- Body condition can be assessed by palpation over the scapula area. In poor condition, the edges and spine of the scapula become prominent.
- Body temperature can be checked. Normal body temperature is 35.5-36.5°C.
- In care having been assessed by a vet.
- There should be a monthly review of koalas in long-term care by the carer group co-ordinator and records to be kept of the decision to remain in care.
- Mature/aged koalas in excess of 8 years, particularly males, should not be held in captive conditions for more than 6 months.
- Koalas in care for more than 6 months should be re-evaluated.
- A check list for assessment should be prepared by the care group. An opportunity exists here for an exchange of information among care groups as to what should be on this list.

Conditions: The health status of the koala must be assessed to decide what treatment the koala requires. A decision must be made and recorded by the carer as to whether the koala is to be released within 48 hours or to go into long-term care.

6.2. Holding /Housing

- Minimum standards should be identified by the group and deal with all aspects of holding and housing. The Standards for Exhibiting Koalas set by NSW Agriculture (Appendix 1) may be used as a guide. Standards should be set for conditions under temporary holding, normal care, intensive care and long-term care.
- Many issues have been identified for consideration. These include:
    - a quiet environment;
    - not accessed by the public;
    - walls and floors should be constructed of materials which can be easily sterilised;
    - design to be such that temperature is controlled, with natural lighting and ventilation;
    - use of lawn lockers, garages and laundries are not suitable.

- Koalas in care for more than 12 hours should be contained in housing more structured than the conditions necessary for the rescue and holding in the first 12 hours.
- Depending on the state of the animal, a licensed carer is to decide how the animal is to be housed. Temporary housing may include baskets, cots or enclosures.
- Diseased koalas should be housed in isolation from other koalas.

Conditions: The minimum standards for enclosure design and management must be prepared by each carer group as a requirement for accreditation. This must include housing requirements for koalas under intensive care as well as non-intensive care, temporary holding and long-term care.

6.3. Diet

6.3.1. Fluid balance

- Dehydration can be critical in sick animals. The following are offered to rectify and maintain positive fluid balance.
- Drip under veterinary supervision.
- Subcutaneous fluids under veterinary supervision.
- Oral fluids can be administered, such as “Lectade” and “Portagen”. Dehydrated koalas which don’t recognise free water should accept fluids via a syringe.
- Koalas should be encouraged to lap fluid from a shallow container. Feeding by unnatural methods, such as syringes and eye droppers, should be restricted to animals which are incapable of lapping.
- Milk supplements should only be given to injured, sick, dehydrated or juvenile animals.
- Other ways to restore and maintain positive fluid balance are:
  - a) feed younger leaves;
  - b) spray leaves with water before offering;
  - c) ensure leaves are as fresh as possible and standing in water.

6.3.2. Dietary supplements

- Supplementary feeding with:
  - a) “Portagen”/ high protein baby cereal. If adding high protein baby cereal, changes in faeces should be closely monitored; excess use can cause diarrhoea.
  - b) “Wombaroo”
  - c) Glucose and water
  - d) “Divetelac”
  - e) “Prosobee”
  - f) Yoghurt in the milk mixtures.

6.3.3. Leaves

- Offer three to five species a minimum of twice daily in areas where this is possible. Wet the leaves with water spray, and stand leaves in container with water supply. Also offer a supply of clean bark, water and dirt, unless on a drip or immobile.

- Leaves are to be collected from trees in such a manner as not to destroy the bush. Leaves should not be collected from the roadside where they are likely to be contaminated with high levels of lead.
- A list should be prepared of preferred koala browse leaves available in the area of the carer group.
- Carers should demonstrate that they have guaranteed access to adequate supplies of fresh leaves.
- Koalas should be offered the leaf species found in the potential release area.

Conditions: The diet, method of feeding and source and species of leaves must be codified by the carer group as a requirement for accreditation.

7. ORPHANED/HAND-REARED KOALAS

- A hand-reared orphan is back or pouch young raised by a carer.
- Orphaned koalas present the problem of knowing the right age or weight for release. Koalas are normally independent at 18 months (2-3 kilograms; the range generally represents the geographical increase in weight from north to south. However, local population variation on weight is acknowledged and in establishing criteria for orphans, local background data are to be included in the submission for accreditation.) The age or weight at release should not be greater than the age or weight at which the koala would normally be independent of its mother. However, orphans from diseased and aged koalas, or mothers who have been sick or injured for some time before being found, are usually debilitated, dehydrated and hence small for their age and slow to grow. On the other hand, orphans from road kills are often well fed and developed and adapt well to hand rearing. Thus discretion must be taken when assessing the weight/age of orphans.
- The regular weighing of an orphan to ensure adequate weekly weight gains, observing progress, independence and activity should help indicate the time for release.
- The date of release and hence the length of time the koala is kept in care is an issue, especially if it coincides with the tick and breeding season. For males, this release time could cause extra stress. Alternatively, this is the normal time for dispersal and establishment for males.

Conditions: The age or weight at release of orphaned koalas must not be greater than the age or weight at which the koala would normally be independent of its mother. Carer groups must establish criteria for identifying, caring for and releasing an orphan, including a weight that is appropriate for the local area, as a requirement for accreditation.

8. PUBLIC EXHIBITION

At no time should koalas being rehabilitated for eventual release be placed on public exhibition or used for educational purposes. Contact with humans should be minimised at all times to ensure koalas maintain a healthy fear of human presence.

Conditions: Koalas in care undergoing rehabilitation must not be placed on public exhibition or be used for educational purposes.

9. CRITERIA FOR RELEASE

- At regular intervals the carer and vet must consult on the welfare and state of the animal. Communication must be maintained between carer, co-ordinator and vet to decide on release date.
- A set of criteria to assess ability to be released to be developed by each carer group.

For example:

Category	**Criteria for release**
Age	> weaning age (2 kg)
Teeth wear	not worn down to gums (Vet assessment required for old koalas)
Eyes	bright, clear, clean
Ability to climb	must be able to climb - check for healing of injuries
Ability to feed	independent feeding - check for healing of jaw injuries
Chlamydia status	absence of wet bottom/ conjunctivitis/ swollen lymph nodes
Body weight maintenance	consistent with age and history and holding body weight
Behaviour	appears alert, ears up, etc.
Signs of capture stress, need to be released immediately	pacing behaviour, vocalisations

- Release at the earliest opportunity. For koalas in long-term care, animals may be retained for one week after treatment has finished to monitor if symptoms return.

Conditions: Koalas must be released at the earliest opportunity, after having satisfied the criteria for release.

10. PRE- RELEASE

10.1 Rehabilitation for koalas in long-term care or hand-reared

- Exercise wherever possible. Koalas with fractures should be in an area where it is at least able to walk after 6-8 weeks.
- Appropriately sized tree forks and cross branches should be available to the koala to match its development and confidence. These should be renewed whenever possible so that the bark is fresh.
- Hand-reared koalas should be gradually weaned into different stage trees and away from contact with the carer.

- Koalas in long-term care or hand-reared are to be placed in a rehabilitation area for a period of tree climbing under normal weather conditions prior to release. They should have access to the ground so they become familiar with travelling on the dirt and grass. Koalas should display natural behaviour as much as possible.
- Capture at night when the koalas come down to the ground is a good option to reduce stress and injury.

Conditions: Koalas in long-term care or hand-reared must be placed in a rehabilitation area for a period of tree climbing under normal weather conditions prior to release.

10.2 Identification

- All koalas must be ear tagged. Ear tagging should be done, if possible, a couple of days before release. Koala ears are to be clipped and prepped with alcohol prior to tagging. Males are to be tagged in the left ear, females right ear. The tag should be placed with the point to the front of the ear so the tagger can check for veins and target the tag away from them.
- Ear tags must be numbered so that individual animals can be identified.
- Ear-tagging is to be applied only to koalas which are already in care and only by a trained person or under the supervision of a veterinary surgeon or a National Parks and Wildlife Service officer with appropriate experience, or a researcher holding a current Research Authority from an accredited Animal Care and Ethics Committee. A koala may not be captured for the sole purpose of tagging without both a Research Authority from the National Parks and Wildlife Service and an appropriate Research Authority from an Animal Care and Ethics Committee.
- Records must be kept of all tagged koalas.
- All koalas may be microchip, ie. a microchip inserted with a needle beneath the skin and read with an electronic microchip reader.
- Plucked hair for genetic studies of population is acceptable, and a convenient time to do this is while the koala is being marked, eg tagged and/or microchipped. The easiest way to pluck the hair is with tweezers of a pair of pliers to make sure that the bulb of tissue at the base of the hair is attached. It is this tissue that is analysed. Eight to ten hairs are sufficient, and on or around the ear can be a convenient site.

Conditions: Koalas must be ear tagged prior to release by an appropriately trained person and records kept. The record form needs to part of the submission for accreditation.

11. RELEASE / RELOCATION

- Koalas should be released as close to their original encounter location as possible so that the animal has a reasonable opportunity to resume life in its original home range.

- Relocation should only be considered as a last resort to remove a koala from immediate and imminent danger or threat and where the koala is considered to be independent and appears to be in a healthy condition. The decision to relocate must be made by two people.
- A potential relocation or release site should not be a site of known high danger or threat (eg. beside a busy road). The original capture site can create dilemma for release if it is deemed to cause recurring injury over the short-term (eg. in a killer dog area or near a black spot on the road).
- A potential relocation site should preferably have secure tenure and compatible land management.
- A potential relocation site should be one known to already support a population of koalas.
- Relocations should be part of an approved strategy or local koala management plan which should consider potential adverse effects associated with manipulation of gene pools, spread of disease, potential inability of a koala to cope with relocation, potential disruption of resident koalas at the relocation site and potential destabilisation of koalas at the encounter site due to removal of a key individual. Care groups should prepare a list of potential relocation and release areas (where site of origin unknown), if there is no local strategy, and gain approval of district office of the National Parks and Wildlife Service and relevant landholders.
- The district office of the National Parks and Wildlife Service should be notified of the proposed release of all koalas so they have the option to attend.
- Release of koalas within Service areas will generally not be approved unless it is consistent with a Plan of Management or the animal was originally recovered from the area.
- Knowledge of koala habitat and any previous release or relocation of the animal is essential for deciding on relocation.
- Koalas which are suffering from a communicable disease should not be relocated to an area outside its home range.

Conditions: The site of release of koalas must be as close to the initial encounter site as possible except for koalas being relocated out of immediate danger. The release of all koalas must be made in consultation with the district office of the National Parks and Wildlife Service.

12. OPTIONS FOR NON RELEASABLE KOALAS

- Option 1 - Euthanasia is acceptable for all suffering animals. If no possibility of reasonable care , euthanasia is the preferred option.
- Option 2 - Released into "safe" areas - eg rehabilitation or feral proof areas.
- Option 3 - Place into a licensed zoo or fauna park, which already holds a captive colony of koalas, with approval from the Director-General of NPWS.
- Option 4 - Used for teaching with approval from an Animal Care and Ethics Committee to be obtained by the recipient of the non-releasable koala .
- Option 5 - Used in research programs with approval from an Animal Care and Ethics Committee to be obtained by the recipient of the non-releasable koala.

Conditions: Koalas deemed to be non-releasable must be either euthanased or, following the recipient obtaining an appropriate authority or licence, be placed in a licensed zoo or fauna park, kept in a "safe area" and/or used for teaching and research.

13. PROTOCOL FOR DEAD KOALAS

- Often when a carer is contacted, the koala is already dead, usually killed by a car or a dog. The information on blackspots is valuable to record, and samples from these koalas can contribute to research. Collect all relevant information, where possible, such as location, cause of death, date, sex and aged of koala.
- Samples are to be made available for research, where possible.
- An autopsy protocol is to be established. All koalas should be autopsied where cause of death is not positively known. An option that can be utilised is the Wildlife Pathology Service (University of Sydney free service).

Conditions: Autopsies must be undertaken where possible, a protocol established, and animals or tissues made available to researchers.

14. RECORD KEEPING

- Each koala must be given a registration number, call number or identifying code at rescue.
- Each carer should keep records of all animals which come into their care and a database should be kept by one nominated person to register and regularly update all details within each group. Records should be kept in duplicate, eg. hardcopy and on disc. Copies should be provided to the district NPWS on a regular basis, who then send these at least annually to the licensing unit in Field Services Division in Head Office.
- Records should be kept on standard forms. The care group should develop a detailed standard record form(s) for individual carers.
- The following details should be recorded: time and date of rescue, location of rescue, name and phone numbers of initial contacts, rescuers and carers, circumstances for being taken into care, approximate age, weight, sex of the koala, condition of the koala, treatment undertaken, veterinary details, daily records of eating, urinating, defecating, observations and approximate volumes, treatments and dosages, type of leaf offered and eaten, identification tag number, fate including release or relocation details or autopsy results.
- Recording of the original location of koalas, including details of habitat, on Atlas of NSW Wildlife data cards is encouraged.

Conditions: A standard record sheet must be prepared for each rescued koala. Each koala rescued must be given an identifying code. The record sheet must accompany the koala and a copy kept in a central record system of the carer group. The care group must develop a detailed standard record form(s) for individual carers as a requirement for accreditation.

ACKNOWLEDGMENTS

These guidelines arose from workshops at Australian Koala Foundation conferences in 1991, 1995 and 1996 and an advanced koala care workshop in Port Stephens on 1-2 June 1996 organised by the Tilligerry Habitat Association and has been prepared in conjunction with carers, veterinarians, Service officers and other interested parties. Specifically we wish to acknowledge the following for their vital input: Ruth Barratt, Friends of the Koala; Rob Becher, Coffs Harbour Zoo; David Blyde, Western Plains Zoo; Debbie Breen, Native Animal Trust Fund and Wildlife Arc; David Burns, NPWS Grafton District; Anne Carey, Native Animal Trust Fund; Emilie Cooper, Koala Preservation Society of New South Wales; Greg Croft, NPWS Port Macquarie; Madeleine Crowley, Koala Preservation Society of NSW; Denise Friedman, WIRES Coordinator; Miriam Graham, Koala Preservation Society of NSW; Catherine Greenwood, NSW Agriculture; Jeff Hardy, NPWS Wildlife Licensing Unit; Anne Hogan; Matthew Jackson, Currumbin Sanctuary; Rhonda James, Tweed Valley Wildlife Carers and Koala Rescue Unit; Joanne Johnston, The Koala Preservation Society of Qld; Audrey Koosmen; Rebecca Larkin, NSW Agriculture; June Lepla; Julia McLean, Tweed Koala Rescue Unit; Heather Michelmore, Cleland Wildlife Park in SA; Chris Moon, Coffs Harbour WIRES; Alan Morris, NPWS Central Coast District; Greg Mulder, Wildlife Animal Rescue and Care Society; Marcia Nash; Dr Jean Olley; Rhonda Parkinson Native Animal Trust Fund; Giovanna Pawson, NSW Association of Fauna and Marine Parks; Robert Payne; Sue Phillips, NPWS Lismore District; Lynda Rochester, Native Animal Trust Fund; Robyn Roe Native Animal Trust Fund; Julie Rose, Northern Tablelands Wildlife Carers; John Single; Jean Starr; Glen and Lynda Stevenson; Deborah Tabart, Australian Koala Foundation; Jill Taylor, Native Animal Trust Fund; Dr Louise Trist, Maitland Veterinary Hospital; June Welsh; Michelle Whackett, Coffs Harbour WIRES; Patricia Whitworth; Steve Wilks, NPWS Port Macquarie; Pam Wilson, Wildlife Carers of Glen Innes; Barbara Witham, Koala Preservation Society of NSW. We also wish to thank the Foundation for National Parks and Wildlife and the Biodiversity Group, Environment Australia (formerly ANCA) for their funding support.

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APPENDIX 1

Standards for Exhibiting Koalas

(Phascolarctos cinereus)

in New South Wales

Exhibited Animals Protection Act, 1986

A publication of the Director-General, NSW Agriculture
pertaining to the conditions of display of koalas
(pursuant to Clause 8(2) of the Exhibited Animals Protection Regulations, 1995

GENERAL REQUIREMENTS

1.1 Construction

a) Enclosures shall be constructed of such materials and be maintained in sufficiently good repair to ensure that they will contain the animals at all times and are to be safe for the animals, for the staff attending them, and for the public.

b) Enclosures, or the perimeter fence in the case of an establishment where koalas are permitted to free range, shall be designed in such a way as to prevent the entry of wild koalas. This requirement only applies to establishments located in areas where wild koalas are known to occur.

c) Enclosures may be of open, semi-enclosed or totally enclosed design.

d) Sufficient shelter must be provided to allow protection from wind, rain and extremes in temperature and allow sufficient access to shade during the hot periods of the day.

e) The size and shape of enclosures for *P.cinereus* shall provide freedom of movement, both vertically and horizontally.

f) The enclosure shall be well drained and have either a readily cleanable substrate or be of a material which can be replaced to avoid the accumulation of faeces and urine.

1.2 Isolation Facilities

Suitable isolation facilities shall be provided for quarantine of incoming or sick animals.

1.3 Protection from Noise, Harassment and Stress

Each operator exhibiting koalas to the public shall:

a) Provide a sufficient number of experienced, identifiable staff in attendance at any session allowing visitors to handle koalas to protect the koalas from abuse and harassment where koala handling occurs and to ensure that stress on the koalas does not occur.

b) Ensure koalas are not placed directly on any visitor or directly held by any visitor for any purpose. Handling koalas by members of the public shall be restricted to patting, stroking and cuddling to the extent of putting an arm around the koala while the animal remains on a fixed perch.

c) Ensure that koalas are not repeatedly removed from objects to which they are clinging.

1.4 Enclosure Furniture

a) There must be at least two tree forks per koala not less than 1.8 metres above ground and not closer than 0.9 metres to the next fork.

b) All supports and branches shall provide sufficient traction for koalas to climb easily and safely.

