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.

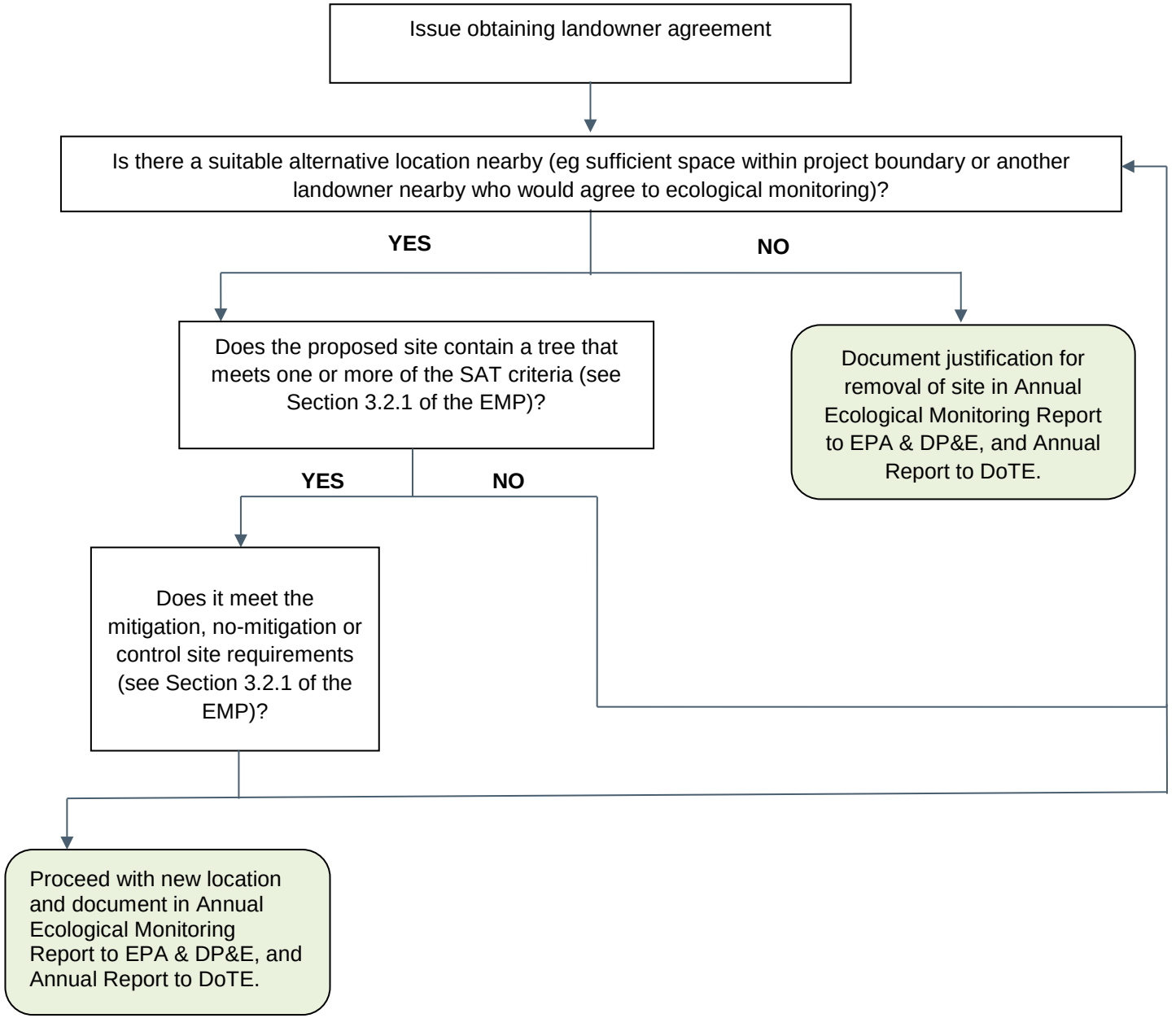
- Scribbly Gum Road, east of the Pacific Highway in proximity to Maria River State Forest.
- Crescent Head Road, east of the Pacific Highway at northern extent of the Project.

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).

