Roads & Maritime

Oxley Highway to Kempsey

Ecological Monitoring Program

Date	Status	Revision	Approved by
Report prepared by SMEC Hyder Joint Venture			
18 November 2013	Final		DP&E
Roads and Maritime Update to report prepared by SMEC Hyder Joint Venture			
19 September 2014	Final	Updates to meet DoTE requirements	DP&E and DoTE
17 February 2016	Draft	Various updates, predominantly regarding landowner access	
04 August 2016	Final	Updates to address DoTE comments	DP&E and DoTE

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1 INTRODUCTION

1.1 THE PROJECT

The Oxley Highway to Kempsey Project (the Project) forms part of the Pacific Highway Upgrade program, that will ultimately provide a continuous four lane divided carriageway between Hexham (near Newcastle) and the Queensland border.

The Project is approximately 37 kilometres in length, commencing approximately 700 metres north of the Oxley Highway interchange and tying in with the existing dual carriageways to the south, and finishing near Stumpy Creek tying in with the dual carriageways of the Kempsey to Eungai Pacific Highway upgrade. Upgrading the highway to a dual carriageway predominantly involves duplicating the existing highway, with the exception of two sections where the Project deviates from the alignment of the existing highway in the vicinity of the Hastings River and the Wilson River.

After consideration of the Project EA and Submissions Report, the Minister for Planning approved the Oxley Highway to Kempsey Pacific Highway upgrade under part 75J of the *Environmental Planning and Assessment Act 1979* (EP&A Act) on 8 February 2012 subject to the Minister's Conditions of Approval (MCoA) being met.

The Project was also referred to the former Department of Sustainability, Environment, Water, Population and Communities (DSEWPC), now the Department of the Environment on 17 August 2012. On 21 September 2012, DSEWPC determined that the Project was a controlled action under section 75 and 87 of the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Project was approved by the Federal Minister for the Environment (the Minister) on 24 January 2014, subject to 15 conditions.

1.2 OBJECTIVE

This Ecological Monitoring Program (EMP) has been developed to address MCoA B10, which states:

The Proponent shall develop an Ecological Monitoring Program to monitor the effectiveness of the biodiversity mitigation measures implemented as part of the Project. The program shall be developed by a suitably qualified and experienced ecologist in consultation with the EPA and DPI (Fishing and Aquaculture) and shall include but not necessarily be limited to:

(a) an adaptive monitoring program to assess the effectiveness of the mitigation measures identified in conditions B1, B4, B7 and B31(b) and allow amendment to the measures if necessary. The monitoring program shall nominate performance parameters and criteria against which effectiveness will be measured and include operational road kill surveys to assess the effectiveness of fauna crossings and exclusion fencing implemented as part of the project;

(b) mechanisms for developing additional monitoring protocols to assess the effectiveness of any additional mitigation measures implemented to address additional impacts in the case of design amendments or unexpected threatened species finds during construction (where these additional impacts are generally consistent with the biodiversity impacts identified for the project in the documents listed under condition A1);

(c) monitoring shall be undertaken during construction (for construction-related impacts) and from opening of the project to traffic (for operation/ ongoing impacts) until such time as the effectiveness of mitigation measures can be demonstrated to have been achieved over a minimum of three successive monitoring periods (i.e 6 years) after opening of the project to traffic, unless otherwise agreed by the Director General. The monitoring period may be reduced

with the agreement of the Director General in consultation with the OEH and DPI (Fishing and Aquaculture), depending on the outcomes of the monitoring;

(d) provision for the assessment of the data to identify changes to habitat usage and whether this can be directly attributed to the project;

(e) details of contingency measures that would be implemented in the event of changes to habitat usage patterns directly attributable to the construction or operation of the project; and

(f) provision for annual reporting of monitoring results to the Director General and the OEH and DPI (Fishing and Aquaculture), or as otherwise agreed by those agencies.

The Program shall be submitted to the Director General for approval no later than 6 weeks prior to the commencement of construction that would result in the disturbance of native vegetation (unless otherwise agreed by the Director General)..

This EMP has also been developed to address the Department of the Environment Condition of Approval (CoA) 4, which states:

*Prior to **commencement of stage 2** and **stage 3** of the action**,** the **person taking the action** must submit an Ecological Monitoring Program for approval by the **Minister** that determines the effectiveness of the mitigation measures implemented as part of the project. The Ecological Monitoring Program must be approved in writing by the **Minister** prior to **commencement** of **stage 2** and **stage 3,** and must include:*

a. *The baseline data collected from surveys undertaken by a **suitably qualified expert** on the Koala, Spotted-tail Quoll and Giant-Barred Frog within all habitat areas outside areas to be cleared of vegetation for the proposed action, that are likely to contain these species and that are likely to be adversely impacted by the action (as determined by a **suitably qualified expert**).The data must address the densities, distribution, habitat use and movement patterns of these species;*

b. *The methodology to be implemented for the ongoing monitoring of road kill, the species densities, distribution, habitat use and movement patterns, and the use of **fauna crossing** during construction and operation of the action, including the timing, and duration of the methodology;*

c. *Goals and performance indicators to measure the success of proposed **fauna crossings**, which must be specific, measureable, achievable, realistic and timely (SMART), and be compared against baseline data described in condition 4a)*

d. *Details of contingency measures that would be implemented in the event of changes to densities, distribution, habitat use and movement patterns that are attributable to the construction or operation of the project.*

*Monitoring must continue until mitigation measures can be demonstrated to have been **effective** for the Koala, Spotted-tail Quoll, and Giant-Barred Frog.*

*Should monitoring associated with this condition demonstrate that the use of **fauna crossings** and/or **fencing** is not achieving its intended purpose or is having a detrimental effect upon Koala, Spotted-tail Quoll, and Giant-Barred Frog (as determined by **the Minister**), **the Minister** may require that the person taking the action implement alternative forms of mitigation and/or corrective actions to address the relevant impacts to Koala, Spotted-tail Quoll, and Giant-Barred Frog, Such measures must be implemented as requested.*

Broadly, this EMP aims to:

- Outline the environmental context of the Project, identify potential impacts of the Project and the subsequent requirement for mitigation measures, which relate to:

- Pre-clearing surveys and clearing procedures.
- Fauna underpasses.
- Rope bridges.
- Glider Poles.
- Fauna Fencing.
- Widened Median.
- Nest Boxes.
- Green-thighed frog breeding ponds.
- Landscaping and revegetation.

- Detail the requirements for baseline monitoring of threatened species (known or likely to occur in the Project area that may be adversely affected by the Project) to be undertaken before construction of the Project commences, including the results of the baseline monitoring for the EPBC listed species.
- Describe the timing and methodology for monitoring of mitigation measures, during construction and upon completion of the Project, and detail performance measures that will measure the effectiveness of mitigation measures.
- Identify potential contingency measures that may be implemented if any mitigation measure proves to be insufficient.
- Describe the maintenance requirements that are relevant to the mitigation measures.
- Detail the reporting requirements, related to monitoring events.

In the event of an inconsistency between this program and individual species management plans contained within the Flora and Fauna Management Plans for each stage, the requirements of this program will prevail.

1.3 SCOPE

The scope of this EMP is prescribed within the Project approval documentation. This EMP has also been developed in accordance with the revised Statement of Commitments (refer Table 1).

Table 1 Statement of Commitments relevant to the Ecological Monitoring Program

SoC Reference	Requirement
SoC F21	A monitoring program will be developed to allow the effectiveness of mitigation and offset measures to be assessed and allow for their modification if necessary. The program will be for a minimum of 12 months after construction completion.

1.4 STRUCTURE OF THIS ECOLOGICAL MONITORING PROGRAM

This Ecological Monitoring Program (EMP) addresses the requirement of MCoA B10 and the Department of the Environment CoA 4. Where each CoA is addressed within this EMP is listed in Table 2.

Table 2: Requirements of this Ecological Monitoring Program

Source	Detail	Where addressed in this document
MCoA B10 (a)	An adaptive monitoring program to assess the effectiveness of the mitigation measures identified in conditions B1, B4, B7 and B31(b) and allow amendment to the measures if necessary. The monitoring program shall nominate performance parameters and criteria against which effectiveness will be measured and include operational road kill surveys to assess the effectiveness of wildlife crossings and exclusion fencing implemented as part of the Project;	Section 4
MCoA B10 (b)	Mechanisms for developing additional monitoring protocols to assess the effectiveness of any additional mitigation measures implemented to address additional impacts in the case of design amendments or unexpected threatened species finds during construction (where these additional impacts are generally consistent with the biodiversity impacts identified for the Project in the documents listed under condition A1);	Section 4.1.1
MCoA B10 (c)	Monitoring shall be undertaken during construction (for construction –related impacts) and from opening of the Project to traffic (for operation/ongoing impacts) until such time as the effectiveness of mitigation measures can be demonstrated to have been achieved over a minimum of three successive monitoring periods (i.e. 6 years) after opening of the Project to traffic, unless otherwise agreed by the Director General. The monitoring period may be reduced with the agreement of the Director General in consultation with the EPA and DPI (Fishing and Aquaculture), depending on the outcomes of the monitoring;	Section 4
MCoA B10 (d)	Provision for the assessment of the data to identify changes to habitat usage and whether this can be directly attributed to the Project;	Section 3
MCoA B10 (e)	Details of contingency measures that would be implemented in the event of changes to habitat usage patterns directly attributable to the construction or operation of the Project; and	Section 5
MCoA B10 (f)	Provision for annual reporting of monitoring results to the Director General and the EPA and DPI (Fishing and Aquaculture), or as otherwise agreed by the agencies.	Section 7

Source	Detail	Where addressed in this document
DoTE 4a.	The baseline data collected from surveys undertaken by a **suitably qualified expert** on the Koala, Spotted-tail Quoll and Giant-Barred Frog within all habitat areas outside areas to be cleared of vegetation for the proposed action, that are likely to contain these species and that are likely to be adversely impacted by the action (as determined by a **suitably qualified expert**).The data must address the densities, distribution, habitat use and movement patterns of these species.	Appendix A Appendix B
DoTE 4b.	The methodology to be implemented for the ongoing monitoring of road kill, the species densities, distribution, habitat use and movement patterns, and the use of **fauna crossing** during construction and operation of the action, including the timing, and duration of the methodology.	Section 3.2.1, 3.2.2, 3.2.3, 3.3 and 4.2.
DoTE 4c.	Goals and performance indicators to measure the success of proposed **fauna crossings**, which must be specific, measureable, achievable, realistic and timely (SMART), and be compared against baseline data described in condition 4a)	Section 4.2.4.
DoTE 4d.	Details of contingency measures that would be implemented in the event of changes to densities, distribution, habitat use and movement patterns that are attributable to the construction or operation of the project.	Section 5

1.5 DEFINITIONS

Barrier Effect

The functional or behavioural barrier to fauna movement, created by a road fragmenting otherwise continuous habitat. The barrier effect may result in mortality of wildlife due to collisions with vehicles or avoidance of roads by wildlife as a result of noise, light and pollutants associated with vehicles.

Contingency measure

Also referred to as a corrective action. An action implemented if a performance measure is not met.

Effective

Result in the complete, safe crossing of the crossing by the targeted **EPBC species** at a sufficient frequency to ensure that habitat connectivity is maintained or improved from baseline conditions (determined by surveys condition 4a and information provided in the preliminary documentation), and ongoing population viability by providing opportunities for species dispersal and re-colonisation; and result in reduced incidence of road kill from baseline conditions (determined by surveys condition 4a and information provided in the preliminary documentation).

Fauna Crossings

Purpose built structures which are designed to allow passage for fauna and facilitate natural permeability of linear infrastructure.

Fencing

Purpose built fencing that is designed to stop fauna accessing the road surface. Fauna fencing must be durable and the design targeted to the relevant species.

Mitigation Measure

In this report, a specific structure or design feature incorporated in the Project that aims to minimise the impact of the Project on flora and fauna in the Project area.

Mitigation measures include procedures (for vegetation clearing), wildlife crossing structures (such as underpasses, rope bridges and glider poles) fauna fencing and structures such as nest boxes and frog breeding ponds.

Performance Measure

A standard or benchmark that quantifies the effectiveness or success of a mitigation measure, or in some cases, monitoring methodology.

Project

The upgrade of the Pacific Highway between the Oxley Highway and Kempsey. The 37 kilometre upgrade section will be widened from the existing single carriageway to a four-lane dual carriageway.

Project footprint

The area in which all Project-related activities required for the completion of the upgrade will occur. The Project footprint will be directly affected by works including vegetation clearing and grubbing, cut and fill, establishment of stockpiles and compound areas.

Project area

The Project footprint in addition to adjoining similar habitat. This includes areas of Cairncross, Ballengarra and Maria River State Forests and Cooperabung and Rawdon Creek Nature Reserves.

Project Ecologist

A Project ecologist will be engaged during construction works by Roads and Maritime Services or the construction contractor. The Project ecologist will be degree qualified, suitably experienced with expertise in fauna rescue and hold current and relevant fauna handling licenses. The Project ecologist will manage and supervise all fauna rescue tasks to minimise the impacts on fauna.

Suitably Qualified Expert

An individual with tertiary qualifications and/or a minimum of three years demonstrated experience relevant to the task in question. The expert engaged to advise on **fauna crossings** must have expertise both in the ecology of Koalas and/or Spotted-tail Quolls and/or the Giant Barred Frog, as well as, the design and application of **fauna crossings** and road ecology.

2 BACKGROUND

2.1 ENVIRONMENTAL CONTEXT

The Project is located within the Port Macquarie-Hastings and Kempsey local government areas on the NSW mid-north coast.

Land use within the Project area includes residential, rural, commercial, industrial, state forests, national parks and reserves. Rural land use (grazing, aquaculture, oyster farming, orchards, tea tree plantations, vineyards, poultry farms, and other agricultural activities), state forests and conservation areas are the dominant land uses. The Project traverses Rawdon Creek Nature Reserve, Cairncross State Forest, Ballengarra State Forest and Maria River State Forest (Table 3). These state forests are scheduled for logging and contribute to State-wide logging production targets (GHD 2010).

Table 3: Conservation areas

State forest/ conservation area	Area (ha)	Location
Rawdon Creek Nature Reserve	560	Located west of the existing highway between the Hastings and Wilson rivers and maintains connectivity with Cairncross State Forest
Cairncross State Forest	5,908	Straddles the existing highway between the Hastings and Wilson rivers
Cooperabung Creek Nature Reserve	325	Previously part of Ballengarra State Forest
Ballengarra State Forest	6,325	Straddles the existing highway at Cooperabung Hill, north of Telegraph Point.
Maria River State Forest	2,119	Located east of the existing highway to the south of the Maria River

National parks in proximity to the Project include Kumbatine National Park, located approximately 100 metres to the west of the proposed alignment at the northern end of the Project, and Maria National Park located two kilometres to the east of the proposed alignment, also at the northern end of the Project. Kumbatine National Park covers approximately 15,100 hectares and adjoins the Kumbatine State Conservation Area, which covers an additional 783 hectares. Maria River National Park covers an area of 2,335 hectares that was formerly part of Maria River State Forest and vacant crown lands.

The Project intercepts five regional and two sub-regional corridors (Scotts 2003) that may facilitate the movement of fauna between coastal and inland habitats in response to seasonal resource ability and habitat conditions. Regional corridors are likely to support resident populations of certain fauna species, and to supplement habitats of wide-ranging, nomadic and migratory species. Sub-regional corridors serve more as routes for dispersal and movement for assemblage reference species and wide-ranging species, rather than habitats in their own right (Scotts 2003).

The Project spans two major rivers; the Hastings and Wilsons River (the Wilson River is a tributary of the Hastings River). There are two State–listed wetlands in the area; Dalhunty Island in the Wilson River and an area on the northern banks of the Wilson River near the Project alignment.

A number of second and third order streams flow through the Project area, such as Smiths Creek, Pipers Creek and Cooperabung Creek. Permanent and ephemeral drainage lines that flow under the existing Pacific Highway provide connectivity corridors for aquatic and riparian species.

2.2 MITIGATION OF POTENTIAL PROJECT IMPACTS

Planning for the Oxley Highway to Kempsey Upgrade, has followed a hierarchy of principles with regard to biodiversity values along the road corridor; avoid, minimise and mitigate impacts. Where impacts are unavoidable, mitigation and management measures are incorporated into the Project to reduce impacts.

2.2.1 IMPACTS OF ROAD UPGRADES

A major impact of roads is habitat fragmentation, where a division of otherwise continuous habitat reduces habitat connectivity. A reduction in habitat connectivity may impact upon the ability of an animal to move through habitat to obtain food, shelter and breeding resources. Other impacts of roads include mortality of wildlife due to collisions with vehicles; avoidance of roads by wildlife as a result of noise, light and pollutants associated with vehicles; and invasion along road edges by weeds and feral animals (QDMR 2000, Goosem 2005, van der Ree *et al* 2010, Mcall *et al* 2010).

These factors create a barrier to the movement of fauna and disrupt ecological processes, such as foraging and breeding activities, dispersal away from natal areas or seasonal migrations (van der Ree *et al* 2007). A disruption to such processes may affect the long-term viability of a population. As populations become smaller and more isolated, they are more susceptible to local extinction (Goosem 2005, Taylor and Goldingay 2009).The widening from the existing single carriageway to a four-lane dual carriageway will likely increase the existing barrier effect of the Pacific Highway, potentially reducing population viability further (Goosem 2005).

2.2.2 THREATENED SPECIES IN THE PROJECT AREA THAT MAY BE IMPACTED

Habitat adjoining the Project supports a diversity of fauna species that may be adversely affected by habitat fragmentation and resultant barrier effects, including threatened species listed under the *Threatened Species Conservation Act* (TSC Act) and *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC Act) (Table 4). The movement of gliders may be particularly affected by road widening: they may be deterred by the larger gap (i.e. a larger distance between trees) that may exceed their gliding capability; or may attempt to cross and fall short of reaching vegetation on the other side of the road, resulting in increased mortality (van der Ree *et al* 2010, Mcall *et al* 2010).

Table 4: Fauna species known or likely to occur in Project area that may be potentially affected by habitat fragmentation

Fauna group	Scientific Name	Common Name	Status under TSC Act	Status under EPBC Act	Occurrence in Project area
Gliders	*Acrobates pygmaeus*	Feathertail glider	-	-	Known
	Petaurus australis	Yellow-bellied glider	Vulnerable	-	Known
	Petaurus breviceps	Sugar Glider	-	-	Known
	Petaurus norfolcensis	Squirrel Glider	Vulnerable	-	Moderate likelihood
Arboreal mammals	*Phascolarctos cinereus*	Koala	Vulnerable	Vulnerable	Known
	Trichosurus vulpecula	Common brushtail possum	-	-	Known
	Pseudocheirus peregrinus	Common ringtail possum	-	-	Known
	Phascogale tapoatafa	Brush-tailed Phascogale	Vulnerable		High likelihood
Frogs	*Mixophyes iteratus*	Giant Barred Frog	Vulnerable	Endangered	Known
	Litoria brevipalmata	Green-thighed frog	Vulnerable		Known
Terrestrial mammals	*Melomys cervinipes*	Fawn-footed melomys	-	-	Known
	Isoodon macrourus	Northern Brown bandicoot	-	-	Known
	Perameles nasuta	Long-nosed bandicoot	-	-	Known
	Rattus fuscipes	Bush rat	-	-	Known
	Rattus lutreolus	Swamp rat	-	-	Known
	Macropus giganteus	Eastern grey kangaroo	-	-	Known
	Macropus rufogriseus	Red-necked wallaby	-	-	Known
	Wallabia bicolor	Swamp wallaby	-	-	Known

Fauna group	Scientific Name	Common Name	Status under TSC Act	Status under EPBC Act	Occurrence in Project area
	Tachyglossus aculeatus	Short-beaked echidna	-	-	Known
	Dasyurus maculatus	Spotted-tailed Quoll	Vulnerable	Endangered	Moderate likelihood

Some of these species will be used as indicator species to measure the success of fauna crossings. This is described in more detail in Section 4.2.4.

The upgrade will not represent a barrier to all species; bats and most birds are readily capable of traversing the gap created by a dual carriageway, and would likely fly between the canopies above traffic height. Species that fly at lower elevations, such as Glossy Black Cockatoos (*Calyptorhynchus lathami*) and Grey-crowned Babblers (*Pomatostomus temporalis temporalis*) may be at increased risk of vehicle strike; potential impacts can be reduced by planting feed trees a short distance away from the carriageways

2.2.3 OBJECTIVE OF MITIGATION MEASURES

Crossing structures such as underpasses (culverts, tunnels) and overpasses (land bridges, rope bridges, glider poles) are increasingly being adopted in highway designs to mitigate barrier effects and reduce mortality rates of fauna (Mata 2003, McKenzie and Royle 2005, Soannes and van der Ree 2007, van der Ree *et al* 2009).

The Project incorporates several physical structures that aim to maintain habitat connectivity, allowing fauna to safely move between areas of habitat to the east and west of the Project. These structures include combined and dedicated fauna underpasses, rope bridges, glider poles, a widened median and associated fauna fencing. Underpasses will typically facilitate movement of smaller animals, while the widened median, rope bridges and glider poles will allow for the safe crossing of arboreal and gliding mammals.

2.2.4 INDICATOR SPECIES

The effectiveness of wildlife crossings will be based on their use by fauna groups previously recorded in proximity to the Project (<one kilometre). It is assumed that the Project bisects the habitat of at least some individuals from each of the nominated fauna groups (Table 4). Fauna species known to occur within the Project area that may be potentially adversely affected by the upgrade are listed in Table 5. These species will indicate the successful usage of crossing structures.

Table 5: Indicator and target species to assess usage of crossings

Fauna group	Indicator species (known from Project area)	Target (threatened) species
Frogs	*Litoria sp., Limnodastyes sp., Crinia sp.,* Giant barred frog	Green-thighed frog, Giant barred frog
Small ground-dwelling mammals	*Antechinus,* rodents and bandicoots, echidna, Spotted-tail Quoll	Spotted-tail Quoll, brush-tailed phascogale
Arboreal mammals	Brush-tail possum, ringtail possum	Brush-tailed phascogale
Koala	Koala	Koala
Gliders	Sugar glider, feathertail glider	Squirrel glider, yellow-bellied glider
Macropods	Swamp wallaby, red-necked wallaby, eastern grey kangaroo	N/A

The effectiveness of each structure for the EPBC species will be determined by the complete, safe crossing of the crossing by the targeted EPBC species at a sufficient frequency to ensure that habitat connectivity is maintained or improved from baseline conditions, and ongoing population viability by providing opportunities for species dispersal and re-colonisation; and result in reduced incidence of road kill from baseline conditions.

For other species effectiveness of each structure will be determined by the complete passage of one or more individuals from each of the six groups, provided that they have been identified as a target species for that underpass (see Table 12).

3 BASELINE MONITORING

In accordance with MCoA B10 (d), baseline monitoring will be undertaken to identify changes in habitat usage before and after construction of the Project, and whether changes can be directly attributed to the Project. Baseline monitoring results for the EPBC listed species, that address the densities, distribution, habitat use and movement patterns of these species, has been included in Appendix A. The CV of the ecologist who conducted these surveys is included in Appendix B to demonstrate that they meet the definition of 'suitably qualified expert'.

Habitat usage refers to the way fauna species use habitat features to survive and reproduce (Lindenmayer and Burgman 2005). Habitat features include food resources (nectar, pollen, blossom, lerp, foliage, or other animals); breeding resources (tree hollows, hollow logs, nests, caves, rocky features or crevices) and shelter (leaf litter, vegetation, tree or log hollows).

Habitat usage by a particular species may vary with seasons, weather conditions, breeding and dispersal periods and the availability of food and shelter resources. Habitat usage may also change as a result of direct or indirect impacts of the Project. A primary impact of the Project, habitat fragmentation, may adversely affect the ability of an animal to access or move through habitat to obtain food, shelter and breeding resources.

3.1 SITE FOR MONITORING: CONTROL AND IMPACT SITES

Baseline monitoring undertaken for this Ecological Monitoring Program has been designed in accordance with the 'Before After Control Impact' (BACI) design. In BACI design, data is collected at Impact sites and at Control sites both before and after the impact occurs (Underwood 1991). This design is preferred over a simple Before-After comparison as a change in the results collected may occur independently of any impact because of temporal effects. For example, changes in the abundance or distribution of a species, between the before and after periods, may be related to external variables such as bushfire rather than the construction of the upgrade.

The exact number and location of Control and Impact sites will be determined during a site visit by the Project Ecologist prior to the commencement of baseline surveys, in consultation with Roads and Maritime. Control and Impact sites will generally be paired, and will be selected with regard to localised habitat conditions at that time; stochastic events between the date of publication of this document and Project completion (e.g. bushfire) may affect the location of Control and Impact sites.

3.1.1 CONTROL SITES

Control sites will be located adjacent to roads in the locality that are not being upgraded and do not support wildlife crossing structures. Control sites should be located in habitat similar to that in which the Impact sites are located, with similar physical features; however Control sites do not need to have identical characteristics as Impact sites (Underwood 1994). Where Control sites are not specified for each target species, potential Control sites could be located at:

- Oxley Highway, west of the Pacific Highway at southern extent of the Project.
- Pembroke Road, west of the Pacific Highway in proximity to Cairncross State Forest and Rawdon Creek Nature Reserve.
- Rollands Plains Road, west of the Pacific Highway and north of the Wilson River.
- Old Coast Road, west of the Pacific Highway in proximity to Maria River State Forest.
- Smiths Creek Road, west of the Pacific Highway in proximity to Ballengarra State Forest.

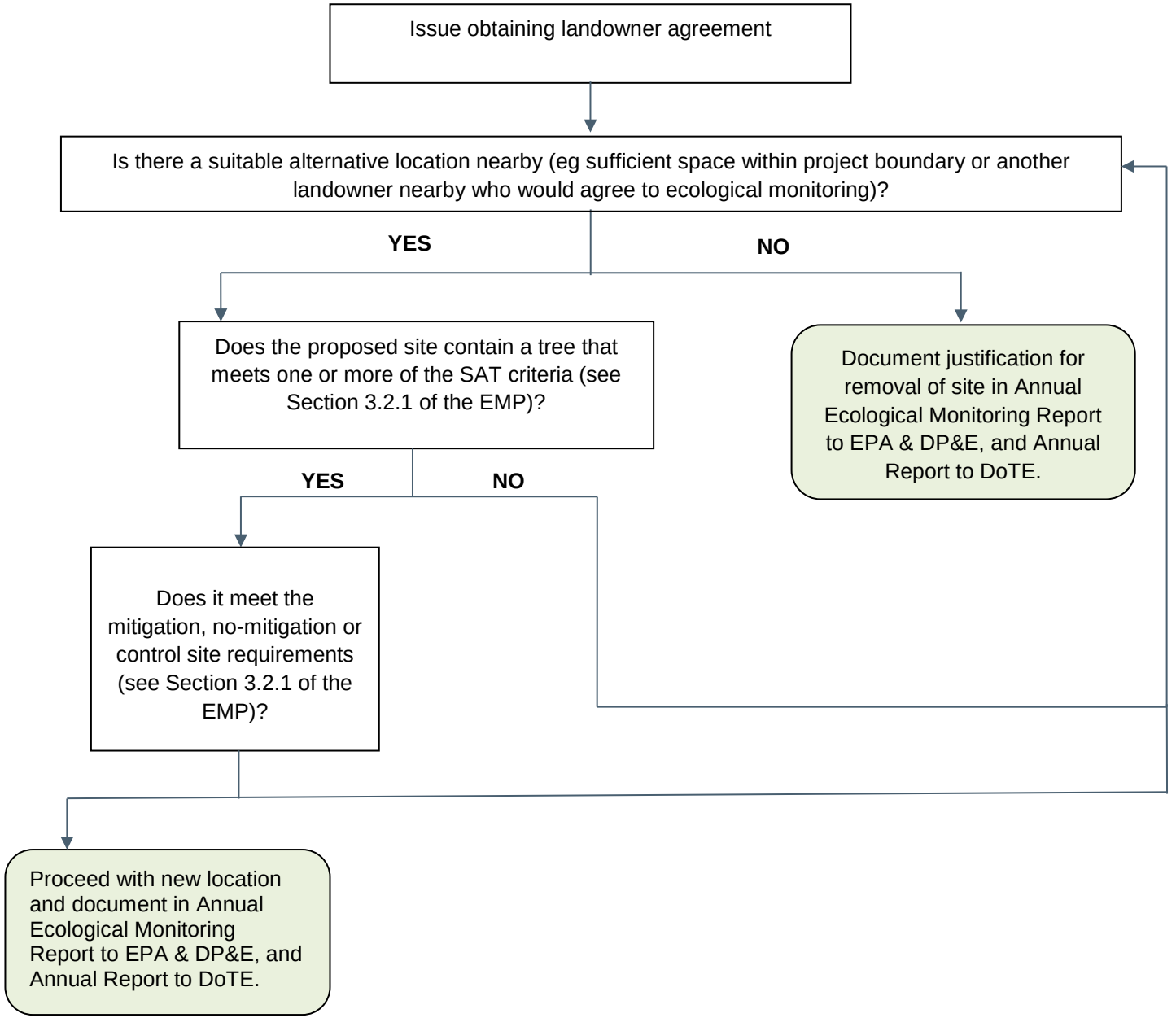
- Scribbly Gum Road, east of the Pacific Highway in proximity to Maria River State Forest.
- Crescent Head Road, east of the Pacific Highway at northern extent of the Project.

3.1.2 IMPACT SITES

Impact sites will be located in habitat adjacent to the completed Project and:

- Near dedicated and combined fauna passes, rope bridges, glider poles and the widened median.
- Some sites should be located away from fauna crossing structures.
- Should be stratified; i.e. be located in each habitat type that occurs adjacent to the Project.
- Should be located both near and away from drainage features.

Where landowner agreement cannot be obtained for control or impact sites, the following process will be implemented:


Issue obtaining landowner agreement
Is there a suitable alternative location nearby (eg sufficient space within project boundary or another landowner nearby who would agree to ecological monitoring)?
YES
NO
Does the proposed site contain a tree that meets one or more of the SAT criteria (see Section 3.2.1 of the EMP)?
Document justification for removal of site in Annual Ecological Monitoring Report to EPA & DP&E, and Annual Report to DoTE.
YES
NO
Does it meet the mitigation, no-mitigation or control site requirements (see Section 3.2.1 of the EMP)?
Proceed with new location and document in Annual Ecological Monitoring Report to EPA & DP&E, and Annual Report to DoTE.

3.2 THREATENED SPECIES TO BE MONITORED

As required by the Department of the Environment CoA 4a., the methodology for the pre-construction baseline surveys for the Spotted-tail Quoll, Koala and Giant Barred Frog are provided below, with the results provided in Appendix A. The baseline survey methodology for the Green-thighed frog and Yellow-belled glider have also been included, given that they are threatened species listed under the EPBC and/or TSC Act, are known to occur in proximity to the proposed alignment and may be potentially affected by habitat fragmentation. The baseline survey methodology for the Squirrel Glider and Brush-tail Phascogale have been included given that they are threatened species listed under the TSC Act, are predicted to occur in proximity to the proposed alignment and may be potentially affected by habitat fragmentation.

Generally, all locations of known or potential habitat identified for each species below comprises an Impact site, as outlined in section 3.1.2. These sites will be monitored before and after construction of the Project and will be compared to Control sites.

3.2.1 KOALA

One Koala was sighted during field surveys undertaken for the EA crossing the highway approximately 200 metres south of Sancrox Road. Searches for koala scats and scratches on potential feed trees indicated recent koala activity within Ballengarra State Forest and south of Sancrox Road (GHD 2010). More recently, road kill koalas have been identified within the Project area at Wharf Road, Cooperabung Road, at the southern extent of Maria River State Forest and near Stumpy Creek (B Lewis 2013 pers. comm. 11 Sept).

Koala feed trees occur throughout much of the Project area, occurring in most vegetation communities (with the exception of swamp oak forest and cleared open pasture/weedy fallow). Koala feed trees are common to dominant canopy species in moist floodplain forest, moist slopes forest, riparian forest and swamp mahogany/forest red gum swamp forest (GHD 2010). Koalas may occur along the entire length of the Project; however, GHD (2010) has identified areas in which koalas are most likely to occur:

- Either side of Sancrox Road.
- Cairncross State Forest.
- Rawdon Creek Naure Reserve.
- Cooperabung Hill (Ballengarra State Forest and Cooperbung Nature Reserve).
- Mingaletta Road to Smiths Creek.
- Kundabung Road to north of Pipers Creek.
- Maria River State Forest.

The *Comprehensive Koala Plan of Management for Eastern Portion of Kempsey Shire LGA* (Kempsey Shire Council 2011) aims to provide for conservation of areas of habitat most important to koala populations in the eastern portion of Kempsey Shire. The Plan includes preferred koala habitat mapping that encompasses the Kundabung to Kempsey portion of the Project. This mapping shows that the Project transects large areas of Secondary Preferred Koala Habitat (Class B). The Project adjoins very few areas of Secondary Preferred Koala Habitat (Class A) and patches of Other Vegetation (not koala habitat) and Unknown Vegetation (predominantly cleared or partially cleared). Maria River State Forest, Kalateenee State Forest and Kumbatine National Park are exempt from any Preferred Koala Habitat classification.

Secondary Preferred Koala Habitat (Class B) comprises vegetation communities and/or associations in which primary food trees are absent and secondary and supplementary food tree species (*E. propinqua, E. globoidea* and/or *E, tindaliae)* are present. Secondary Preferred

Koala Habitat (Class A) comprises vegetation communities and/or associations in which primary food trees are sub-dominant components of the overstorey tree species and usually (but not always) growing in association with one or more secondary food tree species.

Timing

Baseline koala surveys were undertaken in the spring-summer period prior to the commencement of works, and will be undertaken in spring-summer once substantial construction has commenced in Year 1, 2 and 3 (construction phase) and Year 4, 5, 6 and 8 (operation phase) or until mitigation measures can be demonstrated to have been effective for the Koala, as defined in the EPBC approval.

Monitoring procedure

The Spot Assessment Technique (SAT) developed by Phillips and Callaghan (2011) will be used to monitor baseline populations of koalas, in accordance with *Interim koala referral advice for proponents* (DSEWPC 2012). The SAT method involves a radial assessment of koala activity within the immediate area surrounding a tree that is known to have been utilised by the species or is considered to be of importance to the species. The SAT will be applied in the eight areas of habitat likely to represent core koala habitat within the project area (Impact sites), listed below:

- South of Sancrox Road.
- North of Sancrox Road
- Cairncross State Forest (south).
- Cairncross State Forest (north).
- Cooperabung Hill (Ballengarra State Forest and Cooperbung Nature Reserve).
- Mingaletta Road to Smiths Creek.
- Kindabung Road to north of Pipers Creek.
- Maria River State Forest.

The treatments include:

- Mitigation (Treatment A) centred on areas of sufficiently large culverts (ie > 1.8m) and floppy top fencing;
- No Mitigation (Treatment B) where the mitigation described above has not been proposed or only part mitigation is proposed;
- Control or reference (Treatment C) located in areas at least 3km and often 5-10km from the Project.

The Spot Assessment method as developed by Phillips and Callaghan (2011) is described below:

1) Locate and mark a tree that meets one or more of the following selection criteria:

    a) A tree of any species beneath which one of more koala faecal pellets have been observed; and/or

    b) A tree in which a koala has been observed; and/or

    c) Any other tree known or considered to be important for koalas, or of interest for other assessment purposes.

2) Identify and mark the 29 nearest trees to the tree marked initially.

3) Undertake a search for koala faecal pellets beneath each of the 30 marked trees. Visually inspect the ground surface beneath trees to a distance of one metre from the trunk. If no pellets are observed, a more thorough inspection involving raking the leaf litter and inspection of the ground cover within the prescribed search area. Two person minute per tree should be dedicated to the search for faecal pellets. The search should be concluded once a single pellet is found or the search time has expired (whichever happens first). Faecal pellets should not be removed from the site unless verification is necessary.

4) The activity level of a site is calculated as the percentage of surveyed trees within the site (of 30 trees) that has a koala faecal pellet recorded within its search area. The result is used to assess whether the site supports "Low", "Medium (normal)" or "High" koala activity (Table 6).

Table 6: Categorisation of koala activity (Phillips and Callaghan 2011)

Activity Category	Low use	Medium (normal) use	High use
East coast (low density area)	-	3.33% but ≤12.59%	>12.59%
East coast (medium-high density area)	<22.52%	≥22.52% but ≤32.84%	>32.84%
Western Plain (medium-high density area)	<35.84%	≥35.84% but ≤46.72%	>46.72%

5) The results of the survey will be recorded. Attributes to be included in the report include date, weather conditions, geographic coordinates of the search area, selection criteria, tree species assessed, DBH of trees assessed and radial search area surveys (distance from centre tree).

Performance Measures

- Monitoring is undertaken during baseline surveys and from Year 1 – Year 6 & 8, or until mitigation measures are demonstrated to be effective.
- Monitoring during Year 1 – 6 & 8 is undertaken at the Impact and Control sites where monitoring was undertaken during baseline surveys, subject to ongoing landowner agreement. Where landowner agreement cannot be obtained and the process in Section 3.1.2 has been followed, this performance indicator will also be considered to have been met.
- Mitigation measures are demonstrated to be effective as defined in the EPBC approval when all monitoring events are considered at Year 8.
- Fauna fence is installed at a minimum in areas identified in Schedule 3 of the EPBC approval at Year 4.
- No change to densities, distribution, habitat use and movement patterns compared to baseline data during monitoring in Year 1 – 6 & 8, and then when all monitoring events are considered at Year 8.

3.2.2 SPOTTED-TAILED QUOLL

The spotted-tail quoll was not recorded in the Project area during field surveys undertaken for the Environmental Assessment (GHD 2010). The habitat assessment performed as part of the field surveys reported suitable den and latrine sites in the form of rock shelters and small caves

were absent whilst large logs were generally found to be sparsely scattered throughout the Project area (GHD 2010). Nonetheless, it was still considered a likely inhabitant of the Project area as this species is known from multiple records in Limeburners Creek Nature Reserve around 5-10 km to the east.

Database searches (registered licence user CONO1022) identified 75 records of Spotted-tailed Quoll within 10 km of the Upgrade. Most of the records have originated from a community survey performed by Dan Lunney with recording dates spanning relatively long time periods of 10-20 years (e.g. 1991-2006). Apart from several records located within the residential landscape of Port Macquarie most records are broadly associated with large patches of contiguous vegetation. Interestingly, there are only a handful of records in close proximity to the existing Pacific Highway with these being located around the southern boundary of the Upgrade (i.e. Port Macquarie Interchange, Cowarra State Forest and Lake Innes), just to the north west of the Telegraph Point and two records in Maria River State Forest in the northern part of the Upgrade. There was a reported road kill quoll from July 1992 at Ch. 35500 with another reported road kill originating from the Oxley Highway which bisects Cowarra State Forest 5 km west of the southern end of the Project.

Timing

Spotted-tail quoll surveys will be undertaken during high movement periods for the species. The spotted-tail quoll typical breeds between April to August and disperses in spring and summer (Belcher 2003).

Baseline camera surveys were conducted in August 2013, prior to the commencement of construction, and additional surveys will be conducted in Autumn/ Winter (preferably March – mid-July) in Year 4, 6 and 8 (operation phase) or until mitigation measures can be demonstrated to have been effective for the Spotted-tail Quoll, as defined in the EPBC approval.

Monitoring procedure

Monitoring for the Spotted-tailed Quoll will be undertaken in three broad areas, which have been selected as they comprise the largest patches of vegetation, referred to here as Cairncross State Forest, Ballengarra State Forest and Maria River State Forest (Table 7).