Clause 2 Hygiene

Substrate of enclosures shall be cleaned daily. The supports and branches shall be replaced as necessary and be maintained in a clean and hygienic condition, free from the accumulation of faeces and urine.

Clause 3 Records

3.1 Identification

Each koala shall be individually identified by an approved method of identification.

3.2 Record-Keeping

a) Establishments shall keep records of all koalas on an individual basis in a form which can be quickly and easily examined, analysed and compared with those kept by other establishments.

b) All documents and other information pertaining to each animal, including records from previous locations, must be kept safely. Animals moving to new locations must be accompanied by copies of all records relevant to those animals.

c) The records shall provide for each koala at least the following information:

   i) the correct identification number, scientific name, any personal name and any distinctive markings;

   ii) the origin (i.e. details of the wild population or of the parents and their origin, and of any previous location);

   iii) the dates of acquisition and disposal, with details of circumstances and addresses;

iv) the date or estimated date of birth, and the basis on which the date is estimated, or the date of the first emergence of the juvenile from the pouch;

v) weight on arrival, and thereafter monthly. The requirement for weighing animals monthly shall not apply to koalas which are either free-ranging within the perimeter barrier of the establishment, or are not dependent on hand-feeding for nourishment.

vi) clinical data, including results of physical examination by a qualified veterinarian and details of and date when any form of treatment was given, together with results of routine health examinations;

vii) breeding and details of any offspring;

viii) the date of death and the results of the post mortem reports which must be performed by a qualified veterinarian.

d) The Director-General may require records of daily leaf collections to be maintained, including details of -

i) leaf species,

ii) area of collection,

iii) weights of leaves before and after feeding,

iv) the identities of the koalas which fed on the leaves.

Records may be required to be submitted to the Director-General at three monthly intervals for a period of two years from the date of initial issue of a permit to exhibit koalas.

3.3 Transaction Records

a) A written report, including records of any clinical observations, shall be submitted to the Director-General within 30 days, on every transport operation, in particular detailing any problems arising and with suggestions as to how these may be avoided.

b) The Director-General must keep a current summary of transport advice, based on these reports and provide a copy to applicants for their information.

Clause 4 Diet and food collection

4.1 General

a) An establishment applying for a permit to exhibit koalas must satisfy the Director-General that it has guaranteed access to adequate fresh supplies of leaves from at least three suitable koala food tree species. This is important when particular species can be susceptible to insect attack at particular times of the year. Known food trees include the species listed below:

E.botryoides	Southern Mahogany
E.camaldulensis	River Red Gum
E.camphora	Broad-leafed Sally
E.citriodora	Lemon-scented Gum
E.cypellocarpa	Mountain Grey Gum
E.goniocalyx	Long-leafed Box
E.grandis	Flooded Gum
E.haemastoma	Scribbly Gum
E.maculata	Spotted Gum
E.microcorys	Tallowwood
E.nicholii	Small-leafed Peppermint
E.obliqua	Messmate
E.ovata	Swamp Gum
E.paniculata	Grey Ironbark
E.pilularis	Blackbutt
E.propinqua	Small-fruited Grey Gum
E.punctata	NSW Grey Gum
E.radiata	Narrow-leafed Peppermint
E.robusta	Small Mahogany
E.rubida	Candle Bark
E.saligna	Sydney Blue Gum
E.scoparia	Wallengarra White Gum
E.sideroxylon	Red Iron Bark
E.tereticornis	Forest Red Gum
E.viminalis	Manna Gum

b) A sufficient quantity of eucalypt leaves shall be provided continuously and replaced at least once daily.

c) Preferred species of eucalypt should be supplemented by a variety of different species of eucalypt as a precaution against local or seasonal differences in digestibility and palatability of dietary leaf matter. Both young and mature leaves should be provided.

d) Feed must be presented as close and accessible to the koalas perch as possible and care taken to prevent wastage of feed placed out of reach.

e) Fresh soil shall be provided, but not around the base of perches, to provide for supplementation of mineral intake or alternatively a mineral salt lick be provided.

f) Clean accessible drinking water facilities shall be provided. Water shall be replaced at least once daily.

4.2 Quality of Food Leaves

Frequency of leaf cutting and the operation of leaf storage facilities shall ensure the koalas receive palatable, uncontaminated, nutritionally adequate food leaves.

Clause 5 Transport

5.1 Quarantine

a) Koalas to be transferred between establishments must be subject to a period of 30 days quarantine at either the importing or exporting establishment unless an exemption from the quarantine period is advised and certified by a veterinarian following a complete veterinary examination.

The certificate must also establish that the koala is -

i) not in a weakened or emaciated condition; and

ii) is free from
- keratoconjunctivitis,
- pneumonia,
- dermatitis, and
- urogenital discharge,

before release from quarantine.

5.2 Transport Cage

Koalas must be transported individually in solid framed cages measuring at least 95cm x 75cm x 95cm high. The cages must have removable, leakproof metal drop trays fitted at the base. Sides and top must be of stout wire mesh and be fitted with light hessian or shadecloth covers. Each cage must be fitted with a resting branch providing at least two forks.

5.3 Feeding in Transit

a) Koalas must each be accompanied by at least 3.6kg of the leaves on which they are normally fed; the leaves being left on the stem and the base of the stem remaining in water or sealed.

b) One kilogram of these leaves must be placed in the cage with the koala before departure.

5.4 Stress Reduction

a) Koalas must not be subjected to temperatures greater than 30 degrees or less than 10 degrees Centigrade during the trip.

b) Koalas must be accompanied by a keeper familiar with the animals being transported at all times except during air transport.

c) Noise must be minimised during transport.

d) Time from caging to destination must be minimised.

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Appendix K Associate Professor Jonathon Rhodes' adequacy review of the Plan

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

School of Geography, Planning and Environmental Management

Dr Jonathan Rhodes
Associate Professor

CRICOS PROVIDER NUMBER 00025B

Bob Higgins
General Manager, Pacific Highway
21 Prince Street
GRAFTON, NSW 2460

10th July 2016

Re: Review of Woolgoolga to Ballina Koala Management Plan

Dear Bob,

I have reviewed the Koala Management Plan that outlines the management steps to minimise and monitor impacts on koalas arising from the Pacific Highway upgrade between Woolgoolga and Ballina. All my queries and comments made during the review process have been addressed in the latest version and I am happy to endorse the plan.

The plan underwent extensive and thorough rounds of review and this has greatly improved the final management plan. As such, I believe the plan now adequately addresses each of the conditions of approval (in particular, NSW MCoA D8 and D9 and DoE Conditions of Approval 8 and 9). An important aspect that I have focussed on in reviewing the plan is ensuring that a robust monitoring strategy is set up that includes triggers to implement management and/or further investigation if management targets are not met. This is a critical component of the management plan to ensure that management objectives are met and that the meeting of objectives is clearly demonstrated.

If you have any further questions please do not hesitate to contact me.

Yours sincerely,

Jonathan Rhodes

Associate Professor Jonathan Rhodes

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Appendix L Addendum to the Ballina Koala Plan

Addendum to the Ballina Koala Plan

Prepared by Dr Rod Kavanagh, Niche Environment and Heritage, 1 May 2016

This report has been prepared at the request of the NSW Roads and Maritime Services and provides my response to the Review of Section 10 Woolgoolga to Ballina Pacific Highway Upgrade - Ballina Koala Plan Report prepared for EDO NSW by Stephen Phillips, April 2016

This report is supported by two attachments:
Attachment 1 details the results of alternative PVA scenarios using the inputs suggested by Dr Phillips and the alternative methodology suggested by Dr Miller.

Attachment 2 has been provided by RMS and details the latest mitigation measures proposed for Section 10, including the additional measures proposed to reduce mortality in this Koala population.
It should be read in conjunction with the Ballina Koala Plan (BKP) which was prepared by me and dated January 2016.

Extract from Dr Stephen Phillips review, April 2016, commencing at p. 4 'Analysis/Critique of the BKP'	**Comments**
12. I have noted that the covering letter to the underlying RMS report and associated BKP is signed by the NSW Government's Chief Scientist and Engineer. With respect and while highlighting some aspects of the mitigation measures proposed by RMS, nowhere does either the covering letter, the underlying report or the BKP provide an upfront outline and/or summary of the potential impacts arising from construction of Section 10 of the Pacific Highway upgrade between the Richmond River and Coolgardie. In my opinion such knowledge is a necessary prerequisite of any impact study because it ideally informs the work that follows.	The BKP clearly states in the Executive Summary in the section "Key results" that: "The impact of the road was estimated to range between no effect and up to a 9.7% decline in the projected population size after 50 years", (compared to the no-road scenario). A similar statement is also presented in the first paragraph of the Conclusion to the report: "…this study has shown that the proposed highway upgrade near Wardell (Section 10) could cause a reduction of between 0-9.7% in projected population size over the next 50 years". Furthermore, the last paragraph of the Discussion states: "The proposed Pacific Highway Upgrade, by itself, is unlikely to contribute adversely to the viability of the Koala population near Wardell; the population is already in steady decline due to other factors (low breeding success, high mortality) and connectivity between the two sub-populations is not a big driver of (projected) population size".
13. The BKP is an important document in terms of informing further progress of the Section 10 upgrade. The commencement of Section 10 is conditional on the Minister's approval of the BKP. The BKP will only be approved if the impacts to the Ballina Koala population are demonstrated to be acceptable, as specified in	The BKP demonstrates that the impact of the road will be 'acceptable' (that is no worse than the population's trajectory without the road) provided that additional mitigation measures are implemented to benefit the population (See discussion at Sections 7.8-7.10).

condition 7 of the Minister's approval. Because of this, the BKP needs to not only be correctly informed, but also to have (ideally) fully explored all options that could realistically be enacted to minimise impacts on the local koala population. In my opinion and for reasons I detail in the paragraphs that follow, the BKP does not correctly inform considerations of impact on the local koala population and because it does not demonstrate that impacts on the Ballina Koala population are acceptable. Instead, the BKP attempts to accommodate the existing Section 10 alignment at the expense of the Ballina Koala population.	The BKP shows that 'saving' 4 animals per year through these additional measures would achieve this goal. The BKP (Section 6.4) references Dr Phillips who estimated annual mortalities within the population due to vehicle strikes at 4-6 animals per year. Dr Phillips observed 6 Koala mortalities caused by vehicle strike in the six months of his field study and at least 10 mortalities in 2015. RMS will also be undertaking dog control activities on its land. Current data (which are thought to be an underestimate due to under-reporting) suggest that at least 1.64 koalas are killed annually by dog predation. These data indicate that there are good prospects that fencing Koala hotspots to prevent road-kills, as well as undertaking dog control activities, can achieve the target of reducing mortalities by at least 4 animals per year. Attachment 2 of this document has been provided by RMS and includes all the mitigation measures proposed for Section 10, including the additional fencing proposed to reduce the mortality caused by vehicles and dogs. The PVA demonstrates that the impact of the proposed road is 'acceptable', on the basis that population projections are likely to be greater than the no-road scenario provided additional mitigation actions are put in place. .
14. Incongruities and/or errors in the supporting vegetation mapping used by the BKP are apparent between Figure 3 on page 6 and Table 3 on page 7 of the BKP. Specifically, examination of Figure 3 implies the presence of Paperbark, Heath, Sub-tropical and Warm Temperate Rainforest, Coastal Sands Blackbutt, Lowland Red Gum, Northern Open Grassy Blackbutt and Foothill Grey Gum -Ironbark - Spotted Gum vegetation 'types'. In contrast Table 3 details unrelated vegetation types that occur within the Section 10 clearing footprint that additionally include Blackbutt – Pink Bloodwood Shrubby Open Forests, Narrow-leaved Red Gum Woodlands, Scribbly Gum – Needlebark Heathy Open Forest and Swamp Mahogany Swamp Forest. In	Table 1 (not Table 3) on p. 7 of the BKP was based on the area (ha) of each Biometric Vegetation Type occurring within the clearing footprint of Section 10, as determined by Pellow and Semeniuk (2015) in their Australian Museum Consulting report to RMS. Fine-scale data using this vegetation classification system was not available for the remainder of the study area (~8,250 ha). However, a coarser-scale vegetation map was available based on other sources and this was presented in Figure 3 only to show the distribution and extent of the broad vegetation types occurring in the study area. <u>Note</u>: only the data reported by Pellow and Semeniuk (2015) were used in the PVA.

my opinion it is difficult – if not impossible - to make sense of the differences between these two pieces of information because one is presented as a map, the other as table, and neither makes reference to the other. While these incongruities may appear trivial because they relate to typological matters in the way that vegetation communities are described, the differences nonetheless serve to highlight a number of deficiencies in the logic underpinning the BKP for reasons I detail in paragraphs 15 – 17 below.	
15. Not all areas of native vegetation that are important to koalas are included in either Figure 3 on page 6 or in Table 3 on page 7; most notably 5 – 6 ha of Lowland Red Gum Woodland in the general area where the Section 10 alignment crosses Wardell Road. Importantly and as demonstrated in Figure 5.2 on page 46 of Appendix 1 of the BKP, this particular area not only supports a high-density, population of koalas but is also the only area along the Section 10 alignment where the eastern and western population cells comprising the important population are in direct contact. I have mapped the location of most of the Forest Red Gums that occur in this low-lying area, and more than 90% occur within the boundaries of the Section 10 highway corridor alignment (Figure 1).	It is unclear why both vegetation surveys (Table 1) and maps (Figure 3) failed to record the presence of Lowland Red Gum Woodland near the Section 10 alignment crossing of Wardell Road. One possibility is that Forest Red Gums may occur as isolated paddock trees in this area, and so would not be recorded as an intact vegetation community.Another possibility is that the Australian Museum Consulting report included these trees within the Narrow-leaved Red Gum Woodlands community type (which was not mapped) and, if so, the Red Gums referred to by Steve Phillips would have been taken into account in the PVA. RMS has provided me with the following information (see Table) about the likely impact of the route on the trees identified by Dr Phillips in his submission. Based on this information, 22% of these trees (and not 90%) will be removed clearing footprint of the road alignment. Whether this loss of Koala food trees results in a loss of habitat carrying capacity, or the loss of up to 14 Koalas, or both, has been re-modelled in Attachment 1 to this Addendum. All three of these alternative scenarios showed no significant differences from the results reported in the BKP. Furthermore, the sensitivity analyses undertaken as part of the PVA (see Figures 10 and 11) demonstrated that the PVA results were quite robust to any variations in the input values that would be required under the conditions referred to by Dr Phillips.

<table>
<tr>
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<tr><th>Location</th><th>No. of key food trees identified by Dr Phillips</th><th>No. of identified trees that will be removed under current design</th></tr>
<tr><td>Laws Point</td><td>70</td><td>12</td></tr>
<tr><td>Jali Land</td><td>12</td><td>2</td></tr>
<tr><td>Wardell Road</td><td>43</td><td>14</td></tr>
</table>
</td>
</tr>
<tr>
<td>16. The BKP considers that only 17 ha of ‘good’ koala habitat will be lost (2nd paragraph on page 18 of BKP). In a subsequent e-mail communication with Dr. Kavanagh dated 29/02/2016, he advised that in his opinion ‘good’ habitat comprised the 8.94 ha of Narrow-leaved Red Gum Woodlands, 2.12 ha of Swamp Mahogany Swamp Forest and 5.96 ha of Paperbark Swamp Forest (Table 3 on page 7), based on the presence in these communities of koala food trees. However, there are 5.38 ha of Blackbutt – Pink Bloodwood Shrubby Open Forest and 3. 6 ha of Blackbutt Grassy Open Forest along the Section 10 alignment (Table 3 on page 7), both of which contain the koala food tree species Tallowwood (Eucalyptus microcorys), the presence of which has neither been recognised nor taken into account as ‘good’ habitat by Dr. Kavanagh’s calculations. In common with Forest Red Gum, Tallowwood is distributed patchily along the Section 10 alignment. Figure 2 illustrates the distribution of individual Tallowwoods and other food tree species that currently support the southern koala population cell on the Melino and Lawes properties. Importantly, the distribution of Tallowwood in this instance remains localised and does not reoccur again for several hundred meters to the north.</td>
<td>This level of resolution, i.e. down to the mapping of individual trees, only became available after the PVA was completed.

