OH2K Pacific Highway Upgrade

Annual Ecological Monitoring Report 2015

Prepared for RMS

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Cover photograph: Mixophyes iteratus at Maria River (photo by Mr Mark Aitkens) and Brush-tailed Phascogale (photo by Mr Chris Mason).

Executive summary

Context

This report details the findings of the Baseline and Year 1 ecological monitoring surveys up to 21 July 2015 as required for the Oxley Highway to Kempsey (OH2K) Pacific Highway upgrade project (the Project).

Aims

The monitoring program has the purpose of determining if the Project is having an impact upon avoided populations and habitat of a range of threatened species including:

- Giant Barred Frog (*Mixophyes iteratus*).
- Yellow-bellied Glider (*Petaurus australis*).
- Squirrel Glider (*Petaurus norfolcensis*).
- Brush-tailed Phascogale (*Phascogale tapoatafa*).
- Koala (*Phascolarctos cinereus*)
- Spotted-tailed Quoll (*Dasyurus maculatus*)
- *Maundia triglochinoides*
- Threatened microbats

In addition, broad monitoring occurred for road kill impacts to all species.

Methods

Each monitoring location was surveyed in accordance with the monitoring method and design specified in Hyder (2014) and Lewis Ecological Surveys (2014).

Key results

- The Brush-tailed Phascogale, Squirrel Glider and Spotted-tailed Quoll were not detected during baseline surveys – this requires some consideration in regards to future monitoring assessments.
- The Yellow-bellied Glider was found across two of the three reference and two of the three impact sites, however was mostly identified by call rather than observation of actual individuals.
- Individuals of the Giant Barred Frog were detected at all four impact and two reference sites, while very few individuals tested positive to the presence of Chytrid Fungus. Based on presence of individuals and the continued recording of juveniles the populations continue to function at the impact sites.
- Koalas were recorded throughout the study area, on both reference and impact sites, via SAT plots and spotlighting transects.
- *Maundia triglochinoides* was detected at 1 of 3 paired sites, showing an increase in flowering at one site, but access issues have hampered data collection and analysis.
- Bat roost box monitoring is indicating ongoing use of the boxes, thus meeting performance measures. The placement of some boxes still does not meet the intentions of the microbat management plan.
- Road kill monitoring indicates a slightly increase in the extent of road kill over the baseline monitoring period, with a range of groups being recorded, but with large macropods and birds being most commonly recorded. Sites adjacent to riparian vegetation remain as hot spots for road kill.

Conclusions

Baseline data for assessing the ongoing impacts of the upgrade and/or mitigation have been collected and are available for the ongoing monitoring program. The failure to record some of the species in the baseline monitoring requires attention to determine if monitoring should change in any way and/or if performance measures need re-evaluation to provide measurable thresholds for impacts.

Management implications

No specific management implications have resulted from the monitoring undertaken to date.

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1. Introduction

1.1 Purpose

This report summarises the findings of the Baseline and Year 1 Construction Phase ecological monitoring surveys and assessments up to 21 July 2015, undertaken in accordance with the Oxley Highway to Kempsey Ecological Monitoring Program (EMP) 2014 (Hyder Consulting Pty Ltd). The EMP is attached as Annex 1.

This report has been prepared as per the Minister's Condition of Approval (MCoA) for the Oxley Highway to Kempsey section of the Pacific Highway Upgrade Project, MCoA B10 (f) which requires the "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".

Specifically, it reports on the timing and results of monitoring activities and baseline surveys undertaken, methodology employed and progress/results measured against previously identified performance measures.

1.2 Background

The Oxley Highway to Kempsey section of the Pacific Highway Upgrade Project (the "Project") was approved in 2012 subject to various Minister's Conditions of Approval (MCoA) and Statement of Commitments (SoC). A subsequent approval with additional conditions of consent (CoA) was granted in 2014 by the Department of Environment (DoE) for matters of national environmental significance listed under the *Commonwealth Environment Protection and Biodiversity Conservation Act 1995* (EPBC Act). Combined, these approvals outline the mitigation, offsetting and monitoring requirements for threatened species and ecological communities impacted by the Project.

Specifically, the Oxley Highway to Kempsey EMP (2014) was developed to address MCoA B10 and Department of the Environment Condition of Approval (CoA) 4. These conditions are detailed below.

MCoA B10

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).

Condition of Approval (CoA) 4

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.

1.2.1 Aim of the Ecological Monitoring Plan (EMP)

The aim of the EMP (2014) is 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.

1.3 Objectives

The EMP (2014) details the schedule of ecological monitoring requirements for the life of the Project. These are shown in Table 1 below.

The current report provides the findings of monitoring activities undertaken in the Baseline and Year 1 Construction phases of the project only, as identified in Table 1. The Year 1 Construction Phase reporting up to 21 July 2015.

As such, ecological monitoring components of the EMP reported on within this document include:

- Koala
- Spotted-tailed Quoll
- Giant Barred Frog
- Green-thighed Frog
- Yellow-bellied Glider
- Brush-tailed Phascogale
- Road Kill
- Pre-clearing/Clearing

- Bat Roost Boxes
- *Maundia* habitat protection
- Landscape monitoring.

Table 1 Summary and schedule of monitoring requirements outlined in the EMP (2104)

Mitigation Measure	Baseline Surveys						Construction Phase															Operation Phase																								
	Year 0 (2013-2014)						Year 1 (2015)					Year 2 (2016)					Year 3 (2017)					Year 4 (2018)					Year 5 (2019)					Year 6 (2020)					Year 7 (2021)					Year 8 (2022)				
	S	Su	A	W	S	Su	Su	A	W	S	Su	Su	A	W	S	Su	Su	A	W	S	Su	Su	A	W	S	Su	Su	A	W	S	Su	Su	A	W	S	Su	Su	A	W	S	Su	Su	A	W	S	Su
Koala																																														
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Maundia Habitat Protection																																														
Green-thighed frog ponds																#					#					#					#					#										
Landscape monitoring																																														

- Su A W S = Summer, Autumn, Winter, Spring.
- [@]during clearing operations, daily for one month following clearing operations, for eight weeks post opening
- [#] timing is dependent on rainfall

Completed

Existing Niche Contract

Additional monitoring completed as part of EPBC Approval (part of Niche contact)

Lewis Ecological

Construction Contractor

2. Koala Monitoring

2.1 Monitoring Timing

Remote cameras were in place in August 2013, while spotlighting and SAT plot surveys occurred in spring 2013.

2.2 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.
- 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.

2.3 Methods

Seven broad areas, within a 20km radius of the Highway upgrade were surveyed and three types of monitoring sites (treatments and controls) were established within each:

- sites with mitigation (i.e. sufficiently large culverts to allow Koalas to pass under the Highway upgrade).)
- sites with no mitigation
- "undisturbed" control/ reference sites..

These included Cairncross State Forest, Ballengarra State Forest, Maria River State Forest and National Park and the Port Macquarie urban area, along with impact sites located immediately adjacent to the Highway upgrade. Further details on the location of field surveys are included in Annex 3 (SAT plots/ cameras) and Annex 4 (spotlighting).

Koala faecal pellet (SAT) plots

Within each treatment class, three SAT plots were established. At each SAT plot, 30 trees were surveyed on one occasion, in accordance with the method described by Phillips and Callaghan (2011). The presence (or absence) of scats was recorded, along with a number of other attributes including the tree species present. SAT plots were surveyed in November 2013. Further details on the results can be found in Annex 3.

Spotlighting

Within each treatment class (mitigation and no mitigation), two 500 m spotlighting transects were established which were visited by two observers on three occasions between September and November 2013. Further details on the spotlighting surveys is included in Annex 4.

Remote camera surveys

The remote cameras deployed for the monitoring of the Spotted-tailed Quoll were also used to survey for the Koala. These consisted of 102 cameras, located across 27 sites. Details on the design of this survey is included in Section 3.1.2 (Spotted-tailed Quoll methods) and within Annex 3.

2.4 Results

SAT plots

The mean level of detected SAT activity (i.e. number of trees with faecal pellets) across that SAT plot locations was 4.91% (SD= 7.95%). This ranged from no pellets at Mingaletta- Smiths Creek to 14.81% (SD= 13.65%) north of Sancrox Road. SAT activity in relation to the three treatment classes was highest in the mitigation class, with a mean of 8.05% (SD= 10.99%), compared to the control/ reference class, mean of 4.03% (SD= 6.37%) and no mitigation with a mean of 2.64% (SD= 4.17%). Scats were recorded under 15 species of trees, however the most common species with detected activity were the Forest Red Gum (*Eucalyptus tereticornis*), Swamp Mahogany (*Eucalyptus robusta*) and Tallowwood (*Eucalyptus microcorys*). Further details on the results of the SAT plots are included in Annex 3.

Spotlighting

Koalas were recorded at five of the six spotlighting transects, at a mean density of one Koala per person hour of spotlighting. A total of 10 Koalas were recorded from the 18 transect traverses (i.e. 6 sites, visited on three occasions). Further details on the spotlighting surveys are included in Annex 4.

Remote camera surveys

Koalas were recorded on remote cameras at five out of the 27 surveyed locations. Reporting rates for the Koala varied among forest, being the highest in Maria River State Forest (0.28% detection), followed by Ballengarra State Forest (0.24% detection), while Cairncross State Forest was the lowest (0.12% detection). Further information is included in Annex 3.

2.5 Discussion

Koalas were found to be moderately common within the broader study area, providing useful baseline ecological information, across all three applied methods. This baseline information to date, satisfies the monitoring program for the collection of data in Year 1. Further information on the baseline Koala monitoring program is included in Annex 3.

3. Spotted Tail Quoll

Results are reported below for the winter 2013 baseline monitoring program, as described in Lewis (2014), which is included as Annex 3.

3.1 Monitoring timing

A single period of baseline monitoring occurred in August 2013.

3.2 Performance measures

The following performance measures were identified:

- 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.

3.3 Methods

Sites were selected within three broad forests, being Cairncross State Forest, Ballengarra State Forest and Maria River State Forest/ National Park. Within each forest, nine monitoring sites were established. These represented three reference sites (> 5 km from the road upgrade), three control sites (>500 m from a mitigation structure) and three treatment sites (<500 m from a dedicated or combined fauna underpass). At each site, a grid of four infrared cameras (Scoutguard 560P) was established, with a distance of 500 m between each camera (referred to hereafter as a 'camera site'). This produced a total of 108 camera sites, however due to theft and malfunction, a total of only 101 camera sites provided data. Cameras were deployed between the 8th and 14th of August 2013 and remained in place for between 22 and 26 nights. Further information is included in Annex 3.

3.4 Results

No Spotted-tailed Quolls were recorded during the remote camera survey. Introduced carnivores, being Cats, Dogs and Foxes were widely distributed across most sties. A range of other fauna were recorded, including Common Brushtail Possum and unspecified Bandicoot and Dasyurid species, however were generally in a low abundance. Further information can be found within Annex 3.

3.5 Discussion

The method applied in this study has been determined to provide for a moderate level of expected detection of the Spotted-tailed Quolls in studies completed in Victoria by Nelson et al. (2010). The failure to detect any Spotted-tailed Quolls may be a result of random chance and the species is still present. It may also indicate a true absence from the study areas at the time, potentially as a result of competition/interactions with introduced carnivores as these taxa, in particular the Red Fox were widely distributed across the study area. Another potential result for the lack of a positive detection may be due to the low abundance of medium sized terrestrial prey items that provides for a poor foraging environment for the Spotted-tailed Quoll. Further surveys should occur to quantify the results from this study, such as within the wider landscape where Spotted-tailed Quolls are known to occur. These may include areas such as Limeburners Creek Nature Reserve.

The failure to detect any Spotted-tailed Quolls has resulted in a failure to be able to determine a pre-construction baseline distribution and density for the species that can be used for comparisons of population changes over time. This means determining any impacts over time will be difficult in regards to any success of the mitigation undertaken. Further discussion of these results is included in Annex 3.

4. Giant Barred Frog

The following information is summarised from the baseline Giant Barred Frog monitoring report, including field surveys completed by Lewis Ecological and Niche Environment and Heritage, the results of which are included in Niche (2015a), which is included as Annex 7.

4.1 Monitoring Timing

Baseline surveys occurred in spring 2013, summer 2014 and autumn 2014.

4.2 Performance Measures

The following performance measures were developed for the Giant Barred Frog:

- 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.
- Continued presence of Giant Barred Frogs during each survey event in Year 1 – 8 at sites where it was identified during baseline surveys.
- 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).
- 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.

4.3 Methods

Four treatment (impact) sites and two reference (control) sites were established. The treatment sites were on streams where the highway upgrade was occurring and consisted of Cooperabung Creek, Smiths Creek, Pipers Creek and Maria River. The reference sites were located at least two kilometres upstream of the highway upgrade on Cooperabung Creek and Pipers Creek.

At each site, a 1 km transect was surveyed on three separate occasions, corresponding with a pre-determined season, being Spring 2013, Summer 2014 and Autumn 2014. The project transects extended 450 m upstream and 550 m downstream of the highway upgrade. Two ecologists searched both sides of the stream and riparian area at a slow speed listening for calling frogs and looking for active individuals using spotlights/headlamps. This was supported by call playback of the call of the Giant Barred Frog that consisted of a 10 minutes of listening, followed by 15 minutes of call playback and then a further 10 minutes of listening. The process was undertaken at the beginning of each transect and then repeated at least every 100m along the length. Any recorded Giant Barred Frogs were captured, if possible and searched for the presence of a pit tag. If present, the number was recorded and, if not, the animal marked with a pit tag to develop mark-recapture estimates of population sizes. All frogs captured were weighed

and measured, sexual status and condition noted and were also swabbed for the presence of Chytrid fungus. The location and habitat being used for each frog seen was also recorded, including frogs not captured. Any other observations of interest were recorded at the same time.

Tadpole searches were conducted along the same transects at 100 m intervals using two methods. The first was a standard bait fish trap placed into the water at each interval and left for a minimum of three hours to capture any tadpoles present. The other was the use of a dip net to sweep through each site at least 10 times to also capture tadpoles, if present.

Water depth and water quality were measured for the six streams. Water depth was taken along the transect and the deepest pool depth recorded. Water quality measurements were undertaken by the RMS. Further information is included in Annex 7.

4.4 Results

All six sites contained Giant Barred Frogs, however the abundance between sites varied and two sites (Maria River impact and Piper's Creek reference) had no recorded frogs in the Autumn 2014 monitoring survey. The mean number of frogs across the sites varied from 5.67- 15.67 Giant Barred Frogs recorded per visit, while the minimum number of Giant Barred Frogs known to be alive at each site ranged from 14 to 45. Population estimates using mark-recapture data provided widely varying levels of variance and so uncertain estimates of the population sizes present along a transect. All age classes were evident for all sites.

The presence of the Chytrid fungus was recorded at just one of the six sites with a low level of infection (i.e. one frog) being detected in the Giant Barred Frogs sampled at the Smiths Creek impact site.

Tadpoles were not collected by either of the pre-determined methods on any of the three seasonal samples. Some Barred Frog tadpoles were seen during the Spring 2013 surveys, but their identity was not able to be confirmed. Additional information is included in Annex 7.

4.5 Discussion

The baseline surveys showed that Giant Barred Frogs were recorded as present across all six sites with juveniles also being recorded at each site. The high levels of variance in the population estimates indicates these estimates were highly uncertain and the data requires further evaluation before they it may be able to used as an effective means to monitor impacts on the Giant Barred Frog. More simple comparisons using the basic counts of frogs or the minimum known to be alive estimate are recommended for ongoing monitoring evaluation.

Conditions at the times of each monitoring event were adequate to ensure activity of the Giant Burrowing Frog, but efforts will continue to be made to ensure that monitoring is conducted in a consistent manner in regards to seasons and that every effort is made to ensure samples are taken during periods of warmer weather to maximise their activity potential and so opportunities for captures and recaptures.

The detected low level of Chytrid infection at one site was not surprising given the known widespread nature of this disease within streams in eastern Australia, but has been mitigated through the use of a wash-down station at the Smiths Creek impact site.

The failure to capture any tadpoles was unexpected and attempts will be made to improve this outcome. However, the ongoing presence of juvenile frogs is providing a clear indication of ongoing recruitment.

The baseline surveys addressed the performance measures that related to the collection of baseline survey information. The level of baseline will allow for comparisons of population change against monitoring performance measures. Additional information is included in Annex 7.

5. Green-thighed Frog

5.1 Monitoring timing

Targeted surveys for the Green-thighed Frog were undertaken over four days from 27th - 30th January 2013, and again on 28th March 2013 by Lewis (2013a) along and within the vicinity of the Project corridor prior to any construction works. The purpose of the surveys was to inform development of a Management Strategy as required under MCoAB31(b) Construction Flora and Fauna Management Sub-plan, to address impacts to this species as a result of the Project.

The surveys undertaken constituted the 'Baseline' monitoring surveys for this species, as required in the EMP (2014). A summary of the survey methodology, results, prescribed performance measures and discussion of results again performance measures are presented below. The Green-thighed Frog Management Strategy is provided in Annex 2.

5.2 Performance measures

Performance measures for the Green-thighed Frog relate to the use of constructed ponds. As construction of these ponds has not yet occurred, these performance measures do not currently apply. These include:

- Continued presence of Green-thighed Frog at three or more of the 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).

5.3 Methods

Site reconnaissance surveys were undertaken between August and December 2012 when almost all drainage lines and potential inundation areas were visited between chainages 0-37750. From this, 27 areas were identified as the most likely locations for Green-thighed Frog and thus subject to remote weather monitoring using the rainfall prediction, 24 hour rainfall totals and radar tabs on the Bureau of Meteorology Website (www.bom.gov.au). Field surveys were then undertaken between the 27th and 30th January 2013 when the study area received in excess of 200 mm over a 48 hour period. The entire study area was traversed either on foot or by vehicle with 27 sites established along with a reference site located in the northern study area (Kemps Road E:483801 N:6554893). Each site was visited between one and three occasions to listen for calling males, with an estimate of the number males provided based on the calling intensity.

The sites were revisited on the 28th March 2013 to investigate the success of the January breeding event. This time period was approximately 57 days after the calling/breeding event and was deemed a suitable median between shaded and unshaded breeding sites for Green-thighed Frog. 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. Further information is included in Annex 2.

5.4 Results

5.4.1 Distribution in the Project locality

Green-thighed Frogs were recorded from seven locations scattered between Cairncross State Forest in the south (Blackmans Point Road), north to Kalateenee State Forest (approximately 0.5 km south of the Bloodwood Ridge Rest Area). Frogs were also recorded in Ballengarra State Forest (i.e. Barrys Creek) and associated with Sub tropical Floodplain Forests bordering Pipers Creek and to a lesser extent Smiths Creek.

Specifically, the targeted pre-construction survey confirmed the presence of Green-thighed Frog at the following seven locations (including chainage location) with an eighth likely site:

- Oxley Highway to Kundabung:
  - Cairncross State Forest (ch. 9050 and 9350)
  - Barrys Creek (ch. 23900)
  - Northern Cairncross State Forest (ch. 11500 – 11800) (identified as potential habitat, to be managed as known Green-thighed Frog habitat).
- Kundabung to Kempsey:
  - Smiths Creek north (ch. 28350)
  - Wharf Road south (ch. 29050)
  - Pipers Creek south (ch. 30650)
  - Pipers Creek north (ch. 30775)
  - Bloodwood Rest Area (ch. 33650).

Green-thighed Frog habitat within the Project locality was also identified and mapped.

5.4.2 Calling intensity

The numbers of calling Green-thighed Frogs was usually less than 10 calling males with only the Pipers Creek south site (Site 11; ch. 30650) recording more than this. The numbers of calling frogs is likely to have varied throughout the breeding event as is often the case. For example, the reference site at Kemps Road was represented by 1-2 calling males during the March 2013 survey compared to between 4-8 males calling at this same site in previous surveys in January 2012. In this context, use of calling intensity as an indication of number of individuals should be used as a guide only during short term surveys such as this study.

5.4.3 Breeding sites

No tadpoles, metamorphs or juvenile Green-thighed Frogs were recorded at the breeding sites where adults were recorded calling. Sites 11 (Pipers Creek south; ch. 30650), 13 (Pipers Creek north; ch. 30775), 16 (Bloodwood Rest Area; ch. 33650) and 23 (Smiths Creek north; ch. 28350) contained standing water at 57 days whilst the remaining three sites contained moist depressions with no visible standing water.

5.5 Discussion

Targeted surveys have confirmed the construction footprint for the Oxley Highway to Kempsey Upgrade will remove or impact on at least seven breeding and non-breeding habitat areas for the Green-thighed Frog. This includes most of the low lying areas within Cairncross State Forest between ch. 8900 and ch. 12200, scattered lower slopes north of Cooperabung Hill to the Mingaletta area (ch. 22500-25500), areas adjacent to riparian habitats of Smiths Creek and Pipers Creek, and the cut area associated with ch. 36350 in Maria River State Forest.

Although the breeding surveys could not locate tadpole, recently metamorphosed or juvenile frogs they are suspected to have successfully breed and left the pond areas at less than 50 days. Previous surveys in the

Kempsey and Eungai areas have shown that tadpoles of this species can start to reach metamorphosis in as little as 28 days (B. Lewis unpublished data). In a number of instances, the Upgrade is considered to lie adjacent to more suitable breeding habitat for the Green-thighed Frog. Further information is included in Annex 2.

5.5.4 Management strategies and recommendations

Seven management strategies were proposed as a means to avoid, minimise, mitigate and monitor impacts to Green-thighed Frog. Details of these can be found within the Green-thighed Frog Management Plan. They include:

1. Identification of Green-thighed Frog habitat
2. Protection of existing habitat
3. Pre-clearing surveys
4. Creation of breeding ponds
5. Design and installation of permanent frog fencing
6. Unexpected finds procedure linking to strategies 2-5 and 7
7. Monitoring of the breeding pond areas and associated frog fencing.

5.5.5 Progress against performance measures

Performance measures for the Green-thighed Frog relate to the use of constructed ponds. These ponds have not yet been established. The first round of monitoring (Year2/Year 3) is to commence once the vegetation on the edges of the constructed ponds is considered sufficient (> 20% groundcover). Monitoring against this performance measure is expected to commence in Summer of Year 2 of the Construction Phase.

6. Yellow-bellied Glider

The monitoring of the Yellow-bellied Glider is described in Lewis (2014), which is included as Annex 3.

6.1 Monitoring timing

Monitoring of the Yellow-bellied Glider occurred in Spring 2013 (Lewis 2014).

6.2 Performance measures

The following performance measures were identified for the Yellow-bellied Glider:

- 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.

6.3 Method

Six sites were established, consisting of three impact sites, located adjacent to the road footprint at Cairncross State Forest, Ballengarra State Forest and Maria River State Forest. The three control sites were located approximately 5-10 km away, as paired locations, in areas where Yellow-bellied Gliders were known to occur or where suitable habitat occurred.

Each site was surveyed on three occasions between September and November 2013. During each survey, 10 minutes of listening occurred, followed by 15 minutes of call playback was performed, where the vocalisation of the Yellow-bellied Glider was played via a megaphone. This was followed by a 15 minute listening period, before a 500 metre transect was surveyed by spotlighting using two observers. Further information is included in Annex 3.

6.4 Results

Yellow-bellied Gliders were recorded at four of the six sites, representing two impact sites and two reference sites, while unconfirmed calls of the species occurred at the other two sites. Detectability ranged from zero to three detections at each site. During spotlighting surveys, only one Yellow-bellied Glider was observed, with the remaining detections occurring via vocalisations alone. Further information is included in Annex 3.

6.5 Discussion

The results of these baseline surveys show that the Yellow-bellied Glider occur within the broader study area. Yellow-bellied Gliders were confirmed to be present at two of the three reference and two of the three treatment sites and may be present at the other two sites. Suitable baseline data occurs in order to test the performance measures after construction is completed. In accordance with recommendation 2 in Annex 3, the clearing footprint around the Maria River bridge has been minimised to allow for the crossing of the Yellow-bellied Glider. Roads and Maritime will consider glide distances at this location when reviewing the required crossing structures.

7. Brush-tailed Phascogale

This section summarises the results of the Brush-tailed Phascogale monitoring completed by Niche, as outlined in Lewis (2014) and included in Annex 3.

7.1 Monitoring timing

Monitoring occurred at the end of summer 2014, over a single week.

7.2 Performance measures

Two performance measures were identified for the Brush-tailed Phascogale. These include:

- Continued presence of Brush-tailed phascogale at sites where it was identified during baseline surveys.
- Presence of adults and/or lactating Brush-tailed phascogales

7.3 Method

A total of four paired (i.e. both sides of the proposed highway upgrade) impact monitoring sites were established, across the project site. Three sites were located adjacent to proposed dedicated fauna culverts, while the remaining site was at the proposed site of a combined bridge/ fauna underpass.

At each site, a 1 ha sampling grid was established. Two survey techniques were used, consisting of hair tubes and arboreal box trapping. In each method the traps were baited with a mixture of rolled oats, peanut butter, honey and sardines in oil. The 10 hair tubes were baited and left in place for 14 consecutive nights in February 2014. Arboreal trapping consisted of 10 Elliott B traps, mounted on brackets approximately two metres above ground and set over four consecutive nights, also in February 2014. This produced a combined effort of 1120 hair tube nights and 320 Elliott trap nights. Further information is included in Annex 3.

7.4 Results

No Brush-tailed Phascogales were recorded during the monitoring, from either the hair tubes or the arboreal trapping. A wide range of other fauna were recorded, including Sugar Glider (*Petaurus breviceps*), Common Brushtail Possum (*Trichosurus vulpecula*), Brown Antechinus (*Antechinus stuartii*) and Rats (*Rattus* sp.). Further information is included in Annex 3.

7.5 Discussion

No Brush-tailed Phascogales were recorded during the baseline monitoring event. This may be due to seasonality, for example there was a high density of insect prey present at the sites during the sampling period. The absence of the Brush-tailed Phascogale from baseline surveys will mean that addressing one of the two performance criteria is not immediately feasible. Criteria may need to be revised.

8. Squirrel Glider

The results of the Squirrel Glider trapping survey are reported in Niche (2015b), which is included as Annex 8.

8.1 Monitoring timing

Monitoring occurred over a single period, in autumn 2014.

8.2 Performance measures

The following performance measures were identified:

- Monitoring is undertaken before and after construction of the upgrade.
- Monitoring is undertaken at Impact and Control sites.
- Squirrel glider populations are maintained at Impact sites where it was identified during Baseline surveys; there is no significant difference in any population declines between Impact and Control sites after completion of the Project.

8.3 Method

Field surveys occurred across four paired locations, representing four control sites and four reference sites, within Cairncross State Forest, Barry's Creek, Mingaletta Road and Maria River. At each site, a two hectare grid was established. Arboreal trapping occurred, through the use of Elliott B traps, mounted on brackets, two metres above the ground. Trapping occurred over four consecutive nights, between 26th and 30th May 2014, with a combined survey effort of 640 trap nights. Further information is included in Annex 8.

8.4 Results

No Squirrel Gliders were captured during the field surveys. The only species captured were Black Rats and Brown Antechinus (*Antechinus stuartii*). Further information is included in Annex 8.

8.5 Discussion

No Squirrel Gliders were recorded during the baseline surveys and to date no confirmed records of the species occur within the construction footprint. This means that addressing the third performance measure will be difficult due to the absence of captured animals. Consideration may be given to changing the performance measures. Further information is included in Annex 8.

9. Road Kill

9.1 Monitoring timing

The approved EMP (Hyder 2014) states the monitoring timing and locations for the road kill surveys as detailed in Table 9.1 below.

Table 9.1: Road kill monitoring timing and location.

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

9.2 Performance Measures

The approved EMP (Hyder 2014) and Construction Flora and Fauna Management sub-plans (Lend Lease 2014, McConnell Dowell OHL JV 2014) specify the following performance indicators for the road kill survey.

- Lower rates of road kill in proximity (i.e. 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.

9.3 Methods

The approved EMP (Hyder 2014) states the following methodology for the road kill survey:

"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, 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.

9.4 Results

The results presented in this report summarise the baseline monitoring undertaken in three monitoring events between 2013-2014 (i.e. spring, summer and autumn), the clearing and post clearing surveys undertaken from November 2014 until July 2015 and the construction phase surveys undertaken from November 2014 until July 2015. The data has been collected from four difference sources (Lewis Ecological Surveys, Niche Environment and Heritage, Lend Lease and McConnell Dowell OHL JV). Annex 3 section 8 contains the spring and summer baseline report prepared by Lewis Ecological Surveys. Annex 5 contains the raw data for the autumn baseline monitoring conducted by Niche Environment and Heritage. Annex 6 contains the raw data obtained during clearing, post clearing and construction phase surveys carried out by Lend Lease and McConnell Dowell OHL JV.

9.4.1 Data limitations and assumptions

In relation to the clearing and post clearing surveys and construction phase surveys, data was not always collected in the standardised manner indicated in the EMP (Hyder 2014). From November to December 2014, clearing and post clearing data on the Oxley Highway to Kundabung section was inadvertently collected weekly instead of daily as outlined in the EMP (Hyder 2014).

For some portions of the Oxley highway to Kempsey project, clearing and post clearing surveys were recorded to have been undertaken along the entire length of the alignment instead of adjacent to a clearing sections as per the EMP (Hyder 2014), but the actual locations of the road kill compared to current clearing was not recorded. That is, it was not clear if the road kill occurred adjacent to recently cleared vegetation or adjacent to areas where vegetation had been removed earlier. For these portions, unless clearly specified in the data, the assumption would be that the road kill recorded was located adjacent to a clearing section.

Table 9.2: Road kill survey effort and data collection during baseline monitoring, clearing, post clearing and construction phases.

Project phase	Period	Road portion	Data collected by	Frequency of data collection/methodology requirement	Location of Data in this report
Baseline survey	Spring 2013	OH2Ku and Ku2K	Lewis Ecological Survey	weekly/weekly	Annex 3 section 8
	Summer 2014			weekly/weekly	Annex 3 section 8
	Autumn 2014		Niche Environment and Heritage	weekly/weekly	Annex 5
Clearing and post clearing survey	November 2014 – January 2015	Clearing portions of OH2Ku	Lend Lease	weekly/daily	Annex 6
	January 2015 - July 2015			daily/daily	

	November 2014 – July 2015	Clearing portions of Ku2K	McConnell Dowell OHL JV	daily/daily	Annex 6
Construction phase	November 2014 - July 2015	OH2Ku	Lend Lease	daily/weekly	Annex 6
	November 2014 –July 2015	Ku2K	McConnell Dowell OHL JV	daily/weekly	Annex 6

9.4.2 Baseline monitoring

For consistency with what was done previously by Lewis Ecological Survey in spring 2013 and summer 2014, the autumn 2014 data has been classified accordingly to:

- Location using a hand held GPS (GDA94) to identify any focal points or hot spots.
- Summarised according to fauna categories that could be interpreted in relation to the types of mitigation measures being proposed.
- Legislative status pursuant to the *TSC* Act (1995) and *EPBC* Act (1999).

One hundred animals representing 33 fauna species have been recorded as road kill during the three events of the baseline surveys. This consisted of 38 animals representing 20 species in spring 2013, 48 animals from 23 species in summer 2014 and 13 animals from 10 fauna species in autumn 2014.

A wide range of fauna were recorded as road kill. The fauna categories with the highest number of road kill were the large terrestrial mammals (kangaroos) with 20 observations. However there were also 17 observations of road killed birds, 16 for arboreal mammals, 13 for reptiles, 11 of introduced species, 8 small terrestrial mammals, 6 for medium terrestrial mammals, 3 for frogs and two observations of road killed flying mammals (bats) (Figure 9.1).

During the 12 weeks of survey effort two different threatened species for a total of 3 individuals have been recorded as road kill (Table 9.3 and Figure 9.4).

Road kills have been recorded across the entire length of the existing Pacific Highway carriageway during all three seasons with records extending from ch. 600 to ch. 37800.

Data from the three baseline survey events indicated three high impacts areas - “hot spots” for road kills (Figure 9.3):

- ch. 3550 (Fernbank Creek) where this is a narrow vegetated habitat linkage running in an east-west direction;
- ch. 12500-15000 (The Hatch) associated with fragmented swamp forest and cleared lands; and
- ch. 16500 (Telegraph Point) which will become a service road once the Project has been constructed.

The baseline monitoring data suggest that the highest numbers of road kill occur close to drainage lines.

Figure 9.1: Cumulative number of road kill records, according to fauna categories, for the three (spring, summer, autumn) baseline events.

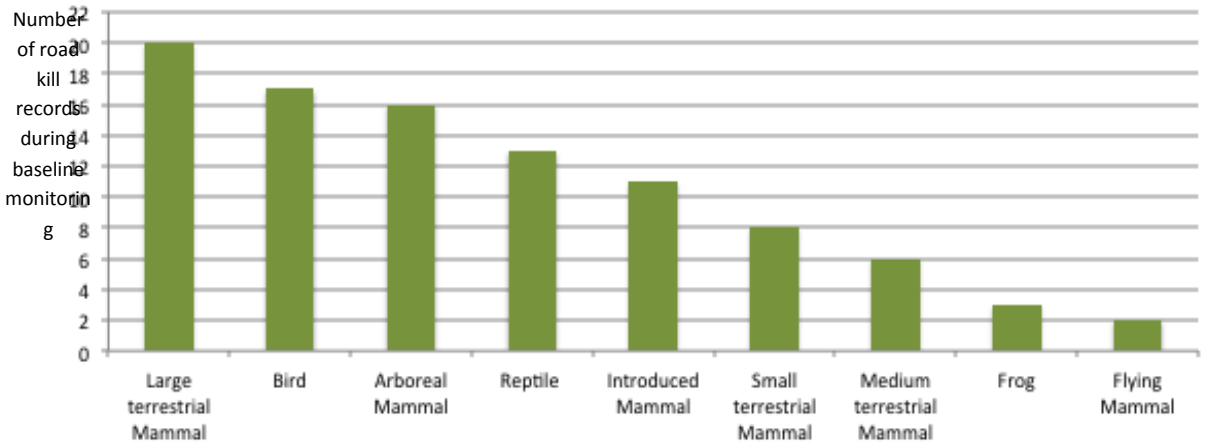


Table 9.3: threatened species road kill during baseline monitoring

Season	Date	Species detected	Location	Note
Spring	04- October 2013	Koala	Ch. 22300	Where the Upgrade passes through Ballengarra State Forest
Spring	04- October 2013	Grey-headed Flying-fox	Ch.13000	Telegraph Point. Likely attracted by the flowering Forest Red Gum (*Eucalyptus tereticornis*)
Summer	7- February -2015	Grey-headed Flying-fox	Ch. 4800	North of Fernbank Creek. Likely attracted by the flowering Broad-leaved Paperbarks (*Melaleuca quinquenervia*)

9.4.3 Clearing and post clearing survey

Between Oxley Highway to Kundabung only one road kill (common brush tail possum) has been observed in a portion of existing highway adjacent to clearing operations. A total of 84 animals have been recorded in the Kundabung to Kempsey (K2K) section but the daily surveys have been undertaken along the entire length of this portion of the project and it is not clear how many of these observations occurred adjacent to clearing operations. The same data for the K2K portion has been provided for the construction phase.

To avoid repetition in the results please see the following section where a full data set (Oxley Highway to Kempsey) of construction phase data is analysed.

9.4.4 Construction phase

For consistency with the baseline monitoring the construction phase survey has, where possible, has been treated as follows:

- Location using a hand held GPS (GDA94) to identify any focal points or hot spots.
- Summarised according to season and fauna categories that could be interpreted in relation to the types of mitigation measures being proposed.
- Legislative status under the *TSC* Act (1995) and *EPBC* Act (1999).

The results below shows the cumulative road kill numbers recorded during the construction phase. These numbers are not directly comparable with the baseline survey results because the survey effort for the construction phase covered approximately 38 weeks (4 weeks in spring, 12.9 in summer, 13.1 in autumn and 8.3 in winter) as opposed to just 12 weeks for the baseline monitoring (4 weeks in spring, 4 in summer and 4 in autumn).

During the 38 weeks of construction phase, 213 animals from 45 fauna species were recorded as road kill consisting of 41, 47, 89 and 36 animals killed in spring 2014, summer 2014-2015, autumn 2015 and winter 2015 respectively.

Relative assessments using proportions can be undertaken among the seasons and the fauna categories to identify if any trends are present. Seasonality between the construction phase and baseline monitoring indicated different trends. During the baseline monitoring, the lowest number of road kill was recorded in autumn (13% of observed road kills) while in the construction phase, autumn was the season with the highest number (41.9% of the road kill). This represented 3.5 more road kill observations per week in autumn 2015 compared to that recorded in autumn 2014.

The fauna categories with the highest number were birds with 49 observations (23%) followed by large terrestrial mammals with 39 (18.3%), introduced species with 33 (15.4%), reptiles with 27 (12.7%), arboreal mammals with 22 (10.3%), medium terrestrial mammals with 16 (7.5%), flying mammals with five (2.3%), and small terrestrial mammals and frog with one each (0.5%) (Figure 9.2). Frogs have been identified in only one event when numerous individuals where spotted from the car. Due to safety reason it wasn't possible to access the road by foot and no indication of the number has been given. In such circumstances only a survey by an experienced frog ecologist would allow for accurate identifications in the short time available.

Figure 9.2: Cumulative number of road kill records, according to fauna categories, during construction phase until 21st July 2015.

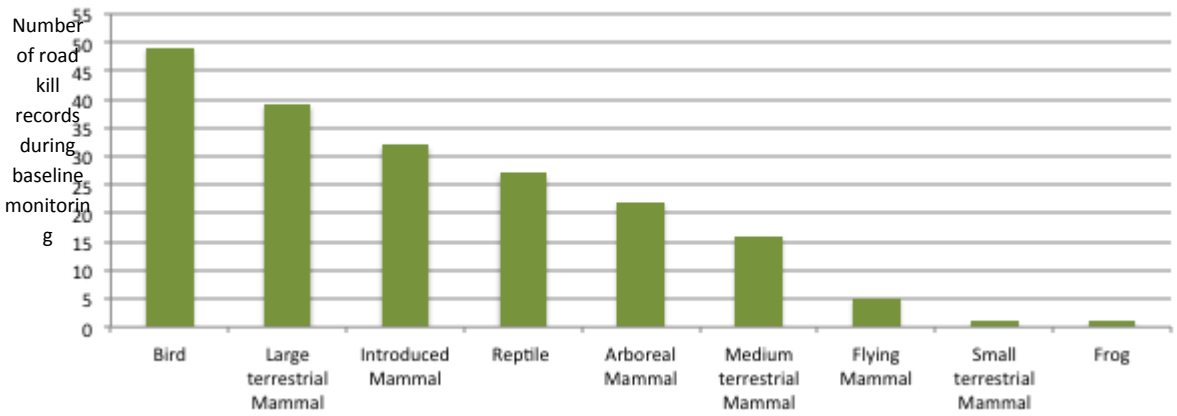
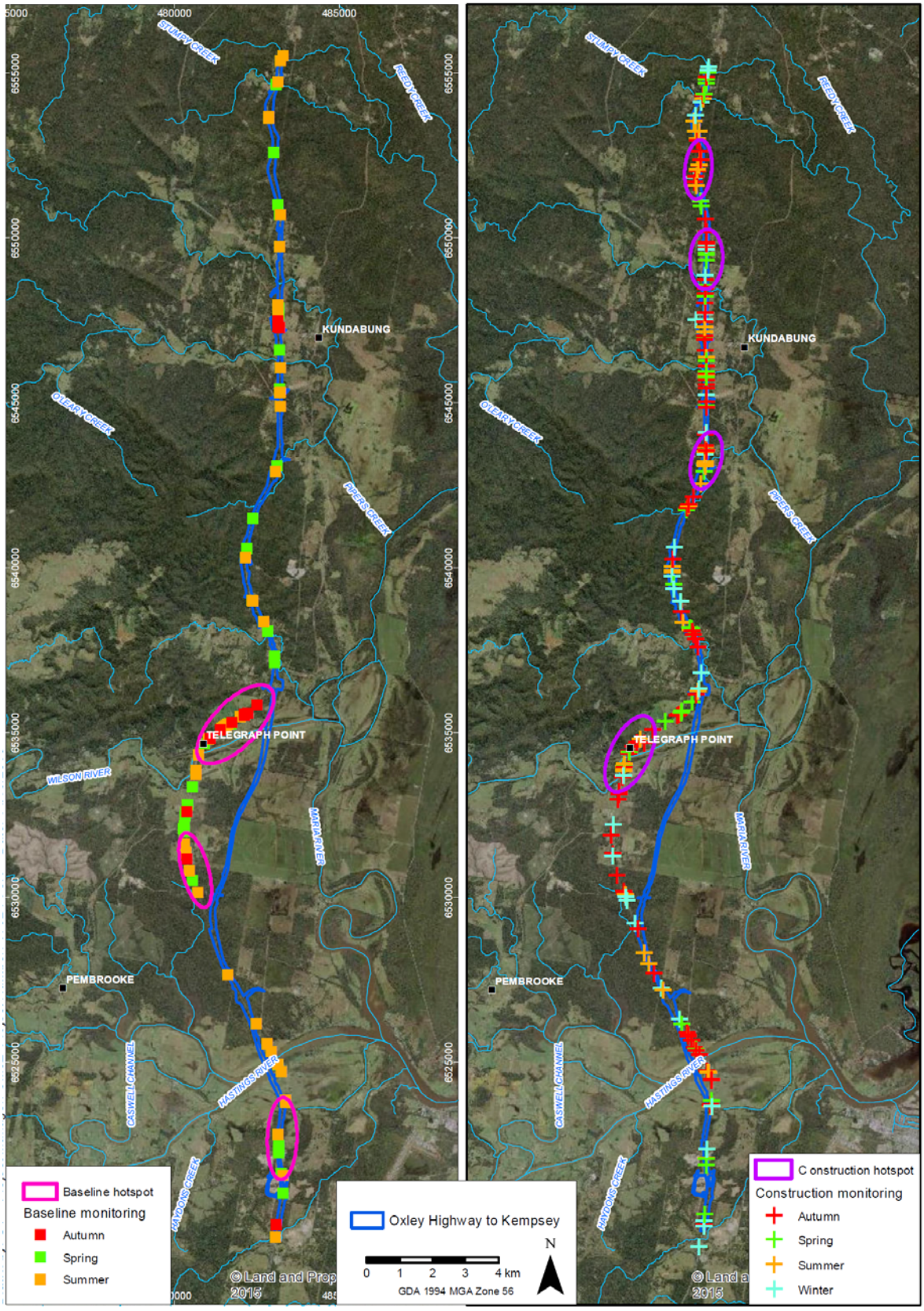


Figure 9.3: Seasonal distribution of road kill along the OH2K project (baseline monitoring vs. construction phase)



Seasonal distribution of road kill along the OH2K project (baseline monitoring vs. construction phase)

Pacific Highway Upgrade - Oxley Highway

niche Environment and Heritage

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FIGURE 9.3

Imagery: (c) LPI 2009-04-17

These results correspond well with the results from the baseline monitoring with the birds and large terrestrial mammals being the categories with most observations.

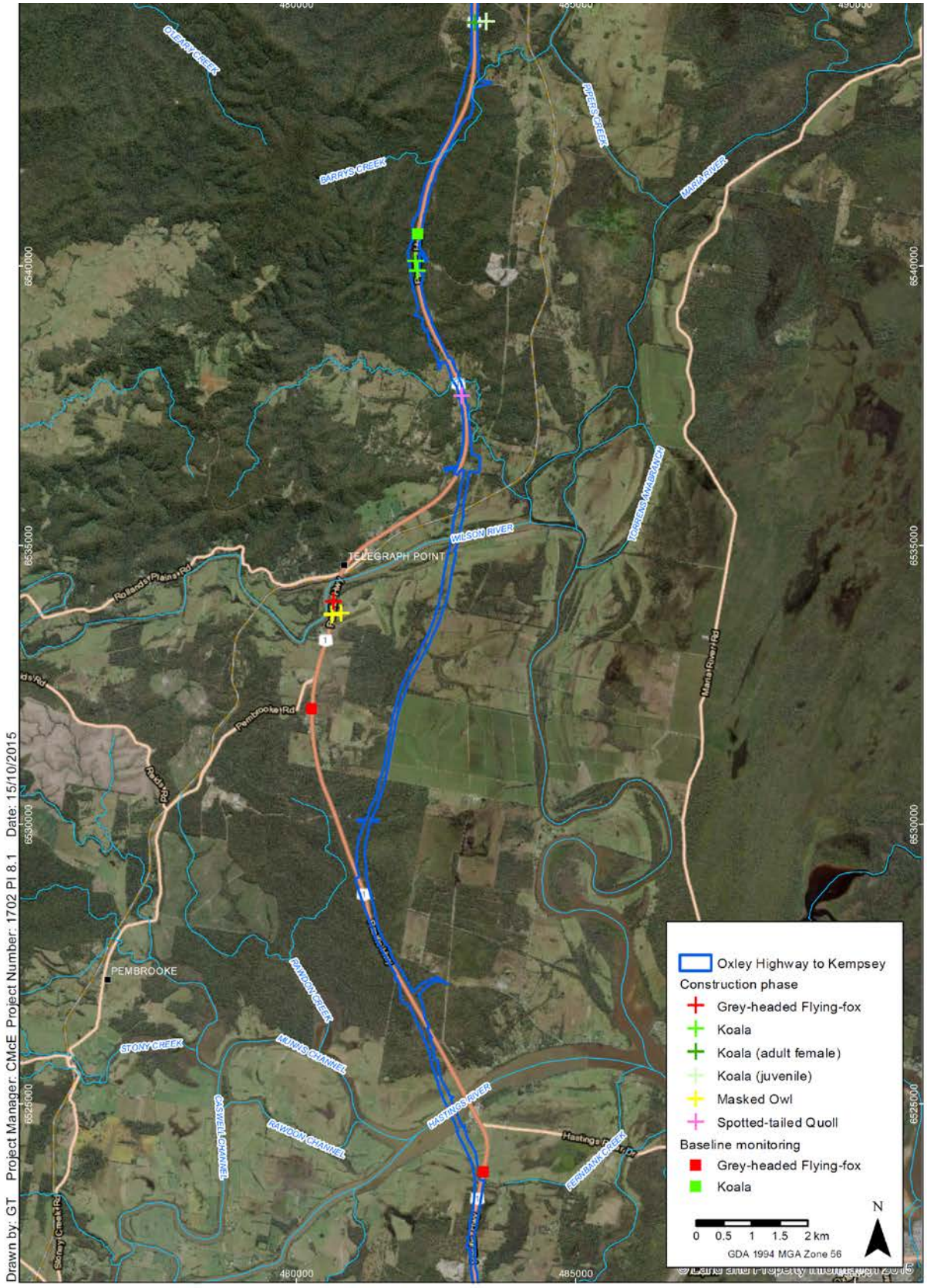
During the 37 weeks of survey effort, four different threatened species for a total of 8 individuals have been recorded dead due to road kill (Table 9.4 and Figure 9.4).

Table 9.4: Threatened species road kill during construction phase until 21st July 2015

Season	Date	Species detected	Location	Note
spring	17-November-2014	Koala	Ch. 26350	Adult female struck on Tuesday/Wednesday (11/12th Nov)
spring	17-November-2014	Koala	Ch. 26350	Young struck on Tuesday/Wednesday (11/12th Nov)
summer	03-December-2014	Grey-headed Flying-fox	100m South of Hacks Ferry	
summer	03-December-2014	Koala	300m North of Yarrabee Rd	
autumn	04-May-2015	Masked Owl	100m before Wilson River Bridge	
autumn	11-May-2015	Masked Owl	100m before Wilson River Bridge	100m from previous masked owl kill 1 week prior
winter	01-July-2015	Spotted-Tail Quoll	200m South of Cooperabung Ck (Ben Lewis)	
winter	21-July-2015	Koala	200 m North of Yarrabee Rd	

Two flying foxes identified as “flying fox sp.” have been recorded in two different events, during the construction phase road kill surveys. Three difference species may occur in the project area, with the Grey-headed Flying-fox being the only threatened species. Because the animals couldn’t be identified at the species level, for analysis purpose, these two records have only been included in the flying mammal categories but not in threatened species.

Figure 9.4: Distribution of threatened species road kill along the OH2K project (baseline monitoring vs. construction phase)



Distribution of threatened species road kill along the OH2K project (baseline monitoring vs. construction phase)

Pacific Highway Upgrade - Oxley Highway

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FIGURE 9.4

Imagery: (c) LPI 2009-04-17

Data from the construction phase surveys indicated four major high impact areas - “hot spots” for road kills. One of them (Telegraph Point) has also been identified previously during the baseline monitoring but the ones close to Barry creek and the two south of Maria River haven’t been identified previously. (See Figure 9.3).

From the beginning of the project until July 2015 these are the six key areas with the highest concentration of animal’s road kill.

- ch. 3550 (Fernbank Creek) where this is a narrow vegetated habitat linkage running in an east-west direction
- ch. 12500-15000 (Tommy Owens Creek - The Hatch) associated with fragmented swamp forest and cleared lands;
- ch. 16500 (Wilson River - Telegraph Point) which will become a service road once the Project has been constructed
- ch. 25600 (Barrys Creek) associated with moist gully forest and moist slopes forest
- ch. 32900-31600 (North of Pipers Creek) associated with fragmented moist slopes forest
- ch. 33700-34550 associated mainly with moist slopes and moist floodplain forests

Both results from baseline monitoring and construction phase have identified that road kill is most likely to be recorded on sections of the carriageway that traverse floodplain or riparian habitats, regardless of the vegetation type.

9.5 Discussion

The following comments can be made about the results obtained compared to the listed performance measures:

Lower rates of road kill in proximity (i.e. 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.

Not currently applicable as fauna mitigation structures are not yet in place or functional.

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.

The performance measure in the approved EMP (Hyder 2014) was met in summer but not in spring and autumn (see Table 9.5). During the baseline monitoring a mean of 9.5 animals per week were recorded as road kills in spring 2013 compared to 10.3 animals per week in spring 2014. In autumn the gap is even bigger 3.3 in 2014 against 6.8 in 2015. (Table 9.4)

The number of threatened species (TS) recorded per week during the baseline monitoring (0.25) and the construction phase is similar (0.21).