Table 7 Monitoring sites for Spotted-tailed Quoll

Area	Monitoring Sites (each is 100 hectares)
Cairncross State Forest (dry sclerophyll forest with some swamp forest associations)	3 Control sites 3 Impact sites in proximity to fauna underpasses 3 Impact sites where no specific quoll mitigation (fauna underpasses) has been proposed
Ballengarra State Forest (dry sclerophyll forest with some moist forest and swamp forest associations)	3 Control sites 3 Impact sites in proximity to fauna underpasses 3 Impact sites where no specific quoll mitigation (fauna underpasses) has been proposed
Maria River State Forest (dry sclerophyll forest with some moist forest and swamp forest associations)	3 Control sites 3 Impact sites in proximity to fauna underpasses 3 Impact sites where no specific quoll mitigation (fauna underpasses) has been proposed

Within each of the three areas, a stratified BACI (Before-After-Control-Impact) survey design will be adopted following consultation with the EPA and include the following three treatments:

- 1 x **reference site** unaffected by the Project. The location of the reference site will be greater than 5 km from the Project corridor and often 7-10 km away. Every attempt will be made to locate a site which exhibits a similar array of topography and habitat attributes as both the nominated control and treatment sites located within the Project corridor.
- 1 x **control site** where no specific quoll mitigation has been proposed within the Project for >500 m. For the purposes of this study, quoll mitigation is deemed as a fauna underpass structure referred to as a dedicated or combined fauna underpass (SMEC-Hyder 2013). Drainage culverts will be ignored in this instance because they are not being installed for the purpose of facilitating fauna movements; and
- 1 x **treatment site** where fauna underpasses will be located in neighbouring areas to the control (no mitigation) site. A treatment site will be considered suitable if there is a

combined or dedicated fauna underpass proposed within 500 m. Bridges will not be considered in this survey design following consultation with the EPA who recognised they provide an acceptable form of habitat connectivity to most ground dwelling fauna.

The above survey design will be repeated at three locations to provide a stratified sampling design of three replicates of each treatment within each of the three survey areas (Cainrcross, Ballengarra, Maria River). This will result in 9 x 100 ha survey plots across three treatments for each area culminating in 2700 ha.

The adopted sampling regime will be commensurate to the Department of Sustainability and Environment Approved Survey Standards: Spot-tailed Quoll *Dasyurus maculatus maculatus* publication (DSE 2011). At each monitoring site, four remotely triggered cameras (Faunatech, ScoutGuard or similar) will be installed 500 metres apart across each 100 ha plot with three plots representing each treatment (n=12 cameras) for each of the large patches of vegetation (Table 7). Cameras will operate continuously for 24 hours over 21 consecutive nights. Camera stations will be baited using an olfactory predator lure of chicken, fish or canned cat food so as to attract the animal into the area and allow sufficient opportunity for the camera to take a picture. This baiting will occur at the commencement of the study with the bait cached into a bag or cage.

At each camera station, the following habitat attributes will be recorded:

- Structure and floristics of vegetation, including dominant species of each vegetation stratum, height and per cent cover.
- Presence and type of hydrological and surface drainage features.
- Presence and type of rocky features.
- Abundance and type of tree and log hollows.

Performance Measures

- Monitoring is undertaken in Year 4, 6 and 8 or until monitoring can demonstrate that mitigation measures are effective.
- Monitoring during Year 4, 6 & 8 is undertaken at the Impact and Control sites where monitoring was undertaken during baseline surveys, subject to ongoing landowner agreement.

3.2.3 GIANT-BARRED FROG

The Giant Barred Frog was recorded at Maria River and suitable habitat was identified at Smiths Creek, Pipers Creek and Cooperabung Creek during surveys undertaken to inform the Environmental Assessment (GHD 2010). Targeted surveys undertaken over eight nights between late November 2012 and late January 2013, involving spotlighting, call- playback and tadpole searches, identified the Giant Barred Frog at Cooperabung Creek (south), Cooperabung Creek downstream at Haydons Wharf Road, Smiths Creek, Pipers Creek and Maria River. Areas of suitable habitat for the Giant Barred Frog were also identified at both Stumpy Creek and Barrys Creek (Lewis Ecological Surveys 2013a).

Timing of monitoring

Baseline data will be collected prior to construction and consist of one survey in autumn, spring and summer (i.e. three surveys) prior to the commencement of construction. Baseline surveys will be conducted within one week following rainfall events when at least 10 millimetres of rain is recorded within a 24 hour period.

Construction monitoring will be conducted once substantial construction has commenced in spring, summer and autumn of Year 1, 2 & 3.

Following completion of the Project, surveys will be undertaken for five consecutive years, in spring and summer and autumn of Year 4, 5, 6, 7 and 8 (operation phase) or until mitigation measures can be demonstrated to have been effective for the Giant-Barred Frog, as defined in the EPBC approval.

Surveys will occur in the middle of each season.

Water quality monitoring is also being conducted within Giant-Barred Frog habitat and potential habitat. Water quality monitoring commenced at least 12 months prior to the commencement of construction, and will continue during construction and for three years post construction completion.

Monitoring Procedure

Monitoring procedures for the Giant Barred Frog described here have been extracted from the *Giant Barred Frog Management Strategy* (Lewis Ecological Surveys 2013).

Four areas of habitat for the Giant Barred Frog will be monitored:

- Cooperabung Creek.
- Smiths Creek.
- Pipers Creek.
- Maria River.

In addition, two reference sites will be monitored:

- Sun Valley Road, where it crosses Cooperabung Creek, several kilometres upstream of the Project footprint.
- Old Coast Road, where it crosses Pipers Creek, several kilometres upstream of the Project footprint.

Each survey period will involve:

- Call-playback. Upon arrival at site, listen for vocalisations for 10 minutes. Play calls intermittently for 15 minutes. Listen for another 10 minutes.
- Frog surveys. Surveys will comprise two person hours per one kilometre transects. A one kilometre transect will be established at each monitoring site, which extends 450 metres upstream and downstream of the Project footprint (assumes project boundary width of 100 metres). This is subject to landowner agreement.
- Habitat surveys. The following variables will be recorded within the 100 metre zones established along the one kilometre transect at each monitoring site (subject to landowner agreement), from the top of the primary stream bank:
    - Overstorey vegetation cover (expressed as a cover percentage out of 100%).
    - Shrub cover (expressed as a cover percentage out of 100%).
    - Ground cover (expressed as a cover percentage out of 100%).
    - Leaf litter cover (expressed as a cover percentage out of 100%).
    - Bare soil/earth (expressed as a cover percentage out of 100%).
    - Presence of cattle (based on hoof marks, manure and whether it is recent or aged evidence).
    - Number of pools and riffles within the zone.
    - Approximate depth of the deepest pool within the zone.
    - Number of breaches in frog fencing, if applicable.

Any captured Giant Barred Frogs will be fitted with a Passive Integrated Transponder (PIT) tag. The PIT system is a radio-frequency identification tag which consists of an electromagnetic coil, tuning capacitor and microchip. The PIT tag is implanted under the skin or in the body cavity. Each PIT tag is encoded with a unique alphanumeric code, which may be read directly by a hand-held scanner.

Juvenile/sub adult frogs (<40 mm snout vent length) may be marked in accordance with the animal care and ethics licence of the Project Ecologist or frog expert. The frog hygiene protocol will be adopted at Giant Barred Frog survey sites. This protocol will be in accordance with Department of Environment and Climate Change (DECC) (now EPA) *Hygiene protocol for the control of disease in frogs Information Circular Number 6* (2008).

For each Giant Barred Frog captured, the following data will be recorded:

- Location according to demarcated survey zone.
- Distance from stream edge.
- Sex (male, female, unknown).
- Breeding condition with:
    - Males assessed on the colouration of their nuptial pads (i.e. no colour, light moderate, dark)
    - Females based on whether they are gravid or not gravid (egg bearing).
- Snout-vent length (millimetres).
- Weight (grams).
- General condition of the frog, including a swab sampled to test for the presence of Chytrid fungus.

Additional variables that will be collected during each survey will include:

- Rainfall measured in four scales:
    - During the survey.
    - Within past 24 hrs.
    - Within past 7 days.
    - With past 30 days.
- Relative humidity measured with wet/dry bulb thermometer at the start and finish of the frog survey.
- Air temperature measured with a thermometer at the start and finish of the frog survey.
- Wind speed measured in subjective scale (0= no wind, 1 = light rustles of leaves on trees, 2 = leaves and branches moving and 3 = whole canopy moving).
- Water level measured with a permanently installed water staff or an electronic device if available from the Bureau of Meteorology (BOM).
- Anecdotal information such as the presence of exotic fish.

Water quality monitoring in Giant-Barred habitat and potential habitat will be undertaken as outlined in Table 8 and Table 9 below.

Table 8 Water quality monitoring frequency in Giant-Barred Frog habitat

Project phase	Frequency
Pre-construction	All parameters except trace metals: one wet event per month and one dry event per month Trace metals: one wet event and one dry event per quarter
Construction*	All parameters except trace metals: two wet events per month and one dry event per month Trace metals: one wet event and one dry event per month
Operations*	All parameters except trace metals: one wet event per month and one dry event per month Trace metals: one wet event and one dry event per quarter

Table 9 Parameters to be measured during water quality monitoring

Parameter type	Parameter	Analysis type
Chemical properties	pH	In field measurement
	Dissolved oxygen (DO)	In field measurement
Physical properties	Electrical conductivity (EC)	In field measurement
	Temperature	In field measurement
	Turbidity (NTU)	In field measurement
	Total suspended solids (TSS)*	Laboratory analysis
Chemical properties	Total Petroleum Hydrocarbons	In field visual assessment. If oils and grease are visually evident, a sample will be forwarded to the laboratory for analysis.
	Trace metals: Aluminium (Al) Arsenic (As) Cadmium (Cd) Chromium (Cr) Copper (Cu) Iron (Fe) Lead (Pb) Manganese (Mn) Mercury (Hg) Nickel (Ni) Silver (Ag) Zinc (Zn)	Laboratory analysis
Nutrients	Total Nitrogen (TN)	Laboratory analysis
	Total Phosphorous (TP)	Laboratory analysis

Performance Measure

- Monitoring is undertaken during baseline surveys and Years 1 – 8 or until monitoring can demonstrate that mitigation measures are effective.

- Monitoring during Year 1 – 8 is undertaken at the Impact and Control sites where baseline monitoring was undertaken, subject to landowner agreement (see Section 3.1.2).
- Continued presence of Giant Barred Frogs during each survey event in Year 1 – 8 at sites where it was identified during baseline surveys, subject to access due to landowner agreement (see Section 3.1.2).
- Mitigation measures are effective as defined in the EPBC approval when all monitoring events are considered at Year 8.
- Median values of all downstream water quality monitoring at GBF habitat or potential habitat locations during construction and operation (Year 1 – 6) is less than the 80th percentile value of the upstream site (where 80th percentile is the value at which median values at the downstream site are *above* 80% of the recorded background water quality records), where this change is found to be attributable to construction or operation.
- No change to densities, distribution, habitat use and movement patterns compared to baseline data during monitoring in Year 1 – 8, and then when all monitoring events are considered at Year 8.

3.2.4 GREEN-THIGHED FROG

A population of at least 10 Green-thighed frogs were observed and heard calling from vegetation surrounding a flooded pool in Maria River State Forest, suggesting this could comprise potential breeding habitat. The species has also been recorded in Rawdon Creek Nature Reserve (GHD 2010). Targeted surveys undertaken in January 2013 identified over 38 Green-thigh frogs at seven locations (all comprising potential breeding sites) between Cairncross State Forest (Ch.9050, Blackmans Point Road) and Kalatennee State Forest (Ch.33650) (Lewis Ecological Surveys 2013b).

Dry sclerophyll forest communities, Riparian Forest, Moist Floodplain Closed Forest with Rainforest Elements, Paperbark Swamp Forest, Swamp Mahogany/Forest Red Gum Swamp Forest, Moist Floodplain Forest, Moist Gully Forest and Moist Slopes Forest in the Project area offer potential habitat to the species (GHD 2010, Lemckert *et al* 2006, Lewis Ecological Surveys 2013 c).

Timing of monitoring

Baseline data was collected between 27th and 30th January 2013, when the study area received in excess of 200 millilitres over a 48 hour period.

Construction of the Project will directly impact (remove) or indirectly impact at least seven known breeding and non-breeding habitat areas for the Green-thighed Frog. As a result, monitoring will be unable to be undertaken at these sites during construction and following completion of the Project. Instead, constructed breeding ponds will be monitored and timing is detailed in Section 4.9.

Monitoring Procedure

Monitoring procedures for the Green-thighed Frog are in accordance with the *Green-thighed Frog Management Strategy* (Lewis Ecological Surveys 2013b) and Lemckert *et a*l (2006).

Baseline Green-thighed Frog surveys were undertaken at 27 sites that were identified as the most likely locations to support the species. Each site was then visited between one to three occasions to listen for calling males with an estimate provided on the calling intensity. The sites were again revisited on the 28th March 2013 to investigate the overall success of the January breeding event, approximately 57 days after the calling/breeding event. During these surveys active searches were performed for 20 minutes to survey for metamorphs around the pond

edges and the surrounding vegetation, litter and beneath logs. Dip-netting for tadpoles was also undertaken.

Following completion of the Project, constructed breeding ponds will be monitored and this methodology is detailed in Section 4.9

Performance Measures

Following completion of the Project, constructed breeding ponds will be monitored and performance measures for this monitoring are detailed in Section 4.9.

3.2.5 YELLOW-BELLIED GLIDER

The Yellow-bellied glider was recorded calling in northern Ballangarra State forest during surveys undertaken in 2007 (GHD 2010). Larger tracts of forest communities offer potential habitat to this species. Hollow-bearing trees are used for sheltering and breeding. More recently, the species has been identified in Caircross State Forest (at approximately Ch. 10400) and Maria River State Forest (east of the Maria River bridge).

Timing of monitoring

Baseline yellow-bellied glider surveys will be undertaken during high movement periods for the species. The yellow-bellied glider typically breeds between July and September and disperses between spring and summer. Surveys will be undertaken in spring prior to the commencement on construction and in August-December in Year 4, 6 and 8 (operation phase).

Monitoring Procedure

Each survey period (Kavanagh and Bamkin 1995, Wintle *et al* 2005) will involve:

- Call-playback. Upon arrival at site, listen for vocalisations for 10 minutes. Play calls intermittently for 15 minutes. Listen for another 10 minutes. Vocalisations of this species can be heard up to 400 metres away. Surveys to be repeated three times in each season
- Spotlighting. Surveys will conducted along 500 metre transects, with the observer walking at a rate of 30 minutes/500 metres. Surveys to be conducted on three non-consecutive nights. Although this species is considered spotlight-shy, it may be detected by its frequent movements during foraging activities. Listen for vocalisations.

Performance Measures

- Monitoring is undertaken before and after construction of the upgrade.
- Monitoring is undertaken at Impact and Control sites.
- Continued presence of Yellow-bellied gliders at sites where it was identified during baseline surveys.

3.2.6 BRUSH-TAILED PHASCOGALE

The Brush-tailed Phascogale (*Phascogale tapoatafa*) has not been identified within the Project area. It was considered likely to occur in Moist Slopes Forest and Dry Ridgetop Forest (GHD 2010).

Ecological investigations undertaken by Lewis Ecological Surveys of the proposed alignment in October 2012 identified areas of potential Brush-tailed phascogale habitat. It was noted that Cairncross State Forest likely facilitates the movement of the species through the landscape, although there is a lack of preferred habitat features such as hollow-bearing trees in the area. Potential phascogale habitat in the north of the Project occurs from Ch. 17100 (Wilsons River) to Ch. 37600, encompassing previous records of the species, mapped regional corridors, expanses of native vegetation contained in Cooperabung Nature Reserve and Ballengarra and Maria River State Forests. There is a recent (<5 years) record of the species partly cleared Swamp Oak Floodplain forest in proximity to the southern bank of the Wilsons River, on the eastern side of the existing highway (B Lewis 2012 pers. comm. 18 Oct.). Potential Phascogale habitat (possible Impact sites) is located at:

- Ch.11680. In proximity to dedicated fauna culvert F11.68. Both sides of carriageway.
- Ch.21240. In proximity to dedicated fauna culvert F21.24. Both sides of carriageway.
- Ch.23100. In proximity to Barrys Creek bridge. Both sides of carriageway.

- Ch. 347200. In proximity to dedicated fauna culvert F34.72. Both sides of carriageway.

Timing of monitoring

Baseline Brush-tail Phascogale surveys will be undertaken during high movement periods for the species. The Brush-tail Phascogale typically breeds between May and July and disperses in mid- summer (Strahan 2005). Surveys will be undertaken in summer prior to the commencement of construction and in winter and summer in Year 4, 6 and 8 (operation phase).

Monitoring Procedure

Surveys will be undertaken in areas of phascogale habitat. Surveys will comprise:

- Arboreal trapping**.** A grid configuration of 10 Elliot B traps will be established in approximately one hectare of habitat on both sides of the carriageway. Elliot B Traps baited with vegetable bait will be positioned on brackets approximately two metres above the ground and left operating over four consecutive nights.Hair tubes. A grid configuration of arboreal hair-tubes will be established in approximately one hectare of habitat and will be baited with vegetable bait. Transects will be established for a period of 14 consecutive nights per season. Hair samples will be sent to an appropriately qualified/experienced specialist for identification.

For each Phascogale captured, the following attributes will be recorded:

- Sex.
- Age class.
- Weight.
- Breeding condition.

Performance Measures

- Monitoring is undertaken before and after construction of the upgrade.
- Monitoring is undertaken at Impact and Control sites.
- Presence of adults and/or lactating Brush-tailed phascogales during Brush-tail Phascogale monitoring and/or nest box monitoring.

3.2.7 SQUIRREL GLIDER

The Squirrel Glider has not been identified within the Project area. It was considered likely to occur in Moist Slopes Forest and Dry Ridgetop Forest (GHD 2010).

Timing of monitoring

Squirrel Glider surveys will be undertaken in gaps between flowering resource availability, when baited traps are likely to have the highest success rate (typically during autumn). Surveys will be undertaken between April and August (exact timing depends on gaps in flowering resources) in Year 4, 6 and 8 (operation phase).

Monitoring Procedure

Each survey period (Kavanagh and Bamkin 1995, Wintle *et al* 2005) will involve:

- Arboreal Trapping. A grid configuration of 20 Elliot B traps will be established in approximately two hectares of habitat. Elliot B Traps will be baited with a standard mixture of rolled oats, peanut butter and honey. The trunk of each tree will be sprayed with a 50:50 honey/water solution to act as an attractant. Traps will be positioned on brackets approximately three metres above the ground and left operating over four consecutive nights.

Performance Measures

- Monitoring is undertaken after construction of the upgrade.
- Monitoring is undertaken at Impact and Control sites.
- There is no significant difference in presence of Squirrel Glider between Impact and Control sites during the operation phase of the Project.

3.3 ROAD KILL MONITORING

3.3.1 TIMING OF MONITORING

Timing of road kill surveys is described in Table 10.

Table 10: Timing and locations of road kill surveys

Project Phase	Timing of survey	Location
Baseline	Weekly during October (spring), January (summer) and April (autumn) prior to commencement of construction (12 weeks)	Entire length of existing highway in Project area
During clearing operations	Daily	Portion of existing highway adjacent to clearing operations
One month following clearing operations	Daily	Portion of existing highway adjacent to clearing operations
For the duration of construction	Weekly	Entire length of existing highway in Project area
Within one month of opening of the Project	Weekly for 12 weeks. If this period does not coincide with the season (i.e. October (spring), January (summer) and April (autumn) in which baseline surveys were undertaken, also undertake weekly surveys during the first survey period (April, October or January) to occur after the opening of the Project (to allow for comparison to baseline results).	Entire length of completed Project
Upon completion of the Project (operation phase)	Weekly during October (spring), January (summer) and April (autumn (12 weeks) in Year 4, 5, 6 and 8, or until mitigation measures can be demonstrated to have been effective as defined in the EPBC approval.	Entire length of completed Project

3.3.2 MONITORING PROCEDURE

Road kill survey methodology is adapted from that described by Taylor and Goldingay (2004) and Ramp *et al* (2006). Baseline road kill surveys will involve a vehicle being driven along the entire length of the existing highway in the Project area and identifying dead wildlife (road kill) seen on the roads and within three metres of the road edge. Both driver and passenger will search the left-hand side of the road and its verge for road kill. When a road kill is observed from the vehicle, a closer inspection of the carcass will be undertaken where access is possible and where safely limitations permit. If safe access is not possible, due to local traffic conditions, binoculars will be used to try to identify carcasses. Road kill fauna will be identified to species level where possible, with reference to field guides. Those too seriously damaged to be accurately identified will be recorded as "unknown". Upon identification of the road kill, the animal should be removed if safe to do so, so as to avoid double counting during subsequent surveys.

For each road kill observed, the following attributes will be recorded:

- Geographic coordinates of the road kill location.
- Species of road kill where possible.

If the animal is identified as a TSC Act or EPBC Act threatened species, the following information will also be recorded:

- Sex and age class (juvenile or adult) where possible and safety limitations permit.
- Presence of pouch young (for marsupials) where possible and safety limitations permit.

In addition, for TSC Act or EPBC Act threatened species, local habitat attributes will be recorded at a point five metres from the road verge at the road kill location, including:

- Structure and floristics of vegetation, including dominant species of each vegetation stratum, height and per cent cover.
- Presence and type of hydrological and surface drainage features.
- Presence and type of rocky features.
- Abundance and type of tree and log hollows.
- Presence, type and abundance of foraging resources.
- Presence and type of microhabitats.

3.3.3 PERFORMANCE MEASURES

- Lower rates of road kill in proximity (ie areas of the main carriageways within areas adjacent to installed fauna fencing, and within 100m of rope bridges and fauna underpasses) to fauna fencing, rope bridges and fauna underpasses than in sections of the upgrade not near wildlife crossing structures or fauna fences in Year 1 – 6 & 8 monitoring events.
- Reduced incidence of road kill from baseline conditions during monitoring events in Years 1 – 6 & 8 and when all monitoring events are considered at Year 8.
- Fauna exclusion fencing is installed at a minimum in the locations identified in Schedule 3 of the EPBC approval at Year 4.

4 MONITORING OF MITIGATION MEASURES

The Project incorporates procedures and several physical structures that aim to reduce fauna mortality, maintain habitat connectivity and allow fauna to safely move between areas of habitat to the east and west of the Project. The mitigation measures will be monitored to determine their effectiveness.

4.1 PRE-CLEARING AND CLEARING PROCEDURES

4.1.1 DESCRIPTION

The Revised Statement of Commitments (SoC) Report includes several mitigation measures to be implemented during the pre-construction and construction phases of the Project. These measures aim to minimise impacts on flora and fauna and include:

- *SoC F1: Detailed design will minimise the area of native vegetation and habitat to be cleared wherever reasonable and feasible.*
- *SoC F2: The limits of clearing and other native vegetation disturbance will be clearly marked on relevant work plans and on site with temporary fencing installed prior to clearing.*
- *SoC F4: Habitat features and resources for native fauna (such as hollow-bearing trees, hollow logs, nest boxes and bush rocks) impacted by the Proposal will be relocated where feasible and reasonable. Such relocation will be undertaken in a manner to limit damage to existing vegetation and will not occur in high condition remnant vegetation.*
- *SoC F9: Threatened plants in proximity to the Proposal that are to be retained will be identified by pre construction surveys and protected during construction through exclusion fencing and education of construction workers through the site induction process.*
- *SoC F10: The feasibility of relocating individuals of threatened species to suitable habitat will be investigated.*
- *SoC F12: A suitably qualified ecologist will undertake preclearance surveys. Searches will include nests and large hollow-bearing trees and target habitats of hollow-dwelling species, koalas and frogs. Fauna species found in pre-clearance surveys will be relocated to suitable habitat as close as possible to the area in which they were found.*
- *SoC F13: Where feasible and reasonable, removal of frog habitat along drainage lines will not be undertaken during periods of wet weather.*
- *SoC F14: The construction contractor will maintain contact details for local DECCW officers, WIRES and/or other relevant local wildlife carer groups.*
- *SoC 15: Surveys will be undertaken for threatened bat species by a suitably qualified ecologist to identify any roosting bats prior to the demolition of the existing highway bridges. Any bats will be moved and relocated following consultation with DECCW.*

Although not specified in the SoC, the EA (GHD 2010) states that a two-stage clearing process will be implemented. Pre-clearing and clearing processes will be undertaken in accordance with *Biodiversity Guidelines: Protecting and managing biodiversity on RTA Projects* (RTA 2011).

Pre-clearing and clearing procedures (including fauna relocation procedures) are also detailed in the Construction Flora and Fauna Management Plans for the Project. A brief description of pre-clearing survey methodology is included in Table 11 in accordance with *MCoA B10 (c): Monitoring construction-related impacts.* The Project ecologist will assess the habitat present

within the clearing footprint each day of clearing operations, and will be responsible for implementing the appropriate level of survey effort accordingly.

Fauna species identified within the clearing footprint will be relocated to similar habitat adjacent to the Project. Release sites for fauna will be identified prior to the commencement of clearing by the Project ecologist and in consultation with EPA. In determining release sites, habitat requirements for each species/fauna group will be considered.

If a threatened fauna or flora species is unexpectedly found within clearing limits, management of the threatened fauna or flora species (Figure 1) will be undertaken in accordance with *Biodiversity Guidelines: Protecting and managing biodiversity on RTA Projects* (RTA 2011).

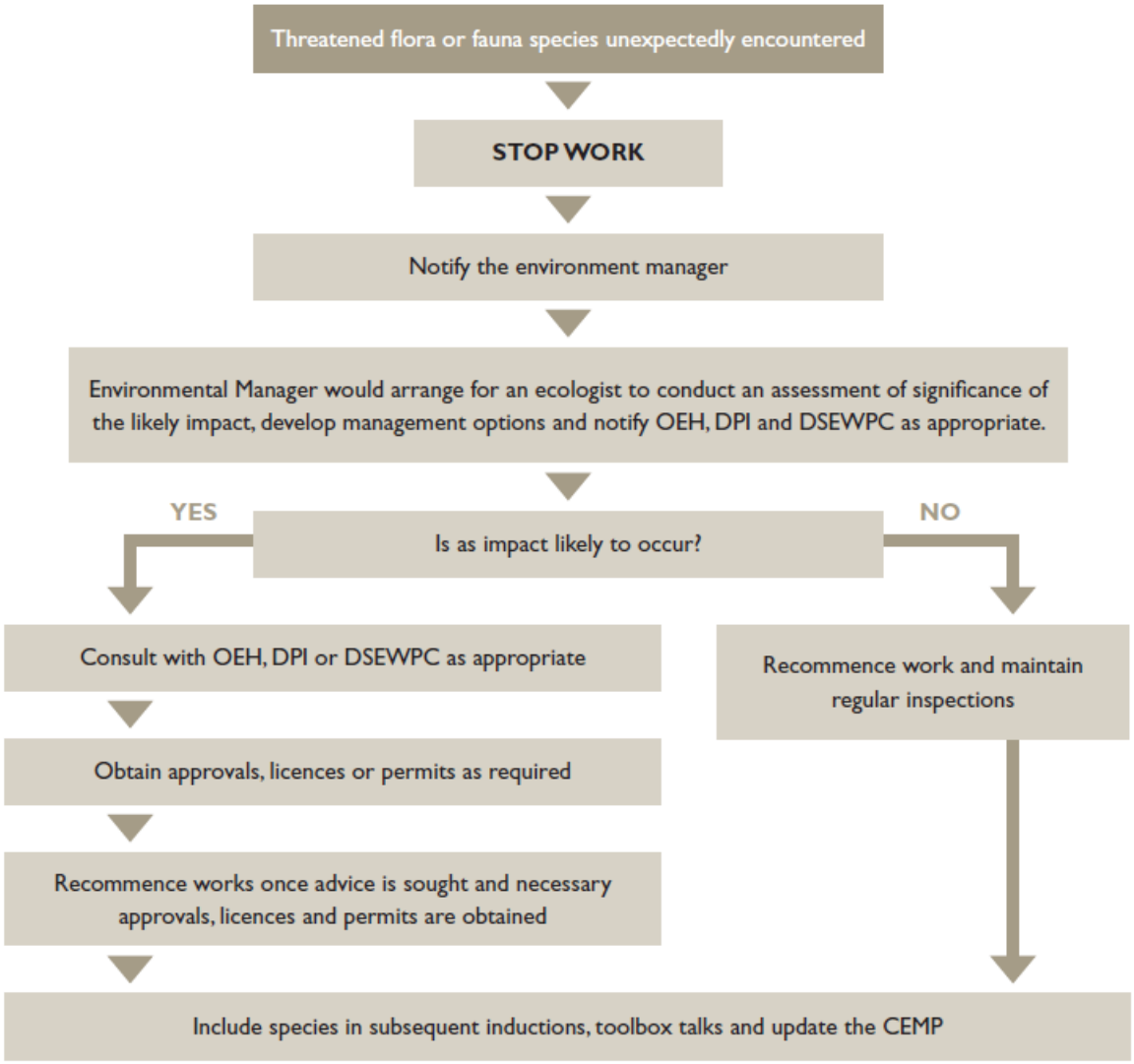


Figure 1: Unexpected find of threatened flora or fauna

Table 11: Methodology of pre-clearing surveys

Flora/Fauna to be protected	Methodology	Timing	Responsibility
Vegetation to be retained	Vegetation to be retained within the Project footprint will be clearly identified and marked on survey plans and delineated. Known locations of threatened flora species and the boundaries of Endangered Ecological Communities (EEC) to be retained within the Project footprint will be clearly delineated	Within twenty days of the commencement of clearing Check and verify limits 48 hours prior to the commencement of clearing. Highly visible flagging tape or fencing that delineates vegetation to be retained will be maintained until no longer required, or until the date of construction completion.	Project Ecologist
Threatened frogs - Green-thighed Frog (*Litoria brevipalmata*)	Targeted searches for Green-thighed Frog (*Litoria brevipalmata*) will be undertaken where known or potential habitat for the species occurs within clearing limits. Frog surveys will consist of nocturnal spotlight searches and call-playback detection. Active searches of microhabitats; turning rocks, logs, debris and checking defoliating bark, will be undertaken immediately prior to (<2 hrs) clearing operations. Captured frogs will held temporarily in a plastic bag with a small amount of water (1 frog per bag). Frogs be relocated to similar habitat adjacent to the clearing footprint. A frog hygiene protocol will be adopted at sites with Giant Barred Frog. This protocol will be in accordance with DECC (now EPA) Hygiene protocol for the control of disease in frogs Information Circular Number 6.	Within 2 hours of scheduled clearing/ground disturbance operations. The need for additional nocturnal surveys will be at the discretion of the Project Ecologist.	Project Ecologist

Flora/Fauna to be protected	Methodology	Timing	Responsibility
Threatened frogs - Giant Barred Frog (*Mixophyes iteratus*	Pre-clearing survey methodology specific to the Giant Barred Frog is detailed in the *Giant Barred Frog Management Strategy* (Lewis Ecological Surveys 2013a) and will also be included in the Flora and Fauna Management Plan. Targeted searches for Giant Barred Frog (*Mixophyes iteratus*) will be undertaken where known or potential habitat for the species occurs within clearing limits. Surveys to last 1 person hour per hectare of habitat to be disturbed/ removed and involve the use of call broadcast, spotlighting and active searches of litter, debris and logs. All Giant Barred Frogs captured will be relocated to the nearest side of the clearing limit with information collected on sex, breeding condition and snout-vent length. Alternative relocation sites may be considered provided they occur within the same drainage. As a general rule frogs should not be relocated further than 300 m from the capture site, which should theoretically remain within an individual's home range. Frogs with a snout-vent length >40 millimetres will be PIT3 tagged to document the performance measure of this as a suitable relocation strategy. Juvenile/sub adult frogs may be marked in accordance with the animal care and ethics licence of the Project Ecologist or frog expert. Toe clipping is one possible method, however, not all animal care and ethics committees support this approach. A frog hygiene protocol will be adopted at sites with Giant Barred Frog. This protocol will be in accordance with DECC (now EPA) Hygiene protocol for the control of disease in frogs Information Circular Number 6.	Within five days of scheduled clearing/ground disturbance operations, surveys will be conducted over a minimum of two non-consecutive nights	Project Ecologist
Arboreal mammals	Arboreal mammal surveys will consist of stag watching, spotlighting and call-playback detection. If an arboreal mammal is identified within the clearing limits during nocturnal surveys, the location will be checked during a diurnal visual inspection undertaken on the following morning immediately prior to clearing. The removal of any arboreal mammals from within the clearing should be undertaken in accordance with *Biodiversity Guidelines: Protecting and managing biodiversity on RTA Projects* (RTA, 2011). If a threatened arboreal mammal is identified within the clearing limits, the tree that it is occupying will be retained, a 50m buffer around the tree will be instated.	Nocturnal spotlighting will be undertaken the night immediately prior to clearing. A diurnal visual inspection of trees identified as supporting arboreal fauna within the clearing limits would be undertaken immediately prior to the commencement of clearing	Project Ecologist

Flora/Fauna to be protected	Methodology	Timing	Responsibility
Koalas	Koala surveys will consist of spotlighting and diurnal surveys. If a koala is identified within the clearing limits during nocturnal surveys, the location will be checked during a diurnal visual inspection undertaken on the following morning immediately prior to clearing. The removal of any arboreal mammals from within the clearing should be undertaken in accordance with *Biodiversity Guidelines: Protecting and managing biodiversity on RTA Projects* (RTA, 2011). If a koala is identified within the clearing limits, the tree that it is occupying will be retained, a 50m buffer around the tree will be instated. If the koala does not vacate the clearing footprint, a corr-flute fence will be erected around the base of the tree occupied by the koalas. A wire cage trap will be placed at the exit in the fence. The trap will be set during the day and checked every 2-3 hours through the night until the koala is caught (AMBS 2011). The wildlife carer will manage any injured koalas, and the Project ecologist will relocate koalas upon confirmation of their health.	Nocturnal spotlighting will be undertaken no earlier than 48 hours prior to clearing. A diurnal visual inspection of trees identified as supporting koalas within the clearing limits would be undertaken immediately prior to the commencement of clearing	Project ecologist
Microchiropteran bats	Searches of potential microbat roost sites such as culverts and bridges likely to be disturbed by clearing works will be undertaken. Surveys will involve active searches of structures for signs of use by microbats and the use of an endoscope, torch and an Anabat if required. Any microbats found should be managed in accordance with the *Microbat Management Plan.*	Timing of microbat surveys will be accordance with the *Microbat Management Strategy.*	Project Ecologist
Natural habitat features	Natural habitat features such as hollow logs, felled branches and bush rocks will be identified from the Project footprint. Locations of habitat features will be recorded with a GPS and marked with flagging tape or fluorescent paint. Habitat features will be considered for relocation or avoided by contractors where possible.	Within twenty days of the commencement of clearing	Project Ecologist
Habitat trees	Habitat trees (trees currently in flower, sap feeding trees, trees supporting nests or dreys) will be clearly demarcated so that they are retained for the second stage of clearing or avoided by contractors, where possible. Its location will be recorded using a GPS.	Within twenty days of the commencement of clearing	Project Ecologist

Flora/Fauna to be protected	Methodology	Timing	Responsibility
Hollow-bearing trees	Hollow-bearing trees (HBT) occurring within the Project footprint were surveyed in October-November 2012 for the preparation of the *Nest Box Plan* (Lewis Ecological Surveys 2013d). The location of each HBT was marked using the following techniques: ▪ Plotted using a handheld GPS ▪ Flagged with fluorescent flagging tape ▪ Spray-painted with a number in the event that the flagging tape was removed ▪ Plotted on survey plans to advise on Project site works Data collected on each HBT included tree species, height, DBH, position of hollows (trunk or limb), estimated size of hollow, suitability for fauna species	The demarcation of HBTs is to be checked within 48 hours of the commencement of clearing.	Project Ecologist

4.1.2 TIMING

Pre-clearing flora and fauna surveys will be conducted prior to Stage 1 removal of vegetation (i.e. non-habitat trees). Inspections of habitat trees and fauna rescue procedures will be undertaken during Stage 2 clearing.

4.1.3 MONITORING PROCEDURE

Pre-clearing survey techniques, timing and responsibilities for surveying are briefly detailed in Table 11. A report will be prepared and submitted to the principal contractor, Roads and Maritime and EPA as part of the subsequent annual ecological monitoring report after the clearing operations have been completed. The reports will include:

- Survey date.
- Time.
- Surveyors.
- Weather conditions.
- Details of methods used during pre-clearing surveys and clearing operations.
- Fauna species displaced by clearing, species captured, species released and any wildlife mortalities resulting either directly or indirectly from the clearing operations.
- Location of fauna within clearing footprint (recorded with GPS) and release locations.
- Hollow-bearing tree register, and comparison of this data to nest box plan (assess the adequacy of nest boxes installed and how they are mitigating the loss of tree hollows).
- Discussion of the effectiveness of those methods employed.
- Recommendations for future pre-clearing and/or clearing procedures.

4.1.4 PERFORMANCE MEASURES

The performance of pre-clearing and clearing procedures will be assessed against:

- Low rates of fauna injury and mortality resulting from clearing operations, and no mortality of TSC Act and EPBC Act threatened species.
- Stop work implemented immediately when fauna observed and successful capture and release of fauna displaced by clearing operations (ie being released within 1 hour without mortality, unless the animal is injured and is instead managed in accordance with the Fauna Handling and Rescue Procedure in the FFMP).
- Immediate contact with Project Ecologist / Suitably Qualified Expert or wildlife carer when injured fauna are identified.
- Accurate quantification of fauna habitat features and hollow-bearing trees being removed against the predicted quantities identified in the Nest Box Management Plan.

4.2 FAUNA UNDERPASSES

4.2.1 DESCRIPTION

The Revised Statement of Commitments includes measures to be implemented to provide for fauna movement:

- *SoC F17: Culverts and bridges identified in the Environmental Assessment as having a potential role in wildlife crossing will be designed to facilitate fauna movements where feasible and reasonable.*

Wildlife crossing structures, locations and target species are described in detail in the *Oxley Highway to Kempsey Upgrade Wildlife crossing Strategy* (HSJV 2012a).

The Project includes over 51 underpasses that may facilitate the passage of fauna species, which comprise of:

- Nine bridges that provide fauna passage beneath them: Fernbank Creek, Hastings River, Wilsons River, Cooperabung Creek, Barrys Creek, Smiths Creek, Pipers Creek, Maria River and Stumpy Creek.
- 11 dedicated underpasses. Dedicated fauna underpasses will support fauna furniture to encourage the passage of target fauna species.
- 30 combined culverts (culverts that provide for both drainage and fauna passage). Fauna furniture has been provided in a few combined culverts to encourage the passage of target fauna species.

It is proposed that 13 fauna underpasses be monitored, including all 11 dedicated fauna underpasses and 2 combined fauna underpasses. Fauna underpasses to be monitored upon completion of the Project are listed in Table 12. The selection criteria for fauna underpasses to be monitored are as follows:

- All dedicated fauna underpasses will be monitored.
- Combined underpasses that are 50 metres or more in length, and located in proximity to intact native vegetation (fauna habitat) will be monitored. There has been limited monitoring of long culverts to date and monitoring has been proposed to capture any fauna using such long culverts.
- No combined underpasses that are located in cleared, disturbed or modified areas will be monitored, as the usage expectancy of these culverts is low (primarily due to a lack of fauna habitat in proximity to the underpass).
- No combined culverts will be monitored, that are located within 600 metres of another monitored underpass that will be monitored.

No incidental underpasses will be monitored. These typically comprise small culverts that are not intended to allow for the passage of fauna. Small terrestrial mammals, reptiles and amphibians may use these underpasses on occasion.