I agree that Blackbutt-Pink Bloodwood Shrubby Open Forest (5.38 ha) and Blackbutt Grassy Open Forest (3.6 ha) do contain some Tallowwood trees, although these are not a major component of these two vegetation communities. However, assuming that these two vegetation communities are significant to Koalas, the total area of Koala habitat within the Section 10 clearing footprint that would be lost would be 26 ha, not 17 ha as modelled.
The implications of this change have been re-modelled and found to have no influence on the projected population outcome after 50 years (see below for further discussion on this point, and Attachment 1 to this Addendum).</td>
</tr>
<tr>
<td>17. Using “no. koalas displaced = ha of ‘good’ habitat*0.63/2”, and Dr. Kavanagh’s understanding of the</td>
<td>Using this formula, the estimated number of Koalas that would be displaced if 26 ha of good habitat is cleared, rather than the 17 ha (i.e. 5 animals)</td>
</tr>
</table>

amount of 'good' habitat to be lost, the BKP identifies the area as likely supporting no more than 5 koalas. It follows that the need to add a further 5.38 ha of Blackbutt – Pink Bloodwood Shrubby Open Forest, 3.6 ha of Blackbutt Grassy Open Forest and 5 – 6 ha of unmapped lowland red gum woodland – all of which contains koala food trees - would mean that 31-32 ha (not 17 ha) of 'good' habitat will be lost during the construction process. Using the same formula adopted by the BKP (i.e. *no. koalas displaced = ha of 'good' habitat*0.63/2*) this implies that at least 10 (not 5) koalas would potentially be displaced. However, and while the increased number in this instance remains an approximation by coincidence, in my opinion even this figure underestimates the likely numbers of animals to be displaced, the basis of which I detail in the following paragraph.	modelled in the PVA, is 8.2 animals (26/2 * 0.63), an increase of approximately 3 Koalas. As discussed in my response to Point 15 above, the report by Pellow and Semeniuk (2015) did not identify the additional 5-6 ha of unmapped Lowland Red Gum Woodland. However, assuming that Dr Phillips is correct, the total area of Koala habitat that would be affected could be as large as 32 ha. If so, the estimated number of Koalas that would be displaced is 10 animals (32/2 * 0.63) As above, the implications of this change have been re-modelled and found to have no influence on the projected population outcome after 50 years (see below for further discussion on this point, and Attachment 1 to this Addendum).
18. The precise locations and extent of habitat occupied by koalas along the Section 10 alignment is indicated in Figure 5.2 of on page 46 of Appendix 1 of the BKP. In my opinion, Figure 5.2 enables a more accurate understanding of where the 'good' habitat is because it unambiguously illustrates the extent of habitat along the Section 10 alignment that is actually being utilised by koalas. Figure 5.2 can be used to accurately estimate the numbers of koalas to be displaced by way of firstly determining the total length of the areas of occupied habitat (i.e. mapped and unmapped areas of vegetation including largely cleared land with scattered trees) contained within the Section 10 alignment by measuring the linear distance between the 7% koala activity contours, ~ 3,500 m. Secondly, multiplying this distance by the approximate width of the habitat to be lost/impacted which I would estimate to approximate 50 m either side of the centre of the road alignment, to derive the number of hectares of 'good' habitat. In	I didn't quite follow the argument here, but I understand that the impact is now asserted to affect the habitat for up to 12 Koalas which would be displaced. As above, the implications of this change have been re-modelled and found to have no influence on the projected population outcome after 50 years (see below for further discussion on this point, and Attachment 1 to this Addendum). Indeed, the "worst case" of 14 Koalas being displaced has been re-modelled. This was done in three ways: i) Assuming that the habitat is lost for 14 Koalas (modelled by reducing the habitat carrying capacity by 14 animals in each year for 50 years) ii) Assuming that the initial size of the Koala population in the study area is reduced by 14 animals (i.e. from 236 to 222 animals) iii) Assuming that <u>both</u> i) and ii) occur (i.e. that both population size and carrying capacity is reduced). In all three scenarios, the projected population size after 50 years was almost identical to the PVA results reported in the BKP – that is, these concerns had no effect on the PVA outcomes for this population.

determining this width I am mindful that this would be the minimum area from within which koalas would be captured for purposes of any translocation event. The result of these calculations indicates that ~ 35 ha of habitat actively being utilised by koalas occurs along the Section 10 alignment. Taking the same approach as that taken by the BKP (i.e. multiply 35 ha by 0.63/2) results in an estimate of 11 koalas that will be displaced, concordant with the 10 – 14 koalas originally recommended in Appendix 1 of the BKP. In my opinion however, the 0.63/2 'rule' adopted by the BKP underestimates the true koala density in these occupied areas which I would estimate to be between 0.42 and 0.63 koalas ha-1 based on other studies I have undertaken in similar habitat types (refer paragraph 26 below). The use of these density estimates implies that between 15 and 22 koalas could be displaced. For the purposes of what follows however, I have used the value of 12 displaced koalas, this number representing the mid point of the 10 – 14 range recommended in Appendix 1 of the BKP.	
19. In order for the potential impacts arising from the displacement of 12 koalas to be properly understood it is important that they be factored in at the appropriate point in the PVA timeline, i.e. when displacement occurs. In my opinion it is not appropriate to subtract the number of displaced koalas from the number of koalas that are speculated to be occupying the replanted habitat areas 7 – 15 years *post* impact as has been done by the BKP. This is simply because the longer-term implications arising from the loss of some or all of these displaced koalas can not be understood if the corresponding influence of the loss of the reproductive output from these animals over the 50 year time frame of the PVA has been incorrectly accommodated. In this case, the assumptions made mean that that the PVA does not recognise a reduced	This is a misunderstanding of the way in which the PVA was performed. The reduction in carrying capacity (by 5 displaced animals) was implemented before (i.e. between initial clearing and year 6) the carrying capacity was increased gradually beyond year 7, up to year 15, when the 130 ha of planted Koala food trees was estimated to be fully utilised. As described above, the displacement and/or loss of 14 Koalas was re-modelled (without the benefit of supply of 130 ha of new habitat after year 7). The concerns expressed opposite were found to have no significant influence on the projected population outcome after 50 years.

reproductive output over the entire time frame of the PVA, because the displacement was not considered to have occurred in the first few years of the project. Given that a minimum of 12 koalas will be displaced during the initial stage (first year) of construction, but even if it was only 5, I would have expected the PVA to examine how this potential loss could have been minimised.	
20. Moreover and in addition to the displacement and death of some or all of the 12 koalas displaced by habitat loss arising from the construction process, there is also the possibility that the two population 'cells' with which these animals are associated (Figures 1 and 2 above refer) may break down as a direct consequence of habitat loss and/or reduction in carrying capacity population, i.e. they will no longer be an effective reproducing population. This possibility is compounded by indirect impacts arising from the noise of construction activities and the reduced recruitment opportunities that will result over the course of the construction, thus extending the scale of potential impact in a worst-case scenario. Precedents for such population breakdowns have already been documented by Phillips (2000), most notably for the Tucki area near Lismore to the west of the study area that is the focus of the BKP.	As described above, the displacement and/or loss of 14 Koalas was re-modelled and found to have no significant influence on the projected population outcome after 50 years. Parameterisation of the social, behavioural and demographic processes that might eventuate from disruption of these two population 'cells' is not possible in Vortex, and the data required to understand the relationships between these factors and demographic rates are not available to my knowledge. In my opinion, too much weight is given in the comments opposite about potentially disruptive effects on population 'cells'. Koalas are polygynous animals that generally do not live in tight, family groups as implied.
21. In my opinion there is a strong likelihood that the event(s) forecast in paragraph 20 above could happen because of the localised nature and distribution of the food resources in the two populations that will be directly impacted, especially given that more than 50% of the food resource available to both populations will be lost through the road construction process. At the very least this will result in a commensurate reduction in the koala carrying capacity of the areas so affected, creating the potential for a dissolution event. For PVA purposes this consideration will impact more severely on the population that will	The loss in carrying capacity that will result from habitat loss was factored into the PVA (see also the sensitivity test results reported in Figure 11 of the BKP). The potential loss of animals was also factored into the PVA, as shown in the sensitivity test results reported in Figure 10 of the BKP, and subsequently confirmed by the results of the re-modelling exercise described above.

remain on the eastern side of the alignment *post* construction because of the lesser number of animals that will remain in this area.	
22. In my opinion the scale of the potential impacts I have described in preceding paragraphs can now be more clearly understood and thus provide the underlying impetus for the PVA analysis, ideally on the basis of worst-case scenario outcomes. Impacts of the Section 10 project can therefore be summarised as follows: i) The further fragmentation of an existing area of important koala habitat known to currently be sustaining a nationally significant koala population, ii) The loss of ~ 90 ha of koala habitat, nearly 40% of which is known to be supporting resident koala populations that are component elements of small and compromised but still viable, koala meta-population of approximately 196 adult koalas, iii) Within the nearly 40% of occupied habit now known to occur along the route, the direct loss through habitat removal required for construction purposes of more than 50% of the preferred food tree resource being mature specimens of the preferentially selected food tree species Swamp Mahogany (*Eucalyptus robusta*), Tallowwood (*E. microcorys*) and Forest Red Gum (*E. tereticornis*) from those otherwise available to the larger population, iv) As a direct consequence of iii) above, the displacement of at least 10 – 14 adult koalas (or 5% - 7% of 2014 Important Population Focal Area (IPFA) population estimate of 196 adult animals) from the areas so affected (best case scenario), v) As a possible and foreseeable direct consequence of iv) above the further loss over ensuing years of the population cells so affected because of a) the lowered carrying capacity of the immediate environment and b) the small numbers of koalas that will be left outside of the cleared areas (worst case scenario), vi) Disturbance arising from the presence of heavy machinery and associated	Several of these points have already been addressed above (i.e. the loss of up to 32 ha of Koala habitat, and the "worst-case" scenario in which up to 14 animals could be lost) and shown to have no significant influence on the projected population outcome after 50 years. It is not clear in (ii) where the figure of 90 ha of lost habitat comes from. Regarding (vi), disturbance due to noise and construction activity could have an impact, but it is unclear how this could be represented in the PVA through impacts on demographic rates. Accordingly, any effects of noise and construction activity were not incorporated in the PVA. Regarding (vii), it is unclear where the reduction of more than 90% of recruitment and dispersal comes from. The historical rate of dispersal in this Koala population were quantified by two studies of the genetics of this population (Appendix 2 of the Ballina Koala Plan). Sensitivity tests of the impact of the proposed highway upgrade were undertaken in relation to uncertainty in the estimates of demographic parameters, including dispersal (see Table 10). These results showed that dispersal rate had very little influence on PVA population projections over 50 years in this declining Koala population.

construction activity and noise along the length of the Section 10 upgrade for a period of approximately 3 years while the road is constructed, and vii) A reduction of more than 90% in the koala recruitment/dispersal opportunities along the length of the Section 10 Pacific Highway upgrade to which the BKP relates.	
23. The current PVA-projected koala population trend over the 50 year time frame in the absence of the highway upgrade (i.e. the status quo) is illustrated on Figure 6 on page 29 of the BKP. The implications of this PVA are that while in steep decline trajectory, the IPFA population of 39 koalas remaining alive at the end of the 50 year time frame. This is presented as a minimal risk of extinction simply because extinction is defined as only one sex remaining. Dr. Kavanagh and I have reached agreement on how that 39 animals has been calculated but this outcome in terms of numbers remains greater than what I consider to be a more pragmatic outcome based on two main differences of opinion between us. The first and lesser of these differences relates to my concern that the impacts of the two catastrophes 'Drought' and 'Fire' have been underestimated by calculations in the BKP, the second and more significant being the matter of gender allocation in the 0 – 1 age class cohort, the BKP allocating a disproportionately greater number of females in accord with the sex ratio bias detected in the adult population, whereas I consider that the sex ratio should be 50:50 in the youngest cohort. For PVA purposes these differences of opinion regarding the sex ratio of juveniles in the youngest cohort amount to approximately 18 animals over the 50 year time frame of the PVA (Figure 3), the primary distinguishing feature between the two being the lower number of females. Interestingly, this outwardly subtle difference results in the predicted Probability of Extinction increasing from zero in terms of the BKP baseline 'no road' modelling to	The sex ratio issue appears to be a misunderstanding. The PVA did assume a 50:50 sex ratio in the 0-1 year age cohort. We have very little data on the frequencies of droughts and fires in the study area, and the impacts of these on the demographics of the Koala population. The information used in the PVA was taken directly from the estimates provided in the report by Phillips et al. (2015) – see Appendix 1 of the BKP.

31% for the alternative which I consider to be the more correct gender allocation (Figure 4).	
24. For reasons which are unclear the BKP (page 30) seeks to portray the value of the baseline input data as a ‘snapshot’ of the population, the underlying interpretation being that it is of diminished value in terms of informing the PVA process. Such an imputation is incorrect, the data collected in fact represents the influence of various factors that have been driving population structure and dynamics over a minimum period of at least the preceding 10 years, this being measureable as the difference between the age of youngest animal observed during the survey program (i.e. small pouch-young) and the oldest – a male in Tooth Wear Class 6 that we estimated to be 10+ years of age. Moreover, the SDEV (Standard Deviation of input parameter due to environmental variation) values recommended for use in the PVA process were modified in response to discussions with Dr. Rhodes using the 26 years of mortality data derived from the FoK database. As such, and within the central tendency measures associated with the sample sizes in each instance, the baseline input parameters are considered to represent a chronologically robust profile of population structure that accurately reflects historical considerations for PVA purposes.	The demographic information for this study was based on a “snapshot” sample of 50 animals that was collected over several months in late 2014/ early 2015. That is fine, given that long-term data sets are unavailable, however, I was simply pointing out that these data do not provide any information about the long-term variability in annual reproductive rates and mortality rates for this population. Sensitivity testing showed that estimates for these variables were very influential in the PVA results and that long-term data collection (i.e. population snapshots in each of several additional years) would have given improved confidence in the population projections. It is not clear to me what the point is here in terms of how the PVA was applied, given the data limitations that are recognised.
25. Again, given that the currently envisaged alignment for Section 10 is located in almost the worst possible area for koalas I would have expected the PVA to model alternative scenarios in order to make the impacts on the Ballina Koala population more acceptable, and to then promote means by which potential impacts could be confidently (as opposed to speculatively) minimised, aspects of which might have included such considerations as adjustments to alignment in order to avoid direct impacts on known population cells. To illustrate this point	Other road alignments were not considered in the PVA because these were not proposed by the RMS. The role of the PVA was to estimate the impact of the activities proposed by RMS.

one of several alternative scenarios is illustrated in Figure 5 below. In my opinion, this scenario avoids all of the key population cells and therefore has minimal impact on the population as a whole, the end result of which is a defendable and arguably acceptable impact. In not having considered alternatives such as this, the BKP has failed in terms of delivering acceptable outcomes as specified in condition 7 of the Minister's conditional approval.	
Avoidance & mitigation measures to minimise impacts is a specific requirement of condition 7	
26. Maximising connectivity options to facilitate ongoing processes of dispersal and recruitment is a necessary and important consideration to minimise impact but is not in its own right a panacea to the longer term consequences of fragmentation brought about by linear infra-structure. The BKP promotes provision of 26 connectivity structures as a positive outcome of highway upgrade process (page 21), in support of which it offers koala density/home range data derived from work undertaken by Dr. Kavanagh and his colleagues (i.e. Kavanagh *et al*. 2007) in the Box woodlands of the Pilliga Scrub in central western NSW. In reality koala densities in the nearly 40% of occupied habitat along the Section 10 alignment will be much higher (0.42 – 0.63 koalas ha-1) than that posited by the BKP. This knowledge – which can be substantiated by reference to work undertaken on behalf of RMS by my company in association with the Oxley Highway upgrade to the west of Port Macquarie in coastal NSW (Biolink Ecological Consultants 2010) - necessitates a connectivity structure every 100 – 150 m rather than every 437 m as proposed by the BKP. In my opinion spacings of 100 – 150 m between connectivity structures are the minimum necessary to enable recruitment and dispersal opportunities to be optimized and/or maintained in those areas along the Section 10 alignment that are	There is almost no data available on the effectiveness of connectivity structures for Koalas at the population level. Therefore, the critique here essentially represents a difference of opinion. The assumptions made in the PVA around the effectiveness of the connectivity structures were agreed on at the workshop of experts prior to the finalisation of the PVA. The PVA was informed by the two genetics studies which showed that, historically, the rate of dispersal between the two sub-populations, which are nominally separated by the proposed road alignment, was approximately 4 animals per year. It is a matter of opinion that the 90-135 connectivity structures required by Dr Phillips would be necessary to achieve this (low) rate of dispersal, rather than the 26 connectivity structures that have been proposed by RMS for Section 10. Moreover, the connectivity structures have been regularly-spaced along the proposed new road such that they provide crossing and dispersal opportunities for most animals living near the Section 10 alignment (see Figure 4 of the Ballina Koala Plan).

currently supporting resident koala populations. Because such spacings are not proposed by the BKP, it is my opinion that opportunities for dispersal and recruitment will be significantly compromised if not negated altogether. This is a primary concern given the need for recruitment to the smaller numbers of koalas (< 50) that will remain on the eastern side of the Section 10 upgrade should it proceed as envisaged.	
27. The BKP considers that the potential loss of koalas as a direct consequence of road construction can be accommodated by adjusting a hypothetical increase in the population as a consequence of a revegetation strategy involving the planting of 130 ha of land. The BKP predicts that this will support 46 animals but is reduced to accommodate a worst case scenario in which all 5 of incorrectly calculated 5 displaced animals die. This strategy ignores the fact that sensitivity analysis in the BKP (Figure 11 on page 33) demonstrates that increasing the carrying capacity makes no difference to population over the 50 years timeframe of the PVA because the current mortality rates driving population decline, specifically vehicle-strike and domestic dog attack - are greater than the population's inherent capacity to sustain them.	There seems to be a misunderstanding here. There is no assumption in the PVA about an increase in the Koala population as a consequence of the revegetation strategy. There is only an assumption that the carrying capacity increases (by 41, not 46). This does not mean that the Koala population will increase; in fact, if the Koala population continues to decline (which it does under most scenarios), the increase in carrying capacity as a result of the revegetation will have almost no effect on the population size.
28. Appendix 1 of the BKP proposed that changes in carrying capacity should not be considered for PVA purposes. This was because there are ongoing impacts across the IPFA associated with Private Native Forestry activities that, amongst other things, target the preferred koala food tree species Tallowwood, while removal of Tallowwood dominated windrows is also ongoing and further contributes to incremental loss of habitat and reduced carrying capacity. Regardless of ongoing losses elsewhere, the BKP promoted the replanting of 130 ha of habitat as a means of progressively raising the carrying capacity of the IPFA over a	These issues have been largely addressed in my previous response. That is, the current population trajectory is one which is in steady decline. Regardless of any significant changes in carrying capacity, this population is likely to continue to decline unless the key limiting factors (i.e. low reproductive rate, high mortality rate) are addressed (see Figure 11 in the BKP). Changes in carrying capacity were modelled firstly by accounting for the loss of habitat as a result of road construction activities, then by accounting for the likely increase that may result following the establishment of 130 ha of new Koala habitat. As indicated above, these and other changes in carrying capacity are likely to be relatively unimportant while current demographic rates apply.