Table 9.4: Comparison of baseline monitoring results against construction phase

	Season	Number of road kill	Survey effort per week	Road kill/week
Baseline monitoring	**spring 2013**	38	4	9.5
	summer 2013-2014	48	4	12.0

	autumn 2014	13	4	3.3
Construction phase	**spring 2014**	41	4	10.3
	summer 2014-2015	47	12.9	3.6
	autumn 2015	89	13.1	6.8
	winter 2015	35	8.3	4.2

These results need to be interpreted with some caution because the data collected during the construction phase has not be always recorded in the standardised manner required in the EMP. A higher number of observations could have been obtained during the construction phase because, for at least some of the monitoring period, data were recorded daily instead of weekly.

The highest probability to record a road kill occurs close to when the event happened. It has been highlighted previously in the spring summer baseline report and also observed in autumn 2014 the detectability of the carcases varies consistently within a few hour from the road kill event. Larger carcases tended to be removed from the carriageway within 24-72 hours of their initial discovery and smaller carcasses (e.g. frogs) get destroyed before they could be counted. However, to analyse the entire data set, the weekly cumulative number of the daily road kill survey have been used.

Fauna exclusion fencing is installed at a minimum in the locations identified in Schedule 3 of the EPBC approval at Year 4.

Not applicable until year 4.

Road kills have been recorded along the entire length of the existing Pacific Highway and the baseline monitoring has identified some hot spots associated with sections of road that traverse floodplain or riparian habitats, regardless of vegetation type.

Systematic road kill surveys are essential in determining the frequency of road kills, and to confirm or to identify new hotspots that may require further mitigation.

10. Clearing Monitoring

10.1 Monitoring timing

Only the Sancrox pre-clearing / clearing monitoring is being reported in this report, as this was the only stage that had completed clearing at the end of this reporting period. The other two stages (completed clearing in August / September 2015) will be reported in the 2015/16 annual report.

The main phase of clearing was undertaken over roughly 9 weeks from the 23rd July to 25th September 2014, with most occurring between 23rd July to 11th August 2014 when the service roads and abutments were cleared. All of the habitat trees were removed during this period.

The quarry road was cleared from 21-22 August and 24-25 September 2014. The northeastern roundabout at the Cassegrain Winery entrance was cleared on 17-19 September. Dewatering was undertaken at the site of a new culvert on the quarry access road on 2-3 February 2015. Fencelines along Service Road 3 were cleared from 17-23 February 2015.

The latest clearing event was an area south of Fernbank Creek Rd and two trees for a roundabout which were cleared on 5th May 2015. Refer Annex 10.

10.2 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 (i.e. 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.

10.3 Methods

A two-stage clearing procedure was implemented across the Project. The first stage included the delineation of clearing areas with coloured tape/exclusion fencing followed by the clearing of vegetation including non-habitat trees. The second stage included the clearing of habitat trees. First stage clearing was undertaken by a bulldozer which cleared undergrowth and non-habitat trees. Habitat trees were later removed by a bulldozer which was at times assisted by an excavator.

Stage 1 clearing monitoring predominantly involved an ecologist standing at a safe distance from tree felling, and constantly monitoring the ground around the machines, vegetation at the clearing front, and adjacent vegetation for fauna either displaced by the work or at risk. Any fauna sighted which needed rescue or buffers would initiate a stop-work procedure previously agreed between the ecologist and plant operators for OH&S and practicality; and implementation of the appropriate action eg temporary stop to enable search, rescue and relocation.

Stage 2 clearing monitoring focussed on supervision of habitat tree and log removal, primary hollow bearing trees and hollow-logs. This required an agreed procedure between the ecologist and plant operator for felling, and then inspecting the tree and all hollows eg turning over trees with hollows facing the ground and a chainsaw operator to cut sections to allow rescue.

Ecologists were on site for all clearing activities to carry out pre-clearing surveys, monitor clearing, relocate animals and care for those injured. The clearing reports list fauna species that were relocated, injured, euthanased or killed during this period. Refer Annex 10.

Monitoring was also undertaken during de-watering activities in February 2015. This involved rescuing and relocating native aquatic species from pools of water that were drained with pumps.

10.4 Results

Ecologists were present for all clearing activities. An ecologist was also present for dewatering of the box culvert on Service Road 2.

Stage 1 – Non-habitat Trees

Despite areas of dense groundcover and undergrowth present in the clearing area, no fauna were observed or rescued during the removal of non-habitat trees and the undergrowth. No fauna, bird nests or possum dreys were identified in any tree which was felled.

Stage 2 – Habitat trees

As mentioned in the pre-clearance report undertaken by Naturecall, 66 potential and actual hollow bearing trees were identified and flagged within the clearing limit. Some of these had been previously flagged for the Oxley Highway to Kundabung upgrade works. These were monitored by an ecologist at the time of clearing.

Habitat trees were brought down as slowly and gently as practically possible by the bulldozer, and checked by the supervising ecologist immediately after felling. This resulted in the capture of 4 Lace Monitors (*Varanus varius*), 1 Blackish Blind Snake (*Ramphotyphlops nigrescens*) and a den containing a family of Sugar Gliders (*Petaurus breviceps*). These are shown in photos in Appendix 1, Annex 10.

None of these animals appeared to be injured aside from one Lace Monitor which had some blood around its mouth from an abrasion but was otherwise fine. All captured fauna were successfully released into adjacent habitat offsite by the ecologist (the sugar gliders were held in a nest box until dusk). The location of fauna releases and habitat log relocations is shown in Figure 1 below.

In addition, hives of native stingless bees (*Trigona carbonaria*) were found in two trees (see Appendix 1). These were given to local native bee enthusiasts for rehabilitation and relocation.

De-watering

A number of native and non-native fish were captured with a small scoop net during de-watering at the culvert construction site on the quarry access road. Four native species were identified, these being the Longfinned Eel (*Anguilla reinhardtii*), Striped Gudgeon (*Gobiomorphus australis*), Firetail Gudgeon (*Hypseleotris galii*) and Empire Gudgeon (*Hypseleotris compressa*). Photos are provided in Appendix 1.

The eel was promptly relocated to the creek outside the works area. The rescued fish were temporarily placed in holding tanks during capture and relocated to the creek. The re-location points are shown in Figure 2.

No mortalities were recorded from the few fauna species that were captured during the clearing operations. Pre-clearing surveys did however detect a single Feathertail Glider (Photo 4) which was found dead on 29/7/14 on open ground near the western overpass abutment.

10.5 Discussion

The 2 stage clearing method required by RMS appeared to be effective in this project, as few fauna were captured during habitat tree removal considering the considerable number of hollows identified (Table 1, Annex 10).

All performance measures as reported in Annex 10 appear to have been met.

11. Nest Boxes

A total of 60 per cent of all nest boxes have been installed on the Project to date. This has included more than 150 on Stage 2 and more than 280 on Stage 3. The nest boxes include various sizes and features for a diversity of animals including, but not limited to, bats, gliders, possums, large and small owls, and various sizes of parrots. A number of these have been used to relocate individuals rescued during pre-clearing and clearing surveys. It should also be noted that a number of habitat features including logs, rocks and similar features have also been relocated within the Project boundary during the clearing process. These features supplement the extensive nest box installation program.

Monitoring of the nest boxes has yet to commence (Year 3).

12. Microbat Roost Boxes

12.1 Monitoring timing

Bat roost boxes were installed prior to the commencement of construction (Year 0) which was 6-12 months prior to plan roost exclusion from existing structures.

The approved EMP (Hyder 2014) states the following monitoring timing; 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.

12.2 Performance Measures

The approved EMP (HYDER 2014) and Construction Flora and Fauna Management sub-plans (Lend Lease 2014, McConnell Dowell OHL JV 2014) specify the following performance indicators of success of bat roost boxes:

- 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

12.3 Methods

The approved EMP (Hyder 2014) and in accordance with the *Microchiropteran Bat Management Strategy* (Lewis Ecological Surveys 2013) states that bat roost box monitoring will involve a visual inspection of each bat roost box and for 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 bat roost 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.

12.4 Results

A total of 158 bat roost boxes were installed in late September / early October 2013. For further details about the installation, please refer to RPS (2013). All boxes installed were tree mounted. The results presented in this report summarise the bat roost box monitoring undertaken in five monitoring events:

- event 1 - winter 2014
- event 2 - spring 2014
- event 3 - summer 2015
- event 4 - autumn 2015
- event 5 - winter 2015.

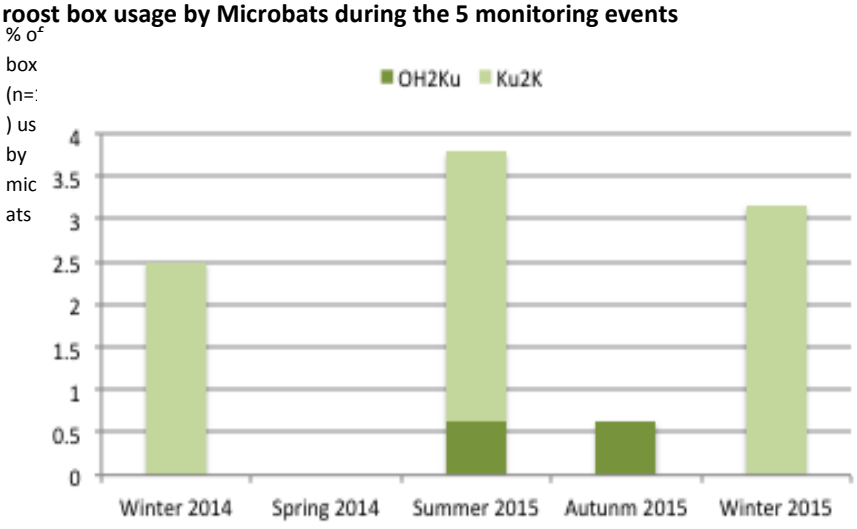
Table 12.1: Bat roost boxes installed

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**

The data has been collected from two difference sources. Sandpiper Ecological Surveys collected the data on behalf of Lend Lease for the project from Oxley highway to Kundabung and Lewis Ecological Surveys collected the data on behalf of McConnell Dowell OHL JV for the project from Kundabung to Kempsey. Please see Annex 9 for the raw data and the single event reports from Sandpiper Ecological Surveys and from Lewis Ecological Surveys.

In four of the five events all, 158 bat roost boxes were inspected. In summer 2015 only 146 boxes were monitored because the remaining 12 boxes, at Mel Properties land (ch. 1000-1550), after the spring 2014 inspection, on landowner request, were taken down and they were re-installed after the summer inspection in an adjacent property. In addition, 44 boxes were relocated during or just after the different monitoring events. Therefore, a total of 35.44% (56) of the bat roost boxes have been relocated through the five monitoring events, with the following reasons being provided; they were too close or within the alignment footprint or they have the wrong aspect and they were not overhanging water has as specified in the *Microchiropteran Bat Management Strategy* (Lewis Ecological Surveys 2013). However, it has been noted that some of the remaining boxes highlighted by Lewis Ecological Surveys still have not been installed in accordance with the *Microchiropteran Bat Management Strategy* (Lewis Ecological Surveys 2013). Roads and Maritime is investigating the relocation of any boxes that don't comply with the Bat strategy.

Figure 12.1: Bat roost box usage by Microbats during the 5 monitoring events



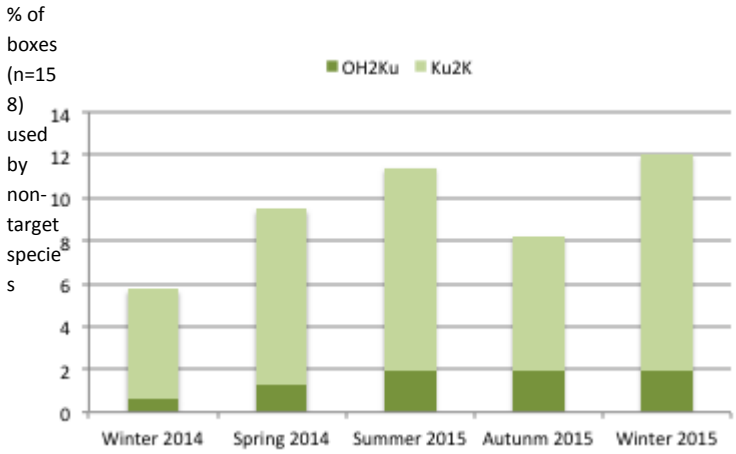
Microbats have been recorded inhabiting bat roost boxes in four events of the five undertaken: winter 2014 four boxes (2.5%); spring 2014 zero (0%); summer 2015 six (3.8%); autumn 2015 one (0.63%) and spring 2015 five (3.16%) (see Figure 12.1). These are clearly low occupancy rates and indicated little about use by bats at this time.

Some difficulty has been encountered inspecting the wedge-shaped boxes because they have a narrow <15mm entrance that limited the visibility to the floor and to a partial view of the internal roof.

Only the genus *Nyctophilus* (long-eared bat) has been specifically identified using the boxes: Lesser Long-eared Bat (*Nyctophilus geoffroyi*) and Gould's Long-eared Bat (*Nyctophilus gouldi*).

Bat roost boxes have been used more frequently by species other than microbats with 19 boxes have been found with signs of non-target fauna species inhabiting them (12.0 %). This has generally been evident in the form of a number of boxes being found with leaf litter nests probably constructed by either the Brown Antechinus (*Antechinus stuartii*), or the Feather-tail Glider (*Acrobates pygmaeus*). The numbers of boxes being seen to be used by other species appears to be gradually increasing (See Figure 12.2).

Figure 12.2: Bat roost box usage by non-target native species during the 5 monitoring events



An increasing number of boxes (7 in summer 2015, 12 in autumn 2015 and 13 in winter 2015) have been found with insect material such as mud wasp nest. These boxes weren't included in the non-target native species statistic because it was not possible to determine if they have been inhabited by native or introduce fauna species.

Only three boxes have needed minor maintenance to date. Other two boxes have indications of termites using them or the tree around them, but neither box shows obvious structural damage that would limit their functionality.

12.5 Discussion

The following is a discussion of how the results obtained to date compare against the performance measures and any recommendations arising.

Use of bat roost boxes by microbats.

The performance measures as in the approved EMP (HYDER 2014) of bats being recorded to use the nest boxes has been met in four of the five monitoring events; Microbats have been using the bat roost boxes during the monitoring program apart from spring 2014.

Only two species of bat have been specifically identified using the bat roost boxes: Lesser Long-eared Bat and Gould's Long-eared Bat. Neither species is listed as threatened in either state (*TSC* Act 1995) or federal (*EPBC* Act 1999) legislation.

Low rate of use of roost boxes by introduced fauna species.

Low rate was not defined in the EMP making it unclear as to what standard needs to be met. Arbitrarily for this report, but needing clarification in the future, the threshold to exceed a low rate has been assigned as ≥10%. This value will be used hereafter as the performance measure until a differing figure is determined to be used.

Based on this proposed threshold, the performance measure as in the approved EMP (HYDER 2014) has been met; no introduced fauna species have been recorded during the five monitoring events. The bat roost boxes with insect material such as spider webs and mud wasp nest inside haven't been counted as bat box used by introduced fauna species because no identification of the species was undertaken. The number of bat roost boxes with insect material is increasing each season and it reached its peak in winter 2015 with 13 (8.2%) boxes.

If the number of bat roost boxes inhabited by non-targeted fauna species increases to over the 10% threshold, corrective actions may be needed to remove them.

Low level of maintenance of roost boxes

The threshold to exceed a low rate was again not specified in the EMP and so again an arbitrary level of 10% has been set as the threshold. This value will be used unless a different threshold is specifically identified.

The performance measure as in the approved EMP (HYDER 2014) has been met; only 3 bat roost boxes during the five monitoring events have needed minor maintenance. Note that the removal of insect nests or nesting material may in the future contribute to maintenance requirements for bat roost boxes.

A total of 35.44% (56) of the bat roost boxes have been relocated through the five monitoring events. It has been noted that some of the remaining boxes have not been installed in accordance with the *Microchiropteran Bat Management Strategy* (Lewis Ecological Surveys 2013) and Road and Maritime Services is investigating the relocation of any boxes that don't comply with the *Bat Management Strategy.*

13. Maundia Habitat Protection

The results of the Maundia Habitat Protection detailed in Niche (2015c) are summarised below. Niche (2015c) is included as Annex 11.

13.1 Monitoring timing

Monitoring occurred in February and May 2015.

13.2 Performance measures

The approved EMP specifies the following performance indicators for *Maundia triglochinoides* (RMS 2014).

Success (protection of retained populations) is indicated by:

- Exclusion fencing, in place with signage identifying these as 'no go' zones.
- Sediment control fencing in place.
- Flowering and/or seeding is consistent with paired control and/or nearest reference site.

13.3 Method

Three paired 'impact - control' monitoring sites were identified to Niche by RMS staff in February 2015. Each monitoring location was surveyed in accordance with the monitoring method specified in the EMP (2014). In summary the following measurements were undertaken at each site:

- Current extent of cover using the Braun-Blanquet scale (20m X 20m quadrat or 400 m2). The monitoring area extends from the installed monitoring marker point into the water body, with the marker point located midway along the quadrat boundary.
- Average water depth was estimated for the quadrat.
- The extent of flowering or seeding (per cent of total number of observed plants within quadrat).
- Signs of recruitment (per cent of total number of observed plants within quadrat).
- Signs of disturbance (i.e. cattle) and to what extent/area.
- Specific photo point installed.

13.4 Key results

Maundia triglochinoides was determined to be present at one monitoring location within the Project boundary. No data exists to demonstrate that the species was present at the other monitoring locations previously. Where observed, the species is at a high abundance in a relatively small area. Flowering and seed set was evident at this site. Management controls (protection fencing) were found to be in place. The monitoring data currently indicates that lifecycle processes for *Maundia triglochinoides* are persisting during the construction phase currently occurring adjacent to the known location of this species. Further details are included in Annex 11.

13.5 Discussion

General compliance with performance indicators 1 and 2 as specified in the *Maundia triglochinoides* monitoring program has been achieved to prevent further unauthorised habitat loss (i.e. fencing and signage to protect the locations of *Maundia triglochinoides* within the Project boundary). Limitations in the data available, no previous data present for the monitoring sites, have prevented the use of statistical analyses to assess the Project's impact in this manner. Further details are included in Annex 11.

14. Green Thighed Frog Ponds

Green-thighed Frog Ponds are not required to have been constructed until 12 months after clearing has completed in those areas, and as such, this requirement is not yet applicable. Note that monitoring will commence in Summer in Year 2/3 as per the EMP.

15. Landscape Monitoring

Landscape monitoring involves assessing the efficacy of landscaping actions. These surveys have yet to be completed, and thus are not included in this report.

References

Hyder Consulting Pty Ltd (2014) Oxley Highway to Kempsey Pacific Highway Upgrade Ecological Monitoring Program 19 September 2014. Prepared for Roads and Maritime Service (RMS) by Smec Hyder Joint Venture.

Lend Lease (2014) Construction Flora and Fauna Management Sub-Plan: Oxley Highway to Kundabung. Prepared by Lend Lease for the Roads and Maritime Service, Sydney.

Lewis, B.D (2014). Pacific Highway Upgrade: Oxley Highway to Kempsey Pre-construction Spring and Summer Baseline Monitoring. Report prepared for RPS-RMS by Lewis Ecological Surveys.

Lewis Ecological Surveys (2013a) Pacific Highway Upgrade: Oxley Highway to Kempsey Green-thighed Frog Management Strategy. Prepared for Roads and Maritime Services by Lewis Ecological Surveys.

Lewis Ecological Surveys (2013b). Pacific Highway Upgrade: Oxley Highway to Kempsey Microchiropteran Bat Management Strategy. Prepared for Roads and Maritime Services by Lewis Ecological Surveys.

McConnell Dowell OHL JV (2014). Construction Flora and Fauna Management Sub-Plan: Kundabung to Kempsey. Prepared by MacDonnell Dowell OHL JV for the Roads and Maritime Service, Sydney.

Niche (2105a). Giant Barred Frog monitoring Baseline Surveys – Oxley Highway to Kempsey, Pacific Highway Upgrade. Prepared for Roads and Maritime Services.

Niche (2015b). Squirrel Glider monitoring Baseline Autumn 2014 Surveys – Oxley Highway to Kempsey Pacific Highway Upgrade. Prepared for Roads and Maritime Services.

Niche (2015c). OH2K Pacific Highway Upgrade *Maundia triglochinoides* Monitoring 2015. Prepared for Roads and Maritime Services.

RPS AUSTRALIA EAST PTY LTD (2013). Pacific Highway Upgrade: Oxley Highway to Kempsey Microchiropteran Roost Box Installation. Prepared for Roads and Maritime Services.

Annex 1 OH2K Ecological Monitoring Program (EMP) (Hyder 2014)

Available online at the following link:

http://www.rms.nsw.gov.au/projects/northern-nsw/oxley-highway-to-kempsey/project-documents.html

Annex 2 Green-thighed Frog management strategy

Available online within the Construction Flora and Fauna Management Plans, at the following link:

http://www.rms.nsw.gov.au/projects/northern-nsw/oxley-highway-to-kempsey/project-documents.html

Annex 3 OH2K Pre-construction Spring and Summer Baseline Monitoring

OXLEY HIGHWAY TO KEMPSEY

PRE-CONSTRUCTION BASELINE MONITORING: WINTER-SUMMER

SEPTEMBER 2014

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The client (RPS) may only use this document for the purposes for which it was commissioned. This report relies upon data, surveys, measurements and results based on a short-term objective study in response to a brief provided and largely defined by the client (RPS: Jesse Death). Although conclusions have been based on the available data at the time, some professional judgement has been applied in reaching these conclusions due to the temporal limitations arising from the dynamic nature of available information, legislation, schedules, individual species and associated habitats. Every attempt has been made to ensure the accuracy and objectivity of the report's findings, conclusions and recommendations. Lewis Ecological Surveys does not accept responsibility for its use beyond the scope of works.

……
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Lyndall Thornhill (RPS Group) - Project management and logistics.

Barbara Triggs (Dead Finish) – Hair tubes analysis.

Photography - Lewis Ecological Surveys © else stated

Top – Road kill Koala (*Phascolarctos cinereus*) from ch. 32700 on the 10th September 2013 (left) and example of crossing structure used to reduce road strike on the adjacent Kempsey Bypass project (right).
Bottom – Giant Barred Frog (*Mixophyes iteratus*) from Smiths Creek.

Report to be cited as: Lewis, B.D (2014). Pacific Highway Upgrade: Oxley Highway to Kempsey Pre-construction Spring and Summer Baseline Monitoring. Report prepared for RPS-RMS by Lewis Ecological Surveys. ©

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ABBREVIATIONS

Abbreviation	Description
RMS	Roads and Maritime Services
LES	Lewis Ecological Surveys
Ch.	Chainage
MCoA	Minister's Condition of Approval
TSC	Threatened Species Conservation Act (1995)
EPBC	Environmental Protection and Biodiversity Conservation Act (1999)
LHPA	Livestock Health and Pest Authority
PWG	Parks and Wildlife Group

1.0 Introduction

1.1 Background

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 Environmental Assessment 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 Department of Environment (formerly Department of Sustainability, Environment, Water, Population and Communities) on 17 August 2012. On 21 September 2012, DOE determined that the Project was a controlled action under section 75 and 87 of the *Environmental Protection and Biodiversity Conservation Act 1999* (*EPBC* Act). On 5 October 2012, DSEWPC requested further information in order to assess the impacts of the Project under the EPBC Act.

An Ecological Monitoring Program (EcMP) 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).
Broadly, this EcMP 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; and
    - 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.

- 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.

2.0 The Scope

Lewis Ecological Surveys was engaged to provide survey design advice and conduct a number of the baseline surveys prior to construction commencing. This included:

- Review Environmental Protection Authority (EPA) comments and develop a survey design for implementing a baseline survey for the Spotted-tailed Quoll (*Dasyurus maculatus*);
- Implement the spring and summer monitoring program for the Giant Barred Frog (*Mixophyes iteratus*) including Chytrid testing during summer only;
- Implement the baseline Koala monitoring survey as described in the EcMP prepared by SMEC-Hyder JV;
- Develop and implement a Yellow-bellied Glider baseline monitoring program using the survey technique outlined in the EcMP;
- Implement the summer Brush-tailed Phascogale (*Phascogale tapoatafa*) baseline monitoring program;
- Perform road kill surveys of the entire existing carriageway in Spring and Summer.

The following reports on each of these components which have been presented as separate sections within this report. Each section provides a brief introduction, survey design and techniques, results, some discussion on the findings and some key recommendations along with supporting documentation and field data to service the autumn round of pre-construction baseline surveys and the post construction monitoring. The sections include:

Section 3 – Spotted-tailed Quoll;

Section 4 – Koala;

Section 5 – Yellow-bellied Glider;

Section 6 – Brush-tailed Phascogale;

Section 7 – Giant Barred Frog; and

Section 8 – Road kill surveys.

3.0 Spotted-tailed Quoll

3.1 Introduction

The spotted-tail quoll (hereafter 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 no suitable den and latrine sites in the form of rock shelters and small caves whilst large logs were described as being 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. The most likely areas were described as the riparian and moist gully forest, which constitutes approximately 11.5 hectares and 40 hectares respectively of the study area (GHD 2010).

Earlier reviews of the EcMP by the EPA indicated a more detailed monitoring program was required to collect pre-construction baseline information on the quoll. In response to this Lewis Ecological Surveys was commissioned to develop a stratified sampling design using BACI (Before-After-Control-Impact) survey design principals outlined below.

3.2 Survey Design For Camera Surveys

In order to more fully gauge the distribution of quoll across the Project area the three largest patches of contiguous vegetation were identified because they provided the most obvious form of habitat linkage for a species that exhibited a large home range (175-1000 ha) and the non-overlapping nature of female ranges necessitate very large areas of habitat to support viable populations (Glen and Dickman 2006). Given this, the following areas were identified:

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

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

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

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

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

Figure 3-1. Distribution of treatments and camera trap locations for the Spotted-tailed Quoll pre-construction baseline survey.

The above survey design was repeated at three locations to provide a stratified sampling design of three replicates of each treatment within each of the three survey areas (Cairncross, Ballengarra, Maria River). This resulted in 9 x 100 ha survey plots across three treatments for each area culminating in 2700 ha (Table 3-1).

Bus tour Monday Table 3-1. Summary of monitoring sites for Spotted-trailed Quoll.

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

3.3 Camera Traps Sampling Regime

The adopted sampling regime was commensurate to the Department of Sustainability and Environment Approved Survey Standards: Spot-tailed Quoll *Dasyurus maculatus maculatus* publication (DSE 2011). Four infrared cameras (Scoutguard 560 P model) were installed 500 m apart across each 100 ha plot with three plots representing each treatment (n=12 cameras) for each of the large patches of vegetation. Cameras were set in continuous 24 hour mode for a minimum of 21 nights using the following parameters:

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

Cameras were installed between the 8 and 14th August 2013 and retrieved between 22-26 days later culminating in 2340 nights of survey effort. At the time of their installation, an olfactory predator lure consisting of chicken drumsticks and 2-3 West Australian Pilchards (*Sardinops sagax*) were used to smear in the immediate vicinity on logs, stone, the base of trees and the remnants hidden within cavities of fallen branches and logs. The objective of this was to reduce the opportunity for a single animal to remove the olfactory lure and improved the opportunity to capture readily identifiable images of fauna entering the recording area. The use of fish as a bait for quoll has been previously demonstrated in Limeburners Creek Nature Reserve when fish heads were used extensively for the trapping program (*see* Andrew 2005).

3.4 Recording of Habitat Variables

At each of the camera stations, the following habitat attributes were 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; and
- Abundance and type of tree and log hollows.

3.5 Interpreting the Camera Data

All images were reviewed by one person (BDL). The maximum abundance or activity levels for any species within a given 1 hour period was one and this applied to quoll, eutherian predators and suitable prey items (i.e. small and medium sized mammals). The only exception to this was where the individuals could clearly be identified from another within that 1 hour period. For example, a tortoise shell Feral Cat that was repeatedly photographed on 10 occasions over the spaced of 30 minutes was counted as a single record of occurrence whilst a tabby coloured cat captured during the same period would allow the counting of a second animal.

3.6 Considerations of Predator Prey Relationship

A quoll study at Limeburners Creek Nature Reserve 5-10 km east of the Upgrade revealed more than half of their diet (63.5%) was comprised of mammals and only 8.8% bird with the residual made up of insects, fish, reptiles and garbage (Andrew 2005). Similarly, studies of quoll in the upland areas of the mid north coast have also reported similar high rates of mammalian consumption, particularly medium sized mammals such as bandicoots (e.g. Glen and Dickman 2008). In an attempt to understand the presence and abundance of this size class in the study area the number of medium and smaller mammals captured by the camera traps was also considered. The three particular classes of interest were arboreal fauna which regularly come to the ground (possums), bandicoots and smaller ground dwelling mammals such as rodents and Antechinus. Their presence and the number of recorded images was recorded in the same manner as described in Section 3.4.

3.7 Considerations of Competitive Interaction with Eutherian Predators

The number of eutherian predators including Feral Cat (*Felis catus*), Wild Dog/Dingo (*Canis familiaris*) and Red Fox (*Vulpes vulpes*) was also considered within each treatment because they are suspected at influencing quoll distribution via competitive interactions for prey (Glen and Dickman 2008). The numbers of each species was calculated to provide a mean abundance for each treatment at each of the three areas. The results were calculated as sample means and graphed using histograms with standard error bars.

3.8 Other Techniques - Road Kill Monitoring

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

3.9 Results

3.9.1 Camera Retrieval

Field surveys retrieved 103 (95%) of the 108 installed cameras with the residual being stolen during the course of the field survey. Two of the retrieved cameras had suffered equipment malfunction leaving 101 functioning cameras which recorded 27208 images (mean=272., SD=469).

3.9.2 Spotted-tailed Quoll

i. Updated Desktop Surveys

Database searches (registered licence user CONO1022) identified 75 records of Spotted-tailed Quoll within 10 km of the Upgrade (Figure 3-2). 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. Oxley Highway 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 (Figure 3-2). Upon closer review of these records 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 Upgrade.

ii. Camera Traps

No Spotted-tailed Quoll were recorded during the survey.

iii. Road Kill Monitoring

No Spotted-tailed Quoll were recorded during the road kill traverses. Other types of dasyurid were recorded during the monitoring period including a road killed Brush-tailed Phascogale near Stumpy Creek in 2010 and several Brown Antechinus near ch. 36000 and throughout the Ballengarra State Forest (ch. 20000-25000) in 2012 and 2013.

3.9.3 Abundance Indices of Suitable Prey Items

The camera traps in Cairncross State Forest recorded only 11 images comprising seven possums and four bandicoots from 808 camera trap nights. In Ballengarra State Forest the number of native prey items recorded doubled with 22 images from 826 camera trap nights comprising 13 possum, four bandicoot and five dasyurid and rodents. In Maria River State Forest the number of native prey items recorded was four images from 706[1] camera trap nights comprising three possum and one bandicoot and no dasyurid and rodents.

3.9.4 Abundance Indices of Introduced Eutherian Predators

i. Types and abundance of Eutherian Predators

In Cairncross State Forest there were 188 images of introduced eutherian predator comprising 48 wild dog, 101 fox and 39 feral cat. The majority of the wild dog images were recorded from the Cairncross reference location to the west of Pembrooke whilst most fox images were associated in areas proposed for no mitigation (Figure 3-3).

In Ballengarra State Forest there were 125 images of introduced predator comprising 51 wild dog, 48 fox and 26 feral cat. The majority of the wild dog and fox images were recorded from the reference location to the west of the Upgrade in the Gum Scrub area whilst Feral Cat showed a consistent presence across all three treatments (Figure 3-3).

In Maria River State Forest there were 206 images of introduced predator comprising 79 wild dog, 96 fox and 31 feral cat. The majority of the wild dog and fox images were recorded from the reference location to the east of the Upgrade whilst Feral Cat showed a consistent presence across all three treatments (Figure 3-3).

[1] Most of the cameras were stolen from this sampling unit.

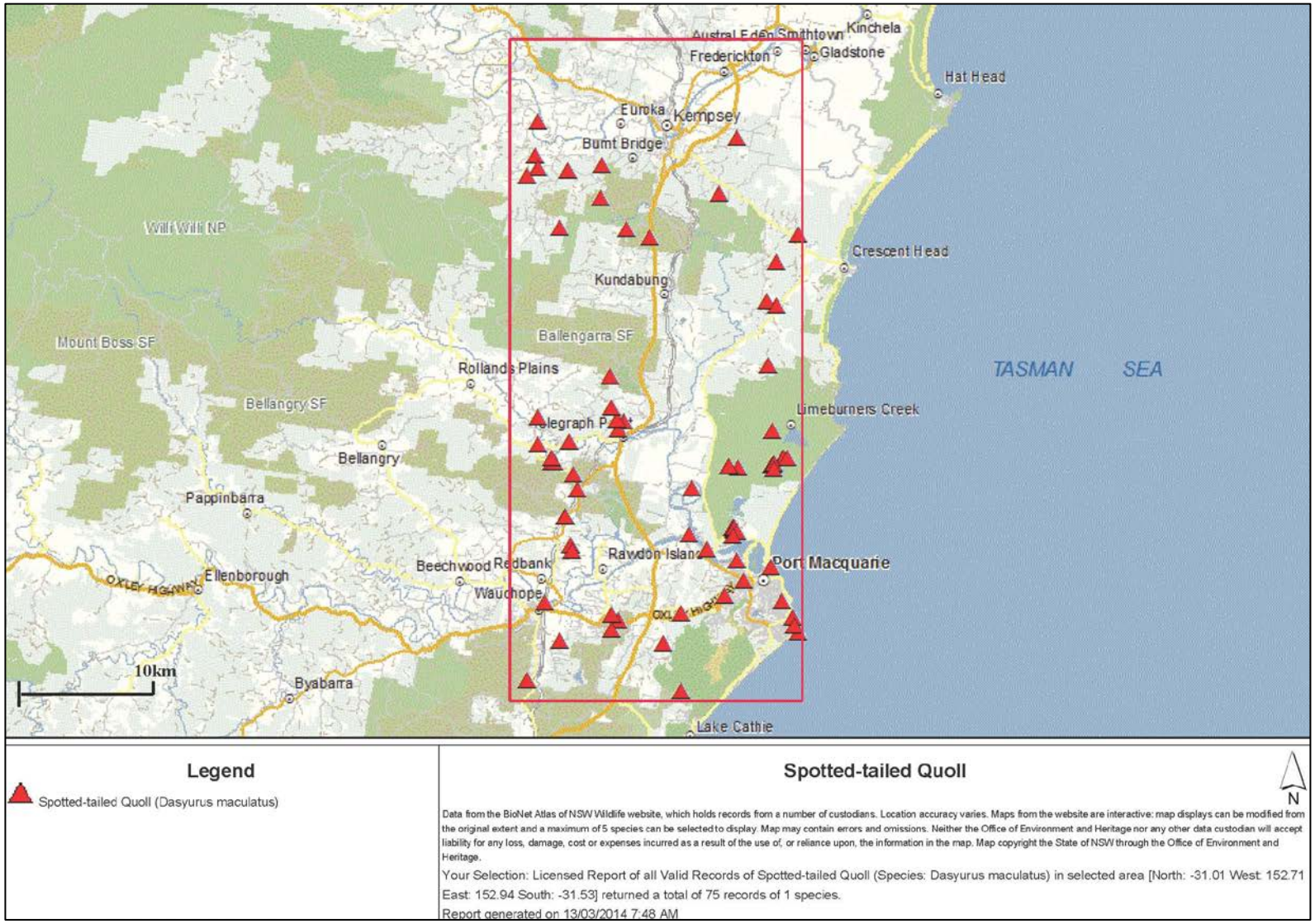

Figure 3-2. Distribution of Spotted-tailed Quoll records in the study area.

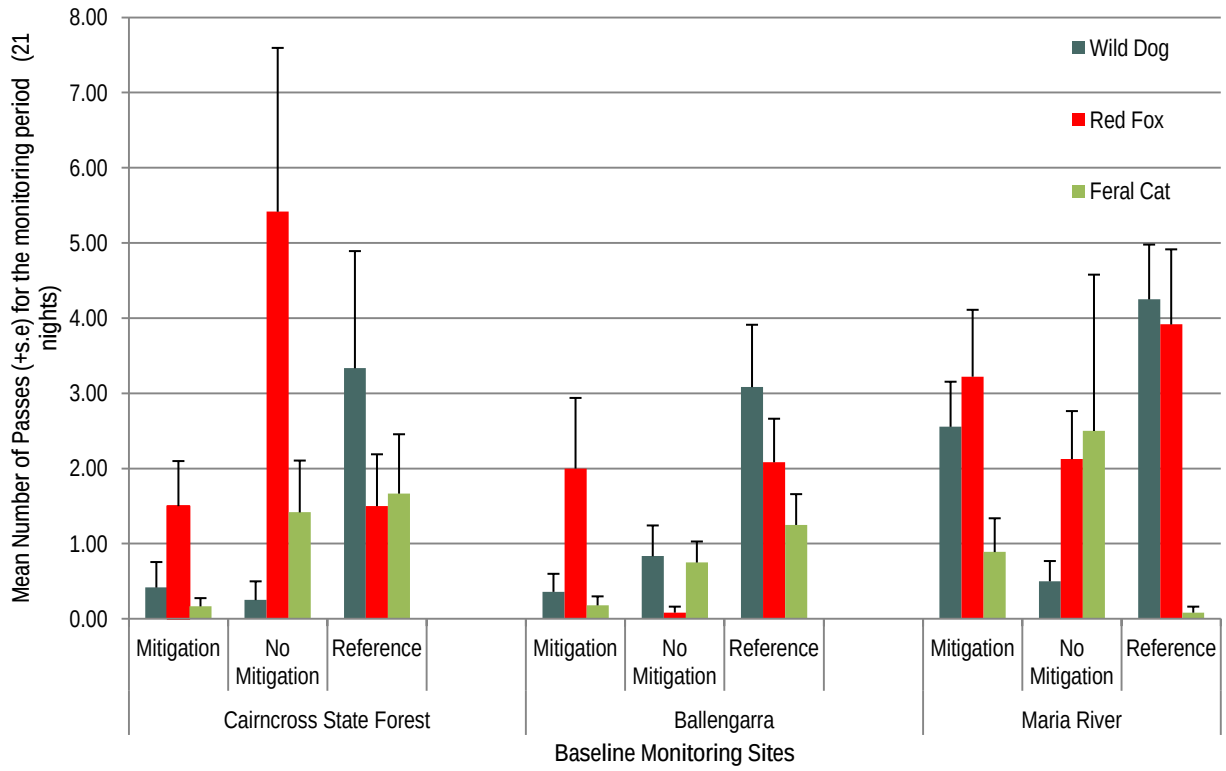

Figure 3-3. Mean number (+s.e bars) of wild dog, red fox and feral cat across each treatment for the monitoring period.

ii. Eutherian Abundance Between Treatments

The highest mean levels of eutherian predators occurred at the reference sites with the activity levels almost three times higher than the mitigation treatment at Cairncross State Forest and Ballengarra State Forest (Figure 3-4). At Maria River State Forest all three treatment classes scored relatively high with the reference site containing the highest overall mean abundance of eutherians.

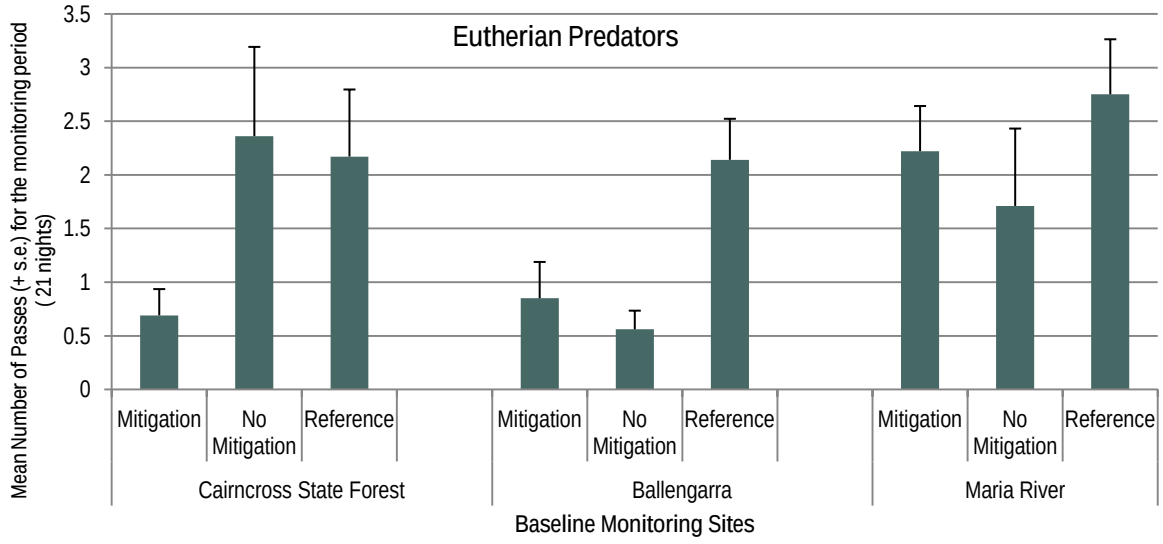

Figure 3-4. Mean number (+s.e bars) of eutherian predators across each treatment for the monitoring period.

3.10 Discussion

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

Other factors should also be considered to have influenced the survey results. The prevailing weather conditions were dry with virtually no rainfall recorded throughout the monitoring period, thus ensuring the chicken baits and pilchards remained effective lures so this is unlikely to have had a negative effect on the survey. The seasonal effect of conducting surveys during August and September best reflects a survey investigating habitat use during the post mating breeding period when breeding females may spend much of their time nurturing young in a den resulting in changed patterns of habitat use from other times of the year. It is unclear whether male Spotted-tailed Quoll undergo the dasyurid 'die off' in the weeks preceding mating but if this is the case then fewer males would have been present during the survey. For example, a radio tracked male quoll in Limeburners Creek Nature Reserve underwent dramatic loss in body weight, possible anaemia, hair loss and excessive parasite load indicating that such a 'die off' is possible (*see* Andrew 2005).

The review of historic records on the NSW Bionet Atlas found a lot of variability in the seasonal reporting rates of quoll with records for every season and the majority of all records originating from a community survey administered by Dan Lunney. Nonetheless, the only record of Quoll using the Upgrade corridor was the road kill individual from mid July 1992 and combined with the research into this species in Limeburners Creek Nature Reserve it would suggest that other times are more suitable for monitoring quoll. For example, surveys conducted between July and October would provide information on habitat use during the breeding period with females in particular using smaller home ranges than they would during the non breeding period. For the purposes of this Upgrade an understanding of how the Project may affect local population viability and broader movements associated with dispersal would benefit from monitoring during the dispersal period regarded as between March and May when juveniles establish new home ranges and adults re-establish their non breeding home ranges. If patterns of habitat use during an alternative period of increased activity were required then the mating period between mid May to mid July would also be an optimum time. Future monitoring should align with these two time periods.

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

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

3.10.1 Influence of Eutherian Predators

The exact influence eutherian predators have on quoll across the broader area is unknown because the former was found to be widespread and relatively common. In fact, it was the reference sites which often supported the highest levels of eutherian activity with the highest of these being the Maria River reference site which had been located in the northern end of Maria River National Park within a few kilometres of the Kempsey landfill site. By contrast, the research conducted in Limeburners Creek Nature Reserve reported low densities of eutherians and there was evidence to

support quoll may have occasionally benefited from this as individuals foraging on the left over spoils of larger mammals including Swamp Wallaby and Eastern Grey Kangaroo (Andrew 2005). The natural geographical barriers of the Hastings River, Maria River, different vegetation communities with dense heaths and woodlands supporting dense shrub layers and perhaps a more strategic predator control program may best explain this as the two areas were often not more than 5-10 km apart. It is also unclear what current predator control programs are in place for areas used in this study.

The abundance of medium sized mammals, particularly bandicoots has been demonstrated as an important dietary component for quoll on the coastal plains (Andrew 2005) and the upland areas of the Great Dividing Range (Glen and Dickman 2008). Given the Upgrade occurs between these two areas it is expected that medium sized mammals would also form an important dietary component for quoll. The fact that both studies also reported medium sized mammals as the most important prey class for eutherian predators would indicate a potential for exploitative interactions. In this study, very few medium sized mammals were recorded with the cameras with Ballengarra State Forest reporting twice the number of medium sized mammals than Cairncross State Forest and Maria River State Forest supporting far fewer. To overcome these exploitative interactions, previous studies have suggested the broader dietary habit of quoll as secondary prey including those with arboreal habits that may assist with coexistence (Glen and Dickman 2008). Therefore, in areas with high levels of introduced predators then more structurally diverse communities which have the capacity to support a more biologically rich source of prey items may become increasingly important for quoll. Obvious examples of these in the Upgrade corridor include Maria River, Barrys Creek and it would be expected that individuals would periodically traverse along Pipers Creek, Smiths Creek and Cooperabung Creek. The value of Wilson River and Hastings River is currently unknown but the latter is surrounded by open grazing land for at least 1 km either side of the northern shoreline and for several kilometres on the southern bank. The Upgrade has designed bridges at all of these locations and their value at providing fauna connectivity has been previously recognised and supported by the EPA.

3.11 Key Recommendations

1. Any subsequent monitoring is undertaken either during the documented dispersal period of March-May or alternatively May-mid July during the mating period.
2. A reference site should be located in known quoll habitat in Limeburners Creek Nature Reserve to improve our understanding of detection probabilities of quoll using remote cameras.
3. The study would benefit from retracting the current BACI survey design of three treatment classes to a paired sampling BACI design involving an impact site and a paired control/reference site. This is because the opportunities for locating 'no mitigation control sites' along the Upgrade corridor is limited because of the mobility of the target species which can travel up to 5-6 km in a single night combined with the presence of fauna mitigation devices (i.e. fauna underpasses) to facilitate fauna connectivity often located only 2-3 km apart and often much closer. The reduction in the number of treatments would allow for an increase in the number of within treatment replicates from three to four (i.e. keeping similar overall survey effort).
4. The study performed by Debbie Andrew should form a key document for the quoll monitoring program.
5. Information on the extent of wild canid control programs should be collected from the Livestock Health and Pest Authority (LHPA) and Parks and Wildlife Group as part of each monitoring event.

3.12 References

Andrew, D.L. (2005). Ecology of the Tiger Quoll *Dasyurus maculatus maculatus* in coastal New South Wales. Masters Thesis. University of Wollongong.

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4.0 Koala

4.1 Introduction

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

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

4.2 Survey Design and Method

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

4.2.1 Measuring Koala Distribution

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

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

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

4.2.2 Measuring Koala Activity

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

1) Locate and mark a tree that is:

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

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

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

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

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

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

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

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

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

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

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

4.2.3 Measuring Koala Density

Koala density was measured in three ways:

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

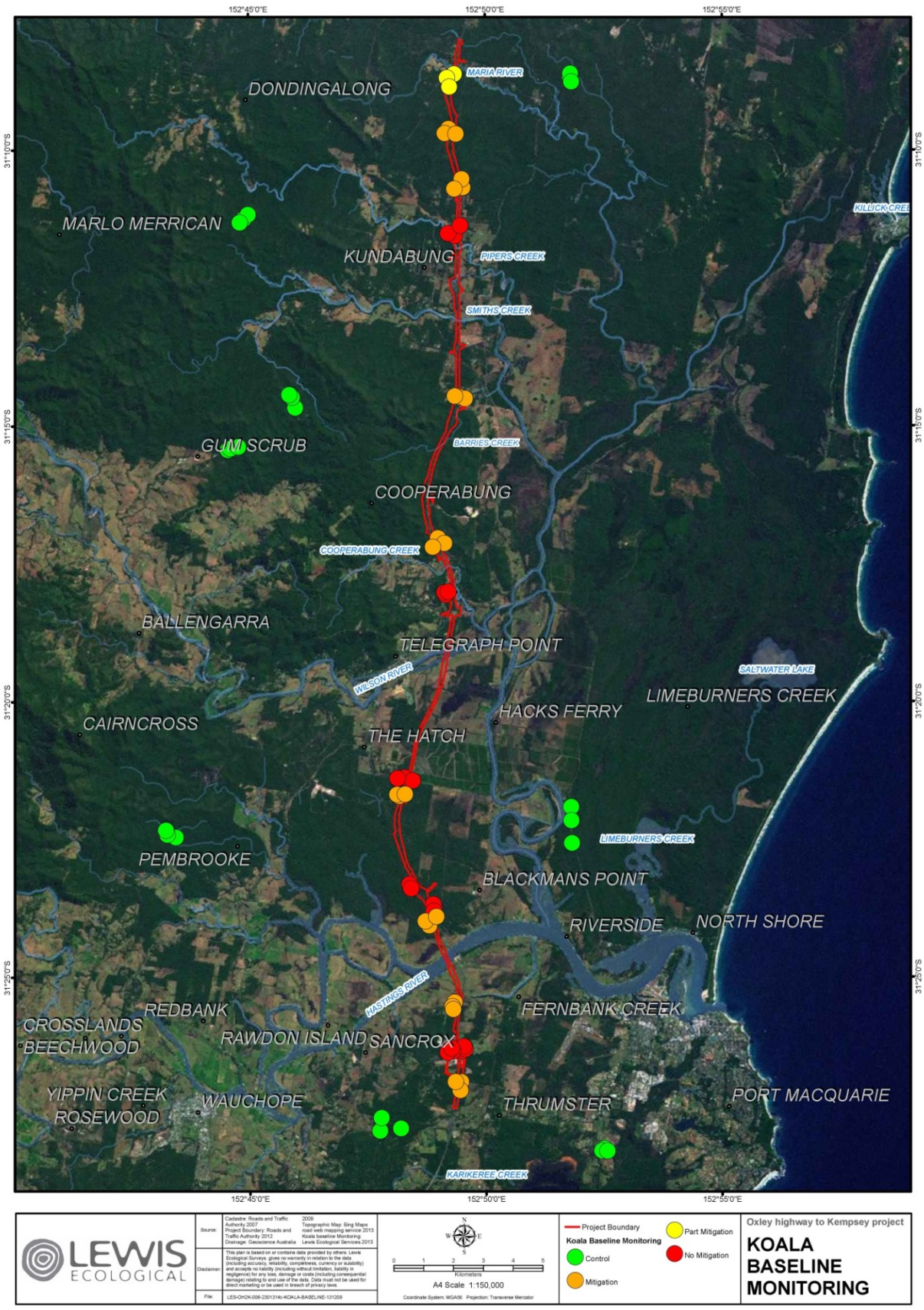

Figure 4-1. Distribution of Koala monitoring sites and treatment classes used during the pre-construction baseline survey.

i. Grid Based Sampling Using Historic Data

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

ii. Spotlighting

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

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

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

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

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

iii. Camera Traps

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

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

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

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

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

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

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

Camera Traps Sampling Regime

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

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

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

Table 4-3. Summary of camera monitoring sites.