Table 12: Fauna underpasses to be monitored upon completion of the Project

Culvert ID	Ch.	Underpass type	Cells	Width (m)	Height (m)	Length (m)	Target species (other species that may use crossing)	Adjoining habitat	Fauna furniture (target species)
F1.04	1040	Dedicated	1	3	3	50	Koala (macropods, small mammals, reptiles, amphibians)	Modified environment. Mapped as Cleared Scattered Trees, adjoining intact Moist Slopes Forest and Moist Gully Forest	Rails and refuge poles (koalas)
F1.62	1670	Dedicated	1	3	3	48	Koala (macropods, possums, small mammals, reptiles, amphibians)	In a mapped sub-regional corridor	Rails and refuge poles (koalas)
C4.46	4450	Combined	3	3	2.1	41	Koala (Small macropods, possums, small mammals, frogs, reptiles)	Located in fragmented habitat in a drainage line. Links native vegetation east and west	Rails and refuge poles (koalas)
C7.26	7270	Combined	1	3	2.4	41.6	Koala (spotted-tailed quoll, possums, smaller macropods, small mammals, reptiles, amphibians	Links native vegetation east and west, Located in vegetation contiguous with Cairncross state forest and Rawdon Creek nature reserve	Rails and refuge poles (koalas)

Culvert ID	Ch.	Underpass type	Cells	Width (m)	Height (m)	Length (m)	Target species (other species that may use crossing)	Adjoining habitat	Fauna furniture (target species)
F9.70	9700	Dedicated	1	3	3	38	Koala (spotted-tailed quoll, possums, smaller macropods, small mammals, reptiles, amphibians	On the margin of a regional corridor in Moist Floodplain Forest in Cairncross state forest	Rails and refuge poles (koalas) Rocks, logs, hollow logs (frogs) Rocks, hollow logs (quolls)
F11.67	11660	Dedicated	1	3	2.4	38	Koala (spotted-tailed quoll, possums, smaller macropods, small mammals, reptiles, amphibians	Dry Ridgetop Forest in Cairncross State Forest	Rails and refuge poles (koalas) Rocks, logs, hollow logs (frogs) Rocks, hollow logs (quolls)
F20.54A	20560	Dedicated	1	3	3	53	Koala (Spotted-tailed quoll, macropods, small mammals, reptiles, amphibians	Links native vegetation to east and west, continuous with regional corridor linking key habitat in Cooperabung Nature reserve and Ballengarra State Forest	Rails and refuge poles (koalas) Rocks, hollow logs (quolls)
F21.24	21240	Dedicated	1	3	3	58	Koala (macropods, spotted-tailed quoll, small mammals, reptiles, amphibians	Regional corridor linking key habitat in Cooperabung Nature reserve and Ballengarra State Forest	Rails and refuge poles (koalas) Rocks, hollow logs (quolls)

Culvert ID	Ch.	Underpass type	Cells	Width (m)	Height (m)	Length (m)	Target species (other species that may use crossing)	Adjoining habitat	Fauna furniture (target species)
F22.32	22320	Dedicated	1	3.6	3.6	59.4	Koala (possums, spotted-tailed quoll, macropods, small mammals, reptiles, amphibians)	Regional corridor linking key habitat to east and west, vegetation continuous with mapped climate change corridor to east	Rails and refuge poles (koalas) Rocks, hollow logs (quolls)
F26.40	26400	Dedicated	1	3	3	49	Koala (macropods, spotted-tailed quoll, small mammals, reptiles, amphibians)	Links vegetation to east and west	Rails and refuge poles (koalas) Rocks, hollow logs (quolls)
C32.35	32350	Combined	1	3	3	64	Koala (macropods, small mammals, reptiles, amphibians)	Located in regional corridor, however, surrounding landscape is modified by farmland and roads. Fragmented connectivity of vegetation adjoining culverts with larger patches of vegetation to east and west.	No
F33.40	33400	Dedicated	1	3	3	49	Koala (possums, spotted-tailed quoll, macropods, small mammals, reptiles, amphibians possibly Green-thighed frog)	Maria River State Forest	Rails and refuge poles (koalas)

Culvert ID	Ch.	Underpass type	Cells	Width (m)	Height (m)	Length (m)	Target species (other species that may use crossing)	Adjoining habitat	Fauna furniture (target species)
C36.40	36400	Combined	1	3	3	66	Koala (possums, spotted-tailed quoll, macropods, small mammals, reptiles, amphibians possibly Green-thighed frog and giant barred frog)	Moist Gully Forest	Rails and refuge poles (koalas)

4.2.2 TIMING

Timing of monitoring of fauna underpasses will coincide with the breeding seasons and dispersal periods of target species (Table 13). Higher frequencies of movements increase the likelihood of fauna to utilise and be detected in underpasses. Timing may require amendment in accordance with the actual completion date of the Project.

Table 13: Breeding seasons and likely dispersal periods of threatened species targeted by underpasses

Scientific Name	Common Name	Breeding season	Likely dispersal period
Dasyurus maculatus	Spotted-tail Quoll	April to July	Spring and summer
Litoria brevipalmata	Green-thighed Frog	Late spring and summer	In association with rainfall events
Mixophyes iteratus	Giant Barred Frog	Late spring to early summer	In association with rainfall events
Phascogale tapoatafa	Brush-tailed Phascogale	May to July	Mid-summer
Phascolarctos cinereus	Koala	Spring and summer	Spring and summer

Fauna underpass monitoring will commence upon completion of the Project (Year 4) and will be undertaken in late autumn and late spring/early summer each year for a minimum of 60 days. Monitoring will continue in Year 6 and 8 of the operation phase and additional monitoring may be required if fauna underpasses are determined to be ineffective.

4.2.3 MONITORING PROCEDURE

Monitoring of underpasses will be undertaken using the following techniques:

- A motion-detecting camera installed in each combined and dedicated fauna underpasses (Table 12). Cameras will be installed in the middle of each underpass and/or at each end of the underpass, depending on what provides the best field of view. Cameras are to operate continuously for a period of 60 days during autumn and eight weeks during late spring/early summer. Cameras will not be installed in all combined underpasses.
- Sand-plots established at each end of combined fauna underpasses for a period of eight nights per monitoring period. Sand plots, at least one metre wide, will be established across the entire width of the underpass and will be inspected each following morning period for tracks each morning and then raked clean.
- Hair-tubes placed upon fauna furniture within crossing structures and placed in habitat adjoining wildlife crossing structures. Hair tubes will be baited with a mixture of peanut butter, honey and oats for 14 nights per monitoring period. Hair samples will be sent to an appropriately qualified/experienced specialist for identification.
- Scat searches within crossing structures (approximately one to two metres from the end to minimise wind and rain disturbance) and in adjoining habitat. Searches to be undertaken when installing and checking sand plots (ie twice per monitoring period).

4.2.4 PERFORMANCE MEASURES

Indicators of success of fauna underpasses include:

- Complete safe crossing of the crossing by the targeted EPBC species at sufficient frequency to ensure that habitat connectivity is maintained or improved from baseline conditions, and ongoing population viability by providing opportunity for species dispersal and re-colonisation when all monitoring events are considered at Year 8.
- For non-EPBC species, recorded presence of indicator species from nominated classes (see section 2.2.4) during underpass monitoring.
- For non-EPBC species, recorded presence of cover dependant species or fauna species with low mobility during underpass monitoring.
- Reduced incidence of road kill from baseline conditions.

4.3 ROPE BRIDGES

4.3.1 DESCRIPTION

Rope bridges will provide connectivity for arboreal mammals and will be suspended across the dual carriageway between poles on each side. General design considerations include:

- The rope ladder must be constructed of marine grade silver (high UV rating) rope and stainless steel cables.
- The rope bridge must be linked to adjacent glider habitat trees by ropes or ladders tied off onto the support poles and the trees.
- Support poles used in the median must include metal guards to prevent animals descending to the ground in the median.
- The rope bridge must have a clearance of no less than 10.6 m above the road pavement surface

Rope bridges at three locations between the Kundabung and Kempsey section of the Project will be monitored (Table 14).

Table 14: Locations of rope bridges to be monitored between Kundabung and Kempsey

Chainage	Target Species	Existing Environment
24120	Squirrel Glider Yellow-bellied Glider	Located in proximity to Barrys Creek and riparian zone Riparian Forest/Moist Floodplain Closed Forest with Rainforest Elements/ Moist Gully Forest Within mapped Regional corridor Ballengarra State Forest

Chainage	Target Species	Existing Environment
34150	Squirrel Glider Yellow-bellied Glider	Located in proximity to Combined underpass C34.10 Located in proximity to glider poles Maria River State Forest Within mapped Regional corridor Moist Slopes Forest/ Moist Gully Forest/ Dry Ridgetop Forest
35700	Squirrel Glider Yellow-bellied Glider	Located in proximity to Combined underpass C35.70 Maria River State Forest In proximity to unnamed watercourse Within mapped Regional corridor Moist Slopes Forest/ Moist Gully Forest/ Dry Ridgetop Forest

Rope bridges for the Oxley Highway to Kundabung section of the Project (eight in total) will be located between:

- Ch. 9000 and Ch. 9400
- Ch.11200 and Ch.11400
- Ch.11700 and Ch.12100.
- Ch.22900 and Ch.23300.
- Ch.23600 and Ch.23900

4.3.2 TIMING

Monitoring of rope bridges will coincide with the breeding seasons and dispersal periods of target (Table 15) and other arboreal species known from the Project area. Higher frequencies of movements increase the likelihood of fauna to utilise and be detected on rope bridges; monitoring will be undertaken in autumn and spring. In autumn, movement of arboreal species generally increases in frequency and range as individuals seek flowering resources, while animals are typically dispersing post-breeding in spring.

Table 15: Breeding seasons and likely dispersal periods of threatened species targeted by rope bridges

Scientific Name	Common Name	Breeding season	Likely dispersal period
Petaurus australis	Yellow-bellied Glider	Between July and September	Winter to spring
Petaurus norfolcensis	Squirrel Glider	Between April and November	Autumn to spring
Phascogale tapoatafa	Brush-tailed Phascogale	May to July	Mid-summer

Rope bridge monitoring would commence within the first six months of operation (Year 4). Cameras are to operate continuously for a period of eight weeks during autumn and eight weeks during late spring/early summer at Year 4, 6 and 8. Additional monitoring may be

required in the event the monitoring data suggests that rope bridges are ineffective and modification/treatments are required.

4.3.3 MONITORING PROCEDURE

Monitoring of rope bridges will be undertaken using the following techniques (Soanes 2009):

- Remotely triggered infrared cameras (Faunatech or similar) will be installed at each end of each rope ladder. Two active infra-red beam sensors will be positioned on the canopy bridge approximately one and four metres from each camera. The sensors will detect an animal's movement across the bridge, triggering the camera to take a series of five consecutive photos each 3 – 5 seconds apart. This should allow for the entire sequence of the animals crossing behaviour to be recorded. All photos will be time and date stamped and stored on a memory card with a capacity of approximately 600 image files.
- Image files will be transferred from the memory card directly to a laptop computer via USB connection and will be downloaded approximately fortnightly.
- At each download, the ground within a 50 metre radius of each rope bridge will be searched for dead animals.
- Fauna is to be identified to species and the following attributes are also to be recorded: date, time, direction of movement. An assessment of whether a full crossing was made, with reference to picture taken at both glider poles in a pair, will be undertaken.

4.3.4 PERFORMANCE MEASURE

Indicators of success of rope bridges include:

- Complete crossing of the rope bridge, (through camera monitoring or other evidence of complete crossings (i.e. ear tags, notches)), by a diversity of native arboreal fauna species known to occur in the Project area, such as Brush tail possum or Sugar glider.
- Complete crossing of the rope bridge, (through camera monitoring or other evidence of complete crossings (i.e. ear tags, notches)), by arboreal target species (Brush-tailed Phascogale, Squirrel Glider, or Yellow-bellied Glider).
- Lower rates of road kill arboreal species in proximity to rope bridge than in sections of the upgrade away from crossing structures.

4.4 GLIDER POLES

4.4.1 DESCRIPTION

Glider poles will provide connectivity for gliding mammals and will comprise of poles located on each side of the dual carriageway. General design considerations include:

- Glider poles must not be located more than 40 metres apart.
- Cross bars on glider poles must point to the desired landing.
- Glider poles must include shelter pipes and predator shields to discourage attack from aerial predators.
- Habitat trees for gliders must be within gliding distance of glider poles for glides in both directions.

Glider poles at three locations between the Kundabung and Kempsey section of the Project will be monitored (Table 16).

Table 16: Locations of glider poles

Chainage	Target Species	Details
25190	Squirrel Glider Yellow-bellied Glider	Located in proximity to Barrys Creek Ballengarra State Forest Within mapped Regional corridor Moist Slopes Forest/ Riparian Forest
25292	Squirrel Glider Yellow-bellied Glider	Located in proximity to Barrys Creek Ballengarra State Forest Within mapped Regional corridor Moist Slopes Forest/ Riparian Forest/
35780	Squirrel Glider Yellow-bellied Glider	Located in proximity to rope bridge at Ch. 35700 Maria River State Forest, within mapped Regional corridor Located in association with drainage line Moist Slopes Forest/ Moist Gully Forest/ Dry Ridgetop Forest

Locations of glider poles for the Oxley Highway to Kundabung section of the Project (will be located between:

- Ch. 9000 and Ch. 9400
- Ch.10700 and Ch.11110.
- Ch.11200 and Ch.11400.
- .

Unless otherwise agreed with the Director-General, in consultation with the Project Ecologist and EPA.

4.4.2 TIMING

Monitoring of glider poles will coincide with the breeding seasons and dispersal periods of target species (Table 17) and other gliding species known from the Project area. Higher frequencies of movements increase the likelihood of fauna to utilise and be detected on glider poles; monitoring will be undertaken in autumn and spring. In autumn, movement of arboreal species generally increases in frequency and range as individuals seek flowering resources, while animals are typically dispersing post-breeding in spring.

Table 17: Breeding seasons and likely dispersal periods of threatened species targeted by glider poles (Tyndale-Biscoe 2005, Goldingay 2008, Van der Ree & Suckling 2008)

Scientific Name	Common Name	Breeding season	Likely dispersal period
Petaurus australis	Yellow-bellied Glider	Between July and September (variable depending on habitat characteristics)	Winter to spring (when young 12-24 months of age)

Scientific Name	Common Name	Breeding season	Likely dispersal period
Petaurus norfolcensis	Squirrel Glider	Between April and November 9peak during winter)	Autumn to spring

Glider pole monitoring would commence within six months of the operation of the project (Year 4) installed and focus on a four week sampling period in autumn and spring at Year 4, 6 and 8. Additional monitoring may be required in the event the monitoring data suggests that rope bridges are ineffective and modification/treatments are required.

4.4.3 MONITORING PROCEDURE

Monitoring of rope bridges will be undertaken using the following techniques (Goldingay *et al* 2011):

- Infrared motion sensor digital camera (Faunatech or similar) will record use of glider poles by glider. As gliders could ascend a pole on any side, making it difficult for a single camera to effectively record pole use, a sheet-metal collar (~300 millimetre wide) will be placed around the pole at a height of 3m above ground. The collar will be mounted at a 40° angle to the pole to direct climbing animals to a high point where a 100 millimetre diameter hole will be cut next to the pole. The camera will be positioned two metres above the collar and directed at the collar hole so that any animals that ascended through the hole will be photographed.
- All photos will be time and date stamped and stored on a memory card with a capacity of approximately 600 image files.
- Image files will be transferred from the memory card directly to a laptop computer via USB connection, and will be downloaded approximately fortnightly.
- At each download, the ground within a 50-metre radius of each pole will be searched for dead animals.
- Downloaded pictures will be enlarged and examined for glider presence. Gliders are to be identified to species where possible and the following attributes are also to be recorded: date, time, direction of movement and location across carriageway, if possible.
- Hair tubes will be screwed onto each pole approximately three metres high. Hair-traps consist of hair-tubes made from 100 millimetre lengths of 40-millimetre diameter PVC. A smaller plastic tube (three centimetres long, two centimetres diameter) with several small holes will be packed with a bait mixture of peanut butter, honey and oats and inserted into the hair-tube. Double-sided tape is to be applied to the end of each tube. Hair-tubes will be in place for approximately four weeks in both autumn and spring.

4.4.4 PERFORMANCE MEASURE

Indicators of success of glider poles include:

- Evidence of use of glider poles by native gliders known to occur in the Project area, such as Sugar glider.
- Evidence of use of glider poles by arboreal target species (Squirrel Glider, or Yellow-bellied Glider).
- Lower rates of road kill gliders in proximity to glider poles than in sections of the upgrade away from crossing structures.

4.5 FAUNA FENCING

4.5.1 DESCRIPTION

The Revised Statement of Commitments includes a commitment to erect fauna fencing, which aims to prevent animals crossing the road surface, thereby reducing road kill. Fauna fencing is also used to guide animals towards safe wildlife crossing structures or passages such as underpasses:

- *SoC F19: Fauna exclusion fencing (eg floppy-top fencing) will be erected along the Proposal at appropriate locations to direct fauna movement towards wildlife crossing structures.*

Standard fauna fencing will be installed at locations describe in the *Oxley Highway to Kempsey Upgrade Fauna Fencing Strategy* (HSJV 2012b). In summary, three types of fauna fencing will be used, including

- Standard floppy-top fencing.
- Frog fencing.
- Phascogale fencing.

Notwithstanding the information detailed below, fauna fencing will be installed at a minimum as per Schedule 3 of the EPBC approval.

Standard floppy-top fencing

Permanent floppy top fencing will comprise of a heavily galvanised, floppy-top mesh fauna fence. Mesh one metre wide will be attached to the base of the fauna fencing and laid over the ground away from the carriageway to provide an effective barrier to burrowing animals. The mesh must be pinned to the ground with metal pins every metre without any gaps between the mesh and the ground. Fauna exclusion fencing at underpass entrances will have wide angled openings to encourage usage by fauna and must have a minimum length of 200 metres of fauna fencing on each side of the underpass and on each side of the carriageway or road.

Standard fauna fencing will be installed:

- Where the Project traverses Cairncross, Ballengarra and Maria River State Forests.
- Where the Project traverses regional habitat corridors.
- Between dual carriageway bridges and culverts where there are gaps between structures to prevent fauna accessing the median strip.
- On the outside of all spill containment / water quality treatment basins to prevent fauna from accessing polluted water sources.

Frog fencing

Giant Barred Frog fencing will be installed in areas where the presence of Giant Barred Frogs has been confirmed and there is a 'high' risk of frogs accessing the carriageway in accordance with the *Giant Barred Frog Management Strategy* (Lewis Ecological Surveys 2013a). Giant Barred frog fencing will be located at:

- Ch.18500. Eastern side of the Project extending north to Ch.19100 (Cooperabung Creek).
- Ch.19550 to Ch.19725. Both side of the carriageway (Cooperabung Creek).
- Ch.28175 to Ch.28325. Both side of the carriageway (Smiths Creek).
- Ch.36800 to Ch.36950. Both side of the carriageway (Maria River).

Giant Barred Frog fencing is to be at least 900 millimetres in height and will comprise of gauze size 30-40millimetres to present frogs from moving through the fence, yet allow for the flow of overland water. The gauze will include a small return of not less than 150 millimetres on the ground.

Green-thighed Frog fencing will be installed in areas of Green-thighed Frog breeding ponds and/ or where there is an obvious threat of frogs accessing the new carriageway, in accordance with the *Green-thighed Frog Management Strategy* (Lewis Ecological Surveys 2013b). Green-thighed Frog fencing will be located at:

- Ch.8900-9400. Both sides of the carriageway (Cairncross State Forest).
- Ch.11500-11800. Both sides of the carriageway (Cairncross State Forest).

Green-thighed Frog fencing is to comprise of 500 millimetres high neoprene rubber sheeting (>4 millimetre thickness) including a small rubber return of not less than 100 millimetres on the ground. The fence must consist of a hot dip galvanized pressed sheet metal or powder coated aluminium pressed sheet mounted on a galvanized star picket.

Both species of frogs occur in association with Pipers Creek. As a result, a combination of fencing requirements is required in this location. Frog fencing will be installed at:

- Ch. 30500 to Ch.30825. West side carriageway (Pipers Creek)
- Ch.30650 to Ch.30900. East side carriageway (Pipers Creek).

Frog fencing at Pipers Creek must account for both frog morphologies (ie include the mimimum requirements for each species, specifically height requirements of GBF fence and thickness/ permeability requirements of GTF fence) and will comprise 900 millimetre high neoprene rubber sheeting (>4 millimetre thickness) and will have a small rubber return of not less 100 millimetre on the ground. The fence must consist of a hot dip galvanized pressed sheet metal or powder coated aluminium pressed sheet mounted on a galvanized star picket.

Phascogale fencing

Phascogale fencing is attached to floppy top fauna fencing. At the base of floppy top fauna fences, a second layer of mesh is installed to 200 millimetres above ground level height, offset from the first layer of mesh to create maximum opening size of 25 millimetres. Above 200 millimetres, 600 millimetre hot dip galvanised pressed steel sheet or powder coated aluminium pressed sheet are affixed to the floppy top fauna fencing.

Phascogale fencing will be installed at areas of known or high potential habitat, to direct phascogales away from the highway and towards underpasses:

- Ch.11680. Attach phascogale fencing treatment to standard fauna fencing 200m south and north of dedicated fauna culvert F11.68. Both sides of carriageway.
- Ch.21240. Attach phascogale fencing treatment to standard fauna fencing 200m south and north of dedicated fauna culvert F21.24. Both sides of carriageway.
- Ch.23100. Attach phascogale fencing treatment to standard fauna fencing 200m south and north of Barrys Creek bridge. Both sides of carriageway.
- Ch. 347200. Attach phascogale fencing treatment to standard fauna fencing 200m south and north of dedicated fauna culvert F34.72. Both sides of carriageway.

4.5.2 TIMING

Where fauna fencing adjoins wildlife crossings, a length of 200m of fencing either side of the crossing will be inspected in conjunction with underpass monitoring periods i.e. four weeks in late autumn and four weeks in late spring/early summer in Years 4, 6 and 8.

4.5.3 MONITORING PROCEDURE

Monitoring of fauna fencing will be undertaken using the following techniques:

- Inspection of the lengths of fauna fencing detailed in Section 4.5.2 to identify and report any breaches.
- Inspection of the entire length of frog and phascogale fencing and the edge of the highway in proximity to frog and phascogale fencing, to identify and report any breaches.
- Searches for threatened frogs will be undertaken on both side of the frog fencing in spring and summer to identify the presence of any frogs that may have breached frog fencing.

4.5.4 PERFORMANCE MEASURE

Indicators of success of fauna fencing include:

- No records of Giant Barred Frog or Green-Thighed Frog road kill on the main carriageways directly adjacent to installed frog fencing in any monitoring event during Year 4, 6 & 8.
- Lower rates of road kill in proximity to fauna fencing than in sections of the upgrade not near fauna fencing during all monitoring events (Year 4, 6 & 8).
- Reduced incidence of road kill from baseline conditions.

- Fauna fence is installed at a minimum in areas identified in Schedule 3 of the EPBC approval at Year 4.

4.6 WIDENED MEDIAN

4.6.1 DESCRIPTION

The Revised Statement of Commitments includes measures to be implemented to provide for fauna movement and maintain habitat connectivity:

- *SoC F18: The feasibility of widening the median will be further investigated in consultation with DECCW during the detailed design.*

Retaining tall trees in the median that separates the carriageways may mitigate the barrier effect of roads on gliders, provided that the gap in tree cover is within their glide distance capacity. Median widening is an alternative means of providing safe crossing opportunities for gliding species in locations where mature vegetation between carriageways would allow gliding species to cross the upgraded highway in a staged manner (GHD 2011).

The feasibility of providing a widened median was investigated (SHJV 2012c) and a widened median is proposed to be located in Cairncross State Forest, between Bill Hill Road in the north (Ch. 11400) and where the carriageways diverge at Ch. 10300 in the south.

The median is approximately 50 metres at its widest at Ch. 10700. Vegetation communities in the widened median and either side of the carriageway include Moist Gully Forest, Paperbark Swamp Forest, Swamp Mahogany/Forest Red Gum Swamp Forest, Moist Floodplain Forest and Dry Ridgetop Forest. One EEC, Swamp Sclerophyll Forest on Coastal Floodplain, occurs between Ch. 11100 and Ch. 11300. Vegetation within and adjoining the widened median is continuous with native vegetation of the regional corridor mapped to the north (Ch. 11600).

4.6.2 TIMING

Monitoring of the widened median will coincide with the breeding seasons and dispersal periods of target species (Table 18) and other gliding species known from the Project area. Higher frequencies of movements increase the likelihood of fauna to utilise and be detected in the widened median; monitoring will be undertaken in autumn and spring. In autumn, movement of arboreal species generally increases in frequency and range as individuals seek flowering resources, while animals are typically dispersing following breeding in spring.

Table 18: Breeding seasons and likely dispersal periods of threatened species targeted by glider poles (Tyndale-Biscoe 2005, Goldingay 2008, Van der Ree & Suckling 2008)

Scientific Name	Common Name	Breeding season	Likely dispersal period
Petaurus australis	Yellow-bellied Glider	Between July and September (variable depending on habitat characteristics)	Winter to spring (when young 12-24 months of age)
Petaurus norfolcensis	Squirrel Glider	Between April and November (peak during winter)	Autumn to spring

Monitoring of the widened median will commence during the first optimal season for target species (Table 18) following completion of the Project (Year 4). Monitoring will be undertaken over 16 weeks from June-September each year for a minimum of three years (Years 4, 6 and

8). Additional years of monitoring may be required if the widened median is found to be ineffective and requires modification or supplementation with alternative crossing structures.

4.6.3 MONITORING PROCEDURE

Monitoring of the widened median will involve sampling within the widened median and within retained habitat either side of the Upgrade corridor. Monitoring will involve the use of several fauna census techniques including, but not limited to:

- Hairtube sampling.
- Spotlighting surveys.
- Nestbox monitoring (see Section 4.7)

Additional or alternative monitoring approaches proposed by the Project Ecologist may also be used to assess the effectiveness of the widened median against the performance measures, subject to agreement with the EPA.

Hair tube sampling

Hair tube sampling will be conducted over three 14-night periods during each monitoring event. The first sampling period will be undertaken in mid-June, the second sampling period during the last week of July and the first week of August and the third sampling period during mid-September.

Hair tube transects, each containing 20 hair tubes (spaced 25 to 30 metres apart), will be established in retained forest habitat either side of the Upgrade corridor at the widened median. One hair tube transect, containing 20 hair tubes (spaced 25 metres apart), will be established in the widened median.

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

Spotlighting surveys

Two observers will conduct spotlighting surveys one night per week over each 16-week monitoring event. Within the widened median spotlighting transects (minimum 500 metres long), will be established in retained forest habitat either side of the Upgrade corridor and within the widened median (three transects in total)

Nest box monitoring

4.6.4 SEE SECTION 4.7. PERFORMANCE MEASURES

Potential indicators of success of the widened median monitoring will include:

- Evidence of use of median vegetation by the target glider species.
- Evidence of use by dispersing individuals and different age cohorts.
- Use by glider species other than threatened species e.g. sugar glider

4.7 NEST BOXES

The monitoring methodology for nest boxes described here has been extracted from the *Nest Box Management Plan* (Lewis Ecological Surveys 2013c).

4.7.1 DESCRIPTION

The Revised Statement of Commitments includes a measure to be implemented to mitigate the loss of tree hollows during vegetation clearing prior to construction of the Project:

- *SoC F16: Development of a nest box strategy will be undertaken.*

A *Nest Box Management Plan* has been prepared by Lewis Ecological Surveys (2013c). The Management Plan describes the attributes of tree hollows to be removed, the number of nest boxes needed to mitigate the loss of tree hollows, the design and distribution of nest boxes and ongoing management of nest boxes.

The Management Plan calculated that 723 nest boxes of various sizes are required for the Oxley Highway to Kempsey project with:

- 469 nest boxes required for the Oxley highway to Kundabung (Ch.0-24040).
- 254 nest boxes required for the Kundabung to Kempsey (Ch.24040-37850).

The contractor will install 60% of the nominated nest boxes prior to or during the clearing works with the objective of providing temporal refuge habitat for those hollow dependent fauna displaced during clearing operations. The remaining 40% of nest boxes will be installed by the contractor once a final tally of functional tree hollows has been compiled and reviewed as a result of the data collected during the clearing supervision.

4.7.2 TIMING

Nest boxes will be installed in Year 1 and 2 (construction phase). Monitoring will commence in summer and winter shortly after the installation period (Year 2) and will continue in summer and winter of Year 4, Year 6, Year 8. A pre-handover maintenance inspection will be undertaken at Year 8.

4.7.3 MONITORING PROCEDURE

A visual inspection of each nest box will be undertaken. During each monitoring period, the following information will be collected for each nest box (Lewis 2013c):

- Inspection date, weather conditions (rain, wind, cloud cover, ambient temperature) and time each nest box was inspected.
- Nest box identification number.
- If the nest box is occupied by native fauna, and if so, the species. If the next box is not occupied by a native species, record any signs of use by native species such as feathers, droppings, scats, hair or nesting material.
- If the nest box is occupied by a pest species such as European bees, or common myna.
- Is there any deterioration of the nest box and is any maintenance required.
- Any changes to the surrounding habitats, such as clearing or installation of wildlife crossing structures.

The maintenance regime will involve:

- The removal of pest species such as common myna, common starlings and European bees.
- The replacement of fallen, damaged or deteriorated nest boxes.
- The repositioning or relocation of nest boxes that show no sign of use after several successive monitoring periods

- The removal of excess nesting material that may block access to the nest box over time.

4.7.4 PERFORMANCE MEASURES

Indicators of success of nest boxes include:

- Use of nest boxes by a wide range of native fauna species.
- Use of next boxes designed for specific species by those same species.
- Low rate of use of nest boxes by introduced fauna species.
- Low level of maintenance of nest boxes.

4.8 MICROBAT ROOST BOXES

The monitoring methodology for roost boxes described here has been extracted from the *Microchiropteran Bat Management Strategy* (Lewis Ecological Surveys 2013d).

4.8.1 DESCRIPTION

A *Microchiropteran Bat Management Strategy* has been prepared by Lewis Ecological Surveys (2013d). The Management Strategy describes existing locations of roosting microbats and management strategies used to avoid, minimise and mitigate impacts on identified bat roosts, which includes the installation of bat roost boxes. 158 bat roost boxes (Table 19) were installed in late September / early October 2013, which is 6-12 months prior to planned roost exclusion from existing structures.

Table 19: Bat roost boxes that have been installed

Location	Roost Box Type A (small slotted style bat box)	Roost Box Type B (wedge style)	Roost Box Type C (tree mounted removable slots)
K2K	31	32	28
OH2Ku	20	23	24
Total	**51**	**55**	**52**

4.8.2 TIMING

Bat roost boxes have been installed prior to the commencement of construction (Year 0). Monitoring of bat boxes will commence six months after their installation (Year 1), followed by quarterly inspections (each season) for two years (Years 2 and 3), before addressing corrective actions. After the first two years of monitoring, monitoring of the bat roost boxes will continue twice a year (summer and winter of Year 4, 6 and 8) up until Year 8 (i.e. 2 surveys per year for Years 4-6).

4.8.3 MONITORING PROCEDURE

A visual inspection of each bat roost box will be undertaken. During each monitoring period, the following information will be collected for each bat roost box:

- Inspection date, weather conditions (rain, wind, cloud cover, ambient temperature) and time each bat roost box was inspected.
- Bat roost box identification number.

- If the bat roost box is occupied by microbats, and if so, the species. If the next box is not occupied by a native species, record any signs of use by microbats.
- If the bat roost box is occupied by a pest species such as European bees.
- Is there any deterioration of the bat roost box and is any maintenance required.
- Any changes to the surrounding habitats, such as changes to flyways or vegetation structure.

4.8.4 PERFORMANCE MEASURES

Indicators of success of bat roost boxes include:

- Use of bat roost boxes by microbats.
- Low rate of use of roost boxes by introduced fauna species.
- Low level of maintenance of roost boxes

4.9 GREEN-THIGHED FROG BREEDING PONDS

The monitoring methodology for Green-thighed Frog breeding ponds described here has been extracted from the *Green-thighed Frog Management Strategy* (Lewis Ecological 2013b).

4.9.1 DESCRIPTION

The Revised Statement of Commitments includes measures to be implemented to mitigate the loss of potential frog breeding habitat:

- *SoC F11:* Consideration would be given to constructing artificial frog ponds if appropriate.

Frog breeding ponds will be constructed at four locations; one or two (see below) within the Oxley Highway-Kundabung section and two within the Kundabung-Kempsey section. These locations and their attributes are described in detail in the *Green-thighed Frog Management Strategy* (Lewis 2013b). Ponds will be constructed as per the design requirements outlined in the *Green-thighed Frog Management Strategy* (Lewis 2013b). Ponds will be located at:

- Ch.9050-9350. Five ponds to be constructed on each side of the carriageway.
- Ch.11550. Five ponds to be constructed on each side of the carriageway (Project Ecologist to investigate the suitability of ponds in consultation with RMS and the EPA and be guided by the results of pre-clearing surveys).
- Ch.30660. Five ponds to be constructed on the western side of the carriageway.
- Ch.33650. Five ponds to be constructed on each side of the carriageway.

4.9.2 TIMING

Monitoring will be undertaken on five occasions commencing in Years 3-7 (construction and operation phase). Each monitoring event should be at least 10-12 months apart but ultimately dependant on rainfall events. On each occasion the site would be surveyed for 30 minutes during Stage 1 and for 20 minutes during stage 2 (see section 4.9.3). Four of the five monitoring events are to occur during the operational phase of the Project (Years 4-7). The first round of monitoring (Year 3) is to commence once the vegetation on the edges of the constructed ponds is considered sufficient (>20% groundcover), to be determined by a suitably qualified Ecologist. The timing would be staggered accordingly for either stage of the Upgrade.

4.9.3 MONITORING PROCEDURE

Monitoring of the constructed breeding ponds would ideally be undertaken on a rainfall event basis when 24-hour rainfall totals exceed 75 millilitres or a cumulative total of 150 millilitres over a 72-hour period. Such rainfall events would be monitored via the Bureau of Meteorology (BOM) website, specifically the Port Macquarie (Station No. 060183) and/or Kempsey (Station No. 059017) weather stations. Where sufficient rainfall is unlikely to occur during the monitoring period, the Project Ecologist will determine whether smaller rainfall events are suitable to conduct a monitoring event. The suitability of the rainfall trigger chosen would be subject to the reference site visit outlined in Stage 1 below. Surveys would be performed using a two-stage process outlined below.

Stage 1 – Determining Presence and Breeding Activity

Upon the study area receiving the required rainfall, a reference site would be visited to determine the extent of Green-thighed Frog activity.

The survey would comprise a 30-minute nocturnal active search at each of the four breeding pond areas using a hand held spotlight. Peripheral habitats (i.e. <50 m) would also be surveyed at this time. Upon the completion of Stage 1 surveys the next stage would be implemented.

Stage 2 – Determining the Success of the Breeding Event

All frog breeding pond areas would be subject to follow-up surveys between 30-40 days after Stage 1 to assess the outcome of the breeding event. This follow up survey will comprise:

- A 20-minute active search for metamorphs and juvenile frogs around the pond edge and vegetation immediately adjacent to the pond (i.e. <10 m).
- Dip netting of the constructed pond and subsequent tadpole identification. Specific attention will be given toward identifying the presence of fish (both native and exotic) along with predatory invertebrates such as dytiscid larvae.
- The depth of the ponds would be measured from the permanently installed water staff.
- Photo taken from a designated photo point (to be established during the first Stage 2 survey).

4.9.4 PERFORMANCE MEASURE

Performance indicators of success will be based on either the:

- Continued presence of Green-thighed Frog at two/three or more of the three/four frog breeding pond sites.
- Green-thighed Frogs calling from the edge of the constructed ponds.
- The presence of tadpoles, juveniles or metamorphs during follow up surveys.

Signs of the mitigation being unsuccessful will be based on the:

- Absence of Green-thighed Frogs from the area.
- Ponds not holding water for a sufficient time to enable tadpoles to reach metamorphosis.
- Ponds holding water for too long and representing unsuitable habitat (i.e. permanent versus ephemeral).

4.10 *MAUNDIA TRIGLOCHNOIDES* HABITAT PROTECTION

4.10.1 DESCRIPTION

Areas of potential *Maundia triglochnoides* habitat were surveyed by the SMEC-Hyder Joint Venture (SHJV) ecologists in November 2012, following the identification of *M. triglochinoides* in the Project corridor in August 2012 by Lewis Ecological Surveys. Three distinct sub-populations of *M. triglochinoides* were recorded in the project area (Table 20).

Table 20: *Maundia triglochnoides* in the project area

Location	*M. triglochinoides* potentially impacted by the project
Fernbank Creek (Ch.4450-5080)	0.75 ha
Wilson River Floodplain –wetlands (Ch.15,890)	0.03 ha
Wilson River Floodplain – canal (Ch.13,900-14,100)	0.09 ha
Barrys Creek	-
Total	**0.87 ha**

4.10.2 TIMING

Monitoring would commence in the summer of Year 1 (construction phase) and be undertaken three times a year (summer, autumn and spring) until Year 4 (operation phase) of the Project. Weekly inspections during construction will be undertaken by the Contractor with regard to exclusion fencing, signage and erosion and sediment controls.

4.10.3 MONITORING PROCEDURE

Monitoring locations will comprise both *M. triglochnoides* sites within the Project boundary that will be retained and protected, and sites outside of the project boundary. Exact locations of Impact (within the project boundary) and Control (outside of the project boundary) sites will be determined during the detailed design of the Oxley Highway to Kundabung section. Impact and Control sites will be paired to enable a paired t test or a non parametric equivalent (i.e. Mann Whitney) of the attributes of each site. At each monitoring location, the following attributes will be recorded:

- Current extent of cover (%) along a 50m transect.
- Water depth recorded from a permanently installed water staff or other suitable method.

- The extent of flowering or seeding.
- Signs of recruitment.
- Signs of disturbance (i.e. cattle) and to what extent/area.
- Specific photo point installed.

4.10.4 PERFORMANCE MEASURE

Indicators of success will focus on the following:

- Exclusion fencing with signage identifying these as ‘no go’ zones (during construction).
- Sediment control fencing in place (during construction).
- Flowering and/or seeding is consistent with paired control and/or nearest reference site.

Signs of the habitat protection procedure not working will be based on the following:

- Breached exclusion fencing;
- No signage identifying the sensitive nature of the location as threatened species habitat.
- A significant (if statistics are used) or substantial difference (15% allowance) between the paired monitoring sites with regard to flowering/seeding and overall extent or recruitment over subsequent monitoring events that cannot be attributed to environmental factors.

4.11 LANDSCAPING AND REVEGETATION

4.11.1 DESCRIPTION

Landscaping and revegetation of disturbed areas will be undertaken in all areas of the project. Urban Design and Landscaping Plans will be prepared for each stage of the project that address the urban design and landscaping requirements of Minister’s Condition of Approval B20.

4.11.2 TIMING

Monitoring of landscaping would be conducted at eight months and 12 months.

The need for additional monitoring would be determined following analysis of the monitoring data.

Maintenance of the landscaping and weeds would continue for the duration of the three year maintenance period as outlined in Section 6 or until such time as the revegetation is determined successful and is no longer requiring active management to maintain its survival.

4.11.3 MONITORING PROCEDURE

All areas of native plant stock would be monitored by the Contractor, Roads and Maritime, and the independent Landscape Representative or Project Ecologist to establish whether the performance measures in Section 4.11.4 have been met.

4.11.4 PERFORMANCE MEASURE

Indicators of success will focus on the following:

- Each area revegetated by native seeding must achieve the following minimum standards as assessed at 12 months following revegetation:

        - One native plant every $6m^2$
        - Average minimum height of 15cm, and
        - Native vegetation diversity to be assessed to the satisfaction of the Landscape Representative or the Project Ecologist.
    - All areas required to be revegetated by native planting must achieve the following minimum standards as assessed at 12 months following revegetation:
        - Minimum plant growth of 30cm following planting, and
        - Minimum plant survival rate of 80%.
    - Weed cover is less than 5% per restored area.

If these performance indicators are not achieved a non-conformance would be raised, to be closed out to the satisfaction of Roads and Maritime, and the Landscape Representative or the Project Ecologist.

Reporting on the outcomes of landscape monitoring would form part of the annual ecological monitoring report, and would be presented in a format similar to the spreadsheet provided in Appendix C.

4.12 SUMMARY OF MONITORING ACTIONS

A summary of monitoring actions, from baseline surveys to be undertaken prior to the commencement of construction, through to Year 8 of the operation phase, is provided in Table 21.