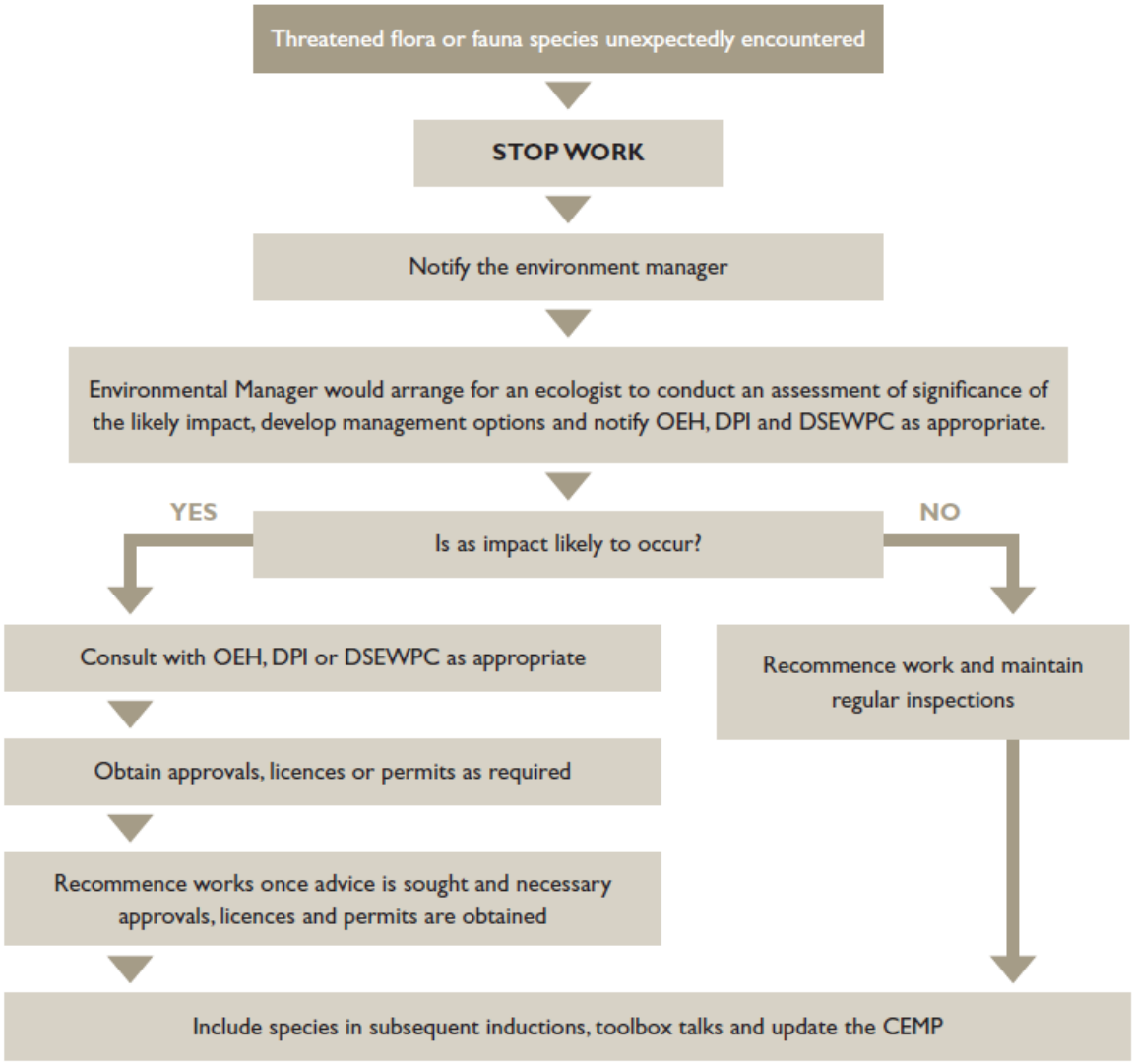


Figure 1: Unexpected find of threatened flora or fauna

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 B

CV of Suitably Qualified Expert

rms.nsw.gov.au/projects/northern-nsw/oxley-highway-to-kempsey/index.html

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Customer feedback
Roads and Maritime
Locked Bag 928,
North Sydney NSW 2059