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

Interpreting the Camera Data

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

4.2.4 Assessing Koala Habitat Use

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

i. Assessing Habitat Use Throughout the Study Area

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

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

ii. Assessing Habitat Use at a Tree Species Scale

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

4.2.5 Assessing Koala Movements

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

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

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

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

4.3 Results

4.3.1 Koala Distribution

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

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

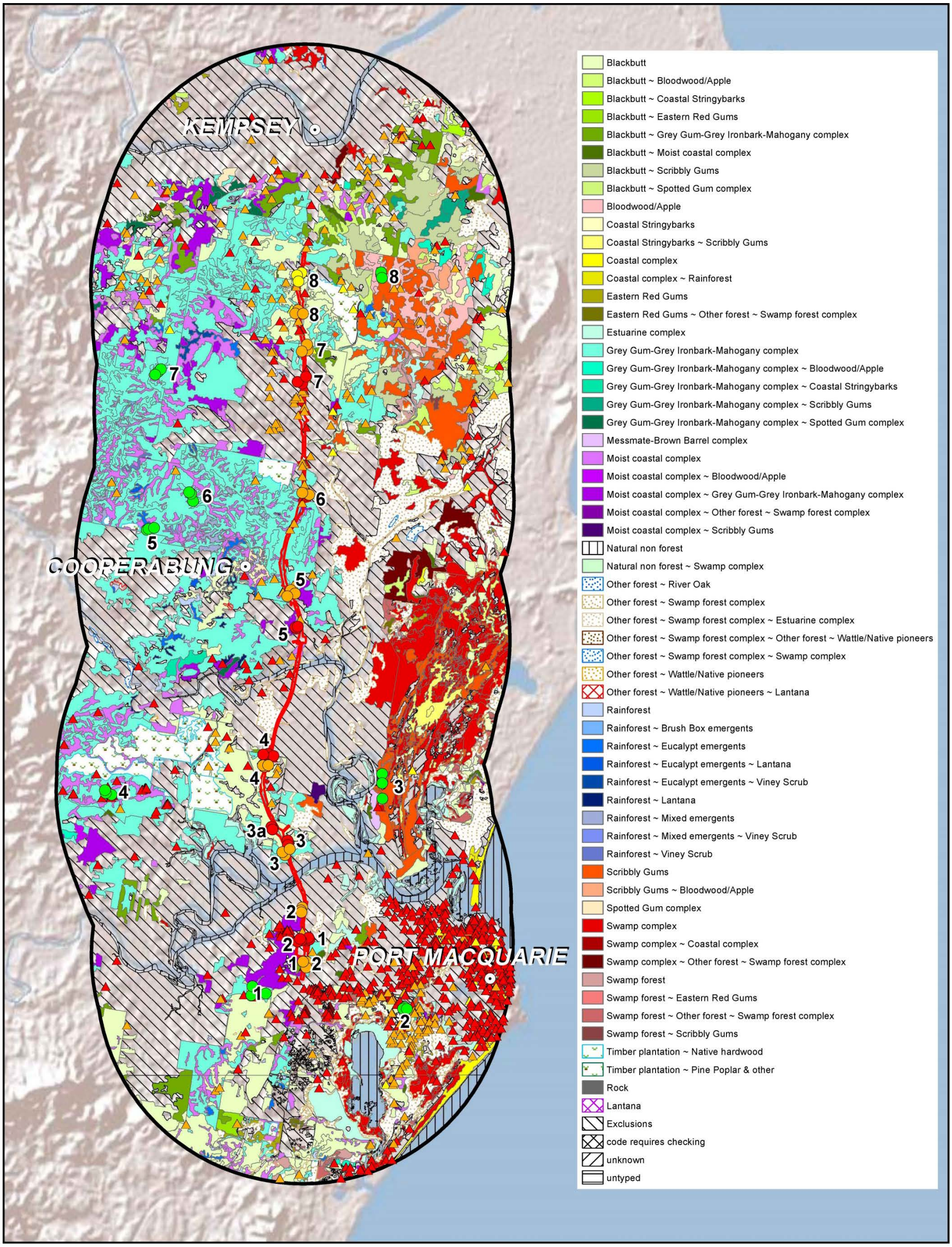

Figure 4-3. Koala distribution through the study area at three chronological scales.

4.3.2 Koala Activity

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

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

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

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

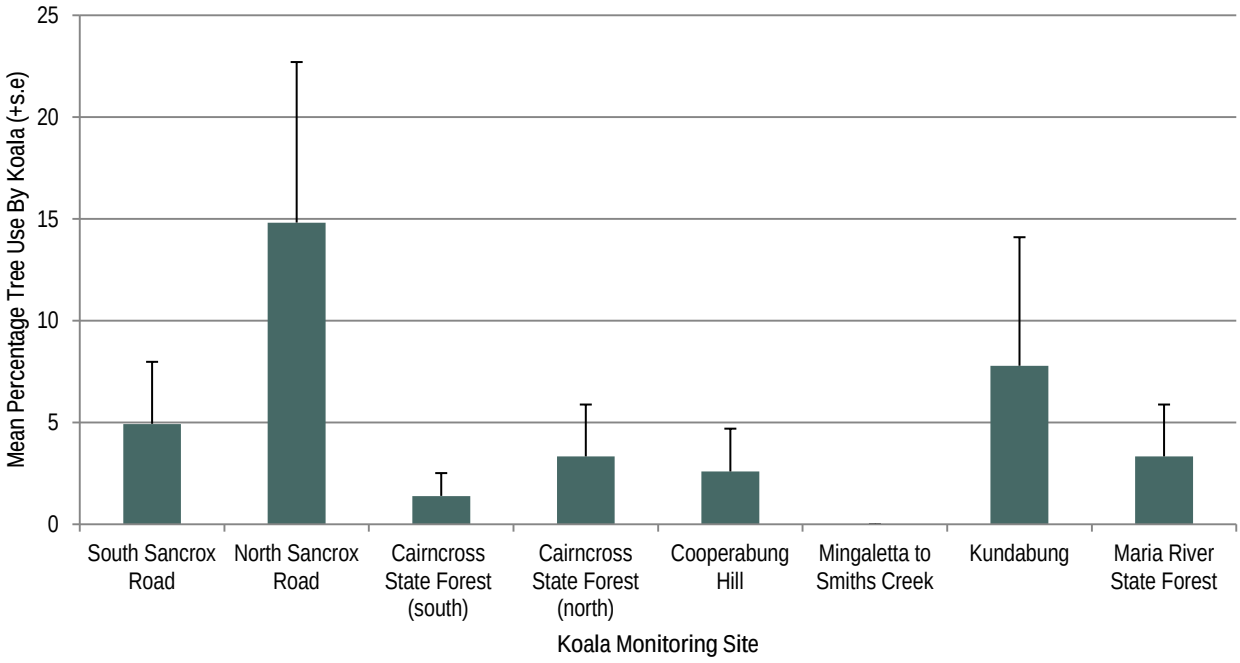

Figure 4-4. Mean (+s.e) SAT activity levels at each of the eight Koala monitoring areas.

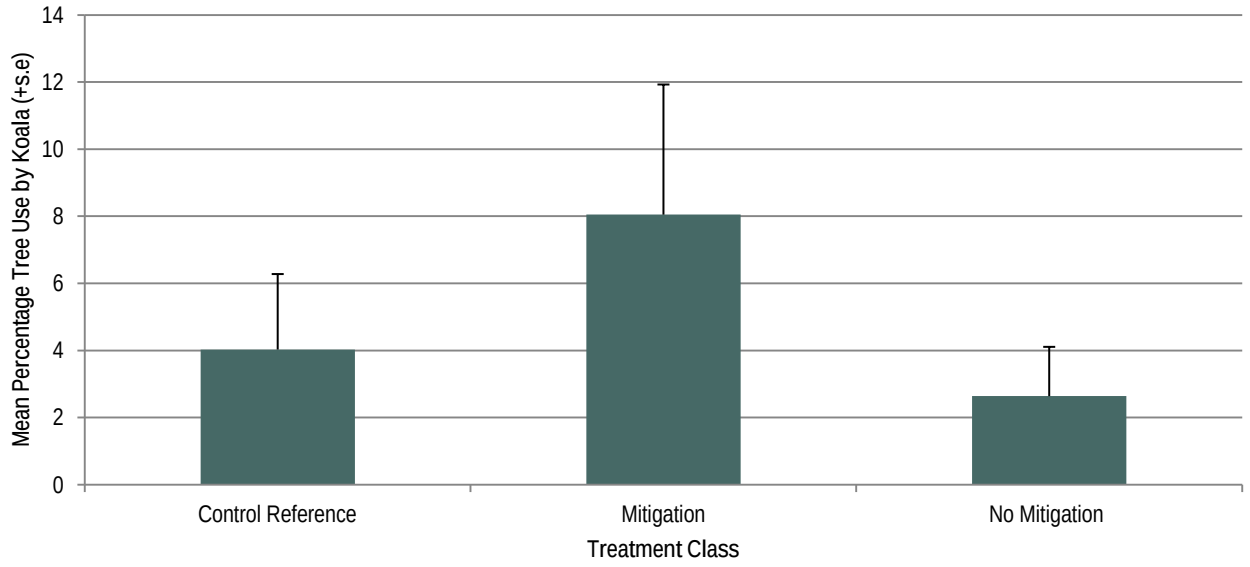

Figure 4-5. Mean (+s.e) Koala use between the three treatment classes.

4.3.3 Koala Density

i. Density Estimate Across the Entire Study Area

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

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

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

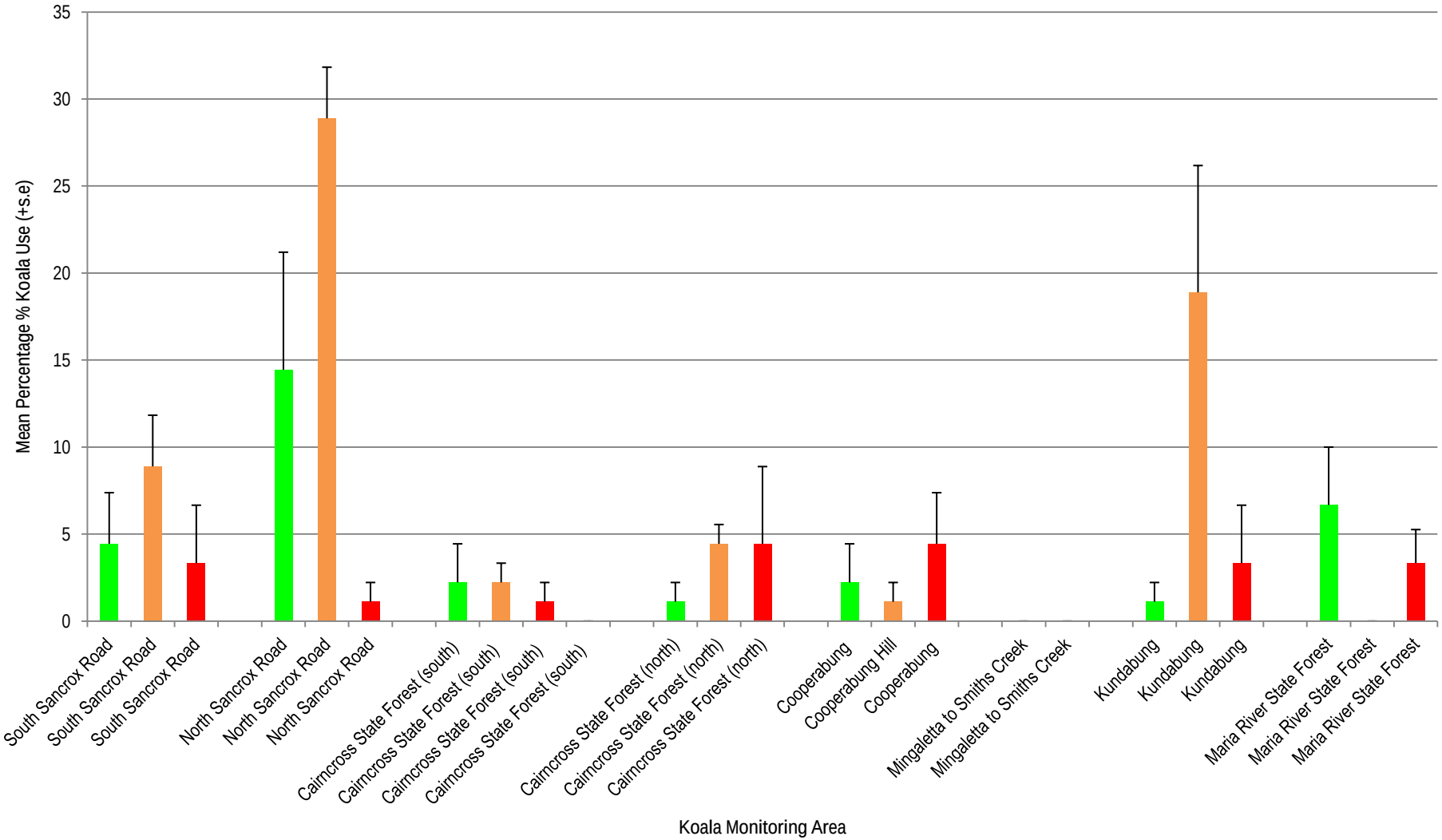

Figure 4-6. Mean recorded activity levels of Koala (+s.e) for each treatment across the eight monitoring areas. Treatment Types Control = Green; Mitigation = Orange, No Mitigation = Red

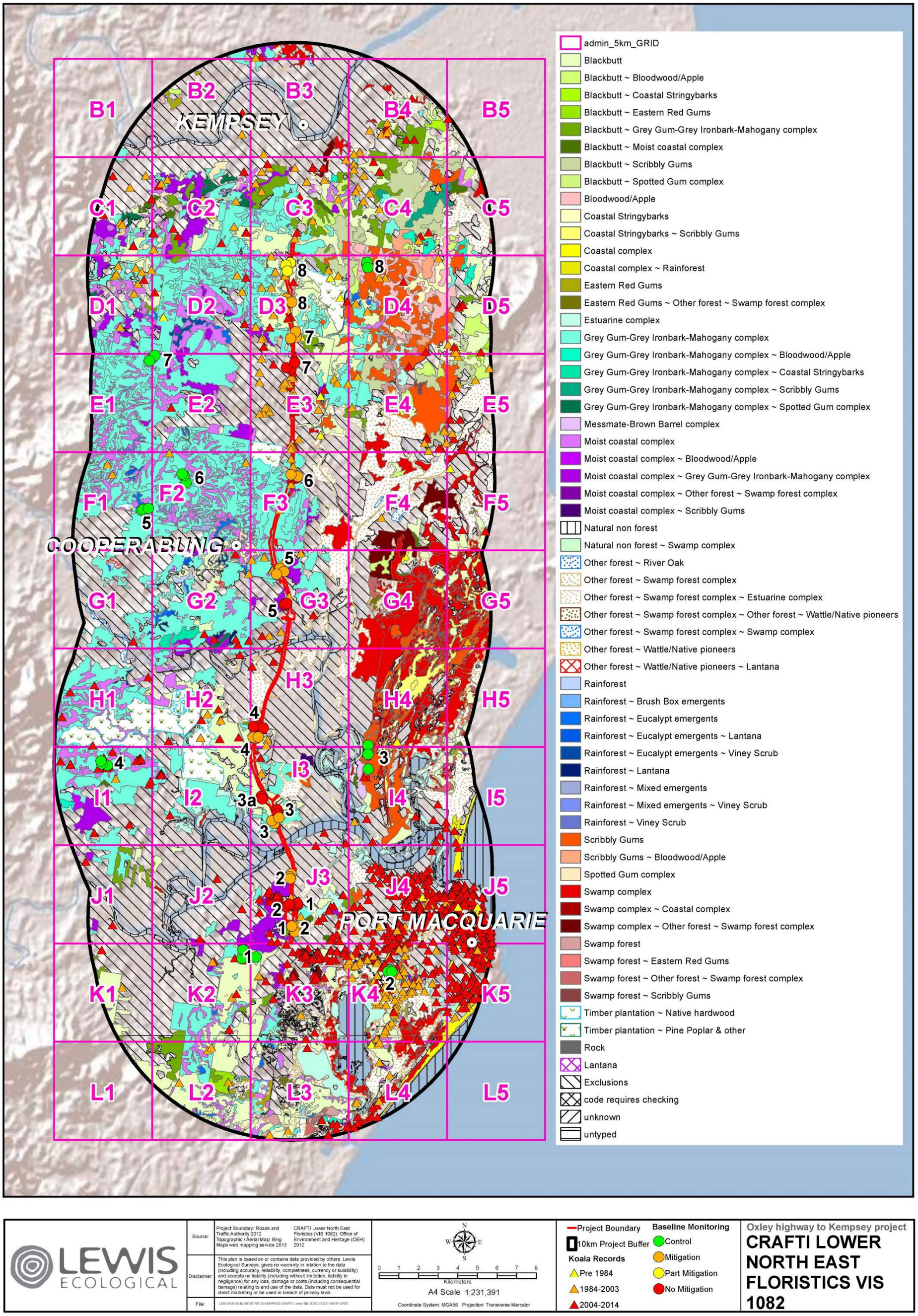

Figure 4-7. Density of Koala records across the study area.

ii. Baseline Count Data

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

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

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

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

4.3.4 Koala Habitat Use

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

i. Landscape and Vegetation Community Scale

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

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

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

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

ii. Tree Species Use

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

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

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

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

4.3.5 Koala Movements

i. Using Atlas Data to Predict Movements

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

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

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

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

ii. Koala Movements and Highway Interactions

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

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

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

4.4 Discussion of Findings

4.4.1 Koala Distribution

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

4.4.2 Koala Activity & Habitat Use

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

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

Both the low count data and the absence of Koala from some sampled sites does raise questions about the usefulness of the SAT technique in regrowth forests. For example, regrowth forests support a greater density of tree stems and Koala are likely to travel distances of many tens of metres to access their preferred feed trees. In this context, a SAT site checking 29 trees from the focal tree may not extend far enough to capture additional feed trees and thus returns a lower than expected activity level. In this context only a handful of preferred browse species may be sampled within a single SAT site as numerous other stems of less suitable species (i.e. *Allocasuarina*) require sampling. To compensate for this during the current baseline survey some additional techniques were used and this proved useful to confirm the continued existence of Koala. For example, the sampled SAT sites between Mingaletta and Smiths Creek returned zero activity, however, the use of camera traps confirm their continued existence in this area. This demonstrates the usefulness of monitoring programs which employ a multidisciplinary approach rather than those reliant on a single survey technique.

4.4.3 Koala Density

Koala density was measured in three ways during the current baseline survey. Spotlighting showed that Koala could be consistently recorded across a range of sclerophyll forests and at a consistent rate of 1 individual per hour effort. This recording rate was heavily reliant on detecting vocalising males indicating that any future monitoring event must be undertaken during the breeding season. One problem encountered during the spotlighting surveys was the presence of an often dense mid stratum reducing the permeability of the light. This was often confounded by the fact that more suitable feed trees were generally found on the lower slopes and gullies which supported this dense mid stratum vegetation.

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

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

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

4.4.4 Koala Movements

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

4.4.5 Performance Indicators

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

- Monitoring being undertaken before and after construction of the upgrade;
- Monitoring being undertaken at impact and control sites; and
- The continued presence of Koalas at sites where it was identified during baseline surveys.

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

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

4.5 Key Recommendations

1. Ensure any future comparison of Koala activity levels take into account the following baseline data and with a 10% tolerance level to account for variability:
    a. Broader study area set at 5% activity;
    b. The three treatment classes of Mitigation set at 8.05%, control reference set at 4.03% and no mitigation set at 2.64%.
2. Ensure habitat use takes into account the proportion of each tree species used versus that actually sampled. Table 4-5 provides an opportunity for direct comparison.
3. Set the density baseline monitoring to 1 individual per 1 hour of spotlight effort and ensure monitoring is performed during spring to coincide with the breeding season.
4. Future monitoring should consider other sampling techniques including underpass monitoring when interpreting the response of the local Koala population to the Upgrade.
5. Set the baseline for road kill Koala to 1 individual every 8 weeks. Ensure operational monitoring includes the entire carriageway, particularly interchanges where Koala are most at risk to road strike.
6. The performance measures outlined in the EcMP be updated to show a reduction in road kill as a positive outcome of the Upgrade.

4.6 References

BioLink (2008). Area 13 Urban Investigation Area Koala Plan of Management. Prepared for Hasting Shire Council.

Comprehensive Koala Plan of Management (2011). Comprehensive Koala Plan of Management for Eastern Portion of Kempsey Shire LGA, Kempsey Shire Council.

GHD (2010). Oxley Highway to Kempsey Environmental Assessment. Report prepared for the Roads and Maritime Services.

Phillips, S. and Callaghan, J. (2011). The Spot Assessment Technique: a tool for determining localised levels of habitat use by Koalas *Phascolarctos cinereus*. *Australian Zoologist* 35 (3), 774-780.

4.7 Appendix – Field Data

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

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

Area	Monitoring Area Name	Site Name	Treatment	Easting	Northing	Activity	Selection Criteria	Radial Search	Notes/Comment
3	Cairncross State Forest (South)	Cairncross State Forest (South)	No Mitigation	482385	6526644	3.33	Tallowwood	14	
3	Cairncross State Forest (South)	Cairncross State Forest (South)	No Mitigation	482393	6526416	0	Tallowwood	18	
3a	Cairncross State Forest (south)	Cairncross State Forest (south)	No Mitigation	481655	6527256	0	Tallowwood	13	
3a	Cairncross State Forest (south)	Cairncross State Forest (south)	No Mitigation	481590	6527316	0	Tallowwood	26	
3a	Cairncross State Forest (south)	Cairncross State Forest (south)	No Mitigation	481637	6527175	13.33	Tallowwood	24	
3	Cairncross State Forest (South)	Cairncross State Forest (South)	Mitigation	482249	6525930	3.33	Tallowwood	18	
3	Cairncross State Forest (South)	Cairncross State Forest (South)	Mitigation	482125	6526077	3.33	Tallowwood	16	
3	Cairncross State Forest (South)	Cairncross State Forest (South)	Mitigation	482488	6526226	0	Tallowwood	13	
3	Cairncross State Forest (South)	Limeburners Creek "The Hatch"	Control	487011	6529909	0	Scribbly Gum	31	
3	Cairncross State Forest (South)	Limeburners Creek "The Hatch"	Control	487014	6529455	3.33	Scribbly Gum	32	
3	Cairncross State Forest (South)	Limeburners Creek "The Hatch"	Control	487035	6528694	0	Scribbly Gum	17	
4	Cairncross State Forest (north)	Cairncross State Forest (North)	No Mitigation	481420	6530890	0	White Mahogany	55	
4	Cairncross State Forest (north)	Cairncross State Forest (North)	No Mitigation	481695	6530786	0	Forest Red Gum	13	
4	Cairncross State Forest (north)	Cairncross State Forest (North)	No Mitigation	481184	6530864	0	Tallowwood	19	
4	Cairncross State Forest (north)	Cairncross State Forest (north)	Mitigation	481238	6530264	3.33	Swamp Mahogany	11	
4	Cairncross State Forest (north)	Cairncross State Forest (north)	Mitigation	481173	6530319	3.33	Tallowwood	13	
4	Cairncross State Forest (north)	Cairncross State Forest (north)	Mitigation	481438	6530335	6.67	Tallowwood	16	
4	Cairncross State Forest (north)	Cairncross State Forest (Pembrooke)	Control	473751	6528881	6.67	Tallowwood	20	
4	Cairncross State Forest (north)	Cairncross State Forest (Pembrooke)	Control	473464	6528969	0	Tallowwood	16	
4	Cairncross State Forest (north)	Cairncross State Forest (Pembrooke)	Control	473424	6529115	0	Tallowwood	18	
5	Cooperabung Hill	Cooperabung	No Mitigation	482793	6537012	3.33	Tallowwood	36	
5	Cooperabung Hill	Cooperabung	No Mitigation	482755	6537093	0	Tallowwood	31	

Area	Monitoring Area Name	Site Name	Treatment	Easting	Northing	Activity	Selection Criteria	Radial Search	Notes/Comment
5	Cooperabung Hill	Cooperabung	No Mitigation	482876	6537115	10	Tallowwood	18	
5	Cooperabung Hill	Cooperabung	Mitigation	482539	6538907	0	Tallowwood	16	
5	Cooperabung Hill	Cooperabung	Mitigation	482750	6538736	3.33	Forest Red Gum	17	
5	Cooperabung Hill	Cooperabung	Mitigation	482364	6538610	0	Tallowwood	14	
5	Cooperabung Hill	Cooperabung Hill (Gum Scrub)	Control	475489	6541854	6.67	Tallowwood	22	
5	Cooperabung Hill	Cooperabung Hill (Gum Scrub)	Control	475570	6541903	0	Tallowwood	14	
5	Cooperabung Hill	Cooperabung Hill (Gum Scrub)	Control	475838	6541962	0	Tallowwood	14	
6	Mingaletta to Smiths Creek	Not possible with current design							Would need to remove some koala fencing to enable no mitigation site to be installed in this area
6	Mingaletta to Smiths Creek	Not possible with current design							Would need to remove some koala fencing to enable no mitigation site to be installed in this area
6	Mingaletta to Smiths Creek	Not possible with current design							Would need to remove some koala fencing to enable no mitigation site to be installed in this area
6	Mingaletta to Smiths Creek	Mingaletta-Smiths Creek	Mitigation	483304	6543632	0	Tallowwood	9	
6	Mingaletta to Smiths Creek	Mingaletta-Smiths Creek	Mitigation	483444	6543585	0	Tallowwood	21	
6	Mingaletta to Smiths Creek	Mingaletta-Smiths Creek	Mitigation	483100	6543670	0	Tallowwood	15	
6	Mingaletta to Smiths Creek	Ballengarra State Forest (Greg's Road)	Control	477750	6543274	0	Tallowwood	10	
6	Mingaletta to Smiths Creek	Ballengarra State Forest (Greg's Road)	Control	477644	6543623	0	Small-fruited Grey Gum	19	
6	Mingaletta to Smiths Creek	Ballengarra State Forest (Greg's Road)	Control	477551	6543709	0	Tallowwood	16	
7	Kundabung Road to North of Pipers Creek	Kundabung	No Mitigation	483095	6549036	0	Tallowwood	23	
7	Kundabung Road to North of Pipers Creek	Kundabung	No Mitigation	482873	6549112	10	Tallowwood	20	
7	Kundabung Road to North of Pipers Creek	Kundabung	No Mitigation	483285	6549374	0	Tallowwood	15	
7	Kundabung Road to North of	Kundabung	Mitigation	483369	6550655	33.33	Tallowwood	26	

Area	Monitoring Area Name	Site Name	Treatment	Easting	Northing	Activity	Selection Criteria	Radial Search	Notes/Comment
	Pipers Creek								
7	Kundabung Road to North of Pipers Creek	Kundabung	Mitigation	483331	6550938	13.33	Tallowwood	16	
7	Kundabung Road to North of Pipers Creek	Kundabung	Mitigation	483083	6550608	10	Forest Red Gum	22	
7	Kundabung Road to North of Pipers Creek	Kumbatine National Park	Control	476044	6549609	3.33	Tallowwood	14	
7	Kundabung Road to North of Pipers Creek	Kumbatine National Park	Control	476165	6549738	0	Tallowwood	16	
7	Kundabung Road to North of Pipers Creek	Kumbatine National Park	Control	475889	6549468	0	Tallowwood	15	
8	Maria River State Forest	Maria River	Part Mitigation	483074	6554460	0	Tallowwood	21	
8	Maria River State Forest	Maria River	Part Mitigation	482836	6554330	3.33	Tallowwood	15	
8	Maria River State Forest	Maria River	Part Mitigation	482917	6554027	6.67	Tallowwood	14	
8	Maria River State Forest	Maria River	Mitigation	482886	6552623	0	Tallowwood	15	
8	Maria River State Forest	Maria River	Mitigation	482754	6552462	0	Tallowwood	17	
8	Maria River State Forest	Maria River	Mitigation	483135	6552449	0	Tallowwood	14	
8	Maria River State Forest	Maria River National Park	Control	486965	6554366	0	Tallowwood	20	Camera trap recorded Koala here in late August 2013
8	Maria River State Forest	Maria River National Park	Control	486971	6554479	10	Tallowwood	25	
8	Maria River State Forest	Maria River National Park	Control	487004	6554203	10	Tallowwood	26	

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

SE = Standard Error, SD = Standard Deviation

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

5.0 Yellow-bellied Glider

5.1 Introduction

The Environmental Assessment recorded Yellow-bellied Glider in the northern part of Ballengarra State Forest (GHD 2010). Additional surveys associated with the design of the carriageway have yielded two more records for this species including a record to the west of ch. 10400 (Cairncross State Forest – Rawdon Creek Nature Reserve) and immediately to the east of the Maria River Bridges (ch. 36850) in Maria River State Forest (B. Lewis pers. obs 2012).

The presence of this species along the road corridor has resulted in a number of mitigation options being formulated including but not limited to aerial crossing structures and the design of the carriageway to accommodate a vegetated widen median in Cairncross State Forest (*see* SMEC-Hyder Consulting 2013). The EcMP which provides the framework to monitor the effectiveness of such mitigation tools provided a survey technique and monitoring schedule but no site selection. The following presents the baseline survey prior to construction and adopts the survey techniques and monitoring timeframe as outlined in the EcMP.

5.2 Survey Design

A paired BACI survey design was developed using sites where this species had been reliably and recently recorded by Lewis Ecological Surveys or as part of the Environmental Assessment. This resulted in the selection of three sites impacted by the Project at Cairncross State Forest (ch. 10400), Ballengarra State Forest (ch. 24000) and Maria River (ch. 36850). Each of these sites were then paired with reference or control sites (hereafter reference) which preferably exhibited similar vegetation/habitat type and landscape features (Figure 5-1; Table 5-1). A summary of this is provided in Table 5-1.

Table 5-1. The BACI survey design for Yellow-bellied Glider monitoring using paired sampling.

Broad Survey Area	Treatment Class	Paired Reference location	Status of Records
Cairncross	Impact but with Mitigation (vegetated widen median)	Cairncross State Forest in Pembrooke area around 10 km west in forest managed by Forests NSW	Impact Site - Recorded by Lewis Ecological Surveys during targeted surveys for widen median and tree height surveys in October-November 2012. Reference/Control – Area of contiguous forest managed by Forests NSW with relevant prescriptions around drainage lines supporting similar vegetation type.
Ballengarra	Impact but with Mitigation (aerial crossing structure)	Greg's Road area around 5 km west in Ballengarra State Forest.	Impact Site – General area as reported in the Environmental Assessment and most likely to occur in association with moist forest types growing along the Barrys Creek drainage line. Reference/Control – An area comprising a ridge with adjoining lower slopes supporting similar vegetation types around 5 km west of the Upgrade.
Maria River	Impact but mitigation in Statement of Commitments (SoC) to reduce clearing limits	Maria River NP east near known feed trees sites	Impact Site - Recorded by Lewis Ecological Surveys in August 2012 during micro bat investigations of bridge and culverts. Dusk records of calling individuals alluding to likely den site close to the eastern side of the Upgrade. Reference/Control – An area known to support Yellow-bellied Glider in the past, accessible and located around 5 km to the east.

5.3 Field Survey Technique

The monitoring or survey technique was undertaken as described in the EcMP (SMEC-Hyder 2013). This involved:

- Call broadcast which comprised listening for calls when first arriving to the location for 10 minutes followed by broadcasting of calls intermittently over the next 15 minutes. A final listening period was then undertaken for a further 15 minutes.
- Spotlighting along 500 metre transects with the two observers walking at a rate of 30 minutes over the 500 m transect.

The above technique was repeated on three separate occasions on non-consecutive nights between the 27th September and the 24th November 2013. The minimum time between consecutive surveys was 7 days and normally coincided with a change in the lunar phase in an attempt to maximize variability in survey conditions. Surveys avoided wet and windy weather.

5.4 Survey Results

Yellow-bellied Glider was recorded at four of the six monitoring sites (Table 5-2). At the two other sites (Ballengarra Impact and Cairncross Reference), unconfirmed calls were recorded but they could not be authenticated during the course of this monitoring episode. Calling records attributed to the use of call broadcast were the most common form of detection and this accounted for records at all four sites. Spotlighting resulted in the observation of Yellow-bellied Glider at only the Cairncross Impact Site.

Yellow-bellied Glider was recorded on all three surveys at the Maria River Reference site and on 1-2 occasions at the remaining three sites (Figure 5-1).

Table 5-2. Summary of the baseline monitoring for Yellow-bellied Glider.

Record Type/Site	Cairncross State Forest Impact	Cairncross State Forest Reference	Ballengarra State Forest Impact	Ballengarra State Forest Reference	Maria River Impact	Maria River Reference
Yellow-bellied Glider (observed)	√	x	x	x	x	x
Yellow-bellied Glider (heard)	√	?	?	√	√	√

√ = detection confirmed; ? = detection unconfirmed; x = absent

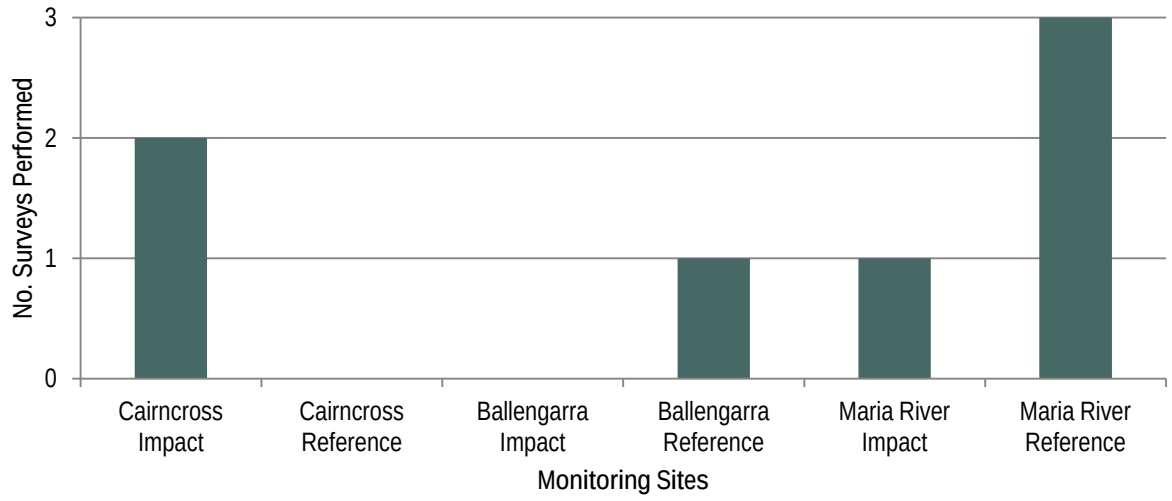

Figure 5-1. Number of surveys Yellow-bellied Glider was recorded during the pre-construction baseline monitoring period.

5.5 Discussion of Findings

The baseline data shows that Yellow-bellied Gliders maintain home ranges that encapsulate the existing Pacific Highway carriageway. Yellow-bellied Glider was confirmed at most of the monitoring sites including two of the impact sites and two of the reference sites. Road noise and the chattering calls of feeding Grey-headed Flying Foxes at the Ballengarra SF impact site made confirming the detection of Yellow-bellied Glider difficult. There was however, some unconfirmed distant calls further to the north of the spotlight transect at Barrys Creek that were probably from this species and this will need to be considered during subsequent monitoring events. Road noise is likely to have also contributed to the absence of Yellow-bellied Glider during some of the surveys at Maria River and Cairncross. Surveys performed later at night at this site may alleviate this problem.

Spotlighting proved to be a useful technique, but this alone is of limited value as a lot of the sites contain a dense mid stratum and reduce the area which can be reliably illuminated. Spotlighting tends to provide a greater opportunity to hear gliders vocalising more than physical observations.

The Cairncross reference site may prove a difficult site to reliably detect Yellow-bellied Glider. This is due to a lot of the forest outside of the buffer zones has been recently logged and may force gliders to occupy a more linear home range than they would otherwise. The site does however represent the workings of a production forest not unlike that closer to the carriageway where Yellow-bellied Gliders tend to be associated with drainage lines.

The Yellow-bellied Gliders at Maria River Bridge present a somewhat unique situation for the RMS. At this location, gliders appear to regularly cross the existing carriageway and provide an opportunity to understand behavioural ecology in association with volplane capabilities for this species. Knowing more about this it would provide a greater understanding on how the RMS can design vegetated widen medians with a greater level of certainty for use.

There are a number of other locations where this species was recorded during the course of broader ecological surveys. These include the Cooperabung Creek and Pipers Creek reference sites used in the Giant Barred Frog monitoring program and they may become useful additions in the event Yellow-bellied Glider is detected at other additional impact locations associated with the OH2K Upgrade.

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5.6 Key Recommendations

1. Any additional new YBG records close (<500m) of the carriageway be considered in the overall monitoring program up to a maximum of 5 sites.
2. RMS ensures all trees greater than 5 m in height are retained within 100 m of the Maria River Bridges (ch. 36870).
3. Future monitoring takes into account road noise which may necessitate late night surveys or at times when there are fewer heavy vehicle movements.

5.7 References

GHD (2010). Oxley Highway to Kempsey Environmental Assessment. Report prepared for the Roads and Maritime Services.

Lewis, B.D. (2012). Glider and Reference Tree Surveys: Widen Median proposal. Letter report prepared for the SMEC-Hyder Joint Venture by Lewis Ecological Surveys.

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5.8 Appendix – Field Data & Mapping

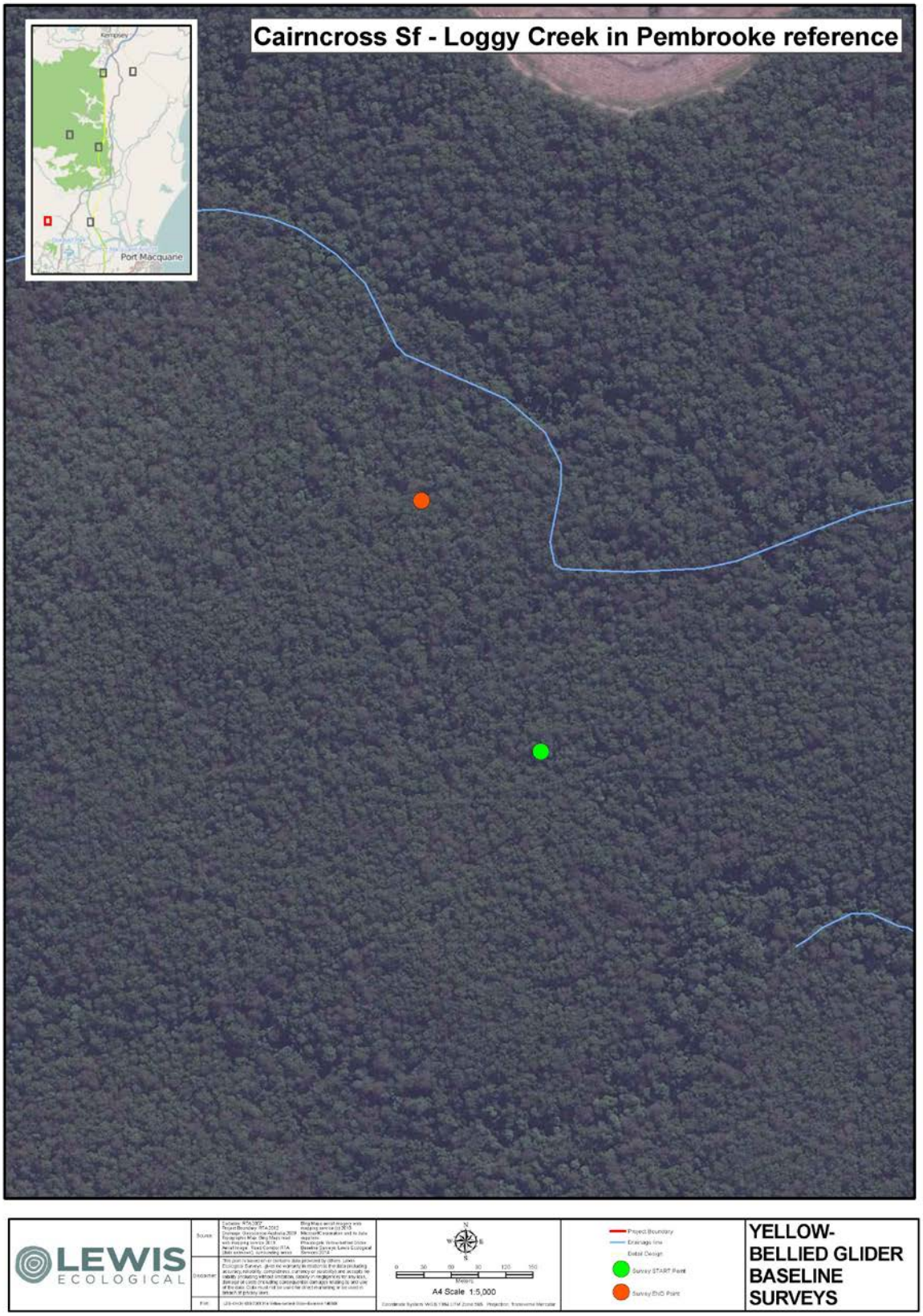

Figure 5-A. Start and finish point for the Cairncross State Forest (reference) Yellow-bellied Glider monitoring site.

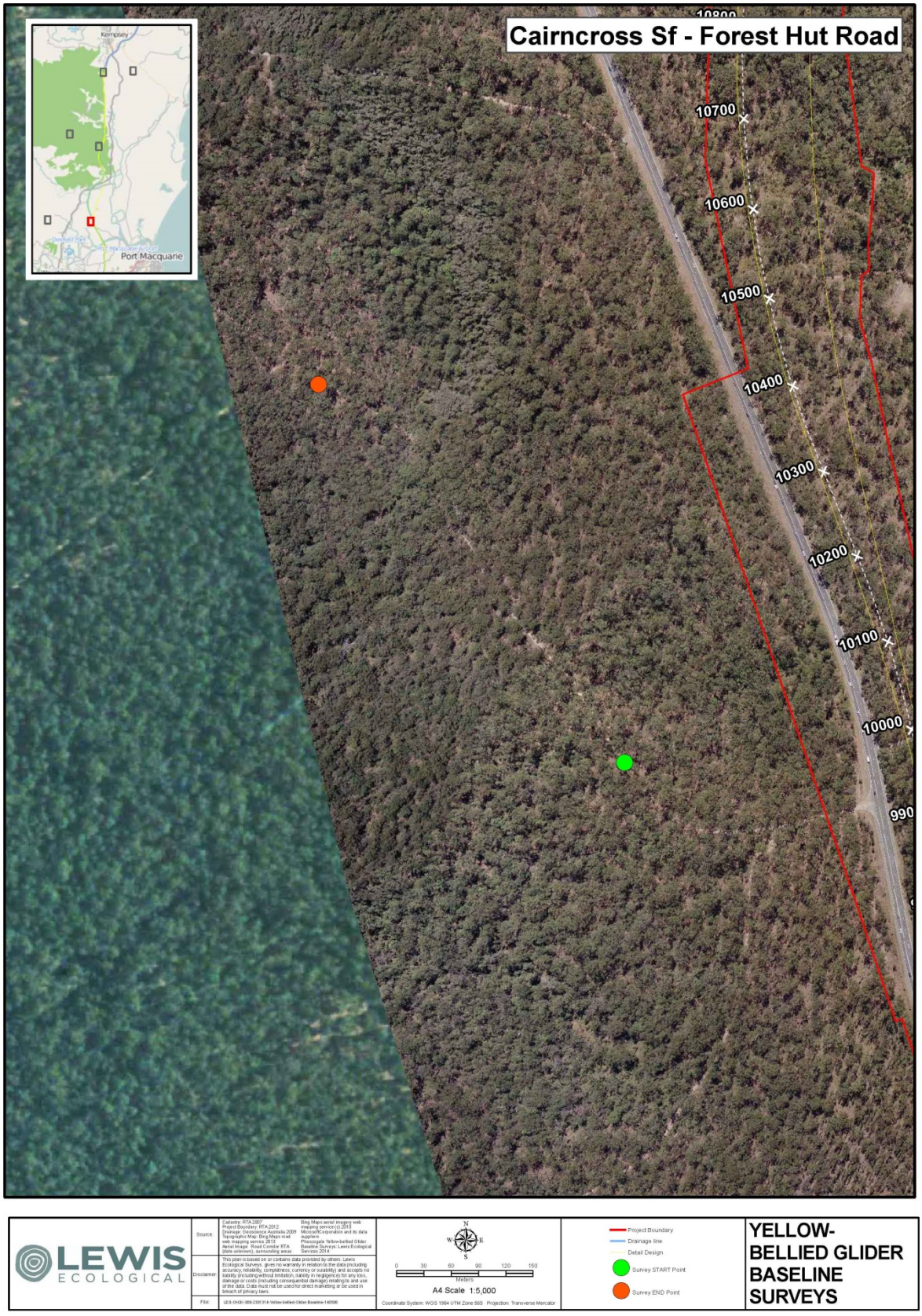

Figure 5-B. Start and finish point for the Cairncross State Forest (impact) Yellow-bellied Glider monitoring site.

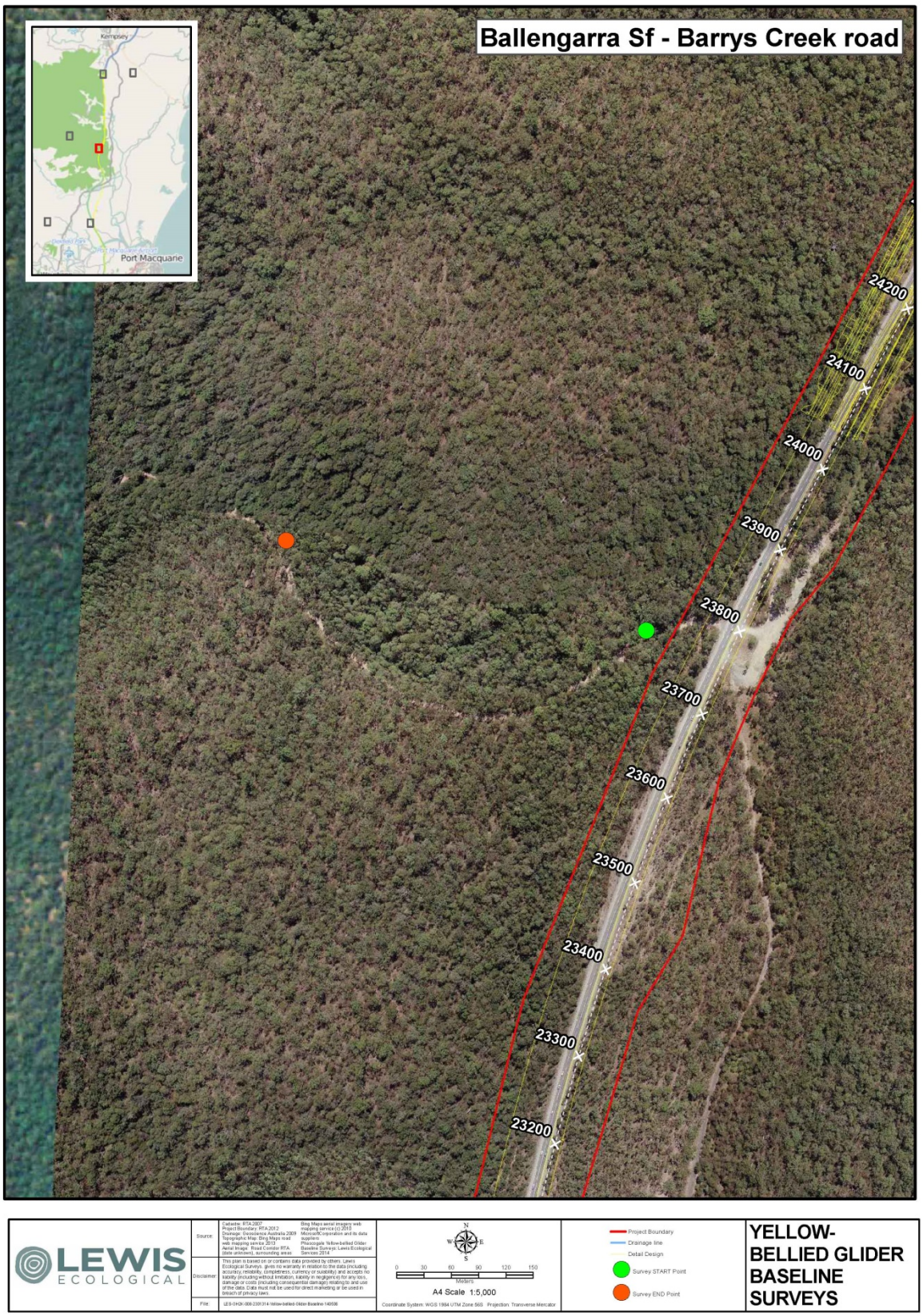

Figure 5-C. Start and finish point for the Ballengarra State Forest (impact) Yellow-bellied Glider monitoring site.