Table 21: Summary of monitoring requirements outlined in this EMP

Mitigation Measure	B				C												O																				
	Year 0				Year 1				Year 2				Year 3				Year 4				Year 5				Year 6				Year 7				Year 8				
	Su	A	W	S	Su	A	W	S	Su	A	W	S	Su	A	W	S	Su	A	W	S	Su	A	W	S	Su	A	W	S	Su	A	W	S	Su	A	W	S	Su
Koala																																					
Spotted-tail Quoll																																					
Giant Barred Frog																																					
Green-thighed Frog																																					
Yellow-bellied Glider																																					
Brush-tailed Phascogale																																					
Squirrel Glider																																					
Road Kill																																					
Pre-clearing / clearing																																					
Fauna underpasses																																					
Rope Bridges																																					
Glider Poles																																					
Fauna Fencing																																					
Widened Median																																					
Nest boxes																																					
Bat Roost Boxes																																					
Maundia Habitat Protection																																					
Green-thighed frog ponds																																					
Landscape monitoring																																					

Su A W S= Summer, Autumn, Winter, Spring.

B, C, O = Baseline, Construction, Operation

5 POTENTIAL CONTINGENCY MEASURES

MCoA B10 (e) and the Department of the Environment CoA 4d require the Ecological Monitoring Program to provide details of contingency measures that would be implemented in the event of changes to densities, distribution, habitat usage and movement patterns directly attributable to the construction and operation of the Project. Types of contingency measures that would be implemented in the event that a mitigation measure is deemed ineffective are dependent upon the nature, location and magnitude of the impact. However, potential problems and contingency measures are detailed in Table 22.

Table 22: Potential contingency measures

Mitigation Measure	Potential Problem	Contingency Measure
Pre-clearing surveys	Previously undetected fauna is located prior to clearing.	Notify Environmental Manager and EPA within 24 hours. Project ecologist to record location of species immediately with GPS. Project ecologist to relocate and release fauna into suitable adjoining habitat. Obtain approval from relevant authorities to relocate threatened species if required, at least 24 hours before relocation is conducted.
	Previously undetected flora species is located prior to clearing.	Notify Environmental Manager and EPA. Project ecologist to record location of species with GPS. Delineate threatened species with highly visible tape to protect it from clearing. Seek approval from relevant authorities to translocate species if required.
	Identification of previously undocumented EEC.	Notify Environmental Manager and EPA. Project ecologist to delineate boundaries of the EEC with a GPS and highly visible tape. Consult with relevant authorities for management of additional EEC
Clearing Procedures	High rates of fauna injury and mortality resulting from clearing operations.	Immediately commence review of clearing procedures and complete review prior to clearing recommencing. Modify habitat tree retention times and/or Stage 2 (habitat tree felling) clearing procedures prior to clearing recommencing. Review approach of clearing contractor prior to clearing recommencing.

Mitigation Measure	Potential Problem	Contingency Measure
Fauna Underpasses and Fauna Fencing	No recorded presence of indicator species from the nominated classes in underpasses, No recorded presence of cover dependent species or fauna species with low mobility in underpasses, Increases incidence of road kill from baseline conditions, in proximity to underpasses, particularly target species. Inferior results compared to baseline surveys for the EPBC species, relevant to reference site monitoring.	Commence review/modification of fauna furniture associated with underpasses within two weeks of results reported by ecologist. Commence review/modification of habitat (ie vegetation composition and structure; type and abundance of natural habitat features) adjoining the underpass within two weeks of results reported by ecologist. Commence review/modification of frequency and/or timing of monitoring periods within two weeks of results reported by ecologist. If it is not reasonable or feasible to redesign/modify the underpass, discussions with EPA, DP&I and DoTE will be undertaken to determine if additional biodiversity offsets are required within 1 month of above reviews being completed.
Fauna fencing	Breach in fauna fencing. High rates of fauna road strike mortality within 200m of fauna underpasses.	Commence review/modification of fauna exclusion fencing design, location or extent depending on species struck by vehicles within two weeks of results reported by ecologist. Inspect fence for breaches and inform maintenance as necessary within two weeks of results reported by ecologist. Any damage to fauna fencing will be temporarily repaired within one week of a breach being identified. Permanent repair to occur as soon as possible and within two months of the breach being identified.
Rope Bridges/glider poles	Low usage rates of rope bridge by arboreal native fauna. Low usage rates of glider poles of gliding species. High rate of arboreal fauna vehicle strike in proximity to rope bridges.	Review/modify frequency and/or timing of monitoring periods. Review/modify habitat (ie canopy species adjoining rope bridge and connectivity to rope bridge).

Mitigation Measure	Potential Problem	Contingency Measure
Nest Boxes	Nest box being used by non-target species. Nest boxes become occupied by exotic or invasive fauna such as European bees. Poor uptake or usage by native fauna species. Nest boxes deteriorating rapidly and requiring maintenance.	Review number and design of next boxes. Review/modify nest box design to exclude undesirable species, treat nest boxes to deter/eradicate pest species, or relocate nest boxes. Review the types and numbers of next box designs, their location or positioning within the tree. Identify causes of nest box failure, modify design and construct accordingly.
Green-thighed frog breeding ponds	Ponds not used by Green-thighed frog. Ponds not being holding water long enough to enable breeding to succeed. Ponds holding water for too long encouraging competition from non-target frog fauna. Exotic fish species recorded in breeding ponds.	Survey adjacent areas to confirm frogs remain in area. Review/modify ponds to improve potential site suitability problems. Review/modify ponds either by placing a semi permeable layer or further excavation. Improve drainage. Modify pond to ensure it dries out.
Widened Median	No evidence of use of the median vegetation by the target glider species.	Investigate alternative crossing structures (eg glider poles and/or rope bridges) in consultation with EPA.
Baseline Surveys Before, After, Control Impact (BACI) design (specifically the Koala, Spotted-tail Quoll, Giant Barred Frog, Yellow-bellied Glider, Brush-tailed Phascogale)	Decline in presence of target species recorded at Impact sites after the upgrade has been completed, when compared to change in Control sites.	The cause of the decline in populations at impacts sites will be investigated in consultation with EPA and DoTE within two weeks of results reported by ecologist. If the cause of decline is considered most likely attributed to the upgrade of the highway (and not another event such as bushfire), mitigation measures, such as the location and types of fauna crossings and fauna fencing will be reviewed within two months of the above consultation being completed.

6 MAINTENANCE

The ongoing function of the mitigation structures discussed in Section 4 is also dependent on a clear commitment to their maintenance. Regular inspections of the mitigation structures are essential to ensure they remain safe for motorists and are functional for wildlife.

During construction, maintenance requirements associated with the mitigation structures will be undertaken by the contractor and will consist of, but not be limited to, the following:

- Weed and landscaping maintenance.
- Unplanned maintenance as required of nest boxes, fauna furniture, fauna fencing, etc. identified through environmental inspections and audits.

Prior to operation of the Project, the ongoing maintenance requirements of the mitigation structures will be identified as part of the hand over process to the road asset manager. During operation, maintenance requirements will be undertaken by Roads and Maritime and will consist of, but not be limited to, the following:

- Weed and landscaping maintenance.
- Planned maintenance of nest boxes, fauna furniture, fauna fencing, glider poles and rope bridges, and green-thighed frog breeding ponds.
- Unplanned maintenance as required of the above structures identified through the monitoring detailed in Section 4.

Roads and Maritime will remain responsible for the roadway and its corridor as part of a Controlled Access Road required to be maintained by NSW legislation in perpetuity.

7 REPORTING

A report on the clearing procedures will be prepared upon the completion of clearing operations and will include:

- Details of methods used during pre-clearing surveys and clearing operations.
- Fauna species displaced by clearing, species, captured, species released and any wildlife mortalities resulting either directly or indirectly from the clearing operations.
- Location of fauna within clearing footprint (recorded with GPS) and release locations.
- Hollow-bearing tree register, and comparison of this data to nest box plan (assess the adequacy of nest boxes installed and how they are mitigating the loss of tree hollows).
- Discussion of the effectiveness of those methods employed.
- Recommendations for future pre-clearing and/or clearing procedures.

Annual reporting of all other monitoring results (i.e. of target fauna species, fauna mitigation measures and habitat usage) will outline:

- Detailed description of monitoring methodology employed.
- Results of the monitoring period, including timing of monitoring period, weather conditions, and fauna species recorded by each monitoring method.
- Discussion of results, including how the results compare against performance measures, if any modifications to timing or frequency of monitoring periods or monitoring methodology are required and any other recommendations.
- If contingency measures should be implemented.

All reports prepared under the Ecological Monitoring Program will be submitted to the Director General of the Department of Planning and Infrastructure and the EPA.

In accordance with Condition 8 of the Commonwealth Department of the Environment approval EPBC2012/6518, within three months of every 12 month anniversary of the commencement of the action a report will be published on the website addressing compliance the implementation of the Ecological Monitoring Plan.

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Appendix A

Baseline Results for EPBC Species

(available on request – currently not WCAG compliant)

Appendix A Baseline Results for EPBC Species

KOALA

Introduction

The Environmental Assessment recorded one Koala crossing the highway approximately 200 metres south of Sancrox Road whilst searches for scats and scratches around potential feed trees indicated recent Koala activity within Ballengarra State Forest and south of Sancrox Road (GHD 2010). The EA reported suitable feed trees occur through most of the identified vegetation communities and often occur as dominant or co dominant in most of the moist floodplain forests, moist slopes forest, riparian forest and swamp mahogany/forest red gum swamp forest (GHD 2010).

Given the above, Koala was nominated as a species requiring specific monitoring in order to measure the impacts associated with the Upgrade and to assess the performance of various mitigation measures being proposed. To address this, the following monitoring program was developed as part of collecting pre construction baseline data.

Survey Design and Method

The following survey design has been developed to provide baseline information in relation to the distribution, activity, density, habitat use and likely movement patterns of Koala in the vicinity of the Upgrade. In order to derive the required information Koala was considered at a broader meso scale with a 10 km buffered search area of the Upgrade or an area of 116,000 ha spanning from the Cowarra region in the south to the Kempsey township and the Macleay River in the north. Together, this area is referred to as the study area for the Koala baseline monitoring.

Measuring Koala Distribution

Baseline Koala distribution was measured using the Office of Environment (OEH) Bionet Wildlife Atlas as a registered user. The search area was buffered to within 10 km of the Upgrade so as to provide some indication on the broader distribution across the coastal plains and adjacent foothills. The atlas data was then divided into the following three chronological time scales:

- Pre 1984 being used to measure historic presence of Koala prior to major expansion of residential and rural residential areas;
- 1984-2003 to reflect a 20 year period when Port Macquarie and rural residential allotments underwent substantial expansion in the study area; and
- 2004-2014 to reflect more recent records for use as a current guide to describe the existing Koala distribution.

This information was illustrated by means of GIS outputs into figures and described both quantitatively and descriptively with reference to obviously clustering of records as focal points for Koala populations and to explore differences in changed reporting rates between historical data (pre 1984) with more recent records (2004-2014).

Measuring Koala Activity

Koala activity was measured using the Spot Assessment Technique (SAT) developed by Phillips and Callaghan (2011). The following describes the application of this technique:

1) Locate and mark a tree that is:

    a) A tree of any species beneath which one of more koala faecal pellets have been observed; and/or

    b) A tree in which a koala has been observed; and/or

    c) Any other tree known or considered to be important for koalas or of interest for other assessment purposes.

2) Identify and mark the 29 nearest trees to the tree marked initially.

3) Undertake a search for koala faecal pellets beneath each of the 30 marked trees. Visually inspect the ground surface beneath trees to a distance of one metre from the trunk. If no pellets are observed, rake the leaf litter within the prescribed search area. Two person minute per tree should be dedicated to the search for faecal pellets. The search should be concluded once a single pellet is found or the search time has expired (whichever happens first). Faecal pellets should not be removed from the site unless verification is necessary.

4) The activity level of a site is calculated as the percentage of surveyed trees within the site (of 30 trees) that has a koala faecal pellet recorded within its search area. Then result is used to assess whether the site supports "Low", "Medium (normal)" or "High" koala activity (Table 4-1).

Table 4-1. Categorisation of Koala activity (Phillips and Callaghan 2011).

Activity Category	Low use	Medium (normal) use	High use
East coast (low density area)	-	3.33% but ≤12.59%	>12.59%
East coast (medium-high density area)	<22.52%	≥22.52% but ≤32.84%	>32.84%
Western Plain (medium-high density area)	<35.84%	≥35.84% but ≤46.72%	>46.72%

The SAT data was collected using a stratified BACI (Before-After-Control-Impact) survey design which included three treatment classes across eight Koala monitoring areas which had been previously proposed in the draft Ecological Monitoring Program (*see* Section 3.1 and Section 3.2.1) and endorsed by the EPA during the consultation and review process. The treatments included:

- Mitigation (Treatment A) centred on the RMS providing sufficiently large culverts (i.e. > 1.8 m) and floppy top fencing (orange circles);
- No Mitigation (Treatment B) where the mitigation described above has not been provided by the RMS (red circles) or only a part mitigation site could be located (yellow); and
- Control or Reference (Treatment C) located in areas at least 3 km and often 5-10 km from the Upgrade (green circles) as shown in Figure 4-1.

Within each treatment class, a subset of three Spot Assessment Technique (SAT) sites (3 x 30 = 90 trees) were established with the objective to increase the confidence level in each treatment sample. This culminated in 2160 trees being searched for Koala scats during late Spring (i.e. November) of 2013.

Measuring Koala Density

Koala density was measured in three ways:

1) Using historic records from the wildlife atlas to describe reporting rates using a standardised 5 km^2 across the study area;
2) Spotlighting within a sub set of these grid sites to compare current surveys with the reporting rates contained within the wildlife atlas; and
3) Using camera traps set in a randomised grid configuration given that Koala regularly move along the ground to access to new trees for foraging and refuge.

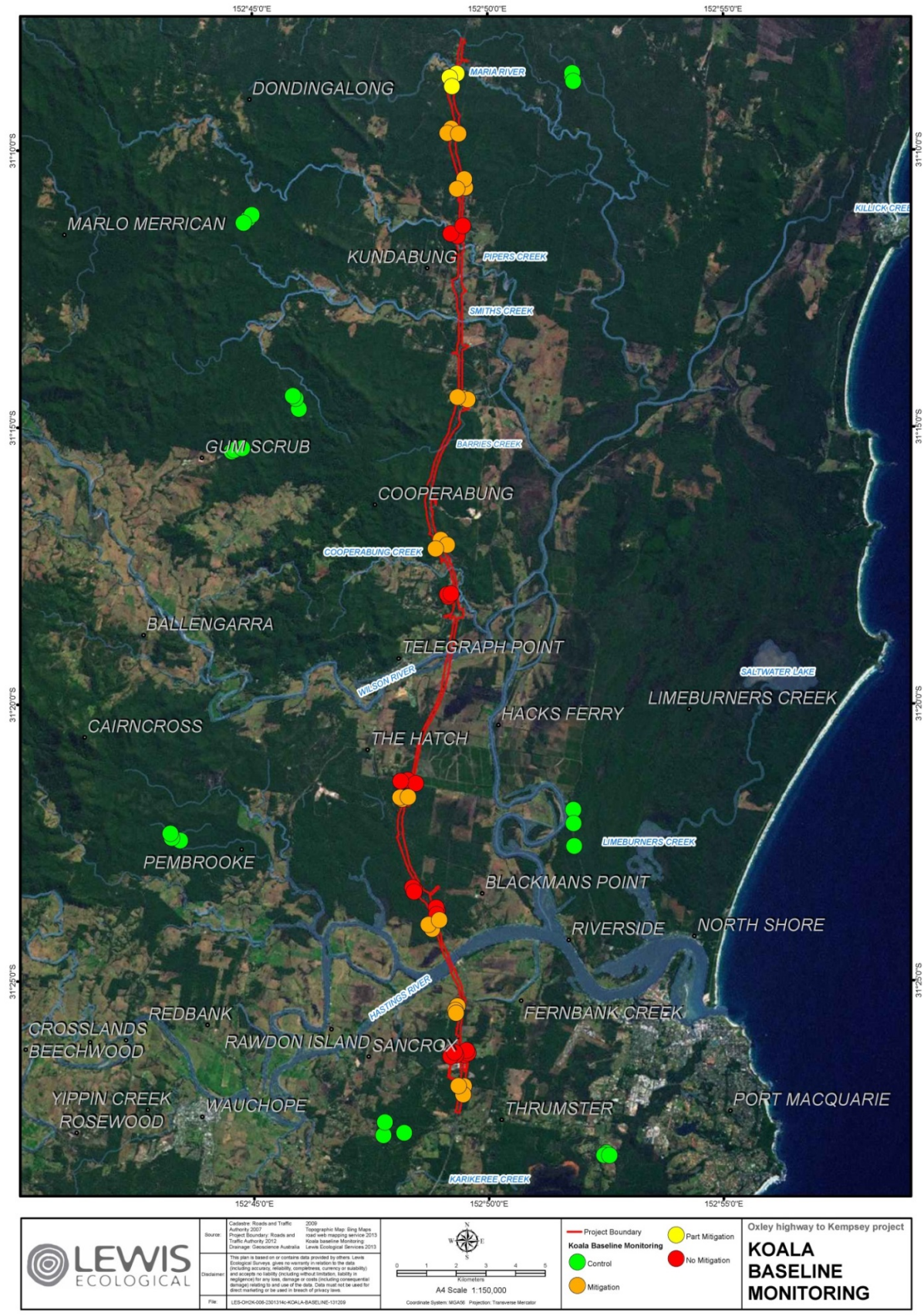


Figure 4-1. Distribution of Koala monitoring sites and treatment classes used during the pre-construction baseline survey.

i. Grid Based Sampling Using Historic Data

The number of records from the Bionet Wildlife Atlas data was measured using a 5 km^2 grid installed across the study area. The number of records reported for the time period 2004-2014 was used as a surrogate measure of Koala density given that area's containing higher densities of Koala should yield a greater number of records. The number of records were then summed with each grid then prioritised or ranked from the highest to lowest.

ii. Spotlighting

Spotlighting was undertaken at a sub set of six sites in Cairncross State Forest (ch. 10400), Ballengarra State Forest (ch. 24000) and Maria River (ch. 36850) with each spotlight location being set up in a paired BACI configuration comprising an impact site and a control or reference site (hereafter reference) which preferably exhibited similar vegetation/habitat type and landscape features (Figure 5-1; Table 5-1).

Field surveys involved a listening period when first arriving at each location for 10 minutes. Spotlighting was then performed by two observers using hand held variable beam 100 watt spotlights whilst walking a timed 500 m transect over 30 minutes (1 person hour effort). This was repeated on three separate occasions on non-consecutive nights between the 27th September and the 24th November 2013. The minimum time between consecutive surveys was 7 days to maximize the opportunity of detection.

The approach described above is broadly consistent with the Kempsey Koala Plan of Management which advocated for the purposes of monitoring "*a minimum of 4-6 randomly selected, permanent spotlighting transects collectively sampling > 50ha of preferred koala habitat within that area captured by the Dondingalong – Kundabung – Crescent Head KMA boundary*" of which the northern 14 km of the Upgrade bisects.

Table 4-2. The BACI survey design for sampling Koala numbers using paired sampling.

Broad Survey Area	Treatment Class	Paired Reference location	Status of Records
Cairncross	Impact but with Mitigation (floppy top fencing and underpasses)	Cairncross State Forest in Pembrooke area around 10 km west in forest managed by Forests NSW	Impact Site – Koala consistently recorded as road kill on the existing Pacific Highway carriageway. Reference/Control – Area of contiguous forest managed by Forests NSW with relevant prescriptions around drainage lines supporting similar vegetation type.
Ballengarra	Impact but with Mitigation (floppy top fencing and underpasses)	Greg's Road area around 5 km west in Ballengarra State Forest.	Impact Site – Koala consistently recorded as road kill on the existing Pacific Highway carriageway. Reference/Control – An area comprising a ridge with adjoining lower slopes supporting similar vegetation types around 5 km west of the Upgrade.
Maria River	Impact but with Mitigation (floppy top fencing and underpasses)	Maria River NP east near suitable feed trees.	Impact Site - Koala consistently recorded as road kill on the existing Pacific Highway carriageway. Reference/Control – An area considered likely to support Koala.

iii. Camera Traps

Camera traps were used as an ancillary technique to obtain a relative measure of Koala density broadly across the three largest patches of contiguous vegetation. These areas provided the most obvious areas for Koala to maintain viable populations and were more likely to remain in an intact state during the monitoring period. Camera traps were established in the following areas:

Patch 1 – Cairncross State Forest and neighbouring private lands where the Upgrade corridor bisects a contiguous patch of predominantly dry sclerophyll forest with some swamp forest associations between chainages 8000 and 13500.

Patch 2 – Ballengarra State Forest and neighbouring private lands where the Upgrade corridor bisects a contiguous patch of predominantly dry sclerophyll forest with some moist forest and swamp forest associations along several drainages between chainages 20000 and 27000.

Patch 3 – Maria River State Forest and neighbouring private lands where the Upgrade corridor bisects a contiguous patch of predominantly dry sclerophyll forest with some moist forest and swamp forest associations along several drainages between chainages 33000 and 38000.

Within each of the three areas, a stratified BACI (Before-After-Control-Impact) survey design was adopted following consultation with the EPA and included the following three treatments:

- 1 x reference site unaffected by the Upgrade (Figure 4-2; Table 4-2). The location of the reference site was normally greater than 5 km from the Upgrade corridor and often 7-10 km away. Every attempt was made to locate a site which exhibited a similar array of topography and habitat attributes as both the nominated control and treatment sites located within the Upgrade corridor. Additional factors including the presence of two fires at Beranghi and Limeburners Creek Nature Reserve necessitated the relocation of the Maria River reference site to a secondary location much further to the north;
- 1 x control site where no specific Koala mitigation has been proposed within the Upgrade for >500 m (Figure 3-1; Table 3-1). For the purposes of this study, Koala mitigation was deemed as a fauna underpass structure referred to as a dedicated or combined fauna underpass >1.8 m in height and supported with floppy top fencing (SMEC-Hyder 2013). Drainage culverts were ignored in this instance because they are not being installed for the purposes of facilitating fauna movements; and
- 1 x treatment site where the RMS providing sufficiently large culverts (i.e. > 1.8 m) and floppy top fencing fauna underpasses have been located in neighbouring areas to the control (no mitigation) site. A treatment site was considered suitable if there was a combined or dedicated fauna underpass within 500 m. Bridges were not considered in this survey design following consultation with the EPA who recognised they provide an acceptable form of habitat connectivity to most ground dwelling fauna.

The above survey design was repeated at three locations to provide a stratified sampling design of three replicates of each treatment within each of the three survey areas (Cairncross, Ballengarra, Maria River). This resulted in 9 x 100 ha survey plots across three treatments for each area culminating in 2700 ha (Table 4-2).

Camera Traps Sampling Regime

Four infrared cameras (Scoutguard 560 P model) were installed 500 m apart across each 100 ha plot with three plots representing each treatment (n=12 cameras) for each of the large patches of vegetation. Cameras were set in continuous 24 hour mode for a minimum of 21 nights using the following parameters:

- Sensor Sensitivity was set at a variable rate from 'normal' or 'high' depending on the amount of grass and other fine vegetation present at the camera site. Some pruning of vegetation was undertaken at sites in order to maximize the opportunity to setting the camera sensitivity to high;
- The number of images was set to 2 with the reset or PIR set at 30 second intervals;
- All images were time and date stamped for later verification and to facilitate in the understanding of Koala and any predator activity and interactions.

Cameras were installed between the 8 and 14th August 2013 and retrieved between 22-26 days later culminating in 2340 nights of survey effort.

Table 4-3. Summary of camera monitoring sites.

Area	Monitoring Sites (each is 100 hectares)
Cairncross State Forest	• 3 Control Sites ("Reference" sites in *Monitoring Strategy)* • 3 Impact sites in proximity to fauna underpasses ("Treatment" sites in *Monitoring Strategy)* • 3 Impact sites where no specific quoll mitigation (fauna underpasses) has been proposed ("Control" sites in *Monitoring Strategy)*
Ballengarra State Forest	• 3 Control Sites ("Reference" sites in *Monitoring Strategy)* • 3 Impact sites in proximity to fauna underpasses ("Treatment" sites in *Monitoring Strategy)* • 3 Impact sites where no specific quoll mitigation (fauna underpasses) has been proposed ("Control" sites in *Monitoring Strategy)*
Maria River State Forest	• 3 Control Sites ("Reference" sites in *Monitoring Strategy)* • 3 Impact sites in proximity to fauna underpasses ("Treatment" sites in *Monitoring Strategy)* • 3 Impact sites where no specific quoll mitigation (fauna underpasses) has been proposed ("Control" sites in *Monitoring Strategy*)

Interpreting the Camera Data

All images were reviewed by one person (BDL). The maximum abundance or activity levels for any species within a given 1 hour period was one and this applied to both Koala and eutherian predators. The only exception to this was where the individuals could clearly be identified from another within that 1 hour period. For example, a sandy coloured Dingo that was repeatedly photographed on 10 occasions over the spaced of 30 minutes was counted as a single record of occurrence whilst a different coloured Dingo captured during the same period would allow the counting of a second animal.

Assessing Koala Habitat Use

Koala habitat use was measured in two ways, firstly, at a broader study area scale (i.e. 10 km buffer), and secondly, using the SAT survey data from the 2160 trees checked to identify and rank the importance of each tree species sampled.

i. Assessing Habitat Use Throughout the Study Area

Vegetation mapping was obtained from OEH using the CRAFTI lower north east florsitics GIS layer. Historic Koala records from the Bionet Wildlife Atlas were then overlayed and summed for each vegetation community at the three chronological times scales of pre 1984; 1984-2003; and 2014-2014. Vegetation communities were then ranked according to the number of records obtained. The results were then compared to other relevant broad scale Koala surveys in the region including the Kempsey Koala Plan of Management for the eastern part of the LGA which includes the northern 14 km of the Upgrade between Mingaletta and South Kempsey (KSC 2011).

Figure 4-2. Distribution of treatments and camera trap locations during the pre-construction baseline survey.

ii. Assessing Habitat Use at a Tree Species Scale

Koala habitat was also assessed at a tree species scale with the data obtained from the 2160 trees sampled during the SAT surveys. Trees that returned positive Koala use were classified as forage species with those that returned higher scores deemed to be of greater importance as Koala foraging habitat.

Assessing Koala Movements

Koala movements were assessed by using the Bionet Wildlife Atlas and summing all of the historic data for each of the CRAFTI derived vegetation community polygons. Those polygons which scored higher were considered to have a potentially higher habitat value to Koala and based on the score obtained the following categories of potential habitat value were derived and displayed using GIS:

High Value: Polygons scoring more than 150 records
Moderate Value: Polygons scoring between 10-150 records
Low Value: Polygons scoring between less than 10 records
Very Low Value: Polygons were no Koala records existed.

The distribution of those polygons which scored a high value were deemed as being potential nodal areas for Koala through the landscape.

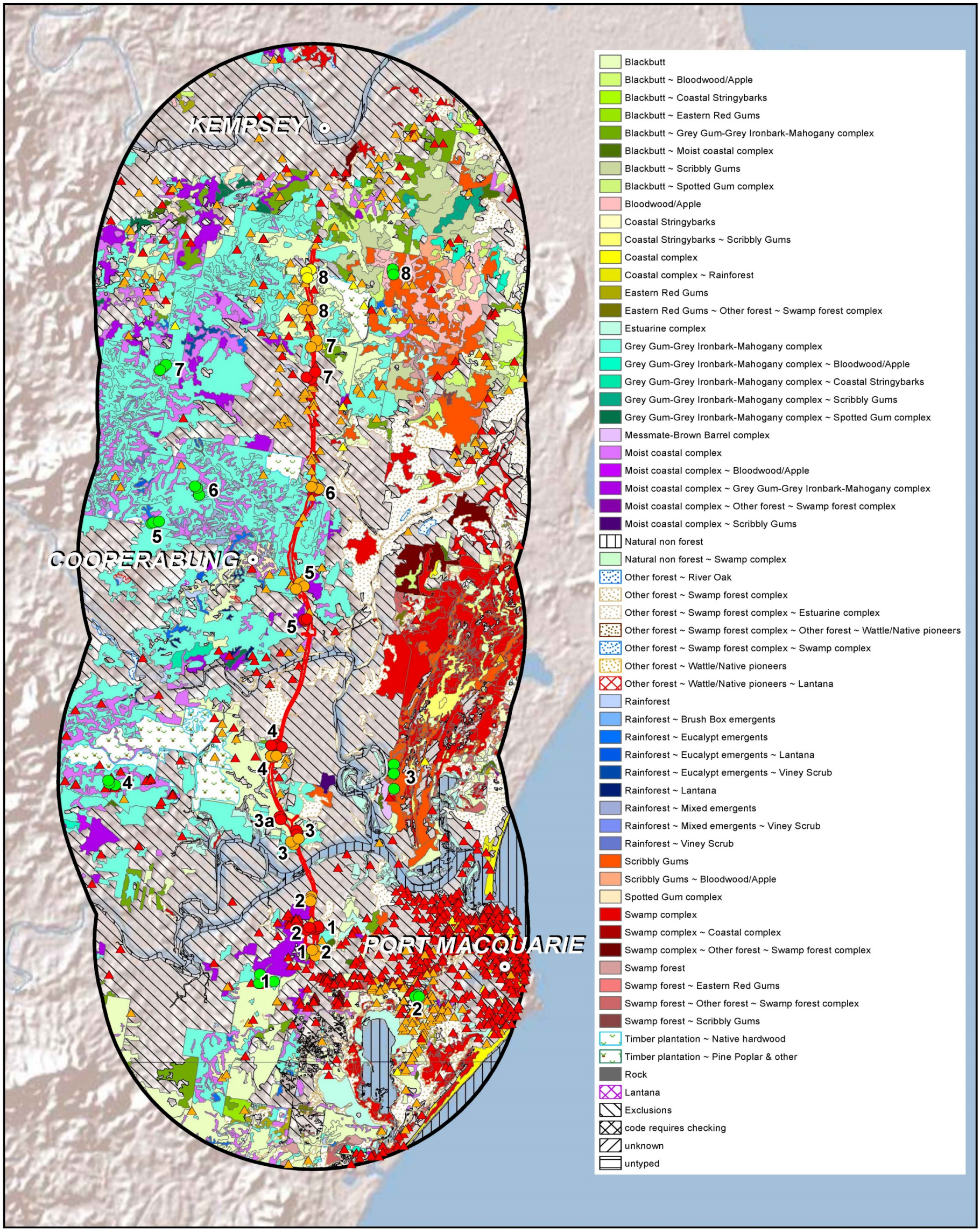
Road kill data was also used to describe localised Koala movements and as a vetting process to the broader mapping approach described above. These road kill surveys were performed weekly over a four week period in October 2013 (i.e. Spring) and repeated again between the 17th January – 7th February 2014 (i.e. Summer) with further information provided in Section 8.0. Some additional information collected by the author over the past 10 years has also been used to describe Koala nodal areas and road kill hot spots.

Results

Koala Distribution

The distribution of Koala in relation to the Upgrade and a 10 km buffer culminated in 1611 records (Figure 4-3). The majority of these records (i.e. 1249 or 77%) were recorded in the past 10 years (2004-2014) indicating it provides an accurate appraisal on the current distribution of Koala.

Koala is broadly distributed throughout the study area with a distinct clustering of records in the south eastern precinct which includes Port Macquarie, Lake Innes and the Thrumster area (Figure 4-3). Records are consistently distributed throughout the Upgrade corridor and these are linked to the vegetated land parcels the Upgrade corridor bisects (e.g. Cairncross State Forest, Ballengarra State Forest, Maria River State Forest). Only the floodplain environs of both the Hastings River and the Wilson River show obvious gaps in Koala distribution due largely to the historic development of these areas for agricultural pursuits. There are a number of records associated with the existing Pacific Highway carriageway with concentrations of records at Cooperabung Hill (ch.21000), northern end of Ballengarra State Forest extending to Mingaletta and Upper Smiths Creek Road (ch. 24000-27000), Kundabung Area (ch. 30000), both the southern and northern extents of Maria River State Forest (ch. 33000 and ch.36000) and at the northern limit of the Upgrade at Stumpy Creek (ch. 38000). A substantial portion of these records have been entered as road killed individuals or injured and requiring rehabilitation.



LEWIS ECOLOGICAL

Source:	Project Boundary: Roads and Traffic Authority 2012 Topographic / Aerial Map: Bing Maps web mapping service 2013 — CRAFTI Lower North East Floristics (VIS 1082): Office of Environment and Heritage (OEH) 2012
Disclaimer:	This plan is based on or contains data provided by others. Lewis Ecological Surveys. gives no warranty in relation to the data (including accuracy, reliability, completness, currency or suiability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to and use of the data. Data must not be used for direct marketing or be used in breach of privacy laws.
File:	LES-OH3K-011-VEGETATION-MAPPING-CRAFTI-Lower-NE-VIS-ID-1082-140917

N W E S

0 1 2 3 4 5 6 7 8 Kilometers

A4 Scale 1:231,391

Coordinate System: MGA56 Projection: Transverse Mercator

Project Boundary
10km Project Buffer

Koala Records
Pre 1984
1984-2003
2004-2014

Baseline Monitoring
Control
Mitigation
Part Mitigation
No Mitigation

Oxley highway to Kempsey project

CRAFTI LOWER NORTH EAST FLORISTICS VIS 1082

Figure 4-3. Koala distribution through the study area at three chronological scales.

Koala Activity

The recorded mean SAT site activity levels across the eight monitoring areas was 4.91% (SD=7.95%) with levels ranging from zero at Mingaletta-Smiths Creek (Area 6) to 14.81% (SD=13.65) north of Sancrox Road (Fernbank Creek area known as Area 2 ch. 3350-4450; Figure 4-4). The remaining sites recorded mean SAT activity levels of <5% except for the Kundabung area with 7.78% (SD= 10.93).

At a treatment level, mean SAT site activity was highest in the 'mitigation' treatment class with 8.05% (SD = 10.99%) which was twice that of the 'control reference' class with 4.03% (SD = 6.37%) and almost three times higher than the 'no mitigation' treatment class with 2.64% (SD = 4.17%; Figure 4-5). At a site level, mean SAT site activity levels were highest in the mitigation treatment for South Sancrox Road, North Sancrox Road, Cairncross State Forest (south) and at Kundabung but not at Cooperabung Hill and Maria River State Forest (Figure 4-6). No activity was recorded at any of the SAT sites for Mingaletta-Smiths Creek for either the 'mitigation' or 'control/reference' treatments and a 'no mitigation' treatment class could not be located due to the RMS providing extensive mitigation devices.

The SAT site activity data was highest at the following locations:

- South of Sancrox Road between ch.1000-1750 and particularly the eastern side of the road where a female was observed and mean activity levels of 8.89% (SD =2.94);
- South of Fernbank Creek between ch. 3350-4450 and particularly the western side of the road where a large male was observed with activity levels reaching 28.89% (SD=2.94); and
- Kundabung in the vicinity of ch. 32700 on both sides of the existing carriageway with activity levels of 18.89% (SD=7.29).

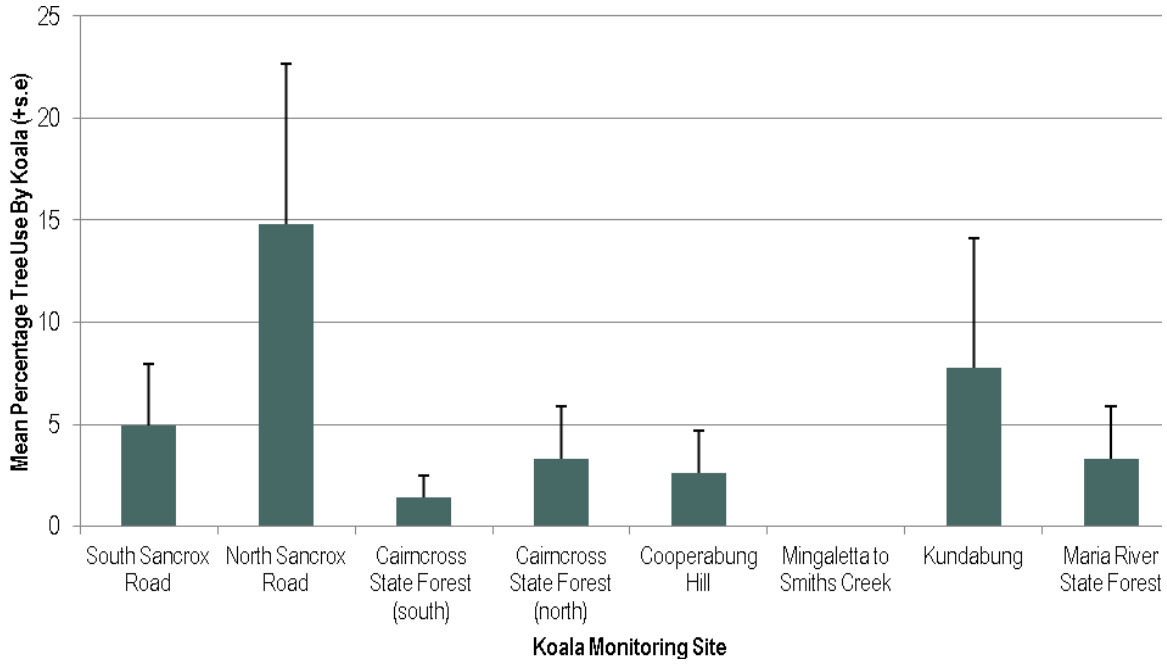


Figure 4-4. Mean (+s.e) SAT activity levels at each of the eight Koala monitoring areas.

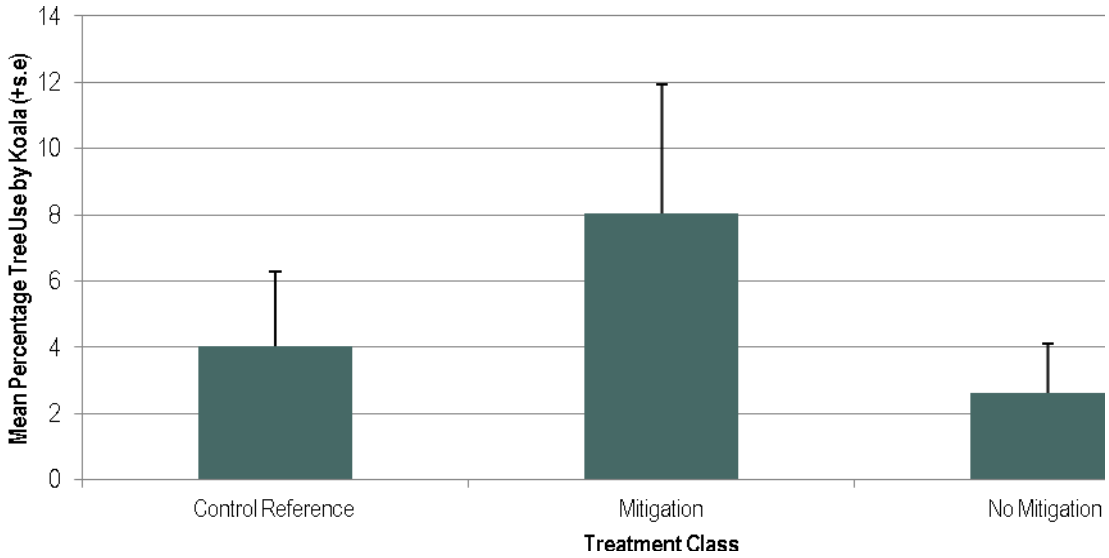


Figure 4-5. Mean (+s.e) Koala use between the three treatment classes.