15 year period to effectively accommodate additional koalas after subtracting those that were presumed to have died as a consequence of displacement. Aside from underestimating the numbers of koalas to be displaced, there are a number of problems associated with this line of reasoning that warrant its rejection as a mitigating factor as follows: - Promotion of the 130 ha does not take into account habitat that will be removed as a direct consequence of road construction, nor the ongoing losses and/or modifications referred to above. - Even were it to occur, the calculation presumes a koala density/carrying capacity of 0.32 koalas within the planted out areas within the 15 year time frame. This begs the question as to where these animals are going to materialise from given an already declining population and that there are already large areas of high carrying-capacity habitat that are unoccupied.	
29. The BKP proposes to increase the fecundity of female koalas by 20% by alluding to the use of a vaccine to supposedly diminish the risks of disease and its capacity to reduce reproductive output. Justification for this measure is premised on the argument that the numbers of females breeding each year (i.e. 44.83% of all females in TWC 3 – 5) is too low. In my opinion there are two reasons as to why this measure should be rejected; firstly, the rate of clinical expression of disease in the IPFA koala population was deemed by the study contained in Appendix 1 of the BKP to be low, while secondly the numbers of females breeding annually is also within the optimal range for this species (i.e. ~ 50% of females reproducing on an annual basis). In short, there is no justification for a vaccination program to increase reproductive output when the population does not need it and factors such as vehicle-strike and domestic dog attack, not disease, continue to be the primary drivers of	This is a misunderstanding. The PVA investigated the likely population response if fecundity could be increased by a nominal 20%. This was because breeding success was identified as a key limiting factor in this population and we wanted to understand the potential response that might result if breeding success could be increased. No justification for a disease vaccination program was provided, nor was it specifically recommended. However, we noted that preliminary work on this subject is underway in Queensland and that further investigation of its relevance and application to this Koala population may be warranted. While the Phillips et al. (2015) report (Appendix 1 of the BKP) found little clinical evidence of disease in this population, it my understanding that further laboratory analysis of the swabs collected from these animals indicated a greater underlying prevalence of Chlamydia than expected. I agree that avoidable mortality, such as vehicle strike and domestic dog attack, should be the priority to address through more determined and focused management efforts. However, I do not believe that population fecundity of 44.83% is near ‘optimal’, and that we as a community should

the decline trajectory.	consider any option that may lead to an improvement in this most influential parameter for population recovery.
30. Translocation of displaced koalas has been mooted as a means of maximizing the survival potential of affected koalas and so reducing the risk of disruption at the local population level. While translocation has been very successfully employed in instances such as the Oxley Highway upgrade to the west of Port Macquarie, the translocation of koalas from within occupied habitat areas along the envisaged Section 10 alignment presents some novel and unique challenges if it is to be undertaken successfully, including the need (in order to maintain the longer-term viability of the population cells from which they have been removed) to translocate the displaced koalas into immediately adjoining areas of habitat rather than habitat located several kilometers away. Without further development of the means by which this could be enacted there is no guarantee that this will be able to be achieved.	I agree. The proposed re-location program does need to be considered carefully. However, it is important to note that the findings of the PVA are quite robust to potential losses and do not depend on the success of the proposed re-location program. It is the role of Koala Management Plan, not the BKP, to assess whether the re-location program is justified and, if so, how it will be undertaken.
31. The BKP correctly alludes to a need to reduce the current mortality rate caused by vehicle-strike and domestic dog attack if the decline is to be halted and the population placed on a more sustainable long-term footing. However, no practical guidance as to how such urgently required reductions are to be realised has been proposed. In my opinion and additional to those concerns already expressed herein, this is a serious failing of the BKP which requires urgent rectification if the proposed objective is to be given any merit.	The BKP established that additional mitigation measures which have the effect of reducing Koala mortality by at least 4 koalas per year is required (in addition to what is proposed for Section 10) for the impact of the road to be considered acceptable (Table 10). 'Acceptable' impact is interpreted by the BKP as no predicted impact on Koala numbers after 50 years compared to projections without the road. The BKP estimates the population response if management can achieve the target of reducing Koala mortality by 4 or 8 animals per year. Given the distribution of known road-kill hotspots in the study area, and the numbers of animals that are killed by vehicle strikes each year, there is potential for RMS to achieve these targets, especially if predation by domestic dogs can also be reduced. Practical guidance on how the reductions in Koala mortality will be achieved will be detailed in the Koala Management Plan. RMS has confirmed the management measures that will be put in place for this Section and on local roads, as well as the dog control activities that will

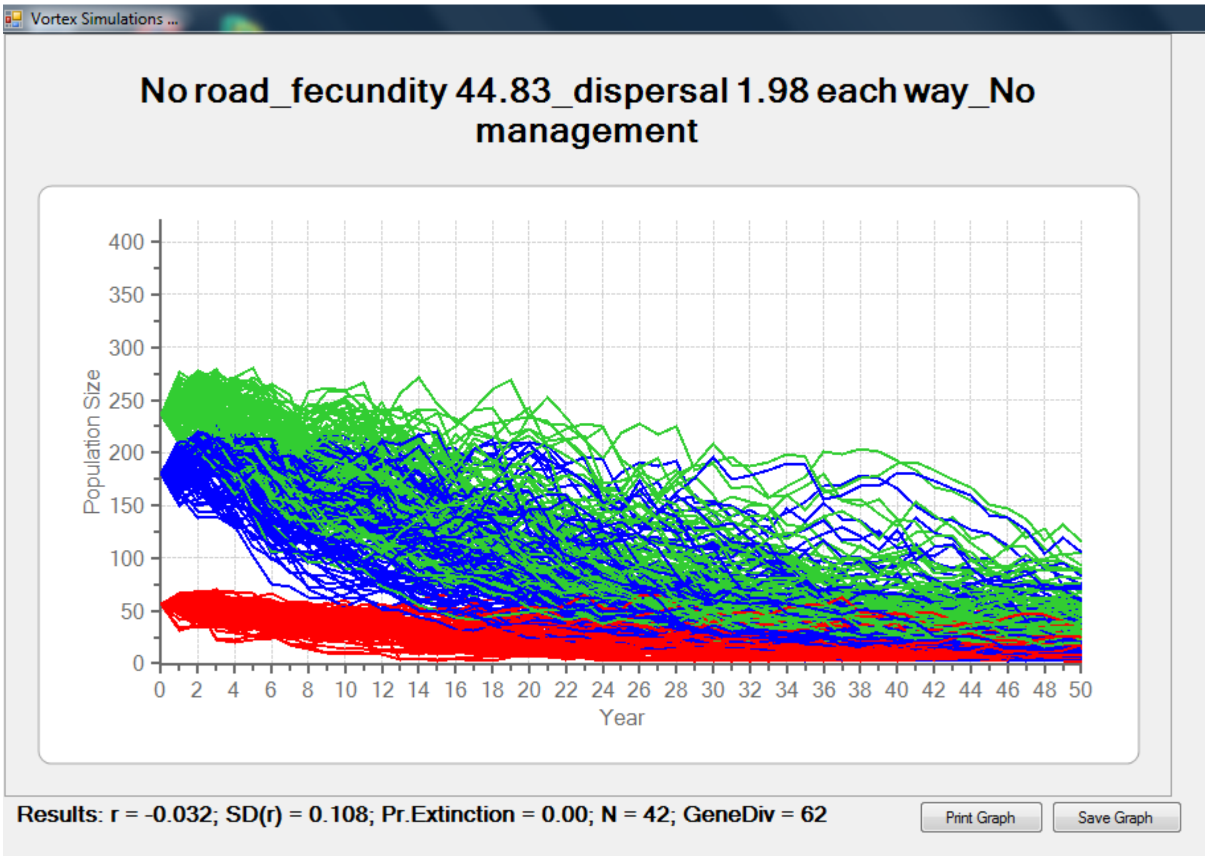
	take place on RMS-owned land (see Attachment 2.
32. In my opinion the BKP has not adequately explored the full gamut of management responses and associated actions that will be required to ensure that a minimal impact upon koalas has resulted. Because of this it is also my opinion that the BKP has failed to demonstrate that the impacts will be acceptable as required by condition 7 of the Minister's approval. Instead it puts the existing Section 10 alignment ahead of the need to provide a more demonstrably sustainable koala management outcome. In so doing the BKP has significantly underestimated the numbers of koalas to initially be displaced by the construction process, as well as compromised the longer-term viability of the two primary koala population cells that currently occupy the envisaged alignment. Factors that will contribute to the dissolution of these two population cells include the immediate loss of food resource and a commensurate lowering of carrying capacity, social disruption and disturbance during the course of road construction, as well as the creation of barriers that will impede recruitment and dispersal processes.	It is not the role of the BKP to define 'acceptibility', only to estimate the likely impact of the proposed road, and this has been done. The Minister's approval requires that the impacts to the Ballina Koala population by the proposed road are demonstrated to be 'acceptable'. No definition of 'acceptable impact' is provided in the Conditions of Consent for this project. However, we have interpreted this to mean 'no impact' or 'no worse' than the status quo. The PVA has shown that the proposed new road could cause a small reduction in projected population size over the next 50 years, however this small impact could be compensated by the provision of a range of mitigation and other management actions. The displacement and/or loss of 14 Koalas was re-modelled and found to have no significant influence on the projected population outcome after 50 years.
33. I have made all the inquiries that I believe are desirable and appropriate and that no matters of significance that I regard as relevant have, to my knowledge, been withheld.	

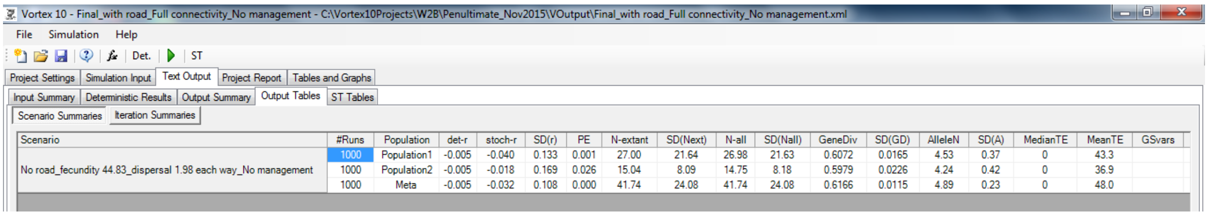
Re-run of Vortex models – 1 May 2016

1. Test of method for implementing dispersal: numbers versus percentages

   A. Implementation of dispersal as a fixed number (1.98) each way per year

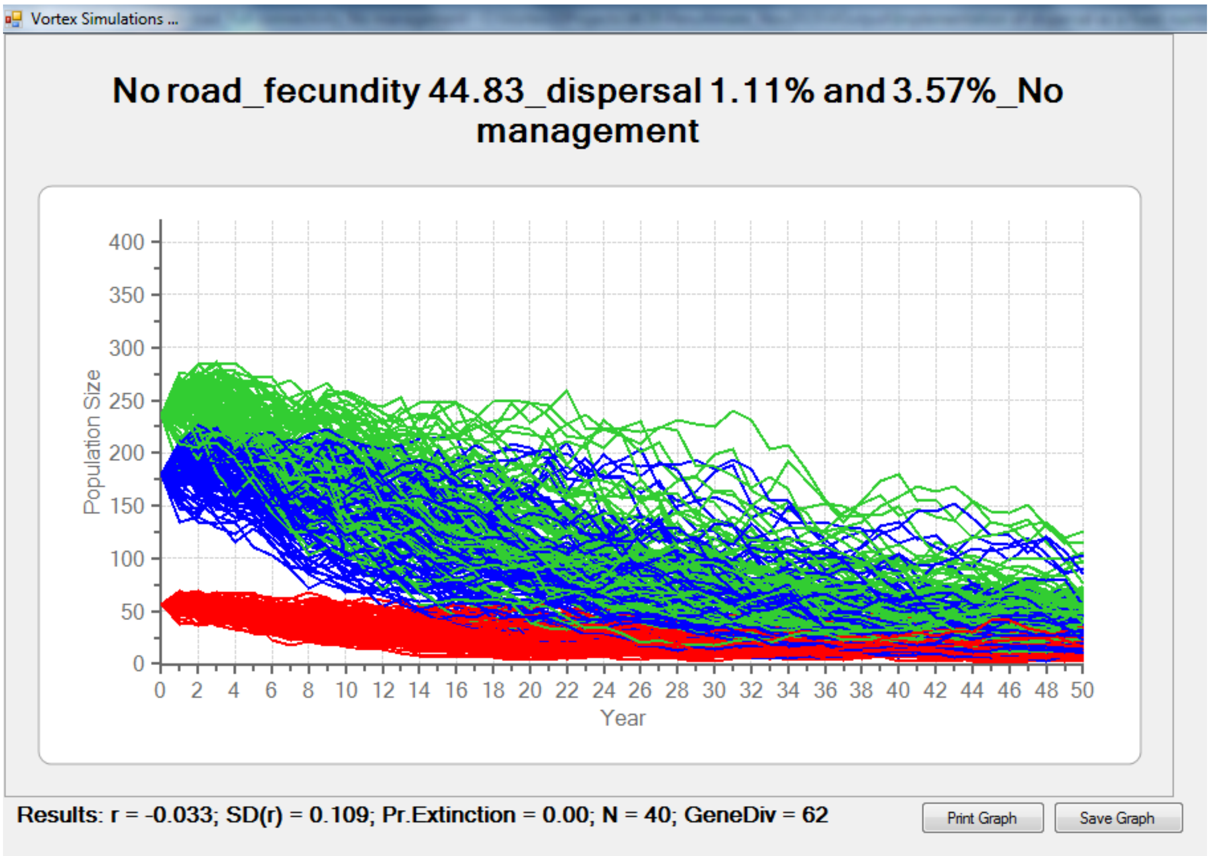
      Duplication of Row 3 model in Table 4 of PVA report (Vortex version 10.0.7.3)

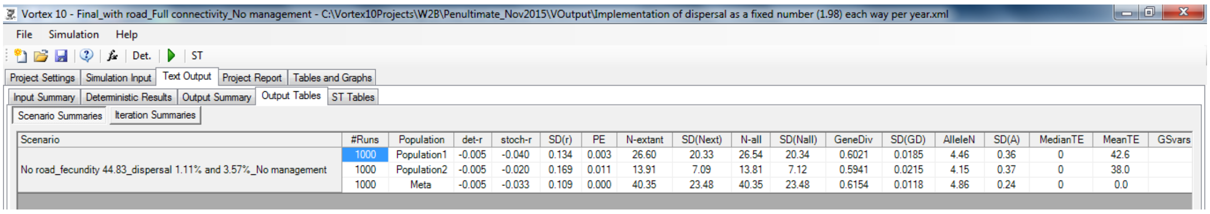




Scenario	#Runs	Population	det-r	stoch-r	SD(r)	PE	N-extant	SD(Next)	N-all	SD(Nall)	GeneDiv	SD(GD)	AlleleN	SD(A)	MedianTE	MeanTE	GSvars
No road_fecundity 44.83_dispersal 1.98 each way_No management	1000	Population1	-0.005	-0.040	0.133	0.001	27.00	21.64	26.98	21.63	0.6072	0.0165	4.53	0.37	0	43.3	
	1000	Population2	-0.005	-0.018	0.169	0.026	15.04	8.09	14.75	8.18	0.5979	0.0226	4.24	0.42	0	36.9	
	1000	Meta	-0.005	-0.032	0.108	0.000	41.74	24.08	41.74	24.08	0.6166	0.0115	4.89	0.23	0	48.0	

B. Implementation of dispersal as an equivalent percentage at year 1 (i.e. 2 animals each way in year 1 expressed as 1.11%/year from west to east and 3.57%/year from east to west, with these same percentages applied in each of the following years).