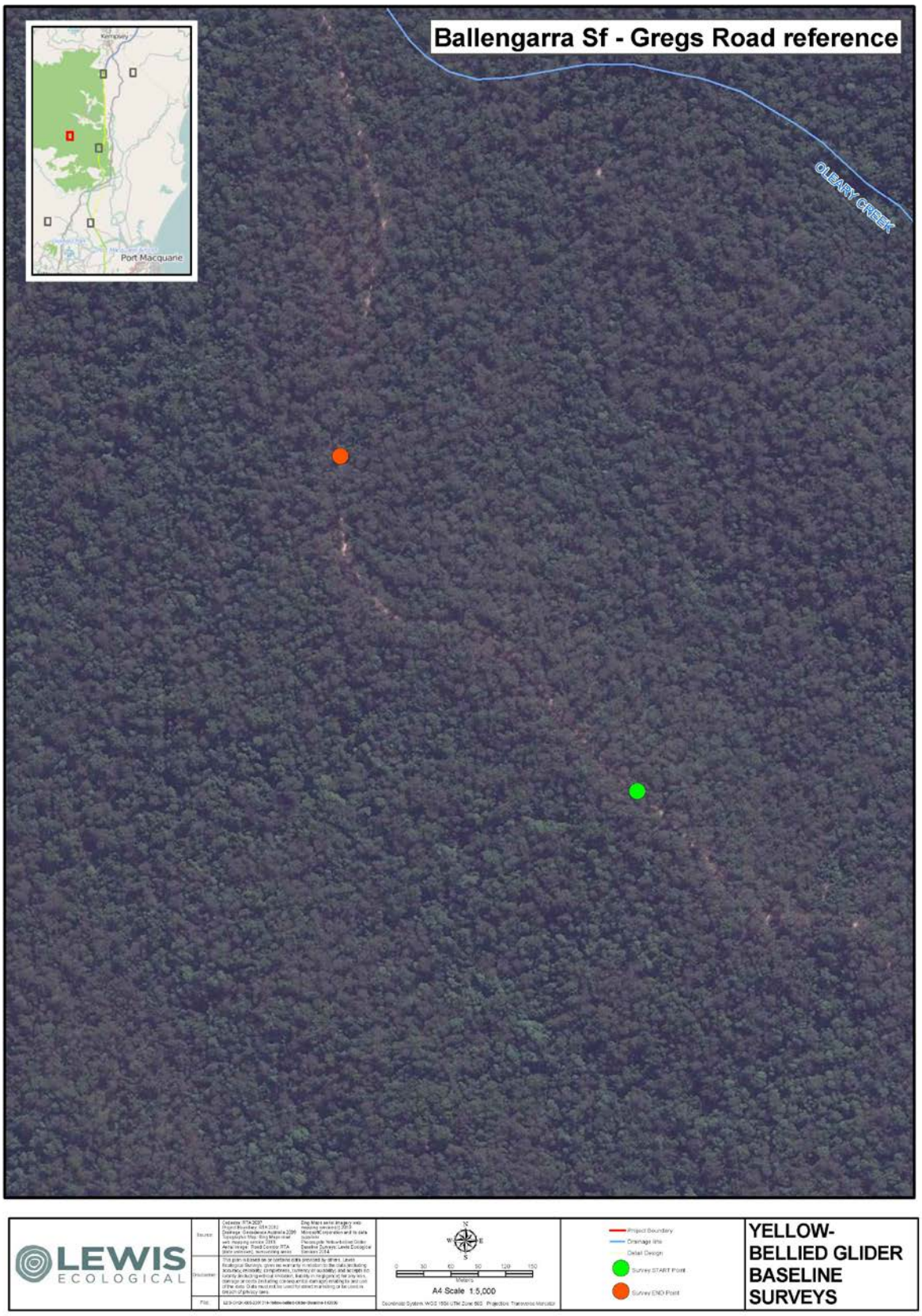

Figure 5-D. Start and finish point for the Ballengarra State Forest (reference) Yellow-bellied Glider monitoring site on Greg's Road.

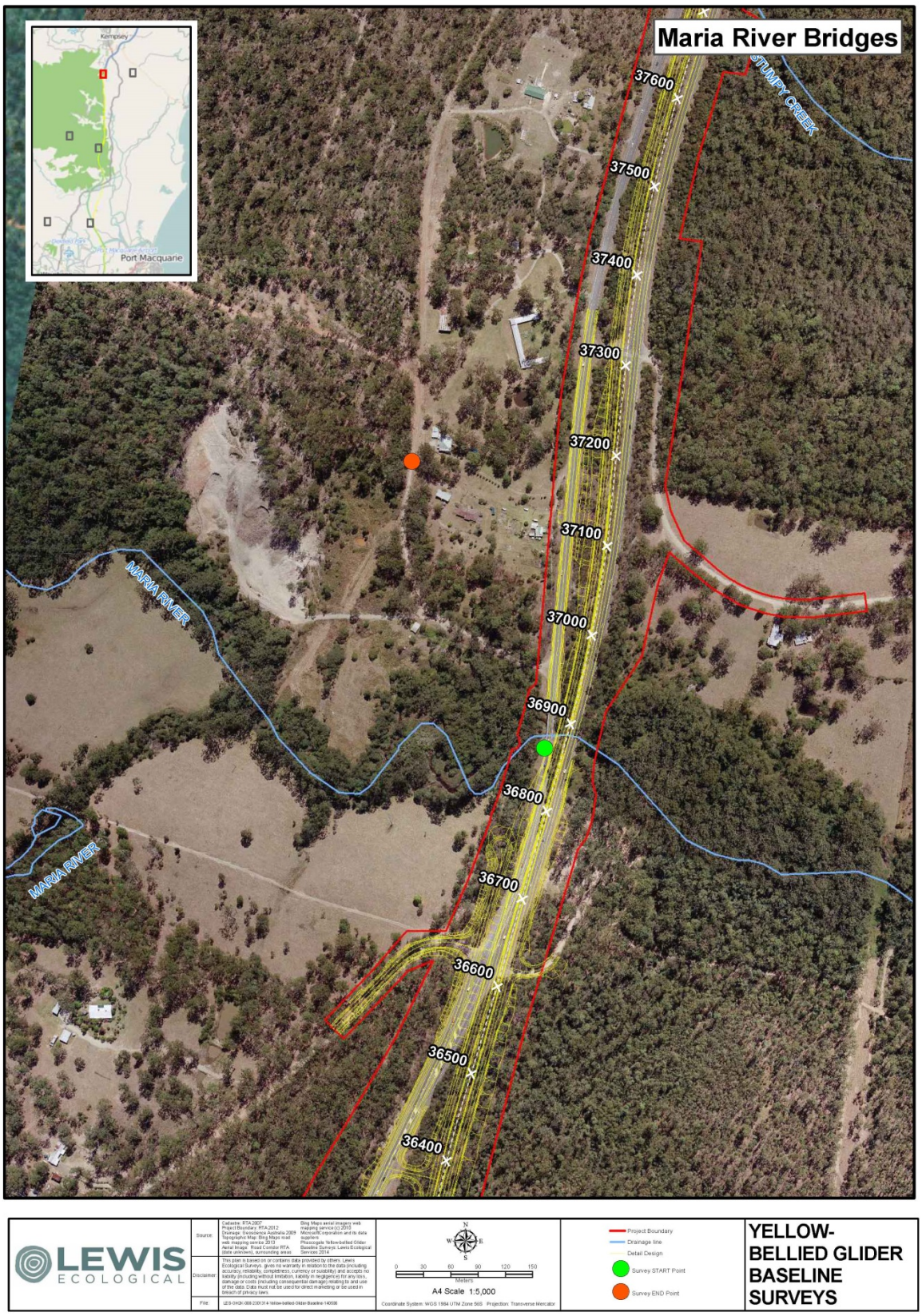

Figure 5-E. Start and finish point for the Maria River (impact) Yellow-bellied Glider monitoring site.

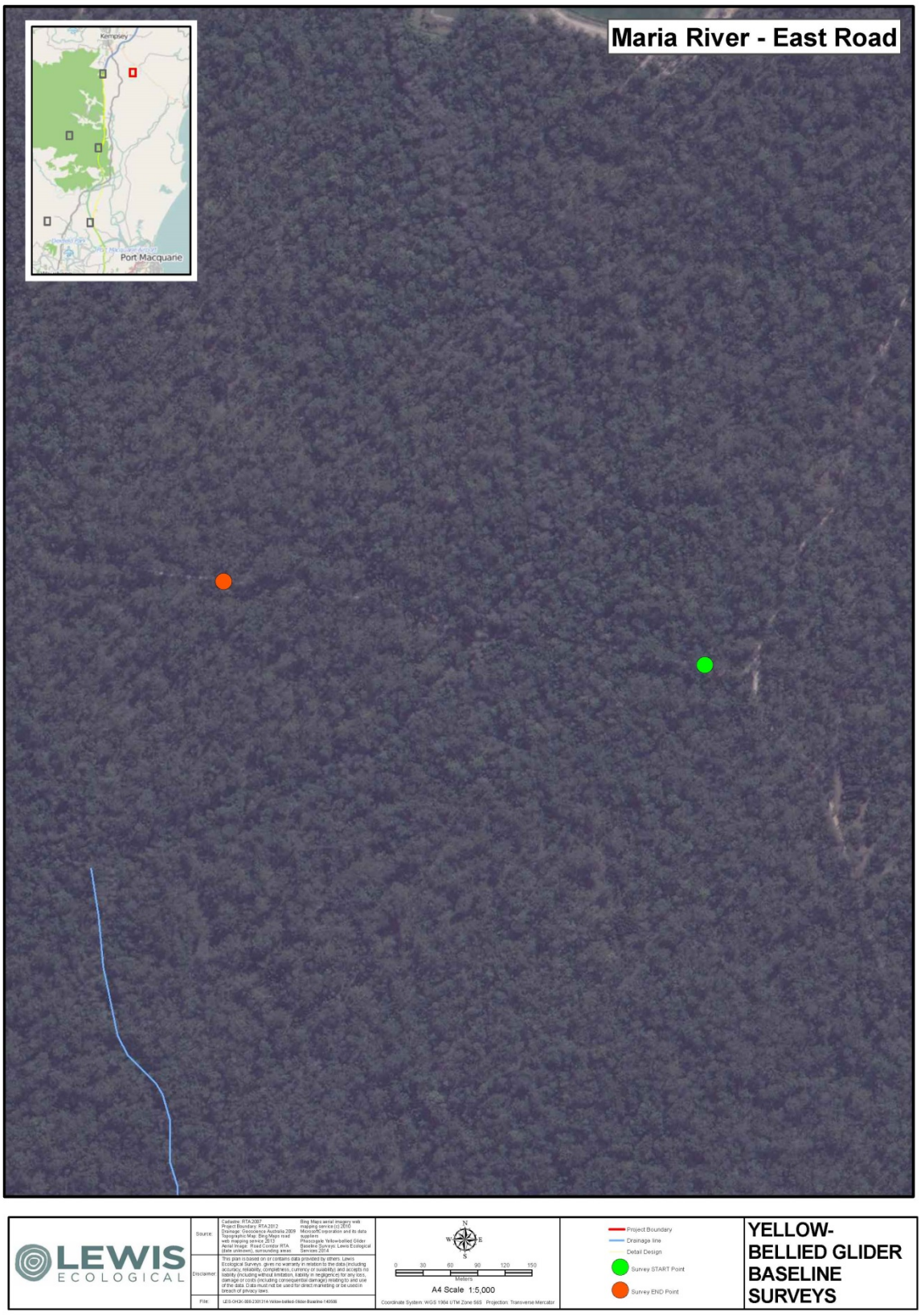

Figure 5-F. Start and finish point for the Maria River National Park (reference) Yellow-bellied Glider monitoring site.

Table 5-A. Summary of the field survey program for the Yellow-bellied Glider surveys.

Site Name	Treatment	Transect Coordinates				Survey Number & Sample Dates & Times				Abiotic Conditions						Survey Results & Comments				
		Easting Start	Northing Start	Easting Finish	Northing Finish	Survey Number	Survey Date	Start Time	Finish Time	Air Temp. oC	Humidity %	Wind	Rain	Night Light	Cloud Cover	Listening Period	Call Broadcast Period	Spotlight	Other threatened fauna	Comments
Cairncross Sf - Forest Hut Road	Impact	480979	6528629	480642	6529045	1	27.9.2013	1845	2000	15.5	61	0	0	0	0	Nil	YBG x 1 @ 100 west	YBG x 1 in mid canopy of Grey Ironbark foraging on limb presumably for invertebrates	Grey-headed Flying Fox x 3	Road noise elevated with holiday traffic but bulk of noise affecting surveys was attributed to trucks
	Impact	480979	6528629	480642	6529045	2	6.10.2013	0051	0159	13.9	64	1	0	0	0	Nil	Nil	Nil	Koala x 1 calling 250 m north west of site + Grey-headed flying Fox x 7	Late night spotlight to counteract the effect of road noise.
	Impact	480979	6528629	480642	6529045	3	26.10.2013	2015	2130	17.1	73	0	0	0	50	Nil	Nil	YBG x 1 heard around 150 m to the south	Koala x 1 heard 250 m to the south	Road noise affecting ability to hear fauna calls
Cairncross Sf - Loggy Creek in Pembrooke reference	Control/reference	473377	6528875	473246	6529151	1	28.9.2013	1825	1945	20	50	1	0	0	0	Nil	Nil	Unconfirmed call heard halfway through spotlight period to north east along drainage line	Grey-headed flying Fox x 10	Site installed within retained filter strips of vegetation post logging event
	Control/reference	473377	6528875	473246	6529151	2	6.10.2013	2304	0031	14.4	52	0	0	0	0	Nil	Nil	Nil	Koala x 1 calling north west of site + Grey-headed Flying Fox x >30	
	Control/reference	473377	6528875	473246	6529151	3	26.10.2013	2158	2314	15.8	76	0	0	0	0	Nil	Nil	Nil	Koala x 1 heard 250 m downstream to the east	YBG expected to occur in the retained filter strips but given their oblong home ranges in this instance following heavy logging their detection may be intermittent
Ballengarra Sf - Barrys Creek road	Impact	482438	6541886	482042	6541985	1	27.9.2013	2015	2137	14	74	0	0	0	0	Nil	Unconfirmed call to the north	nil	Koala x 1 male calling to north	Road noise elevated with holiday traffic but bulk of noise affecting surveys was attributed to trucks
	Impact	482438	6541886	482042	6541985	2	6.10.2013	2132	2245	17.2	54	0	0	0	0	Nil	Nil	Nil	Koala x 1 male calling to the south	
	Impact	482438	6541886	482042	6541985	3	12.10.2013	1935	2103	22	81	1	0	2	50	Nil	Nil	Nil	Koala x 1 male calling to the south + Grey-headed Flying Fox x 2	
Ballengarra Sf - Greg's Road reference	Control/reference	477352	6543849	477025	6544218	1	28.9.2013	2216	2330	15.5	43	0	0	0	0	Nil	Nil	Nil	Grey-headed flying Fox x 5	
	Control/reference	477352	6543849	477025	6544218	2	6.10.2013	1945	2115	18	52	1	0	0	0	Nil	Nil	Nil	Masked owl x 1 + >20 Grey-headed Flying Foxes	
	Control/reference	477352	6543849	477025	6544218	3	12.10.2013	2117	2249	20	88	0	0	2	30	Nil	YBG x 1 250 m to east	Nil	Koala x 1 + Grey-headed Flying Fox x 2	
Maria River - East Road	Control/reference	488492	6555068	487962	6555160	1	27.9.2013	2207	2331	12	77	0	0	0	0	Nil	YBG x 1 calling 200-300 m south	Nil	Koala x 1 male calling to north + Grey-headed Flying Fox x 1	Site installed at northern extent of National park to allow for access on foot during wet weather periods
	Control/reference	488492	6555068	487962	6555160	2	11.10.2013	2020	2151	18.8	82	0	0	1	100	Nil	YBG calling south west of site x 1	YBG x 1 heard calling once in same general area	Koala x 1 calling male	
	Control/reference	488492	6555068	487962	6555160	3	24.11.2013	2105	2137	19.3	87	0	1	1	100	Nil	YBG calling to the south	Nil	Grey-headed Flying Fox x 5	Survey after rainfall
Maria River Bridges	Impact	483092	6554739	482946	6555055	1	28.9.2013	2041	2157	17	51	1	0	0	0	YBG x 2 calling within 100 m of northbound bridge	Didn't perform as gliders already recorded	YBG x 1 calling within riparian zone of Maria River	Grey-headed flying Fox x 1	Ybg previously recorded on the 18th September at same location and on the 28th August 2012 on eastern site at dusk
	Impact	483092	6554739	482946	6555055	2	11.10.2013	2219	2357	19	81	1	1	1	100	Nil	Nil	Nil	Grey-headed Flying Fox x 9	Light shower of rain recorded
	Impact	483092	6554739	482946	6555055	3	24.11.2013	2207	2246	18.7	83	0	1	1	85	Nil	Nil	Nil	Grey-headed Flying Fox x 3	Road noise making it difficult to identify any calling YBGs

6.0 Brush-tailed Phascogale

6.1 Introduction

The Brush-tailed Phascogale (*Phascogale tapoatafa*) was not recorded during field surveys for the Environmental Assessment, however, it was considered likely to occur in Moist Slopes Forest and Dry Ridgetop Forest types (GHD 2010). This was confirmed during subsequent consultation with Lewis Ecological Surveys with records from the Stumpy Creek area at the northern end of the Project and another location to the south of the Wilson River where a deceased male had been reported from the Swamp Oak Floodplain Forest in 2002. Potential Phascogale habitat was noted as occurring in Cairncross State Forest and north from the Wilson River between ch.17100-37600.

Guided with the information above, the SMEC-Hyder JV identified the following areas for future monitoring in the Ecological Monitoring Program:

- 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.

The monitoring regime proposed a summer survey prior to the commencement of construction and in winter and summer in Year 4, 6 and 8 (operation phase).

6.2 Survey Technique

Field surveys were undertaken in accordance with the Ecological Monitoring Program (Hyder Consulting 2014). A 1 ha sampling grid was identified on either side of the carriageway at four locations known as Cairncross State Forest, Cooperabung Hill, Ballengarra State Forest and Maria River State Forest (Figure 6-1). The coordinates for each trap/hair tube location is presented in the Appendix.

At each of the four locations a grid was established on either side of the carriageway and included:

- Ten (10) hair tubes arranged in a 1 ha grid configuration. Hair tubes were baited with peanut butter, limited honey, oats and sardines in oil and left operating over 14 consecutive nights between the 1st and 15th February. During this time, there was less than 5 mm recorded across the study area (BOM 2014). Hair samples were sent to Barbara Triggs of Dead Finish for analysis.
- Arboreal trapping comprised of 10 Elliot B traps in a 1 ha grid configuration. Traps were positioned on tree mounted brackets 2 m above the ground and baited with a vegetable bait from the mixture described above and left operating over four consecutive nights between the 24th and 28th February.

6.3 Survey Results

No Brush-tailed Phascogale were recorded during either the hair tubing surveys in early February nor the arboreal tree trapping in late February. Despite this, there was an 18% trap success rate for other native and non native fauna including Brown Antechinus, Sugar Glider, Brush-tailed Possum, Bush Rat, Black Rat and House Mouse (Appendix).

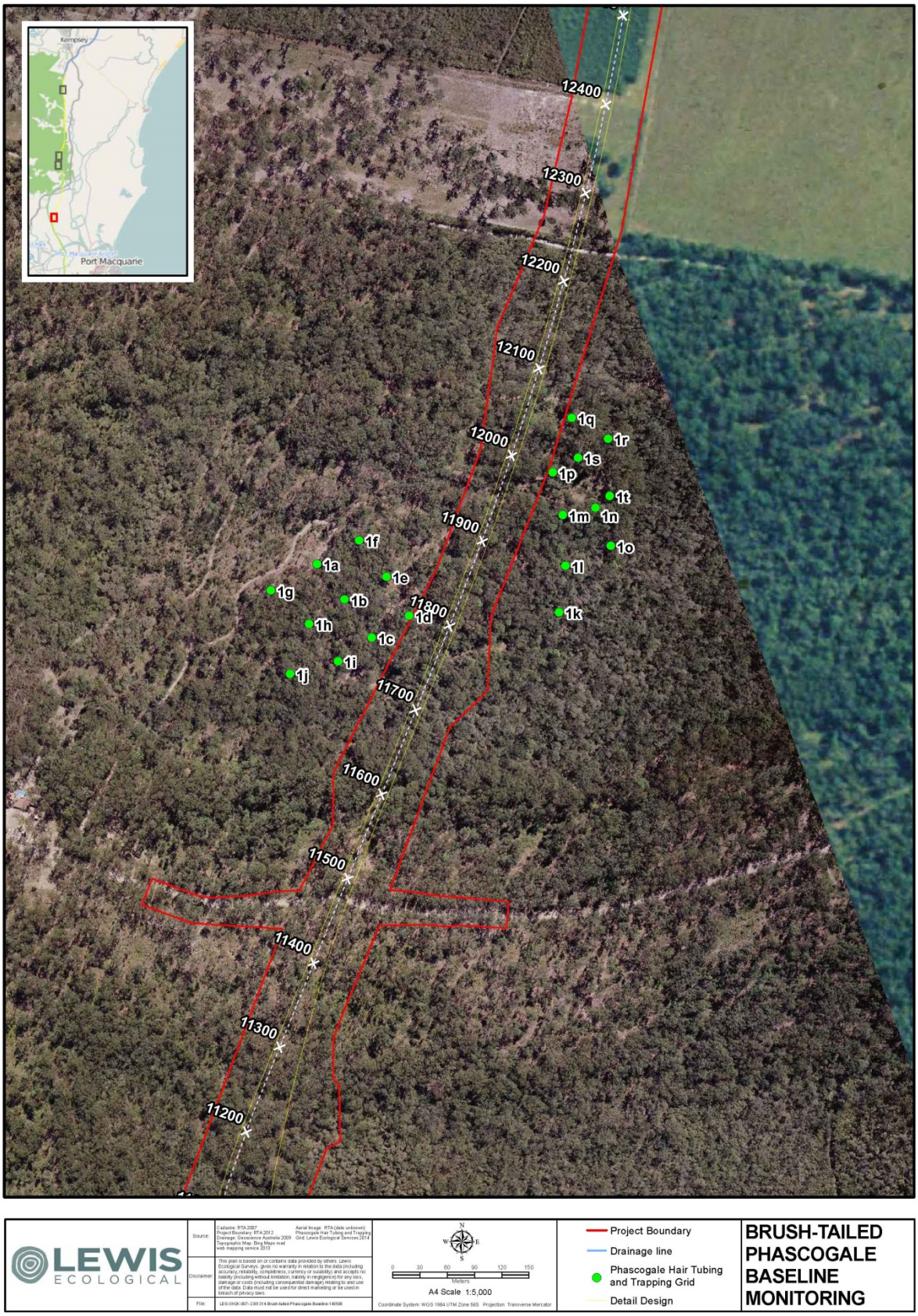

Figure 6-1. Location of the phascogale monitoring grid in relation to the carriageway at Cairncross State Forest.

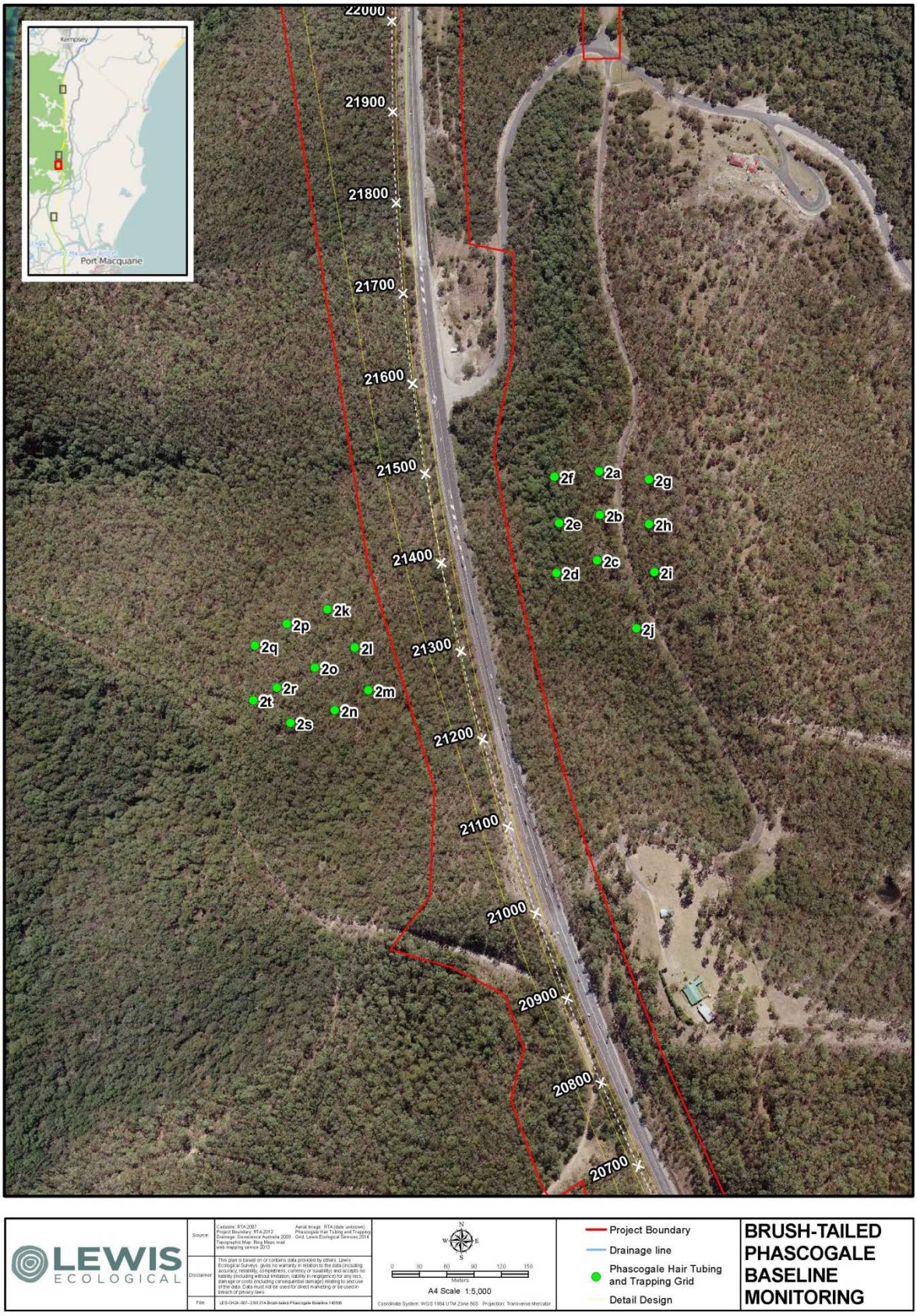

Figure 6-2. Location of the phascogale monitoring grid in relation to the carriageway at Cooperabung Hill.

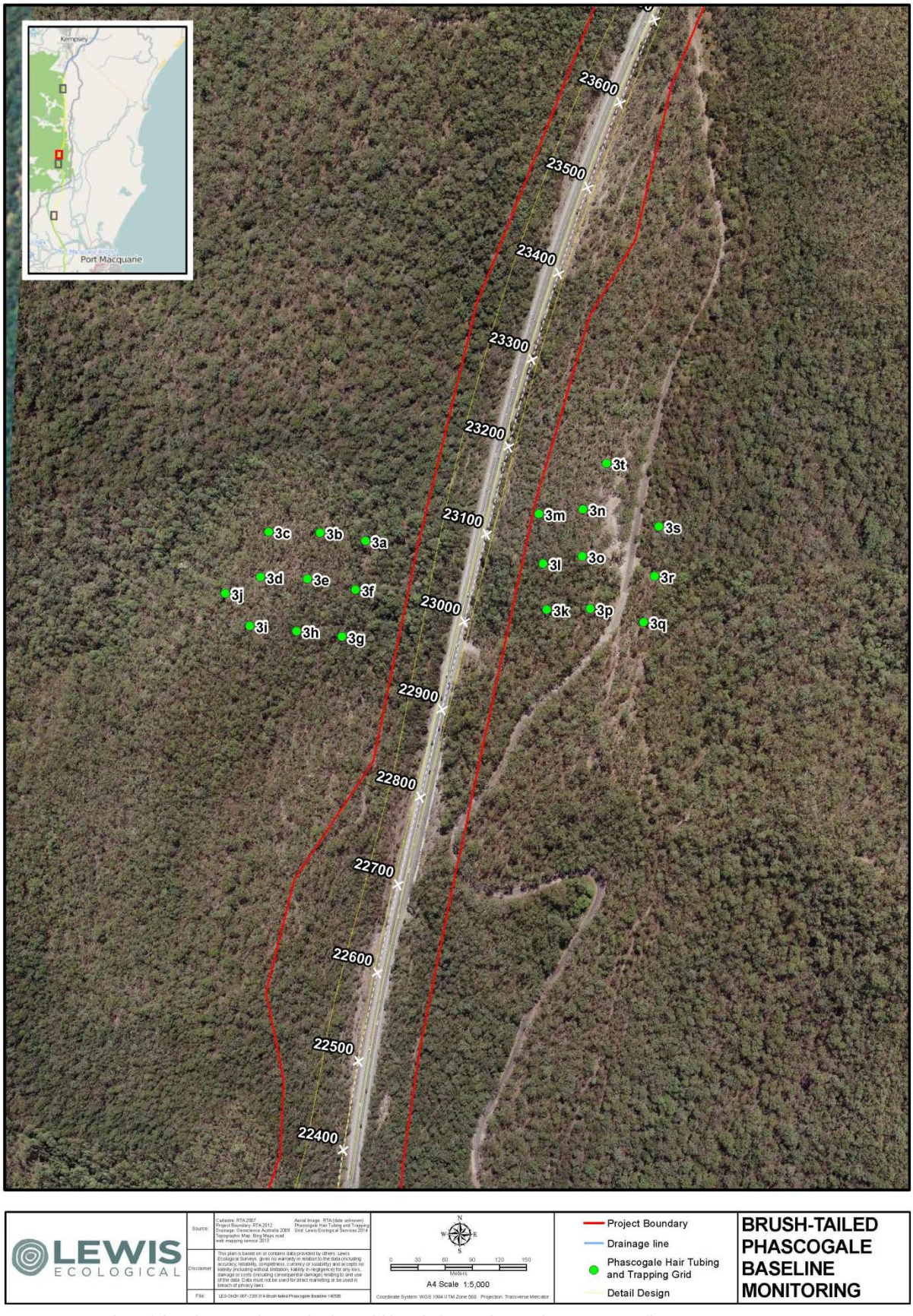

Figure 6-3. Location of the phascogale monitoring grid in relation to the carriageway at Ballengarra State Forest.

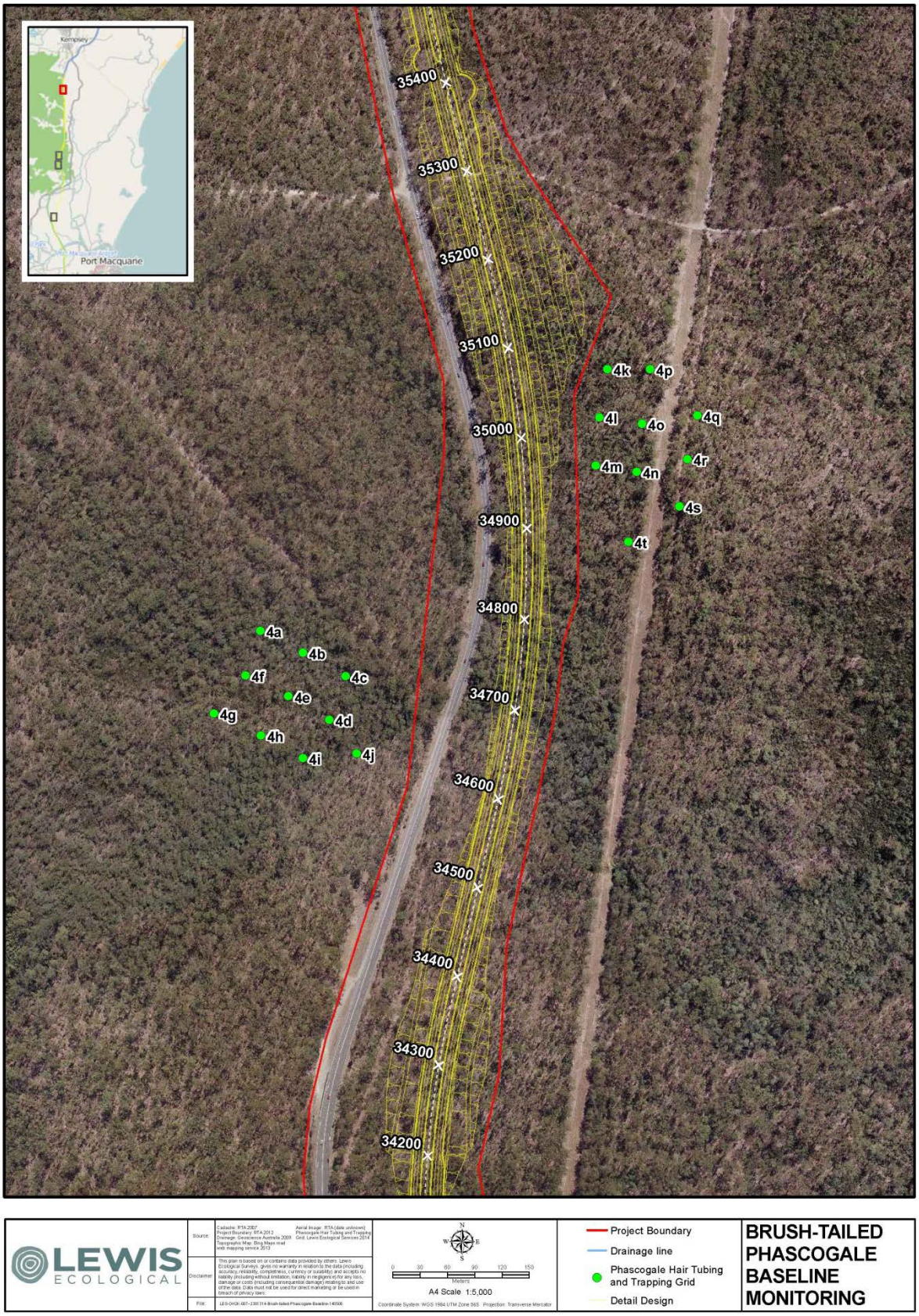

Figure 6-4. Location of the phascogale monitoring grid in relation to the carriageway at Maria River State Forest.

6.4 Discussion of Findings

The baseline monitoring did not record Brush-tailed Phascogale inhabiting the OH2K study area. The field sampling did coincide with a large and extended hatching period for Cicada's and this is likely to have influenced the foraging habits of Phascogale making them more difficult to trap. This should be considered prior to implementing the post construction surveys and the EcMP should be updated to reflect this. The absence of Phascogale may also imply this species occurs at relatively low densities than perhaps the neighbouring Kempsey and Collombatti areas where similar surveys have been undertaken in the past. Monitoring at these sites around 3-20 km north of the OH2K project have generally yielded 1-2 individuals at some of the trapping grids, none at some others and upwards of 5-6 individuals in exceptional circumstances (i.e. Collombatti area). Future monitoring for both projects (OH2K and F2E) will provide a greater understanding as both areas are likely to be surveyed simultaneously as part of the Environmental Services contract.

The current Phascogale sampling strategy could be improved. Whilst arboreal trapping remains an effective technique the usefulness of hair tubes has been questioned in preference for improvements in technology associated with infrared cameras. Hair tubing has consistently provided lower rates of detection even in areas where trapping has revealed densities of 2-3 individuals per hectare (BDL pers. obs). Moreover, the current survey has also shown the inaccuracies associated with hair sampling with species like the Pale Field Rat (*Rattus tunneyi*) and Swamp Rat (*R. lutreolus*) being identified from hair tubes placed in arboreal locations typically 1-2 m off the ground. In this context, the former species is not known from the study area and would represent a range extension whilst the latter is not known to have arboreal habits. A more constructive use of resources would be integrating camera traps into the survey design as they have been regularly out performing arboreal tree trapping during the development of the Phascogale monitoring program for the Woolgoolga to Ballina Upgrade (Lewis in prep).

Similar to the above, the monitoring program presented in the EcMP would benefit from the contribution of the nest box monitoring program. This has been recently demonstrated during the monitoring of nest boxes for the Kempsey Bypass Project which provided several new records for the species including locations where arboreal trapping has remained ineffective (Lewis 2013). On the OH2K Upgrade more than 700 nest boxes have been identified for installation with 60% of these due to be installed over the next 12 months. The monitoring of these is likely to provide an integral part in understanding the way Phascogale use habitat adjacent to the carriageway.

6.5 Key Recommendations

1. Grid on the eastern side of Cairncross State Forest (1k-1t) should be reconfigured to include more suitable habitat within retained vegetation within the project boundary.
2. Post construction monitoring to consider the extent of existing foraging resources prior to implementing the trapping surveys. In this context it may be more equitable to conduct the trapping in autumn which coincides for a reduction in invertebrate activity, a general reduction in the availability of flowering resources and aligns with the onset of the breeding season.
3. Consideration be given to updating the EcMP with:
    a. replacing the hair tubes with camera traps using the same locations as the hair tubes;
    b. clearly state that nest box monitoring will form an integral role in monitoring Phascogale during the post construction phase of the project.

6.6 References

Bureau of Meteorology (BOM). www.bom.nsw.gov.au

GHD (2010). Oxley Highway to Kempsey Environmental Assessment. Report prepared for the Roads and Maritime Services.

Lewis, B.D. (2013b). Kempsey Bypass Project: Nest Box Monitoring Episode 1. Report prepared by Lewis Ecological Surveys © for Kempsey Bypass Alliance and Roads and Maritime Services.

SMEC-Hyder Consulting (2014). Oxley Highway To Kempsey Pacific Highway Upgrade—Ecological Monitoring Program. Report prepared for the NSW Roads and maritime Services by the SMEC-Hyder Joint Venture.

6.7 Appendix – Field Data

Table 6-A. Summary of hair and arboreal trap location data and survey period.

Area Name	Site	SoC	Easting	Northing	Hair Tube	Elliot B	Phascogale Recorded
Cairncross State Forest	1a	West	481263	6530453	Early February	Late February	No
Cairncross State Forest	1b	West	481293	6530414	Early February	Late February	No
Cairncross State Forest	1c	West	481323	6530372	Early February	Late February	No
Cairncross State Forest	1d	West	481364	6530396	Early February	Late February	No
Cairncross State Forest	1e	West	481339	6530439	Early February	Late February	No
Cairncross State Forest	1f	West	481309	6530479	Early February	Late February	No
Cairncross State Forest	1g	West	481212	6530424	Early February	Late February	No
Cairncross State Forest	1h	West	481254	6530387	Early February	Late February	No
Cairncross State Forest	1i	West	481286	6530346	Early February	Late February	No
Cairncross State Forest	1j	West	481233	6530332	Early February	Late February	No
Cairncross State Forest	1k	East	481529	6530400	Early February	Late February	No
Cairncross State Forest	1l	East	481536	6530451	Early February	Late February	No
Cairncross State Forest	1m	East	481533	6530507	Early February	Late February	No
Cairncross State Forest	1n	East	481569	6530515	Early February	Late February	No
Cairncross State Forest	1o	East	481586	6530473	Early February	Late February	No
Cairncross State Forest	1p	East	481522	6530554	Early February	Late February	No
Cairncross State Forest	1q	East	481543	6530614	Early February	Late February	No
Cairncross State Forest	1r	East	481583	6530591	Early February	Late February	No
Cairncross State Forest	1s	East	481550	6530570	Early February	Late February	No
Cairncross State Forest	1t	East	481585	6530528	Early February	Late February	No
Cooperabung Hill	2a	West	482349	6539649	Early February	Late February	No
Cooperabung Hill	2b	West	482350	6539601	Early February	Late February	No
Cooperabung Hill	2c	West	482347	6539551	Early February	Late February	No
Cooperabung Hill	2d	West	482302	6539537	Early February	Late February	No
Cooperabung Hill	2e	West	482305	6539592	Early February	Late February	No
Cooperabung Hill	2f	West	482300	6539643	Early February	Late February	No
Cooperabung Hill	2g	West	482404	6539640	Early February	Late February	No
Cooperabung Hill	2h	West	482404	6539591	Early February	Late February	No
Cooperabung Hill	2i	West	482410	6539538	Early February	Late February	No
Cooperabung Hill	2j	West	482390	6539476	Early February	Late February	No
Cooperabung Hill	2k	East	482050	6539497	Early February	Late February	No
Cooperabung Hill	2l	East	482080	6539455	Early February	Late February	No
Cooperabung Hill	2m	East	482095	6539408	Early February	Late February	No
Cooperabung Hill	2n	East	482058	6539386	Early February	Late February	No
Cooperabung Hill	2o	East	482036	6539433	Early February	Late February	No
Cooperabung Hill	2p	East	482005	6539481	Early February	Late February	No
Cooperabung Hill	2q	East	481970	6539457	Early February	Late February	No
Cooperabung Hill	2r	East	481994	6539411	Early February	Late February	No

Cooperabung Hill	2s	East	482009	6539372	Early February	Late February	No
Cooperabung Hill	2t	East	481968	6539397	Early February	Late February	No
Ballengarra State Forest	3a	West	482179	6541217	Early February	Late February	No
Ballengarra State Forest	3b	West	482129	6541226	Early February	Late February	No
Ballengarra State Forest	3c	West	482072	6541227	Early February	Late February	No
Ballengarra State Forest	3d	West	482063	6541177	Early February	Late February	No
Ballengarra State Forest	3e	West	482115	6541175	Early February	Late February	No
Ballengarra State Forest	3f	West	482168	6541163	Early February	Late February	No
Ballengarra State Forest	3g	West	482153	6541111	Early February	Late February	No
Ballengarra State Forest	3h	West	482103	6541117	Early February	Late February	No
Ballengarra State Forest	3i	West	482051	6541123	Early February	Late February	No
Ballengarra State Forest	3j	West	482024	6541159	Early February	Late February	No
Ballengarra State Forest	3k	East	482380	6541141	Early February	Late February	No
Ballengarra State Forest	3l	East	482376	6541192	Early February	Late February	No
Ballengarra State Forest	3m	East	482371	6541247	Early February	Late February	No
Ballengarra State Forest	3n	East	482420	6541252	Early February	Late February	No
Ballengarra State Forest	3o	East	482419	6541200	Early February	Late February	No
Ballengarra State Forest	3p	East	482428	6541142	Early February	Late February	No
Ballengarra State Forest	3q	East	482487	6541127	Early February	Late February	No
Ballengarra State Forest	3r	East	482499	6541178	Early February	Late February	No
Ballengarra State Forest	3s	East	482504	6541233	Early February	Late February	No
Ballengarra State Forest	3t	East	482446	6541303	Early February	Late February	No
Maria River State Forest	4a	West	482779	6552692	Early February	Late February	No
Maria River State Forest	4b	West	482826	6552668	Early February	Late February	No
Maria River State Forest	4c	West	482873	6552642	Early February	Late February	No
Maria River State Forest	4d	West	482855	6552594	Early February	Late February	No
Maria River State Forest	4e	West	482810	6552620	Early February	Late February	No
Maria River State Forest	4f	West	482763	6552643	Early February	Late February	No
Maria River State Forest	4g	West	482728	6552601	Early February	Late February	No
Maria River State Forest	4h	West	482780	6552577	Early February	Late February	No
Maria River State Forest	4i	West	482826	6552552	Early February	Late February	No
Maria River State Forest	4j	West	482885	6552557	Early February	Late February	No
Maria River State Forest	4k	East	483161	6552980	Early February	Late February	No
Maria River State Forest	4l	East	483152	6552927	Early February	Late February	No
Maria River State Forest	4m	East	483148	6552874	Early February	Late February	No
Maria River State Forest	4n	East	483193	6552867	Early February	Late February	No
Maria River State Forest	4o	East	483199	6552920	Early February	Late February	No
Maria River State Forest	4p	East	483208	6552980	Early February	Late February	No
Maria River State Forest	4q	East	483260	6552929	Early February	Late February	No
Maria River State Forest	4r	East	483249	6552881	Early February	Late February	No
Maria River State Forest	4s	East	483240	6552829	Early February	Late February	No
Maria River State Forest	4t	East	483184	6552790	Early February	Late February	No

Table 6-B. Summary of arboreal trapping data.