Koala Density

i. Density Estimate Across the Entire Study Area

The highest density of Koala records occurs in the south eastern study area in the vicinity of Port Macquarie with more than 200 records in the 5 km^2 grids of J5, K5 and J4 (Figure 4-7). Vegetation that supports suitable browse tree species (i.e. Tallowwood, Small-fruited Grey Gum, Scribbly Gum, Swamp Mahogany) within each of these grids is likely to support high densities of Koala. The neighbouring grids of K3 and K4 in the Lake Innes and Thrumster area recorded 85 and 77 records respectively with K3 forming the southern extent of the Upgrade corridor. These areas are likely to support medium to high densities of Koala. All three grids occur some distance away from the Upgrade.

The grid J3 which includes the Upgrade between ch. 0-6000 recorded the 6th highest density of Koala records with 41 whilst I1 which features the control sites for the spotlighting program and the SAT activity levels in the western extent of Cairncross State Forest returned 36 Koala records (Figure 4-7). These areas are likely to support medium densities of Koala. The remaining grids which returned >10 records included I4 (Settlement Point, Port Macquarie), C2 (Burnt Bridge, Kempsey) and L4 (Lake Cathie) which lie some distance adjacent to the Upgrade. The grid E3 (Kundabung) includes the Upgrade between ch. 25000-30000 and D3 (Maria River State Forest) which extends from ch. 30000-36000 contain records on both sides of the Upgrade. These areas are likely to support moderate to lower densities of Koala.

The remaining grids returned <10 records indicating Koala probably occur at low densities. This includes a lot of the Upgrade corridor from the Cairncross State Forest area (I3 and H3), Cooperabung area (G3), Ballengarra State Forest (F3) and South Kempsey (C3). Grids C5 (Beranghi), E1 (Ballengarra-Gum Scrub), H5 (Limeburners Creek) returned no Koala records indicating that Koala may be occasionally absent from some small areas due to unsuitable habitat types. Other grids including B1, L1, L5 were at the limit of the buffered search area and no density estimate has been provided.

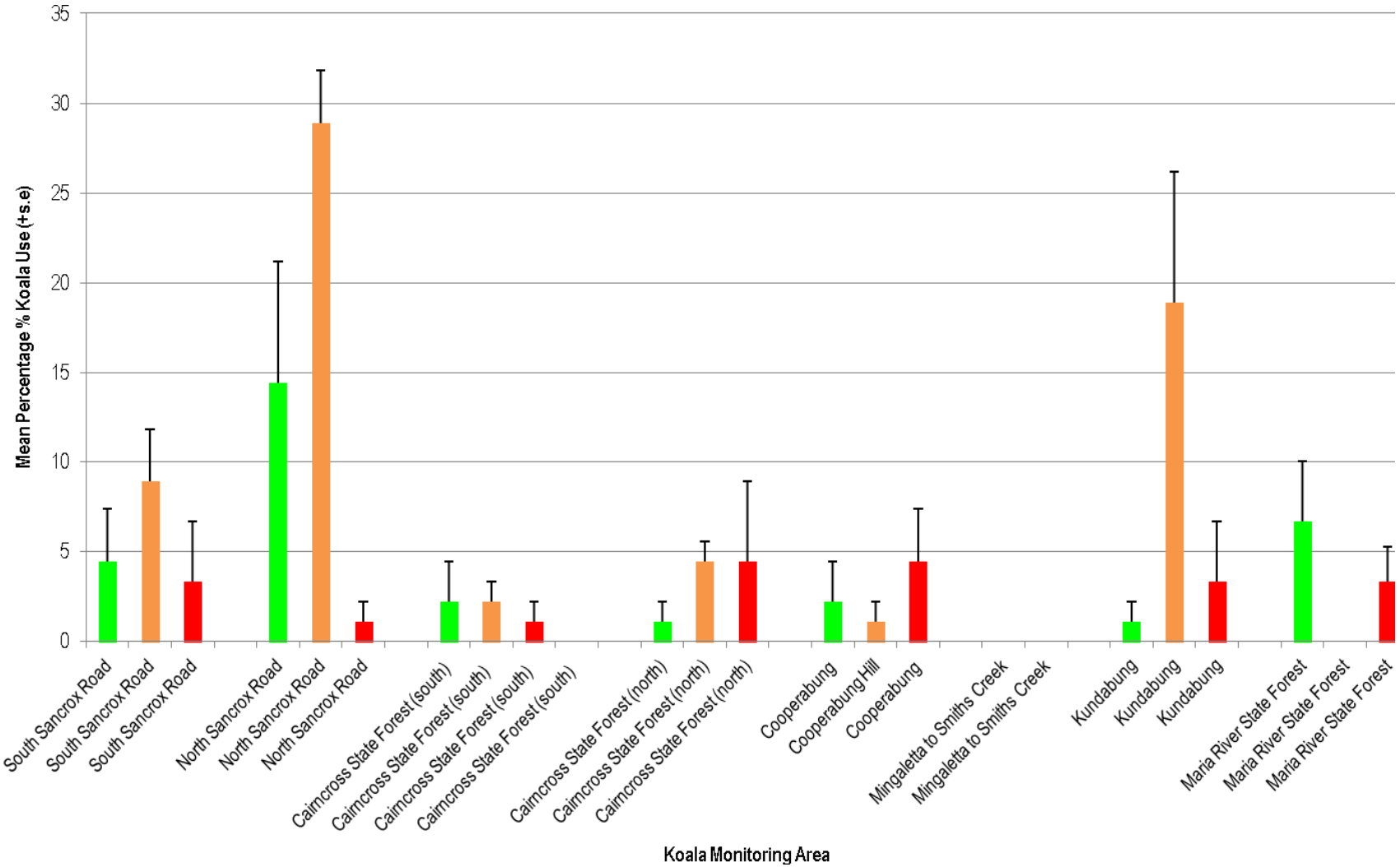


Figure 4-6. Mean recorded activity levels of Koala (+s.e) for each treatment across the eight monitoring areas. Treatment Types Control = Green; Mitigation = Orange, No Mitigation = Red

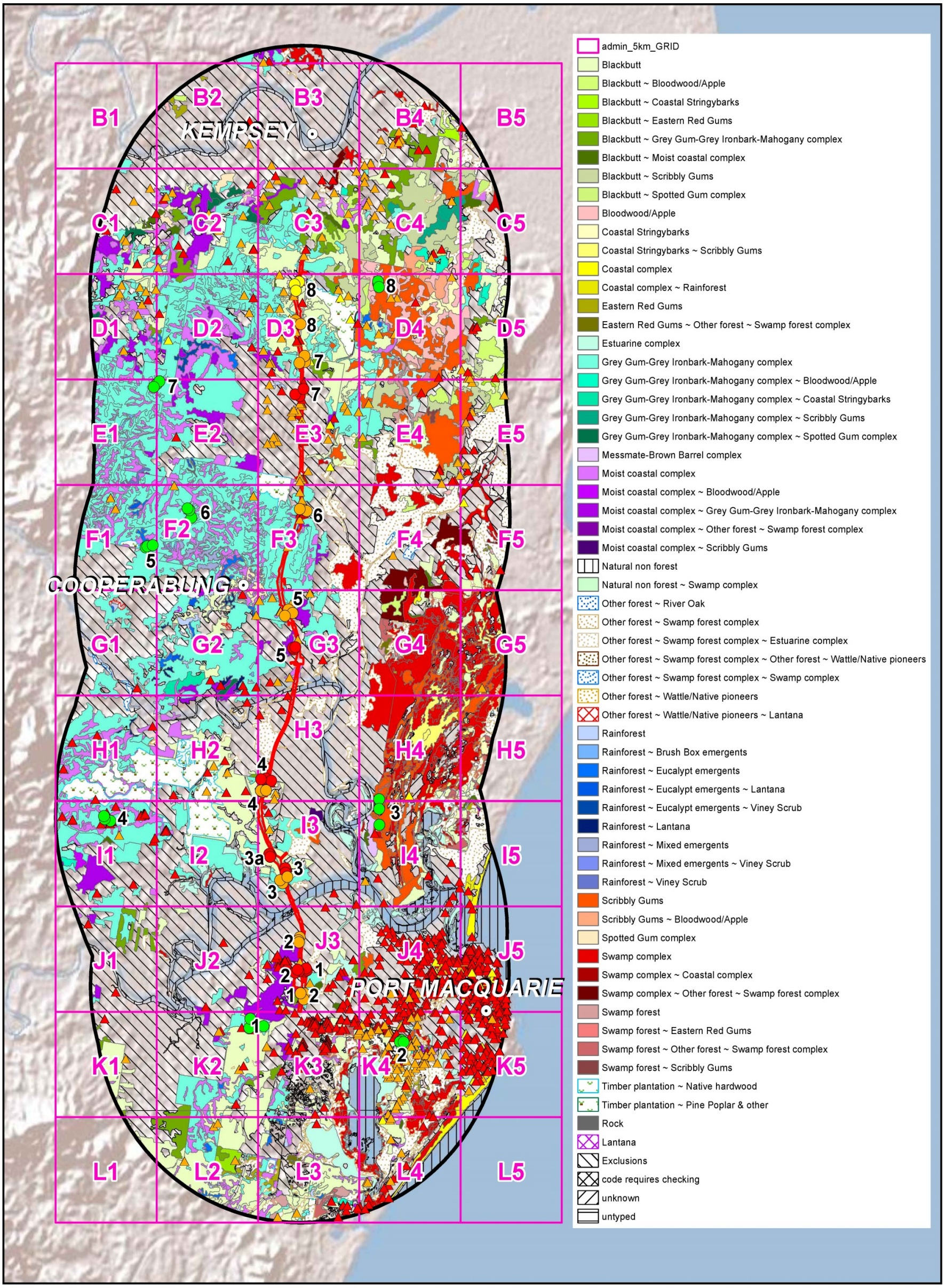


Figure 4-7. Density of Koala records across the study area.

ii. Baseline Count Data

Spotlighting resulted in Koala being recorded at five (83%) of the six spotlighting sites with only the riparian forest site located along the Maria River unable to detect Koala (Table 4-4). Koala were normally detected at a reporting rate of 1 individual per 60 minutes of search effort and this has been used as a baseline measure of Koala density for any spotlighting surveys in sclerophyllous forests supporting suitable browse tree species. The repeated sampling regime recorded Koala during 10 (56%) of the 18 spotlight transects with most of the records being attributed to vocalising males and confirms the importance of performing comparable surveys during the breeding season.

Camera traps resulted in Koala being recorded at five (18%) of the 27 locations with a reporting rate summarised as follows:

- Cairncross State Forest with one individual from 808 nights or 0.12%
- Ballengarra State Forest with two individuals from 826 camera trap nights or 0.24%
- Maria River State Forest two individuals from 706 camera traps nights or 0.28%;

These reporting rates are considered the baseline data for camera trap use to randomly monitor Koala density across the three largest tracts of continuous vegetation the Upgrade will bisect.

Koala Habitat Use

Koala habitat use was measured in two ways, firstly, at a broader study area scale (i.e. 10 km buffer), and secondly, using the SAT survey data from the 2160 trees checked to identify and rank the importance of each tree species sampled.

i. Landscape and Vegetation Community Scale

The potential habitat value of vegetation communities across the study area is shown in Figure 4-8. Areas of 'potential high value' for Koala are widespread across the study area and are mostly linked to the low foothills some distance from the coast. Areas of 'potential medium value' to Koala are more widely scattered throughout the study area whilst those communities assigned as being of 'potential low and very low value' to Koala are either more coastal and linked with heathland or rainforest communities, or are comprised of forestry plantations such as the central precincts of Cairncross State Forest or the northern extent of Ballengarra State Forest.

The Upgrade has been mapped as a mosaic of 'potential medium and high value' to Koala (Figure 4-8). Areas considered to have 'potential high value' to Koala include the area to the south of Sancrox (i.e. ch. 1500) and east of the Upgrade, Cairncross State Forest (ch. 8000-13000), Ballengarra State Forest (ch. 20000-25000), Maria River State Forest (ch. 33000-36500) and the northern extent associated with Stumpy Creek(~ch. 38000). Vegetation communities in these areas comprise suitable browse tree species including Tallowwood and Small-fruited Grey Gum with higher densities generally found on the southern slopes of hills or along drainage lines. In this capacity, these areas are more likely to be frequented by Koala.

Table 4-4. Summary of the field survey program for the Koala spotlight surveys.

Site Name	Treatment	Transect Coordinates				Survey Number & Sample Dates & Times				Abiotic Conditions						Survey Results & Comments	
		Easting Start	Northing Start	Easting Finish	Northing Finish	Survey Number	Survey Date	Start Time	Finish Time	Air Temp. oC	Humidity %	Wind	Rain	Night Light	Cloud Cover	Spotlight	Comments
Cairncross Sf - Forest Hut Road	Impact	480979	6528629	480642	6529045	1	27.9.2013	1845	2000	15.5	61	0	0	0	0	Nil	Road noise elevated with holiday traffic but bulk of noise affecting surveys was attributed to trucks
	Impact	480979	6528629	480642	6529045	2	6.10.2013	0051	0159	13.9	64	1	0	0	0	Koala x 1 calling 250 m north west of site	Late night spotlight to counteract the effect of road noise.
	Impact	480979	6528629	480642	6529045	3	26.10.2013	2015	2130	17.1	73	0	0	0	50	Koala x 1 heard 250 m to the south	Road noise affecting ability to hear fauna calls
Cairncross Sf - Loggy Creek in	Control/reference	473377	6528875	473246	6529151	1	28.9.2013	1825	1945	20	50	1	0	0	0	Nil	Site installed within retained filter strips of vegetation post logging event
	Control/reference	473377	6528875	473246	6529151	2	6.10.2013	2304	0031	14.4	52	0	0	0	0	Koala x 1 calling north west of site	
	Control/reference	473377	6528875	473246	6529151	3	26.10.2013	2158	2314	15.8	76	0	0	0	0	Koala x 1 heard 250 m downstream to the east	Koala expected to rely heavily on the retained filter strips
Ballengarra Sf - Barrys Creek road	Impact	482438	6541886	482042	6541985	1	27.9.2013	2015	2137	14	74	0	0	0	0	Koala x 1 male calling to north	Road noise elevated with holiday traffic and trucks
	Impact	482438	6541886	482042	6541985	2	6.10.2013	2132	2245	17.2	54	0	0	0	0	Koala x 1 male calling to the south	
	Impact	482438	6541886	482042	6541985	3	12.10.2013	1935	2103	22	81	1	0	2	50	Koala x 1 male calling to the south	
Ballengarra Sf - Greg's Road reference	Control/reference	477352	6543849	477025	6544218	1	28.9.2013	2216	2330	15.5	43	0	0	0	0		
	Control/reference	477352	6543849	477025	6544218	2	6.10.2013	1945	2115	18	52	1	0	0	0		
	Control/reference	477352	6543849	477025	6544218	3	12.10.2013	2117	2249	20	88	0	0	2	30	Koala x 1 Ad	
Maria River - East Road	Control/reference	488492	6555068	487962	6555160	1	27.9.2013	2207	2331	12	77	0	0	0	0	Koala x 1 male calling to north	Site at northern extent of National park to allow for access during wet weather
	Control/reference	488492	6555068	487962	6555160	2	11.10.2013	2020	2151	18.8	82	0	0	1	100	Koala x 1 calling male	
	Control/reference	488492	6555068	487962	6555160	3	24.11.2013	2105	2137	19.3	87	0	1	1	100		Survey after rainfall
Maria River Bridges	Impact	483092	6554739	482946	6555055	1	28.9.2013	2041	2157	17	51	1	0	0	0		
	Impact	483092	6554739	482946	6555055	2	11.10.2013	2219	2357	19	81	1	1	1	100		Light shower of rain recorded
	Impact	483092	6554739	482946	6555055	3	24.11.2013	2207	2246	18.7	83	0	1	1	85		Road noise making it difficult to hear calls

ii. Tree Species Use

Koala scats were recorded from 15 tree species with overall tree use calculated at 5% (Table 4-5). The most commonly encountered feed tree was Tallowwood (*Eucalyptus microcorys*) which comprised 22.9% of all recorded feed tree species. From a proportional perspective, Koala scats were most frequently recorded beneath Forest Red Gum (*Eucalyptus tereticornis*) and Swamp Mahogany (*Eucalyptus robusta*) with 18.2% and 15.6% although both tree species were uncommon at the SAT sites. Other commonly used tree species included Tallowwood (*Eucalyptus microcorys*), Snow-in-summer (*Melaleuca linariifolia*), Broad-leaved White Mahogany (*Eucalyptus umbra*), Scribbly Gum (*Eucalyptus signata*), Small-fruited Grey Gum (*Eucalyptus propinqua*), White Stringybark (*Eucalyptus globoidea*), Coastal Blackbutt (*Eucalyptus pilularis*) and Broad-leaved Paperbark (*Melaleuca quinquenervia*) with the proportion of use ranging from 6.1-9.5% (Table 4-5). Other species including Red Mahogany (*Eucalyptus resinifera*), Grey Ironbark (*Eucalyptus siderophloia*), Pink Bloodwood (*Corymbia intermedia*), White Mahogany (*Eucalyptus acmenoides*) and Turpentine (*Syncarpia glomulifera*) are used less often.

The proportion of tree use shown in Table 4-5 should be used as the baseline data set to compare with future monitoring events.

Table 4-5. Summary of tree species used by Koala during the SAT surveys (n=2160).

Common name	Species Name	No. Trees With Koala Scats	No. Trees Surveyed	Proportion of Use (%) & Baseline Dataset
Forest Red Gum	*Eucalyptus tereticornis*	4	22	18.2
Swamp Mahogany	*Eucalyptus robusta*	5	32	15.6
Tallowwood	*Eucalyptus microcorys*	40	419	9.5
Snow in Summer	*Melaleuca linariifolia*	6	73	8.2
Broad-leaved White Mahogany	*Eucalyptus umbra*	2	25	8
Scribbly Gum	*Eucalyptus signata*	5	70	7.1
Small-fruited Grey Gum	*Eucalyptus propinqua*	13	189	6.9
White Stringybark	*Eucalyptus globoidea*	8	125	6.4
Coastal Blackbutt	*Eucalyptus pilularis*	10	158	6.3
Broad-leaved Paperbark	*Melaleuca quinquenervia*	2	33	6.1
Red Mahogany	*Eucalyptus resinifera*	2	43	4.7
Grey Ironbark	*Eucalyptus siderophloia*	2	82	2.4
Pink Bloodwood	*Corymbia intermedia*	5	254	2
White Mahogany	*Eucalyptus acmenoides*	2	191	1
Turpentine	*Syncarpia glomulifera*	1	114	0.9
		107		5.0%

Koala Movements

i. Using Atlas Data to Predict Movements

The records of Koala show a broad pattern that alludes to Koala moving predominantly in an east west direction to the south of the Hastings River. The clustering of records in the Sancrox area suggest that some individuals maintain home ranges that abut or encompass the existing carriageway (Figure 4-7). This is similar for the area north of the Hastings River where there is some clustering of records in Cairncross State Forest north of Blackmans Point Road.

The records of Koala associated with the Wilson River show individuals move along the floodplain habitats and associated foothills. There are, however, lower reporting rates from the eastern precincts of Grids G3 and H3 indicating Koala movements may be restricted in this area due in part to unsuitable habitat (Figure 4-7). Grids G4 and H4 further to the east have very low reporting rates of 0 and 1 records respectively. The multiple records around Cooperabung Hill suggest individuals probably reside in this area but perform occasional movements across the existing Pacific Highway carriageway. This is supported by the presence of road killed individuals during January and August 2013 which includes both upper slope and gully movements across the carriageway.

In the Mingaletta and Kundabung areas the presence of records on either side of the highway indicates that Koala frequently maintain home ranges in close proximity to the Upgrade and it would be expected that individuals occasionally attempt to cross it. The absence of Koala road kill in this area during the road kill monitoring period indicates that Koala may either move up to the edge of the highway and don't cross it or only small numbers of individuals may occasionally cross the existing carriageway. For example, males during the breeding season or there may be some reliance or learned behaviours with individuals potentially traversing along the watercourses and beneath the bridges at Smiths Creek and Pipers Creek.

The Koala records from Maria River State Forest indicate movements may be concentrated toward the southern extent of the forest bordering private land with a second nodal area around 0.5–1 km south of the Maria River. Another movement corridor occurs at the northern limit of the Upgrade at Stumpy Creek.

ii. Koala Movements and Highway Interactions

Only one Koala was recorded during the weekly road kill transects performed in Spring and again in Summer. This animal had been struck in the south bound lane at ch. 22300 on the 22nd August and it's remains were still present during the initial road kill survey in Spring (4th October). Records compiled between August 2013 and February 2014 shows at least four Koala were killed from road strike over the 7 month period. They include:

- Adult hit in the middle of the south bound lane at ch. 22300 on 22nd August 2013 (Moist Forest growing in gully in Ballengarra State Forest);
- Adult hit in the south bound lane at ch. 32700 on the 10th September 2013 (Southern extent of Maria River State Forest);
- Adult hit on the north bound lane at approximate ch. 11000 on the 29th October 2013 (northern extent of Cairncross State Forest); and
- Adult hit on the edge of the south bound carriageway just south of the Project southern boundary on the 21st February 2014 (Cowarra State Forest and neighbouring private lands).

Only the animal from the 22nd August remained on the carriageway way for any length of time whilst the remaining individuals had been removed within 48 hours. Based on the data above, the baseline count for road kill should be set at 1 individual per 8 weeks.

Discussion of Findings

Koala Distribution

The wildlife atlas data show a widespread population or populations of Koala exist across the entire Project. This is consistent with the mapping prepared for the *Comprehensive Koala Plan of Management for Eastern Portion of Kempsey Shire LGA* which shows the Upgrade traverses large areas of Secondary Preferred Koala Habitat (Class B) and some scattered areas of Secondary Preferred Koala Habitat (Class A) in the Kundabung area (KKPoM 2011). Although the same level of comprehensive mapping is not yet available for the Oxley Highway to Kundabung section of the Project (i.e. Port Macquarie-Hastings LGA) the wildlife atlas data indicates these areas are likely to be similarly mapped as Preferred Koala Habitat (Class B) and some scattered areas of Secondary Preferred Koala Habitat (Class A). For example, the mapping compiled by BioLink (2008) for Area 13 Urban Investigation Area (Thrumster) identifies secondary rather than primary habitat borders the south eastern part of the Project between chainages 0-1750.

Koala Activity & Habitat Use

The results of the baseline SAT monitoring show that whilst the Koala population may be widespread across the Upgrade corridor the activity levels align with medium use of a low density east coast Koala population with some occasional high use areas such as the Fernbank Creek area to the north of Sancrox Road. This is consistent with the findings of Phillips and Callaghan (2011) categorisation of habitat use when describing the application of the Spot Assessment Technique. The results of the baseline survey infer vegetation communities which support Tallowwood, Small-fruited Grey Gum and to a lesser extent Coastal Blackbutt and White Stringybark tend to support Koala populations in the Project area regarding of the topographic relief. At lower relief sites, species including Forest Red Gum, Swamp Mahogany and *Melaleuca* also form important feed tree species whilst Scribbly Gum growing on sandy soils tends to be used in the eastern study area. The overall importance of Tallowwood to Koala has been previously used as the basis for defining 'Primary' Koala habitat in the eastern portion of the Kempsey Shire LGA which extends south to Kundabung (ch. 25350). Given that Tallowwood is both widespread, was frequently surveyed and still yielded relatively high activity scores (i.e. 9.5%) it should be used for future comparison with successive monitoring events.

At a treatment level, Koala activity was highest in the 'mitigation' treatment class which was twice that of the 'control reference' class and almost three times higher than the 'no mitigation' treatment class. This provides some confidence in the fact that a lot of the mitigation devices have been placed in areas of relatively high Koala activity for the Project. In contrast, the data obtained from Cairncross State Forest (north) suggest comparable activity levels between the mitigation and no mitigation treatment classes whilst Cooperabung Hill and Maria River State Forest showed lower activity levels at sites where mitigation has been proposed. In these later two instances, the no mitigation treatments feature no floppy top fencing for the western side of the Cooperabung Hill (ch. 19100) and breaks in the fauna fencing as part of service roads at Maria River (ch. 36550). This existing design may present a risk of some future road kill of Koala.

Regrowth forests support a greater density of tree stems and Koala are likely to travel distances of many tens of metres to access their preferred feed trees. In this context, a SAT site checking 29 trees from the focal tree may not extend far enough to capture additional feed trees and thus may return a lower than expected activity level. In this context only a handful of preferred browse species may be sampled within a single SAT site as numerous other stems of less suitable species (i.e. *Allocasuarina*) require sampling. During the current baseline survey some additional techniques were used and this proved useful to confirm the continued existence of Koala. For example, the sampled SAT sites between Mingaletta and Smiths Creek returned zero activity, however, the use of camera traps confirm their continued existence in this area. This demonstrates the usefulness of a multidisciplinary approach that uses other monitoring technicaues across the Ecological Monitoring Program, rather than relying on a single survey technique.

Koala Density

Koala density was measured in three ways during the current baseline survey. Spotlighting showed that Koala could be consistently recorded across a range of sclerophyll forests and at a consistent rate of 1 individual per hour effort. This recording rate was heavily reliant on detecting vocalising males indicating that any future monitoring event must also be

undertaken during the breeding season. One problem encountered during the spotlighting surveys was the presence of an often dense mid stratum reducing the permeability of the light. This was often confounded by the fact that more suitable feed trees were generally found on the lower slopes and gullies which supported this dense mid stratum vegetation.

The use of historic records to obtain a relative measure of Koala density through record reporting was useful to describe the likely density of Koala across the entire study area. Ideally, it would require a vetting process to measure its accuracy and be reliant on spotlight transect counts at a number of these grids. This approach was able to identify that Koala probably reach their highest densities in and around the Port Macquarie area and radiate out into the satellite areas of Lake Innes and Thrumster. Given that a lot of these areas now face expanding residential estate the residual tracts of vegetation are likely to support Koala densities at a magnitude well above the densities expected around the Upgrade. This is supported by some casual distance surveys which have been performed in the past which often result in the detection of Koala at densities far greater than 1 individual per hour (B. Lewis unpublished data).

The use of camera traps provide a repeatable way in which to standardise a survey effort to measure Koala density across the three largest tracts of forest the Upgrade bisects. Whilst this technique relies purely on chance occurrences of individuals wondering past the camera the approach is systematic in that survey effort can be standardised and can be more extensive with longer periods of monitoring.

The results described above tend to be broadly consistent with the SAT activity levels obtained for the baseline survey which in themselves align with that of low density Koala population of medium (normal) use but the regularity with which individuals were recorded with other ancillary techniques including spotlighting and road kill surveys would suggest at least some areas support at least a medium density Koala population. Examples of this occur to the South of Sancrox Road and particularly the area to the east of ch. 1000-1750, south of Fernbank Creek between ch. 3350-4350 and to the north of Kundabung around ch. 32700 where SAT activity levels were relatively high for the Project and animals were observed or encountered during the course of the field study.

Koala Movements

Fundamental to the maintenance of Koala meta population dynamics across the study area is the issue of habitat linkages, or connectivity. The broader landscape between Oxley Highway Interchange and Kempsey is effectively bisected by the Pacific Highway, which currently contributes significantly to annual Koala mortalities within the study area. This is due to the broader movements being in an east-west direction and the fact that Koala maintain home ranges that abut and occasional encompass the existing carriageway. During the current baseline survey only one individual was recorded during the weekly surveys performed in October and January/February. Ad hoc monitoring which spanned a 7 month period revealed additional road killed individuals but was consistent with Koala being struck every 6-8 weeks during the breeding period. Given the Upgrade will provide mitigation measures in the form of floppy top fencing and fauna underpasses of suitable size there are opportunities to clearly measure how road kill mortality changes in response to the Upgrade.

Performance Indicators

The draft Ecological Monitoring Program has identified the performance indicators of the Koala monitoring program as being reliant on

- Monitoring is undertaken during baseline surveys and from Year 1 – Year 8, or until mitigation measures are demonstrated to be effective.
- Monitoring during Year 1 – 8 is undertaken at the Impact and Control sites where monitoring was undertaken during baseline surveys.
- Mitigation measures are demonstrated to be effective as defined in the EPBC approval when all monitoring events are considered at Year 8.
- Fauna fence is installed at a minimum in areas identified in Schedule 3 of the EPBC approval at Year 4.

- No change to densities, distribution, habitat use and movement patterns compared to baseline data.

This study represents the first part of the Koala monitoring program with baseline data being collected during the Spring 2013 with several ancillary techniques spanning a broader time period, all well in advance of construction. The use of a three treatment BACI design for Koala monitoring proved problematic for this Project. Whilst this design was able to comfortably locate and collect data at impact sites receiving mitigation in the form of suitably sized culverts to maintain connectivity and floppy top fencing to prevent animals was venturing onto the carriageway the extent of this across most of the vegetated areas meant that 'no mitigation' treatments were difficult to locate and with any form of data independence from neighbouring mitigation sites (i.e. often only a few hundred metres from mitigation sites). This resulted in the Mingaletta to Smiths Creek area not being able to meet the survey design requirements of having a 'no mitigation' treatment and having to locate other 'no mitigation' treatments in areas best described as offering partial mitigation whereby there was some floppy top fencing but with obvious openings in the vicinity of interchanges or entry and exit points of connecting roads. Examples of this occurred at Maria River, Cooperabung Hill, Cairncross State Forest (south) and to some extent Sancrox and all of these areas may present a risk of reporting Koala road kills during the operational phase of the Upgrade.

Considering the above, the removal of the 'no mitigation' treatments would allow for a more simplified paired BACI design using impact mitigation sites (mitigation baseline sites in this study) and simply pairing them for later comparison with the control/reference sites. This approach is consistent with a number of monitoring programs being currently developed for the Woolgoolga to Ballina Pacific Highway Upgrade.

Key Recommendations

1. Ensure any future comparison of Koala activity levels take into account the following baseline data and with a 10% tolerance level to account for variability:
    a. Broader study area set at 5% activity;
    b. The three treatment classes of Mitigation set at 8.05%, control reference set at 4.03% and no mitigation set at 2.64%.
2. Ensure habitat use takes into account the proportion of each tree species used versus that actually sampled. Table 4-5 provides an opportunity for direct comparison.
3. Set the density baseline monitoring to 1 individual per 1 hour of spotlight effort and ensure monitoring is performed during spring to coincide with the breeding season.
4. Set the baseline for road kill Koala to 1 individual every 8 weeks. Ensure operational monitoring includes the entire carriageway, particularly interchanges where Koala are most at risk to road strike.

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Appendix – Field Data

Table 4-A. Summary of the Spot Assessment Technique (SAT) used in the baseline survey.

Area	Monitoring Area Name	Site Name	Treatment	Easting	Northing	Activity	Selection Criteria	Radial Search	Notes/Comment
1	South Sancrox Road	Sancrox South	Mitigation	483321	6520694	13.33	Tallowwood	12	
1	South Sancrox Road	Sancrox South	Mitigation	483296	6520413	3.33	Tallowwood	13	Female koala observed in Blackbutt 90 m further north
1	South Sancrox Road	Sancrox South	Mitigation	483139	6520700	10	Tallowwood	19	
1	South Sancrox Road	Sancrox East - Cassegrains	No Mitigation	483348	6521736	10	Tallowwood	13	
1	South Sancrox Road	Sancrox East - Cassegrains	No Mitigation	483455	6521789	0	Tallowwood	13	
1	South Sancrox Road	Sancrox East - Cassegrains	No Mitigation	483412	6521882	0	Tallowwood	16	
1	South Sancrox Road	Cowarra State Forest	Control	480608	6519056	0	Tallowwood	18	
1	South Sancrox Road	Cowarra State Forest	Control	480658	6519496	3.33	Tallowwood	17	
1	South Sancrox Road	Cowarra State Forest	Control	481305	6519136	10	Tallowwood	13	
2	North Sancrox Road	Sancrox North - Expressway Spares	No Mitigation	483042	6521731	3.33	Swamp Mahogany	15	
2	North Sancrox Road	Sancrox North - Expressway Spares	No Mitigation	482869	6521683	0	Tallowwood	12	
2	North Sancrox Road	Sancrox North - Expressway Spares	No Mitigation	482999	6521818	0	Tallowwood	11	
2	North Sancrox Road	Fernbank Creek	Mitigation	483101	6523362	33.33	Tallowwood	15	
2	North Sancrox Road	Fernbank Creek	Mitigation	483032	6523223	30	Tallowwood	12	
2	North Sancrox Road	Fernbank Creek	Mitigation	483056	6523123	23.33	Male Koala in Tallowwood	17	
2	North Sancrox Road	Lake Innes	Control	488124	6518469	26.67	Tallowwood	15	
2	North Sancrox Road	Lake Innes	Control	488047	6518398	13.33	Swamp Mahogany	16	
2	North Sancrox Road	Lake Innes	Control	488228	6518390	3.33	Swamp Mahogany	18	Very wet in this area and couldn't establish plot further to the east
3	Cairncross State Forest (South)	Cairncross State Forest (South)	No Mitigation	482428	6526536	0	Tallowwood	19	
3	Cairncross State Forest (South)	Cairncross State Forest (South)	No Mitigation	482385	6526644	3.33	Tallowwood	14	

Area	Monitoring Area Name	Site Name	Treatment	Easting	Northing	Activity	Selection Criteria	Radial Search	Notes/Comment
3	Cairncross State Forest (South)	Cairncross State Forest (South)	No Mitigation	482393	6526416	0	Tallowwood	18	
3a	Cairncross State Forest (south)	Cairncross State Forest (south)	No Mitigation	481655	6527256	0	Tallowwood	13	
3a	Cairncross State Forest (south)	Cairncross State Forest (south)	No Mitigation	481590	6527316	0	Tallowwood	26	
3a	Cairncross State Forest (south)	Cairncross State Forest (south)	No Mitigation	481637	6527175	13.33	Tallowwood	24	
3	Cairncross State Forest (South)	Cairncross State Forest (South)	Mitigation	482249	6525930	3.33	Tallowwood	18	
3	Cairncross State Forest (South)	Cairncross State Forest (South)	Mitigation	482125	6526077	3.33	Tallowwood	16	
3	Cairncross State Forest (South)	Cairncross State Forest (South)	Mitigation	482488	6526226	0	Tallowwood	13	
3	Cairncross State Forest (South)	Limeburners Creek "The Hatch"	Control	487011	6529909	0	Scribbly Gum	31	
3	Cairncross State Forest (South)	Limeburners Creek "The Hatch"	Control	487014	6529455	3.33	Scribbly Gum	32	
3	Cairncross State Forest (South)	Limeburners Creek "The Hatch"	Control	487035	6528694	0	Scribbly Gum	17	
4	Cairncross State Forest (north)	Cairncross State Forest (North)	No Mitigation	481420	6530890	0	White Mahogany	55	
4	Cairncross State Forest (north)	Cairncross State Forest (North)	No Mitigation	481695	6530786	0	Forest Red Gum	13	
4	Cairncross State Forest (north)	Cairncross State Forest (North)	No Mitigation	481184	6530864	0	Tallowwood	19	
4	Cairncross State Forest (north)	Cairncross State Forest (north)	Mitigation	481238	6530264	3.33	Swamp Mahogany	11	
4	Cairncross State Forest (north)	Cairncross State Forest (north)	Mitigation	481173	6530319	3.33	Tallowwood	13	
4	Cairncross State Forest (north)	Cairncross State Forest (north)	Mitigation	481438	6530335	6.67	Tallowwood	16	
4	Cairncross State Forest (north)	Cairncross State Forest (Pembrooke)	Control	473751	6528881	6.67	Tallowwood	20	
4	Cairncross State Forest (north)	Cairncross State Forest (Pembrooke)	Control	473464	6528969	0	Tallowwood	16	
4	Cairncross State Forest (north)	Cairncross State Forest (Pembrooke)	Control	473424	6529115	0	Tallowwood	18	
5	Cooperabung Hill	Cooperabung	No Mitigation	482793	6537012	3.33	Tallowwood	36	
5	Cooperabung Hill	Cooperabung	No Mitigation	482755	6537093	0	Tallowwood	31	
5	Cooperabung Hill	Cooperabung	No Mitigation	482876	6537115	10	Tallowwood	18	
5	Cooperabung Hill	Cooperabung	Mitigation	482539	6538907	0	Tallowwood	16	

Area	Monitoring Area Name	Site Name	Treatment	Easting	Northing	Activity	Selection Criteria	Radial Search	Notes/Comment
5	Cooperabung Hill	Cooperabung	Mitigation	482750	6538736	3.33	Forest Red Gum	17	
5	Cooperabung Hill	Cooperabung	Mitigation	482364	6538610	0	Tallowwood	14	
5	Cooperabung Hill	Cooperabung Hill (Gum Scrub)	Control	475489	6541854	6.67	Tallowwood	22	
5	Cooperabung Hill	Cooperabung Hill (Gum Scrub)	Control	475570	6541903	0	Tallowwood	14	
5	Cooperabung Hill	Cooperabung Hill (Gum Scrub)	Control	475838	6541962	0	Tallowwood	14	
6	Mingaletta to Smiths Creek	Not possible with current design							Would need to remove some koala fencing to enable no mitigation site to be installed in this area
6	Mingaletta to Smiths Creek	Not possible with current design							Would need to remove some koala fencing to enable no mitigation site to be installed in this area
6	Mingaletta to Smiths Creek	Not possible with current design							Would need to remove some koala fencing to enable no mitigation site to be installed in this area
6	Mingaletta to Smiths Creek	Mingaletta-Smiths Creek	Mitigation	483304	6543632	0	Tallowwood	9	
6	Mingaletta to Smiths Creek	Mingaletta-Smiths Creek	Mitigation	483444	6543585	0	Tallowwood	21	
6	Mingaletta to Smiths Creek	Mingaletta-Smiths Creek	Mitigation	483100	6543670	0	Tallowwood	15	
6	Mingaletta to Smiths Creek	Ballengarra State Forest (Greg's Road)	Control	477750	6543274	0	Tallowwood	10	
6	Mingaletta to Smiths Creek	Ballengarra State Forest (Greg's Road)	Control	477644	6543623	0	Small-fruited Grey Gum	19	
6	Mingaletta to Smiths Creek	Ballengarra State Forest (Greg's Road)	Control	477551	6543709	0	Tallowwood	16	
7	Kundabung Road to North of Pipers Creek	Kundabung	No Mitigation	483095	6549036	0	Tallowwood	23	
7	Kundabung Road to North of Pipers Creek	Kundabung	No Mitigation	482873	6549112	10	Tallowwood	20	
7	Kundabung Road to North of Pipers Creek	Kundabung	No Mitigation	483285	6549374	0	Tallowwood	15	
7	Kundabung Road to North of Pipers Creek	Kundabung	Mitigation	483369	6550655	33.33	Tallowwood	26	
7	Kundabung Road to North of Pipers Creek	Kundabung	Mitigation	483331	6550938	13.33	Tallowwood	16	
7	Kundabung Road to North of Pipers Creek	Kundabung	Mitigation	483083	6550608	10	Forest Red Gum	22	

	Monitoring Area Name	Site Name	Treatment	Easting	Northing	Activity	Selection Criteria	Radial Search	Notes/Comment
7	Kundabung Road to North of Pipers Creek	Kumbatine National Park	Control	476044	6549609	3.33	Tallowwood	14	
7	Kundabung Road to North of Pipers Creek	Kumbatine National Park	Control	476165	6549738	0	Tallowwood	16	
7	Kundabung Road to North of Pipers Creek	Kumbatine National Park	Control	475889	6549468	0	Tallowwood	15	
8	Maria River State Forest	Maria River	Part Mitigation	483074	6554460	0	Tallowwood	21	
8	Maria River State Forest	Maria River	Part Mitigation	482836	6554330	3.33	Tallowwood	15	
8	Maria River State Forest	Maria River	Part Mitigation	482917	6554027	6.67	Tallowwood	14	
8	Maria River State Forest	Maria River	Mitigation	482886	6552623	0	Tallowwood	15	
8	Maria River State Forest	Maria River	Mitigation	482754	6552462	0	Tallowwood	17	
8	Maria River State Forest	Maria River	Mitigation	483135	6552449	0	Tallowwood	14	
8	Maria River State Forest	Maria River National Park	Control	486965	6554366	0	Tallowwood	20	Camera trap recorded Koala here in late August 2013
8	Maria River State Forest	Maria River National Park	Control	486971	6554479	10	Tallowwood	25	
8	Maria River State Forest	Maria River National Park	Control	487004	6554203	10	Tallowwood	26	

Table 4B. Summary of the mean Spot Assessment Technique (SAT) activity levels across each treatment class for the eight Koala monitoring areas.