Vortex 10 - Final_with road_Full connectivity_No management - C:\Vortex10Projects\W2B\Penultimate_Nov2015\VOutput\Implementation of dispersal as a fixed number (1.98) each way per year.xml

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Scenario Summaries | Iteration Summaries

Scenario	#Runs	Population	det-r	stoch-r	SD(r)	PE	N-extant	SD(Next)	N-all	SD(Nall)	GeneDiv	SD(GD)	AlleleN	SD(A)	MedianTE	MeanTE	GSvars
No road_fecundity 44.83_dispersal 1.11% and 3.57%_No management	1000	Population1	-0.005	-0.040	0.134	0.003	26.60	20.33	26.54	20.34	0.6021	0.0185	4.46	0.36	0	42.6	
	1000	Population2	-0.005	-0.020	0.169	0.011	13.91	7.09	13.81	7.12	0.5941	0.0215	4.15	0.37	0	38.0	
	1000	Meta	-0.005	-0.033	0.109	0.000	40.35	23.48	40.35	23.48	0.6154	0.0118	4.86	0.24	0	0.0	

Test of method for implementing dispersal: numbers versus percentages

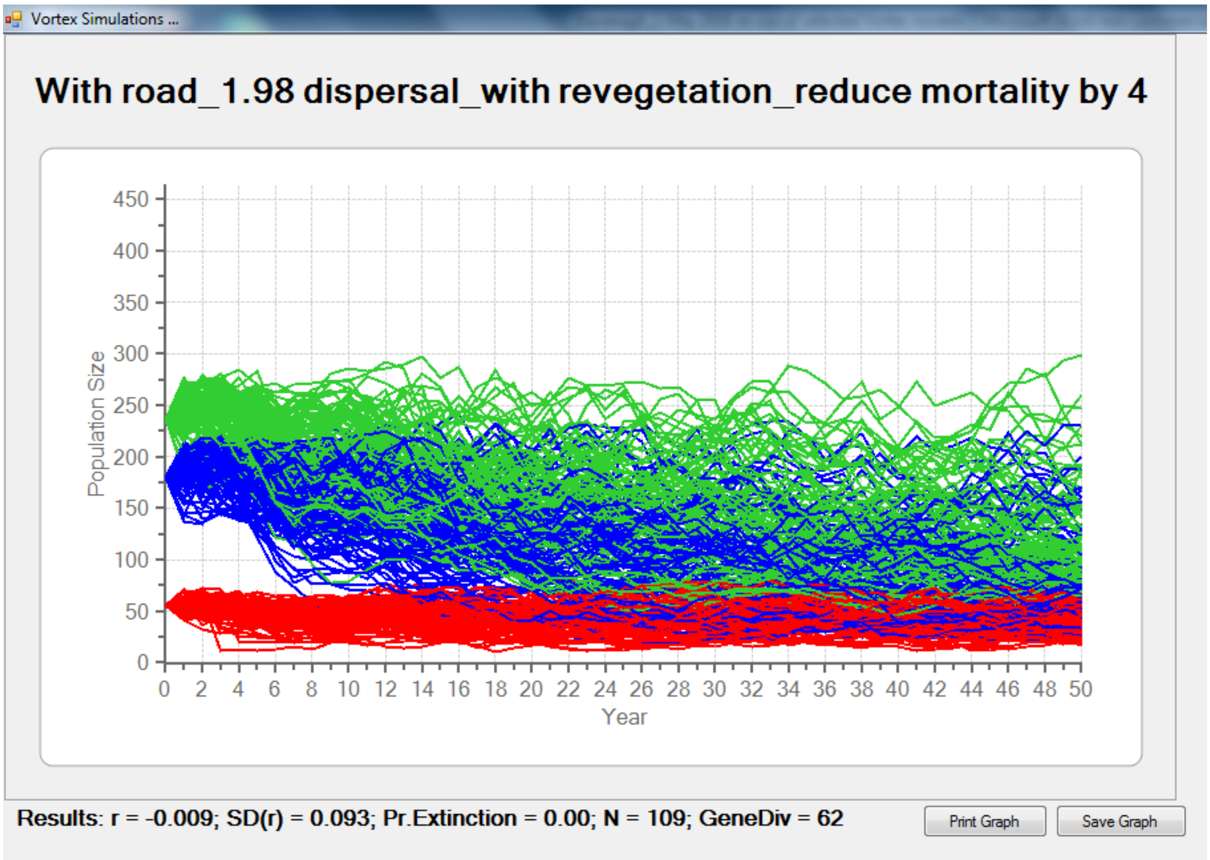
Summary: very similar results

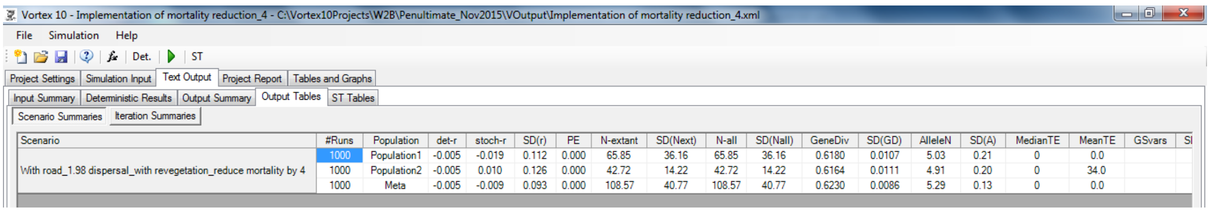
Scenarios	Population P(E)	Population N	Western sub-Pop P(E)	Western sub-Pop N	Eastern sub-Pop P(E)	Eastern sub-Pop N
Two sub-populations, with dispersal 1.98 animals each way per year (100% connectivity) **i.e. BASIC NO-ROAD SCENARIO**	0.00	41.7	0.00	27.0	0.03	15.0
Two sub-populations, with dispersal set as an equivalent percentage at year 1 (100% connectivity) **i.e. BASIC NO ROAD SCENARIO**	0.00	40.4	0.00	26.6	0.01	13.9

2. Test of method for implementing management to limit mortality: reducing emigration/increasing immigration into the study area versus reducing the percentage mortality for young animals in the population.

   A. Implementation of mortality reduction by increasing immigration and eliminating emigration from the study area

   Duplication of the Row 1 model in Table 9 of PVA report (Vortex version 10.0.7.3)





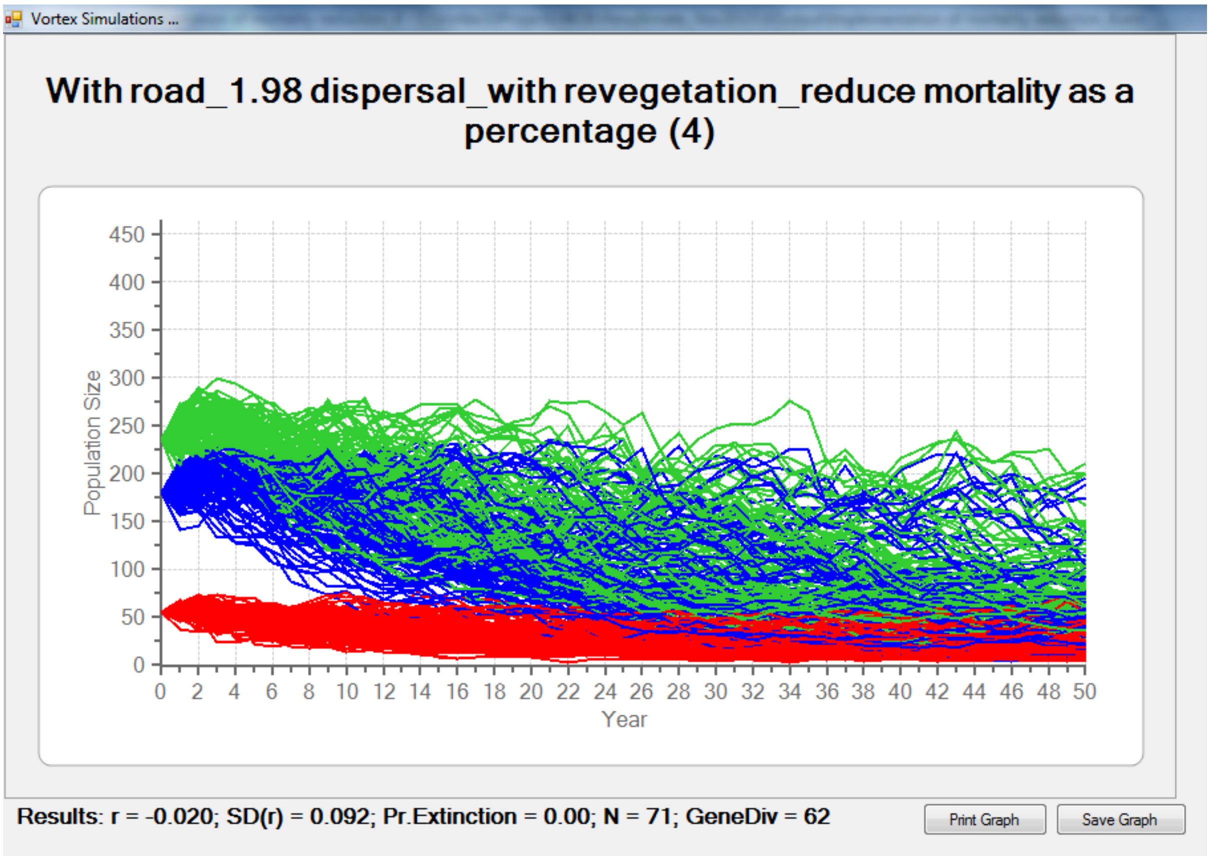
Scenario	#Runs	Population	det-r	stoch-r	SD(r)	PE	N-extant	SD(Next)	N-all	SD(Nall)	GeneDiv	SD(GD)	AlleleN	SD(A)	MedianTE	MeanTE	GSvars	SI
With road_1.98 dispersal_with revegetation_reduce mortality by 4	1000	Population1	-0.005	-0.019	0.112	0.000	65.85	36.16	65.85	36.16	0.6180	0.0107	5.03	0.21	0	0.0		
	1000	Population2	-0.005	0.010	0.126	0.000	42.72	14.22	42.72	14.22	0.6164	0.0111	4.91	0.20	0	34.0		
	1000	Meta	-0.005	-0.009	0.093	0.000	108.57	40.77	108.57	40.77	0.6230	0.0086	5.29	0.13	0	0.0		

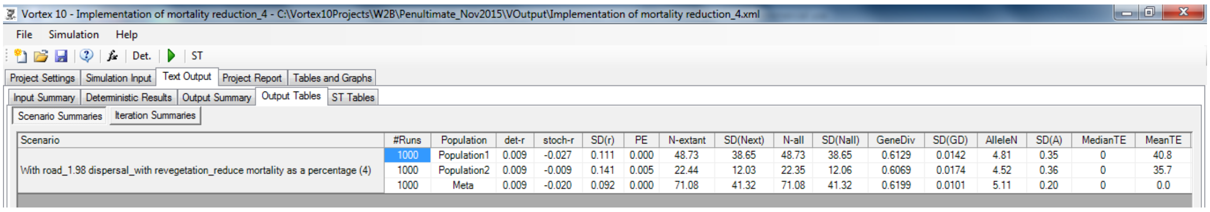
B. Implementation of mortality reduction by reducing the percentage mortality of young dispersing-aged animals in year 1 by an amount that would result in an increase of either 4 or 8 animals, and applying this mortality rate across all years (up to 50 years)

The reduction in mortality for 4 animals per year was implemented by ‘saving’ 1.5 females per year and 2.5 males per year. This was done to reflect the propensity for males to disperse and wander more extensively than females, and hence become more likely to be killed by vehicles while crossing roads. The largest reductions in mortality were applied to animals in the 1-4 year age classes – i.e. those most likely to disperse.

To achieve this, mortality rates in Vortex were modified as follows:
No change made to mortality rate for juveniles in the 0-1 age class
Mortality rate for 1-2 year females reduced to 16.7%/year (from 19.7%)
Mortality rate for 1-2 year males reduced to 5.95%/year (from 19.45%)
Mortality rate for 2+ aged females reduced to 6.5%/year (from 7.5%)
Mortality rate for 2-3 year males reduced to 17.06%/year (from 30.56%)
Mortality rate for 3-4 year males reduced to 1.8%/year (from 4.3%)
Mortality rate for 4+ aged males reduced to 3.0%/year (from 4.0%)

Note: these reductions were applied to the existing population size and structure in the first year of the simulation to achieve a ‘saving’ of 4 animals. These percentages were retained throughout the following 49 years of the projection. However, population size declined during the 50 year period, so these reductions in mortality rates would not have continued to ‘save’ 4 animals in each of the subsequent years.





Scenario	#Runs	Population	det-r	stoch-r	SD(r)	PE	N-extant	SD(Next)	N-all	SD(Nall)	GeneDiv	SD(GD)	AlleleN	SD(A)	MedianTE	MeanTE
With road_1.98 dispersal_with revegetation_reduce mortality as a percentage (4)	1000	Population1	0.009	-0.027	0.111	0.000	48.73	38.65	48.73	38.65	0.6129	0.0142	4.81	0.35	0	40.8
	1000	Population2	0.009	-0.009	0.141	0.005	22.44	12.03	22.35	12.06	0.6069	0.0174	4.52	0.36	0	35.7
	1000	Meta	0.009	-0.020	0.092	0.000	71.08	41.32	71.08	41.32	0.6199	0.0101	5.11	0.20	0	0.0

Test of method for implementing mortality reduction to achieve the goal of 'saving' 4 animals per year through management intervention

Summary: different results depending on the method used to implement this management intervention in the PVA. However, both methods resulted in population projections after 50 years that were greater than the baseline projections (Table 4; approx. 42 animals).

It should be noted that the second method, in this declining population, would not achieve the desired goal of 'saving' 4 animals per year through management intervention because the population size is not constant.

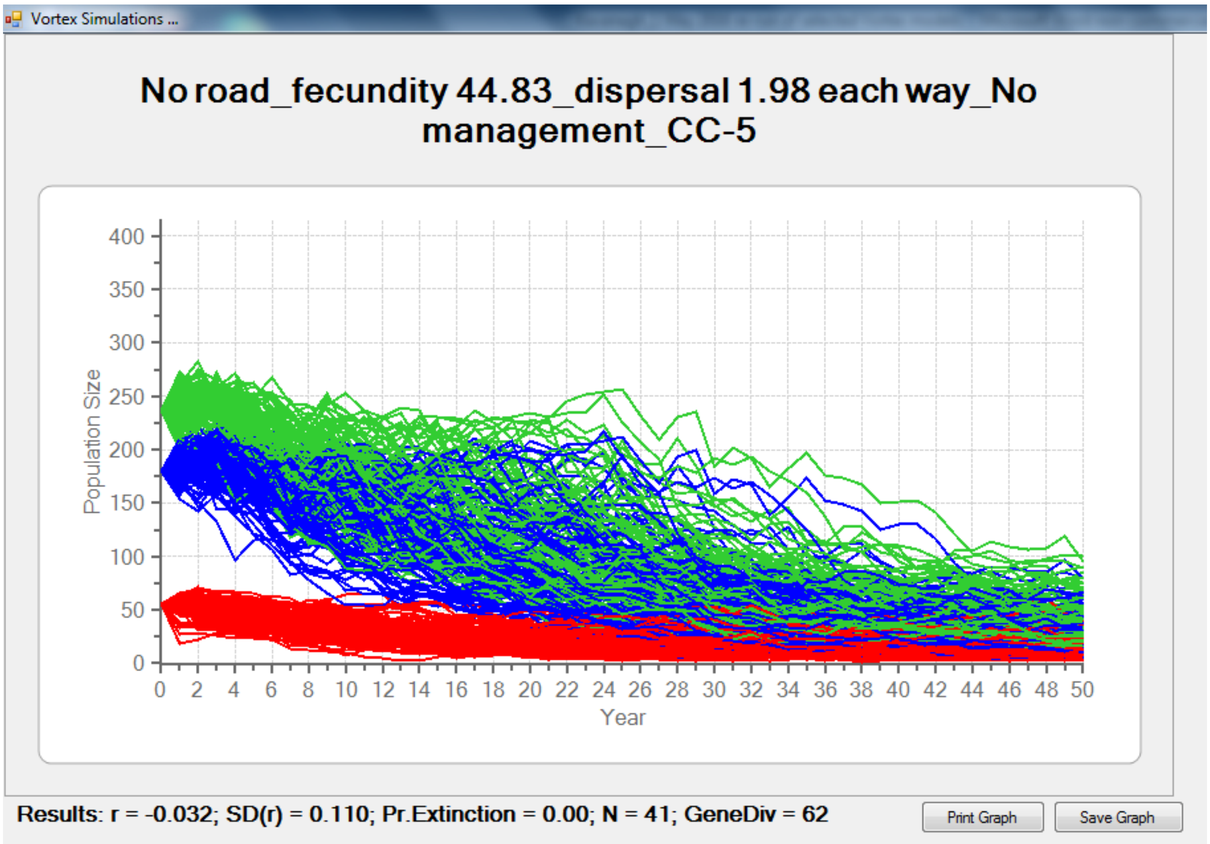
Scenarios	Population P(E)	Population N	Western sub-Pop P(E)	Western sub-Pop N	Eastern sub-Pop P(E)	Eastern sub-Pop N
Mortality reduced by 4 animals per year by limiting the numbers of Koalas emigrating from, and increasing the numbers immigrating into, the study area (Table 9)	0.00	108.6	0.00	65.9	0.00	42.7
Mortality reduced by 4 animals in the first year by reducing mortality rates, and continuing these rates into all subsequent years of the projection.	0.00	71.1	0.00	48.7	0.01	22.4

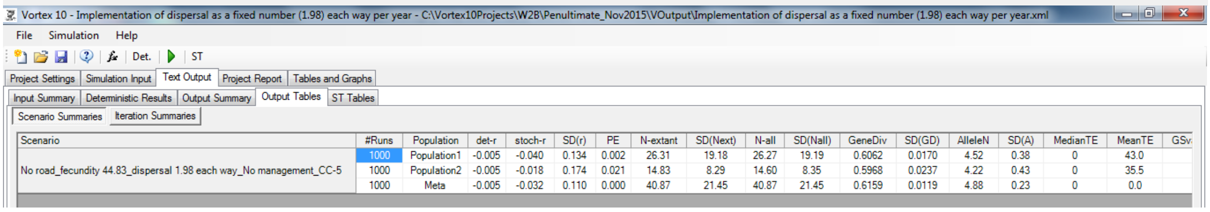
3. Test of reduction in carrying capacity by 14 Koalas.