Date	Trap Site	Trap Number	Species (Common)	Species (Scientific)	Sex	Age	Comments
25/02/2014	1 East	E 6	Brown Antechinus	*Antechinus stuartii*	Male	Immature	
25/02/2014	2 East	E 6	Brown Antechinus	*Antechinus stuartii*	Male	Immature	
25/02/2014	2 East	E 8	Brown Antechinus	*Antechinus stuartii*	Male	Immature	
25/02/2014	2 East	E 10	Brown Antechinus	*Antechinus stuartii*	Male	Immature	
25/02/2014	2 East	E 3	Brown Antechinus	*Antechinus stuartii*	Female	Immature	
26/02/2014	1 East	E 9	Brown Antechinus	*Antechinus stuartii*	Male	Immature	
26/02/2014	2 West	E 4	Black Rat	*Rattus rattus*	Male	Mature	
26/02/2014	2 East	E 7	Bush Rat	*Rattus fuscipes*	Female	Mature	
26/02/2014	2 East	E 8	Brown Antechinus	*Antechinus stuartii*	Male	Immature	
26/02/2014	2 East	E 10	Brown Antechinus	*Antechinus stuartii*	Male	Immature	
26/02/2014	2 East	E 2	Brown Antechinus	*Antechinus stuartii*	Female	Immature	
26/02/2014	2 East	E 4	Brown Antechinus	*Antechinus stuartii*	Male	Immature	
27/02/2014	1 West	E 8	Brown Antechinus	*Antechinus stuartii*	Male	Immature	Trap E 4 knocked off platform
27/02/2014	2 West	E 1	Sugar Glider	*Petaurus breviceps*	Male	Mature	
27/02/2014	2 West	E 3	Black Rat	*Rattus rattus*	Male	Mature	
27/02/2014	2 West	E 7	Bush Rat	*Rattus fuscipes*	Male	Mature	
27/02/2014	2 East	E 6	Brown Antechinus	*Antechinus stuartii*	Male	Immature	
27/02/2014	2 East	E 7	Bush Rat	*Rattus fuscipes*	Female	Mature	
27/02/2014	2 East	E 10	Brown Antechinus	*Antechinus stuartii*	Male	Immature	
27/02/2014	2 East	E 3	Brown Antechinus	*Antechinus stuartii*	Female	Immature	
27/02/2014	2 East	E 4	Brown Antechinus	*Antechinus stuartii*	Female	Immature	
28/02/2014	1 East	E 4	NA	*NA*	NA	NA	Knocked off platform
28/02/2014	1 West	E 1	Brown Antechinus	*Antechinus stuartii*	Male	Immature	
28/02/2014	1 West	E 6	Brown Antechinus	*Antechinus stuartii*	Female	Immature	
28/02/2014	1 West	E 8	Brush-tailed Possum	*Trichosurus vulpecula*	NA	NA	Large adult
28/02/2014	2 West	E 1	Sugar Glider	*Petaurus breviceps*	Male	Mature	
28/02/2014	2 West	E 3	Brown Antechinus	*Antechinus stuartii*	Female	Immature	
28/02/2014	2 West	E 4	Bush Rat	*Rattus fuscipes*	NA	NA	Escaped before sex could be determined
28/02/2014	2 West	E 8	Brown Antechinus	*Antechinus stuartii*	Male	Immature	
28/02/2014	2 East	E 8	Brown Antechinus	*Antechinus stuartii*	Male	Immature	
28/02/2014	2 East	E 9	Brown Antechinus	*Antechinus stuartii*	Male	Immature	
28/02/2014	2 East	E 3	Brown Antechinus	*Antechinus stuartii*	Male	Immature	
28/02/2014	2 East	E 4	Brown Antechinus	*Antechinus stuartii*	Male	Immature	
25/02/2014	3 West	E1	Bush Rat	*Rattus fuscipes*			Weather - Overnight shower of 1 mm and some scattered showers throughout trap installation but not enough to affect baits
25/02/2014	3 East	E1	Brown Antechinus	*Antechinus stuartii*			
25/02/2014	3 East	E3	Brown Antechinus	*Antechinus stuartii*			
25/02/2014	3 East	E8	Brown Antechinus	*Antechinus stuartii*			
25/02/2014	3 East	E9	Bush Rat	*Rattus fuscipes*			
26/02/2014	3 west	E10	Sugar Glider	*Petaurus breviceps*			

26/02/2014	3 East	E1	Brown Antechinus	*Antechinus stuartii*			
26/02/2014	3 East	E3	Brown Antechinus	*Antechinus stuartii*			
26/02/2014	3 East	E8	Brown Antechinus	*Antechinus stuartii*			
26/02/2014	3 East	E9	Brown Antechinus	*Antechinus stuartii*			
26/02/2014	3 East	E10	Brown Antechinus	*Antechinus stuartii*			
26/02/2014	4 West	nothing					
26/02/2014	4 East	E8	Bush Rat	*Rattus fuscipes*			
27/02/2014	3 west	E6	Bush Rat	*Rattus fuscipes*			
27/02/2014	3 East	E3	Brown Antechinus	*Antechinus stuartii*			
27/02/2014	3 East	E8	Brown Antechinus	*Antechinus stuartii*			
27/02/2014	3 East	E10	Brown Antechinus	*Antechinus stuartii*			
27/02/2014	3 East	E9	Bush Rat	*Rattus fuscipes*			
27/02/2014	4 East	E6	Bush Rat	*Rattus fuscipes*			
28/02/2014	4 West	E5	House Mouse	*Mus musculus*			
28/02/2014	4 East	E6	Bush Rat	*Rattus fuscipes*			
28/02/2014	3 East	E1	Brown Antechinus	*Antechinus stuartii*			
28/02/2014	3 East	E3	Brown Antechinus	*Antechinus stuartii*			
28/02/2014	3 East	E7	Brown Antechinus	*Antechinus stuartii*			
28/02/2014	3 East	E9	Brown Antechinus	*Antechinus stuartii*			
28/02/2014	3 East	E10	Brown Antechinus	*Antechinus stuartii*			
28/02/2014	3 West	E1	Sugar Glider	*Petaurus breviceps*			

Table 6-C. Hair analysis from the arboreal hair tubes performed by Barbara Triggs of Dead Finish

Supplied Sample No.	Area	Site	Hair Tube	Mammal ID - definite	Mammal ID - probable
1	Maria River State Forest	4 east	1A	one rodent hair	*Rattus sp.*
2	Maria River State Forest	4 east	2A	no hairs	
3	Maria River State Forest	4 east	2B	no hairs	
4	Maria River State Forest	4 east	2C	no hairs	
5	Maria River State Forest	4 east	3A	*Rattus lutreolus*	
6	Maria River State Forest	4 east	3B	*R. lutreolus*	
7	Maria River State Forest	4 east	3C	few fine hairs	
8	Maria River State Forest	4 east	3D	no hairs	
9	Cooperabung Hill	2 west	1A	no hairs	rodent
10	Cooperabung Hill	2 west	2A	*R. tunneyi*	
11	Cooperabung Hill	2 west	3A	*R. tunneyi*	
12	Cooperabung Hill	2 west	3B	*R. tunneyi*	
13	Cooperabung Hill	2 west	3C	no hairs	
14	Maria River State Forest	4 west	1A	one rodent hair	*Rattus sp.*
15	Maria River State Forest	4 west	1B	*Rattus sp.*	*R. tunneyi*
16	Maria River State Forest	4 west	1C	no hairs	
17	Maria River State Forest	4 west	2A	no hairs	

18	Maria River State Forest	4 west	3A	no hairs	
19	Maria River State Forest	4 west	3B	one fine hair	rodent
20	Maria River State Forest	4 west	3C	no hairs	
21	Ballengarra State Forest	3 east	1A	no hairs	
22	Ballengarra State Forest	3 east	2A	*R. lutreolus*	
23	Ballengarra State Forest	3 east	2B	few rodent hairs	*Rattus sp.*
24	Ballengarra State Forest	3 east	2C	few rodent hairs	*Rattus sp.*
25	Ballengarra State Forest	3 east	3A	no hairs	
26	Ballengarra State Forest	3 east	3B	no hairs	
27	Ballengarra State Forest	3 east	3C	no hairs	
28	Ballengarra State Forest	3 east	3D	no hairs	
29	Ballengarra State Forest	3 east	4A	*R. tunneyi*	
30	Ballengarra State Forest	3 east	4B	*R. lutreolus*	
31	Ballengarra State Forest	3 east	4C	*R. lutreolus*	
32	Ballengarra State Forest	3 east	5A	no hairs	
33	Ballengarra State Forest	3 east	5B	few fine hairs	rodent
34	Ballengarra State Forest	3 east	6A	few fine hairs	rodent
35	Ballengarra State Forest	3 east	6B	one rodent hair	*Rattus sp.*
36	Ballengarra State Forest	3 east	6C	*Rattus sp.*	*R. lutreolus*
37	Ballengarra State Forest	3 east	6D	no hairs	
38	Ballengarra State Forest	3 east	7A	no hairs	
39	Ballengarra State Forest	3 east	7B	no hairs	
40	Ballengarra State Forest	3 east	7C	one fine hair	rodent
41	Ballengarra State Forest	3 east	7D	rodent tail hairs	
42	Ballengarra State Forest	3 east	8A	no hairs	
43	Ballengarra State Forest	3 east	8B	*R. lutreolus*	
44	Ballengarra State Forest	3 east	8C	*R. lutreolus*	
45	Ballengarra State Forest	3 east	8D	*R. lutreolus*	
46	Ballengarra State Forest	3 east	9A	no hairs	
47	Ballengarra State Forest	3 east	9B	no hairs	
48	Ballengarra State Forest	3 east	9C	no hairs	
49	Ballengarra State Forest	3 east	9D	no hairs	
50	Cairncross State Forest	1 west	1A	no hairs	
51	Cairncross State Forest	1 west	1B	*Trichosurus sp.*	*T. vulpecula*
52	Cairncross State Forest	1 west	2A	*Trichosurus sp.*	*T. vulpecula*
53	Cairncross State Forest	1 west	2B	one rodent hair	*Rattus sp.*
54	Cairncross State Forest	1 west	2C	*Trichosurus sp.*	*T. vulpecula*
55	Cairncross State Forest	1 west	3A	*Trichosurus sp.*	*T. vulpecula*
56	Cairncross State Forest	1 west	3B	*Trichosurus sp.*	*T. vulpecula*
57	Cairncross State Forest	1 west	3C	no hairs	
58	Cairncross State Forest	1 west	4A	no hairs	
59	Cairncross State Forest	1 west	4B	no hairs	
60	Ballengarra State Forest	3 west Barrys	1A	one fine hair	rodent

61	Ballengarra State Forest	3 west Barrys	1B	no hairs	
62	Ballengarra State Forest	3 west Barrys	1C	no hairs	
63	Ballengarra State Forest	3 west Barrys	1D	*R. lutreolus*	
64	Ballengarra State Forest	3 west Barrys	2A	no hairs	
65	Ballengarra State Forest	3 west Barrys	2B	one rodent hair	*Rattus sp.*
66	Ballengarra State Forest	3 west Barrys	3A	*R. lutreolus*	
67	Ballengarra State Forest	3 west Barrys	3B	no hairs	
68	Ballengarra State Forest	3 west Barrys	3C	*Trichosurus sp.*	*T. vulpecula*
69	Ballengarra State Forest	3 west Barrys	3D	*R. lutreolus*	
70	Ballengarra State Forest	3 west Barrys	4A	*Trichosurus sp.*	*T. vulpecula*
71	Ballengarra State Forest	3 west Barrys	4B	*Trichosurus sp.*	*T. vulpecula*
72	Ballengarra State Forest	3 west Barrys	4C	*R. lutreolus*	
73	Ballengarra State Forest	3 west Barrys	5A	no hairs	
74	Cooperabung Hill	2 east Cooperabung	1A	no hairs	
75	Cooperabung Hill	2 east Cooperabung	2A	*Trichosurus sp.*	*T. vulpecula*
76	Cooperabung Hill	2 east Cooperabung	2B	*Trichosurus sp.*	*T. vulpecula*
77	Cooperabung Hill	2 east Cooperabung	3A	*Trichosurus sp.*	*T. vulpecula*
78	Cooperabung Hill	2 east Cooperabung	3B	*R. lutreolus*	
79	Cooperabung Hill	2 east Cooperabung	3C	*Trichosurus sp.*	*T. vulpecula*
80	Cooperabung Hill	2 east Cooperabung	4A	*R. lutreolus*	
81	Cooperabung Hill	2 east Cooperabung	4B	*R. lutreolus*	
82	Cooperabung Hill	2 east Cooperabung	4C	*R. lutreolus*	
83	Cooperabung Hill	2 east Cooperabung	5A	no hairs	
84	Cooperabung Hill	2 east Cooperabung	5B	no hairs	
85	Cairncross State Forest	1 east	1A	*Trichosurus sp.*	*T. vulpecula*
86	Cairncross State Forest	1 east	1B	*Trichosurus sp.*	*T. vulpecula*
87	Cairncross State Forest	1 east	2A	few fine hairs	rodent
88	Cairncross State Forest	1 east	2B	no hairs	
89	Cairncross State Forest	1 east	3A	few rodent hairs	*Rattus sp.*
90	Cairncross State Forest	1 east	3B	few rodent hairs	*Rattus sp.*
91	Cairncross State Forest	1 east	4A	*R. lutreolus*	
92	Cairncross State Forest	1 east	4B	no hairs	
93	Cairncross State Forest	1 east	4C	*Isoodon macrourus*	
94	Cairncross State Forest	1 east	4D	*I. macrourus*	
95	Cairncross State Forest	1 east	5A	*I. macrourus*	
96	Cairncross State Forest	1 east	5B	no hairs	
97	Cairncross State Forest	1 east	5C	no hairs	
98	Cairncross State Forest	1 east	5D	one fine hair	rodent
99	Cairncross State Forest	1 east	6A	one rodent hair	*Rattus sp.*
100	Cairncross State Forest	1 east	7A	no hairs	
101	Cairncross State Forest	1 east	7B	no hairs	
102	Cairncross State Forest	1 east	7C	one rodent hair	*Rattus sp.*
103	Cairncross State Forest	1 east	7D	one rodent hair	*Rattus sp.*

104	Cairncross State Forest	1 east	8A	few rodent hairs	*Rattus sp.*
105	Cairncross State Forest	1 east	8B	*Rattus sp.*	*R. lutreolus*
106	Cairncross State Forest	1 east	8C	*Rattus sp.*	*R. lutreolus*
107	Cairncross State Forest	1 east	8D	one fine hair	rodent

7.0 Giant Barred Frog

7.1 Introduction

The Environmental Assessment identified Giant Barred Frog at Maria River and suitable habitat at Smiths Creek, Pipers Creek and Cooperabung Creek (GHD 2010). Subsequent surveys of the Project in 2012/2013 confirmed the presence of Giant Barred Frog at Cooperabung Creek, Smiths Creek, Pipers Creek and Maria River and identified suitable areas of habitat at Barrys Creek and downstream of the carriageway at Stumpy Creek (Lewis 2013). This resulted in the development of a specific management strategy for this species which included provisions for both baseline and post construction operational monitoring at all four sites where it had been detected and at two reference sites located in the upper reaches of Cooperabung Creek and Pipers Creek. The following presents the results from implementing the spring and summer monitoring including the Chytrid testing but does not include the autumn sampling which is subject to the Environmental Services contract.

7.2 Sampling Technique

7.2.1 Frog Surveys

Frog surveys were performed in the manner outlined in the Giant Barred Frog management strategy (Lewis 2013). This involved:

- Surveys being performed within 7 days of a rainfall event exceeding 10 mm in 24 hours using the Bureau of Meteorology (BOM) weather stations at Maria River (station number 560003) and Telegraph Point (560011);
- 1 km transect with 450 m either side of the construction footprint (100 m represents construction footprint);
- Each field survey involved a meandering transect on both sides of the stream bank with all captured Giant Barred Frogs permanently marked using a PIT tag (i.e. micro-chipped) and specifically a Trovan Nanotransponder (000735#### series). Survey effort ranged from 3.25 – 6.25 hours per transect with variability in time length attributed to variations in habitat, accessibility and the number of frogs being processed;
- For each frog, the following information was collected:
  - Location according to demarcated survey zone (20 x 50 m zones);
  - Distance from the stream edge measured to the nearest 0.1 m;
  - Position within the microhabitat (i.e. under litter, above litter, exposed, on rock/log)
  - Sex (male, female, unknown);
  - Age class (adult = >60 mm; sub adult = 40-60 mm; juvenile = <40 mm)
  - Snout-vent length (mm);
  - Weight (grams); and
  - Breeding condition with:
    - males assessed on the colouration of their nuptial pads (i.e. no colour, light, moderate, dark) in accordance with a classification developed by Lewis Ecological Surveys (Table 6-1);
    - females based on whether they are gravid (i.e. typically adult weighing > 100 grams) or not gravid (egg bearing);
    - frogs with a snout vent length of <60 mm were classified as immature.

7.2.2 Tadpole Surveys

Tadpole surveys were undertaken using the following procedure:

- The 1 km transect was divided up into 10 x 100 m zones with 4-5 zones in the downstream corridor, one zone within the corridor (i.e. construction site) and 4-5 zones upstream of the road corridor.
- Within each zone, two bait traps (~300 mm x 200 mm) were installed and left operating for 3 hours. This equated to 20 bait traps and 60 hours of survey effort.

Some dip-netting was undertaken to confirm the presence of Giant Barred Frog tadpoles at the monitoring sites. During these surveys the presence of exotic fish was also recorded.

Table 7-1. A key developed for determining reproductive condition in male barred frogs (*Mixophyes*).

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

7.2.3 Abiotic Data

The following abiotic variables were collected during the survey.

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

7.2.4 Habitat Surveys

Habitat surveys provide an opportunity to measure changes in the receiving environment over the life of the monitoring program. The following variables were measured in the 100 m zones of the monitoring transect (as detailed above) from standing at the top of the primary stream bank:

- Over storey 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%);
- 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 riffle within the zone;
- Approximate depth of the deepest pool within each zone;
- In stream habitat variables including the percentage cover of silt/sediment, detritus, sand, gravel/loose rocks, aquatic vegetation and bedrock.

7.2.5 Development of a Habitat Quality Rating

A subjective scale was developed for measuring eight habitat attributes thought to influence the distribution of Giant Barred Frogs. Undisturbed sites supporting populations of Giant Barred Frogs on the coastal foothills of the mid north coast tend to support the following attributes:

- A dense overstorey of either eucalypts, rainforest species and occasional palms with a foliage projection cover exceeding 50%;
- An often sparse shrub layer of <20% and similarly sparse groundcover of <35%. Groundcovers may be occasionally clumped and often comprise tussock species such as *Lomandra longifolia*;
- Often a consistent ground cover of leaves/litter which provides more than 50% cover;
- There are few exposed or bare patches of dirt and hoofed livestock are absent;
- The aquatic habitat is comprised of pools and riffles with the deeper sections often exceeding 1.0 m in depth; and
- There is little to no sign of sediment/silt covering the stream bed.

Using a sliding scale from optimal habitat attributes scoring 2 and progressively scaling lesser representations with 1 and 0 respectively a cumulative scale has been developed. In this way, a perfect site unaffected by anthropogenic disturbances would achieve a maximum of 16. The scoring attributes table is presented in Table 7-2.

i. Benchmarking Habitat Quality

A benchmarking exercise was used to overcome illogical rational used to assign habitat quality. The Pipers Creek reference site scored a 12.7 out of a possible 16. Although the maximum possible score was 16 the score achieved for Pipers Creek was considered more realistic in nature because the site showed evidence of past storm events with trees falls and breaks in the canopy, some bank collapse resulting from flood events in January 2013 and the resulting dense and extensive (>25m^2) clusters of ground covers which are not considered particularly suitable for Giant Barred Frog.

High quality habitat is considered when a site or broad zone achieves a score of >11.25. Moderate quality of habitat has been assigned to sites with scores of 10-11.25 and low quality for sites which achieve scores of <10.0.

Table 7-2. Habitat attributes used to measure habitat quality.

Habitat Attribute	0	1	2
Overstorey Cover	<25%	26-50%	>50%
Shrub Cover	>35%	20-35%	<20%
Groundcover	>55%	35-55%	<35%
Litter Cover	<25%	25-49%	>49%
Soil Cover (bare ground)	>9%	4-9%	<4%
Livestock (i.e. cattle)	Current	Recent Past < 12 months	No Evidence
Maximum Pool Depth	<0.3 m	0.3 – 1.0 m	>1.0 m
Sediment/Silt Instream Cover	>10%	1-10	0

7.2.6 Determining Population Size

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

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

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

Where, as before,

N = Estimate of total population size
M = Total number of animals captured and marked on the first visit
C = Total number of animals captured on the second visit
R = Number of animals captured on the first visit that were then recaptured on the second visit

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

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

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

7.3 Survey Results

The survey results have been presented for each site as a separate section using a standard set of sub headings. The four impact sites starting in the south have been presented first followed by the two reference sites.

7.3.1 Cooperabung Creek (Impact)

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

ii. Abiotic Conditions: A summary of the prevailing abiotic variables is shown in Table 7-3. The conditions in September were described as mild and becoming more difficult to locate frogs following rainfall earlier in the week. Conditions had improved during the summer survey with some 25 mm of rainfall in the week leading up to the survey in an otherwise very dry season.

iii. Number of Giant Barred Frogs Recorded

a. Spring - Three Giant Barred Frogs were recorded/captured during the spring survey. They comprised two sub adult males and one adult female (Appendix). Although no male frogs were recorded/captured they have been previously recorded a further 300 m downstream of the monitoring transect. At the time of the survey male frogs are likely to have been dormant beneath the leaf litter and overhanging vegetation on the primary creek bank or within 10 m of it.
b. Summer - Nine Giant Barred Frogs were recorded/captured during the summer survey. They comprised two juveniles, one sub adult, one female and five males (Appendix). At the time of the survey, male frogs displayed a range of nuptial pad colours with one frog each exhibiting 'no colour', 'light' nuptials, 'medium' nuptials and three frogs exhibited 'dark' nuptials indicating most males were in a reproductive state to commence breeding (Appendix).

Table 7-3. Spring abiotic conditions during the spring survey of Cooperabung Creek impact site.

Date	Time	Time (24 hours)	Air Temp °C	Water Temp °C	Cloud Cover %	Humidity %	Wind[1]	Rain[2]	Steam Depth (mm)
22.9.2013	Start Time	1900	14.2	15	0	77	0	0	
	Finish time	2235	10.6	14.75	0	88	0	0	
	Spring Summary	3 hrs 35 minutes	12.4	14.9	0.0	82.5	0.0	0.0	
22.9.2013	Start Time	2125	21.3	19.5	10	67	0	1	0
	Finish time	0220	18.6	19.0	90	88	0	0	0
	Summer Summary	4 hrs 55 minutes	19.95	19.25	50	77.5	0	0.5	0

Rain	During (mm)	Past 24 Hours (mm)	Past 7 Days (mm)	Past 30 Days (mm)
22.9.2013	0	0	13.9	15.2
26.1.2014	0	1	25.6	38.7

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

v. Evidence of Breeding Recorded: Yes via the presence of two sub adult frogs in spring and two juveniles and a young sub adult frog during the summer survey. Although no tadpoles were recorded using bait traps some *Mixophyes* tadpoles were observed in zones C11-C15.

vi. Zones Inhabited By Giant Barred Frogs: Restricted to zones C10, C11-C13, C15 and C18 which lie within and immediately upstream of the existing carriageway (Figure 7-1). Both zones C10 and C11 are considered to form part of the construction footprint and are likely to require the relocation of Giant Barred Frogs.

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

viii. Habitat: The overall habitat quality score was 10.65 with the individual zones scoring between 10.33 and 10.77 (Figure 7-2).

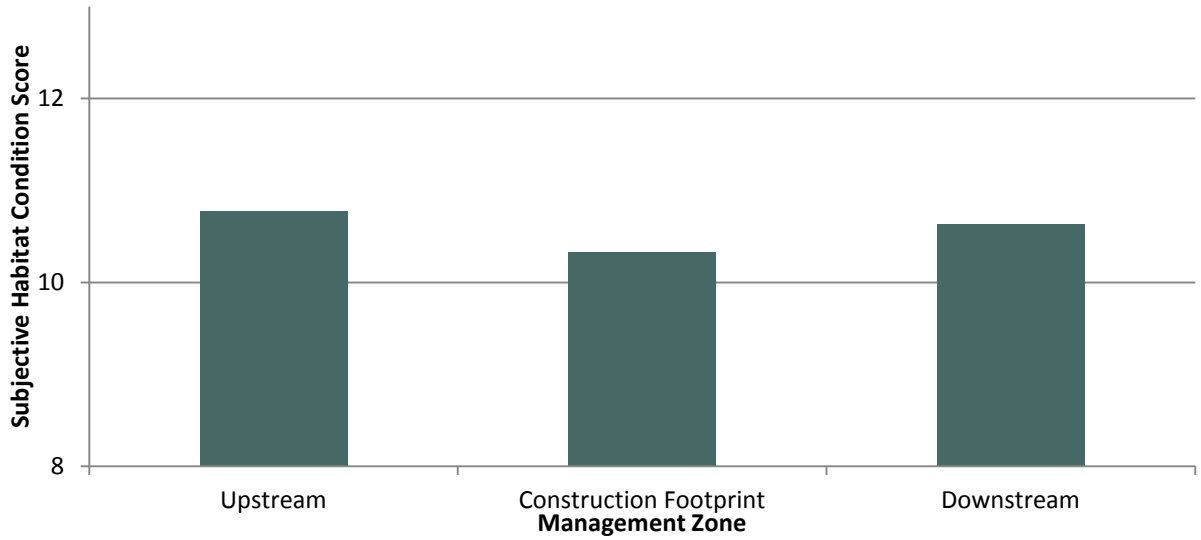

Figure 7-2. Habitat quality scores derived for the three management zones along the 1 km transect at Cooperabung Creek (impact).

Figure 7-1. Cooperabung Creek (impact) Giant Barred frog monitoring site.

7.3.2 Smiths Creek (Impact)

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

ii. Abiotic Conditions: A summary of the prevailing abiotic variables is shown in Table 7-4. Following a significant rainfall event in the Kundabung area on the 16th September conditions were mild with the cool dry air resulting in low levels of humidity. Larger adult frogs tended to react to this by emerging later at night. Conditions had improved during the summer survey with some 25 mm of rainfall in the week leading up to the survey in an otherwise very dry season. The temperature were, however, in a range when male frogs would be expected to respond to broadcast/mimicked calls.

Table 7-4. Abiotic conditions during the survey of Smiths Creek (Impact).

Date	Time	Time (24 hours)	Air Temp °C	Water Temp °C	Cloud Cover %	Humidity %	Wind[1]	Rain[2]	Steam Depth (mm)
19.9.2013	Start Time	1845	15.7	17	0	76	0	0	
	Finish time	0020	9	15.5	0	90	0	0	
	Spring Summary	5 hrs 35 minutes	12.4	16.3	0.0	83.0	0.0	0.0	
28.1.2014	Start Time	2102	20.4	22.5	10	68	0	0	0
	Finish time	0302	16.5	22.5	0	91	0	0	0
	Summer Summary	5 hrs	18.45	22.5	5	79.5	0	0	0

Rain	During (mm)	Past 24 Hours (mm)	Past 7 Days (mm)	Past 30 Days (mm)
19.9.2013	0	0	13.9	15.2
28.1.2014	0	1	26.6	38.7

iii. Number of Giant Barred Frogs Recorded: Spring - Ten (10) Giant Barred Frogs were recorded/captured during the survey. They comprised two females and one male with the remainder classified as sub adults although frog with the identifier 000735C27C is likely to be a male frog showing some early pigmentation on its throat and abdomen (Appendix).

Summer – Sixteen (16) Giant Barred Frogs were recorded/captured during the survey. They comprised one female, four males, nine sub adults and two juveniles (Appendix).Two frogs were recaptures from the spring survey.

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

v. Evidence of Breeding Recorded: Yes via the presence of seven sub adult frogs. No tadpoles were recorded using bait traps. Tadpoles were observed in the shallower pools and expected to occur also in the deeper pools.

vi. Zones Inhabited By Giant Barred Frogs: Distributed across 10 zones (C1, D2, D5, D6, U1, U3, U6, U7, U8, U9) including the construction footprint (Appendix; Figure 7-3). Most of the frogs were located in the upper reaches of the upstream part of the transect.

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

viii. Habitat: The overall habitat quality score was 11.12 with the individual zones scoring between 10.76 (construction footprint), 10.94 for the downstream areas and 11.8 for the upstream area (Figure 7-4).

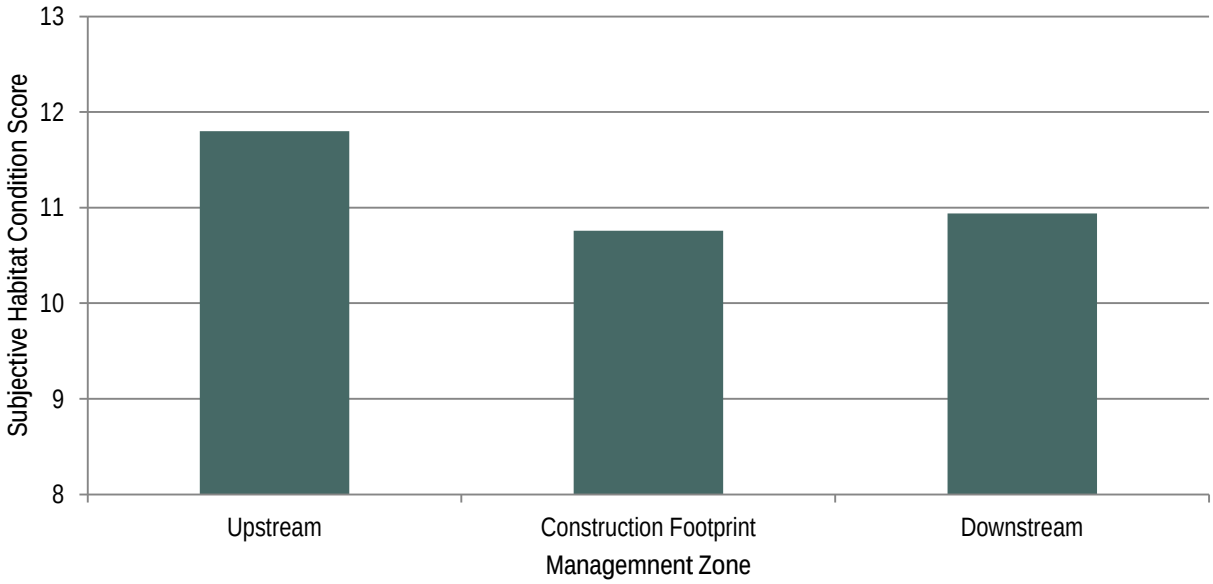

Figure 7-4. Habitat quality scores derived for the three management zones along the 1 km transect at Smiths Creek (impact).

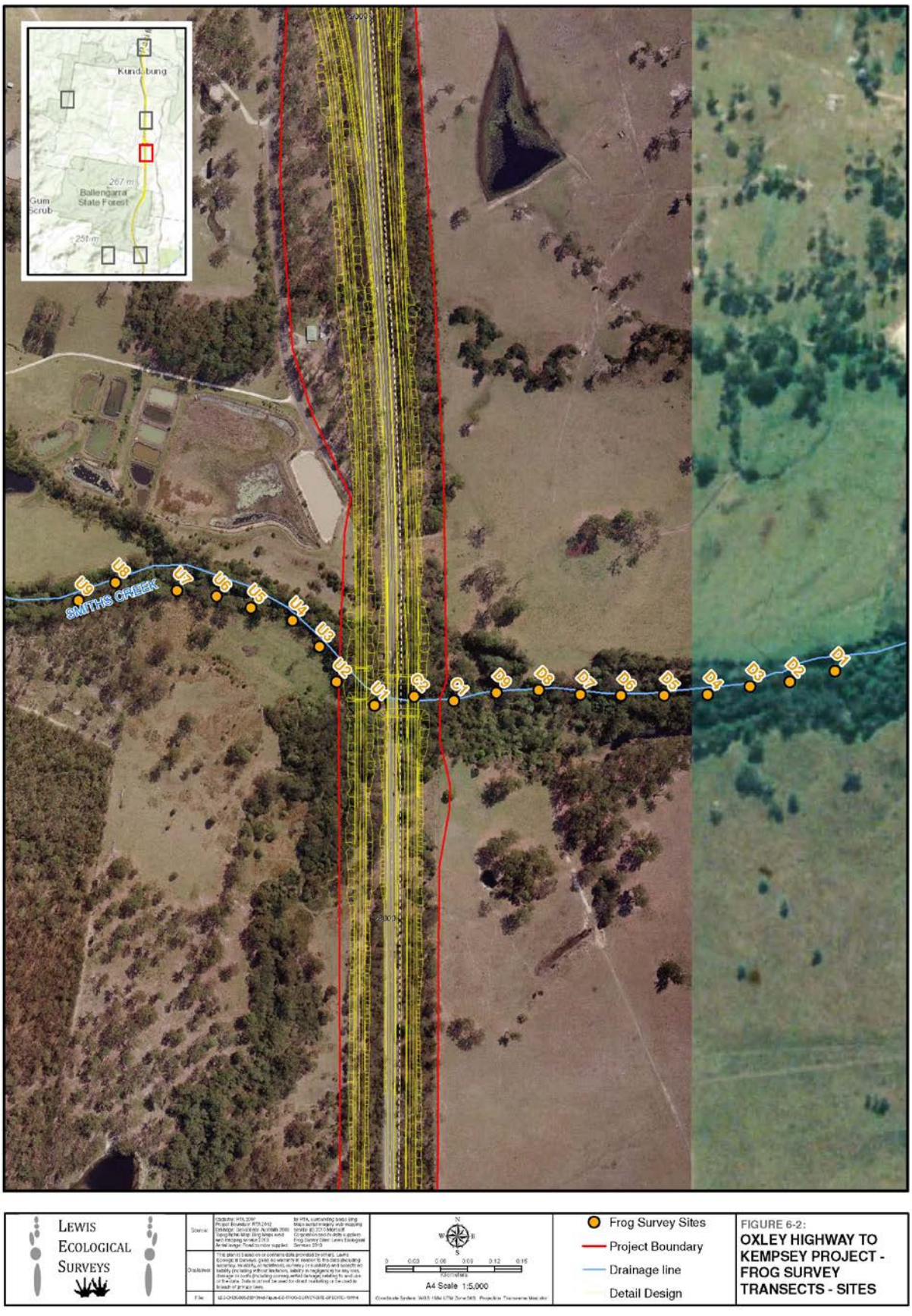

Figure 7-3. Smiths Creek (impact) Giant Barred Frog monitoring site.

7.2.3 Pipers Creek (Impact)

i. Date and Time Taken To Complete The Survey: The spring field survey was undertaken on the 18th October 2013 between 1958-0048 hours and the summer survey on the 28th January 2014 between 2045-0220 hours.

ii. Abiotic Conditions: A summary of the prevailing abiotic variables is shown in Table 7-5. The spring conditions were described as very dry for the month leading up to this survey until a significant rainfall event of ~25 mm was recorded 12 hours prior to the survey. Some light rain fell for up to 3 hours before the survey but then conditions changed with cloud dissipating and air temperature dropping rapidly to 11°c. Conditions had improved during the summer survey with some 25 mm of rainfall in the week leading up to the survey in an otherwise very dry season. The recorded air temperature was in the range when male frogs would be expected to respond to broadcast/mimicked calls.

Table 7-5. Abiotic conditions during the spring survey of Pipers Creek.

Date	Time	Time (24 hours)	Air Temp °C	Water Temp °C	Cloud Cover %	Humidity %	Wind[1]	Rain[2]	Steam Depth (mm)
18.10.2013	Start Time	2000	16.6	15	95	79	0	1	
	Finish time	0205	11	15	0	100	0	1	
	Spring Summary	6 hours 5 minutes	13.8	15.0	47.5	89.5	0.0	1.0	550
28.1.2014	Start Time	2045	25	19	25	70	0	0	
	Finish time	0220	23	19	0	90	0	0	
	Summer Summary	5 hours 35 minutes	24	19	12.5	80	0	0	210

Rain	During (mm)	Past 24 Hours (mm)	Past 7 Days (mm)	Past 30 Days (mm)
18.10.2013	0	10.1	24.3	27.4
28.1.2014	0	1	26.6	38.7

iii. Number of Giant Barred Frogs Recorded: Spring - Eight Giant Barred Frogs were recorded during the spring survey with three identified as adult males, two females and three sub adults of unknown sex (Appendix).

Summer - Nine Giant Barred Frogs were captured with five identified as females, two adult males and two sub adults of unknown sex. Four of the frogs were recaptures from the spring survey.

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

v. Evidence of Breeding Recorded: Yes via the presence of sub adult frogs during both the spring and summer survey. No tadpoles were recorded using bait traps. No tadpoles were recorded dip-netting.

vi. Zones Inhabited By Giant Barred Frogs: Restricted to one location downstream of the construction footprint at Zone 4. Recorded from Zone 10 within the construction footprint and from Zones 12, 13, 15, 17 and 18 upstream of the construction footprint (Figure 7-5).

vii. Summer Testing of Chytrid: All of the eight captured frogs showed no sign of being infected with Chytrid (Appendix).

vii. Habitat: The habitat condition score differed markedly across the three management zones with the upstream area scoring 11.1 and the downstream area scoring 9.11 due largely to a reduction in riparian vegetation, erosion and

sedimentation from cattle affecting both the terrestrial and aquatic scores. The construction footprint scored quite high due to a lot of the footprint containing intact vegetation (Figure 7-6).

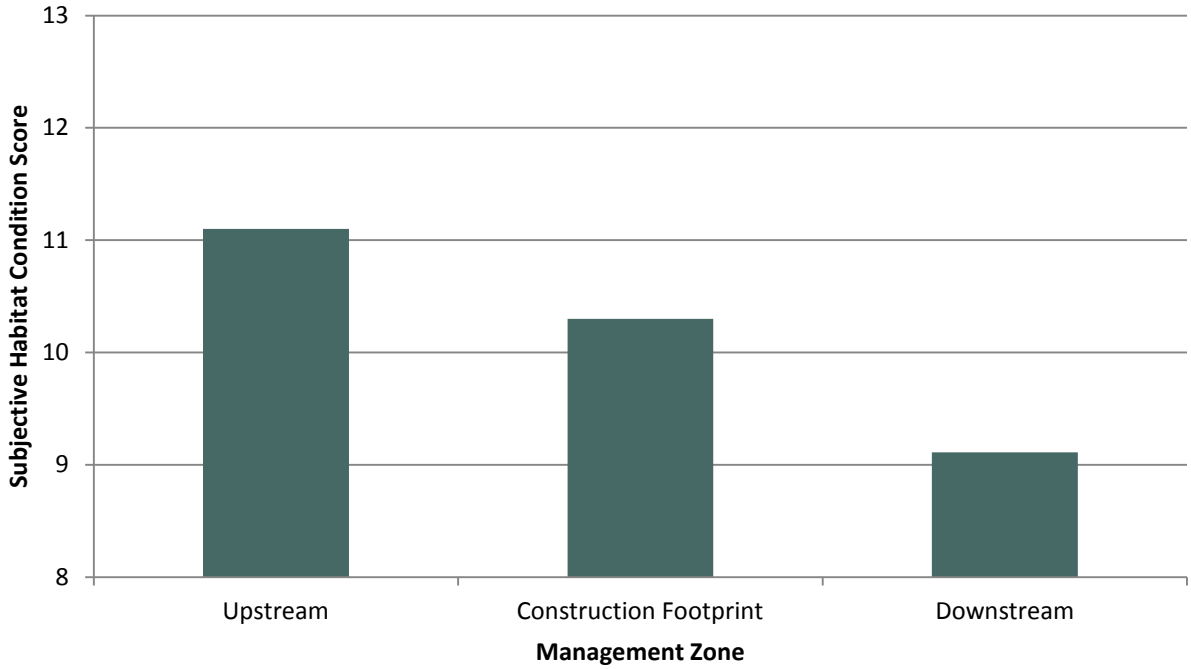

Figure 7-6. Habitat quality scores for each of the management zones at Pipers Creek.

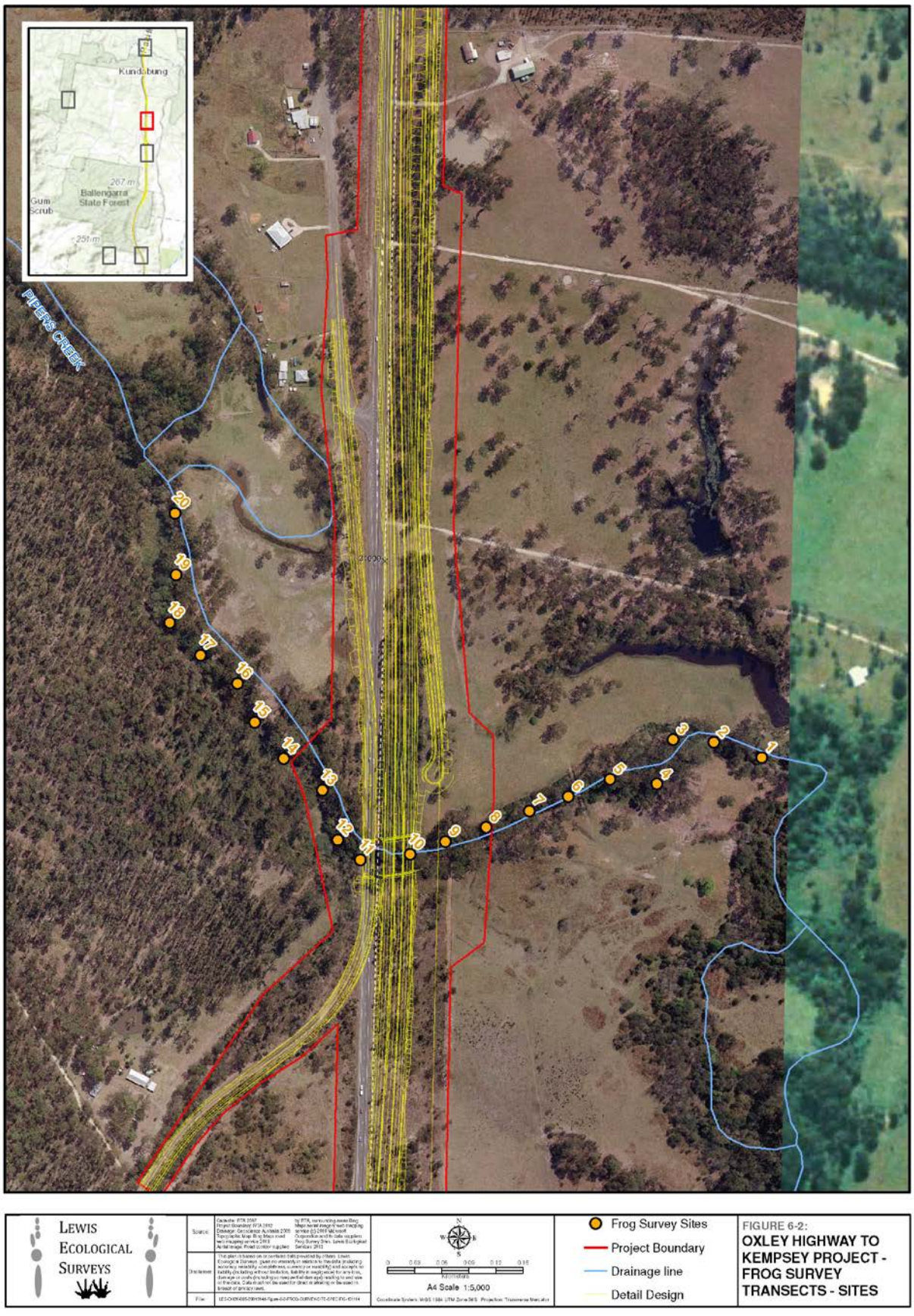

Figure 7-5. Distribution of survey zones at Pipers Creek (Impact).

7.2.4 Maria River (Impact)

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

ii. Abiotic Conditions: A summary of the prevailing abiotic variables is shown in Table 6-6. Surveys commenced on the 18th September following a rainfall event of 12 mm on the 16th September and the 31st January following a rainfall event of 15 mm. The spring surveys were conducted during somewhat mild conditions whilst the summer surveys were very dry leading up to a suitable rainfall event.

Table 7-6. Abiotic conditions during the spring survey of Maria River (impact).

Date	Time	Time (24 hours)	Air Temp °C	Water Temp °C	Cloud Cover %	Humidity %	Wind[1]	Rain[2]	Steam Depth (mm)
18.9.2013	Start Time	1928	16	19.5	0	58	0	1	-
	Finish time	0022	9.7	17.5	0	90	0	0	-
	Spring Summary	4 hours 54 minutes	12.9	18.5	0.0	74.0	0.0	0.5	410
31.1.2014	Start Time	2055	23.3	18	0	70	0	0	-
	Finish time	0315	15.9	18	0	89	0	0	-
	Summer Summary	6 hours 20 minutes	19.6	18	0	79.5	0	0	290
Rain	During (mm)		Past 24 Hours (mm)			Past 7 Days (mm)		Past 30 Days (mm)	
18.10.2013	0		0			13.9		15.2	
28.1.2014	0		0			19.3		31.9	

iii. Number of Giant Barred Frogs Recorded: Spring - Ten (10) Giant Barred Frogs were recorded/captured during the survey. They comprised six females with the remainder classified as sub adults although the frog with the identifier 0007357806 is likely to be a male nearing maturity (Appendix).

Summer – Nine Giant Barred Frogs were recorded during the survey comprising three adult males, one female, one sub adult and two juveniles. There were no recaptures.

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

v. Evidence of Breeding Recorded: Yes via the presence of both sub adult and juvenile frogs. No tadpoles were recorded using bait traps. Some follow up dip netting wasn't able to record tadpoles.

vi. Summer Testing of Chytrid: All of the six captured frogs showed no sign of being infected with Chytrid (Appendix).

vii. Zones Inhabited By Giant Barred Frogs: Distributed across nine zones including zones bordering the construction footprint. They include sites immediately above the construction footprint at U1, U2, U8 and U9 and at a few downstream zones including D3, D4, D5, D6 and D8 (Figure 7-7; Appendix).

viii. Habitat: The habitat quality was highest in the downstream management zone with 9.89 and lowest in the upstream zones with 8.78 (Figure 7-8). This is attributed to a high level of past disturbances at the upstream site where much of the understorey is comprised of dense Noxious Lantana and parts of the southern riparian zone are grazed cattle paddocks. Within the construction zone, past management of weeds and associated rehabilitation with the construction of the twin bridges in 2005 has a slightly improved habitat score of 9.0. The downstream section of this transects is more representative of naturally occurring habitat with dense overstorey, sparse understorey and dense

leaf litter. The bottom zone (D1) occurs partly within a powerline easement and has the usual edge associated impacts of dense ground covers dominated by weeds and a reduced overstorey.

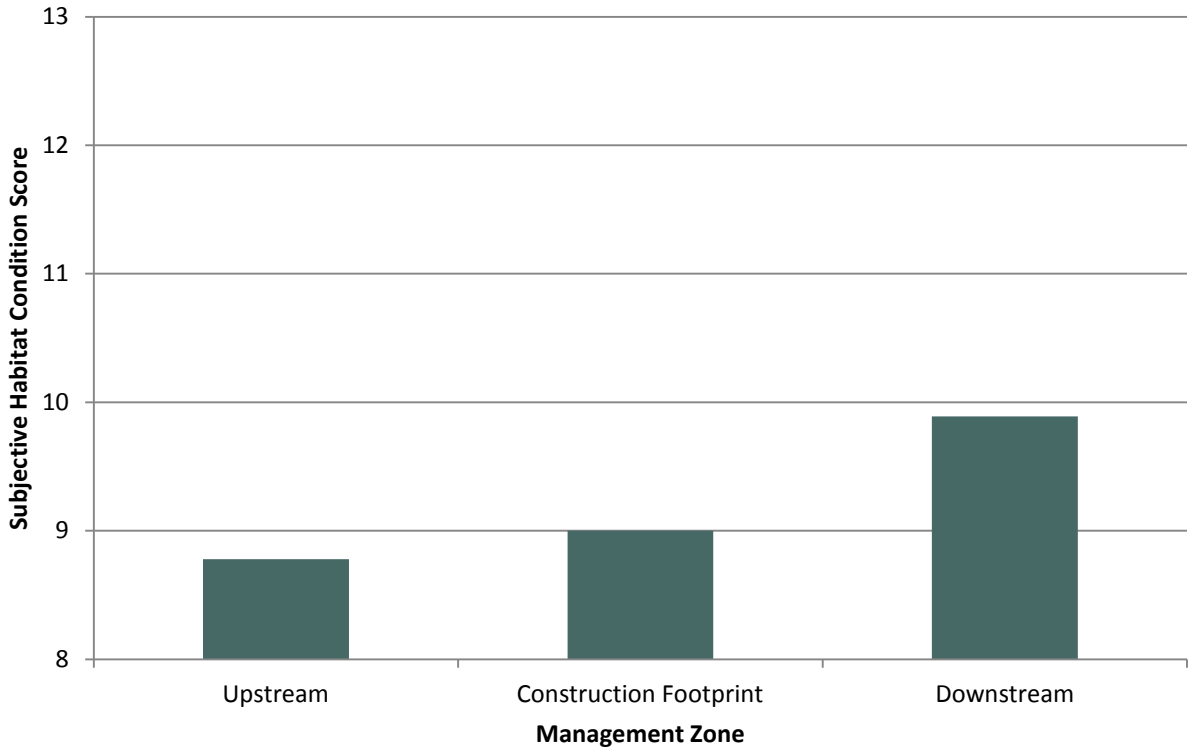

Figure 7-8. Habitat quality scores derived for the three management zones at Maria River (impact).

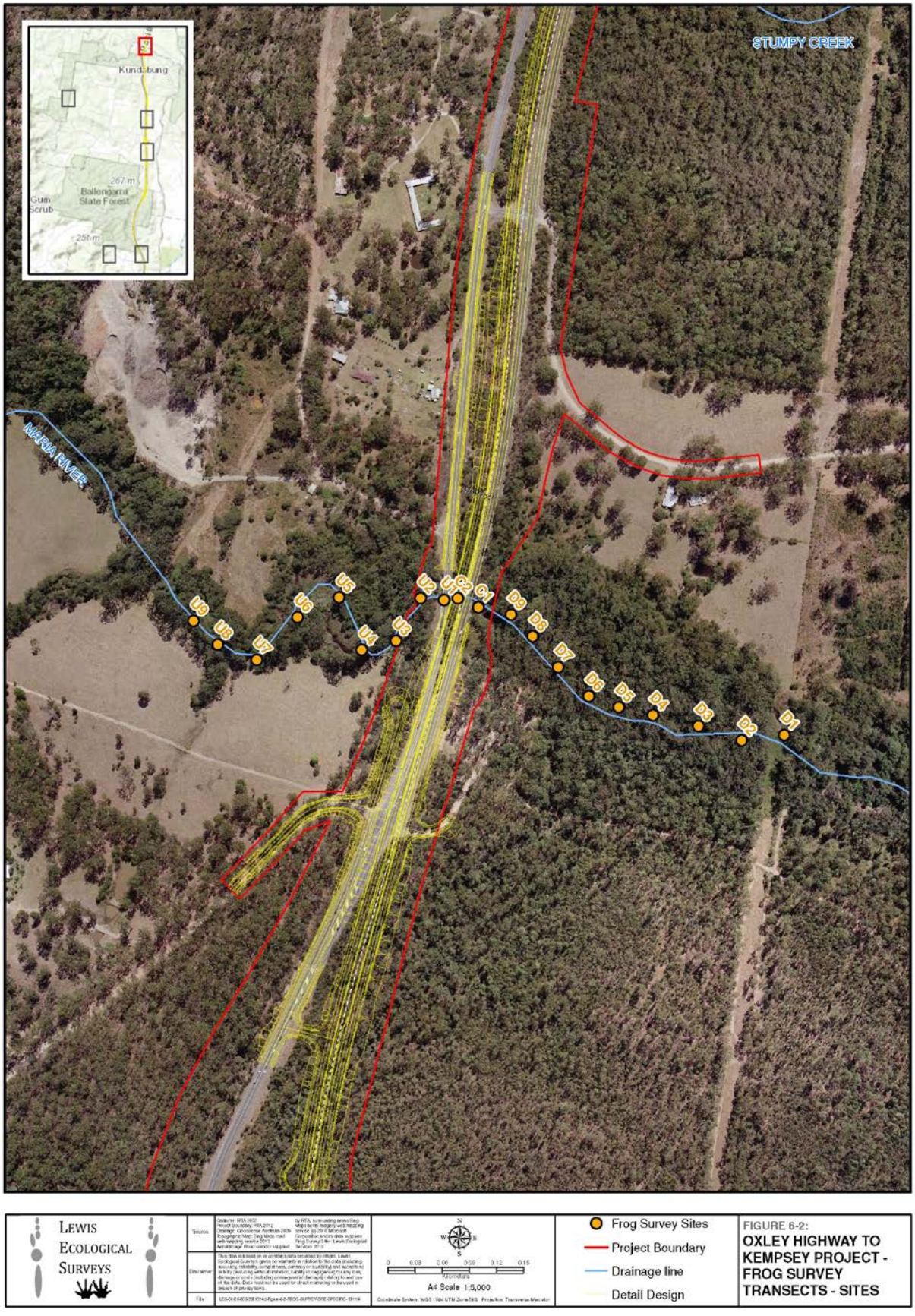

Figure 7-7. Distribution of survey zones at Maria River (Impact).

7.2.5 Cooperabung Creek (Reference Site)

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

ii. Abiotic Conditions: A summary of the prevailing abiotic variables is shown in Table 7-7. The spring survey was undertaken in association with the highest spring rainfall event when the area received around 25 mm of rainfall. Some light rain fell immediately prior and during the initial stages of the spring survey. The summer survey coincided with a similar rainfall event with warmer air temperatures.

Table 7-7. Abiotic conditions during the spring survey of Cooperabung Creek (reference) west of the Upgrade.

Date	Time	Time (24 hours)	Air Temp °C	Water Temp °C	Cloud Cover %	Humidity %	Wind[1]	Rain[2]	Steam Depth (mm)
19.10.2013	Start Time	1958	18.3	16	95	82	0	1	na
	Finish time	0048	14.8	15	0	100	0	1	na
	Spring Summary	4 hrs 50 minutes	16.6	15.5	47.5	91.0	0.0	1.0	270
30.1.2014	Start Time	2050	18.4	21	0	83	0	0	na
	Finish time	0145	16.8	21	0	91	0	0	na
	Summer Summary	4 hours 55 minutes	17.6	21	0	87	0	0	190
Rain	During (mm)		Past 24 Hours (mm)			Past 7 Days (mm)		Past 30 Days (mm)	
19.10.2013	0.5		0			24.3		27.4	
30.1.2014	0		0			26.6		38.7	

iii. Number of Giant Barred Frogs Recorded: Spring - Twenty (20) Giant Barred Frogs were recorded during the survey with 17 of these captured for PIT tagging. The three uncaptured frogs were adult males calling in the lower reaches of the transect. Of the captured frogs, seven were males, seven were females and three were sub adults of unknown sex (Appendix).

Summer – Twenty-one (21) Giant Barred Frogs were recorded with two of these being recaptures from the spring survey. The captured frogs comprised four females, four males, nine sub adults and four juveniles. There were two recaptures from the spring survey.

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

v. Evidence of Breeding Recorded: Yes via the presence of sub adult and juvenile frogs. No tadpoles were recorded using bait traps. Tadpoles were present in most pools during the spring sampling and none were observed during the summer monitoring.

vi. Zones Inhabited By Giant Barred Frogs: Broadly distributed across 15 zones with some consistent presence in the middle and lower reaches of the transect (Figure 7-9; Appendix).

vii. Summer Testing of Chytrid: One of the 10 frogs swabbed for Chytrid returned a positive result across all three tested replications (Appendix). The infected frog was located at the downstream end of this transect. This confirms Chytrid as being present in the upstream reaches a number of kilometres upstream of the Project.