SE = Standard Error, SD = Standard Deviation

Koala Monitoring Area	Treatment Type	Monitoring Area Name	Mean	SE	SD
1	Control Reference	South Sancrox Road	4.44	2.94	5.09
1	Mitigation	South Sancrox Road	8.89	2.94	5.09
1	No Mitigation	South Sancrox Road	3.33	3.33	5.77
2	Control Reference	North Sancrox Road	14.44	6.76	11.71
2	Mitigation	North Sancrox Road	28.89	2.94	5.09
2	No Mitigation	North Sancrox Road	1.11	1.11	1.92
3	Control Reference	Cairncross State Forest (south)	2.22	2.22	3.85
3	Mitigation	Cairncross State Forest (south)	2.22	1.11	1.92
3	No Mitigation 1	Cairncross State Forest (south)	1.11	1.11	1.92
3	No Mitigation 2	Cairncross State Forest (south)	0	0	0
4	Control Reference	Cairncross State Forest (north)	1.11	1.11	1.92
4	Mitigation	Cairncross State Forest (north)	4.44	1.11	7.7
4	No Mitigation	Cairncross State Forest (north)	4.44	4.44	1.93
5	Control Reference	Cooperabung	2.22	2.22	5.09
5	Mitigation	Cooperabung Hill	1.11	1.11	3.85
5	No Mitigation	Cooperabung	4.44	2.94	1.92
6	Control Reference	Mingaletta to Smiths Creek	0	0	0
6	Mitigation	Mingaletta to Smiths Creek	0	0	0
7	Control Reference	Kundabung	1.11	1.11	5.77
7	Mitigation	Kundabung	18.89	7.29	1.92
7	No Mitigation	Kundabung	3.33	3.33	12.62
8	Control Reference	Maria River State Forest	6.67	3.33	5.77
8	Mitigation	Maria River State Forest	0	0	3.34
8	No Mitigation	Maria River State Forest	3.33	1.93	0

SPOTTED-TAILED QUOLL

The methodology outlined in Section 3.2.2 was followed for the Spotted-tailed Quoll surveys, with the exception of the Maria River State Forest reference site. Additional factors including the presence of two fires at Beranghi and Limeburners Creek Nature Reserve necessitated the relocation of the Maria River reference site to a secondary location much further to the north.

Cameras were installed between the 8 and 14th August and retrieved between 22-26 days later culminating in 2340 nights of survey effort. See Figure 5 for camera distribution. At the time of their installation an olfactory predator lure consisting of chicken drumsticks and 2-3 West Australian Pilchards (*Sardinops sagax*) were used to smear in the immediate vicinity on logs, stone, the base of trees and the remnants hidden within cavities of fallen branches and logs. The objective of this was to reduce the opportunity for a single animal to remove the olfactory lure and improved the opportunity to capture readily identifiable images of fauna entering the camera trap. The use of fish as a bait for quoll has been previously demonstrated in Limeburners Creek Nature Reserve when fish heads were used extensively for the trapping program (*see* Andrew 2005).

Cameras were set in continuous 24 hour mode for 21 nights using the following parameters:

- Sensor Sensitivity was set at a variable rate from 'normal' or 'high' depending on the amount of grass and other fine vegetation present at the camera site. Some pruning was undertaken at sites in order to maximize the opportunity to setting the camera sensitivity to high;
- The number of images was set to 2 with the reset or PIR set at 30 second intervals;
- All images were time and date stamped for later verification and to facilitate in the understanding of quoll or other predator and prey activity.

Interpreting the Camera Data

All images were reviewed by one person (BDL). For determining the abundance or activity levels of quoll, eutherian predators and suitable prey items (i.e. small and medium sized mammals) the maximum number of a species within a 1 hour period was set at one unless it could be clearly distinguished as a separate individual. For example, a tortoise shell Feral Cat that was repeatedly photographed on 10 occasions over the spaced of 30 minutes was counted as a single record of occurrence whilst a tabby coloured cat captured during the same period would allow the counting of a second animal.

Considerations of Predator Prey Relationship

A quoll study at Limeburners Creek Nature Reserve 5-10 km east of the Upgrade revealed more than half of their diet (63.5%) was comprised of mammals and only 8.8% bird with the residual made up of insects, fish, reptiles and garbage (Andrew 2005). Similarly, studies of quoll in the upland areas of the mid north coast have also reported similar high rates of mammalian consumption, particularly medium sized mammals such as bandicoots (e.g. Glen and Dickman 2008). In an attempt to understand the presence and abundance of this size class in the study area the number of medium and smaller mammals captured by the camera traps was also considered. The three particular classes of interest were arboreal fauna which regularly come to the ground (possums), bandicoots and smaller ground dwelling mammals such as rodents and Antechinus. Their presence and the number of recorded images were recorded as above.

Considerations of competitive interaction with eutherian predators

The number of eutherian predators including feral cat, wild dog/dingo and red fox was also considered within each treatment because they are suspected at influencing quoll distribution via competitive interactions for prey (Glen and Dickman 2008). The numbers of each species was calculated to provide a mean abundance for each treatment at each of the three areas.

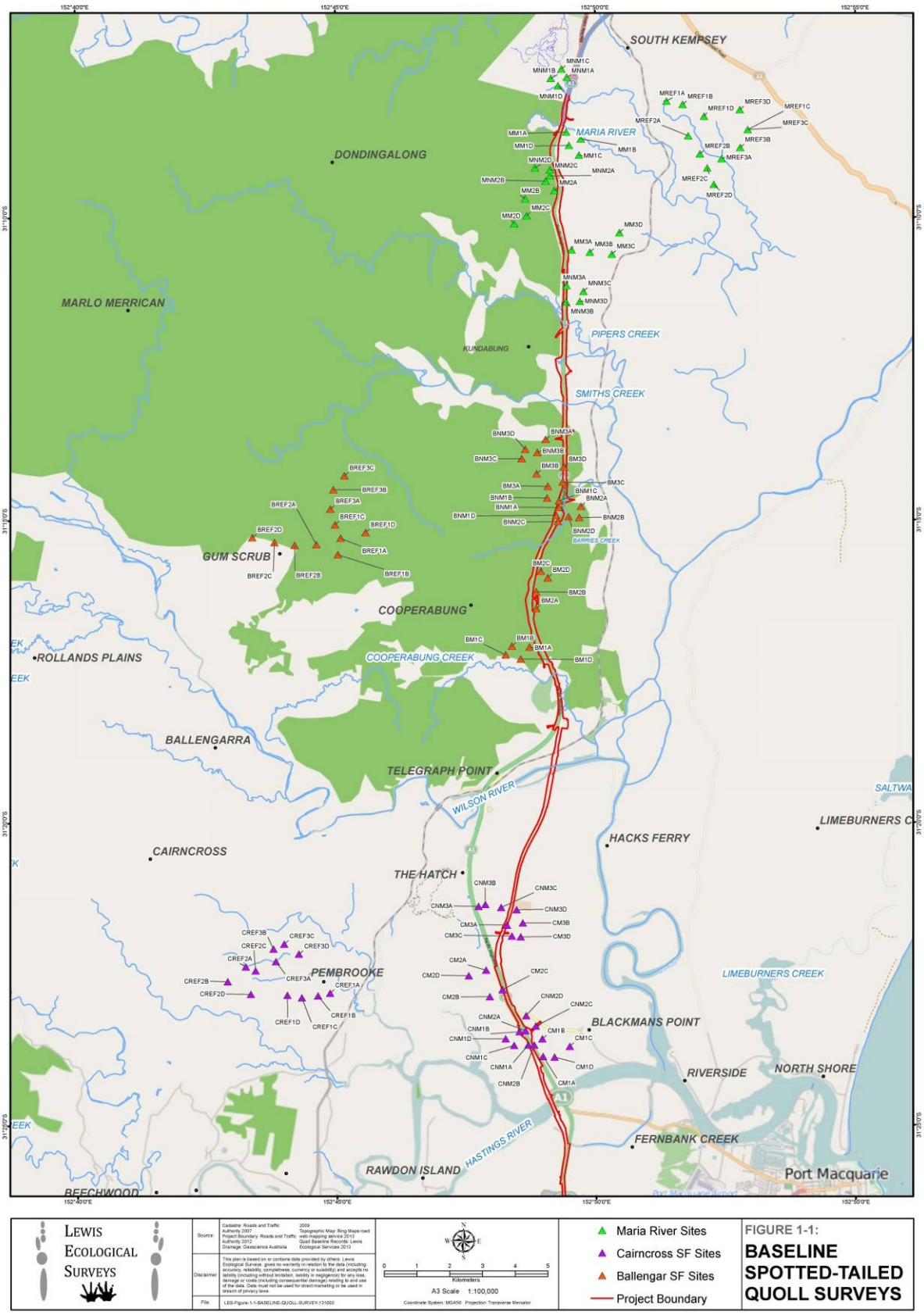

Figure 5 Baseline Spotted-tailed Quoll monitoring locations

Results

Camera Surveys

Field surveys retrieved 103 of the 108 installed cameras with the residual being stolen during the course of the field survey. Two of the retrieved cameras had suffered equipment malfunction leaving 101 functioning cameras which recorded 27208 images (mean=272 SD=469).

No Spotted-tailed Quoll were recorded during the camera surveys.

Abundance Indices of Suitable Prey Items

The camera traps in Cairncross State Forest recorded only 11 images comprising seven possums and four bandicoots from 808 camera trap nights. In Ballengarra State Forest the number of native prey items recorded doubled with 22 images from 826 camera trap nights comprising 13 possum, four bandicoot and five dasyurid and rodents. In Maria River State Forest the number of native prey items recorded was four images from 706 camera trap nights comprising three possum and one bandicoot and no dasyurid and rodents.

Abundance Indices of Introduced Eutherian Predators

In Cairncross State Forest there were 188 images of introduced eutherian predator comprising 48 wild dog, 101 fox and 39 feral cat. The majority of the wild dog images were recorded from the Cairncross reference location to the west of Pembrooke whilst most fox images were associated in areas proposed for no mitigation (Figure 6).

In Ballengarra State Forest there were 125 images of introduced predator comprising 51 wild dog, 48 fox and 26 feral cat. The majority of the wild dog and fox images were recorded from the reference location to the west of the Upgrade in the Gum Scrub area whilst Feral Cat showed a consistent presence across all three treatments (Figure 6).

In Maria River State Forest there were 206 images of introduced predator comprising 79 wild dog, 96 fox and 31 feral cat. The majority of the wild dog and fox images were recorded from the reference location to the east of the Upgrade whilst Feral Cat showed a consistent presence across all three treatments (Figure 6).

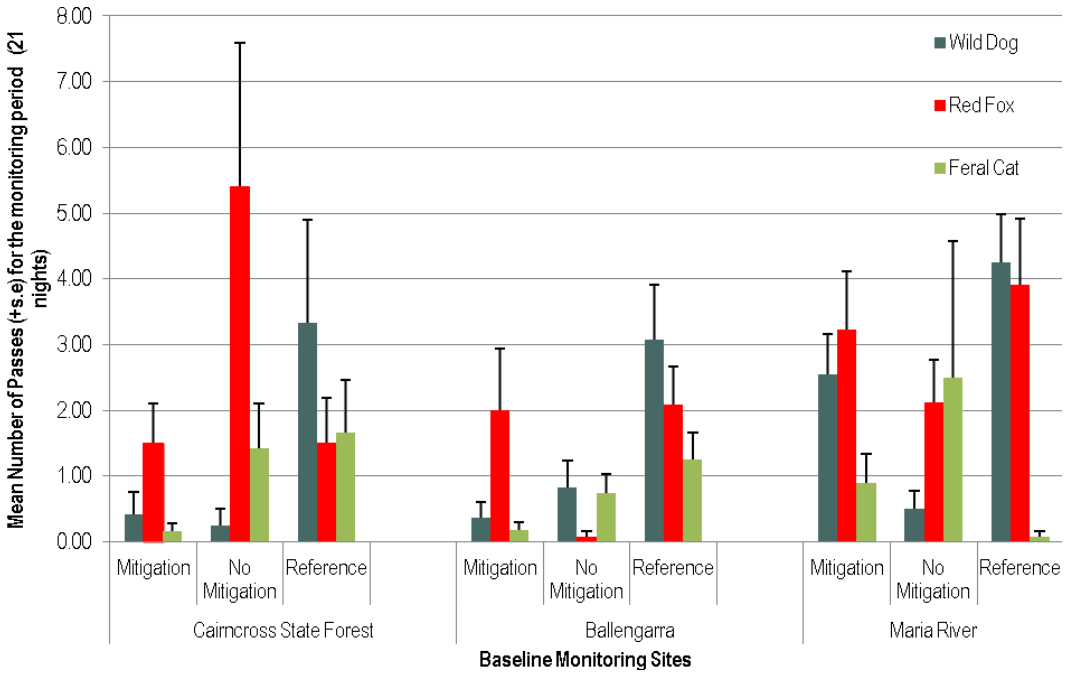

Figure 6 Mean number (+s.e bars) of wild dog, red fox and feral cat across each treatment for the monitoring period.

The highest mean levels of eutherian predators occurred at the reference sites with the activity levels almost three times higher than the mitigation treatment at Cairncross State Forest and Ballengarra State Forest (Figure 7). At Maria River State Forest all three treatment classes scored relatively high with the reference site containing the highest overall mean abundance of eutherians.

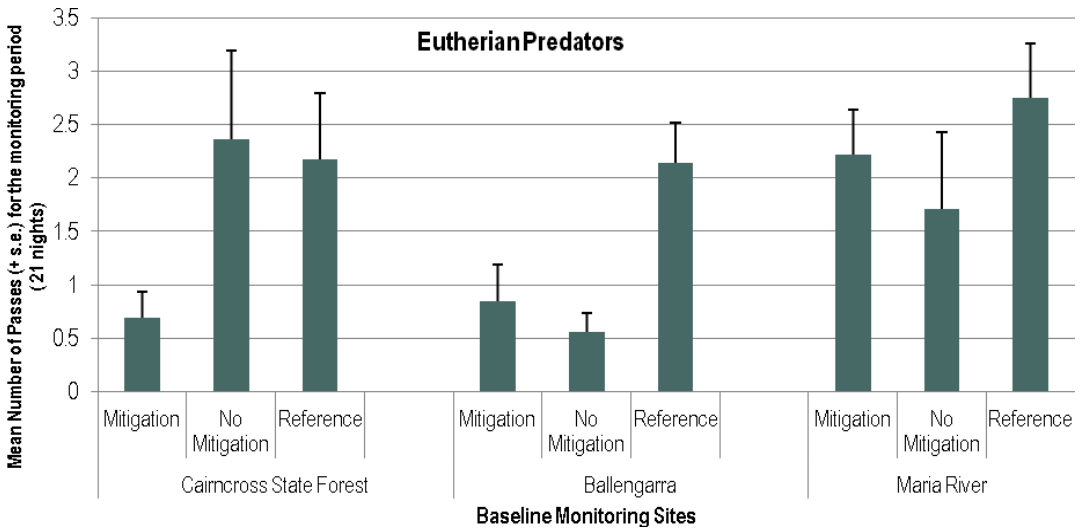

Figure 7 Mean number (+s.e bars) of eutherian predators across each treatment for the monitoring period.

Road Kill Monitoring

Road kill monitoring was undertaken in two ways, as part of the overall Ecological Monitoring Program. Firstly, a systematic survey was undertaken over 4 weeks in October 2013 and January-February 2014 and involved a weekly vehicle traverse of the existing Pacific Highway to observe and record all road kill fauna. The second approach was of a more *ad hoc* nature and reflects numerous vehicle traverses undertaken along the existing highway route between Port Macquarie Interchange and Kempsey between the period of 2010-2014. During this time more than 200 traverses were completed shortly after dawn (0600-0830 hours).

No Spotted-tailed Quoll were recorded during the road kill traverses.

Discussion

No quoll were recorded during the field surveys for this baseline monitoring program. The sampling approach adopted in this study has been proven elsewhere to provide a 'probability of detection' ranging from 80% in areas supporting high densities of quoll (i.e. Alpine areas of NSW/Victoria) to a much lower 34% in areas supporting lower quoll densities (*see* Nelson et al. 2010). The desktop surveys confirm quoll is a widely distributed species through the broader area but apart from Limeburners Creek Nature Reserve there does not appear to be a reliable population which could be used as a reference point to gauge the effectiveness of camera traps for monitoring quoll populations in lowland coastal forest on northern New South Wales. This area was originally identified as a reference site but the ignition of two fires burning in the area for weeks (Limeburners Creek Nature Reserve and Beranghi) prevented this from occurring. Without knowingly sampling in an area of higher density quoll habitat the probability of detection rate best aligns with an area supporting lower densities of quoll.

Other factors should also be considered to have influenced the survey results. The prevailing weather conditions were dry with virtually no rainfall recorded throughout the monitoring period, thus ensuring the chicken baits and pilchards remained effective lures so this is unlikely to have had a negative

effect on the survey. The seasonal effect of conducting surveys during August and September best reflects a survey investigating habitat use during the post mating breeding period when breeding females may spend much of their time nurturing young in a den resulting in changed patterns of habitat use from other times of the year. It is unclear whether male Spotted-tailed Quoll undergo the dasyurid 'die off' in the weeks preceding mating but if this is the case then fewer males would have been present. For example, a radio tracked male quoll in Limeburners Creek Nature Reserve underwent dramatic loss in body weight, possible anaemia, hair loss and excessive parasite load indicating that such a 'die off' is possible (see Andrew 2005).

The review of historic records on the NSW Bionet Atlas found a lot of variability in the seasonal reporting rates of quoll with records for every season and the majority of all records originating from a community survey administered by Dan Lunney. Nonetheless, the only record of Quoll using the Project corridor was the road kill individual from mid July 1992. This highlights the need to consider the appropriate time during the year for monitoring quoll. For example, surveys conducted between July and October would provide information on habitat use during the breeding period with females in particular using smaller home ranges than they would during the non breeding period. Therefore, to understand broader movements associated with dispersal monitoring would be beneficial during the dispersal period regarded in this study area as between March and May when juveniles establish new home ranges and adults re-establish their non breeding home ranges. If patterns of habitat use during an alternative period of increased activity were required then the mating period between mid May to mid July would also be an optimum time.

The absence of quoll from the road kill data also suggests it may be an infrequent visitor to the Project or at least the existing Pacific Highway carriageway. This was supported by both the desktop surveys and the road kill monitoring data and would indicate that quoll probably occur at very low densities in the Project area. Comparative road kill surveys in the upland areas of the Great Dividing Range have noted quoll as being a regular road kill species in areas such as Cotton-Bimbang National Park (Oxley Highway) and areas much further to the north in Girard State Forest between Drake and Tenterfield (B. Lewis unpublished data).

Little information could be gained from the habitat assessment performed at each camera trap site because there were no confirmed records of quoll. Fallen logs with hollows capable of supporting den sites were recorded in multiple plots of all treatments and assessing these in isolation would be misleading.

Influence of Eutherian Predators

The exact influence eutherian predators have on quoll across the broader area is unknown because the former was found to be widespread and relatively common. In fact, it was the reference sites which often supported the highest levels of eutherian activity with the highest of these being the Maria River reference site which had been located in the northern end of Maria River National Park within a few kilometres of the Kempsey landfill site. By contrast, the research conducted in Limeburners Creek Nature Reserve reported low densities of eutherians and there was evidence to support quoll may have occasionally benefited from this as individuals foraging on the left over spoils of larger mammals including Swamp Wallaby and Eastern Grey Kangaroo (Andrew 2005). The natural geographical barriers of the Hastings River, Maria River, different vegetation communities with dense heaths and woodlands supporting dense shrub layers and perhaps a more strategic predator control program may best explain this as the two areas were often not more than 5-10 km apart. It is also unclear what current predator control programs are in place for areas used in this study.

Influence of Suitable Prey Items

The abundance of medium sized mammals, particularly bandicoots has been demonstrated as an important dietary component for quoll on the coastal plains (Andrew 2005) and the upland areas of the Great Dividing Range (Glen and Dickman 2008). Given the Project occurs between these two areas it is expected that medium sized mammals would also form an important dietary component for

any quoll inhabiting the study area. The fact that both studies also reported medium sized mammals as the most important prey class for eutherian predators would indicate a potential for exploitative interactions. In this study, very few medium sized mammals were recorded with the cameras, with Ballengarra State Forest reporting twice the number of medium sized mammals than Cairncross State Forest and Maria River State Forest supporting far fewer. To overcome these exploitative interactions, previous studies have suggested the broader dietary habit of quoll as secondary prey including those with arboreal habits that may assist with coexistence (Glen and Dickman 2008). Therefore, in areas with high levels of introduced predators then more structurally diverse communities which have the capacity to support a more biologically rich source of prey items may become increasingly important for quoll. Obvious examples of these in the Project corridor include Maria River, Barrys Creek and it would be expected that individuals would periodically traverse along Pipers Creek, Smiths Creek and Cooperabung Creek. The value of Wilson River and Hastings River is currently unknown but the latter is surrounded by open grazing land for at least 1 km either side of the northern shoreline and for several kilometres on the southern bank.

Recommendations

1. Operational monitoring is undertaken either during the dispersal period of March-May or alternatively May-mid July during the mating period.
2. A reference site should be located in known quoll habitat in Limeburners Creek Nature Reserve to improve our understanding of detection probabilities of quoll using remote cameras.
3. The study would benefit from retracting the current BACI survey design of three treatment classes to a paired sampling BACI design involving an impact site and a paired control/reference site. This is because the opportunities for locating ‘no mitigation control sites’ along the Project corridor is limited because of the mobility of the target species, which can travel a number of kilometres in an evening, combined with the presence of suitable fauna underpasses located only 2-3 km apart and often much closer. The reduction in the number of treatments would allow for an increase in the number of within treatment replicates from three to four.

GIANT BARRED FROG

The survey methodology outlined in Section 3.2.3 of the Ecological Monitoring Program was adopted for Giant Barred Frog surveys, which is also consistent with the methodology outlined in the Giant Barred Frog Management Strategy (Lewis 2013).

In accordance with this strategy, breeding condition of males was assessed on the colouration of their nuptial pads (i.e. no colour, light moderate, dark) (see Table 4).

Table 4 A key developed for determining reproduction condition in barred frogs (*Mixophyes*).

Nuptial Pad Colour	Comments
No Colour	• Males may be active or dormant but don't present as being sexually active to mate with females. • No colour can occur at any time throughout the year but pronounced periods include dry springs and late autumn with the onset of winter.
Light	• Some colouration indicating frogs are likely to become active (late winter) or have been active but generally not breeding. For example, prevailing weather conditions are unsuitable. • Frogs with light nuptials are generally on the shoulder periods of breeding events and a small percentage of the male population is likely to classify into this category at almost any time of the year apart from June and July.
Moderate	• Males are normally active, will often readily respond to calls. ready to mate with gravid females if conditions are suitable. • These frogs may occasionally be involved in intraspecific aggression indicating their readiness to mate with females. • Colouring may be evident between August-May and is considered cyclic and surrounding breeding events.
Very Dark	• Males are normally active, ready to mate with gravid females if conditions are suitable. • Some observations of intraspecific aggression can occur between males at this stage. • Colouring may be evident between August-May and is considered cyclic with early season suspected of being driven through warming air temperature whilst prevailing rainfall conditions are considered the primary queue during summer and autumn.

Determining Population Size

The **Lincoln–Petersen method** (also known as the Petersen–Lincoln index) can be used to estimate population size if only two visits are made to the study area. This method assumes that the study population is "closed". In other words, the two visits to the study area are close enough in time so that no individuals die, are born, move into the study area or move out of the study area between visits. The model also assumes that no marks fall off animals between visits to the field site by the researcher, and that the researcher correctly records all marks.

The Lincoln–Peterson estimator is asymptotically unbiased as sample size approaches infinity, but is biased at small sample sizes. An alternative less biased estimator of population size is given by the **Chapman estimator.**

$$N = \frac{(M+1)(C+1)}{R+1} - 1,$$

Where, as before,

N = Estimate of total population size

M = Total number of animals captured and marked on the first visit

C = Total number of animals captured on the second visit

R = Number of animals captured on the first visit that were then recaptured on the second visit

An approximately unbiased variance of *N*, or var(*N*), can be estimated as:

$$\operatorname{var}(N) = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)(R+1)(R+2)}.$$

Juvenile frogs were removed from the population estimation process because frogs less than 40 mm snout-vent length would have metamorphed between the spring and summer sampling event. This is based on some cross referencing at each site with recaptured frogs and working out their mean growth rate between the two time periods. For example, at Smiths Creek one recapture sub adult was 45.1 mm in September 2013 and had grown to 56.2 mm in January whilst another frog was 46.2 mm in September and 55.4 mm in January. The mean difference being 10.15 mm over the four month period. For most metamorphs their snout vent length is in the general vicinity of 28-31 mm.

Results

A detailed summary of all survey results in provided in Table 17.

Baseline data for the spring and summer surveys has been provided below, however compliance with the submission and approval timeframes in the Department's Condition of Approval 4 could not be achieved if the report was delayed to include the autumn monitoring results. These results will be provided in the first annual report, to be prepared in accordance with Condition of Approval 8.

Impact Sites

Cooperabung Creek

Date and Time Taken To Complete The Survey: Spring - 22nd September 2013 between 1900-2235 hours. Summer – 26th January 2014 between 2125-0220 hours

Abiotic Conditions: A summary of the prevailing abiotic variables is shown in Tables 5 & 6. The conditions were described as mild and becoming more difficult to locate frogs following rainfall earlier in the week.

Table 5 Spring abiotic conditions during the spring survey of Cooperabung Creek

Date	Time		Air Temp °C	Water Temp °C	Cloud Cover %	Humidity %	Wind[1]	Rain[2]	Steam Depth (mm)
22.9.2013	Start Time	1900	14.2	15	0	77	0	0	
	Finish time	2235	10.6	14.75	0	88	0	0	
Summary		3 hrs 35 minutes	12.4	14.9	0.0	82.5	0.0	0.0	

Table 6 Summer abiotic conditions during the summer survey of Cooperabung Creek

Date	Time		Air Temp	Water	Cloud Cover	Humidity	Wind[1]	Rain[2]	Steam Depth

			°C	Temp °C	%	%			(mm)
22.9.2013	Start Time	2125	21.3	19.5	10	67	0	1	0
	Finish time	0220	18.6	19.0	90	88	0	0	0
Summary		4 hrs 55 minutes	19.95	19.25	50	77.5	0	0.5	0

Number of Giant Barred Frogs Recorded: Spring - Three Giant Barred Frogs were recorded/captured during the survey. They comprised two sub adult males and one adult female. Although no male frogs were recorded/captured they have been previously recorded a further 300 m downstream of the monitoring transect. At the time of the survey male frogs are likely to have been dormant beneath leaf litter and overhanging vegetation on the primary creek bank. **Summer** - Nine Giant Barred Frogs were recorded/captured during the survey. They comprised two juveniles, one sub adult, one female and five males. At the time of the survey, male frogs displayed a range of nuptial pad colours with one frog each exhibiting 'no colour', light nuptials, medium nuptials and three frogs exhibited dark nuptials indicating most males were in a reproductive state to commence breeding.

Population Estimate: No recaptures of frogs has taken place over the course of the two monitoring surveys. As such, a cursory estimate of seven adults comprising two females and five males is known with three sub adults and two juveniles.

Evidence of Breeding Recorded: Yes via the presence of two sub adult frogs in spring and two juveniles and a young sub adult frog during the summer survey.

Zones Inhabited By Giant Barred Frogs: Restricted to zones C10, C11-C13, C15 and C18 which lie within and immediately upstream of the existing carriageway. Both zones C10 and C11 are considered to form part of the construction footprint (see Figure 8).

Summer Sampling of Chytrid: All nine frogs were swabbed and tested negative for Chytrid (Table 18).

Giant Barred Frog Tadpoles: No tadpoles were recorded using bait traps. Mixophyes tadpoles were observed in zones C11-C15 (see Figure 8).

Habitat: See Figure 8 for the zones within the Cooperabung Creek survey area in which the Giant Barred Frogs were identified. In addition, microhabitat within these zones included flood debris as overhang shelter, grass and leaf litter.

Figure 8 Cooperabung Creek Frog Survey Sites

Smiths Creek

Date and Time Taken To Complete The Survey: Spring - 19th September 2013 between 1845-0020 hours. Summer – 28th January 2014 between 2102-0302 hours

Abiotic Conditions: A summary of the prevailing abiotic variables is shown in Table 7 & 8. Following a significant rainfall event in the Kundabung area on the 16th September conditions were mild with relative low rates of humidity and cool dry air. Larger adult frogs tended to react to this by emerging later at night.

Table 7 Abiotic conditions during the spring survey at Smiths Creek

Date	19.9.2013	Air Temp °C	Water Temp °C	Cloud Cover %	Humidity %	Wind[1]	Rain[2]	Steam Depth (mm)
Start Time	1845	15.7	17	0	76	0	0	
Finish time	0020	9	15.5	0	90	0	0	
Summary	5 hrs 35 minutes	12.4	16.3	0.0	83.0	0.0	0.0	

Table 8 Abiotic conditions during the summer survey at Smiths Creek

Date	28.1.2014	Air Temp °C	Water Temp °C	Cloud Cover %	Humidity %	Wind[1]	Rain[2]	Steam Depth (mm)
Start Time	2102	20.4	22.5	10	68	0	0	
Finish time	0302	16.5	22.5	0	91	0	0	
Summary	5 hrs	18.45	22.5	5	79.5	0	0	

Number of Giant Barred Frogs Recorded: Spring - Ten (10) Giant Barred Frogs were recorded/captured during the survey. They comprised two females and one male with the remainder classified as sub adults although frog with the identifier 000735C27C is likely to be a male frog showing early pigmentation on its throat and abdomen. **Summer** – Sixteen (16) Giant Barred Frogs were recorded/captured during the survey. They comprised one female, four males, nine sub adults and two juveniles. Two frogs were recaptures from the spring survey.

Population Estimate: For the purposes of mark recapture calculations 2 juvenile frogs <40 mm snout-vent were removed from the population estimate leaving 14 of the 16 captured frogs during the summer survey. This resulted in a population estimate of 54 individuals with variance of 20.98. The 95% confidence interval was calculated at 41.12.

Evidence of Breeding Recorded: Yes via the presence of seven sub adult frogs.

Zones Inhabited By Giant Barred Frogs: Distributed across seven zones including the construction footprint (see Figure 9).

Giant Barred Frog Tadpoles: No tadpoles were recorded using bait traps. Tadpoles were observed in the shallower pools and expected to occur also in the deeper pools.

Summer Testing of Chytrid: Two of the 12 swabbed frogs contained infected zoospores. One of these was a recaptured sub adult frog and another being an adult male from the edge of the construction footprint (see Table 18).

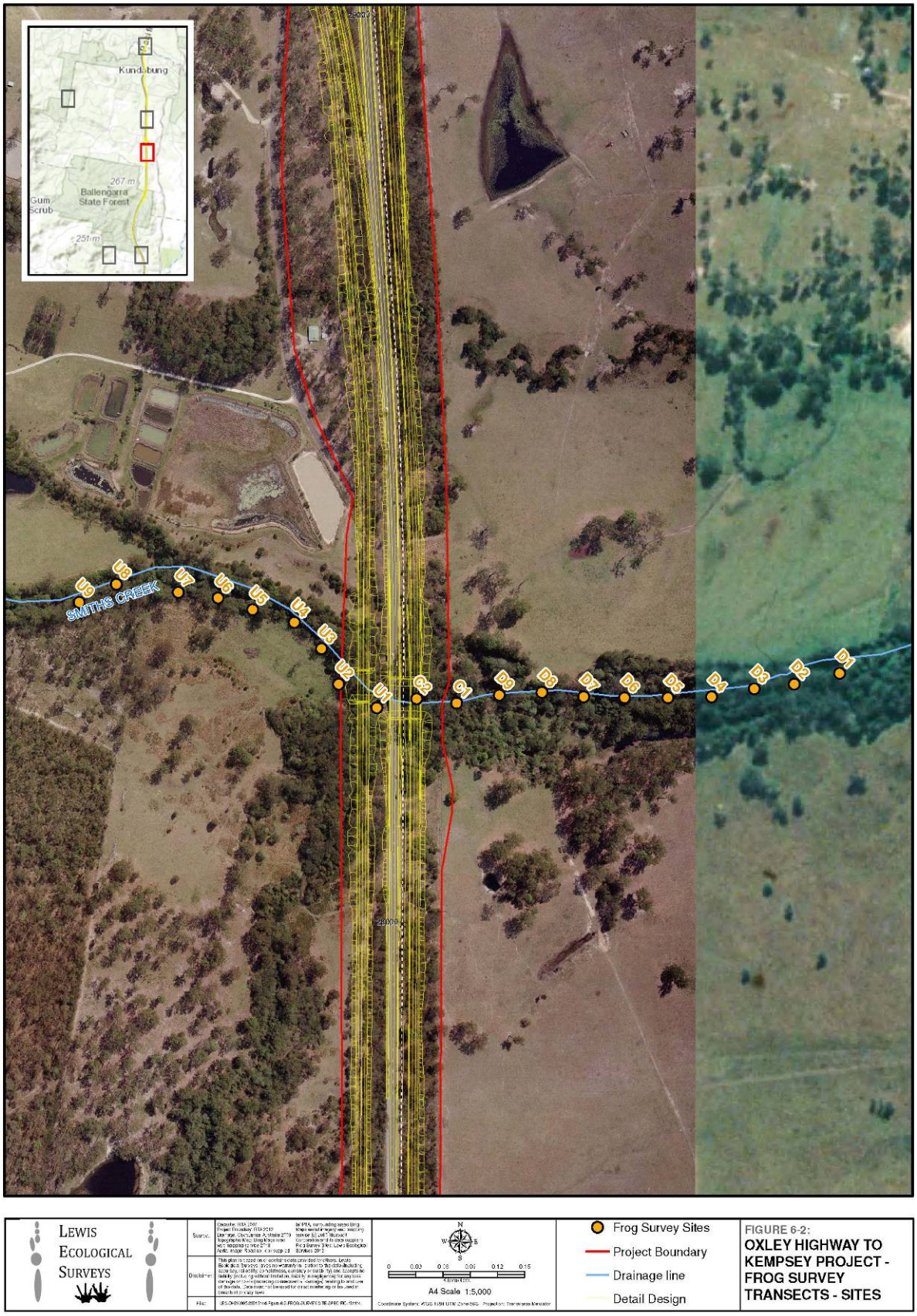

Figure 9 Smiths Creek Frog Survey Sites

Habitat: See Figure 9 for the zones within the Smiths Creek survey area in which the Giant Barred Frogs were identified. In addition, microhabitat within these zones included above and partially buried in leaf litter, sheltering beneath Lomandra, and on dirt, gravel, and logs.

Pipers Creek

Date and Time Taken To Complete The Survey: 18th October between 1958-0048 hours and 28th January between 2045-0220 hours.

Abiotic Conditions: A summary of the prevailing abiotic variables is shown in Table 9 & 10. The spring conditions were described as very dry for the month leading up to this survey until a significant rainfall event of 29 mm was recorded 12 hours prior to the survey. Some light rain fell for up to 3 hours before the survey but then conditions changed with cloud dissipating.

Table 9 Abiotic conditions during the spring survey of Pipers Creek

Date	18.10.2013	Air Temp °C	Water Temp °C	Cloud Cover %	Humidity %	Wind[1]	Rain[2]	Steam Depth (mm)
Start Time	2000	16.6	15	95	79	0	1	
Finish time	0205	11	15	0	100	0	1	
Summary	6 hours 5 minutes	13.8	15.0	47.5	89.5	0.0	1.0	550

Table 10 Abiotic conditions during the summer survey of Pipers Creek

Date	28.1.2014	Air Temp °C	Water Temp °C	Cloud Cover %	Humidity %	Wind[1]	Rain[2]	Steam Depth (mm)
Start Time	2045	25	19	25	70	0	0	
Finish time	0220	23	19	0	90	0	0	
Summary	5 hours 35 minutes	24	19	12.5	80	0	0	210

Number of Giant Barred Frogs Recorded: Spring - Eight Giant Barred Frogs were recorded during the spring survey with three identified as adult males, two females and three sub adults on unknown sex. **Summer** - Nine Giant Barred Frogs were captured with five identified as females, two adult males and two sub adults of unknown sex. Four of the frogs were recaptures from the spring survey.

Population Estimate: All frogs captured during the summer survey would have been present in the population during the spring sampling. This resulted in a population estimate of 15.2 individuals with variance of 2.94. The 95% confidence interval was calculated at 5.76.

Evidence of Breeding Recorded: Yes via the presence of sub adult frogs.

Zones Inhabited By Giant Barred Frogs: Recorded from zones 4 downstream, zone 10 within the construction footprint and zones 12, 13, 15, 17 and 18 upstream (see Figure 10).

Giant Barred Frog Tadpoles: No tadpoles were recorded using bait traps. No tadpoles were recorded dip-netting.

Summer Testing of Chytrid: All of the eight captured frogs showed no sign of being infected with Chytrid (see Table 18).

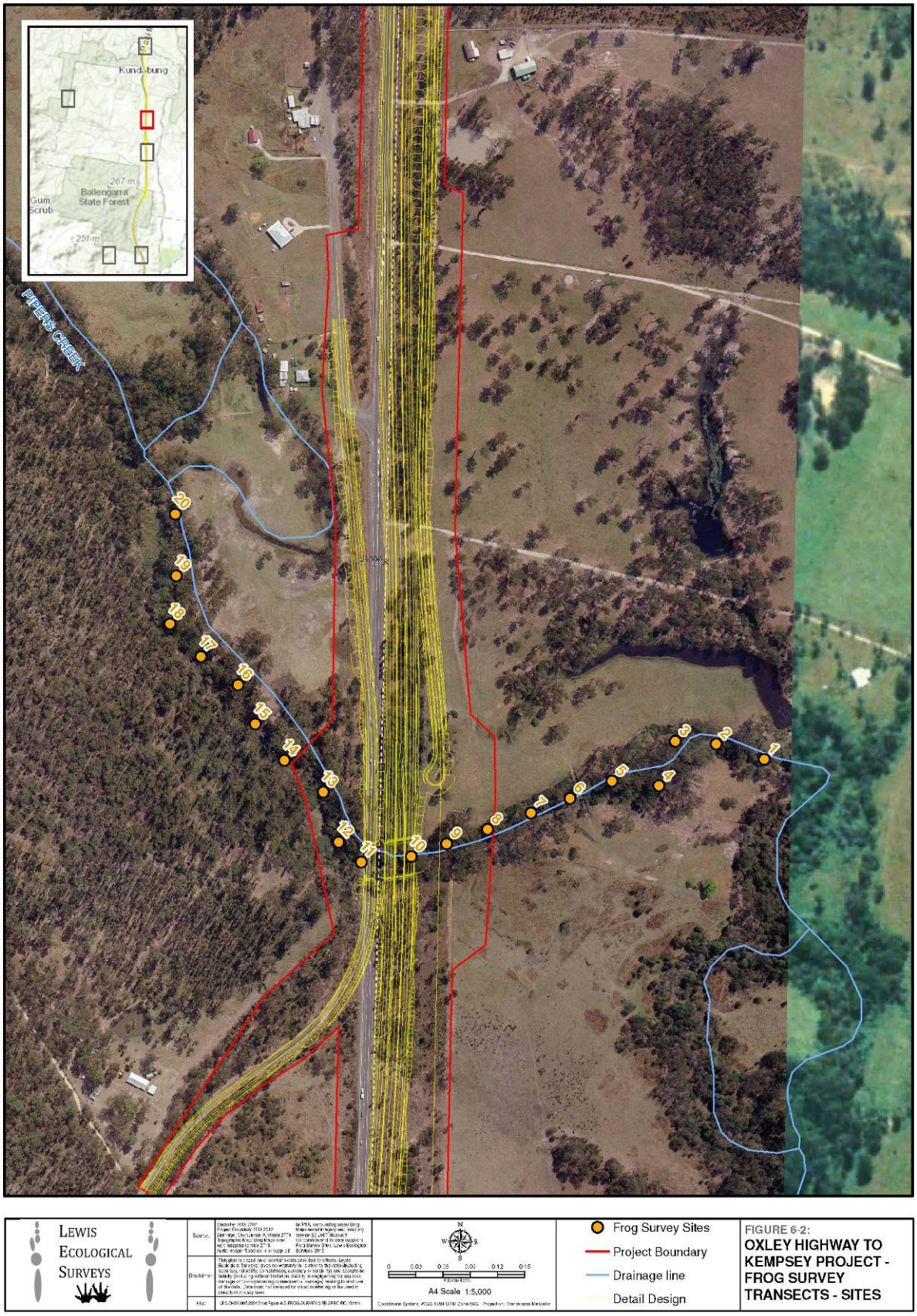

Figure 10 Pipers Creek Frog Survey Sites

Habitat: See Figure 10 for the zones in which the Giant Barred Frogs were identified within the Pipers Creek survey area. In addition, microhabitat within these zones included above and partially buried within leaf litter, and on bare ground.