   A. Implementation of loss of habitat for 5 Koalas (as per Table 10)

      Duplication of Row 1 model in Table 10 of PVA report (Vortex version 10.0.7.3)

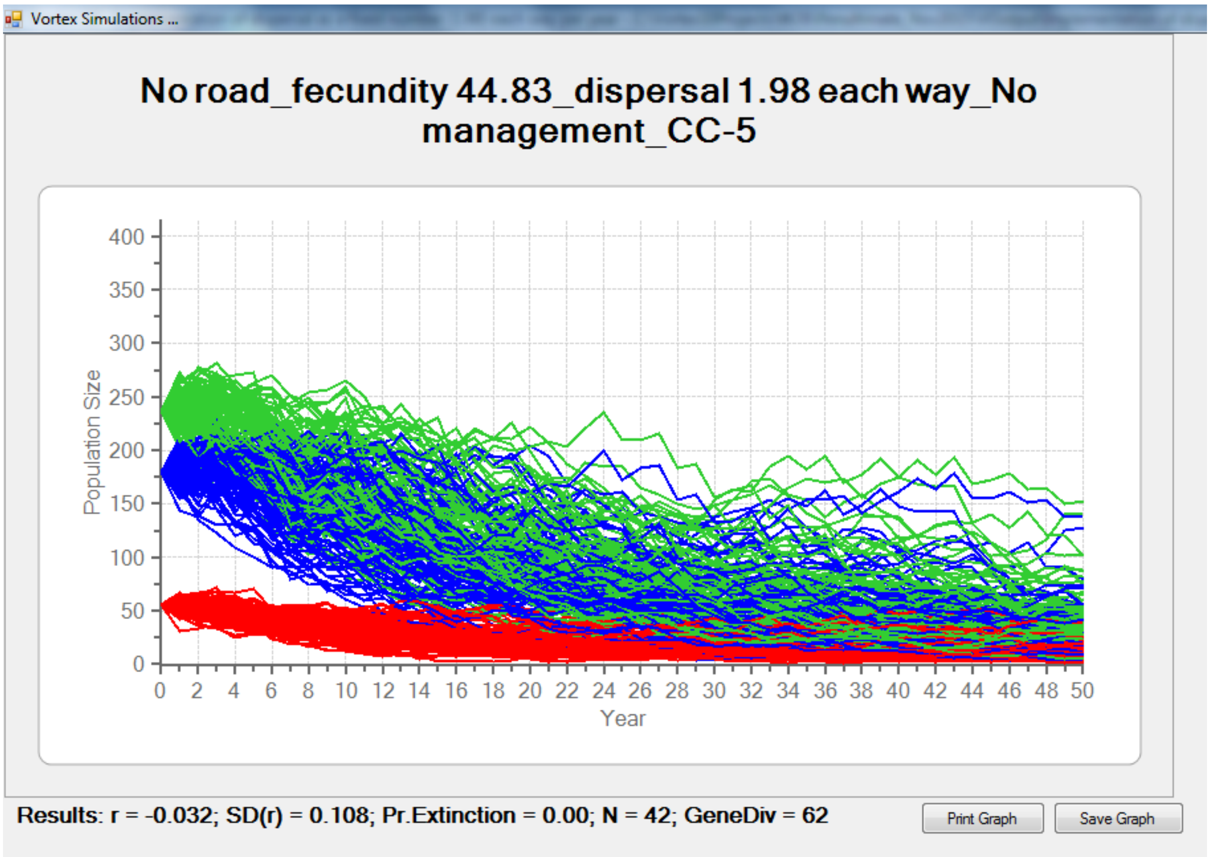
      CC-5 expressed as 4/1 loss for Pop1 and Pop2, respectively





Scenario	#Runs	Population	det-r	stoch-r	SD(r)	PE	N-extant	SD(Next)	N-all	SD(Nall)	GeneDiv	SD(GD)	AlleleN	SD(A)	MedianTE	MeanTE	GSv
No road_fecundity 44.83_dispersal 1.98 each way_No management_CC-5	1000	Population1	-0.005	-0.040	0.134	0.002	26.31	19.18	26.27	19.19	0.6062	0.0170	4.52	0.38	0	43.0	
	1000	Population2	-0.005	-0.018	0.174	0.021	14.83	8.29	14.60	8.35	0.5968	0.0237	4.22	0.43	0	35.5	
	1000	Meta	-0.005	-0.032	0.110	0.000	40.87	21.45	40.87	21.45	0.6159	0.0119	4.88	0.23	0	0.0	

CC-5 expressed as 3/2 loss for Pop1 and Pop2, respectively



Vortex 10 - Implementation of dispersal as a fixed number (1.98) each way per year - C:\Vortex10Projects\W2B\Penultimate_Nov2015\VOutput\Implementation of dispersal as a fixed number (1.98) each way per year.xml

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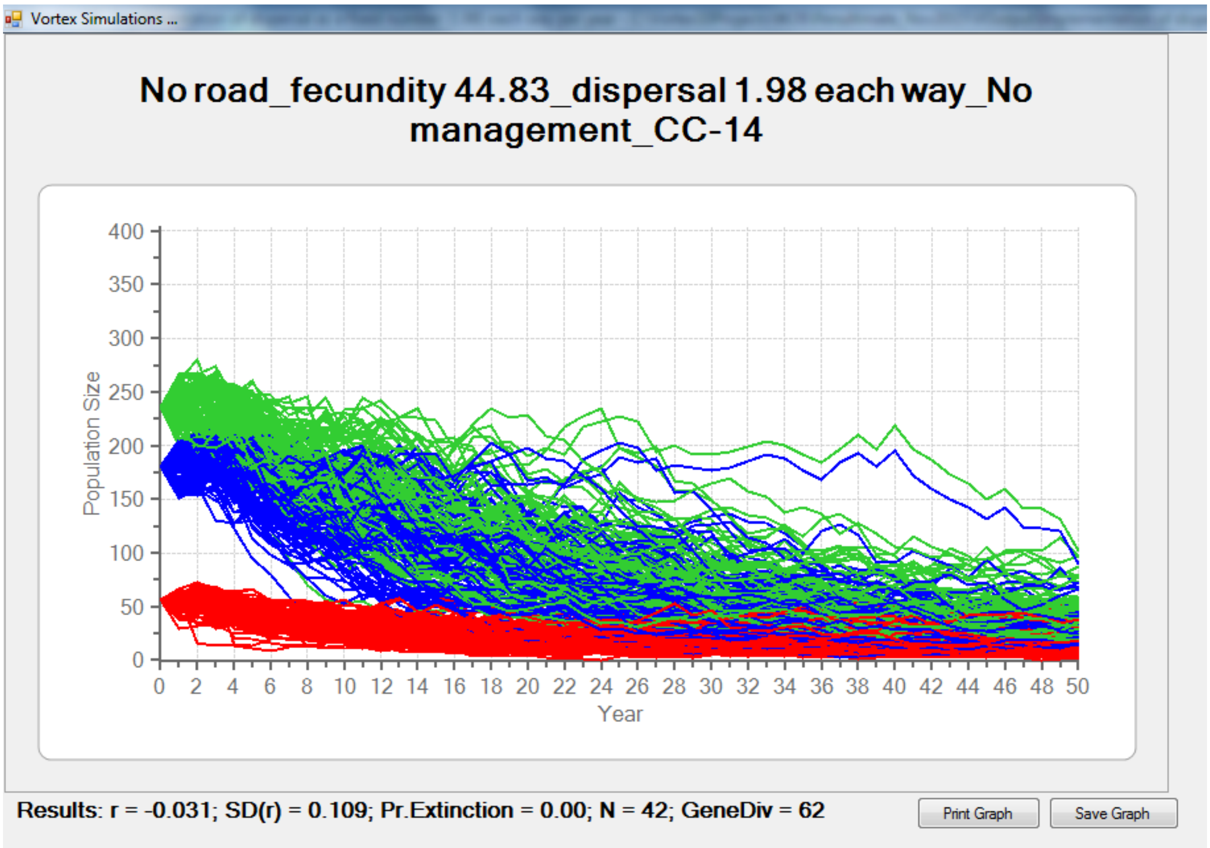
Scenario	#Runs	Population	det-r	stoch-r	SD(r)	PE	N-extant	SD(Next)	N-all	SD(Nall)	GeneDiv	SD(GD)	AlleleN	SD(A)	MedianTE	MeanTE	GSv
No road_fecundity 44.83_dispersal 1.98 each way_No management_CC-5	1000	Population1	-0.005	-0.039	0.134	0.007	27.42	20.63	27.27	20.64	0.6065	0.0172	4.54	0.38	0	42.1	
	1000	Population2	-0.005	-0.018	0.170	0.021	14.78	7.70	14.57	7.77	0.5981	0.0226	4.24	0.41	0	35.6	
	1000	Meta	-0.005	-0.032	0.108	0.001	41.87	22.69	41.84	22.71	0.6163	0.0114	4.89	0.23	0	51.0	

B. Implementation of loss of habitat for 14 Koalas (most extreme estimate by Phillips et al. 2015)

CC-14 expressed as 11/3 loss for Pop1 and Pop2, respectively



Vortex 10 - Implementation of dispersal as a fixed number (1.98) each way per year - C:\Vortex10Projects\W2B\Penultimate_Nov2015\VOutput\Implementation of dispersal as a fixed number (1.98) each way per year.xml

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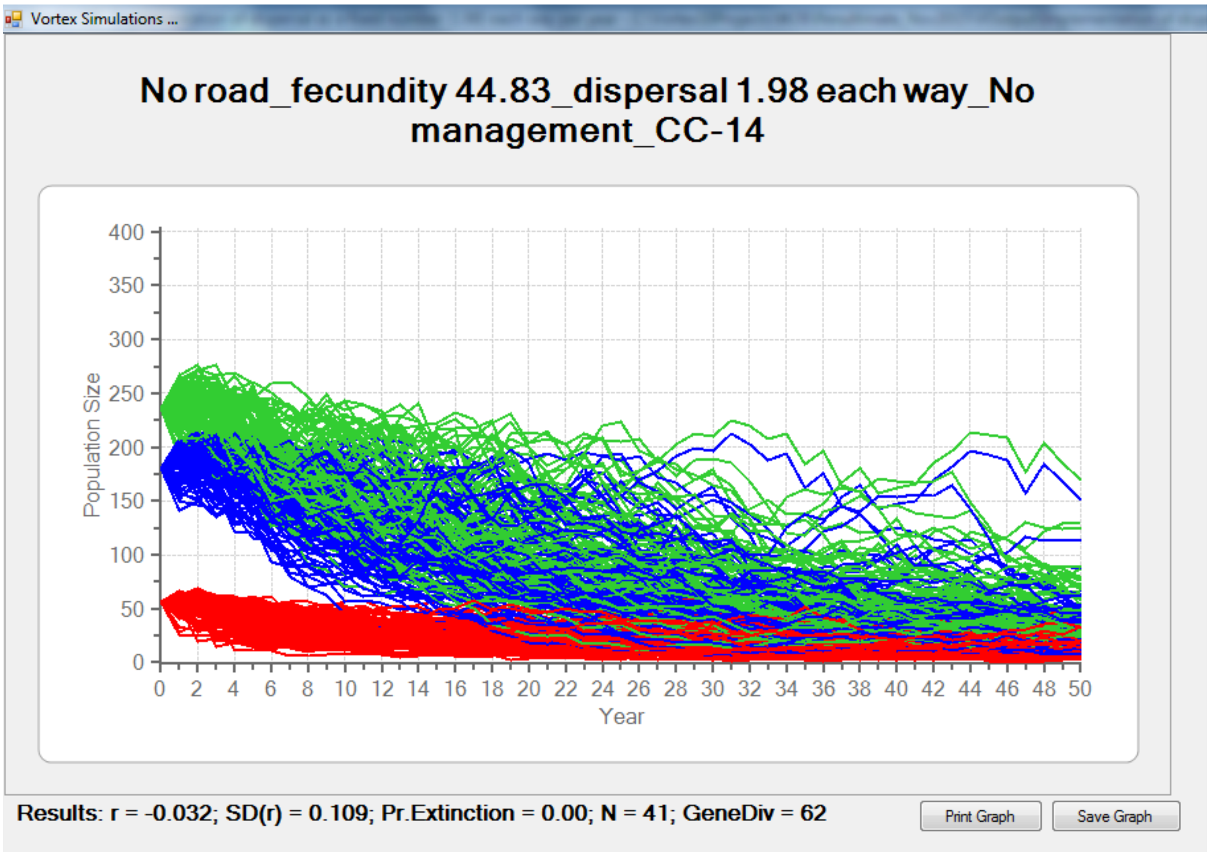
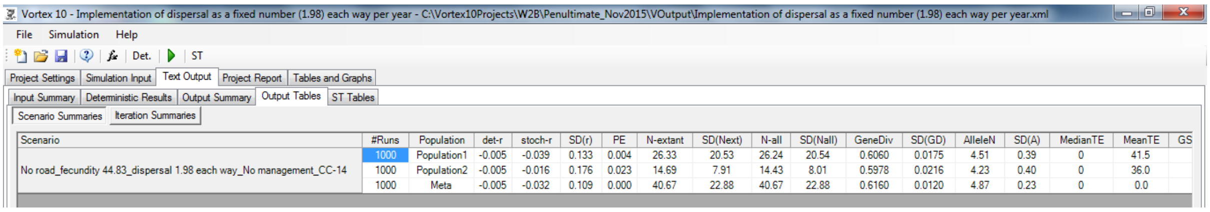
Scenario	#Runs	Population	det-r	stoch-r	SD(r)	PE	N-extant	SD(Next)	N-all	SD(Nall)	GeneDiv	SD(GD)	AlleleN	SD(A)	MedianTE	MeanTE	GS
No road_fecundity 44.83_dispersal 1.98 each way_No management_CC-14	1000	Population1	-0.005	-0.039	0.135	0.003	26.74	21.84	26.68	21.84	0.6056	0.0165	4.50	0.39	0	43.3	
	1000	Population2	-0.005	-0.016	0.171	0.015	15.39	8.67	15.20	8.74	0.5986	0.0205	4.25	0.40	0	35.5	
	1000	Meta	-0.005	-0.031	0.109	0.000	41.88	24.07	41.88	24.07	0.6158	0.0111	4.88	0.23	0	0.0	

CC-14 expressed as 10/4 loss for Pop1 and Pop2, respectively





Vortex 10 - Implementation of dispersal as a fixed number (1.98) each way per year - C:\Vortex10Projects\W2B\Penultimate_Nov2015\VOutput\Implementation of dispersal as a fixed number (1.98) each way per year.xml

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Scenario	#Runs	Population	det-r	stoch-r	SD(r)	PE	N-extant	SD(Next)	N-all	SD(Nall)	GeneDiv	SD(GD)	AlleleN	SD(A)	MedianTE	MeanTE	GS
No road_fecundity 44.83_dispersal 1.98 each way_No management_CC-14	1000	Population1	-0.005	-0.039	0.133	0.004	26.33	20.53	26.24	20.54	0.6060	0.0175	4.51	0.39	0	41.5	
	1000	Population2	-0.005	-0.016	0.176	0.023	14.69	7.91	14.43	8.01	0.5978	0.0216	4.23	0.40	0	36.0	
	1000	Meta	-0.005	-0.032	0.109	0.000	40.67	22.88	40.67	22.88	0.6160	0.0120	4.87	0.23	0	0.0	

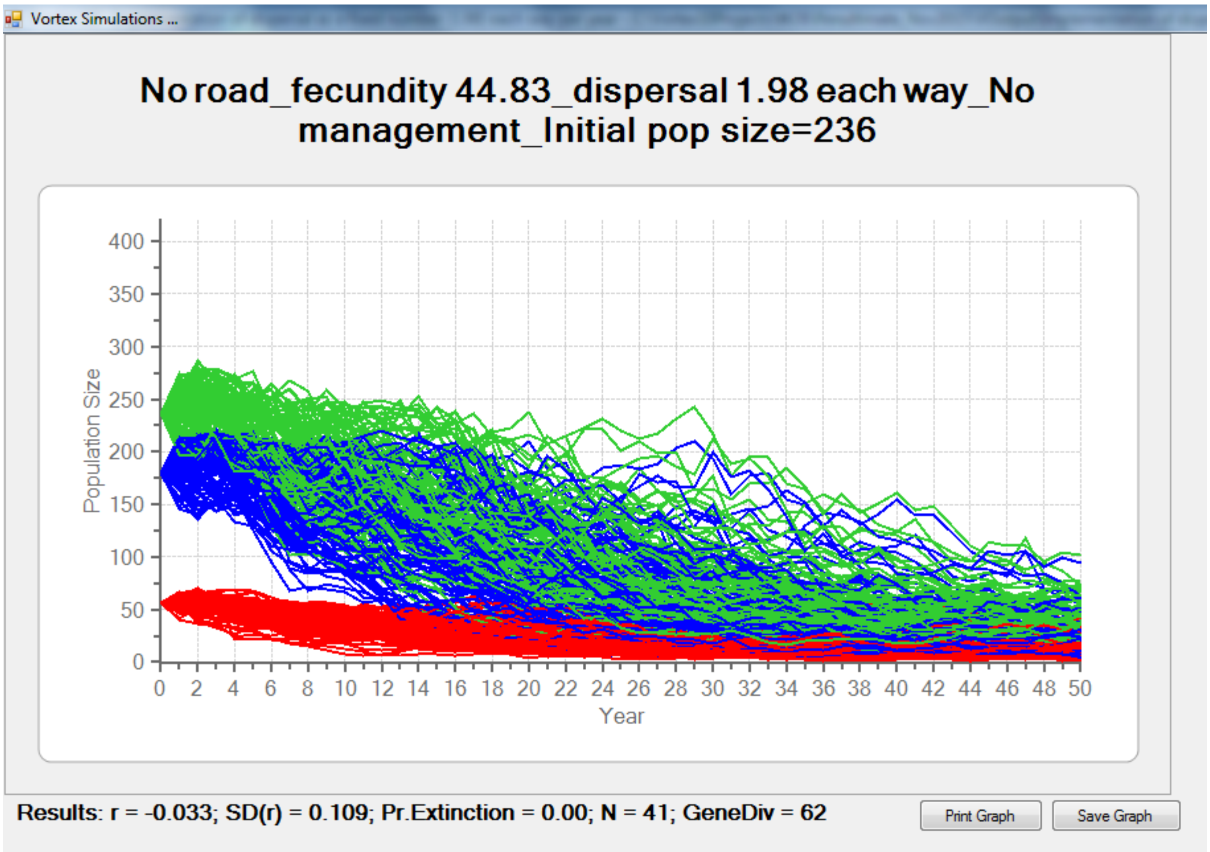
Test of reduction in carrying capacity by 14 Koalas – Summary: almost identical results