Habitat: The overall habitat quality score was 8.5 and has been assigned a low habitat quality rating. There are no specific management zones to graph as this is a reference site and is indicative of Giant Barred Frogs occurring on partly cleared farm land used for cattle grazing.

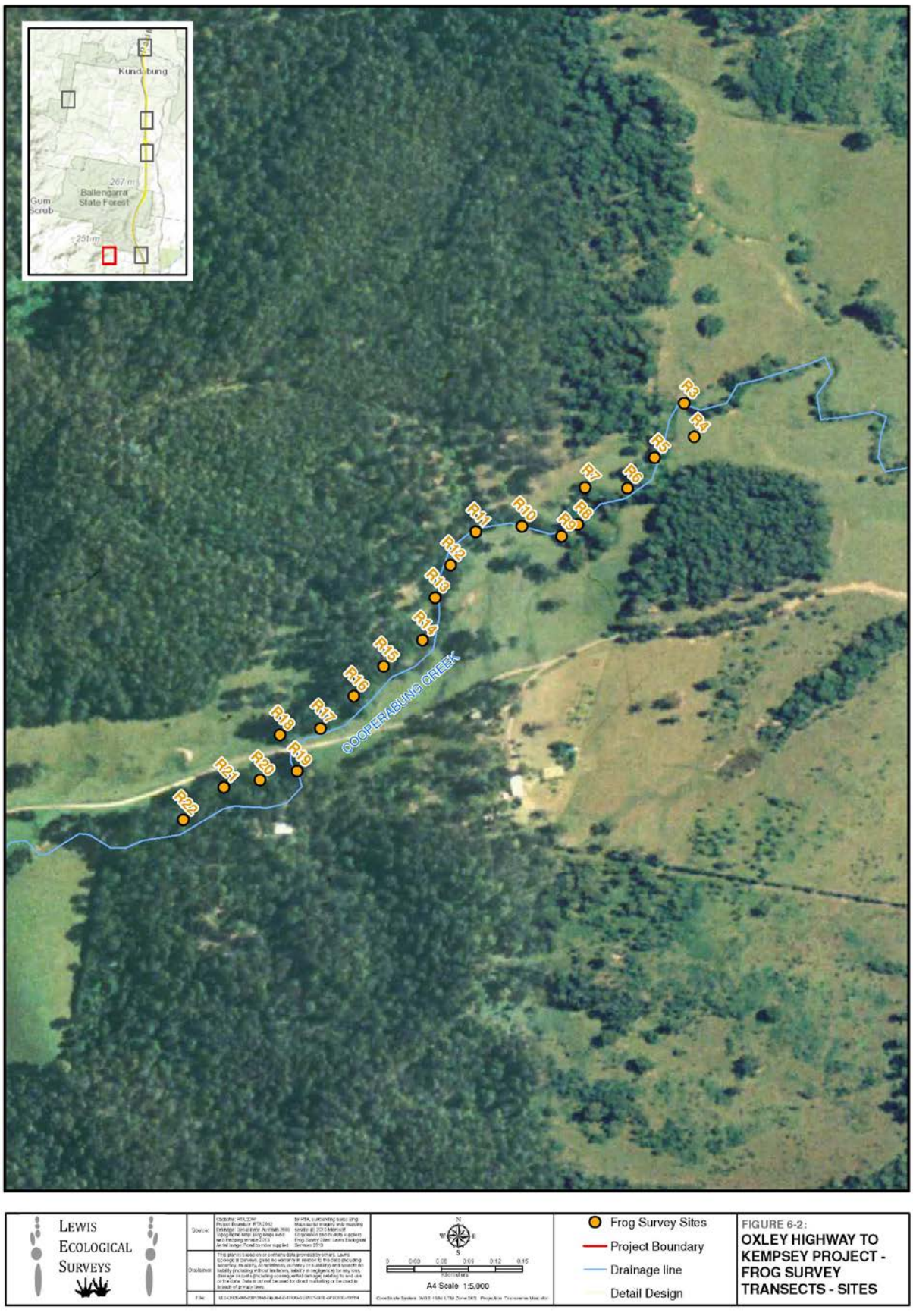

Figure 7-9. Distribution of survey zones at Cooperabung Creek (Reference).

7.2.6 Pipers Creek

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

ii. Abiotic Conditions: A summary of the prevailing abiotic variables is shown in Table 7-8. The spring conditions were described as mild and becoming more difficult to locate frogs following rainfall earlier in the week. The summer conditions were described as ideal following a notable rainfall event and warm evening temperatures ensuring that some frogs would be calling.

Table 7-8. Abiotic conditions during the spring survey of Pipers Creek in Kalantenee National Park.

Date	Time	Time (24 hours)	Air Temp °C	Water Temp °C	Cloud Cover %	Humidity %	Wind[1]	Rain[2]	Steam Depth (mm)
21.9.2013	Start Time	1837 hrs	14.7	15.5	0	70	0	0	na
	Finish time	2245 hrs	9.5	15	0	84	0	0	na
	Spring Summary	4 hours 8 minutes	12.1	15.3	0.0	77.0	0.0	0.0	575.0
27.1.2014	Start Time	2045	24.7	20	100	78	0	0	na
	Finish time	0250	19.0	20	0	85	0	0	na
	Summer Summary	6 hours 5 minutes	21.9	20	50	81.5	0	0	170.0

Rain	During (mm)	Past 24 Hours (mm)	Past 7 Days (mm)	Past 30 Days (mm)
19.9.2013	0	0	13.9	15.2
27.1.2014	0	2.2	27.6	38.7

iii. Number of Giant Barred Frogs Recorded: Spring - Ten (10) Giant Barred Frogs were recorded/captured during the survey. They comprised one sub adult frog of unknown sex, four males and five adult females (Table 7-5).
Summer – Thirteen (13) Giant Barred Frogs comprising eight adult males and five adult females. There were no recaptures.

iv. Population Estimate: There were no recaptures to allow a calculation of population size. Based on the capture data for the spring and summer survey there is at least 10 males, 10 females and the sub adult frog from spring 2013 is unlikely to have grown into an adult at the time of the summer 2014 survey.

v. Evidence of Breeding Recorded: Yes via the presence of one sub adult frog. No tadpoles were recorded using bait traps.

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

vii. Summer Testing of Chytrid: None of the 10 frogs swabbed for Chytrid returned a positive result.

viii. Habitat: The overall habitat quality score was 12.7 and has been assigned a high habitat quality rating. There are no specific management zones to graph as this is a reference site.

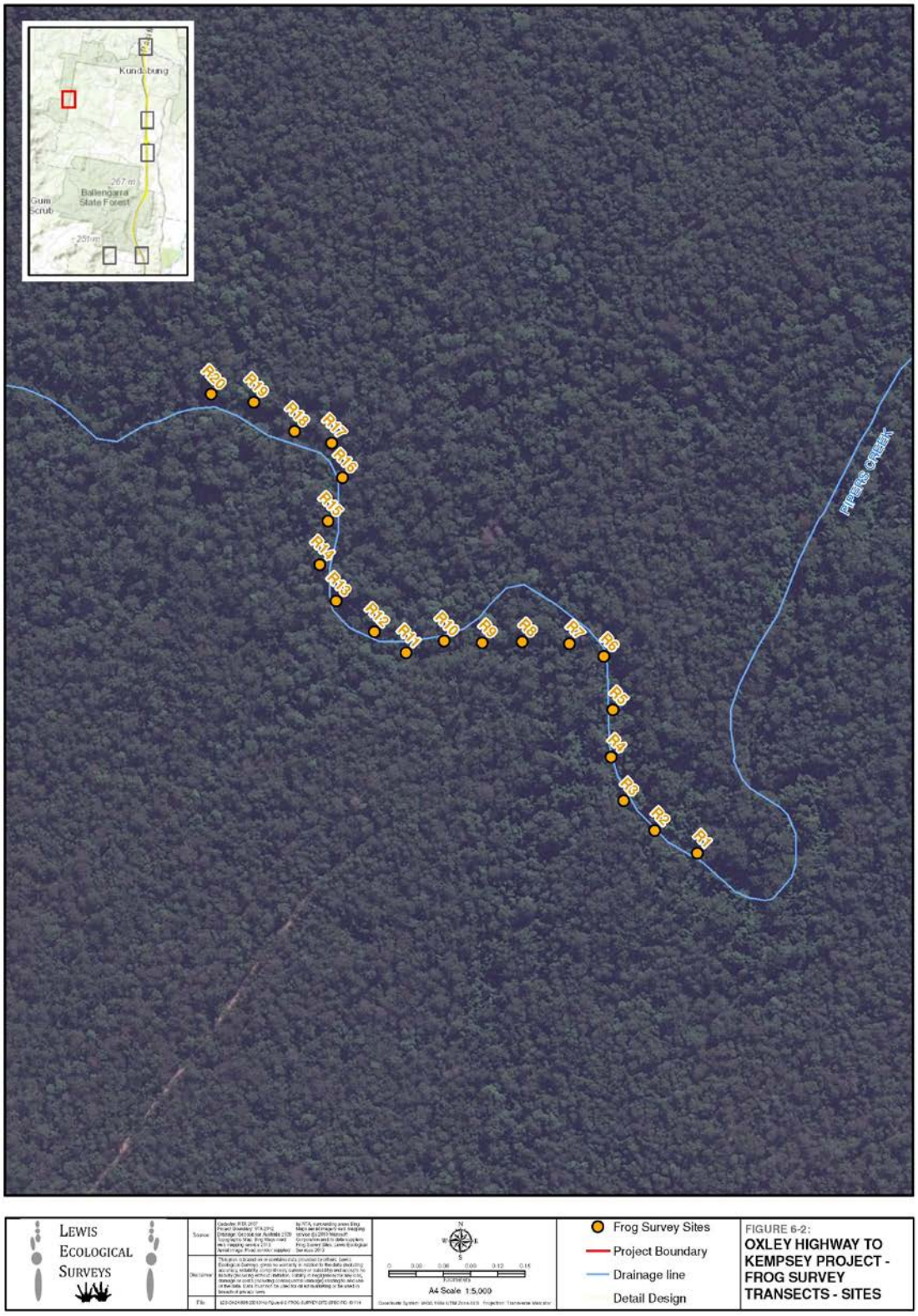

Figure 7-10. Distribution of survey zones at Pipers Creek (Reference).

7.4 Discussion of Findings

The current survey presents two thirds of the pre-construction baseline data with the field surveys being performed during a period of prolonged dry weather. Despite this, all transects recorded frogs during both the spring and summer monitoring events and the presence of juvenile and sub adult frogs indicate that each population has breed successfully in the past two seasons (i.e. multiple age cohorts present). Summer proved to be a more productive time for sampling but not always as was the case at Maria River where fewer frogs were captured in summer than spring.

The absence or difficulty associated with sampling for tadpoles indicates one of two things, firstly, that bait traps may not be a particularly useful technique for this type of tadpole and secondly, that alternative techniques may be difficult to implement with any form of consistency along the transect due to the structure of the streams themselves which often contain abundant instream logs, detritus and are often quite deep (> 1 m). An opportunistic yet recorded survey effort for tadpole sampling may be the only practical way for future tadpole monitoring at these locations.

The collation of two data sets and only a handful of recaptures allude to frogs only moving short distances between the two monitoring events. Typically most frogs removed within their capture zone or moved into the neighbouring one. Similarly, most frogs remained close to the stream edge often in the order of less than 10 m and this was to be expected given the dry survey conditions. A monitoring event that coincides with a pronounced period of rainfall is likely to yield on average far greater distances from the stream edge.

The pattern of microhabitat use at the time of capture was also related to the ongoing dry conditions. Typically, most frogs were captured via direct observation following their detection of illuminated eyes. In the few events where this did not occur, male frogs were often only calling at dusk or shortly after it indicating surveys were probably not going to coincide with a breeding event. In a lot of cases frogs became more active a number of hours after dark (i.e. past 2230 hours) as the humidity exceeded 85% and were attributed to foraging movements over a very small area.

Giant Barred Frogs were often patchily distributed along the monitoring transect and there were repeated occasions where transects of less than 500 m would have resulted in no frogs being detected. This improved when surveys were repeated in summer although substantial areas remained absent of Giant Barred Frogs. At the Cooperabung Creek impact site, frogs appear restricted to the area above the existing Pacific Highway carriageway indicating that any relocation efforts should occur further upstream and not immediately downstream of the construction footprint. This should, however, be guided with the results of the autumn monitoring event because we do know Giant barred Frogs extends for hundreds of metres below the monitoring transect (Lewis 2013). At the remaining three known impact sites (Smiths, Pipers, Maria) frogs are known to occupy areas either within the construction footprint or a short distance from it indicating the important role of the pre-clearing surveys and frog relocations and how the population will respond to this during the construction of the Upgrade.

Chytrid fungus was recorded at both impact and the control/reference sites indicating an inconsistent pattern of occurrence. The disease itself is believed to probably occur throughout the broader area but occur patchily within the Giant Barred Frog population. Given that Chytrid is now known to occur at some sites and not at others the procedures documented in *Hygiene protocol for the control of disease in frogs. Information Circular Number 6* (DECC 2008) should form part of the work method statements for the construction of the Upgrade.

7.5 Key Recommendations

1) The autumn monitoring data is used to finalise the population estimate in accordance with the approved Giant Barred Frog Management Strategy. Together, this will finalise the pre-construction baseline population size data.
2) There is an allowance for amending the sampling technique to sample tadpoles in a more opportunistic way and the survey effort is recorded.
3) A property access agreement be developed with relevant land holder to maximise the opportunity to continue the program in accordance with the Giant Barred Frog management strategy.
4) A strategy is developed for delivering the pre clearing survey data at the Giant Barred Frog locations to the contractor appointed for the Environmental Services contract.

7.6 References

Lewis, B.D (2013). Oxley Highway to Kempsey: Giant Barred Frog (*Mixophyes iteratus*) Management Strategy. Report prepared for SMEC-Hyder Joint Venture by Lewis Ecological Surveys. ©

7.7 Appendix – Field Data

Table 7A-1. Summary table of Giant Barred Frog captures for the spring and summer components of the baseline ecological monitoring.

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
Impact Sites													
Cooperabung Creek													
Spring Sample													
1	Male	Sub Adult	Immature	52.4	17.5	000735C1E9	11	North Bank	1.5	First time capture	Observed	Using flood debris as overhang shelter on dirt	Yellowing throat indicating likely to be a male frog once it matures
2	Male	Sub Adult	Immature	54.1	19.75	000735A97E	12	South Bank	2.1	First time capture	Observed	Above litter	Yellowing throat indicating likely to be a male frog once it matures
3	Female	Adult	Not Gravid	95.6	143.0	000735B40B	13	South Bank	3.7	First time capture	Observed	Above litter	
Summer Sample													
1	Unknown	Juvenile	Immature	38.2	8.25	000735B812	11	North Bank	3.2	First time capture	Observed	Above litter	Swabbed
2	Male	Adult	No Colour	77.7	58.25	0007352F47	12	South Bank	7.3	First time capture	Observed	Above litter	Swabbed
3	Female	Adult	Not Gravid	91.0	118.0	000735830E	18	North Bank	6.8	First time capture	Observed	On Grass	Swabbed
4	Male	Adult	Dark Nuptial	69.7	44.0	0007352816	18	North Bank	5.5	First time capture	Observed	Above litter	Swabbed
5	Male	Adult	Dark Nuptial	68.1	38.25	0007359A50	18	North Bank	2.3	First time capture	Observed	Using flood debris	Swabbed
6	Unknown	Juvenile	Immature	32.5	5.25	0007359E3E	15	South Bank	1.6	First time capture	Observed	Above litter	Swabbed
7	Male	Adult	Moderate Nuptial	73.7	56.0	0007358413	15	South Bank	3.5	First time capture	Observed	Above litter	Swabbed
8	Male	Adult	Light Nuptial	64.7	33.75	0007359026	12	South Bank	3.8	First time capture	Observed	Above litter	Swabbed
9	Unknown	Juvenile	Immature	40.2	10.0	0007357F41	10	North Bank	1.0	First time capture	Observed	On Grass	Swabbed
Smiths Creek													
Spring Sample													
1	Unknown	Sub Adult	Immature	39.6	9.5	000735797B	C1	North Bank	1.5	First time capture	Observed	Above Litter	
2	Unknown	Sub Adult	Immature	40.5	10.5	000735A06F	D5	North Bank	1.0	First time capture	Observed	Above Litter	

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
3	Unknown	Sub Adult	Immature	46.0	10.75	000735C27C	D6	North Bank	1.0	First time capture	Observed	Above Litter	Yellowing underbody indicative of a young male frog
4	Male	Adult	Light Nuptial	74.1	63	0007357455	U6	North Bank	3.5	First time capture	Observed	Partially Buried	
5	Unknown	Sub Adult	Immature	45.1	13.75	000735C206	U6	North Bank	1.5	First time capture	Observed	Above Litter	
6	Unknown	Sub Adult	Immature	41.5	9	00073546CD	U7	North Bank	4.0	First time capture	Observed	Above Litter	
7	Female	Adult	Not Gravid	117.5	190	00073587DF	U6	North Bank	4.0	First time capture	Observed	Sheltering beneath Lomandra	
8	Unknown	Sub Adult	Immature	46.2	12	00073564F9	U9	North Bank	3.0	First time capture	Observed	Above Litter	
9	Female	Adult	Not Gravid	96.0	149	000735AC9F	U9	North Bank	4.5	First time capture	Observed	Sheltering beneath Lomandra	
10	Unknown	Sub Adult	Immature	45.8	11.75	000735B72A	U8	North Bank	1.0	First time capture	Observed	On Dirt	
Summer Sample													
1	Unknown	Sub Adult	Immature	55.5	19.75	0007354559	C1	South Bank	8.0	First time capture	Observed	Above Litter	Probably a male frog. Swabbed
2	Male	Adult	No Colour	66.7	33.25	000735B6F8	D6	South Bank	7.5	First time capture	Observed	Above Litter	Swabbed
3	Unknown	Sub Adult	Immature	41.5	9.25	0007356DEB	D5	South Bank	2.3	First time capture	Observed	Above Litter	Swabbed
4	Unknown	Sub Adult	Immature	58.2	27.25	0007353FA9	D2	North Bank	4.1	First time capture	Observed	Above Litter	Probably a male frog. Swabbed
5	Unknown	Juvenile	Immature	36.9	7.75	000735B8C9	D5	North Bank	3.0	First time capture	Observed	Above Litter	Swabbed
6	Unknown	Juvenile	Immature	36.0	6.75	000735A09D	D5	North Bank	3.3	First time capture	Observed	Above Litter	Swabbed
7	Male	Adult	Moderate Colour	70.2	44.75	0007358B84	U1	North Bank	3.2	First time capture	Observed	On Log	Swabbed
8	Unknown	Sub Adult	Immature	45.3	12.75	000735C7EC	U3	North Bank	4.4	First time capture	Observed	Above Litter	Swabbed
9	Male	Adult	No Colour	59.6	26.5	0007357443	U5	North Bank	4.0	First time capture	Observed	Partially buried under litter	Swabbed
10	Unknown	Sub Adult	Immature	46.7	12	0007355C06	U5	North Bank	8.5	First time capture	Observed	Above Litter	Swabbed
11	Unknown	Sub Adult	Immature	56.2	23.75	000735C206	U6	North Bank	9.3	Remained in same zone and same side of creek as spring	Observed	Above Litter	Swabbed
12	Unknown	Sub Adult	Immature	49.0	15.5	000735CB5C	U7	North Bank	1.3	First time capture	Observed	On Gravel	Swabbed
13	Male	Adult	Moderate Colour	64.6	39.0	000735C3ED	U8	North Bank	6.2	First time capture	Observed	Above Litter	
14	Unknown	Sub Adult	Immature	43.9	12.0	0007357690	U8	North Bank	2.3	First time capture	Observed	Above Litter	

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
15	Unknown	Sub Adult	Immature	55.4	18.75	00073564F9	U9	North Bank	3.8	Remained in same zone and same side of creek as spring	Observed	Above Litter	
16	Female	Adult	Gravid	98.7	165.0	00073542D7	U9	South Bank	7.5	First time capture	Observed	Above Litter	
Pipers Creek													
Spring Sample													
1	Unknown	Sub Adult	Immature	48.2	16.0	000735C107	4	South bank	3.9	First time capture	Observed	Above litter	
2	Unknown	Sub Adult	Immature	56.0	21.5	000735B231	4	North Bank	2.7	First time capture	Observed	Above litter	
3	Unknown	Sub Adult	Immature	53.5	19.0	0007356DF2	4	North Bank	2.9	First time capture	Observed	Above litter	
4	Male	Adult	Dark Nuptials	83.9	86.0	000735BFCC	18	South bank	5.8	First time capture	Observed	Above litter	
5	Male	Adult	Light Nuptials	81.0	82.5	000735BCBE	18	South bank	7.3	First time capture	Observed	Above litter	
6	Male	Adult	No Colour	66.0	36.5	0007353695	18	South bank	8.4	First time capture	Observed	Above litter	Some yellowing spots not recorded at other locations. This frog deemed very light very its size and possible unhealthy or feeling the effects of a long dry spring
7	Male	Adult	Moderate Nuptials	75.6	56.0	0007358A4C	17	South bank	5.2	First time capture	Observed	Above litter	Some yellowing spots not recorded at other locations
8	Female	Adult	Not Gravid	66.6	41.0	0007358DDC	17	South bank	6.2	First time capture	Observed	Above litter	Some yellowing spots not recorded at other locations
Summer Sample													
1	Female	Adult	Not Gravid	63.8	31.0	000735B231	4	North Bank	5.0	Remained in same zone and same side of creek but 2.3 m further from water	Observed	Partially buried under litter	Swabbed
2	Unknown	Sub Adult	Immature	58.9	28.0	000735C107	4	Centre Island	2.7	Remained in same zone and same side of creek	Observed	Above litter	Swabbed
3	Female	Adult	Not Gravid	64.1	38.0	0007356DF2	4	North Bank	5.0	Remained in same zone and same side of creek	Observed	Above litter	Swabbed
4	Male	Adult	Moderate	63.6	32.0	000735BA08	10	North Bank	2.3	First time capture	Observed	Above Litter	Swabbed

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
			Nuptials										
5	Unknown	Sub Adult	Immature	53.0	18.0	00073585C3	12	South Bank	2.1	First time capture	Observed	On Bare Ground	Swabbed
6	Female	Adult	Gravid	99.9	181.0	0007354BC4	13	North Bank	1.0	First time capture	Observed	Above Litter	Swabbed
7	Female	Adult	Gravid	94.3	132.0	0007359B0F	15	South Bank	6.0	First time capture	Observed	Above Litter	Swabbed
8	Female	Adult	Not Gravid	78.8	64.0	0007358DDC	17	South Bank	2.3	Same zone and side of creek but closer to water	Observed	Partially buried under litter	Swabbed
Maria River													
Spring													
1	Unknown	Sub Adult	Immature	49.2	19.75	00073531A8	U9	North Bank	3.5	First time capture	Observed	Above Litter	
2	Female	Adult	Not Gravid	96.6	145	000735B70C	U1	North Bank	3	First time capture	Observed	Above Litter	
3	Female	Adult (young)	Not Gravid	77.8	67.5	00073579A3	U1	North Bank	3.2	First time capture	Observed	Using Undercut of Bank	
4	Sub Adult	Sub Adult	Immature	57.8	28.5	0007357806	U1	North Bank	3.7	First time capture	Observed	Sheltering beneath lantana	Predict this will be a male frog once it matures
5	Female	Adult	Not Gravid	99.2	148	0007357A85	U1	South Bank	2.6	First time capture	Observed	Part Buried Under Litter	
6	Female	Adult	Not Gravid	85.6	83	000735974B	D8	South Bank	7.8	First time capture	Observed	Above Litter	
7	Male	Sub Adult	No Colour	59.9	30	0007356F68	D6	North Bank	2.4	First time capture	Observed	Above Litter	
8	Female	Adult	Not Gravid	90.4	103	000735BEBE	D5	North Bank	13.3	First time capture	Observed	Above Litter	
9	Male	Sub Adult	No Colour	59.9	27	00073531B0	D5	South Bank	1.8	First time capture	Observed	Under Vines	
10	Female	Adult	Not Gravid	99.8	147	000735508E	D4	South Bank	1.9	First time capture	Observed	Above Litter	
Summer													
1	Male	Adult	Light Nuptials	64.6	38.0	000735B2F4	U1	North Bank	2.0	First time capture	Observed	Above Litter	Swabbed
2	Unknown	Juvenile	Immature	38.2	8.5	000735BE05	U1	North Bank	0.8	First time capture	Observed	Above Litter	Swabbed
3	Unknown	Sub Adult	Immature	49.4	13.0	0007359976	U1	North bank	1.5	First time capture	Observed	Above Litter	Swabbed
4	Male	Adult	No data	No data	No data	No data	D3	No data	No data	No data	Calling	Under Litter	Could not be captured
5	Female	Adult	Not Gravid	94.4	158.0	000735D09C	U2	South Bank	3.0	First time capture	Observed	On Dirt	Swabbed
6	Unknown	Juvenile	Immature	37.4	11.0	000735AEE9	U8	North Bank	0.3	First time capture	Observed	On dirt using hole in bank	Swabbed
7	Male	Adult	Light Nuptials	75.8	70.0	000735B020	U9	North Bank	3.0	First time capture	Observed	Part buried under litter	Swabbed

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
8	Unknown	Juvenile	Immature	No data	No data	No data	D8	North Bank	No Data	No Data	Observed	Above Litter	Could not be captured
9	Unknown	Juvenile	Immature	No data	No data	No data	D8	South Bank	No Data	No Data	Observed	Above Litter	Could not be captured
Reference Sites													
Cooperabung Creek													
Spring													
1	Male	Adult	Dark Nuptial	70.8	50.5	000735C3DB	15	North Bank	3.1	First time capture	Call response	Above Litter	
2	Male	Adult	Light Nuptial	74.4	64	0007359C3A	15	North Bank	4.1	First time capture	Observed	Above Litter	
3	Male	Adult	Light Nuptial	71.9	63.5	00073588FF	14	North Bank	1.9	First time capture	Observed	Above Litter	
4	Unknown	Sub Adult	Immature	50.3	21.5	0007356F32	14	North Bank	2.1	First time capture	Observed	Above Litter	
5	Female	Adult	Not Gravid	110.6	142.5	00073576C7	13	North Bank	8.5	First time capture	Observed	Above Litter	
6	Unknown	Sub Adult	Immature	44.9	13.5	00073599EE	11	South bank	2.6	First time capture	Observed	On Pasture Grass	
7	Male	Adult	Moderate Nuptial	71.2	61.5	000735A504	10	South bank	1.2	First time capture	Call response	Above Litter	
8	Female	Adult	Not Gravid	97.0	132.5	000735613C	9	North Bank	2.8	First time capture	Observed	Above Litter	
9	Female	Adult	Not Gravid	96.6	141	0007359F76	5	South bank	1.3	First time capture	Observed	Above Litter	
10	Female	Adult	Not Gravid	97.7	124	00073546F4	9	South bank	7.2	First time capture	Observed	On Pasture Grass	
11	Female	Adult	Not Gravid	94.0	132	0007353E49	17	North Bank	5.9	First time capture	Observed	Above Litter	
12	Unknown	Sub Adult	Immature	54.9	25.5	0007359659	17	North Bank	0.9	First time capture	Observed	Above Litter	
13	Female	Adult	Part Gravid	97.2	147	00073530F3	18	North Bank	3.3	First time capture	Observed	Above Litter	
14	Male	Sub Adult	Immature	57.9	28.5	0007359D56	20	South bank	3.1	First time capture	Observed	Above Litter	Yellow underbody indicating probably a young sub adult male
15	Female	Adult	Part Gravid	98.0	172	000735ADC9	20	South bank	2.4	First time capture	Observed	Above Litter	
16	Male	Sub Adult	Immature	58.3	28.5	0007353F6E	22	North Bank	5.7	First time capture	Observed	Above Litter	
17	Male	Sub Adult	Immature	53.7	22.5	0007358D13	19	South bank	3.2	First time capture	Observed	Above Litter	Yellow underbody indicating probably a young sub adult male
Summer													
1	Unknown	Sub adult	Immature	44.9	13.5	0007357B14	16	South Bank	0.5	First time capture	Observed	Above Litter using Lomandra shelter Site	Swabbed

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
2	Female	Adult	Not Gravid	91.7	130.0	0007359D67	15	North Bank	1.0	First time capture	Observed	Partially Buried Under Litter	Swabbed
3	Unknown	Juvenile	Immature	40.1	10.0	0007357BBC	15	North Bank	0.3	First time capture	Observed	Above Litter	Swabbed
4	Male	Adult	Light Nuptials	73.6	61.0	000735C59A	15	South Bank	0.7	First time capture	Observed	On Dirt	Swabbed
5	Male	Adult	Light Nuptials	75.5	62.0	0007359C3A	15	South Bank	1.1	Same zone but changed side of creek and closer to water	Observed	On Rock	Swabbed
6	Unknown	Sub adult	Immature	45.0	13.5	0007352C3A	14	North Bank	0	First time capture	Observed	Above Litter at Waters Edge	Swabbed
7	Unknown	Sub adult	Immature	45.0	14.0	0007359E7B	11	North Bank	0.3	First time capture	Observed	Using Bank Undercut	
8	Unknown	Sub adult	Immature	45.6	14.5	000735A74D	8	North Bank	2.6	First time capture	Observed	On Grass	
9	Unknown	Juvenile	Immature	37.3	9.0	000735A4D1	8	North Bank	2.9	First time capture	Observed	On Grass	
10	Female	Adult	Not Gravid	95.7	123.0	0007359F76	7	South Bank	4.2	Moved 2 zones upstream	Observed	On Grass	Swabbed
11	Male	Adult	Dark Nuptials	74.1	57.5	00073535CD	7	South Bank	3.6	First time capture	Observed	On Grass	Swabbed
12	Unknown	Sub Adult	Immature	48.5	17.0	0007359D2A	5	South Bank	1.4	First time capture	Observed	Above Litter	
13	Female	Adult	Not Gravid	78.7	68.0	00073563EA	3	South Bank	1.4	First time capture	Observed	Partially Buried Under Litter	Swabbed
14	Male	Adult	Moderate Nuptials	65.9	40.25	000735B0E5	3	North Bank	5.0	First time capture	Observed	On Grass	Swabbed
15	Female	Adult	Not Gravid	68.7	38.75	000735C733	3	South Bank	0.8	First time capture	Observed	Using Bank Undercut	
16	Unknown	Sub Adult	Immature	47.5	18.0	000735C584	15	South Bank	1.9	First time capture	Observed	Above Litter	
17	Unknown	Sub Adult	Immature	41.7	12.5	000735BD28	17	South Bank	1.2	First time capture	Observed	On Grass	
18	Unknown	Juvenile	Immature	39.7	10.0	000735B42E	19	North Bank	2.7	First time capture	Observed	Above Litter	
19	Unknown	Sub Adult	Immature	43.5	13.0	000735A858	19	North Bank	3.0	First time capture	Observed	Above Litter	
20	Unknown	Juvenile	Immature	39.5	11.25	0007354212	22	North Bank	2.4	First time capture	Observed	Above Litter	
21	Unknown	Sub Adult	Immature	40.6	11.25	000735546E	22	South Bank	0.7	First time capture	Observed	Above Litter	
Pipers Creek (Boonie Corner Road)													
Spring													
1	Female	Adult	Not Gravid	93	130	000735AE22	16	North bank	1.1	First time capture	Observed	Partially buried under litter @ 1910 hrs	

Sites	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
2	male	Adult	Medium Nuptials	77.8	60	0007359C08	16	North bank	1.4	First time capture	Observed	Partially buried under litter/moss	
3	male	Adult	Light Nuptials	67.6	39	0007359F7C	19	North bank	2	First time capture	Observed	Shelter beneath Lomandra fronds	
4	Unknown	Sub Adult	Immature	44	13.5	0007352736	9	North bank	2.1	First time capture	Observed	Partially buried under litter	Yellowing underbody indicative of a young male
5	Female	Adult	Not Gravid	89.2	98	0007358076	7	North bank	3.3	First time capture	Observed	Above litter	Missing right hand - photographed
6	male	Adult	Dark Nuptials	77.8	68	0007355C05	7	North bank	1.1	First time capture	Observed	Under litter	Just eye of frog protruding
7	Female	Adult	Not Gravid	97.6	148	0007355ED1	7	Southbank	2.1	First time capture	Observed	Partially buried under litter	
8	male	Adult	Dark Nuptials	78.1	57	00073581E2	6	Southbank	0.9	First time capture	Observed	Above litter	
9	Female	Adult	Not Gravid	113.1	153	0007354E33	5	Southbank	2.1	First time capture	Observed	Above litter	
10	Female	Adult	Not Gravid	91.2	117	00073525A5	7	North bank	1.1	First time capture	Observed	Partially buried under litter and Lomandra	
Summer													
1	Male	Adult	Dark Nuptials	64.9	37.0	000735C44D	7	South Bank	4.0	First time capture	Observed	Partially Buried Under Litter	Swabbed
2	Male	Adult	Moderate Nuptials	72.8	57.0	0007355572	6	North Bank	2.5	First time capture	Observed	Partially Buried Under Litter	Swabbed
3	Female	Adult	Not Gravid	61.7	27.0	0007352335	6	South Bank	0.5	First time capture	Observed	Above Litter	Swabbed
4	Female	Adult	Not Gravid	66.1	41.0	00073593EC	6	South Bank	4.0	First time capture	Observed	Above Litter	Swabbed
5	Male	Adult	Moderate Nuptials	76.1	74.0	00073555B9	8	North Bank	1.5	First time capture	Observed	Partially Buried Under Litter	Swabbed
6	Male	Adult	Moderate Nuptials	74.1	55.0	0007357086	9	North Bank	2.0	First time capture	Observed	Partially Buried Under Litter	Swabbed
7	Female	Adult	Gravid	98.6	178.0	00073573F1	10	North Bank	1.5	First time capture	Observed	Using hole in bank	Swabbed
8	Male	Adult	Moderate Nuptials	76.0	68.0	00073529AE	13	South Bank	1.0	First time capture	Observed	Partially Buried Under Litter	Swabbed
9	Male	Adult	Dark Nuptials	73.7	52.0	000735CA5F	15	South Bank	2.5	First time capture	Observed	Above Litter	Swabbed
10	Female	Adult	Gravid	96.0	165.0	0007356674	19	South Bank	3.6	First time capture	Observed	Above Litter	Swabbed
11	Female	Adult	Gravid	94.6	141.0	0007356F20	19	South Bank	5.0	First time capture	Observed	Above Litter	Swabbed
12	Male	Adult	No Data	No Data	No Data	No Data	6	No Data	No Data	No Data	Call Response	No Data	Frog could not be captured
13	Male	Adult	No Data	No Data	No Data	No Data	18	No Data	No Data	No Data	Call Response	No Data	Frog could not be captured

Table 7A-2. Results of the summer Chytrid testing conducted in January 2014.

Date	Species	Animal number	Location	Sex	Rep 1	Rep 2	Rep 3	Mean calculated concentration	Chytrid Outcome Based on Newcastle University - James Garnham
26/01/2014	*Mixophyes iteratus*	0735830E	Cooperabung Creek	Female	0	0	0	0	No
26/01/2014	*Mixophyes iteratus*	07359E3E	Cooperabung Creek	Juvenile	0	0	0	0	No
26/01/2014	*Mixophyes iteratus*	07359A50	Cooperabung Creek	Male	0	0	0	0	No
26/01/2014	*Mixophyes iteratus*	07352F47	Cooperabung Creek	Male	0	0	0	0	No
26/01/2014	*Mixophyes iteratus*	07358413	Cooperabung Creek	Male	0	0	0	0	No
26/01/2014	*Mixophyes iteratus*	07359026	Cooperabung Creek	Male	0	0	0	0	No
26/01/2014	*Mixophyes iteratus*	07352816	Cooperabung Creek	Male	0	0	0	0	No
26/01/2014	*Mixophyes iteratus*	07357F41	Cooperabung Creek	Juvenile	0	0	0	0	No
26/01/2014	*Mixophyes iteratus*	0735B812	Cooperabung Creek	Juvenile	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	07356F20	Pipers Creek Reference/Control	Female	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	073593EC	Pipers Creek Reference/Control	Female	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	07356674	Pipers Creek Reference/Control	Female	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	073573F1	Pipers Creek Reference/Control	Female	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	073529AE	Pipers Creek Reference/Control	Male	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	07357086	Pipers Creek Reference/Control	Male	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	0735CA5F	Pipers Creek Reference/Control	Male	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	07355572	Pipers Creek Reference/Control	Male	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	073555B9	Pipers Creek Reference/Control	Male	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	07352335	Pipers Creek Reference/Control	Female	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	07359B0F	Pipers Creek	Female	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	0736DF2	Pipers Creek	Female	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	07358DDC	Pipers Creek	Female	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	0735B231	Pipers Creek	Female	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	07354BC4	Pipers Creek	Female	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	0735BA08	Pipers Creek	Male	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	073585C3	Pipers Creek	Sub Adult	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	0735C107	Pipers Creek	Sub Adult	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	07356DEB	Smiths Creek	Juvenile	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	0735A09D	Smiths Creek	Juvenile	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	0735B8C9	Smiths Creek	Juvenile	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	07358B84	Smiths Creek	Male	1.866	0	0.9	0	Yes
28/01/2014	*Mixophyes iteratus*	07353FA9	Smiths Creek	Male	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	0735C7EC	Smiths Creek	Sub Adult	0	0	0	0	No

28/01/2014	*Mixophyes iteratus*	0735CB5C	Smiths Creek	Sub Adult	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	07355C06	Smiths Creek	Sub Adult	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	0735C206	Smiths Creek	Sub Adult	0.052	0	0	0	Yes
28/01/2014	*Mixophyes iteratus*	07354559	Smiths Creek	Sub Adult	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	07357443	Smiths Creek	Male	0	0	0	0	No
28/01/2014	*Mixophyes iteratus*	0735B6F8	Smiths Creek	Male	0	0	0	0	No
27/01/2014	*Mixophyes iteratus*	0735C44D	Pipers Creek Reference/Control	Male	0	0	0	0	No
30/01/2014	*Mixophyes iteratus*	073563EA	Cooperabung Creek Reference/Control	Female	0	0	0	0	No
30/01/2014	*Mixophyes iteratus*	07359D67	Cooperabung Creek Reference/Control	Female	0	0	0	0	No
30/01/2014	*Mixophyes iteratus*	07359F76	Cooperabung Creek Reference/Control	Female	0	0	0	0	No
30/01/2014	*Mixophyes iteratus*	07357BBC	Cooperabung Creek Reference/Control	Juvenile	0	0	0	0	No
30/01/2014	*Mixophyes iteratus*	07359C3A	Cooperabung Creek Reference/Control	Male	0	0	0	0	No
30/01/2014	*Mixophyes iteratus*	0735535CD	Cooperabung Creek Reference/Control	Male	0	0	0	0	No
30/01/2014	*Mixophyes iteratus*	0735B0E5	Cooperabung Creek Reference/Control	Male	5.029	10.689	6.455	7.027	Yes
30/01/2014	*Mixophyes iteratus*	07357B14	Cooperabung Creek Reference/Control	Sub Adult	0	0	0	0	No
30/01/2014	*Mixophyes iteratus*	07352C3A	Cooperabung Creek Reference/Control	Sub Adult	0	0	0	0	No
30/01/2014	*Mixophyes iteratus*	0735C59A	Cooperabung Creek Reference/Control	Male	0	0	0	0	No
31/01/2014	*Mixophyes iteratus*	0735D09C	Maria River	Female	0	0	0	0	No
31/01/2014	*Mixophyes iteratus*	0735AEE9	Maria River	Juvenile	0	0	0	0	No
31/01/2014	*Mixophyes iteratus*	0735BE05	Maria River	Juvenile	0	0	0	0	No
31/01/2014	*Mixophyes iteratus*	0735B2F4	Maria River	Male	0	0	0	0	No
31/01/2014	*Mixophyes iteratus*	0735B020	Maria River	Male	0	0	0	0	No
31/01/2014	*Mixophyes iteratus*	07359976	Maria River	Sub Adult	0	0	0	0	No

8.0 Road Kill Monitoring

8.1 Introduction

Road kill monitoring has been proposed to address the NSW Minister for Planning and Infrastructure Conditions of Approval 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*; and Department of Environment (formally DSEWPC) 2(a) Request for additional information including *a) Adequate pre-construction baseline data, or the monitoring to be undertaken to determine adequate pre-construction baseline data for the Koala and Spotted-tail Quoll, including, but not limited to: ix) Relevant data for populations in the vicinity of the highway, such as distribution and abundance; x) current movement across the existing highway; and current road kill records and proposed monitoring*.

The following represents the spring and summer component for the baseline road kill monitoring surveys and presents two thirds of the pre-construction baseline data.

8.2 Sampling Technique

The road kill monitoring survey was undertaken in accordance with the EcMP (*see* SMEC-Hyder 2014). This involved a vehicle traverse of the entire 37 km of the existing Pacific Highway carriageway with weekly surveys over a 4 week period (Friday or alternatively Saturday) in the months of October 2013 for the spring monitoring and January/February 2014 for the summer monitoring. The autumn monitoring scheduled for April 2014 is believed to be the focus of the Environmental Services contract.

The vehicle traverse was performed at a variable speed of 60-80 kmph (i.e. depending on traffic) to inspect for all dead wildlife (road kill) on the carriageway or within 3 m of the road verge. Both the driver (BDL) and passenger (SV, CJ, NL) performed a search of the left hand side of the road and it's verge for road kill and involved a commute of both the south and north bound lanes of the carriageway. Once road kill had been observed, a closer inspection of the carcass was undertaken to identify the species of animal, its age, sex and in the case of macropods or dasyurids whether any pouch young were present.

The ecological monitoring program has proposed the removal of carcases from the carriageway. This was viewed as confounding the data as it altered the way scavenger species may interact with vehicles and may become road kill themselves. Subsequently, all road kill were left *in situ.*

Habitat data were also collected at the road kill site. The Ecological Monitoring Program proposed the following data would be collected from a 5 metre pint radius at the edge of the road verge:

- 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; and
- Presence and type of microhabitats.

8.3 Data Summaries

Data were classified accordingly to:

- Location using a hand held GPS (GDA94) to identify any focal points or hot spots;
- Summarized according to season to compare variation between the two monitoring periods;
- Legislative status pursuant to the *TSC* Act (1995) and *EPBC* Act (1999).

Mammals were divided into categories that could be interpreted in relation to the types of mitigation measures being proposed. For example, small ground dwelling mammals included fauna which could still be expected to move freely (i.e. permeable) through the standard floppy top fauna fence design without some specific modification (i.e. sheeting panelling and double meshing used for the phascogale fence). In contrast, medium and large ground dwelling mammals would not be able to move freely through this fence design and enter the carriageway.

8.4 Results

8.4.1 Abundance & Diversity

Eighty-seven (87) animals comprising 32 species of fauna were recorded as road kill during the spring and summer monitoring. This included one species of frog, five species of reptile, 12 species of bird which included one unrecognisable species (due to condition/remains) and 14 species of mammal including a range of ground dwelling, arboreal, flying and introduced mammals (Appendix X).

The most commonly recorded fauna group were the large ground dwelling mammals with 19 observations followed by birds with 16, arboreal mammals and reptiles each with 13 observations (Figure 8-1). Very few flying mammals (i.e. bats) and frogs were recorded during the monitoring period.

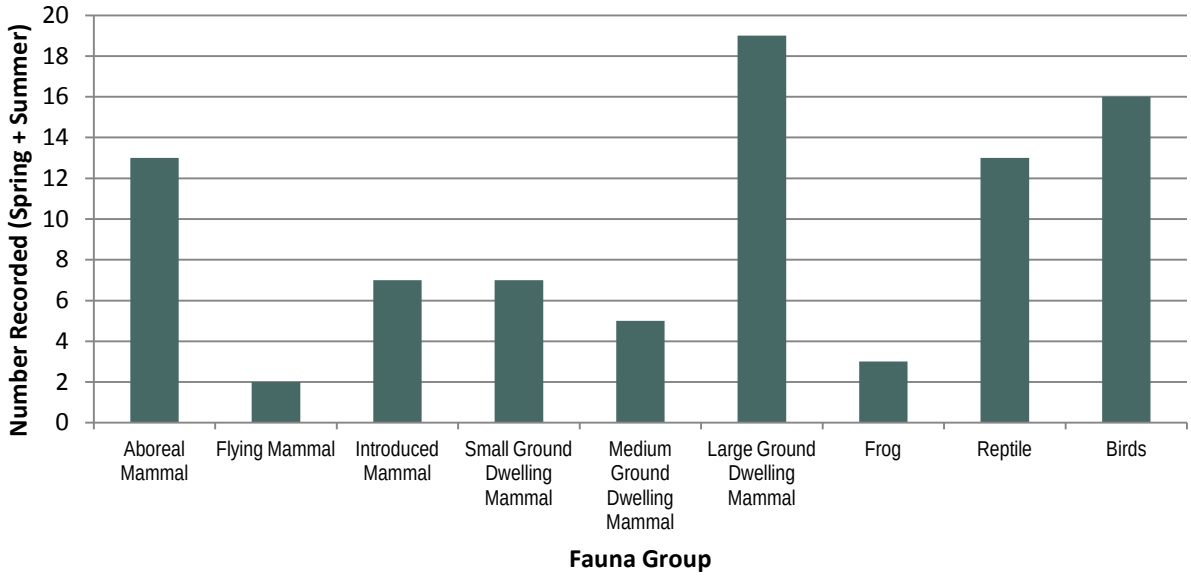

Figure 8-1. Cumulative number of road kills accordingly to broad fauna group for the spring and summer monitoring.

8.4.2 Seasonal Variation

The spring monitoring recorded 38 animals comprising 20 species of fauna whilst the summer monitoring yielded 48 animals comprising 23 species with an additional four that couldn't be identified to species level.

8.4.3 Threatened Species

Two species of threatened fauna were recorded during the monitoring. One Koala was recorded during the initial road kill survey on the 4th October although it's pelt had remained beside the carriageway after being struck on the 22nd August in the south bound lane at ch. 22300 (Ballengarra State Forest). Regular (i.e. several times per month) *ad hoc* traverses of the study area between August 2013 and February 2014 shows at least four Koala were killed from road strike over this 7 month period. They include:

- The adult hit in the middle of the south bound lane at ch. 22300 on 22nd August 2013;
- Adult hit in the south bound lane at ch. 32700 on the 10th September 2013;
- Adult hit on the north bound lane at approximate ch. 11000 on the 29th October 2013; and
- Adult hit on the edge of the south bound carriageway just south of the Project's southern boundary on the 21st February 2014.

Only the animal from the 22nd August remained on the carriageway way for any length of time whilst the remaining individuals had been removed by unknown sources within 48 hours. This equates to some variability in the reliability of once a week surveys.

The Grey-headed Flying Fox was recorded on two occasions during the monitoring period. One individual was recorded from ch. 13000 (Telegraph Point) during the spring sampling and was probably attracted to the flowering Forest Red Gum (*Eucalyptus tereticornis*) whilst the second individual had been struck just to the north of Fernbank Creek (ch. 4800) in early February 2014 which coincided with some initial flowering of Broad-leaved Paperbark (*Melaleuca quinquenervia*).

No Giant Barred Frog or Spotted-tailed Quoll were recorded as road kill during the monitoring period nor have these species been recorded during *ad hoc* surveys of the OH2K project over the past decade.

8.4.3 Focal Points for Road Kill

Road kill was recorded across the entire length of the existing Pacific Highway carriageway with records extending from ch. 600 (Pheasant Coucal) to ch. 37800 (Diamond Python; Figure 7-2). Focal points of road kill were recorded at:

- ch. 3550 (Fernbank Creek) where this is a narrow vegetated habitat linkage running in an east-west direction;
- ch. 12500-15000 (The Hatch) associated with fragmented swamp forest and cleared lands; and
- ch. 16500 (Telegraph Point) which will become a service road once the Project has been constructed.

From a habitat or landscape perspective the majority of road kill were associated with drainage lines.