Maria River

Date and Time Taken To Complete The Survey: The spring survey was undertaken on the 18th September 2013 between 1928-0022 hours and the summer survey on the 31st January between 2055-0315 hours.

Abiotic Conditions: A summary of the prevailing abiotic variables is shown in Table 11 & 12. Following a significant rainfall event at Maria River 16th September conditions were mild with relative low rates of humidity and cool dry air.

Table 11 Abiotic conditions during the spring survey of Maria River

Date	18.9.2013	Air Temp °C	Water Temp °C	Cloud Cover %	Humidity %	Wind[1]	Rain[2]	Steam Depth (mm)
Start Time	1928	16	19.5	0	58	0	1	
Finish time	0022	9.7	17.5	0	90	0	0	
Summary	4 hours 54 minutes	12.9	18.5	0.0	74.0	0.0	0.5	410

Table 12 Abiotic conditions during the summer survey of Maria River

Date	31.1.2014	Air Temp °C	Water Temp °C	Cloud Cover %	Humidity %	Wind[1]	Rain[2]	Steam Depth (mm)
Start Time	2055	23.3	18	0	70	0	0	
Finish time	0315	15.9	18	0	89	0	0	
Summary	6 hours 20 minutes	19.6	18	0	79.5	0	0	290

Number of Giant Barred Frogs Recorded: Spring - Ten (10) Giant Barred Frogs were recorded/captured during the survey. They comprised 6 females with the remainder classified as sub adults although frog with the identifier 0007357806 is likely to be a male nearing maturity (Table 17). **Summer** – Nine Giant Barred Frogs were recorded during the survey comprising three adult males, one female, one sub adult and two juveniles. There were no recaptures.

Population Estimate: There were no recaptures to allow a calculation of population size. Based on the number of captures to date there is at least seven females, three males, five sub adults and two juveniles present along the transect.

Evidence of Breeding Recorded: Yes via the presence of sub adult and juvenile frogs.

Summer Testing of Chytrid: All of the six captured frogs showed no sign of being infected with Chytrid (see Table 18).

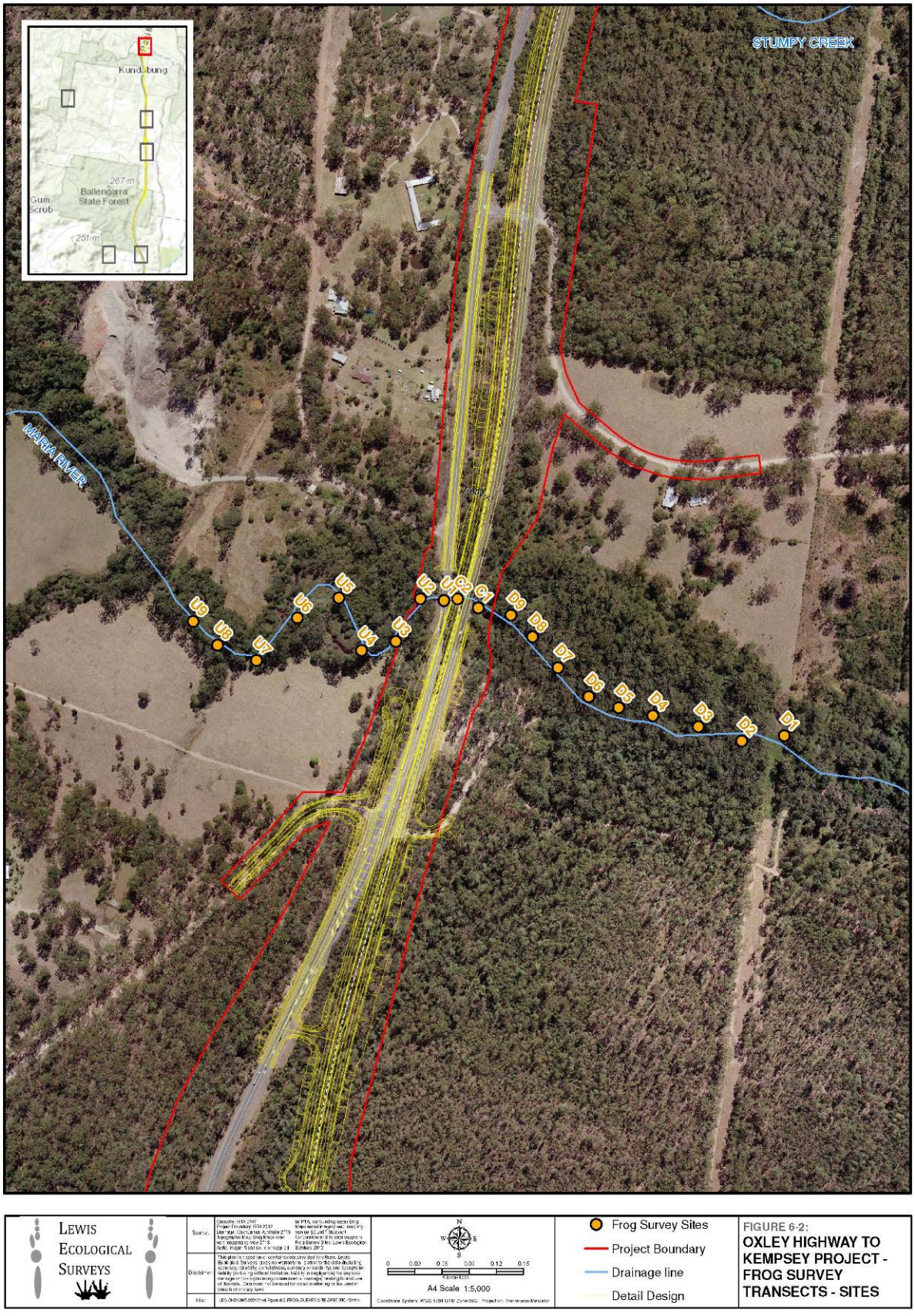

Figure 11 Maria River Frog Survey Sites

Zones Inhabited By Giant Barred Frogs: Distributed across nine zones including zones bordering the construction footprint (see Figure 11).

Giant Barred Frog Tadpoles: No tadpoles were recorded using bait traps. Some follow up dip netting wasn't able to record tadpoles.

Habitat: See Figure 11 for the zones in which the Giant Barred Frogs were identified within the Maria River survey area. In addition, microhabitat within these zones included above and partially buried within leaf litter, the undercut of the bank, sheltering under lantana, under vines and on bare ground.

Reference Sites

Cooperabung Creek

Date and Time Taken To Complete The Survey: The spring survey was undertaken on the 19th October between 1958-0048 hours and the summer survey on the 30th January between 2050-0145 hours.

Abiotic Conditions: A summary of the prevailing abiotic variables is shown in Table 13 & 14. The conditions were described as very dry for the month leading up to this survey until a significant rainfall event of 29 mm was recorded 36 hours prior to the survey. Some light rain fell immediately prior and during the initial stages of the survey.

Table 13 Abiotic conditions during the spring survey of Cooperabung Creek (reference) west of the Upgrade

Date	19.10.2013	Air Temp °C	Water Temp °C	Cloud Cover %	Humidity %	Wind[1]	Rain[2]	Steam Depth (mm)
Start Time	1958	18.3	16	95	82	0	1	
Finish time	0048	14.8	15	0	100	0	1	
Summary	4 hrs 50 minutes	16.6	15.5	47.5	91.0	0.0	1.0	270

Table 14 Abiotic conditions during the summer survey of Cooperabung Creek (reference) west of the Upgrade

Date	30.1.2014	Air Temp °C	Water Temp °C	Cloud Cover %	Humidity %	Wind[1]	Rain[2]	Steam Depth (mm)
Start Time	2050	18.4	21	0	83	0	0	
Finish time	0145	16.8	21	0	91	0	0	
Summary	4 hours 55 minutes	17.6	21	0	87	0	0	190

Number of Giant Barred Frogs Recorded: Spring - Twenty (20) Giant Barred Frogs were recorded during the survey with 17 of these captured for PIT tagging. The three uncaptured frogs were adult males calling in the lower reaches of the transect. Of the captures frogs, seven were males, seven were females and three were sub adults of unknown sex (Table 17). **Summer** – Twenty-one (21) Giant Barred Frogs were recorded with two of these being recaptures from the spring survey. The captured frogs comprised four females, four males, nine sub adults and four juveniles. There were two recaptures from the spring survey.

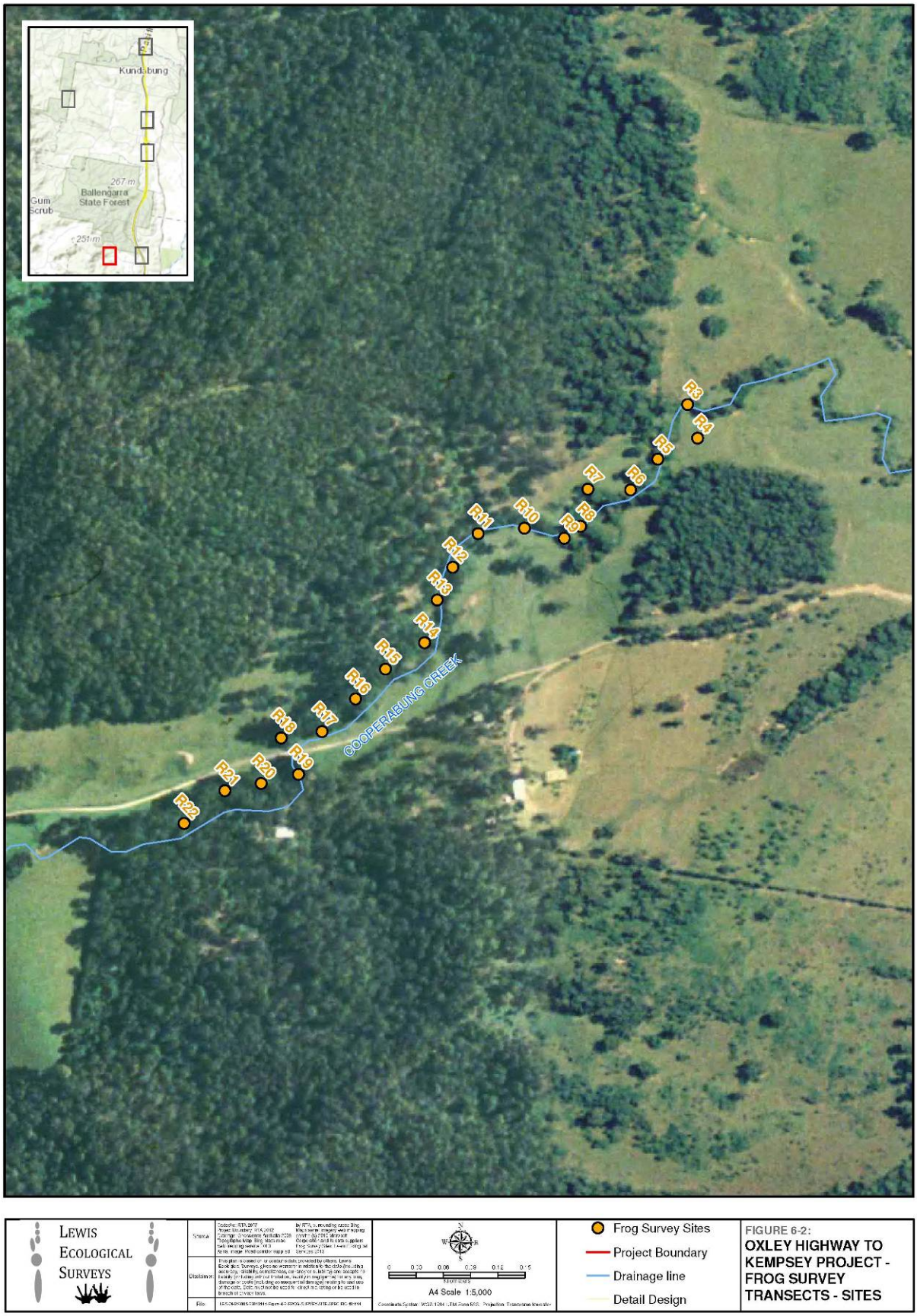

Figure 12 Cooperabung Creek (reference) survey sites

Population Estimate: Five of the 21 frogs captured were removed from the population estimate as they were considered unlikely to be part of the population during the spring sampling. This resulted in a population estimate of 118 individuals with variance of 51.36. The 95% confidence interval was calculated at 100.7.

Evidence of Breeding Recorded: Yes via the presence of sub adult and juvenile frogs.

Zones Inhabited By Giant Barred Frogs: Broadly distributed across 15 zones with some consistent presence in the middle and lower reaches of the transect (see Figure 12).

Giant Barred Frog Tadpoles: No tadpoles were recorded using bait traps. Tadpoles were present in most pools during the spring sampling.

Summer Testing of Chytrid: One of the 10 frogs swabbed for Chytrid returned a positive result across all three tested replications. The infected frog was located at the downstream end of this transect (see Table 18).

Habitat: See Figure 12 for the zones in which the Giant Barred Frogs were identified within the Cooperabung Creek (reference) survey area. In addition, microhabitat within these zones included above and partially buried within leaf litter (some of which included Lomandra shelters), pasture grass, within the undercut of the bank, and on dirt and rock.

Pipers Creek

Date and Time Taken To Complete The Survey: The spring survey was undertaken on the 21st September 2013 between 1837-2245 hours whilst the summer survey was undertaken on the 27th January 2014 between 2045-0250 hours.

Abiotic Conditions: A summary of the prevailing abiotic variables is shown in Table 15 & 16. The conditions were described as mild and becoming more difficult to locate frogs following rainfall earlier in the week.

Table 15 Abiotic conditions during the spring survey of Pipers Creek in Kalantenee National Park.

Date	21.9.2013	Air Temp °C	Water Temp °C	Cloud Cover %	Humidity %	Wind[1]	Rain[2]	Steam Depth (mm)
Start Time	1837 hrs	14.7	15.5	0	70	0	0	
Finish time	2245 hrs	9.5	15	0	84	0	0	
Summary	**4 hours 8 minutes**	**12.1**	**15.3**	**0.0**	**77.0**	**0.0**	**0.0**	**575.0**

Table 16 Abiotic conditions during the summer survey of Pipers Creek in Kalantenee National Park.

Date	27.1.2014	Air Temp °C	Water Temp °C	Cloud Cover %	Humidity %	Wind[1]	Rain[2]	Steam Depth (mm)
Start Time	2045	24.7	20	100	78	0	0	
Finish time	0250	19.0	20	0	85	0	0	
Summary	**6 hours 5 minutes**	**21.9**	**20**	**50**	**81.5**	**0**	**0**	**170.0**

Number of Giant Barred Frogs Recorded: Spring - Ten (10) Giant Barred Frogs were recorded/captured during the survey. They comprised 1 sub adult frog of unknown sex, four males and 5 adult females (Table 17). **Summer** – Thirteen (13) Giant Barred Frogs comprising eight adult males and five adult females. There were no recaptures.

Population Estimate: There were no recaptures to allow a calculation of population size. Based on the captured data for the spring and summer survey there is at least 10 males, 10 females and the sub adult frog is unlikely to have grown into an adult at the time of the summer survey.

Evidence of Breeding Recorded: Yes via the presence of one sub adult frog.

Zones Inhabited By Giant Barred Frogs: Distributed across 10 zones 5,6,7,8, 9,10,13,15, 16 and 19 (see Figure 13).

Giant Barred Frog Tadpoles: No tadpoles were recorded using bait traps.

Summer Testing of Chytrid: None of the 10 frogs swabbed for Chytrid returned a positive result (see Table 18).

Habitat: See Figure 13 for the zones in which the Giant Barred Frogs were identified within the Pipers Creek (reference) survey area. In addition, microhabitat within these zones included above, partially buried and completely buried within leaf litter, sheltering under Lomandra, and within holes in the bank.

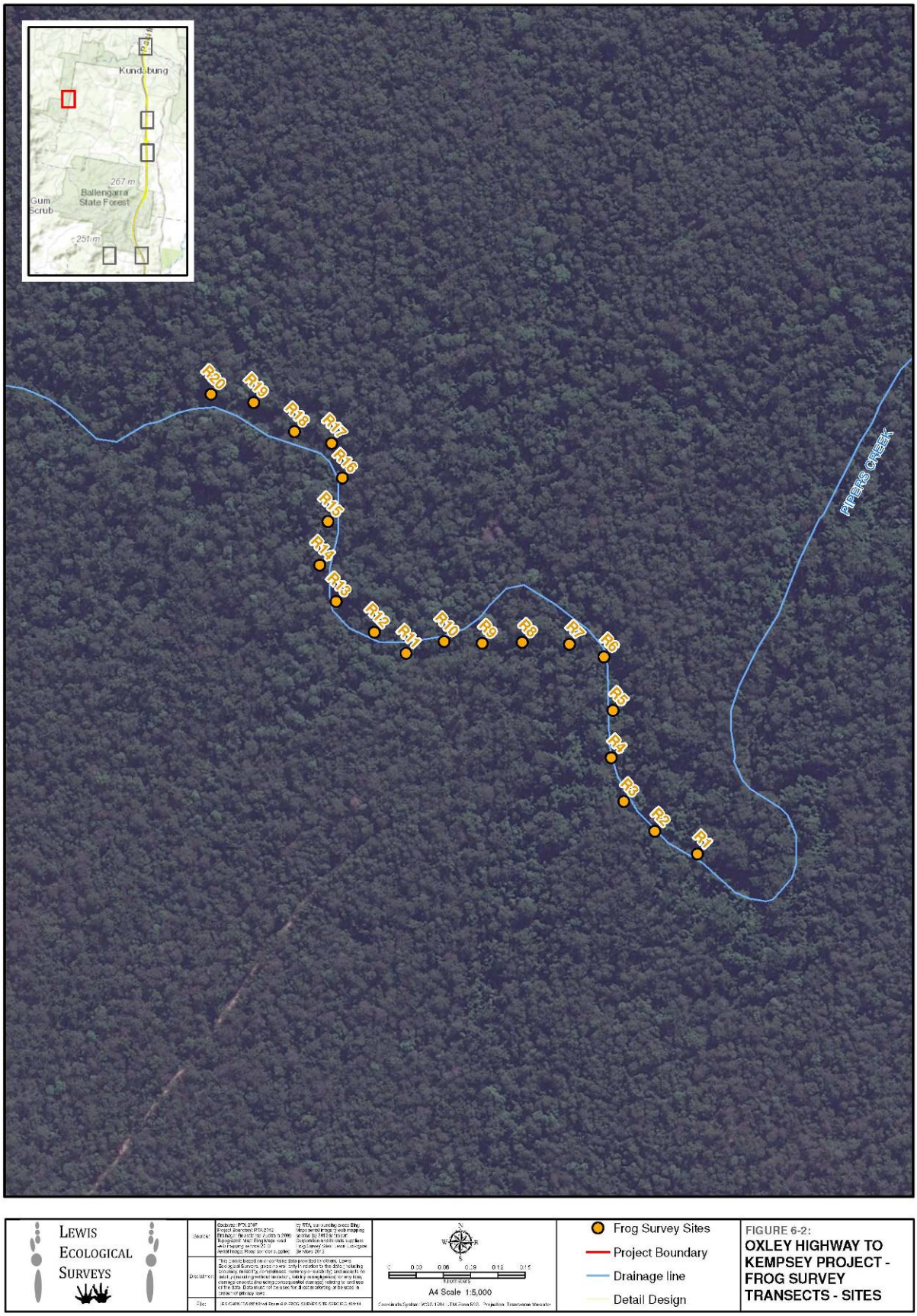

Figure 13 Pipers Creek (reference) survey sites

Discussion

All six of the monitoring sites show that a successful breeding event occurred in the past 2012/13 summer. Male frogs were noticeably absent from Smiths Creek and Cooperabung Creek but this is believed to be a result of the one off survey rather than an imbalance in the population structure. For example, surveys around 300 m downstream of the Cooperabung transect during the development of the Giant barred Frog management strategy recorded 4 males over a 500 m transect.

Table 17 Summary of Giant Barred Frog captures for the spirng and summer ecological monitoring

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
Impact Sites													
Cooperabung Creek													
Spring Sample													
1	Male	Sub Adult	Immature	52.4	17.5	000735C1E9	11	North Bank	1.5	First time capture	Observed	Using flood debris as overhang shelter on dirt	Yellowing throat indicating likely to be a male frog once it matures
2	Male	Sub Adult	Immature	54.1	19.75	000735A97E	12	South Bank	2.1	First time capture	Observed	Above litter	Yellowing throat indicating likely to be a male frog once it matures
3	Female	Adult	Not Gravid	95.6	143.0	000735B40B	13	South Bank	3.7	First time capture	Observed	Above litter	
Summer Sample													
1	Unknown	Juvenile	Immature	38.2	8.25	000735B812	11	North Bank	3.2	First time capture	Observed	Above litter	Swabbed
2	Male	Adult	No Colour	77.7	58.25	0007352F47	12	South Bank	7.3	First time capture	Observed	Above litter	Swabbed
3	Female	Adult	Not Gravid	91.0	118.0	000735830E	18	North Bank	6.8	First time capture	Observed	On Grass	Swabbed

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
4	Male	Adult	Dark Nuptial	69.7	44.0	0007352816	18	North Bank	5.5	First time capture	Observed	Above litter	Swabbed
5	Male	Adult	Dark Nuptial	68.1	38.25	0007359A50	18	North Bank	2.3	First time capture	Observed	Using flood debris	Swabbed
6	Unknown	Juvenile	Immature	32.5	5.25	0007359E3E	15	South Bank	1.6	First time capture	Observed	Above litter	Swabbed
7	Male	Adult	Moderate Nuptial	73.7	56.0	0007358413	15	South Bank	3.5	First time capture	Observed	Above litter	Swabbed
8	Male	Adult	Light Nuptial	64.7	33.75	0007359026	12	South Bank	3.8	First time capture	Observed	Above litter	Swabbed
9	Unknown	Juvenile	Immature	40.2	10.0	0007357F41	10	North Bank	1.0	First time capture	Observed	On Grass	Swabbed
Smiths Creek													
Spring Sample													
1	Unknown	Sub Adult	Immature	39.6	9.5	000735797B	C1	North Bank	1.5	First time capture	Observed	Above Litter	
2	Unknown	Sub Adult	Immature	40.5	10.5	000735A06F	D5	North Bank	1.0	First time capture	Observed	Above Litter	
3	Unknown	Sub Adult	Immature	46.0	10.75	000735C27C	D6	North Bank	1.0	First time capture	Observed	Above Litter	Yellowing underbody indicative of a young male frog

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
4	Male	Adult	Light Nuptial	74.1	63	0007357455	U6	North Bank	3.5	First time capture	Observed	Partially Buried	
5	Unknown	Sub Adult	Immature	45.1	13.75	000735C206	U6	North Bank	1.5	First time capture	Observed	Above Litter	
6	Unknown	Sub Adult	Immature	41.5	9	00073546CD	U7	North Bank	4.0	First time capture	Observed	Above Litter	
7	Female	Adult	Not Gravid	117.5	190	00073587DF	U6	North Bank	4.0	First time capture	Observed	Sheltering beneath Lomandra	
8	Unknown	Sub Adult	Immature	46.2	12	00073564F9	U9	North Bank	3.0	First time capture	Observed	Above Litter	
9	Female	Adult	Not Gravid	96.0	149	000735AC9F	U9	North Bank	4.5	First time capture	Observed	Sheltering beneath Lomandra	
10	Unknown	Sub Adult	Immature	45.8	11.75	000735B72A	U8	North Bank	1.0	First time capture	Observed	On Dirt	
Summer Sample													
1	Unknown	Sub Adult	Immature	55.5	19.75	0007354559	C1	South Bank	8.0	First time capture	Observed	Above Litter	Probably a male frog. Swabbed
2	Male	Adult	No Colour	66.7	33.25	000735B6F8	D6	South Bank	7.5	First time capture	Observed	Above Litter	Swabbed
3	Unknown	Sub Adult	Immature	41.5	9.25	0007356DEB	D5	South Bank	2.3	First time capture	Observed	Above Litter	Swabbed

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
4	Unknown	Sub Adult	Immature	58.2	27.25	0007353FA9	D2	North Bank	4.1	First time capture	Observed	Above Litter	Probably a male frog. Swabbed
5	Unknown	Juvenile	Immature	36.9	7.75	000735B8C9	D5	North Bank	3.0	First time capture	Observed	Above Litter	Swabbed
6	Unknown	Juvenile	Immature	36.0	6.75	000735A09D	D5	North Bank	3.3	First time capture	Observed	Above Litter	Swabbed
7	Male	Adult	Moderate Colour	70.2	44.75	0007358B84	U1	North Bank	3.2	First time capture	Observed	On Log	Swabbed
8	Unknown	Sub Adult	Immature	45.3	12.75	000735C7EC	U3	North Bank	4.4	First time capture	Observed	Above Litter	Swabbed
9	Male	Adult	No Colour	59.6	26.5	0007357443	U5	North Bank	4.0	First time capture	Observed	Partially buried under litter	Swabbed
10	Unknown	Sub Adult	Immature	46.7	12	0007355C06	U5	North Bank	8.5	First time capture	Observed	Above Litter	Swabbed
11	Unknown	Sub Adult	Immature	56.2	23.75	000735C206	U6	North Bank	9.3	Remained in same zone and same side of creek as spring	Observed	Above Litter	Swabbed
12	Unknown	Sub Adult	Immature	49.0	15.5	000735CB5C	U7	North Bank	1.3	First time capture	Observed	On Gravel	Swabbed

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
13	Male	Adult	Moderate Colour	64.6	39.0	000735C3ED	U8	North Bank	6.2	First time capture	Observed	Above Litter	
14	Unknown	Sub Adult	Immature	43.9	12.0	0007357690	U8	North Bank	2.3	First time capture	Observed	Above Litter	
15	Unknown	Sub Adult	Immature	55.4	18.75	00073564F9	U9	North Bank	3.8	Remained in same zone and same side of creek as spring	Observed	Above Litter	
16	Female	Adult	Gravid	98.7	165.0	00073542D7	U9	South Bank	7.5	First time capture	Observed	Above Litter	
Pipers Creek													
Spring Sample													
1	Unknown	Sub Adult	Immature	48.2	16.0	000735C107	4	South bank	3.9	First time capture	Observed	Above litter	
2	Unknown	Sub Adult	Immature	56.0	21.5	000735B231	4	North Bank	2.7	First time capture	Observed	Above litter	
3	Unknown	Sub Adult	Immature	53.5	19.0	0007356DF2	4	North Bank	2.9	First time capture	Observed	Above litter	
4	Male	Adult	Dark Nuptials	83.9	86.0	000735BFCC	18	South bank	5.8	First time capture	Observed	Above litter	

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
5	Male	Adult	Light Nuptials	81.0	82.5	000735BCBE	18	South bank	7.3	First time capture	Observed	Above litter	
6	Male	Adult	No Colour	66.0	36.5	0007353695	18	South bank	8.4	First time capture	Observed	Above litter	Some yellowing spots not recorded at other locations. This frog deemed very light very its size and possible unhealthy or feeling the effects of a long dry spring
7	Male	Adult	Moderate Nuptials	75.6	56.0	0007358A4C	17	South bank	5.2	First time capture	Observed	Above litter	Some yellowing spots not recorded at other locations
8	Female	Adult	Not Gravid	66.6	41.0	0007358DDC	17	South bank	6.2	First time capture	Observed	Above litter	Some yellowing spots not recorded at other locations
Summer Sample													
1	Female	Adult	Not Gravid	63.8	31.0	000735B231	4	North Bank	5.0	Remained in same zone and same side of creek but 2.3 m further from water	Observed	Partially buried under litter	Swabbed
2	Unknown	Sub Adult	Immature	58.9	28.0	000735C107	4	Centre Island	2.7	Remained in same zone and same side of creek	Observed	Above litter	Swabbed

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
3	Female	Adult	Not Gravid	64.1	38.0	0007356DF2	4	North Bank	5.0	Remained in same zone and same side of creek	Observed	Above litter	Swabbed
4	Male	Adult	Moderate Nuptials	63.6	32.0	000735BA08	10	North Bank	2.3	First time capture	Observed	Above Litter	Swabbed
5	Unknown	Sub Adult	Immature	53.0	18.0	00073585C3	12	South Bank	2.1	First time capture	Observed	On Bare Ground	Swabbed
6	Female	Adult	Gravid	99.9	181.0	0007354BC4	13	North Bank	1.0	First time capture	Observed	Above Litter	Swabbed
7	Female	Adult	Gravid	94.3	132.0	0007359B0F	15	South Bank	6.0	First time capture	Observed	Above Litter	Swabbed
8	Female	Adult	Not Gravid	78.8	64.0	0007358DDC	17	South Bank	2.3	Same zone and side of creek but closer to water	Observed	Partially buried under litter	Swabbed
Maria River													
Spring													
1	Unknown	Sub Adult	Immature	49.2	19.75	00073531A8	U9	North Bank	3.5	First time capture	Observed	Above Litter	
2	Female	Adult	Not Gravid	96.6	145	000735B70C	U1	North Bank	3	First time	Observed	Above Litter	

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
										capture			
3	Female	Adult (young)	Not Gravid	77.8	67.5	00073579A3	U1	North Bank	3.2	First time capture	Observed	Using Undercut of Bank	
4	Sub Adult	Sub Adult	Immature	57.8	28.5	0007357806	U1	North Bank	3.7	First time capture	Observed	Sheltering beneath lantana	Predict this will be a male frog once it matures
5	Female	Adult	Not Gravid	99.2	148	0007357A85	U1	South Bank	2.6	First time capture	Observed	Part Buried Under Litter	
6	Female	Adult	Not Gravid	85.6	83	000735974B	D8	South Bank	7.8	First time capture	Observed	Above Litter	
7	Male	Sub Adult	No Colour	59.9	30	0007356F68	D6	North Bank	2.4	First time capture	Observed	Above Litter	
8	Female	Adult	Not Gravid	90.4	103	000735BEBE	D5	North Bank	13.3	First time capture	Observed	Above Litter	
9	Male	Sub Adult	No Colour	59.9	27	00073531B0	D5	South Bank	1.8	First time capture	Observed	Under Vines	
10	Female	Adult	Not Gravid	99.8	147	000735508E	D4	South Bank	1.9	First time capture	Observed	Above Litter	
Summer													
1	Male	Adult	Light Nuptials	64.6	38.0	000735B2F4	U1	North Bank	2.0	First time capture	Observed	Above Litter	Swabbed

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
2	Unknown	Juvenile	Immature	38.2	8.5	000735BE05	U1	North Bank	0.8	First time capture	Observed	Above Litter	Swabbed
3	Unknown	Sub Adult	Immature	49.4	13.0	0007359976	U1	North bank	1.5	First time capture	Observed	Above Litter	Swabbed
4	Male	Adult	No data	No data	No data	No data	D3	No data	No data	No data	Calling	Under Litter	Could not be captured
5	Female	Adult	Not Gravid	94.4	158.0	000735D09C	U2	South Bank	3.0	First time capture	Observed	On Dirt	Swabbed
6	Unknown	Juvenile	Immature	37.4	11.0	000735AEE9	U8	North Bank	0.3	First time capture	Observed	On dirt using hole in bank	Swabbed
7	Male	Adult	Light Nuptials	75.8	70.0	000735B020	U9	North Bank	3.0	First time capture	Observed	Part buried under litter	Swabbed
8	Unknown	Juvenile	Immature	No data	No data	No data	D8	North Bank	No Data	No Data	Observed	Above Litter	Could not be captured
9	Unknown	Juvenile	Immature	No data	No data	No data	D8	South Bank	No Data	No Data	Observed	Above Litter	Could not be captured
Reference Sites													
Cooperabung Creek													
Spring													
1	Male	Adult	Dark Nuptial	70.8	50.5	000735C3DB	15	North Bank	3.1	First time capture	Call response	Above Litter	

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
2	Male	Adult	Light Nuptial	74.4	64	0007359C3A	15	North Bank	4.1	First time capture	Observed	Above Litter	
3	Male	Adult	Light Nuptial	71.9	63.5	00073588FF	14	North Bank	1.9	First time capture	Observed	Above Litter	
4	Unknown	Sub Adult	Immature	50.3	21.5	0007356F32	14	North Bank	2.1	First time capture	Observed	Above Litter	
5	Female	Adult	Not Gravid	110.6	142.5	00073576C7	13	North Bank	8.5	First time capture	Observed	Above Litter	
6	Unknown	Sub Adult	Immature	44.9	13.5	00073599EE	11	South bank	2.6	First time capture	Observed	On Pasture Grass	
7	Male	Adult	Moderate Nuptial	71.2	61.5	000735A504	10	South bank	1.2	First time capture	Call response	Above Litter	
8	Female	Adult	Not Gravid	97.0	132.5	000735613C	9	North Bank	2.8	First time capture	Observed	Above Litter	
9	Female	Adult	Not Gravid	96.6	141	0007359F76	5	South bank	1.3	First time capture	Observed	Above Litter	
10	Female	Adult	Not Gravid	97.7	124	00073546F4	9	South bank	7.2	First time capture	Observed	On Pasture Grass	
11	Female	Adult	Not Gravid	94.0	132	0007353E49	17	North Bank	5.9	First time capture	Observed	Above Litter	
12	Unknown	Sub Adult	Immature	54.9	25.5	0007359659	17	North Bank	0.9	First time	Observed	Above Litter	

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
										capture			
13	Female	Adult	Part Gravid	97.2	147	00073530F3	18	North Bank	3.3	First time capture	Observed	Above Litter	
14	Male	Sub Adult	Immature	57.9	28.5	0007359D56	20	South bank	3.1	First time capture	Observed	Above Litter	Yellow underbody indicating probably a young sub adult male
15	Female	Adult	Part Gravid	98.0	172	000735ADC9	20	South bank	2.4	First time capture	Observed	Above Litter	
16	Male	Sub Adult	Immature	58.3	28.5	0007353F6E	22	North Bank	5.7	First time capture	Observed	Above Litter	
17	Male	Sub Adult	Immature	53.7	22.5	0007358D13	19	South bank	3.2	First time capture	Observed	Above Litter	Yellow underbody indicating probably a young sub adult male
Summer													
1	Unknown	Sub adult	Immature	44.9	13.5	0007357B14	16	South Bank	0.5	First time capture	Observed	Above Litter using Lomandra shelter Site	Swabbed
2	Female	Adult	Not Gravid	91.7	130.0	0007359D67	15	North Bank	1.0	First time capture	Observed	Partially Buried Under Litter	Swabbed
3	Unknown	Juvenile	Immature	40.1	10.0	0007357BBC	15	North Bank	0.3	First time capture	Observed	Above Litter	Swabbed
4	Male	Adult	Light Nuptials	73.6	61.0	000735C59A	15	South Bank	0.7	First time capture	Observed	On Dirt	Swabbed

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
5	Male	Adult	Light Nuptials	75.5	62.0	0007359C3A	15	South Bank	1.1	Same zone but changed side of creek and closer to water	Observed	On Rock	Swabbed
6	Unknown	Sub adult	Immature	45.0	13.5	0007352C3A	14	North Bank	0	First time capture	Observed	Above Litter at Waters Edge	Swabbed
7	Unknown	Sub adult	Immature	45.0	14.0	0007359E7B	11	North Bank	0.3	First time capture	Observed	Using Bank Undercut	
8	Unknown	Sub adult	Immature	45.6	14.5	000735A74D	8	North Bank	2.6	First time capture	Observed	On Grass	
9	Unknown	Juvenile	Immature	37.3	9.0	000735A4D1	8	North Bank	2.9	First time capture	Observed	On Grass	
10	Female	Adult	Not Gravid	95.7	123.0	0007359F76	7	South Bank	4.2	Moved 2 zones upstream	Observed	On Grass	Swabbed
11	Male	Adult	Dark Nuptials	74.1	57.5	00073535CD	7	South Bank	3.6	First time capture	Observed	On Grass	Swabbed
12	Unknown	Sub Adult	Immature	48.5	17.0	0007359D2A	5	South Bank	1.4	First time capture	Observed	Above Litter	
13	Female	Adult	Not Gravid	78.7	68.0	00073563EA	3	South Bank	1.4	First time capture	Observed	Partially Buried Under Litter	Swabbed

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
14	Male	Adult	Moderate Nuptials	65.9	40.25	000735B0E5	3	North Bank	5.0	First time capture	Observed	On Grass	Swabbed
15	Female	Adult	Not Gravid	68.7	38.75	000735C733	3	South Bank	0.8	First time capture	Observed	Using Bank Undercut	
16	Unknown	Sub Adult	Immature	47.5	18.0	000735C584	15	South Bank	1.9	First time capture	Observed	Above Litter	
17	Unknown	Sub Adult	Immature	41.7	12.5	000735BD28	17	South Bank	1.2	First time capture	Observed	On Grass	
18	Unknown	Juvenile	Immature	39.7	10.0	000735B42E	19	North Bank	2.7	First time capture	Observed	Above Litter	
19	Unknown	Sub Adult	Immature	43.5	13.0	000735A858	19	North Bank	3.0	First time capture	Observed	Above Litter	
20	Unknown	Juvenile	Immature	39.5	11.25	0007354212	22	North Bank	2.4	First time capture	Observed	Above Litter	
21	Unknown	Sub Adult	Immature	40.6	11.25	000735546E	22	South Bank	0.7	First time capture	Observed	Above Litter	
Pipers Creek (Boonie Corner Road)													
Spring													
1	Female	Adult	Not Gravid	93	130	000735AE22	16	North bank	1.1	First time	Observed	Partially buried	

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
										capture		under litter @ 1910 hrs	
2	male	Adult	Medium Nuptials	77.8	60	0007359C08	16	North bank	1.4	First time capture	Observed	Partially buried under litter/moss	
3	male	Adult	Light Nuptials	67.6	39	0007359F7C	19	North bank	2	First time capture	Observed	Shelter beneath Lomandra fronds	
4	Unknown	Sub Adult	Immature	44	13.5	0007352736	9	North bank	2.1	First time capture	Observed	Partially buried under litter	Yellowing underbody indicative of a young male
5	Female	Adult	Not Gravid	89.2	98	0007358076	7	North bank	3.3	First time capture	Observed	Above litter	Missing right hand - photographed
6	male	Adult	Dark Nuptials	77.8	68	0007355C05	7	North bank	1.1	First time capture	Observed	Under litter	Just eye of frog protruding
7	Female	Adult	Not Gravid	97.6	148	0007355ED1	7	Southbank	2.1	First time capture	Observed	Partially buried under litter	
8	male	Adult	Dark Nuptials	78.1	57	00073581E2	6	Southbank	0.9	First time capture	Observed	Above litter	
9	Female	Adult	Not Gravid	113.1	153	0007354E33	5	Southbank	2.1	First time capture	Observed	Above litter	
10	Female	Adult	Not Gravid	91.2	117	00073525A5	7	North bank	1.1	First time capture	Observed	Partially buried under litter and Lomandra	