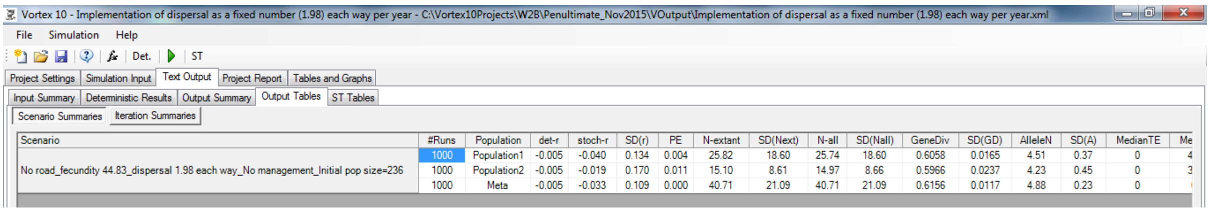
Scenarios	Population P(E)	Population N	Western sub-Pop P(E)	Western sub-Pop N	Eastern sub-Pop P(E)	Eastern sub-Pop N
No change in base rates (Table 4), including loss of habitat for 5 Koalas (implemented as 3/2 loss for sub-population 1 and sub-population 2, respectively)	0.00	41.9	0.01	27.4	0.02	14.9
No change in base rates (Table 4), including loss of habitat for 14 Koalas (implemented as 10/4 loss for sub-population 1 and sub-population 2, respectively)	0.00	40.7	0.00	26.3	0.02	14.7

4. Test of reduction of initial population size by 14 Koalas.

Duplication of Row 1 model in Table 10 of PVA report (Vortex version 10.0.7.3)

A. No change in initial population size (n=236) (as per Table 10)





Vortex 10 - Implementation of dispersal as a fixed number (1.98) each way per year - C:\Vortex10Projects\W2B\Penultimate_Nov2015\VOutput\Implementation of dispersal as a fixed number (1.98) each way per year.xml

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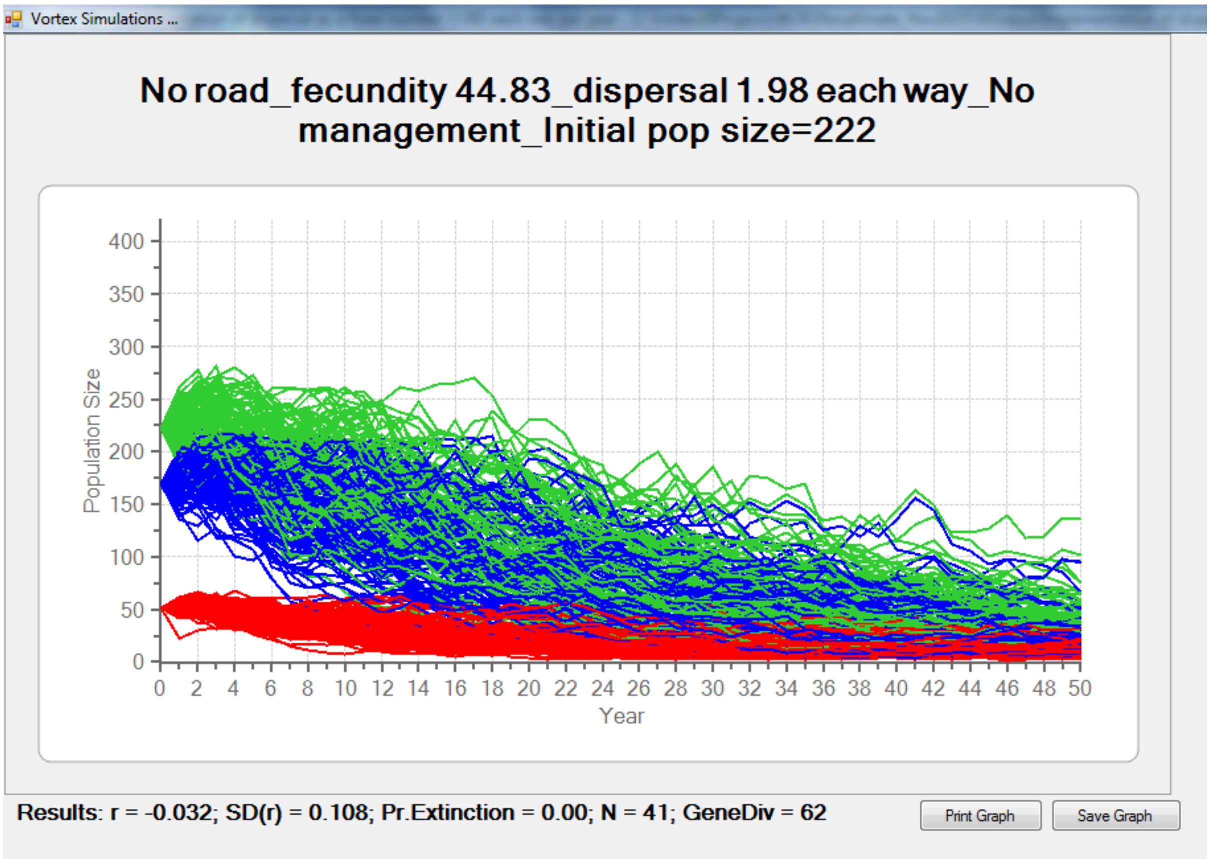
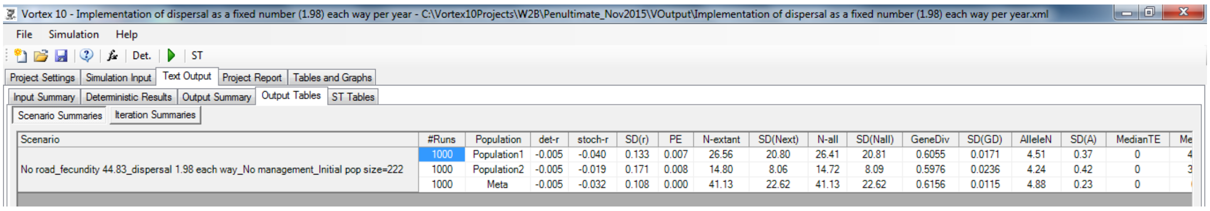
Scenario Summaries | Iteration Summaries

Scenario	#Runs	Population	det-r	stoch-r	SD(r)	PE	N-extant	SD(Next)	N-all	SD(Nall)	GeneDiv	SD(GD)	AlleleN	SD(A)	MedianTE	Me
No road_fecundity 44.83_dispersal 1.98 each way_No management_Initial pop size=236	1000	Population1	-0.005	-0.040	0.134	0.004	25.82	18.60	25.74	18.60	0.6058	0.0165	4.51	0.37	0	4
	1000	Population2	-0.005	-0.019	0.170	0.011	15.10	8.61	14.97	8.66	0.5966	0.0237	4.23	0.45	0	3
	1000	Meta	-0.005	-0.033	0.109	0.000	40.71	21.09	40.71	21.09	0.6156	0.0117	4.88	0.23	0	[illegible]

B. Initial population size reduced by 14 to n=222




Vortex 10 - Implementation of dispersal as a fixed number (1.98) each way per year - C:\Vortex10Projects\W2B\Penultimate_Nov2015\VOutput\Implementation of dispersal as a fixed number (1.98) each way per year.xml

File Simulation Help

Det. ST

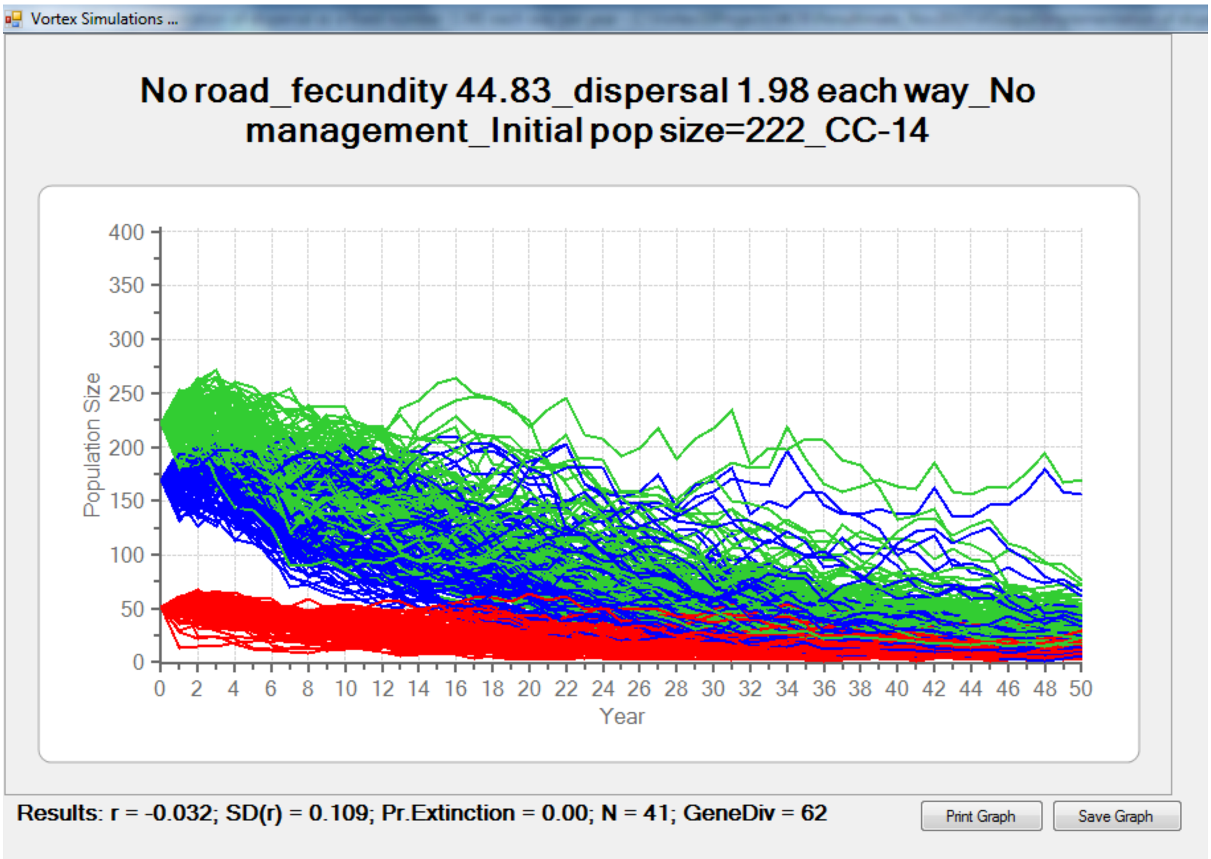
Project Settings | Simulation Input | Text Output | Project Report | Tables and Graphs

Input Summary | Deterministic Results | Output Summary | Output Tables | ST Tables

Scenario Summaries | Iteration Summaries

Scenario	#Runs	Population	det-r	stoch-r	SD(r)	PE	N-extant	SD(Next)	N-all	SD(Nall)	GeneDiv	SD(GD)	AlleleN	SD(A)	MedianTE	Me
No road_fecundity 44.83_dispersal 1.98 each way_No management_Initial pop size=222	1000	Population1	-0.005	-0.040	0.133	0.007	26.56	20.80	26.41	20.81	0.6055	0.0171	4.51	0.37	0	4
	1000	Population2	-0.005	-0.019	0.171	0.008	14.80	8.06	14.72	8.09	0.5976	0.0236	4.24	0.42	0	3
	1000	Meta	-0.005	-0.032	0.108	0.000	41.13	22.62	41.13	22.62	0.6156	0.0115	4.88	0.23	0	[illegible]

C. Initial population size reduced by 14 to n=222, and Carrying Capacity reduced by 14



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Scenario Summaries | Iteration Summaries

Scenario	#Runs	Population	det-r	stoch-r	SD(r)	PE	N-extant	SD(Next)	N-all	SD(Nall)	GeneDiv	SD(GD)	AlleleN	SD(A)	MedianTE
No road_fecundity 44.83_dispersal 1.98 each way_No management_Initial pop size=222_CC-14	1000	Population1	-0.005	-0.040	0.134	0.003	25.77	20.85	25.70	20.85	0.6057	0.0174	4.51	0.38	0
	1000	Population2	-0.005	-0.016	0.172	0.017	15.01	7.73	14.82	7.80	0.5980	0.0222	4.25	0.40	0
	1000	Meta	-0.005	-0.032	0.109	0.000	40.52	22.35	40.52	22.35	0.6157	0.0120	4.88	0.22	0

Test of reduction of initial population size by 14 Koalas – Summary: No differences

Scenarios	Population P(E)	Population N	Western sub-Pop P(E)	Western sub-Pop N	Eastern sub-Pop P(E)	Eastern sub-Pop N
No change in initial population size (n=236) (as per Table 10)	0.00	40.7	0.00	25.8	0.00	15.1
Initial population size reduced by 14 to n=222	0.00	41.1	0.01	26.6	0.01	14.8
Initial population size reduced by 14 to n=222, AND carrying capacity reduced by 14 (implemented as 10/4 loss for sub-population 1 and sub-population 2, respectively)	0.00	40.5	0.00	25.8	0.02	15.0

Transport
Roads & Maritime Services

Dr Rod Kavanagh
C/- Niche Environment and Heritage
PO Box 2443
NORTH PARRAMATTA NSW 1750

Woolgoolga to Ballina Upgrade: Section 10 (Broadwater to Coolgardie) Key Design, Construction and Operational Inputs into the PVA

Dear Rod

This letter outlines Roads and Maritime's key design, construction and operational measures proposed for the Section 10 highway alignment and nearby local roads between Broadwater and Coolgardie, as key inputs into the population viability analysis for Ballina Koala population.

The letter:

- Will form part of an addendum to the Ballina Koala Plan that you are preparing in response to issues raised by the Federal Department of Environment in correspondence dated 29 April 2016 and by Stephen Philips in correspondence dated April 2016; and
- Outlines mitigation measures for a highway alignment as described in the project Submissions and Preferred infrastructure Report dated December 2013.

Each of these measures are summarised in further detail below.

Enhanced Connectivity Structures

Roads and Maritime are committing to the provision of enhanced connectivity structures within Section 10 with a total of 26 connectivity structures being provided within this Section.

The detailed field survey (reported in Appendix 1 of the Ballina Koala Plan) and the location of proposed koala revegetation areas totalling 130Ha have been key inputs into the location of connectivity measures.

Since submission of the Ballina Koala Plan, Roads and Maritime has progressed the preliminary design of the fauna connectivity structures on Section 10. The type, locations and dimensions of connectivity structures are provided in the enclosed preliminary detailed design drawings and these details to be included in the draft Koala Management Plan. Importantly, the dimensions of the connectivity structures comply with the requirements NSW Ministers Condition of Approval D9 (d)(vi) and accordingly EPBC Approval Condition No. 8 and located such that the home ranges of koalas have been taken into account (refer to Section 5.6 and Figure 4 of the Ballina Koala Plan).

Preventing Koala Road Strike on the New Alignment

Roads & Maritime can confirm that the new highway will be a fully enclosed system by providing koala grids and new underpasses at the new Coolgardie interchange and connected to the Koala -proof fencing along the entire section 10 corridor.

An additional 2km of koala proof fencing to north of Coolgardie interchange will also be installed, extending into Section 11.

Like the fauna connectivity structures, Roads and Maritime has also progressed the design of the preliminary fauna fencing. The enclosed preliminary detailed design drawings show the fauna fence layout and how they tie into the fauna connectivity structures.

Additional Koala Proof Fencing Existing Roads

Roads and Maritime have committed to providing additional Koala proof fencing at other koala hot spots such as along:

- the existing highway between Wardell and Coolgardie; and
- sections of Wardell Road where the new highway comes close to the existing Wardell Road to reduce existing koala mortality.

Further details of the location of the fencing and additional fauna connectivity structures are also shown in the enclosed preliminary design drawings.

Roads and Maritime has committed to these additional measures with the aim of helping to achieve a reduction in the current koala mortality in these known hot spots for koala road strike and was developed in response the PVA modelling which highlighted reducing Koala mortality by 4 animals per year provides a substantial benefit to koala population compared to scenarios without the highway upgrade proceeding.

Koala Revegetation Works

Planting 130 hectares of koala food trees on cleared land owned by Roads and Maritime which will be protected by an in perpetuity conservation agreement. The revegetation sites will be additional to the direct offsets provided for the Coolgardie/Bagotville koala population under the Biodiversity Offset Package for Approval EPBC 2012/6394. Roads and Maritime consider the provision of this new habitat will improve the carrying capacity for the koala population as well as enhancing dispersal between the western and eastern sub-populations over time. Details of planting locations are provided in Appendix 4 of the Ballina Koala Plan.

Predator Control

Roads & Maritime are committed to a predator control program associated with 130 ha of revegetation works as well as any other offset properties used under the Biodiversity Offset Package approval EPBC 2012/6394. Predator control will be undertaken on an ongoing basis and will be funded in perpetuity as part the conservation agreements placed on the title of the subject lands. This program will also help contribute to reducing the existing koala mortality rates in the local area.

Other preconstruction and construction management actions

The Koala Management Plan will provide a detailed breakdown of the proposed management measures to be implemented in the pre-construction, construction and operational phases of the project. Below is dot point summary of key measures.