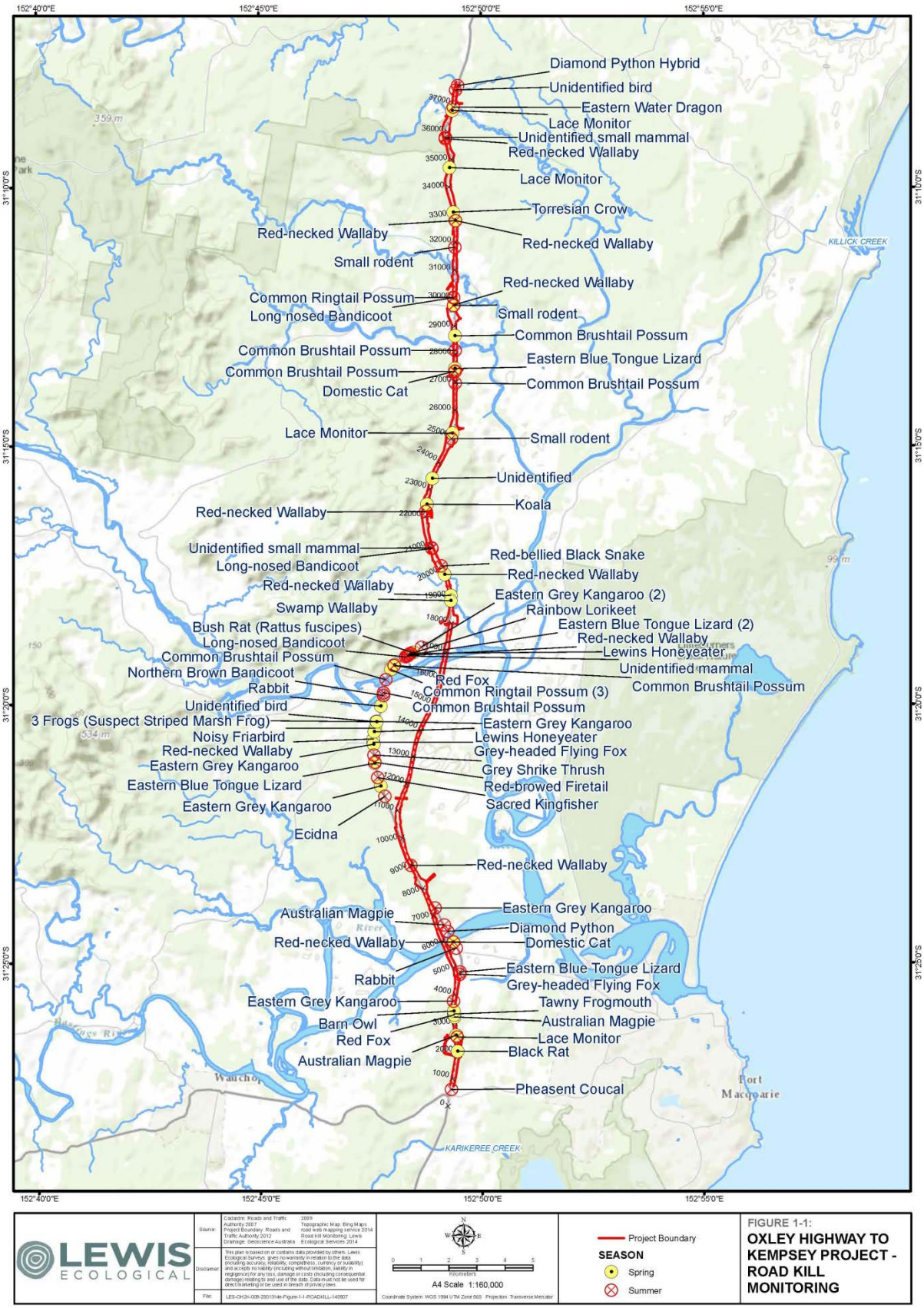

Figure 8-2. Distribution of road kill along the existing carriageway during the spring (October) and summer (January/February) monitoring.

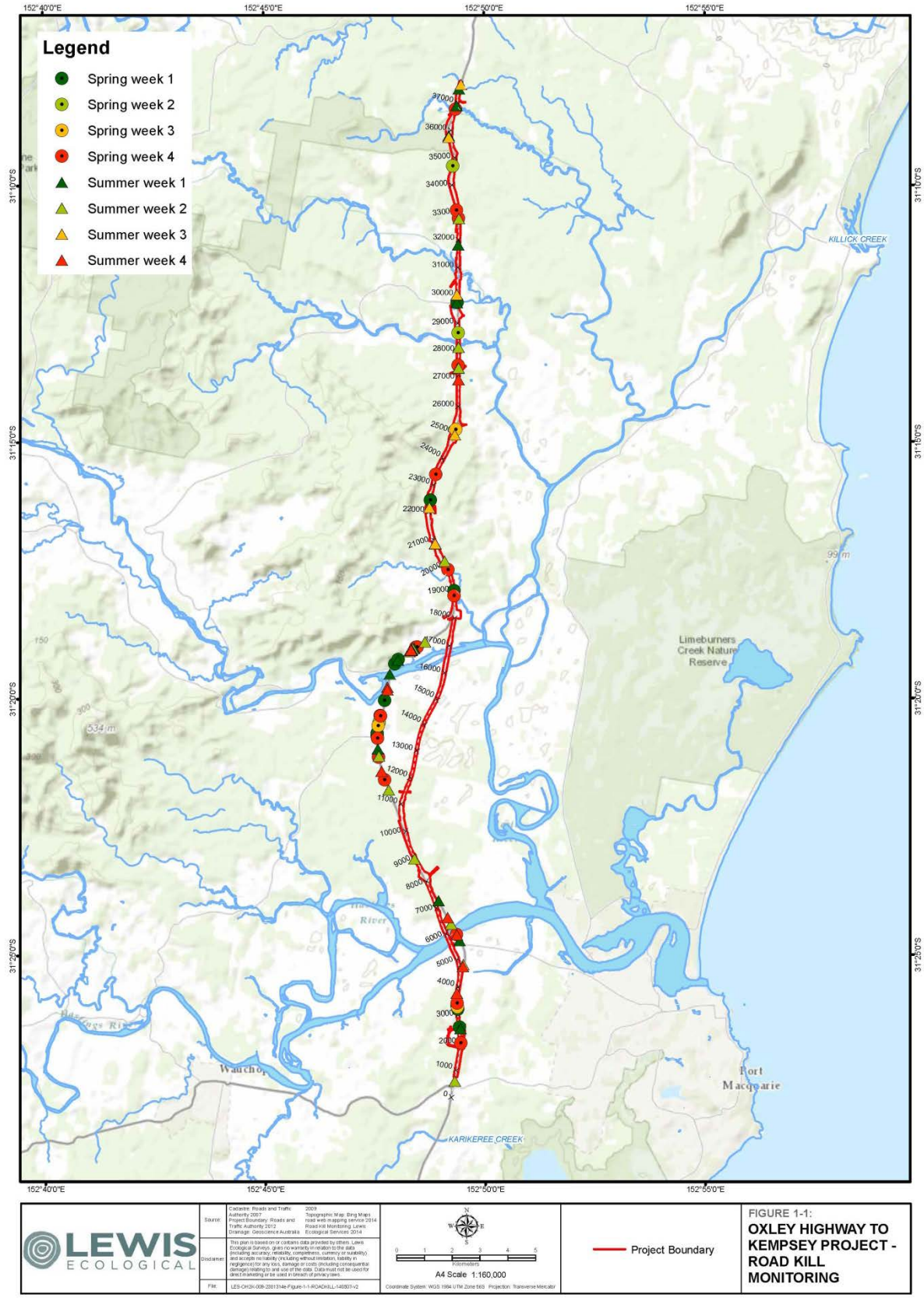

Figure 8-3. Distribution of road kill along the existing carriageway during the spring (October) and summer (January/February) monitoring.

8.5 Discussion of Findings

Traffic using the existing Pacific Highway results in a constant source of road kill and does not tend to discriminate on whether the animal flies (birds), is large and mobile (i.e. macropods) or small and somewhat cryptic (i.e. frogs). Similarly, the monitoring confirmed that some threatened species including Koala and Grey-headed Flying Fox are being struck, however, the relatively short duration of the monitoring points to some uncertainty about its potential impact. For example, only one Koala was actually recorded during the 8 weeks of monitoring yet another three individuals were confirmed to have been killed by vehicles over the seven month period of *ad hoc* monitoring. This shows that 75% of records went undetected and knowing most of these carcases were removed within 48 hours indicates other individuals may have also been struck. Nonetheless, these *ad hoc* surveys suggest that a Koala is subject to road strike approximately once every 8 weeks along this 37 km stretch of Pacific Highway. This may provide a useful baseline data point from which the effectiveness of fauna fencing and underpasses can be measured against.

It is difficult to collect an accurate picture of road kill over a relatively short period of time. *Ad hoc* surveys performed by the author over the past decade show several other threatened species have been recorded as road kill including Sooty Owl from ch. 34100 in 2005, Masked Owl from ch. 5400 in 2003 and another potential bird from ch. 33350 in April 2014, Spotted Harrier from ch. 5000 in 2013 and the Brush-tailed Phascogale from ch. 37700 in 2010. What can be gleaned from this is they are irregular casualties of road strike and additional records are likely to occur during the construction phase when almost daily monitoring has been proposed.

The current monitoring was undertaken during a period of pronounced dry weather and this alone is believed to have attributed to far fewer road kill, particularly frogs and turtles. During past surveys many hundreds of frogs have been recorded as road kill but none of these have been identified as Giant Barred Frog. Similarly, no Green-thighed Frog have been recorded as road kill but observations close to the road at Pipers Creek indicate this is likely to occur. Future road kill monitoring should at least attempt to measure this at points where frog mitigation is proposed.

The monitoring data has identified that road kill takes place on sections of the carriageway that traverse floodplain or riparian habitats regardless of the vegetation type. This is probably a response to these areas supporting more mobile fauna which are forced to undertake more regular movements in the fragmented landscape combined with the often low and dense vegetation at the road verge which leads to changed behaviours. For example, a bird moving from low dense shrubs close to the road verge as opposed to more open road verge areas in some of the state forests (i.e. Cairncross State Forest). Interestingly, areas similar to this habitat description (ch. 7500-11000) recorded very few road kill during this monitoring.

Some additional monitoring of road kill revealed that larger carcases tended to be removed from the carriageway within 24-72 hours of their initial discovery. It is not known whether this is the actions of RMS road crew personnel, members of the general public concerned for the safety of scavenging species (i.e. raptors) or some combination of both. Interestingly, only one of the observed road killed Koala remained on the carriageway for any length of time. This differs from surveys performed at other sections of the Pacific Highway (i.e. Bulahdelah to Coolongolook deviation) where road killed Koala tend to remain *in situ* for weeks and months during the 2013/14 season (B. Lewis pers. obs).

Some road kill was linked to fauna being attracted to the roadside verge with examples being flowering Forest Red Gum (*Eucalyptus tereticornis*) during the start of the spring monitoring and the Broad-leaved Paperbark (Melaleuca quinquenervia) at the end of the summer monitoring. Other obvious examples included the grass verge which sits immediately adjacent to the existing carriageway which attracted macropods during the dry seasonal conditions. Whilst grass and low shrubs provide a source of erosion and sediment control around the newly constructed carriageway mitigation measures including fauna fencing are designed to reduce road strike of macropods whilst increasing public safety. Similarly, many of the drainage or riparian zones or similarly bottlenecks of vegetated land (i.e. ch. 3550) will receive culverts designed to greatly increase the permeability of the newly constructed carriageway.

8.6 Key Recommendations

1) The autumn data is combined with the spring and summer data presented in this data report to form the baseline road kill monitoring for the Project. Without there is likely to be a baseline data set which does not feature a period of wet weather.
2) Habitat data associated with road kill should only be collected for threatened species or particular species groups which need to be specifically monitored. For example, Koala, Phascogale, Spotted-tailed Quoll, Yellow-bellied Glider, Giant Barred Frog and Green-thighed Frog.
3) The collection of habitat data if required should be expected beyond the 5 m radius proposed in the EcMP. Too often this area forms either part of the construction 'fill' or 'cut' and comprises habitat attributes which are entirely different from the surrounding landscape.

8.7. Appendix – Field Data

Table 8A – Summary of raw data collected during the road kill monitoring for spring and summer.

Season	Week Number	Date	Easting	Northing	Species	No.	Assigned Vertebrate Group	Sex	Age	Pouch Young	Broad Habitat Type	Overstorey	Mid Stratum	Shrub layer	Groundcover	Hydrological Features	Rock (%)	Log (%)	Hollow Bearing Trees (density/ha)	Foraging resources Associated with fauna	Likely Attractant	Comments
Spring	4	25.10.2013	480388	6532812	3 Frogs (Suspect Striped Marsh Frog)	1	Frog	Unknown	Adult	Not applicable	Cleared Land	Absent	Absent	Absent	Rhodes Grass + Bladey Grass	Unnamed drainage line 20 m	0	0	0	Unknown	Unknown	Struck in southbound lane.
Spring	1	4.10.2013	483166	6522266	Australian Magpie	2	Bird	Unknown	Adult	Not applicable	Dry Sclerophyll Forest (regrowth)	Coastal Blackbutt	Black She-oak	Regenerating Upper Strata	Rhodes Grass, Wiregrass	Nil	0	0	0	Nil	Unknown	
Spring	1	4.10.2013	483224	6521626	Australian Magpie	2	Bird	Unknown	Adult	Not applicable	Cleared land with scattered Eucalypts	Tallowwood + Coastal Blackbutt	Absent	Absent	Carpet Grass	Fernbank Creek tributary 50 m north	0	0	0	Open cleared areas	Unknown	
Spring	4	25.10.2013	483144	6522477	Barn Owl	3	Bird	Unknown	Adult	Not applicable	Dry Sclerophyll Forest	Coastal Blackbutt	Black She-oak	Regrowth	Rhodes Grass, Wiregrass	Tributary of Fernbank Creek around 100 m to the north	0	0	0	Nil	Open cleared area bordering vegetation	Struck from south bound traffic
Spring	4	25.10.2013	483280	6521053	Black Rat	4	Introduced Mammal	Unknown	Adult	Not applicable	Dry Sclerophyll Forest	Coastal Blackbutt + Pink Bloodwood	Black She-oak	Acacia	Bracken and Bladey Grass	Nil	0	0	0	Unknown	Unknown	
Spring	4	25.10.2013	481658	6535280	Bush Rat (Rattus fuscipes)	5	Scansorial Mammal	Male	Adult	Not applicable	Weedy regrowth	Absent	Cheese Tree + Privet	Acacia + Lantana	Bladey Grass + Cobblers Pegs	Nil	0	0	0	Unknown	Unknown	Struck on north bound lane
Spring	1	4.10.2013	481029	6534836	Common Brushtail Possum	6	Arboreal Mammal	Unknown	Adult	Not applicable	Dry Sclerophyll Forest	Tallowwood + White mahogany	Black She-oak + regrowth	Brush box + regrowth	Bladey Grass, Purpletop	Nil	30	0	0	Nil	Vegetated linkage either side of highway	
Spring	2	11.10.2013	483184	6546594	Common Brushtail Possum	6	Arboreal Mammal	Unknown	Adult	Not applicable	Dry Sclerophyll Forest	Coastal Blackbutt + Tallowwood	Black She-oak	Regrowth + Lantana	Bladey Grass, Wire Grass	Unnamed drainage line 60 m to north	0	4	0	Nil	Vegetation growing up to guard rail on either side of highway - potential localised crossing point	
Spring	1	4.10.2013	483147	6547904	Common Ringtail Possum	7	Arboreal Mammal	Unknown	Adult	Unknown	Dry Sclerophyll Forest (regrowth)	Tallowwood + Small-fruited Grey Gum	Acacia's	Leptospernum + Acacia	Lomandra, Bracken, Wiregrass	Nil	0	0	0	Nil	Shrub layer growing close to carriageway	Road kill fauna recorded 10 days prior to survey
Spring	1	4.10.2013	480898	6534679	Common Ringtail Possum	7	Arboreal Mammal	Unknown	Adult	Not applicable	Weedy regrowth	Absent	Cheese Tree + Privett	Acacia + Lantana	Bladey Grass + Cobblers Pegs	Wilson river 100 m to south	0	0	0	Nil	Dense shrub layer	
Spring	4	25.10.2013	480323	6531329	Eastern Blue Tongue Lizard	10	Reptile	Unknown	Adult	Not applicable	Dry Sclerophyll Forest	Coastal Blackbutt + White mahogany + White Stringybark + Pink Bloodwood	Black She-oak + regrowth	Absent	Rhodes Grass + Bladey Grass	Nil	0	0	0	Nil	Basking point associated with bitumen	Struck in turning lane for Mooreside Drive
Spring	4	25.10.2013	483188	6545431	Eastern Blue Tongue Lizard	10	Reptile	Unknown	Adult	Not applicable	Dry Sclerophyll Forest	Scribbly Gum, Coastal Blackbutt	Black She-oak + Regrowth	Regrowth + Acacia's	Seteria + Rhodes Grass	Nil	0	0	0	Nil	Unknown	Struck in southbound lane
Spring	1	4.10.2013	480375	6532820	Eastern Grey Kangaroo	11	Macropod	Unknown	Adult	Unknown	Cleared grazing land	Absent	Absent	Scattered small-leaved privet	Mown Seteria road verge with adjacent rank Seteria and Vasey grass	Unnamed drainage line	0	0	0	Mown grass verge and more extensive grazing land either side of highway	Pasture grasses both sides of highway	Struck in north bound lane
Spring	4	25.10.2013	480540	6530520	Eastern Grey Kangaroo	11	Macropod	Unknown	Adult	Unknown	Dry Sclerophyll Forest	Coastal Blackbutt	Tallowwood + Pink Bloodwood	Absent	Bladey grass, Kangaroo Grass	Nil	0	3	0	Grass verges on either side of highway	Grass verges on either side of highway	
Spring	4	25.10.2013	481712	6535295	Eastern Grey Kangaroo	11	Macropod	Unknown	Adult	Unknown	Cleared Land	Absent	Absent	Absent	Rhodes Grass + Bladey Grass	Unnamed drainage line to north	0	0	0	Pasture areas either side of highway	Pasture grasses	

Spring	4	25.10.2013	480282	6532007	Eastern Grey Kangaroo	11	Macropod	Female	Adult	Deceased	Swamp Forest	Swamp Oak + Forest Red Gum	Large-leaved privet + Regrowth	Lantana + Regrowth	Basket Grass	Unnamed drainage line	0	0	0	Pasture grasses either side of highway	Pasture grasses either side of highway	Struck in southbound lane and found in roadside ditch
Spring	1	4.10.2013	480268	6532080	Grey-headed Flying Fox	15	Flying Mammal	Unknown	Adult	Not applicable	Swamp Forest	Swamp Oak + Forest Red Gum	Large-leaved privet + Regrowth	Lantana + Regrowth	Basket Grass	Unnamed drainage line	0	0	0	Flowering Forest Red Gum	Regenerating and semi mature flowering Forest red Gum growing either side of highway	Struck in northbound lane
Spring	1	4.10.2013	482178	6540579	Koala	16	Arboreal Mammal	Female	Adult	Unknown	Dry Sclerophyll Forest	Tallowwood + Small-fruited Grey Gum + Grey Ironbark	Curracabah Wattle + Turpentine and regrowth	Lantana + Regrowth	Lantana + Wiregrass	Nil	3	2	0	Preferred Koala feed trees on either side of carriageway particularly tallowwood	Movement corridor linked vegetation and preferred Koala feed trees	Road kill recorded from the night of 14th August. Pelt still evident and recognisable in the emergency breakdown lane southbound.
Spring	2	11.10.2013	482991	6552604	Lace Monitor	17	Reptile	Unknown	Sub Adult	Not applicable	Dry Sclerophyll Forest	Coastal Blackbutt + White mahogany + White Stringybark + Pink Bloodwood	Black She-oak + Weeping Bottlebrush	Acacia + Regrowth	Bladey Grass + Wiregrass	Unnamed drainage line	0	7	2	Potential road kill scavenging habits	Potential road kill scavenging habits	
Spring	3	18.10.2013	483099	6543114	Lace Monitor	17	Reptile	Unknown	Adult	Not applicable	Moist Sclerophyll Forest	Tallowwood + Flooded Gum	Black She-oak	Lantana	Bladey grass + Wire Grass and Kangaroo Grass	Barrys Creek riparian Corridor	0	5	4	Potential road kill scavenging habits	Potential road kill scavenging habits	Bells Phase of Lace monitor
Spring	4	25.10.2013	483083	6554649	Lace Monitor	17	Reptile	Unknown	Sub Adult	Not applicable	Moist Sclerophyll Forest	Flooded Gum	Flooded Gum	Lilly Pilly , Waterhousia	Lantana, Native Grape	Maria River	0	0	0	Probably scavenging along roadway	Probably scavenging along roadway	Struck on southbound Maria River Bridges
Spring	3	18.10.2013	480307	6532454	Lewins Honeyeater	18	Bird	Unknown	Adult	Not applicable	Swamp Forest	Swamp Oak + Forest Red Gum	Large-leaved privet + Regrowth	Lantana + Regrowth	Basket Grass	Unnamed drainage line	0	0	0	Flowering Forest Red Gum	Regenerating and semi mature flowering Forest red Gum growing either side of highway	
Spring	2	11.10.2013	480340	6532583	Noisy Friarbird	20	Bird	Unknown	Adult	Not applicable	Cleared grazing land	Absent	Absent	Absent	Seteria, Vasey Grass, Carpet Grass	Unnamed drainage line 80 m to the north	0	0	0	Nil	Unknown	
Spring	1	4.10.2013	480541	6533365	Rabbit	23	Introduced Mammal	Unknown	Adult	Not applicable	Cleared grazing land	Absent	Absent	Scattered small-leaved privet	Mown Seteria road verge with adjacent rank Seteria and Vasey grass	Unnamed drainage line	0	0	0	Mown grass verge and more extensive grazing land either side of highway	Pasture grasses both sides of highway	
Spring	3	18.10.2013	483157	6522339	Red Fox	25	Introduced Mammal	Unknown	Adult	Not applicable	Dry Sclerophyll Forest	Coastal Blackbutt	Black She-oak	Regrowth	Rhodes Grass, Wiregrass	Tributary of Fernbank Creek around 100 m to the north	0	0	0	Nil	Area where road kill has been recorded in previous weeks	
Spring	1	4.10.2013	483146	6547702	Red-necked Wallaby	28	Macropod	Unknown	Adult	unknown	Revegation/Plantings around Kundabung Southbound Rest Area	Absent	Black She-oak + Acacia	Acacia	Mown and rank Seteria, Digitaria and Rhodes Grasses	Nil	0	0	0	Mown grass verges	Mown grass verges	Animal flattened into the bitumen
Spring	1	4.10.2013	483039	6537320	Red-necked Wallaby	28	Macropod	Unknown	Adult	Unknown	Sub tropical Coastal Floodplain Forest	Forest Red Gum + Pink Bloodwood + Flooded Gum	Curracabah Wattle + regrowth	Lantana + Regrowth	Seteria, Vasey Grass, Carpet Grass	Cooperabung Creek ~ 60 m away	0	0	1	Local movement corridor with pasture for grazing either side of highway	Dense cover bordering pasture suitable for grazing either side of highway	Struck in southbound lane
Spring	1	4.10.2013	480275	6532197	Red-necked Wallaby	28	Macropod	Unknown	Adult	Unknown	Swamp Forest	Swamp Oak + Forest Red Gum	Large-leaved privet + Regrowth	Lantana + Regrowth	Basket Grass	Unnamed drainage line	0	0	0	Flowering Forest Red Gum	Pasture grasses both sides of highway with small patch of dense swamp forest providing cover refuge habitat	Struck in northbound lane

Spring	4	25.10.2013	482824	6538080	Red-necked Wallaby	28	Macropod	Unknown	Adult	Unknown	Moist Sclerophyll Forest	Flooded Gum	Lilly Pilly	Lantana + Acacia	Seteria + Vasey Grass	Cooperabung Creek	0	0	0	Grassed areas either side of highway	Riparian fauna corridor	Struck in north bound lane
Spring	4	25.10.2013	483120	6524936	Red-necked Wallaby	28	Macropod	Male	Adult	Not applicable	Swamp Forest	Swamp Oak + Forest Red Gum	Large-leaved privet + Regrowth	Lantana + Regrowth	Basket Grass	Unnamed drainage line	0	0	0	Unknown	Weedy riparian zone probably used for localised movements and refuge point	
Spring	4	25.10.2013	483190	6550715	Red-necked Wallaby	28	Macropod	Female	Adult	No	Dry Sclerophyll Forest (regrowth)	Tallowwood + Small-fruited Grey Gum	Acacia's + Black She-oak	Black-She-oak	Seteria, Rhodes Grass, Lomandra, Wiregrass	Nil	0	0	0	Nil	Localised movement area connecting southern extent of Maria River State Forest	Same area where an adult koala was struck in September 2013
Spring	4	25.10.2013	483036	6537135	Swamp Wallaby	31	Macropod	Male	Adult	Not applicable	Sub-tropical Coastal Floodplain Forest	Forest Redgum	Acacia's	Acacia's	Seteria	Cooperabung Creek 150 m to the east	0	0	0	rank grassland	Rank grassland either side of highway providing foraging resources	Struck in north bound lane. This animal was removed from the highway within 24 hrs of being struck
Spring	3	18.10.2013	483154	6522375	Tawny Frogmouth	32	Bird	Unknown	Adult	Not applicable	Dry Sclerophyll Forest	Coastal Blackbutt	Black She-oak	Regrowth	Rhodes Grass, Wiregrass	Tributary of Fernbank Creek around 100 m to the north	0	0	0	Nil	Open area to forage	
Spring	4	25.10.2013	483128	6551019	Torresian Crow	33	Bird	Unknown	Adult	Not applicable	Dry Sclerophyll Forest	Tallowwood, Small-fruited Grey Gum, White Mahogany	Regrowth	Black She-oak	Rhodes Grass, Bladey Grass, Kangaroo Grass	Nil	0	0	0	Nil	Probably scavenging along roadway	Struck in overtaking lane north bound
Spring	4	25.10.2013	482374	6541504	Unidentified	34	Unknown	Unknown	Unknown	Unknown	Dry Sclerophyll Forest	Tallowwood + Small-fruited Grey Gum + Grey Ironbark	Curracabah Wattle + Turpentine and regrowth	Lantana + Regrowth	Lantana + Wiregrass	Nil	3	2	0	Unknown	unknown	Small amount of remnant material left
Spring	4	25.10.2013	480388	6532812	Unidentified bird	35	Bird	Unknown	Adult	Not applicable	Cleared Land	Absent	Absent	Absent	Rhodes Grass + Bladey Grass	Unnamed drainage line 20 m	0	0	0	Unknown	Unknown	Struck in southbound lane.
Summer	4	7.2.2014	482799	6525557	Australian Magpie	2	Bird	Unknown	Adult	Not applicable	Cleared land											
Summer	1	17.1.2014	480713	6534313	Common Brushtail Possum	6	Arboreal Mammal	Unknown	Adult	Not applicable	Swamp Oak Floodplain Forest & Weedy Regrowth	Swamp Oak	Swamp Oak	Lantana	Setaria, Rhodes Grass etc	Wilson River 100 m to the west	0	0	0	Riparian movement corridor	Riparian fauna corridor	Southern end of the bridge over the Wilson River. Carcase about 3 weeks old and struck in north bound land
Summer	1	17.1.2014	481013	6534816	Common Brushtail Possum	6	Arboreal Mammal	Unknown	Adult	Not applicable	Dry Sclerophyll Forest	Tallowwood + White mahogany	Black She-oak + regrowth	Brush box + regrowth	Bladey Grass, Purpletop	Nil	30	0	0	Nil	Vegetated linkage either side of highway	
Summer	1	17.1.2014	483181	6545324	Common Brushtail Possum	6	Arboreal Mammal	Unknown	Juvenile	Not applicable	Dry Sclerophyll Forest	Coastal Blackbutt, Pink Bloodwood, Scribbly Gum										Upper Smiths Creek Road area
Summer	2	24.1.2014	483202	6546080	Common Brushtail Possum	6	Arboreal Mammal	Unknown	Adult	Not applicable	Moist Sclerophyll Forest	Flooded Gum	Waterhousia	Privet		Smiths Creek						
Summer	4	7.2.2014	480641	6533851	Common Brushtail Possum	6	Arboreal Mammal	Unknown	Adult	Not applicable	Swamp Oak Floodplain Forest & Weedy Regrowth											
Summer	4	7.2.2014	483194	6544908	Common Brushtail Possum	6	Arboreal Mammal	Unknown	Adult	Not applicable	Dry Sclerophyll Forest											
Summer	3	31.1.2014	483141	6547973	Common Ringtail Possum	7	Arboreal Mammal	Unknown	Adult	Not applicable	Dry Sclerophyll Forest and plantings from Kundabung Rest area											
Summer	4	7.2.2014	481513	6535185	Common Ringtail Possum	7	Arboreal Mammal	Unknown	Adult	Not applicable	Weedy regrowth											
Summer	2	24.1.2014	482931	6525326	Diamond Python	8	Reptile	Unknown	Adult	Not applicable	Weedy road verge											

Summer	3	31.1.2014	483279	6555536	Diamond Python Hybrid	8	Reptile	Unknown	Adult	Not applicable	Regrowth dry sclerophyll forest	Absent	Allocasuarina littoralis, Eucalyptus and callistemon salignus								
Summer	2	24.1.2014	483198	6545336	Domestic Cat	9	Introduced Mammal	Unknown	Adult	Not applicable	Dry Sclerophyll Forest										
Summer	4	7.2.2014	483132	6524939	Domestic Cat	9	Introduced Mammal	Unknown	Adult	Not applicable	Weedy road verge										
Summer	1	17.1.2014	481513	6535192	Eastern Blue Tongue Lizard	10	Reptile	Unknown	Adult	Not applicable	Not recorded										
Summer	3	31.1.2014	483365	6523872	Eastern Blue Tongue Lizard	10	Reptile	Unknown	Adult	Not applicable	Swamp Oak Floodplain Forest & Weedy Regrowth										
Summer	4	7.2.2014	481499	6535176	Eastern Blue Tongue Lizard	10	Reptile	Unknown	Adult	Not applicable	Weedy regrowth										
Summer	1	17.1.2014	482481	6526162	Eastern Grey Kangaroo	11	Macropod	Male	Adult	Not applicable	Dry Sclerophyll Forest	Coastal Blackbutt									Struck on edge of southbound lane
Summer	2	24.1.2014	481991	6535482	Eastern Grey Kangaroo	11	Macropod	Female	Sub Adult	No	Dry Sclerophyll Forest (regrowth west) & cleared to east										
Summer	4	7.2.2014	483133	6522824	Eastern Grey Kangaroo	11	Macropod	Male	Adult	Not applicable	Swamp Forest										
Summer	1	17.1.2014	483117	6554765	Eastern Water Dragon	12	Reptile	Unknown	Adult	Not applicable	Moist Sclerophyll Forest	Flooded Gum									North bound end of Maria River Bridge
Summer	2	24.1.2014	480680	6530148	Echidna	13	Ground dwelling Mammal	Unknown	Adult	Not applicable	Dry Sclerophyll Forest										
Summer	1	17.1.2014	480297	6531618	Grey Shrike Thrush	14	Bird	Unknown	Adult	Not applicable	Dry Sclerophyll Forest	Coastal Blackbutt									
Summer	4	7.2.2014	483347	6523793	Grey-headed Flying Fox	15	Flying Mammal	Unknown	Adult	Not applicable	Swamp Oak Floodplain Forest & Weedy Regrowth										
Summer	1	17.1.2014	483272	6521563	Lace Monitor	17	Reptile	Unknown	Sub Adult	Not applicable	Dry Sclerophyll Forest										
Summer	1	17.1.2014	481599	6535249	Lewins Honeyeater	18	Bird	Unknown	Adult	Not applicable	Not recorded										
Summer	3	31.1.2014	483139	6547965	Long nosed Bandicoot	19	Ground dwelling Mammal	Unknown	Adult	Not applicable	Dry Sclerophyll Forest and plantings from Kundabung Rest area										
Summer	3	31.1.2014	481426	6535127	Long-nosed Bandicoot	19	Ground dwelling Mammal	Unknown	Adult	Not applicable	Weedy regrowth										
Summer	3	31.1.2014	482367	6539002	Long-nosed Bandicoot	19	Ground dwelling Mammal	Unknown	Adult	Not applicable	Dry Sclerophyll Forest										On top of Cooperabung Hill Cut
Summer	4	7.2.2014	480632	6533746	Northern Brown Bandicoot	21	Ground dwelling Mammal	Unknown	Adult	Not applicable	Weedy regrowth										
Summer	2	24.1.2014	483059	6519684	Pheasant Coucal	22	Bird	Unknown	Adult	Not applicable	Regrowth road verge										
Summer	1	17.1.2014	483234	6524729	Rabbit	23	Introduced Mammal	Unknown	Adult	Not applicable	Cleared Pasture Land										Southern side of Hastings River Bridge
Summer	2	24.1.2014	481548	6535228	Rainbow Lorikeet	24	Bird	Unknown	Adult	Not applicable	Regrowth road verge										
Summer	1	17.1.2014	481012	6534814	Red Fox	25	Introduced Mammal	Unknown	Adult	Not applicable	Dry Sclerophyll Forest	Tallowwood + White mahogany	Black She-oak + regrowth	Brush box + regrowth	Bladey Grass, Purpletop	Nil	30	0	0	Nil	Vegetated linkage either side of highway	
Summer	2	24.1.2014	482697	6538374	Red-bellied Black Snake	26	Reptile	Unknown	Adult	Not applicable	Weedy regrowth										
Summer	2	24.1.2014	480327	6531362	Red-browed Firetail	27	Bird	Unknown	Adult	Not applicable	Dry Sclerophyll Forest		Allocasuarina littoralis on east side and Acacia leiocalyx on west								
Summer	2	24.1.2014	483206	6550710	Red-necked Wallaby	28	Macropod	Male	Adult	Not applicable	Dry sclerophyll forest	Tallowwood + Small-fruited Grey Gum + Grey Ironbark	Curracabah Wattle + Turpentine and regrowth	Lantana + Regrowth	Lantana + Wiregrass	Nil	3	2	0	Preferred Koala feed trees on either side of carriageway particularly tallowwood	Movement corridor linked vegetation and preferred Koala feed trees	Road kill recorded from the night of 14th August. Pelt still evident and recognisable in the emergency breakdown lane southbound.
Summer	2	24.1.2014	481612	6527672	Red-necked Wallaby	28	Macropod	Female	Adult	No	Dry Sclerophyll Forest										

Summer	3	31.1.2014	482842	6553642	Red-necked Wallaby	28	Macropod	Unknown	Adult	Unknown	Dry Sclerophyll Forest					Dry unnamed drainage line						
Summer	3	31.1.2014	482151	6540317	Red-necked Wallaby	28	Macropod	Male	Adult	Not applicable	Dry Sclerophyll Forest	Small-fruited Grey Gum, Tallowwood and Grey Ironbark				Drainage line dry						
Summer	4	7.2.2014	481497	6535179	Red-necked Wallaby	28	Macropod	Female	Adult	Unknown	Weedy regrowth											
Summer	4	7.2.2014	480434	6530817	Sacred Kingfisher	29	Bird	Unknown	Adult	Not applicable	Dry Sclerophyll Forest	Coastal Blackbutt										
Summer	1	17.1.2014	483185	6549761	Small rodent	30	Ground dwelling Mammal	Unknown	Unknown	Not applicable	Dry Sclerophyll Forest											Probably a Bush Rat or Black Rat
Summer	1	17.1.2014	483138	6547678	Small rodent	30	Ground dwelling Mammal	Unknown	Unknown	Not applicable	Dry Sclerophyll Forest											
Summer	3	31.1.2014	483055	6542929	Small rodent	30	Ground dwelling Mammal	Unknown	Unknown	Not applicable	Moist Sclerophyll Forest	Flooded Gum + Tallowwood				Barrys Creek and tributaries nearby						Probably Rattus fuscipes
Summer	1	17.1.2014	483217	6555384	Unidentified bird	35	Bird	Unknown	Adult	Not applicable	Not recorded											
Summer	4	7.2.2014	481475	6535161	Unidentified mammal	36	Ground dwelling Mammal	Unknown	Unknown	Not applicable	Weedy regrowth											
Summer	1	17.1.2014	482841	6553691	Unidentified small mammal	37	Ground dwelling Mammal	Unknown	Unknown	Not applicable	Dry Sclerophyll Forest											
Summer	3	31.1.2014	482354	6539023	Unidentified small mammal	37	Ground dwelling Mammal	Unknown	Unknown	Not applicable	Dry Sclerophyll Forest											On top of Cooperabung Hill Cut

Notes

1 On either side of the shoulder period of this survey 2 Koala were recorded as road kill. The first from 11th September at E: 483190 N: 6550715 and another from Cairncross State Forest on the 29th October. A third Koala was recorded on the top of Cooperabung Hill in January 2013.

2 Very dry conditions resulted in very few frog fauna being recorded. This is considered abnormal. Some nocturnal transects were performed on the 18th October at pipers creek and Maria River but no frogs recorded and detailed 1 km frog transect the same evening at Pipers creek revealed frogs were not very active despite the site receiving 25 mm of rain in past 24 hrs.

3 There appears to be some removal of larger fauna from the carriageway. This is likely to have influenced the results for larger animals.

4 Ben Lewis has previously recorded the following threatened fauna as road strike on this section of the highway (Sooty Owl 2005, Masked Owl 2003, Brush-tailed Phascogale 2010, Koala 2003 and 2013)

5 Koala road kill reported for the 29th October near the Cairncross Waste Facility. I am trying to get some more data for this record.

6 Spotted Harrier recorded 0.9 km south of Hastings River bridge on edge of south bound lane in December 2013 between monitoring periods 1 & 2

7 Koala road kill reported in early April in Blackmans Point Road area

8 Koala female road kill 0.75 km south Port Macquarie Oxley Highway Interchange in February 2014

Annex 4 OH2K – Koala abundance baseline surveys (Spotlighting)

Ref: OH2KKoalaAbundanceSurveys

8th December 2014

Roads and Maritime Services
59 Darby St
Newcastle, NSW 2300
Attention: Aleesha Darlington/David Ledlin

Re: Oxley Highway to Kempsey - Koala Baseline Abundance Surveys (Spotlighting)

In accordance with our proposal dated the 12th September we enclose the field survey data for the spotlighting surveys performed on behalf of the Roads and Maritime for the Oxley Highway to Kempsey Upgrade. We have outlined the field survey methods employed, the results obtained and provided some cursory interpretation of this data in relation to the existing Spot Assessment Technique (SAT) collected in spring 2013.

Sampling Regime

An alternative preconstruction baseline dataset was obtained within each of the three treatments (i.e. control, mitigation, no mitigation) for all eight of the Koala Management Areas identified in the Oxley Highway to Kempsey Ecological Monitoring Program (SMEC-Hyder JV 2014). This involved a standardized nocturnal sampling regime involving:

- Spotlighting for 1 person hour (2 persons for 30 minutes) with this repeated on a non-consecutive night to derive a maximum or cumulative count of Koala;
- Call broadcast was performed before commencing the field survey. The objective of this was to record any male Koala's within a perceived search area estimated to be within a 250 m radius of the call broadcast point.

Field surveys were undertaken over six consecutive nights between the 23rd and 29th October. This time was chosen because it reflected the median period of spring and the breeding period for Koala when males would be vocalizing and females would be carrying back young.

Survey Results

Koala were recorded from four of the eight management areas summarized as follows:

- Koala Management Area 1 (Sancrox South) with a female and back young recorded from the mitigation treatment and another adult recorded from the no mitigation treatment adjacent to Fernbank Creek Road (i.e. Sancrox Interchange);
- Koala Management Area 2 with a male and female recorded from the control site located at Lake Innes;

- Koala Management Area 4 with a male heard calling to the east of the control site in Cairncross State Forest.
- Koala Management Area 8 with a male recorded in the mitigation treatment moving along the ground before scaling a Tallowwood.

The spotlighting field data has been summarized and compared to the existing SAT levels recorded from the 2013 survey in Table 1-1. This table also has the spotlight transect coordinates and hence the locations for all Koala recorded.

Discussion of Field Data

Field surveys confirm that Koala are broadly distributed through the Oxley Highway to Kempsey study area with individuals confirmed in close proximity to the carriageway (i.e. Sancrox South) and at considerable distances from it at the control sites (i.e. Lake Innes). Koala were recorded around Fernbank Creek Road where the Sancrox Interchange makes it difficult to provide standard mitigation devices in the form of underpasses and floppy top fauna fencing. This set of surveys was able to confirm the presence of Koala in Koala Management Area 8 (Maria River State Forest north) where previous surveys have failed to find any scats. The absence of scats in this area was previously thought to have been linked to a fire which burnt through the area several months before the survey.

When comparing the SAT data there was no consistency between the scat activity levels and the spotlight data with individuals spotlighted from sites where previous SAT surveys had yielded no activity or alternatively, there were numerous examples of where SAT surveys had recorded some level of activity yet no individuals could be spotlighted. The SAT sites are believed to provide a more comprehensive picture of Koala distribution and activity simply because scats themselves are expected to remain around the tree for a number of months whilst spotlighting surveys are simply a snap shot in time from two evenings of survey.

One other obvious difference between the spotlighting data from 2013 and the current dataset was the general lack of calling males. The current survey recorded just one male calling over a 6 night period involving some 48 spotlight surveys compared to the 2013 season when calling males were recorded from five (83%) of the six spotlight transects. Moreover, these earlier 2013 surveys did not employ call broadcast as a technique. This variation in the seasonal calling rates of males is of interest and future monitoring events should seek to gain a greater understanding of this pattern of vocalizing as it contributes substantially to the dataset in the 2013 survey.

A preconstruction baseline count could take place using one of the following approaches:

1. A simple comparison of cumulative number of Koala recorded and compared to each successive monitoring event that involves spotlighting and call broadcast;
2. A mean count comparison on the number of Koala recorded and compared to each successive monitoring event that segregates the data between individuals observed and those that were heard calling.

If you require any further information please contact me at your convenience.

Kind Regards

Ben Lewis
Director
Lewis Ecological Surveys
(ACN – 166970378)

References

SMEC-Hyder (2014). Oxley Highway To Kempsey Pacific Highway Upgrade—Ecological Monitoring Program. Report prepared for the Roads and Maritime Services.

Table 1-1. Summary of the spotlight surveys for each of the Koala management areas and corresponding Spot Assessment Technique activity data (scat surveys).

Koala Management Area	Treatment Type	Spotlight Survey 1	Spotlight Survey 2	No. Koala Recorded	Mean SAT Koala Activity
1	No Mitigation	0	1 adult sitting in turpentine after storm	1 Adult (sex unknown)	3.33
1	Mitigation	1 Female with young foraging in Red Mahogany	0	1 Female with young	8.89
1	Control	0	0	0	4.44
2	No Mitigation	0	0	0	1.11
2	Mitigation	0	0	0	28.89
2	Control	0	1 male sitting in Tallowwood 1 female sitting in Swamp Mahogany	1 male sitting in Tallowwood 1 female sitting in Swamp Mahogany	14.44
3	No Mitigation	0	0	0	1.11
3	Mitigation	0	0	0	2.22
3	Control	0	0	0	2.22
4	No Mitigation	0	0		4.44
4	Mitigation	0	0		1.11
4	Control	0	1 male heard calling to the east	1 Male	1.11
5	No Mitigation	0	0	0	4.44
5	Mitigation	0	0	0	1.11
5	Control	0	0	0	2.22
6	No Mitigation	No treatment available	No treatment available	No treatment available	No Treatment Available
6	Mitigation	0	0	0	0
6	Control	0	0	0	0
7	No Mitigation	0	0	0	3.33
7	Mitigation	0	0	0	18.89
7	Control	0	0	0	1.11
8	No Mitigation	0	0		3.33
8	Mitigation	1 male on ground moving into Tallowwood	0	1 Male	0
8	Control	0	0		6.67

KMA	Monitoring Area Name	Site Name	Treatment	Easting	Northing	SAT Activity	Selection Criteria	Easting Start - GDA 94	Easting End - GDA 94	Date	Time	Air Temp Start	Night Light	Rain	Wind	cloud	No. Koala Recorded	Comments (sex, tree etc)	Other Threatened Fauna Recorded	Date	Time	Air Temp	Night Light	Rain	Wind	Cloud	No. Koala Recorded	Comments (sex, tree etc)	Other Threatened Fauna Recorded
1	South Sancrox Road	Sancrox South	Mitigation	483321	6520694	13.33	Tallowwood	483285 6520741	483188 6520533	24/10/2014	0203-0233	19°C	0	0	1	4 / 8	2	Female with joey, browsing in young Red Mahogany		26/10/2014	2103-2134	23.6	0	2	1	2 / 8	0		
1	South Sancrox Road	Sancrox South	Mitigation	483296	6520413	3.33	Tallowwood																						
1	South Sancrox Road	Sancrox South	Mitigation	483139	6520700	10	Tallowwood																						
1	South Sancrox Road	Sancrox East - Cassegrains	No Mitigation	483348	6521736	10	Tallowwood	483514 6521770	483532 6521798	23/10/2014	0202-0222	17.8	0	0	0	1 / 8	0			26/10/2014	2024-2054	23.6	0	1	1	7 / 8	1	Sex could not be determined, sitting in a Turpentine approximately 15 minutes after a storm had finished passing	
1	South Sancrox Road	Sancrox East - Cassegrains	No Mitigation	483455	6521789	0	Tallowwood																						
1	South Sancrox Road	Sancrox East - Cassegrains	No Mitigation	483412	6521882	0	Tallowwood																						
1	South Sancrox Road	Cowarra State Forest	Control	480608	6519056	0	Tallowwood	480658 6519094	480719 6518968	24/10/2014	2207-2237	19.9	0	0	2	3 / 8	0			26/10/2014	2154-2224	21.9	0	0	0	1 / 8	0		
1	South Sancrox Road	Cowarra State Forest	Control	480658	6519496	3.33	Tallowwood																						
1	South Sancrox Road	Cowarra State Forest	Control	481305	6519136	10	Tallowwood																						
2	North Sancrox Road	Sancrox North - Expressway Spares	No Mitigation	483042	6521731	3.33	Swamp Mahogany	482988 6521815	482902 6521679	23/10/2014	0127-0157	15.5	1	0	1	1 / 8	0			26/10/2014	2240-2310	22.3	0	0	0	1 / 8	0		
2	North Sancrox Road	Sancrox North - Expressway Spares	No Mitigation	482869	6521683	0	Tallowwood																						
2	North Sancrox Road	Sancrox North - Expressway Spares	No Mitigation	482999	6521818	0	Tallowwood																						
2	North Sancrox Road	Fernbank Creek	Mitigation	483101	6523362	33.33	Tallowwood	483117 6523132	483240 6523392	23/10/2014	1940-2010	19.6	0	0	0	0	0			26/10/2014	2327-2357	20	0	0	0	1 / 8	0		
2	North Sancrox Road	Fernbank Creek	Mitigation	483032	6523223	30	Tallowwood																						
2	North Sancrox Road	Fernbank Creek	Mitigation	483056	6523123	23.33	Male Koala in Tallowwood																						
2	North Sancrox Road	Lake Innes	Control	488124	6518469	26.67	Tallowwood	488049 6518392	488080 6518513	24/10/2014	2050-2120	19.9	0	0	2	4 / 8	0			27/10/2014	2038-2108	22.2	0	0	0	2 / 8	2	Koala 1 - male observed foraging on a tallowwood at the edge of the bush fragment. Koala 2 - female? (no obvious chest gland stains) observed sitting in a Swamp Mahogany	
2	North Sancrox	Lake Innes	Control	488047	6518398	13.33	Swamp Mahogany																						

KMA	Area Name	Site Name	Treatment	Easting	Northing	Activity	Criteria	GDA 94	GDA 94	Date	Time	Start	Light	Rain	Wind	Cloud	Recorded	(sex, tree etc)	Recorded	Date	Time	Temp	Light	Rain	Wind	Cloud	Recorded	etc)	Fauna Recorded
	Road																												
2	North Sancrox Road	Lake Innes	Control	488228	6518390	3.33	Swamp Mahogany																						
3	Cairncross State Forest (South)	Cairncross State Forest (South)	No Mitigation	482428	6526536	0	Tallowwood	482371 6526403	482278 6526499	23/10/2014	0035-0105	13.2	1	0	1	1 / 8	0			26/10/2014	1932-2002	23.5	1	0	1	4 / 8	0		
3	Cairncross State Forest (South)	Cairncross State Forest (South)	No Mitigation	482385	6526644	3.33	Tallowwood																						
3	Cairncross State Forest (South)	Cairncross State Forest (South)	No Mitigation	482393	6526416	0	Tallowwood																						
3	Cairncross State Forest (South)	Cairncross State Forest (South)	Mitigation	482249	6525930	3.33	Tallowwood	482330 6526192	482365 6526045	23/10/2014	2035-2105	17.3	0	0	1	0	0			26/10/2014	0022-0052	19.9	0	0	0	0	0		
3	Cairncross State Forest (South)	Cairncross State Forest (South)	Mitigation	482125	6526077	3.33	Tallowwood																						
3	Cairncross State Forest (South)	Cairncross State Forest (South)	Mitigation	482488	6526226	0	Tallowwood																						
3	Cairncross State Forest (South)	Limeburners Creek "The Hatch"	Control	487011	6529909	0	Scribbly Gum	486936 6529772	486960 6529351	24/10/2014	1940-2010	20.9	0	0	1	2 / 8	0			27/10/2014	1938-2008	22.4	0	0	0	7 / 8	0		
3	Cairncross State Forest (South)	Limeburners Creek "The Hatch"	Control	487014	6529455	3.33	Scribbly Gum																						
3	Cairncross State Forest (South)	Limeburners Creek "The Hatch"	Control	487035	6528694	0	Scribbly Gum																						
4	Cairncross State Forest (north)	Cairncross State Forest (North)	No Mitigation	481420	6530890	0	White Mahogany	481204 6539830	481699 6530725	23/10/2014	2335-0005	14.5	0	0	0	0	0			27/10/2014	2311-2341	14.5	0	0	0	0	0		
4	Cairncross State Forest (north)	Cairncross State Forest (North)	No Mitigation	481695	6530786	0	Forest Red Gum																						
4	Cairncross State Forest (north)	Cairncross State Forest (North)	No Mitigation	481184	6530864	0	Tallowwood																						
4	Cairncross State Forest (north)	Cairncross State Forest (north)	Mitigation	481238	6530264	3.33	Swamp Mahogany	481680 6530098	481320 6530212	23/10/2014	2235-2305	15.1	0	0	0	0	0			27/10/2014	2236-2306	21.4	0	0	0	0	0		
4	Cairncross State Forest (north)	Cairncross State Forest (north)	Mitigation	481173	6530319	3.33	Tallowwood																						
4	Cairncross State Forest (north)	Cairncross State Forest (north)	Mitigation	481438	6530335	6.67	Tallowwood																						
4	Cairncross State Forest (north)	Cairncross State Forest (Pembrooke)	Control	473751	6528881	6.67	Tallowwood	473817 6528998	473300 6529077	24/10/2014	0056-0126	18.1	0	0	1	2 / 8	0			27/10/2014	2138-2208	22.1	0	0	0	0	1	Koala - male heard calling (not in response to playback) due east of Waypoint KOALAC1	
4	Cairncross State Forest (north)	Cairncross State Forest (Pembrooke)	Control	473464	6528969	0	Tallowwood																						
4	Cairncross State Forest (north)	Cairncross State Forest (Pembrooke)	Control	473424	6529115	0	Tallowwood																						