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
Summer													
1	Male	Adult	Dark Nuptials	64.9	37.0	000735C44D	7	South Bank	4.0	First time capture	Observed	Partially Buried Under Litter	Swabbed
2	Male	Adult	Moderate Nuptials	72.8	57.0	0007355572	6	North Bank	2.5	First time capture	Observed	Partially Buried Under Litter	Swabbed
3	Female	Adult	Not Gravid	61.7	27.0	0007352335	6	South Bank	0.5	First time capture	Observed	Above Litter	Swabbed
4	Female	Adult	Not Gravid	66.1	41.0	00073593EC	6	South Bank	4.0	First time capture	Observed	Above Litter	Swabbed
5	Male	Adult	Moderate Nuptials	76.1	74.0	00073555B9	8	North Bank	1.5	First time capture	Observed	Partially Buried Under Litter	Swabbed
6	Male	Adult	Moderate Nuptials	74.1	55.0	0007357086	9	North Bank	2.0	First time capture	Observed	Partially Buried Under Litter	Swabbed
7	Female	Adult	Gravid	98.6	178.0	00073573F1	10	North Bank	1.5	First time capture	Observed	Using hole in bank	Swabbed
8	Male	Adult	Moderate Nuptials	76.0	68.0	00073529AE	13	South Bank	1.0	First time capture	Observed	Partially Buried Under Litter	Swabbed
9	Male	Adult	Dark Nuptials	73.7	52.0	000735CA5F	15	South Bank	2.5	First time capture	Observed	Above Litter	Swabbed
10	Female	Adult	Gravid	96.0	165.0	0007356674	19	South Bank	3.6	First time capture	Observed	Above Litter	Swabbed

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
11	Female	Adult	Gravid	94.6	141.0	0007356F20	19	South Bank	5.0	First time capture	Observed	Above Litter	Swabbed
12	Male	Adult	No Data	No Data	No Data	No Data	6	No Data	No Data	No Data	Call Response	No Data	Frog could not be captured
13	Male	Adult	No Data	No Data	No Data	No Data	18	No Data	No Data	No Data	Call Response	No Data	Frog could not be captured

Table 18 Results of the chytrid testing

Date	Species	Animal number	Location	Sex	Rep 1	Rep 2	Rep 3	Mean calculated concentration	Chytrid Outcome Based on Newcastle University - James Garnham
26/01/2014	*Mixophyes iteratus*	0735830E	Cooperabung Creek	Female	0	0	0	0	No
26/01/2014	*Mixophyes iteratus*	07359E3E	Cooperabung Creek	Juvenile	0	0	0	0	No
26/01/2014	*Mixophyes iteratus*	07359A50	Cooperabung Creek	Male	0	0	0	0	No
26/01/2014	*Mixophyes iteratus*	07352F47	Cooperabung Creek	Male	0	0	0	0	No
26/01/2014	*Mixophyes iteratus*	07358413	Cooperabung Creek	Male	0	0	0	0	No
26/01/2014	*Mixophyes iteratus*	07359026	Cooperabung Creek	Male	0	0	0	0	No
26/01/2014	*Mixophyes iteratus*	07352816	Cooperabung Creek	Male	0	0	0	0	No
26/01/2014	*Mixophyes iteratus*	07357F41	Cooperabung Creek	Juvenile	0	0	0	0	No
26/01/2014	*Mixophyes iteratus*	0735B812	Cooperabung Creek	Juvenile	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	07356F20	Pipers Creek Reference/Control	Female	0	0	0	0	No

27/01/2014	*Mixophyes iteratus*	073593EC	Pipers Creek Reference/Control	Female	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	07356674	Pipers Creek Reference/Control	Female	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	073573F1	Pipers Creek Reference/Control	Female	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	073529AE	Pipers Creek Reference/Control	Male	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	07357086	Pipers Creek Reference/Control	Male	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	0735CA5F	Pipers Creek Reference/Control	Male	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	07355572	Pipers Creek Reference/Control	Male	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	073555B9	Pipers Creek Reference/Control	Male	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	07352335	Pipers Creek Reference/Control	Female	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	07359B0F	Pipers Creek	Female	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	0736DF2	Pipers Creek	Female	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	07358DDC	Pipers Creek	Female	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	0735B231	Pipers Creek	Female	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	07354BC4	Pipers Creek	Female	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	0735BA08	Pipers Creek	Male	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	073585C3	Pipers Creek	Sub Adult	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	0735C107	Pipers Creek	Sub Adult	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	07356DEB	Smiths Creek	Juvenile	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	0735A09D	Smiths Creek	Juvenile	0	0	0	0	No

28/01/2014	*Mixophyes iteratus*	0735B8C9	Smiths Creek	Juvenile	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	07358B84	Smiths Creek	Male	1.866	0	0.9	0	Yes
28/01/2014	*Mixophyes iteratus*	07353FA9	Smiths Creek	Male	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	0735C7EC	Smiths Creek	Sub Adult	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	0735CB5C	Smiths Creek	Sub Adult	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	07355C06	Smiths Creek	Sub Adult	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	0735C206	Smiths Creek	Sub Adult	0.052	0	0	0	Yes
28/01/2014	*Mixophyes iteratus*	07354559	Smiths Creek	Sub Adult	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	07357443	Smiths Creek	Male	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	0735B6F8	Smiths Creek	Male	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	0735C44D	Pipers Creek Reference/Control	Male	0	0	0	0	No
30/01/2014	*Mixophyes iteratus*	073563EA	Cooperabung Creek Reference/Control	Female	0	0	0	0	No
30/01/2014	*Mixophyes iteratus*	07359D67	Cooperabung Creek Reference/Control	Female	0	0	0	0	No
30/01/2014	*Mixophyes iteratus*	07359F76	Cooperabung Creek Reference/Control	Female	0	0	0	0	No
30/01/2014	*Mixophyes iteratus*	07357BBC	Cooperabung Creek Reference/Control	Juvenile	0	0	0	0	No
30/01/2014	*Mixophyes iteratus*	07359C3A	Cooperabung Creek Reference/Control	Male	0	0	0	0	No
30/01/2014	*Mixophyes iteratus*	0735535CD	Cooperabung Creek Reference/Control	Male	0	0	0	0	No
30/01/2014	*Mixophyes iteratus*	0735B0E5	Cooperabung Creek Reference/Control	Male	5.029	10.689	6.455	7.027	Yes
30/01/2014	*Mixophyes iteratus*	07357B14	Cooperabung Creek Reference/Control	Sub Adult	0	0	0	0	No

30/01/2014	*Mixophyes iteratus*	07352C3A	Cooperabung Creek Reference/Control	Sub Adult	0	0	0	0	No
30/01/2014	*Mixophyes iteratus*	0735C59A	Cooperabung Creek Reference/Control	Male	0	0	0	0	No
31/01/2014	*Mixophyes iteratus*	0735D09C	Maria River	Female	0	0	0	0	No
31/01/2014	*Mixophyes iteratus*	0735AEE9	Maria River	Juvenile	0	0	0	0	No
31/01/2014	*Mixophyes iteratus*	0735BE05	Maria River	Juvenile	0	0	0	0	No
31/01/2014	*Mixophyes iteratus*	0735B2F4	Maria River	Male	0	0	0	0	No
31/01/2014	*Mixophyes iteratus*	0735B020	Maria River	Male	0	0	0	0	No
31/01/2014	*Mixophyes iteratus*	07359976	Maria River	Sub Adult	0	0	0	0	No

Appendix B

CV of Suitably Qualified Expert

Name	Ben Dean Lewis
DOB	13th July 1975
Business Registration Details	Lewis Ecological Surveys U9629936
ABN/ACN	ABN: 84 166 970 378 ACN: 166 970 378
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Qualifications (summary)	Higher School Certificate (1992) Bachelor of Applied Science (Honours) 1994-1997
Summary	Ben Lewis is a senior ecologist with more than 17 years full time professional experience in the fields of ecology and natural resource management. He has considerable experience assisting developing outcomes to meet project specific Conditions of Approval in relation to managing and monitoring impacts on biodiversity for large scale infrastructure projects. This includes extensive experience in the design and implementation of threatened species survey and monitoring programs, management plans and construction strategies. Key examples include: • Design and implementation of the Kempsey Bypass Ecological Monitoring Program (2010-2013); • Design of the Frederickton to Eungai Ecological Monitoring Program and early works Project ecologist for the RMS (2011-2014) • Design and implementation of the Tugun Bypass Integrated Long-nosed Potoroo Plan of Management (2003-2015) • Biodiversity benchmarking surveys for mammals across the Murrumbidgee Irrigation Area (2004-2005) • Development of several nest box plans of management for the Pacific Highway Upgrades • Design and early works procedures for micro bat management plans for the removal of bridges and culverts on several highway upgrades • Developing BACI design monitoring systems for both state and nationally listed threatened species on sections of the Pacific Highway Upgrades • Biodiversity Offsetting Strategies for several highway projects. Ben has performed hundreds of surveys over the past 17 years with many tens of these targeting commonwealth listed species including but not limited to the Giant Barred Frog, Koala and Spotted-tailed Quoll. Whilst his research back ground is in the fields of frogs and avifauna he has performed numerous surveys on other vertebrates and considered to have a broad area of expertise on terrestrial vertebrate fauna. In this capacity, he has attended several recovery planning workshops, been involved in predicted habitat monitoring programs for the EPA and been appointed by the judicial system as a court appointed expert on occasions. A chronological project list has been provided to demonstrate this experience.
Relevant Qualifications	Class C Drivers License (No: 07503313) Category AB Shooters License (No: 404682597) Unrestricted Boat License Open Water Scuba Certificate (PADI) Rail Safety Awareness (NSW) QLD Generic Coal Surface Induction Anglo Coal Callide Induction Collinsville Contractor Induction & Driver Competency Valid Coal Board Medical Rio Tinto Contractor Induction (TCC0002432) Consolidated Rutile Limited Contractor Induction Chainsaw Operators Ticket (C10260) Working at Heights Training (5497)
Consulting Skills	• Undertaken extensive surveys (>300) for vertebrate fauna throughout temperate, arid and sub tropical eastern Australia. • Conducted specialist surveys for many species listed on NSW TSC Act (1995), Queensland NCR (2006), EPBC Act (1999) and ICUN. • Expertise in fauna identification, research and survey design. • Work as both team member and leader during field surveys. • Reporting at senior and junior levels for consulting and scientific publications. • Fully licensed and insured to industry standards. • Own all survey equipment and experienced in the use of specialist techniques including mist netting, radio telemetry and electro fishing.
Relevant Employment History	• Demonstrator for Resource Assessment Techniques II and Biology at Southern Cross University 1997-1999 • Technical position (casual) with Australian Museum specialising in frogs 2001-2003

Name Consulting History as the principal or sub consultant	Ben Dean Lewis
2014	• Development of the BACI survey design program and implementation of baseline surveys for the Wallum Sedge Frog for the Woolgoolga to Ballina Pacific Highway Upgrade Project. • Development of the BACI survey design program and implementation of baseline surveys for the Giant Barred Frog for the Woolgoolga to Ballina Pacific Highway Upgrade Project. • Development of the BACI survey design program and implementation of baseline monitoring surveys for the Brush-tailed Phascogale on the Woolgoolga to Ballina Pacific highway Upgrade. • Development of the BACI survey design program and implementation of baseline monitoring surveys for the Rufous Bettong on the Woolgoolga to Ballina Pacific highway Upgrade. • Implementation of seasonal survey requirements for the Oxley Highway to Kempsey Pacific Highway Upgrade Ecological monitoring Program. • Implementation of Year 5 Long-nosed Potoroo long term monitoring program for the tugun Bypass Project in accordance with commonwealth approval conditions.
2013	• Targeted weed surveys and critique of rehabilitation works for the Abigroup Macleay Floodplain Bridge project: January • Green-thighed Frog monitoring program for Kempsey Bypass Alliance: January and March. • Technical review of the Warrell Creek to Urunga Biodiversity Offsets Strategy and development of habitat quality mapping for the dry sclerophyll forest communities into the offsets ratio for RMS. • Targeted surveys for the Giant Barred Frog for the Nambucca Heads to Urunga Pacific Highway Upgrade. • Targeted threatened frog surveys for the Woolgoolga to Glenugie Pacific Highway Upgrade program. • Advice on fauna fence design for the Woolgoolga to Glenugie Upgrade. • Common Blossom Bat Monitoring and radio telemetry surveys to determine day roost use at Koala Beach Estate. • Long-nosed Potoroo Plan of Management – Implementation of Year 4 program of works. • Glossy Black Cockatoo baseline monitoring surveys for the Frederickton to Eungai Pacific Highway Upgrade program. • Nest box monitoring program for Kempsey Bypass Alliance. • Baseline Spotted-tailed Quoll surveys for the Oxley Highway to Kempsey Upgrade. • Design and implementation of the spring baseline survey program for Oxley Highway to Kempsey: Yellow-bellied Glider, Giant Barred Frog, Koala and road kill surveys. • Pre-construction Giant Barred Frog surveys for the Warrell Creek to Nambucca Heads Upgrade. • Ecological services including pre-clearing surveys, fauna rescue and baseline ecological monitoring for the North West Rail Link project on behalf of Australian Museum Consulting. • Project ecologist services for the Frederickton to Eungai Upgrade for Thiess Pty Ltd. • Biodiversity offsetting strategy works for the Kempsey to Eungai Project – Flora and fauna surveys of the Latham and McCallister Land Parcels.
2012	• Systematic terrestrial vertebrate fauna surveys of the Atlas Deposit in south western NSW: January • Continuation of the Project Ecologist position for the Kempsey Bypass project centred around small scale ecological assessments, clearing supervision, dewatering strategies, threatened species surveys and implementation of biodiversity mitigation tools including fauna underpasses, fauna fencing, plantings and glider crossings: January-December • Implementation of the Kempsey Bypass Ecological Monitoring Program: Nest Box Monitoring, Green-thighed Frog breeding pond surveys: January-December • Nest box plan of management for Warrell Creek to Urunga Pacific Highway Upgrade: January-June • Micro bat management strategy for the Warrell Creek to Urunga Pacific Highway Upgrade: January-July • Giant Barred Frog (*Mixophyes iteratus*) management strategy for Warrell Creek to Urunga Pacific Highway Upgrade: January-July. • Green-thighed Frog (*Litoria brevipalmata*) management strategy for Warrell Creek to Urunga Pacific Highway Upgrade: January-July. • Target surveys for threatened raptor nests for Warrell Creek to Urunga Pacific Highway Upgrade: January-April • Preparation of the Ecological Monitoring Program for the Frederickton to Eungai Pacific Highway Upgrade: March • Preparation of the nest box plan for the Frederickton to Eungai Pacific Highway Upgrade: February-April • Target surveys for the vulnerable wetland plant *Maundia triglochinodes* on the Kempsey Bypass project: May • Target surveys for the vulnerable wetland plant *Maundia triglochinodes* on the Frederickton to Eungai Pacific Highway Upgrade: February-August • Biodiversity offsets package – compensatory land assessment of the following properties: Yerbury and Ainsworth: February-November • Implementation of the Long-nosed Potoroo Plan of Management for the Tugun Bypass Project: January-December • Biodiversity offsets package – compensatory land assessment of the following properties: Blair and Whalen: July-August • Bat box installation for the Nambucca Heads to Urunga Pacific Highway Upgrade. • Development of management strategies and plans of management for the Oxley Highway to Kempsey Pacific Highway Upgrade: Nest Box Plan of Management, Giant Barred Frog Management Strategy, Green-thighed Frog Management Strategy and Microbat Management Strategy: July-December. • Targeted glider surveys and advice on habitat connectivity for proposed widen median in Cairncross State Forest. • Targeted bird surveys for the Moreton Bay Rail Link Project: November.

Name	Ben Dean Lewis
2011	• Systematic terrestrial vertebrate fauna surveys of the Campaspe Deposit in south western NSW. • Field validation of endangered ecological communities and targeted surveys for threatened fauna and flora for the Frederickton to Eungai Pacific Highway Upgrade. • Compensatory assessment for offsetting the ecological impacts of the Kempsey to Eungai Pacific Highway Upgrade: Yerbury Property. • Continuing role as Project Ecologist for the Kempsey Bypass Project. • Flora and fauna assessment for proposed Abi Group site compound options adjacent Old Station Road, Verges Creek. • Expert advice in the NSW Land and Environment Court regarding Wallum Froglet and the likelihood of impacts arising from a bentonite spill at Thrumster Wetland. • Expert advice on de-watering and relocation strategies for the endangered Giant Barred Frog on the Sapphire to Woolgoolga Pacific Highway Upgrade. • Ecological constraints for proposed service centre at 556 Pacific Highway, South Kempsey. • Field validation of endangered ecological communities and targeted searches for threatened species for geotechnical works as part of the Frederickton to Eungai Pacific Highway Upgrade • Compensatory assessment for offsetting the ecological impacts of the Kempsey to Eungai Pacific Highway Upgrade: Griffin property • Compensatory assessment for offsetting the ecological impacts of the Kempsey to Eungai Pacific Highway Upgrade: Lallemand property • Implementation of the ecological monitoring program for the Kempsey Bypass Project: Glossy Black Cockatoo and Brush-tailed Phascogale monitoring.
2010	• Fauna assessment for proposed 11kv line maintenance at North Narrabeen: January. • Project ecologist for the Kempsey Bypass project performing: o Nest box plans of management and implementation; o Targeted surveys for rare flora and fauna; o Noxious weed surveys; o Design and advice on fauna underpasses, fauna fencing, frog fencing; o Design and advice on Green-thighed Frog breeding ponds; o Design and implementation of ecological monitoring program; o Numerous ecological assessments associated with flood mitigation works; o Compensatory land assessment as part of the Biodiversity offset Package for the Kempsey to Eungai project; and o Clearing supervision involving capture, relocation of terrestrial and aquatic fauna: March 2010- January 2011. • Flora and fauna assessment for proposed Kirkwood Road at part of Tweed Heads Traffic Master Plan: May. • Blossom bat monitoring program at Koala Beach: July. • Ecological assessment and pre clearing surveys for Nirvana Way fence line: August & November. • Coolumboola to Wandoan Sub Station Powerline EIS: November.
2009	• Constraints and opportunities surveys and habitat mapping for the Abbott Point State Development Area near Bowen: January 2009 • Conservation assessment and advice on the flora and fauna values at Collinsville Mine Project: February • Targeted fauna survey as part of a proposed 25 km gas pipeline near Wandoan: February • Fauna surveys for proposed water pipeline from Miles to Wandoan: February • Biological flora, fauna and aquatic ecology monitoring with performance indices for the Spring Gully Coal Seam Gas Project Area for Origin Pty Ltd and advice on Squatter Pigeon: March-April • Biological monitoring of the Coleambally Irrigation Area in Riverina area of NSW: May & November • Pre-clearing surveys, delineation of fauna mitigation devices and associated clearing supervision for a transmission line at Tomago: June-July • Nest-box plan for the Oxley Highway Upgrade project: August-October. • Square-tailed Kite nest site selection survey for Oxley Highway Upgrade project: August-November.
2008	• Woolooga to Cooroy Transmission Line EIS: Target surveys for rare and threatened fauna: March and May. • Targeted pre-clearing surveys for threatened fauna associated with the Oxley Highway Upgrade between Pacific Highway and Wrights Road: March-July • Vertebrate fauna survey as part of proposed mining activities at Wandoan: March-April • Water for Bowen Pipeline Route Survey and benefited areas: April • Targeted fauna survey to assess impacts on the Mardi Dam to Mangrove proposed pipeline route: April-May • Long-nosed Potoroo workshop to improve habitat predication modelling for DECC: May. • Targeted surveys for threatened fauna for proposed re routing of a 11 KVA power line easement along Wyee Road: June • Targeted surveys for threatened fauna for proposed upgrading of transmission lines between Woodberry and Tomago: July • Targeted surveys for matters of national significance as part of the Kunioon Mine Project: July • Vertebrate fauna survey for proposed water pipeline between Spring Gully and the Wandoan Coal Project: August • Vertebrate fauna survey for proposed water pipeline between Condamine Power Station and the Wandoan Coal Project: August • Vertebrate fauna survey for the proposed eastern gas pipeline near Wandoan: August • Targeted surveys for the Black-breasted Button Quail near Gympie and Cooroy: September • Targeted surveys for Wallum Frogs and Coastal Planigale at six candidature sites in north–east NSW: October-December

Name	Ben Dean Lewis
	• Site selection for compensatory habitat package associated with upgrading of transmission lines and associated infrastructure at Tomago: October
2007	• Target surveys for rare and threatened fauna along the proposed conveyor route for the Tarong Transport Alliance: January & February • Development of an Integrated Plan of Management for Long-nosed Potoroo as part of the Tugun Bypass and Boyd Street Overpass Approvals Process: February • Review and advice on Oxbow Fauna Monitoring Program at Brisbane: February. • Fauna surveys for the proposed re-routing of the Pacific Highway at Banora Point: February-March. • Target surveys, delineation of important life cycle resources and mapping for the Yellow-bellied Glider along the proposed Kempsey to Eungai Pacific Highway Upgrade: March. • Target surveys for Five-clawed Worm Skink and Grassland earless Dragon for proposed fuel source route in the New Acland area: April-May. • Site assessment for proposed conveyor re-alignment between Meandu Creek and Tarong Power Station: May • Clarification of threatened species issues for a proposed retirement village at St Georges Basin: May. • Surveys as part of the DECC Bio-banking Pilot Study at Ballina and Pillar Valley: June. • Common Blossom Bat monitoring at Koala Beach: July • Habitat mapping and target surveys for the Coopernook to Herons Creek Pacific Highway Upgrade: July & August • Assessment of Wallum Froglet habitat and the potential impacts of dewatering strategies for the Tugun Bypass Project: August • Fauna survey for the proposed Port Macquarie Airport Runway Upgrade: August. • Ecological assessments for additional parcels of land associated with the Coopernook to Herons Creek Pacific Highway Upgrade: September-November • Fauna survey of proposed coal mine near Wandoan in Queensland Brigalow Belt: October. • Fauna surveys as part of route selection and design strategies for the proposed Water for Bowen project (130 km pipeline): October. • Clearing supervision and habitat critiquing as part of the Coopernook to Herons Creek Pacific Highway Upgrade. • Assessment of candidature sites identified as suitable compensatory habitat for Coastal Planigale and Wallum Sedge Frog: November. • Fauna surveys of lands identified as compensatory habitat for proposed mine activities in the Callide Range of central Queensland: November-December. • Target surveys for the Southern Bell Frog in the Lower Murray-Darling CMA December-January.
2006	• Targeted frog survey for Pacific Highway Upgrade Between Sapphire and Arrawarra: January. • Targeted frog survey for Pacific Highway Upgrade Between Iluka Road and Woodburn: February. • Proposed two lot sub-division of rural lands located at Lot 5 Manning Hill Road, Bunyah: February-March. • Fauna survey for the Glen Wilga Project at Chinchilla: March. • Fauna survey on selected lands identified for compensatory habitat as part of the Oxley Highway Upgrade Project: March-August. • Independent investigations of the Woodburn to Ballina Proposed Pacific Highway Upgrade study area: August • Pre-clearing surveys for Geo-technical Investigations for proposed upgrade of Pacific Highway between Moorland and Herons Creek: August-September. • Fauna survey and assessment of lands for proposed retirement village at St Georges Basin: September. • Target surveys for the Green-thighed Frog in the Bulahdelah region on NSW mid north coast, September. • Fauna survey of proposed Kunioon MDL and associated conveyor transport corridor near Kingaroy: September-October. • Fauna survey for proposed rail route between New Acland Coal Mine and Tarong Power Station: October-November. • Target surveys and assessment of local landscape for the Black-breasted Button Quail and Collared Delma lizard on the Kunioon MDL: December • Target surveys for Green and Golden Bell Frog on the Cronulla Rail Line Duplication Project: December.
2005	• Continuation of Species Impact Statement surveys for proposed Pacific Highway Upgrade: Kempsey-Eungai: January-April. • Flora and fauna assessment for proposed residential dwelling at Booral: February. • Target surveys for coastal planigale for proposed Pacific Highway Upgrade at Tugun: February. • Target surveys for frogs and bats for the proposed train support facility at Thornton: March. • Review and facilitation of the wallum sedge frog (*Litoria olongburensis*) and other related wallum species national recovery plan. • Baseline mammal survey of the Murrumbidgee Irrigation Area: Autumn Surveys: March-May. • Fauna survey of lands identified for compensatory habitat at Cobaki Broadwater: June. • Targeted fauna survey for proposed resort in the Wolgan Valley: August • Fauna assessment for proposed rail infrastructure upgrading on North Coast Rail Corridor: August-October. • Court Appointed Expert to conduct surveys for Wallum Sedge Frog on selected lands at Kingscliff: August • Fauna assessment of selected crown lands at Byron Bay: October • Targeted survey for wallum frogs and coastal planigale on selected lands at Bogangar for the Tugun Bypass Project: October • Fauna survey for the Glen Wilga Project at Chinchilla: November • Design and implementation of frog and bird monitoring at Eighteen Mile Swamp, North Stradbroke Island: November

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2004	• Microchiropteran bat survey of timber bridges along Kyogle Road, Tweed Shire Council: January. • Fauna assessment for the proposed Myall Way-Pacific Highway Intersection: January. • Conservation assessment for the southern bell frog between Balranald and NSW/South Australian border: January-March. • Assessment and delineation of *Callistemon linearifolius* for the proposed re-routing of Tea Garden – Pacific highway Intersection: March. • Biodiversity benchmarking surveys of the Coleambally Irrigation Area and neighbouring Kerarbury region in SW NSW with AMBS: April-May. • Clearing supervision for the removal of senescent trees at The Lakes Way – Pacific Highway intersection: May-July. • Target surveys and detailed habitat appraisal for coastal planigale in Tugun-Cobaki Area: June. • Flora and fauna assessment of Lot 14, 259 Cape Hawke Drive, Forster: July-August. • Fauna survey & section 5a assessment of selected lands at Goolawah Estate, Dept. Lands: July-September. • Targeted fauna surveys for proposed upgrading of Weakley's Drive – New England Hwy Intersection: September. • Implement baseline mammal survey in the Murrumbidgee Irrigation Area (500,000 ha) in SW NSW: September-October. • Independent assessment of Brush-tailed Rock Wallaby and proposed mitigation measures for the Shannon Creek Dam Proposal: November. • Species Impact Statement surveys for proposed Pacific Highway Upgrade: Kempsey-Eungai: December.
2003	• Population census of the green and golden bell frog at Homebush: January • Specialist bird survey assessment for the Coolangatta Airport Extensions: January & May • Site assessment of selected lands at Nambucca South for proposed medical centre: January • Site assessment at Wyee Point for proposed residential dwelling: February • Review of green-thighed frog monitoring program and implementation of field methodology in Nerong State Forest: February • Target surveys for threatened species on selected lands at Nambucca Heads: February • Desktop assessment of fauna at Trial Bay Goal: February • Vertebrate fauna survey and vegetation mapping at South Urunga: March • Assessment of selected lands for Mid Coast Water Depot at Forster: March • Ecological studies of the long-nosed potoroo at Cobaki for the proposed Pacific Highway upgrade at Tugun: April to July • Fauna survey of selected lands at Moonee: July • Additional SIS surveys and section 5a assessment for the proposed Bulahdelah Pacific Highway Bypass Project: July-September • Ecological assessment along the proposed Kempsey-Eunagi Pacific Highway Upgrade: August – September • Red-crowned Toadlet assessment at Little Bay for University of NSW: August • Mapping of *Eucalyptus fergusonii* and *Angophora inopina* along the proposed Bulahdelah Pacific Highway Bypass Project: August • REF 'The Lakes Way – Pacific Highway Intersection' for RTA/Acacia Pty Ltd. October. • Department Lands – Flora & Fauna Assessment at Goolawah Estate November. • Route surveys for the proposed Oxley re-routing project for AMBS: November & December.
2002	• Vertebrate fauna survey for route selection of the Kempsey Pacific Highway Bypass Project (Stage 1): January • Vertebrate fauna survey for the proposed Lilli Pilli Estate near Bateman's Bay: January • Site assessment for land capability statement at Shark Park (Caringbah): January • Supplementary surveys for insectivorous bats and other rare fauna at Lot 8 Kurnell: January • Fauna assessment of second ponds creek for Rous Hill Infrastructure Project: January – February • Site assessment of selected lands at Garden Street in Warriewood: February • Target surveys for the green and golden bell frog at Lot 101 Kurnell: February • Site assessment of selected lands at Wahroonga (north Sydney): February • Target surveys for glossy black cockatoo, common blossom bat, and common planigale at Kings Beach (north-east NSW): February • Vertebrate fauna assessment of selected lands at Sanctuary Point in southern NSW: March • Site assessment of selected lands for sewerage treatment facility at Tingha on northern tablelands: June • Pre-clearing surveys for threatened species along the construction route for the Shannon Creek pipeline: June & September • Site assessment and route design for the proposed Vodaphone mobile phone tower at Karuah: July • Squirrel glider assessment of selected lands at Tuncurry recycling centre: August • Assessment of the rare ironbark (*Eucalyptus fergusonni*) and foraging resources (swamp mahogany) for the squirrel glider along the proposed Bulahdelah Pacific Highway Bypass route: September • Auditory assessment of green and golden bell frog at Homebush: September • Fauna assessment of selected lands at South Urunga: September-October • Hair tube assessment for the Kempsey-Eungai Pacific Highway Upgrade: November • Annual vegetation and habitat monitoring for the endangered eastern bristlebird in the Border Ranges National Park: November • Population census of the green and golden bell frog at Homebush: December • Vertebrate fauna survey for proposed extension of Bellwood and Palmwood Estate at Nambucca Heads: December
2001	• Target surveys for threatened species along the proposed Summerland Highway upgrade at Woodenbong for RTA/Sandpiper Ecological Surveys: January

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	• Fauna survey for land compensation at Kinghorn Point in southern NSW: January • Fauna survey for land compensation at Culburra Urban Expansion area in southern NSW: January-March • Species Impact Statement for Forest Glades Development at Suffolk Park: January-February • Bird surveys for RTA/DMR along the proposed Chinderah-Tugun Bypass (SES): February • Target surveys for the green and golden bell frog, yellow-bellied glider, threatened bats, and large forest owls at Sussex Inlet in southern NSW: March • Fauna survey for land compensation at Vincentia in southern NSW: April • Fauna survey for proposed sub-division at Longbeach (Batemans Bay): July • Habitat assessment and target survey for common blossom bat and common planigale at proposed Kings Beach residential estate, northern NSW: August • Fauna survey for proposed Guranang powerline easement on the Summerland and Pringles Way in northern NSW: August • Population monitoring of eastern bristlebird territories and vegetation monitoring in north-east NSW: September-December • Site inspection for DA (erection of fence) of SEPP 26 remnant littoral rainforest at Lennox Head: September • Site assessment of selected lands in Richmond Range National Park for a proposed underground *Telstra* cable: October • Fauna survey for proposed powerline easement at Fat Duck Lane (Woombah): October • Target surveys for owls, squirrel glider, frogs, and microchiropteran bats at Mardi and Bushells Ridge on NSW central coast: November • Vertebrate fauna survey for route selection of the Kempsey Pacific Highway Bypass Project (Stage 1): November • LES study of selected lands at south Taree: November – December • Targeted surveys for southern bell frog (*Litoria raniformis*) in the Coleambally Irrigation Area, AMBS: November – December.
2000	• Threatened species surveys along an existing power line easement at Byron Bay: January • Bird surveys for the proposed Pacific Highway Deviation: Chinderah-Tugun Bypass (SES): January • Flora/fauna survey for the proposed ring road at Port Macquarie: February • Little tern surveys for NSW NPWS in the Tweed River estuary (SES): February • Population monitoring surveys for the eastern bristlebird: NPWS – Lismore District (SES): March. • Vertebrate fauna survey for Macmin Pty Ltd at the proposed Twin Hills Silver Project at Texas (SES): April • Conduct bird surveys for RTA/DMR along the proposed Chinderah-Tugun Bypass (SES): May • Population count of comb-crested jacana in stormwater canals in the Terranora region (SES): May • Vertebrate fauna survey at the Bonville International Golf Club and surrounding habitats: June • Eight part test for proposed building site at Pacific Palms: September • Field assessment (REF) for proposed developments at Sandbar and Bushlands, Pacific Palms: October • Vertebrate fauna survey for the proposed Tasman Mine Project at Maitland: October • Fauna/Flora Survey for a proposed sub-division at Smith's Lake: October • Bird surveys for RTA/DMR along the proposed northern alignment of the Chinderah-Tugun Bypass (SES): October • Assessment of fauna habitats at Shara Boulevard, north Ocean Shores (SES): November • Surveys for threatened species including Mitchell's Land Snail along the proposed re-routing of Johnson St bypass (Byron Bay) – November 2000 - January 2001 (SES) • Fauna survey for land compensation assessment at Vincentia, southern NSW: November-December
1999	• Surveys for the eastern bristlebird in the western Border Ranges National Park for NPWS – Lismore District(SES): March • Microchiropteran bat surveys along the proposed underground power line route from Mullumbimby-Terranora: April • Research assistant for the Australian Maritime College Research Project undertaking day/night comparisons on catch rates and fish quality in nets for the Tasmanian Aquaculture and Fisheries Institute (TAFI), April-May. Results were used in establishing recreational fishery regulations in northern Tasmania. • Provide assistance in determining the habitat requirements of the eastern bristlebird in the Border Ranges National Park for NPWS – Lismore District (SES): May-June • Target surveys for the wallum froglet (*Crinia tinnula*) at the Riley's Hill rock quarry: July • Assessment on the nesting/breeding activity of the peregrine falcon at Ilarwill Rock Quarry: August • Vertebrate fauna survey for the proposed sub division/golf course at Kings Beach/Kingscliff: October • Provide assistance in determining the potential impacts (edge affects) of the Karuah to Bulahdelah Pacific Highway upgrade using bird densities (SES): November • Target surveys for threatened species along the proposed underground cable route at Bogangar: December
1998	• Threatened bat surveys and radio telemetric studies of *Mormopterus spp*., *Myotis adversus* and *Scoteanax rueppellii* in the proposed Shannon Creek inundation area (Grafton). Department of Public Works: CVWSS: January-February • Flora/fauna survey of selected lands near Wauchope: March • Pre-logging surveys for NSW State Forests targeting threatened species: March • Species Impact Statement (SIS) surveys for the giant barred frog (*Mixophyes iterates*), large-footed myotis (*Myotis adversus*), greater broad-nosed bat (*Scoteanax rueppellii*), brush-tailed rock wallaby, and black bittern in the Shannon Creek/Grafton region: March-April • Implementation of baseline vertebrate fauna survey at Nymboi-Binderay National Park for NPWS – Dorrigo District: April-May • Pre-logging surveys for NSW State Forests targeting threatened species in the Nulla Five Day State Forest: May

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	• Target surveys for black bittern and brush-tailed rock wallaby in the Shannon Creek/Grafton region: May • Pre-clearing surveys on the Timbarra Plateau. This involved intensive standard fauna surveys and pre-clearing supervision over a continuos period of four months: May-September • Pre-logging surveys for NSW State Forests in Mistake State Forest: July-August • Population counts of waterbirds in the Tweed River Estuary for NSW NPWS/SES: October • Target searches for threatened herpetofauna (*Litoria brevipalmata* & *Hoplocephalus stephensi*) along the proposed Karuah-Bulahdelah Pacific Highway upgrade: November • Conduct fish surveys (incl. electro-fisher) and aquatic habitat assessments along the proposed Karuah-Bulahdelah Pacific Highway upgrade, December
1997	• Population census on the Green and Golden Bell Frog (*Litoria aurea*) on Metal Manufacture Lands (Port Kembla), Wollongong: January-March • Vertebrate fauna survey of lands below the proposed Kangaroo Creek Dam Storage (Grafton). Department of Public Works: Clarence Valley Water Supply Scheme (CVWSS): March • Vertebrate fauna surveys of lands below the proposed Shannon Creek inundation area (Grafton). Department of Public Works: CVWSS: November • Vertebrate fauna survey of the proposed Shannon Creek inundation area (Grafton): Public Works Department (CVWSS): December
1996	• Vertebrate fauna survey at Coombabah Creek for Department of Main Roads – Queensland (Rust PPK): July • Vertebrate fauna survey at Carol Park for Queensland Department of Small Business and Tourism (Rust PPK): September.
1995	• Vertebrate fauna survey at Border Ranges National Park for NPWS (Lismore District) in 1995 (volunteer). • Volunteer for the collation of wildlife records for the NSW NPWS Wildlife Atlas in northern NSW, 1995 onwards.
Current Projects	• Kempsey Bypass Project Ecologist • Long-nosed Potoroo Plan of Management Implementation
Additional Field Experience	• Field assistant (1996) for invertebrate surveys in the Richmond River estuary. The survey formed part of a PhD project on the foraging behaviour of migratory waders. • Field assistant (1996-1997) for pied oystercatcher surveys along northern NSW beaches for NPWS and Southern Cross University Honours Student. • Field assistant (April-May 1999) for Master of Research candidate at the Australian Maritime College looking at fish catch rates in various mesh sizes in northern Tasmania. • Volunteer (May 1999) for a fauna survey at Bean Creek Falls (Old Bonalbo) for Landcare (Terry Moody). • Volunteer (October 1999) to conduct migratory bird census counts in the Tweed River estuary. • Field assistant (November-December 1999) to conduct water bird surveys between Grafton and Rockhampton for PhD thesis. • Field assistant (March-April 2000) to conduct fish sampling in the lower Richmond River estuary. • Conduct census counts of migratory/sedentary birds in northern NSW for NSW wader study group, November 2000. • Assist in the collection of Stuttering Frogs (*Mixophyes balbus*) for the implementation of an endangered species-breeding program at Melbourne Zoo, February 2001. • Assist in research on the green and golden bell frog (*Litoria aurea*) at Broughton Island and Sandgate for the Australian Museum, January & April 2002. • Currently monitoring populations of the wallum frogs (*Litoria olongburensis* & *Crinia tinnula*) in northern NSW. • Currently monitoring giant barred frog (*Mixophyes iteratus*) populations in the Bungawalbin Catchment in northern NSW. • Currently looking at the population dynamics of stream dwelling frogs in the Bulga Plateau region in northern NSW. • Currently looking at the distribution of Pugh's Mountain Frog (*Philoria pugheii*) and New England Tree Frog (*Litoria subglandosa*) in northern NSW.
Plans of Management and Management Strategies	• Preparation of Wallum Frog (*Crinia tinnula, Litoria olongburensis*) PoM for proposed construction of the Tugun Bypass Project (SKM-Thiess): November • Preparation of Integrated Long-nosed Potoroo PoM for proposed construction of the Tugun Bypass Project: December-May 2007 • Preparation of PoM for compensatory habitat blocks A and E as part of the Tugun Bypass Project (QLD DMR): May-June. • Micro bat management strategy for Warrell Creek to Urunga Pacific Highway Upgrade: 2012 • Nest Box Plan of Management for several projects including Coopernook to Herons Creek (2007), Oxley Highway (2009), Kempsey Bypass (2010), Warrell Creek to Urunga (2012), Frederickton to Eungai (2012). • Giant Barred Frog management strategy for Warrell Creek to Urunga (2012) • Green-thighed Frog management strategy for Warrell Creek to Urunga (2012)
Independent Review	• Review of fauna issues relating to *SEPP 71* and other statutory requirements (EPBC 1999; TSC 1995; DCP's) associated with development application for DIPNR (formerly NSWPlanning) March 2003 to present. • Review and co-author of the national Acid Frog Recovery Plan. • Review of assessment of significance for Black-breasted Button Quail, Dunmalls Snake and Collared Delma as part of referral to Department of Environment and Water (DEW). • Technical review of the Kunioon fauna report.
Publications	• Lewis, B.D. (1997). An observation of the Beach Thick-Knee (*Esacus magnirostris*) attempting to forage on a pipi

(*Donax deltoides*). *The Stilt*, Vol. 31: 42.

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