- Pre-clearing surveys to identify Koalas within the construction corridor.
- Identification of exclusion zones and fencing to prevent damage to native vegetation and Koala habitat.
- Siting of ancillary facilities to avoid impacts to known and potential Koala habitat.
- Implementation of a dog policy to ensure that no domestic dogs are brought onto the site.
- Induction and training of construction staff to make them aware of Koala habitat requirements, clearing extents and no-go areas. This training would identify areas of Koala habitat, crossing zones and key threats to the species. The importance of following the clearing and rehabilitation protocols would be made clear to all project personnel.
- Clearing of trees will be undertaken in a way that ensures Koalas living in or near the clearing area have enough time to move out of the site without human intervention. In summary this involves: Staged clearing, i.e. sequential thinning or partial removal of trees in progressive stages, to allow Koalas to safely leave the clearing area and relocate to adjacent habitat. An ecologist will undertake surveys of the scheduled clearing area 2 hrs pre-dawn (spotlighting) and in the early morning (daylight) prior to vegetation clearing to identify trees in which a Koala is present and any adjacent trees with overlapping crowns.
- Suspension of clearing works for a minimum period of 48 hours if a Koala is found within a clearing area to allow the animal to move out of the construction site on its own volition.
- The direction of sequential clearing will be away from threatening processes or hostile environments, i.e. roads. The ecologist is responsible for verifying that sequential clearing has taken place.
- Each tree identified by the ecologist as being a risk to a Koala if felled, will not be felled, damaged or interfered with until the Koala has moved from the clearing site. The ecologist will physically move Koalas if necessary in accordance with Biodiversity Guidelines: Protecting and managing biodiversity on RTA Projects (RTA 2011).
- In the event that a Koala remains in the clearing site for more than 48 hours, it will be captured and translocated by a suitably qualified person to the nearest area of
- habitat identified as suitable for Koala release and where the individual is at no risk of further harm
- An ecologist will be present on site prior to and during all vegetation clearing to
- allow Koalas to safely leave the clearing site and relocate to adjacent habitat without human intervention. In the event that a Koala does not move on its own volition after a period of two nights, it will be trapped. The ‘corflute method’ would be used for trapping Koalas. This typically involves the use of a plastic guard, or similar material (approximately 100 centimetres tall) and, optionally, a cage trap arrangement placed in the fence near the base of the target tree
- Once captured, the Koala’s health will be assessed and details recorded of age,sex, weight, body measurements, and presence of pouch or back young (for females). All healthy animals will be ear tagged, micro-chipped (using a PIT tag and relocated into adjacent habitat identified for Koala release. Release points will be not more than 100 metres away provided that suitable habitat is present. If an injured Koala is captured, it will be transported to an experienced wildlife veterinarian for treatment. The NSW Code of Practice for Injured, Sick and Orphaned Koalas (OEH, 2011) will be followed for trapping and relocating Koalas and dealing with any injured Koalas encountered during the clearing procedure.

- Direct interactions with Koalas must only be conducted by a suitably qualified and experienced ecologist who holds the necessary capture and handling permits ssued by the OEH, or other licensed wildlife carers.
- Areas where Koalas have been captured will be recorded for consideration of inclusion as a monitoring site
- A licensed wildlife carer/ecologist will be present on site during all vegetation clearing and habitat removal activities to redirect Koalas that may be encountered during clearing activities.
- Following the clearing works and throughout the remainder of the construction period, any observations of Koalas in the construction corridor will also follow the unexpected threatened species find procedure (Biodiversity Guidelines RTA 2011).
- Given the likely increased traffic on local roads during the construction period, Koala awareness signs will be erected on local roads in potential road kill areas to make motorists aware of the potential for Koalas to cross the road and the need to restrain dogs, particularly between the hours of 6 pm and 6 am when Koalas are most active. Koala awareness signs will also to be constructed along the highway upgrade at locations in close proximity to the fauna crossing zones. Signage locations will be identified in the Koala Fencing Strategy
- Relocation of koalas in key areas to identified suitable habitat within the locality prior to construction commencing. Details are provided in the draft Koala Management Plan.
- Installation of koala proof fencing on sections of Wardell Road adjacent to the Section 10 alignment and existing Pacific Highway between Wardell and Coolgardie prior to construction activities occurring

RMS will also be undertaking a number of adaptive management actions should monitoring indicate that these actions are required. Further details will be provided in Koala Management Plan. RMS will also be submitting an advanced draft of this document to the Department of Environment in response to their letter of 29 April 2016.

To further assist you in preparing the addendum to the Ballina Koala Plan, RMS has mapped the location of the preferred koala feed trees identified in Dr Philips submission against the proposed route for Section10. Please note that the final design has 'tweaked' the alignment and reduced the number of preferred koala feed trees to be removed.

Location	**No. of key food trees identified by Dr Phillips**	**No. of identified trees removed**	
		SPIR	**Current SMEC Design**
Lawspoint	70	14	12
Jali Land	12	2	2
Wardell Road	43	17	14

Yours sincerely

Robert (Bob) Higgins 12/5/16
General Manager Pacific Highway

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

School of Geography, Planning and Environmental Management

Dr Jonathan Rhodes
Associate Professor

CRICOS PROVIDER NUMBER 00025B

Bob Higgins
General Manager, Pacific Highway
21 Prince Street
GRAFTON, NSW 2460

10th May 2016

Dear Bob,

I have now reviewed the Addendum to the Ballina Koala Plan (BKP) and believe that it adequately addresses the major criticisms of Dr Phillips and P. Miller. Many of the criticisms raised were focussed around the assumptions of the PVA model. Where applicable, these assumptions have been addressed in the Addendum through additional sensitivity analyses to test the effect of those assumptions on the estimated impact of the road upgrade in Section 10. This shows that making the assumptions proposed by Dr Phillips and P. Miller only had minor effects on the estimated impact of the road upgrade in most cases. The assumption about the reduction in mortality achieved by mitigation measures on existing roads nearby, which was proposed by P. Miller, had the largest impact on predictions. However, this potential mitigation strategy was still shown to be able to more than counteract the impact of the road over a 50 year period. These sensitivity analyses provide additional confidence that the conclusions of the PVA are robust. Consequently, the overall finding that the road upgrade could have a small negative impact, but that this could be counteracted by additional mitigation measures to reduce existing mortality on roads nearby appears to be robust.

As I have previously stated, and as is the case with any PVA, considerable uncertainties still exist in the PVA predictions. Therefore, the actual impact of the road upgrade should be assessed through the monitoring program and additional mitigation implemented if necessary based on the monitoring outcomes.

Yours sincerely,

Jonathan Rhodes

Associate Professor Jonathan Rhodes

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Appendix M Addendum to Appendix I - Koala Revegetation Strategy

Woolgoolga to Ballina Pacific Highway Upgrade

Koala Revegetation Strategy Addendum

Roads and Maritime Services | December 2018

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Woolgoolga to Ballina Pacific Highway upgrade

Koala Revegetation Strategy Addendum

Roads and Maritime Services | December 2018

Prepared by Roads and Maritime Services

Contents

1. Introduction

1.1 Background

In 2014 the NSW Minister for Roads and Freight committed to plant at least 130 hectares of new habitat for the Koala on RMS owned land with at least 50 per cent planted prior to construction and the remainder after construction. This commitment was further developed and documented in the Koala Revegetation Strategy for Section 10 (Niche 2015) which was included in the Koala Management Plan. The Koala Management Plan was developed in consultation with relevant government agencies and approved as follows:

- MCoA D8 & D9 - NSW Department of Planning & Environment – approved on 4/8/2016
- CoA 8 & 9 - Commonwealth Department of Environment & Energy – approved on 11/8/2016

The Koala Revegetation Strategy identified approximately 151 ha of cleared land available for new Koala habitat across 21 sites acquired by RMS along Section 10. These properties consist of various combinations of cleared land used for grazing or sugar cane production and areas of remnant native vegetation.

Following receipt of approval detailed plans were developed and ecological investigations were undertaken. These investigations identified a threatened grass species known as Hairy Joint Grass that needed to be protected from planting out with koala food trees. In addition a number of properties had building entitlements which required 2 ha parcels to be left unplanted. This resulted in 116 ha being available for planting with a further 14 ha required to meet the 130 ha.

1.2 Purpose of the report

The purpose of this addendum is to provide details of the proposed planting areas to achieve the remaining 14 ha of the total 130 ha of koala habitat to be planted.

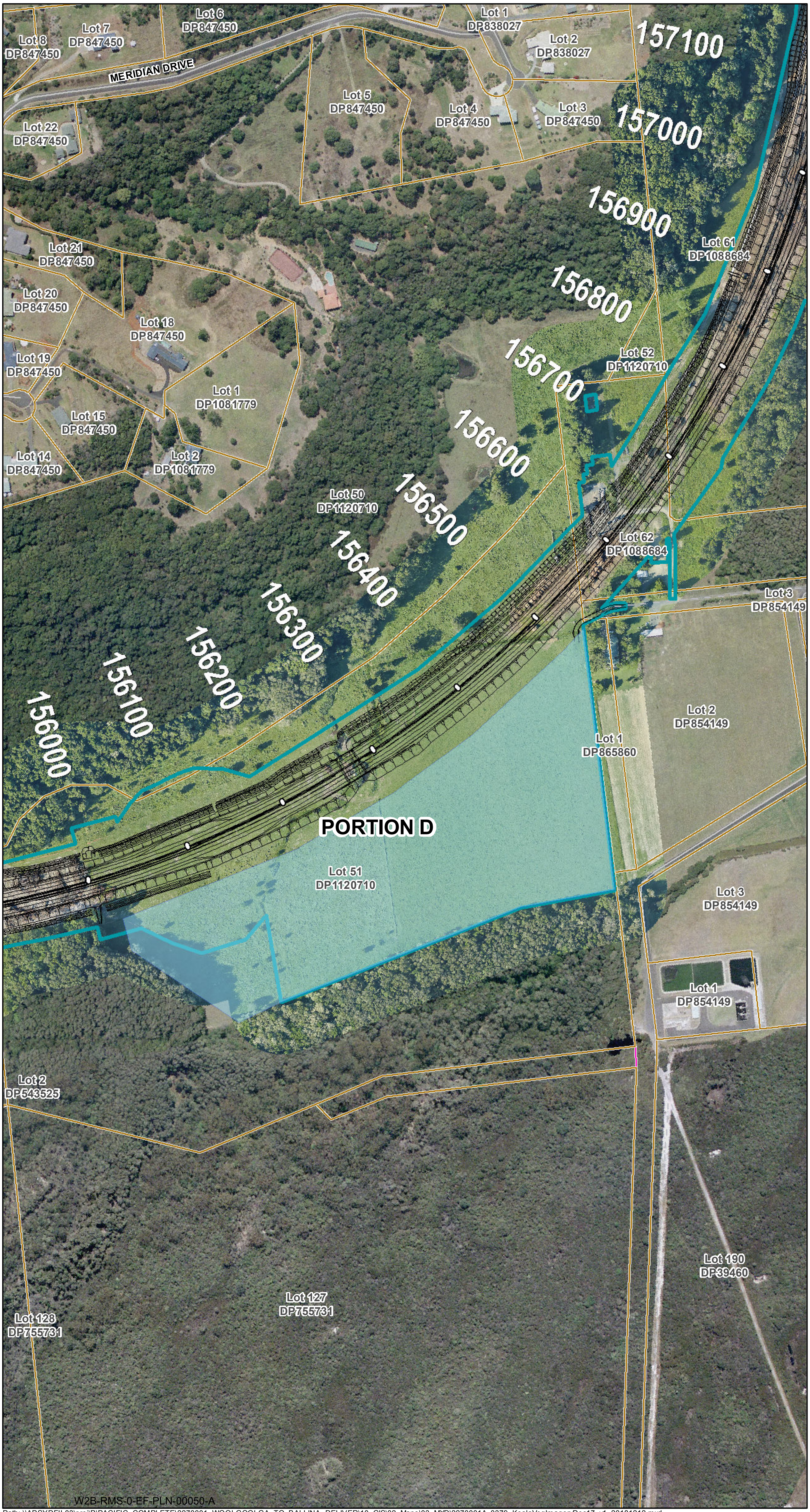
2. Proposed planting areas

2.1 Kays Road site, Chainage 156300

The Kays Road site will provide approximately 6.6 ha of koala habitat. The site is positioned well to meet the three main objectives of the revegetation program: *to establish new habitat for Koalas using preferred Koala food tree species to compensate for habitat lost as a result of clearing for the proposed road-works; to improve habitat connectivity within this fragmented landscape; and thirdly, to guide the movement of Koalas towards the road connectivity structures (e.g. underpasses) that will be provided to ensure the safe passage of dispersing Koalas.*

The proposed koala food tree plantings will improve habitat connectivity and guide koalas towards the bridge connectivity structure at chainage 156234 which is currently adjacent to a cleared farmland.

Part of the site is currently within the construction footprint and will be planted out during the later stages of construction or post construction.



PACIFIC COMPLETE

PACIFIC HIGHWAY UPGRADE
Woolgoolga to Ballina

Koala revegetation planting areas (December, 2018)

Map 1 of 1

Proposed Planting Area

IFC Design (Updated - 20/04/2018)

Approved Project Boundary draft Version 12A (12/12/2017)

Portion D

Cadastre (within 10km)

Crown Land

Major Road

Secondary Road

Local Road

Track and Access

Dedicated Busway

NPWS Reserves

State Forests

1:3,500
at A3

0 90 180
Metres

Print Date:	13/12/2018
Author:	SPALDINGC

Map produced by Pacific Complete in partnership with RMS.

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2.2 Lumleys site, Chainage 152300

The Lumleys site will provide approximately 11.2 ha of koala habitat. The site is also positioned well to meet the three main objectives of the revegetation program mentioned above. The site adjoins koala revegetation areas to the south and will improve habitat connectivity within a known koala hotspot area.

Part of the site is currently within the Lumleys Hill Borrow Site. As per section 8.3 of the Lumelys Borrow Site Management Plan it is proposed to be rehabilitated with koala habitat.

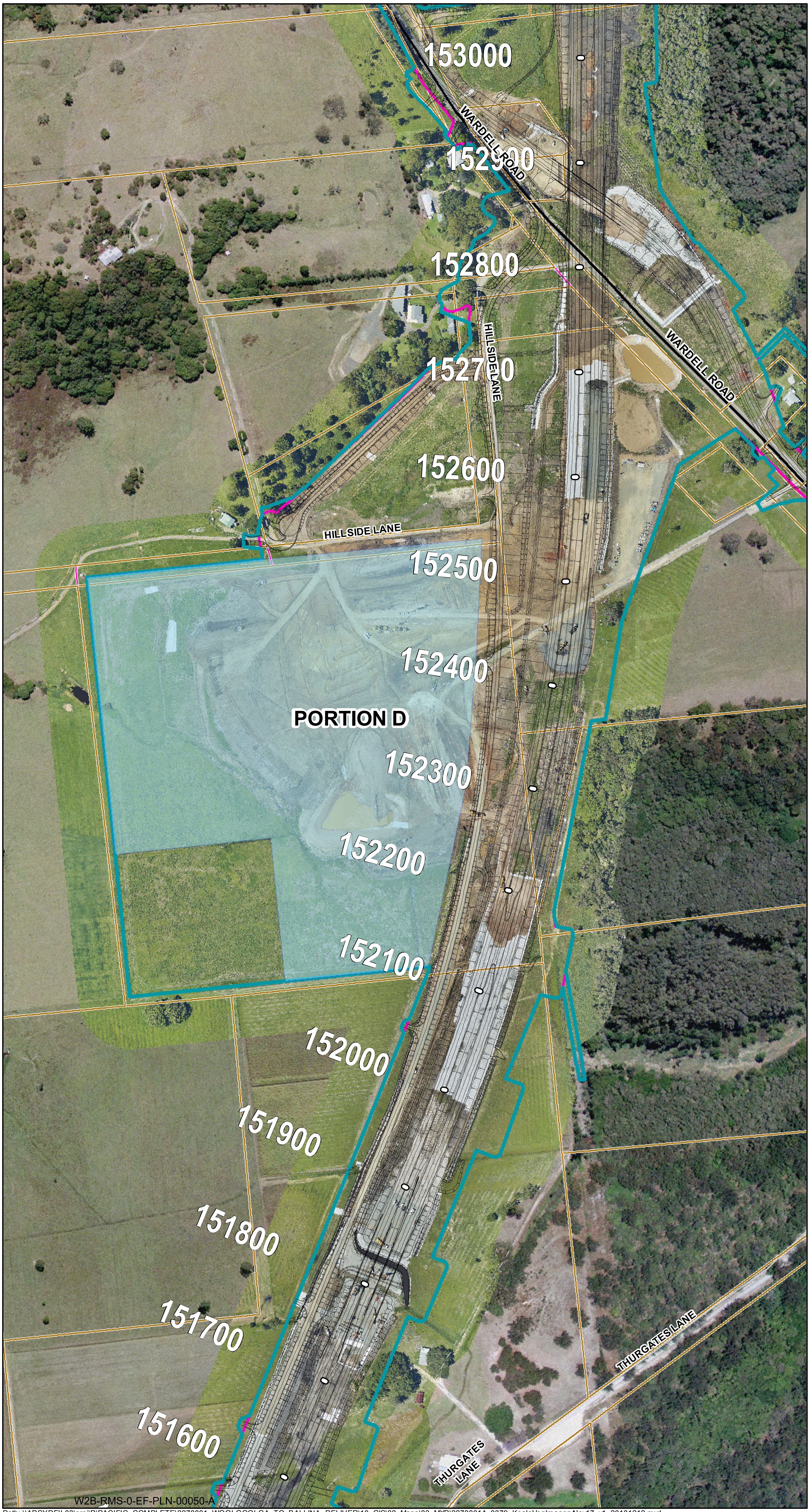
Both sites will be prepared, planted and maintained in accordance with the Koala Revegetation Strategy. Koala food tree species will also be in accordance with the Strategy and will consider learnings from planting in the area over the last 18 months. Species will include but not limited to the following; *Eucalyptus robusta, Melaleuca quinquenervia, Eucalyptus tereeticornis, Eucalyptus resinifera, Eucalyptus grandis, and Eucalyptus microcorys.*

PACIFIC COMPLETE

PACIFIC HIGHWAY UPGRADE
Woolgoolga to Ballina

Koala revegetation planting areas (November, 2018)

Map 1 of 1



IFC Design (Updated - 20/04/2018)

Proposed Planting Area

Approved Project Boundary draft Version 12A (12/12/2017)

Portion D

Approved Project Boundary Version 10 (May 2016)

Cadastre (within 10km)

Crown Land

Major Road

Secondary Road

Local Road

Track and Access

Dedicated Busway

NPWS Reserves

State Forests

1:3,500
at A3

0 87.5 175
Metres

Print Date:	13/12/2018
Author:	SPALDINGC

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3. Recommendation

Both sites have been discussed during Koala Interest Group meetings which include representatives from Environmental Protection Authority, Ballina Shire Council, Sandpiper Ecological Surveys and Friends of the Koala.

Roads and Maritime are seeking endorsement for the above mentioned sites to be included as part of the Section 10 Koala Revegetation Strategy.