KMA	Area Name	Site Name	Treatment	Easting	Northing	Activity	Criteria	GDA 94	GDA 94	Date	Time	Start	Light	Rain	Wind	Cloud	Recorded	(sex, tree etc)	Recorded	Date	Time	Temp	Light	Rain	Wind	Cloud	Recorded	etc)	Fauna Recorded
5	Cooperabung Hill	Cooperabung	No Mitigation	482793	6537012	3.33	Tallowwood	482990 6537307	483012 6536787	24/10/2014	2310-2340	17.4	0	0	1	1 / 8	0	Poor spotlighting site with little visibility along transect. Locations limited due to private property		27/10/2014	0001-0031	13	0	0	0	0	0		
5	Cooperabung Hill	Cooperabung	No Mitigation	482755	6537093	0	Tallowwood																						
5	Cooperabung Hill	Cooperabung	No Mitigation	482876	6537115	10	Tallowwood																						
5	Cooperabung Hill	Cooperabung	Mitigation	482539	6538907	0	Tallowwood	482634 6538571	482562 6538902	24/10/2014	2346-0016	18.6	0	0	1	0	0			27/10/2014	0046-0116	12.9	0	0	0	0	0		
5	Cooperabung Hill	Cooperabung	Mitigation	482750	6538736	3.33	Forest Red Gum																						
5	Cooperabung Hill	Cooperabung	Mitigation	482364	6538610	0	Tallowwood																						
5	Cooperabung Hill	Cooperabung Hill (Gum Scrub)	Control	475489	6541854	6.67	Tallowwood	475507 6541869	475843 6541982	25/10/2014	0242-0312	16.9	0	0	1	0	0			28/10/2014	1947-2017	21	0	0	0	0	0		
5	Cooperabung Hill	Cooperabung Hill (Gum Scrub)	Control	475570	6541903	0	Tallowwood																						
5	Cooperabung Hill	Cooperabung Hill (Gum Scrub)	Control	475838	6541962	0	Tallowwood																						
6	Mingaletta to Smiths Creek	Mingaletta-Smiths Creek	Mitigation	483304	6543632	0	Tallowwood	483250 6543728	483212 6543417	25/10/2014	0206-0236	17.8	0	0	0	0	0			28/10/2014	0226-0256	13.4	1	0	0	0	0		
6	Mingaletta to Smiths Creek	Mingaletta-Smiths Creek	Mitigation	483444	6543585	0	Tallowwood																						
6	Mingaletta to Smiths Creek	Mingaletta-Smiths Creek	Mitigation	483100	6543670	0	Tallowwood																						
6	Mingaletta to Smiths Creek	Ballengara State Forest (Gregs Road)	Control	477750	6543274	0	Tallowwood	477725 6543285	477577 6543719	25/10/2014	0121-0151	18.1	0	0	1	0	0	Control burn has recently gone through area		28/10/2014	2038-2108	19.4	0	0	0	0	0		
6	Mingaletta to Smiths Creek	Ballengara State Forest (Gregs Road)	Control	477644	6543623	0	Small-fruited Grey Gum																						
6	Mingaletta to Smiths Creek	Ballengara State Forest (Gregs Road)	Control	477551	6543709	0	Tallowwood																						
7	Kundabung Road to North of Pipers Creek	Kundabung	No Mitigation	483095	6549036	0	Tallowwood	482990 6548521	482912 6548997	25/10/2014	2043-2113	20.2	0	0	0	0	0			28/10/2014	2219-2249	16.7	1	0	1	0	0		
7	Kundabung Road to North of Pipers Creek	Kundabung	No Mitigation	482873	6549112	10	Tallowwood																						
7	Kundabung Road to North of Pipers Creek	Kundabung	No Mitigation	483285	6549374	0	Tallowwood																						
7	Kundabung Road to North of Pipers Creek	Kundabung	Mitigation	483369	6550655	33.33	Tallowwood	483357 6550920	483810 6550863	25/10/2014	2132-2202	19.3	0	0	0	0	0			28/10/2014	0145-0215	13.4	1	0	0	0	0		
7	Kundabung Road to North of Pipers Creek	Kundabung	Mitigation	483331	6550938	13.33	Tallowwood																						
7	Kundabung Road to	Kundabung	Mitigation	483083	6550608	10	Forest Red Gum																						

KMA	Area Name	Site Name	Treatment	Easting	Northing	Activity	Criteria	GDA 94	GDA 94	Date	Time	Start	Light	Rain	Wind	Cloud	Recorded	(sex, tree etc)	Recorded	Date	Time	Temp	Light	Rain	Wind	Cloud	Recorded	etc)	Fauna Recorded
	North of Pipers Creek																												
7	Kundabung Road to North of Pipers Creek	Kumbatine National Park	Control	476044	6549609	3.33	Tallowwood	475878 6549454	476225 6549816	25/10/2014	1944-2014	23.9	0	0	0	0	0			28/10/2014	2129-2159	16.9	1	0	1	0	0		
7	Kundabung Road to North of Pipers Creek	Kumbatine National Park	Control	476165	6549738	0	Tallowwood																						
7	Kundabung Road to North of Pipers Creek	Kumbatine National Park	Control	475889	6549468	0	Tallowwood																						
8	Maria River State Forest	Maria River	Part Mitigation	483074	6554460	0	Tallowwood	483103 6554498	483513 6554447	25/10/2014	2333-0003	17.3	0	0	0	0	1	Male observed moving on ground before climbing a Tallowwood sapling		28/10/2014	0102-0132	13.9	1	0	0	0	0		
8	Maria River State Forest	Maria River	Part Mitigation	482836	6554330	3.33	Tallowwood																						
8	Maria River State Forest	Maria River	Part Mitigation	482917	6554027	6.67	Tallowwood																						
8	Maria River State Forest	Maria River	Mitigation	482886	6552623	0	Tallowwood	482875 6552691	482760 6552459	25/10/2014	2230-2300	18.4	0	0	0	0	0	Note: koala incidental record at E 482955 N 6552601. Same night as survey. Observed crossing the road and climbing a Tallowwood		28/10/2014	2256-2326	14.4	1	0	0	0	0		
8	Maria River State Forest	Maria River	Mitigation	482754	6552462	0	Tallowwood																						
8	Maria River State Forest	Maria River	Mitigation	483135	6552449	0	Tallowwood																						
8	Maria River State Forest	Maria River National Park	Control	486965	6554366	0	Tallowwood	487023 6554205	486866 6554557	25/10/2014	0034-0104	18.9	0	0	0	0	0			28/10/2014	2358-0028	13.9	1	0	0	0	0		
8	Maria River State Forest	Maria River National Park	Control	486971	6554479	10	Tallowwood																						
8	Maria River State Forest	Maria River National Park	Control	487004	6554203	10	Tallowwood																						
3a	Cairncross State Forest (south)	Cairncross State Forest (south)	No Mitigation	481655	6527256	0	Tallowwood	481737 6527252	481732 6527220	23/10/2014	2142-2212	15.4	1	0	0	0	0			26/10/2014	0101-0131	19.5	0	0	2	0	0		
3a	Cairncross State Forest (south)	Cairncross State Forest (south)	No Mitigation	481590	6527316	0	Tallowwood																						
3a	Cairncross State Forest (south)	Cairncross State Forest (south)	No Mitigation	481637	6527175	13.33	Tallowwood																						

Annex 5 Road kill baseline monitoring data (Autumn 2014)

The following surveys were conducted weekly on Friday and included the entire OH2K alignment. Data provided by Niche Environment and Heritage										
Season	**Week**	**Date**	**Observers**	**Roadkill?**	**Easting**	**Northing**	**Species**	**No.**	**Fauna Categories**	**Adjacent Vegetation Type**
Autumn	1	02/05/2014	CM	Yes	483168	6547303	Rabbit	1	Introduced Mammal	Dry Grassy Tallowwood-Grey Gum
					481371	6535085	Unknown bird	1	Unknown	Tall moist forest regrowth
					480351	6532616	Boobook Owl	1	Bird	Exotic pasture
					480361	6531177	Bush rat	1	Small Terrestrial Mammal	Tall forest
	2	09/05/2014	CM	No						
	3	16/05/2014	CM	Yes	482112	6535550	Rabbit	1	Introduced Mammal	Moist forest regrowth
					482111	6535572	Tawny Frogmouth	1	Bird	Moist forest regrowth
					482207	6535583	Small macropod	1	Medium Terrestrial Mammal	Highly disturbed roadside vegetation
	4	23/05/2014	CM	Yes	483139	6547499	Red Fox	1	Introduced Mammal	Dry Grassy Tallowwood-Grey Gum
					483139	6547310	Eastern Grey Kangaroo	1	Large Terrestrial mammals	Dry Grassy Tallowwood-Grey Gum

					482492	6535838	Brush-tailed Possum	1	Arboreal Mammal	Moist forest regrowth
					481731	6535316	Domestic Cat	1	Introduced Mammal	Highly disturbed roadside vegetation
					481066	6534816	Brush-tailed Possum	1	Arboreal Mammal	Moist forest regrowth
					483088	6520068	Brush-tailed Possum	1	Arboreal Mammal	Blackbutt, Bloodwood, Turpentine

Please see Annex 3 section 8 for Spring and summer data

Annex 6 Road kill clearing, post-clearing and construction phase data until 21st July 2015

OH2Ku road kill summary

Date of Survey	Observers	Start location	Record No.	Carriage way (NB, SB)	Distance of kill from start	Species/ group	Accuracy	Adj clearing <48hrs	Adj Clearing	Barrier (fence/concrete)	Location (approx)	Easting	Northing	Adjacent Vegetation Cleared	Comments	Frequency
6/11/2014	TW/JE	Oxley/Pac Hwy roundabouts	1	NB	18.5	Fox	Definite	No	No	Nil	Opposite Wilmaria rd	482460	6535780	no		Weekly
11/11/2014	NP/TW	Oxley/Pac hwy roundabout	2	NB	3.4	Crow	Definite	No	No	Nil	1km nth Sancrox	483197	6521871	yes AR		Weekly
			3	NB	17.9	Large mammal	Probable	No	No	Nil	600m Sth Wilmaria	481946	6535473	no	Fox. Pos.	
			4	NB	20.8	Small bird	Definite	No	No	Nil	30m nth Cooperabung drive	482690	6538360	yes, AR		

			5	SB	28.5	Medium mammal	Low	No	No	Nil	Sth Yarabee	482184	6539692	no	Swamp wallaby. Pos.	
			6	SB	31.7	Medium mammal	Probable	No	No	Nil	Opp Coopera bung drive	482724	6538325	no	CBP. Pos	
			7	SB	36.9	Flying fox spp.	Definite	No	No	Nil	10m Nth of Wilson River Bridge	480826	6534542	no		
			8	NB	19.4	Med bird	Probable	No	No	Nil	100m Sth of Haydons Wharf Rd	482880	6536296	no	Probable Kookaburra	
19/11/2014	NP/DR	Oxley/PAC Hwy roundabouts	9	NB	1.2	UnID mammal	N/A	No	No	No	1.2 km north of Oxley/Pac hwy interchange	483140	6520340	yes, AR		Weekly
			10	NB	6.5	Black FF	Definite	No	No	No	200m north of Hastings river bridge	482880	6525410	no		

			11	NB	7.4	Echidna	Definite	No	Yes	No	400m north of Lend Lease compound entry	482450	6526192	yes		
			12	NB	18.9	CBTP	Definite	No	No	No	370m south of Haydons Warf Rd	482746	6536077	no		
			13	SB	40.7	UnID mammal	N/A	No	No	No	170m north of Barries Creek	482587	6541980	yes, AR		
26/11/2014	NP/GM	Oxley/Pac Hwy roundabout	14	NB	6.9	Eastern grey kangaroo	Definite	No	Yes	Fence	North side compound driveway	482638	6525838	yes		Weekly
			15	NB	15.6	Bird spp.	NA	No	No	Nil	150m South Wilson river	480679	6534154	no	Possible kookaburra	
			16	SB	35	Unidentified mamal	N/A	No	No	Nil	50m south Wilmaria rd	482431	6535746	no		
			17	SB	38.3	Unidentified animal	N/A	No	No	Nil	200 north Fernbank creek	483357	6523849	no	Possible reptile	

			18	SB	50	Unidentified bird spp.	N/A	No	No	Nil	500m north Sancrox rd	483193	6522042	yes, AR	Possible karrawong	
3/12/2014	NP/JE	Mingaletta Rd	19	SB	3.4	Koala	Definite	No	No	Nil	300m north of Yarrabee Rd	482130	6540098	no	Rock batters both sides of road	Weekly
			20	SB	12.5	Grey-headed Flying-fox	Definite	No	No	Nil	100m south of Hacks Ferry	480656	6533991	no		
			21	NB	34.5	Fox	Probable	Yes	Yes	Nil	50m south of Wharf rd	481845	6527238	yes		
10/12/2014	NP/DR	Oxley/PAC Hwy roundabouts	22	NB	5.8	Buff Banded Rail x2	Definite	No	No	Nil	Glen Ewan Rd	483239	6524714	no	In small flock, crossing rd	Weekly
			23	NB	12.1	Lizard spp.	N/A	No	No	Nil	Near Bill Hill Rd	480690	6530154	no		
			24	NB	14.2	Lizard spp	N/A	No	No	Nil	Hacks Ferry rd	480661	6534091	no		
			25	NB	19.7	Bird spp.	N/A	Yes	Yes	Yes concrete barrier	Haydons wharf rd	482925	6536405	yes		
			26	SB	32.4	UnID mammal	N/A	No	Yes	Nil	100m north Cooperabung Drive	482465	6538520	yes		

			27	SB	40.4	Blue Tongue	Definite	No	No	Nil	100m south Hacks ferry Rd	480655	6533984	no		
			28	SB	48.4	UnID large mammal	N/A	No	No	Nil	Glen Ewan Rd	483270	6524693	no		
16/12/2014	NP/GM	Mingaletta Rd	29	SB	3.4	Small passerine	N/A	No	No	Yes	300 N Yarrabee rd	482150	6540057	no		Weekly
			30	SB	21.9	Flying fox	Definite	No	No		On Fernbankck bridge	483316	6523658	no		
			31	NB	37.1	Red - necked wallaby	Probable	No	Yes	Nil	300 South Mahogany rd	481303	6528355	no		
			32	NB	41.5	Purple swamphen	Definite	No	No	Yes	100 Sth Hacks Ferry rd	480648	6533977	no		
6/01/2015	NP/GM	Oxley/PAC Hwy roundabouts	33	NB	3	Large mammal	N/A	No	No	Concrete jersey barrier	500 Nth Sancrox rd	483181	6522072	yes, AR	Likely trapped by barrier	Weekly
			34	SB	30.4	Fox	Definite	No	No		500 Nth Yarrabee rd	482148	6540237	yes, NB not SB?	Jersey barrier opposite side of rd.	

			35	SB	38.2	Bird spp.	N/A	No	No	No barrier	Between Hacks Ferry and Wilson river.	480683	6534177	no	Unidentified small to medium bird	
15/01/2015	DR	Mingaletta Rd	36	SB	16.7	Unid mammal	N/A	No	Yes	No	550 m north Blackmans Point Rd	481432	6528030	yes		Weekly
			37	NB	42.9	Purple swamp hen	Definite	No	No	No	60m south of Rolands Plains Rd	481170	6534944	no		
			38	NB	52.4	Unid mammal	N/A	No	No	Yes	320m north of Barries Creek, northern extent of construction site	482650	6542108	yes, AR		
3/03/2015	NP	22000-23000	39	SB& NB	NA	Brushtail Possum spp.	Definite	No	Yes	At end of barries	200m North of new Yarrabee rd	482159	6540459	yes	200m North of recent clearing	
2/04/2015	NP	Oxley/PAC Hwy roundabouts	40	SB	43.6	Fox	Definite	No	No	No	On bridge at Hacks Ferry	480665	6534094	no		

9/04/2015	NP/GM	Oxley/PAC Hwy roundabouts	41	SB	46.4	Kookaburra	Definite	No	No	No	Bill Hill rd	480686	6530195	no		
10/04/2015	NP	Oxley/PAC Hwy roundabouts	42	NB	6.4	Fox	Probable	Yes	Yes	No	Fernbank creek	483326	6523717	yes		
13/04/2015	NP/TW	Oxley/PAC Hwy roundabouts	43	NB	14.8	Ringtail possum	Possible	No	No	No	Telegraph point	480534	6533314	no		
			44	NB	20.5	Wallaby spp.	Probable	No	Yes	Yes	Cooperabung drive	482792	6538167	yes	Probably stuck behind barrier and struck	
15/04/2015	NP/TW	Oxley/PAC Hwy roundabouts	45	SB	50.9	Brushtail possum	Definite	No	No	No	Compound entrance	482640	6525830	no		
16/04/2015	NP/TW	Mingaletta Rd	46	SB	20	Cat	Definite	No	No	Bridge	On Hastings bridge	482977	6525225	no		
17/04/2015	NP/TW	Mingaletta Rd	47	SB	10	Blue tongue	Probable	No	No	No	Telegraph point	480812	6534546	no	Nth of bridge	
21/04/2015	NP/JE	Mingaletta Rd	48	NB	43.7	Bird spp.	N/A	No	No	No	1km north of Wilson river	481555	6535220	no	Brown morph Tawny?	

22/04/2015	NP	Oxley/PAC Hwy roundabouts	49	SB	39	UnID animal	N/A	No	No	No	Wilson River bridge	480799	6534502	no	
23/04/2015	NP/JE	Oxley/PAC Hwy roundabouts	50	SB	34.2	Cat	Definite	No	No	Yes	50m South Cooperabung Close	482757	6538261	yes, AR	
24/04/2015	NP/JE	Mingaletta Rd	51	SB	0.7	Carpet Python	Definite	No	Yes	Yes	Barries creek	482641	6542082	yes	Stuck behind barrier
			52	SB	8.3	Kookaburra	Definite	No	No	No	100m south of Wilmaria rd	482343	6535692	no	
			53	SB	12.2	Common Ringtail Possum	Definite	No	No	No	Hacks ferry	480522	6533260	no	
			54	NB	32.5	UnID animal	N/A	No	No	No	Glen Ewan Rd	483219	6524746	no	
27/04/2015	NP	Oxley/PAC Hwy roundabouts	55	SB	42	Red-necked Wallaby	Definite	No	No	No	100m north of Bill Hill rd	480645	6530277	no	
29/04/2015	NP/TW	Mingaletta Rd	56	SB	9.7	Tawny	Definite	No	No	No	Hacks Ferry	48130	6534826	no	
			57	SB	21	Common Ringtail Possom	Possible	No	Yes	Yes	Fernbank creek area	483359	6524483	yes	

			58	SB	21	UnID small raptor	N/A	No	No	No	Fernbank creek	483356	6524462	no	
			59	NB	33	UnID	N/A	No	No	No	Hastings	482844	6525460	no	Recent roadside clearing by council
			60	NB	33.5	Kookaburra	Definite	No	Yes	No	100m North of compound entrance	482603	6525921	yes	
4/05/2015	NP	Oxley/PAC Hwy roundabouts	61	NB	6.9	Fox	Definite	No	No	No	Under existing steel barrier above culvert	482728	6525683	no	
			62	NB	16.2	Masked Owl	Definite	No	No	No	100m before Wilson River Bridge	480632	6533771	no	
5/05/2015	NP/GM	Oxley/PAC Hwy roundabouts	63	SB	35.5	Kookaburra	Probable	No	No	No	Hacks Ferry rd			no	
6/05/2015	NP/GM	Oxley/PAC Hwy roundabouts	64	NB	18.4	Kookaburra	Low	No	No	No	200m Sth Wilmaria rd	482290	6535666	no	Kookaburra?

			65	SB	41	Un-identified mammal	Possible	No	No	No	500 nth Mahogany rd	481077	6529100	no	Un-identified mammal
			66	SB	45.4	Long necked turtle	Definite	No	No	No	~100m North of Hastings river bridge	482890	6525386	no	Killed one day prior attempting to cross road (East to west).
8/05/2015	JE	Oxley/PAC Hwy roundabouts	67	SB	39.4	Northern Brown Bandicoot	Probable	No	No	No	350m north of Pear Tree Rd	480306	6531418	no	
11/05/2015	NP	Mingaletta Rd	68	SB	4.3	UnID animal	N/A	No	Yes	Yes	Coop close	482937	6537780	yes	
			69	SB	6.2	UnID medium mammal	N/A	No	No	No	100m South Haydons wharf rd	482889	6536296	no	Brushtail possum?
			70	SB	9.9	UnID Snake	N/A	No	No	No	200m South Wilson River Bridge	480640	6533801	no	Very long spinal cord, black? Skin.

			71	NB	43.7	Masked Owl	Definite	No	No	No	300m South Wilson River Bridge	480636	6533758	no	100m from previous masked owl killed 1 week prior	
12/05/2015	NP	Mingaletta Rd	72	NB	40.9	Fox	Definite	No	No	No	1km south of Hacks ferry rd	480461	6533097	no		
			73	NB	49.1	Bird	N/A	No	Yes	Yes	Cooperabung range hill	482431	6538840	yes		
13/05/2015	NP	Mingaletta Rd	74	SB	9.7	Small Raptor	N/A	No	No	No	Hacks ferry rd	481059	6534846	no		
			75	SB	11.6	Large mammal	N/A	No	No	No	2km south of Hacks Ferry rd	480277	6531986	no	Roo?	
			76	SB	26	Deer-Stag	Definite	No	Yes	No	Southern median	483106	6520010	yes		
14/05/2015	NP	Oxley/PAC Hwy roundabouts	77	NB	17.7	UnID animal	N/A	No	No	No	200m north of Wilson river bridge	480920	6534704	no		

18/05/2015	NP	Oxley/PAC Hwy roundabouts	78	NB	9.7	Medium mammal	N/A	No	Yes	Yes	100m north of Blackmans Point rd	481564	6527743	yes	Fox?	
			79	SB	45.2	Med mammal	N/A	No	No	No	Compound turning lane	482638	6525861	no	Fox??	
20/05/2015	DR/GM/NP	Oxley/PAC Hwy roundabouts	80	NB	15	Rattus sp	N/A	No	No	No	Bridge at Hacks ferry area	480651	6534021	no		
			81		16	Small bird	N/A	No	No	No	20m north of Wilson River bridge	480821	6534551	no		
22/05/2015	NP	Oxley/PAC Hwy roundabouts	82	NB	21.2	Med mammal	N/A	No	Yes	Yes	Cooperabung Creek bridge	482867	6537990	yes		
26/05/2015	TW	Oxley/PAC Hwy roundabouts	83	NB	12.5	Fox	Definite	No	No	Nil	South of Telegraph point	480456	6530756	no		
1/06/2015	JE	Oxley/Pac hwy roundabout	84	NB	12.6	Red fox	Definite	No	No	No	100m sth BillHill Rd	480717	6530083	no		

			85	SB	41.7	White headed pigeon	Definite	No	No	No	700m north of Mahogany Dr	481005	6529286	no		
			86	SB	51.7	Magpie	Definite	No	No	No	850m north of Oxley/Pac hwy roundabout	483107	6519997	yes, AR		
10/06/2015	JE	Oxley/Pac hwy roundabout	87	NB	22.1	Sthn Boobook	Definite	No	Yes	Yes	200m Sth Yarrabee Rd	482203	6539530	yes		
11/06/2015	JE	Oxley/Pac hwy roundabout	88	NB	nil	Magpie	Definite	No	No	No	200m Sth Bill Hill Rd	480750	6529982	no		
12/06/2015	JE	Mingaletta Rd	89	SB	6.7	Fox	Probable	No	No	No	670m south of Cooperabung Close	483047	6536961	yes, AR		
15/06/2015	DO	Oxley/Pac hwy roundabout	90	NB	7.5	Eastern grey kangaroo	Definite	No	yes	No	600m north of compound driveway	482362	6526341	yes		
			91	SB	41.1	Rabbit	Definite	No	No	No	Moorside Drive	480327	6531334	no		

			92	SB	51.8	White-headed pigeon	Definite	No	No	No	~200m north of Oxley/Pac hwy roundabout	482973	6519345	no		
17/06/2015	TW	Oxley/Pac hwy roundabout	93	SB	51	Deer	Definite	no	yes	no	~1km north of Oxley/Pac hyw roundabout	483117	6520141	yes		
22/06/2015	DO	Oxley/Pac hwy roundabout	94	NB	8.3	Red fox	possible	no	yes	no	Wharf Road	481814	6527285	yes		
26/06/2015	JE	Oxley/Pac hwy roundabout	95	NB	19.2	Cat	Probable	no	Yes	Yes	150m Nth Haydons Wharf RD	482953	6536474	yes	Remains in middle of Rd, fur - black & white.	

Date of Survey	Observers	Start location	Roadkill?	Carriageway (NB, SB)	Species/group	Accuracy	Adj clearing <48hrs	Adj Clearing	Barrier (fence/ concrete)	Location (approx)	Easting	Northing
The following surveys were conducted weekly and included the entire OH2Ku alignment.												

01/07/2015	NR	Oxley Highway to 200m Nth of Barries Ck	YES	?? SB	Spotted-Tail Quoll Kookaburra	Definite Definite	N N	N N	Barrier Barrier	200m Sth of Cooperabung Ck (Ben Lewis) Opp cut 19A	152 48.9	31 16.9
09/07/2015	NR	Oxley Highway to 200m Nth of Barries Ck	YES	SB	Magpie	Definite	N	N	Barrier	South of Tele Pt Service Station - sml bridge	152 47.6	31 20.6
13/07/2015	NR	Oxley Highway to 200m Nth of Barries Ck	YES	NB SB	Wallaby Wallaby	Definite Probable	N N	N N	Barrier Barrier	Sth of Wilson River bridge Nth of Fernbank Ck bridge	152 47.8 152 49.5	31 19.8 31 25.3
21/07/2015	NR	Oxley Highway to 200m Nth of Barries Ck	YES	SB Middle NB	Possum Koala Wallaby	Probable Definite Definite	N N N	N N N	Barrier Barrier Barrier	Yarrabee Rd Acceleration lane 200m Nth of Yarrabee Rd Gate 7	152 48.8 0482151 152 49.4	31 16 6539923 31 26

OH2Ku road kill habitat data

Road Kill No.	Carriageway (NB, SB)	Dominant Species (% cover)			Hydrological features		Presence & Type of Rocky features		No. Hollow Logs	No. Hollow Trees	Foraging Resources
		Overstorey	Midstorey	Understorey	P/A	Type	P/A	Type			
1	NB	Cleared									
2	NB	Eucalyptus sp. 25%	Melaluca sp. 15%	Gahnia sp. 35%	P	Seepage line, small swamp area	A		no	no	Tree blossom, leaf litter
3	NB	No Access									
4	NB	Cleared									
5	SB	Ecalyptus sp. (grey gum) 5%, E. microcorys 10%	Iron Bark 5%, Lantana 5%	Aplismasus grass? 50%	A		P	Road batter - small boulders	no	no	Euc blossom
6	SB	Cleared									
7	SB	No Access									
8	NB	Cleared									
9	NB	Cleared									
10	NB			grazed pasture	A		A		no	no	no
11	NB	E. pilularis 10%, Euc sp. 5%	Melaluca sp. 15%	Gahnia sp. 40%	P	Swampy drainage line	A		no	no	Euc blossom
12	NB	Cleared									
13	SB	Cleared									

Road Kill No.	Carriageway (NB, SB)	Dominant Species (% cover)			Hydrological features		Presence & Type of Rocky features		No. Hollow Logs	No. Hollow Trees	Foraging Resources
		Overstorey	Midstorey	Understorey	P/A	Type	P/A	Type			
14	NB	E. pilularis 40%	Acacia sp. >5%	Andropogon virginicus 5%, Imperata cylindrica 10%, Gahnia sp. 5%	A		A		no	no	Leaf litter
15	NB	Allocasurina sp. 20%	Lantana 10%, Senna cassia 5%	Setaria 90%	A		A		no	no	Allocasurina sp., small mamals in setaria.
16	SB	E. microcorys 15%	Lantana 15%	Hardenbergia violacea 5%, Kennadia rubicunda 5%	A		A		no	no	Euc blossom
17	SB	Cleared									
18	SB	Cleared									
19	SB	E. tereticornis <5%, Allocasurina 20%	Allocasurina 20%	Right angle grass (Entolasia sp?) 40%	A		P	Roadside batter ~5m above road	no	no	Allocasurina seed
20	SB	No Access									

21	NB	Cleared									
22	NB	Erythrina sp. (coral tree) 5%	Lantana 80%	Grass sp. 25%	A		A		no	no	Possible small mammals in grass
23	NB	E. piluaris 10%, E. microcorys 30%	Allocasurina 20%	Imperata cylindrica 60%	A		A		no	no	Euc blossom, Allocasurina seed
24	NB	Unidentifiable site									
25	NB	Cleared									
26	SB	Cleared									
Road Kill No.	Carriageway (NB, SB)	Dominant Species (% cover)			Hydrological features		Presence & Type of Rocky features		No. Hollow Logs	No. Hollow Trees	Foraging Resources
		Overstorey	Midstorey	Understorey	P/A	Type	P/A	Type			
27	SB	No Access									
28	SB	Erythrina sp. (coral tree) 60%	Solanum mauritianum 30%, Lantana 20%	Ipomoea sp. 5%	P	Floodplain	A		no	no	no
29	SB	E. tereticornis <5%, Allocasurina 20%	Allocasurina 20%	Right angle grass (Entolasia sp?) 40%	A		P	Roadside batter ~5m above road	no	no	Allocasurina seed
30	SB	No Access									

31	NB	E. pilularis 15%	Allocasurina 5%	Imperata cylindrica 20%	A		A		no	no	Euc blossom, Allocasurina seed, grass foraging for small mammals/prey
32	NB	Melauca sp. <5%, Allocasurina 5%	nil	Setaria 80%	A		A		no	no	Grass foraging for small mammals/prey
33	NB	Cleared									
34	SB	Cleared									
35	SB	No Access									
36	SB	Cleared									
37	NB	Cleared									
38	NB	E. grandis 20%	Lantana 40%	Aplismanus grass? 40%	A		P	Large boulders road batter ~ 5m below road	no	no	Euc blossom, small mammals in rocks/grass
39	SB& NB	Cleared									
Road Kill No.	Carriageway (NB, SB)	Dominant Species (% cover)			Hydrological features		Presence & Type of Rocky features		No. Hollow Logs	No. Hollow Trees	Foraging Resources
		Overstorey	Midstorey	Understorey	P/A	Type	P/A	Type			
40	SB	No Access									

41	SB	E. pilularis <5%	Corymbia sp. (bloodwood) <5%, Allocasurina <5%	Andropogon virginicus 5%	A		A		no	no	Euc blossom, Allocasurina seed
42	NB	Melauca sp. 40%		Phragmites 40%, lantana 35%, Gahnia 10%	P	Fernbank ck/swamp	A		no	no	Melauca blossom
43	NB	Unidentifiable site									
44	NB	Cleared									
45	SB	No Access									
46	SB	No Access									
47	SB	Unidentifiable site									
48	NB	No Access									
49	SB	Cleared									
50	SB	Cleared									
51	SB	Cleared									
52	SB	Euc sp. (Grey gum) 15%	E. microcorys 7.5%, Melauca <5%	Lantana 20%	P	Small culvert drainage line/gully	P	Bouldersexposed around culvert exit point ~8m below rd	no	no	Euc blossom
Road Kill No.	Carriageway (NB, SB)	Dominant Species (% cover)			Hydrological features		Presence & Type of Rocky features		No. Hollow Logs	No. Hollow Trees	Foraging Resources

		Overstorey	Midstorey	Understorey	P/A	Type	P/A	Type			
53	SB	No Access									
54	NB	Erythrina sp. (coral tree) 5%	Lantana 80%	Grass sp. 25%	A		A		no	no	Possible small mamals in grass
55	SB	E. piluaris 5%	Lantana 80%	Grass sp. 25%	A		A		no	no	Possible small mammals in grass
56	SB	No Access									
57	SB	Cleared									
58	SB	Cleared									
59	NB	nil	nil	Pasture	A		A		no	no	no
60	NB	E. pilularis 40%	Acacia sp. >5%	Andropogon virginicus 5%, Imperata cylindrica 10%, Gahnia sp. 5%	A		A		no	no	Leaf litter
61	NB	E. pilularis 40%	Acacia sp. >5%	Andropogon virginicus 5%, Imperata cylindrica 10%, Gahnia sp. 5%	A		A		no	no	Leaf litter

62	NB	Allocasurina sp 20%	Lantan 5%	Setaria 90%	A		A		no	no	Possible small mammals in grass
63	SB	No Access									
64	NB	No Access									
65	SB	Cleared									
Road Kill No.	Carriageway (NB, SB)	Dominant Species (% cover)			Hydrological features		Presence & Type of Rocky features		No. Hollow Logs	No. Hollow Trees	Foraging Resources
		Overstorey	Midstorey	Understorey	P/A	Type	P/A	Type			
66	SB	nil	nil	Pasture, Setaria 90%	A		A		no	no	Possible small mammals in grass
67	SB	No Access									
68	SB	Cleared									
69	SB	Iron bark 15%, Corymbia sp. (bloodwood) 5%	Euc sp. 5%, Allocasurina 5%	Imperata cylindrica 25%	A		P	Roadside batter small boulders 4 - 5m above rd	no	no	Euc blossom
70	SB	No Access									
71	NB	Allocasurina 10%	nil	Setaria 100%	A		A		no	no	Possible small mammals in grass

72	NB	nil	nil	Setaria 90%	A		A		no	no	Possible small mammals in grass
73	NB	Cleared									
74	SB	No Access									
75	SB	nil	nil	Andropogan virginicus 10%, lantan 20%, Braken fern 10%	A		A		no	no	Possible small mammals in grass
76	SB	Cleared									
77	NB	Iron bark 10%, E. microcorys 10%, Camphor laurel 5%	Lantan 10%, Lophostemon (brushbox) 15%	Lantana 10%, Paspalam 10%, Gahnia sp. 5%	P	Gully drain line, small culvert	P	Large and small scattered boulders	no	no	Euc blossom
78	NB	No Access									
Road Kill No.	Carriageway (NB, SB)	Dominant Species (% cover)			Hydrological features		Presence & Type of Rocky features		No. Hollow Logs	No. Hollow Trees	Foraging Resources
		Overstorey	Midstorey	Understorey	P/A	Type	P/A	Type			
79	SB	No Access									
80	NB	No Access									
81		No Access									
82	NB	Cleared									
83	NB	Unidentifiable site									

84	NB	E. microcorys 30%, E. pilularis 10%	Allocasurina 20%	Imperata cylindrica 60%	A		A		no	no	Euc blossom, allocasurina seed, small mammals in grass
85	SB	Cleared									
86	SB	Cleared									
87	NB	Cleared									
88	NB	E. pilularis 25%, E. microcorys 5%	Allocasurina sp. 15%	Imperata cylindrica 60%	A		A		no	Yes 1	Euc blossom, allocasurina seed, small mammals in grass
89	SB	Cleared									
90	NB	Cleared									
91	SB	E. pilularis 5%, Allocasurina sp. 50%	Lantna 5%	Gahnia sp. 10%, Imperata cylindrica 5%	A		A		no	no	Euc blossom, allocasurina seed, small mammals in grass
Road Kill No.	Carriageway (NB, SB)	Dominant Species (% cover)			Hydrological features		Presence & Type of Rocky features		No. Hollow Logs	No. Hollow Trees	Foraging Resources
		Overstorey	Midstorey	Understorey	P/A	Type	P/A	Type			
92	SB	South of clearing limit									

93	SB	Cleared									
94	NB	Cleared									
95	NB	Cleared									

Ku2K raw data provided

Date	Day	Chainage	Company	Site name	Species detected	Chainage + notes	Easting	Northing	Adjacent Vegetation Type (Adopted from the Environmental Assessment)	Clearing Phase	Clearing Classification
03-Nov-14	Monday	24100-37850	Lewis Ecological Surveys	Whole Site	Short-beaked Echidna (adult)	Ch. 24900 in south bound emergency breakdown lane	483114	6543170	Dry Ridgetop Forest	Pre-clearing weekly survey 1 month prior to clearing commencing	Pre-clearing Weekly
03-Nov-14	Monday	24100-37850	Lewis Ecological Surveys	Whole Site	Common Ringtail Possum (adult)	Ch. 28600 in centre of north bound lane	483184	6546568	Moist Floodplain Forest	Pre-clearing weekly survey 1 month prior to clearing commencing	Pre-clearing Weekly
03-Nov-14	Monday	24100-37850	Lewis Ecological Surveys	Whole Site	Eastern Water Dragon (adult)	Ch. 30625 south bound verge of Pipers Creek Bridge	483164	6548533	Moist Floodplain Forest	Pre-clearing weekly survey 1 month prior to clearing commencing	Pre-clearing Weekly

03-Nov-14	Monday	24100-37850	Lewis Ecological Surveys	Whole Site	Red-necked Wallaby (adult)	Ch. 33300 in south bound emergency breakdown lane	483022	6551438	Moist Slopes Forest	Pre-clearing weekly survey 1 month prior to clearing commencing	Pre-clearing Weekly
03-Nov-14	Monday	24100-37850	Lewis Ecological Surveys	Whole Site	Common Ringtail Possum (adult)	Ch. 37275 in south bound lane	483202	6555199	Moist Slopes Forest	Pre-clearing weekly survey 1 month prior to clearing commencing	Pre-clearing Weekly
10-Nov-14	Monday	24100-37850	Lewis Ecological Surveys	Whole Site	Northern Brown Bandicoot (sub adult)	Ch. 28000 in centre of road - individual was actually struck 6 days ago	483202	6546042	Moist Floodplain Forest	Pre-clearing weekly survey 1 month prior to clearing commencing	Pre-clearing Weekly
10-Nov-14	Monday	24100-37850	Lewis Ecological Surveys	Whole Site	Torresian Crow (adult)	Ch. 29175 or just south of Kundabung Road Intersection in north bound lane	483136	6547268	Moist Slopes Forest	Pre-clearing weekly survey 1 month prior to clearing commencing	Pre-clearing Weekly
10-Nov-14	Monday	24100-37850	Lewis Ecological Surveys	Whole Site	Grey Goshawk (adult)	Ch. 31800 in south bound emergency breakdown lane	483196	6549822	Moist Slopes Forest	Pre-clearing weekly survey 1 month prior to clearing commencing	Pre-clearing Weekly
10-Nov-14	Monday	24100-37850	Lewis Ecological Surveys	Whole Site	Swamp Wallaby (adult)	Ch. 34800 in centre of road	483013	6552731	Moist Gully Forest	Pre-clearing weekly survey 1 month prior to clearing commencing	Pre-clearing Weekly

10-Nov-14	Monday	24100-37850	Lewis Ecological Surveys	Whole Site	Yellow-faced Honeyeater (adult)	Ch. 37400 in south bound lane to north of Kemps Road	483201	6555214	Moist Slopes Forest	Pre-clearing weekly survey 1 month prior to clearing commencing	Pre-clearing Weekly
17-Nov-14	Monday	24100-37850	Lewis Ecological Surveys	Whole Site	Koala (juvenile) + (adult female)	Ch. 26350 with adult female and back young struck on Tuesday/Wednesday (11/12th Nov)	483187	6544354	Moist Gully Forest	Pre-clearing weekly survey 1 month prior to clearing commencing	Pre-clearing Weekly
17-Nov-14	Monday	24100-37850	Lewis Ecological Surveys	Whole Site	Rabbit (adult)	Ch. 27000 on edge of north bound lane	483185	6545174	Dry Ridgetop Forest	Pre-clearing weekly survey 1 month prior to clearing commencing	Pre-clearing Weekly
17-Nov-14	Monday	24100-37850	Lewis Ecological Surveys	Whole Site	Common Brushtail Possum (adult)	Ch. 31700 in south bound lane	483189	6549637	Moist Slopes Forest	Pre-clearing weekly survey 1 month prior to clearing commencing	Pre-clearing Weekly
17-Nov-14	Monday	24100-37850	Lewis Ecological Surveys	Whole Site	Common Brushtail Possum (adult)	Ch. 31825 in centre of road	483194	6549836	Moist Slopes Forest	Pre-clearing weekly survey 1 month prior to clearing commencing	Pre-clearing Weekly
17-Nov-14	Monday	24100-37850	Lewis Ecological Surveys	Whole Site	Diamond Python (Morelia spilota spilota) - adult	Ch. 36850 on southern abutment area of south bound Maria River bridge	483115	6554729	Riparian Forest	Pre-clearing weekly survey 1 month prior to clearing commencing	Pre-clearing Weekly

17-Nov-14	Monday	24100-37850	Lewis Ecological Surveys	Whole Site	Diamond Python (Morelia spilota spilota) - adult	Ch. 37075 on edge of south bound between Maria River and Kemps Road	483189	6555068	Moist Slopes Forest	Pre-clearing weekly survey 1 month prior to clearing commencing	Pre-clearing Weekly
17-Nov-14	Monday	24100-37850	Lewis Ecological Surveys	Whole Site	Common Ringtail Possum (adult)	Ch. 37500 in edge of south bound lanes between Stumpy Creek and Kemps Road	483232	6555398	Moist Slopes Forest	Pre-clearing weekly survey 1 month prior to clearing commencing	Pre-clearing Weekly
24-Nov-14	Monday	24100-37850	Lewis Ecological Surveys	Whole Site	Diamond Python (Morelia spilota spilota) - sub adult	Ch. 25750 opposite Mobbs Drive on edge of north bound emergency breakdown lane	483167	6543727	Moist Gully Forest	Pre-clearing weekly survey 1 month prior to clearing commencing	Pre-clearing Weekly
24-Nov-14	Monday	24100-37850	Lewis Ecological Surveys	Whole Site	Diamond Python (Morelia spilota spilota) - adult	Ch. 28200 Smiths Creek southside in north bound lane	483191	6546215	Riparian Forest	Pre-clearing weekly survey 1 month prior to clearing commencing	Pre-clearing Weekly
24-Nov-14	Monday	24100-37850	Lewis Ecological Surveys	Whole Site	Swamp Wallaby - adult	Ch. 30800 in north bound lane to north of Pipers Creek	483159	6548866	Moist Slopes Forest	Pre-clearing weekly survey 1 month prior to clearing commencing	Pre-clearing Weekly
24-Nov-14	Monday	24100-37850	Lewis Ecological Surveys	Whole Site	Blackish Blind Snake (adult)	Ch. 33200 in north bound lane	483049	6551309	Moist Slopes Forest	Pre-clearing weekly survey 1 month prior to clearing commencing	Pre-clearing Weekly

25-Nov-14	Tuesday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
26-Nov-14	Wednesday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
27-Nov-14	Thursday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
28-Nov-14	Friday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
01-Dec-14	Monday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
02-Dec-14	Tuesday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
03-Dec-14	Wednesday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
04-Dec-14	Thursday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	Eastern Grey Kangaroo (adult)	Ch. 34500 opposite construction basin in centre line of road	482908	6552365	Dry Ridgetop Forest	During clearing for mainline	During Clearing
04-Dec-14	Thursday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	Eastern Grey Kangaroo (adult)	Ch. 35700 south bound	482854	6553605	Moist Gully Forest	During clearing for mainline	During Clearing
05-Dec-14	Friday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
06-Dec-14	Saturday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						

08-Dec-14	Monday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	Dwarf Crowned Snake (Cacophis krefftii) - adult	Ch.25350 in middle of Mingaletta Road near timber bridge	483180	6543324	Riparian Forest	Post 30 days from mainline clearing	Post Clearing
09-Dec-14	Tuesday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
10-Dec-14	Wednesday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
11-Dec-14	Thursday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
12-Dec-14	Friday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
15-Dec-14	Monday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
16-Dec-14	Tuesday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
17-Dec-14	Wednesday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
18-Dec-14	Thursday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
19-Dec-14	Friday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
22-Dec-14	Monday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						

23-Dec-14	Tuesday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	Common Brushtail Possum (adult)	Ch. 25800 in turning/merge lane	483180	6543745	Moist Gully Forest	During clearing for mainline	During Clearing
24-Dec-14	Wednesday	No surveys undertaken									
25-Dec-14	Thursday	No surveys undertaken									
26-Dec-14	Friday	No surveys undertaken									
27-Dec-14	Saturday	No surveys undertaken									
28-Dec-14	Sunday	No surveys undertaken									
29-Dec-14	Monday	No surveys undertaken									
30-Dec-14	Tuesday	No surveys undertaken									
31-Dec-14	Wednesday	No surveys undertaken									
01-Jan-15	Thursday	No surveys undertaken									
02-Jan-15	Friday	No surveys undertaken									

05-Jan-15	Monday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	Swamp Wallaby (adult)	Ch. 24750 edge of south bound lane against concrete barriers	483019	6542769	Moist Slopes Forest	Post 30 days from mainline clearing	Post Clearing
05-Jan-15	Monday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	Swamp Wallaby (adult)	Ch. 25400 north bound lane and appears to have been deceased for 3-5 days	483154	6543393	Moist Gully Forest	Post 30 days from mainline clearing	Post Clearing
05-Jan-15	Monday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	Blackish Blind Snake (adult)	Ch. 33900 edge of south bound lane	482923	6552410	Dry Ridgetop Forest	During clearing for mainline	During Clearing
05-Jan-15	Monday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	Red-necked Wallaby (adult)	Ch. 35500 in middle of road	482900	6553371	Dry Ridgetop Forest	During clearing for mainline	During Clearing
06-Jan-15	Tuesday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	Eastern Grey Kangaroo (sub adult)	Ch. 31700 in south bound lane	483189	6550163	Moist Slopes Forest	Prior to clearing	Prior to Clearing
07-Jan-15	Wednesday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
08-Jan-15	Thursday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	Eastern Grey Kangaroo	Ch. 26000 on north bound lane	483180	6543918	Dry Ridgetop Forest	During clearing for mainline	During Clearing
09-Jan-15	Friday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
10-Jan-15	Saturday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
12-Jan-15	Monday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						

13-Jan-15	Tuesday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
14-Jan-15	Wednesday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
15-Jan-15	Thursday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
16-Jan-15	Friday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
17-Jan-15	Saturday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
19-Jan-15	Monday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
20-Jan-15	Tuesday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
21-Jan-15	Wednesday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
22-Jan-15	Thursday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	Numerous frogs but couldn't access roadway	Numerous frogs from ch. 24100-36650 but couldn't access roadway to identify				Mixed of all temporal scales (pre-clearing, during clearing, post clearing and during construction)	
23-Jan-15	Friday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						

24-Jan-15	Saturday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
26-Jan-15	Monday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
27-Jan-15	Tuesday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
28-Jan-15	Wednesday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
29-Jan-15	Thursday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
30-Jan-15	Friday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	Common Brushtail Possum (adult)	Ch. 28600 south bound lane	483183	6546657	Moist Floodplain Forest	Post 30 days from mainline clearing	Post Clearing
02-Feb-15	Monday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
03-Feb-15	Tuesday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
04-Feb-15	Wednesday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
05-Feb-15	Thursday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
06-Feb-15	Friday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						

07-Feb-15	Saturday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	Lace Monitor (adult)	Ch. 25400 edge of north bound	483162	6543454	Moist Gully Forest	Post 30 days from mainline clearing	Post Clearing
09-Feb-15	Monday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	Eastern Forest Bat (*Vespadelus pumulis*)	Ch. 25800 on edge of south bound lane	483191	6543807	Moist Gully Forest	Post 30 days from mainline clearing	Post Clearing
09-Feb-15	Monday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	Diamond Python (adult)	Ch. 35800 and ~300 m north of any clearing to date	482811	6553911	Moist Slopes Forest	Prior to clearing	Prior to Clearing
09-Feb-15	Monday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	Red-necked Wallaby (adult)	Ch. 36650 edge of south bound	483079	6554608	Dry Ridgetop Forest	Prior to clearing	Prior to Clearing
10-Feb-15	Tuesday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
11-Feb-15	Wednesday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
12-Feb-15	Thursday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
13-Feb-15	Friday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
14-Feb-15	Saturday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
16-Feb-15	Monday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	Common Ringtail Possum (adult)	Ch. 34500 opposite construction basin in centre line of road	482965	6552563	Dry Ridgetop Forest	Post 30 days from mainline clearing	Post Clearing

17-Feb-15	Tuesday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	Common Ringtail Possum (adult)	Ch. 35700 south bound	482854	6553605	Moist Gully Forest	Prior to clearing	Prior to Clearing
18-Feb-15	Wednesday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	Red-necked Wallaby	Ch. 35800 north bound	482954	6553605	Moist Gully Forest	Prior to clearing	Prior to Clearing
19-Feb-15	Thursday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	No new road kill animals						
20-Feb-15	Friday	24100-36650	Lewis Ecological Surveys	Mingaletta, Kundabung, Maria SF	Eastern Blue Tongue Lizard	Ch. 33900 edge of south bound lane	482874	6551913	Dry Ridgetop Forest	Post 30 days from mainline clearing	Post Clearing
23-Feb-15	Monday	24100-36650	Lewis Ecological Surveys	Whole site	Tawny Frogmouth (adult)	Ch. 28100 in south bound lane	483190	6546111	Moist Floodplain Forest	During mainline clearing	During Clearing
23-Feb-15	Monday	24100-36650	Lewis Ecological Surveys	Whole site	Lace monitor at 34700	Ch. 34700 in south bound lane	483013	6552731	Moist Gully Forest	During clearing for minor widening works to the mainline	During Clearing
24-Feb-15	Tuesday	24100-36650	Lewis Ecological Surveys	Whole site	No new fauna found						
25-Feb-15	Wednesday	24100-36650	Lewis Ecological Surveys	Whole site	No new fauna found						
26-Feb-15	Thursday	24100-36650	Lewis Ecological Surveys	Whole site	Lace Monitor (adult)	Ch. 25400 where concrete barriers installed - struck during the day	483169	6543369	Riparian Forest	During construction	During Construction

26-Feb-15	Thursday	24100-36650	Lewis Ecological Surveys	Whole site	Domestic Dog	Ch. 29500 on eastern side of highway	483154	6547576	Moist Floodplain Forest	Post 30 days from mainline clearing	Post Clearing
27-Feb-15	Friday	24100-36650	Lewis Ecological Surveys	Whole site	Eastern Long-necked Turtle (adult)	Ch. 29425 in centre of road	483139	6547431	Moist Floodplain Forest	During mainline clearing for Kundabung Interchange	During Clearing
02-Mar-15	Monday	24100-36650	Lewis Ecological Surveys	Whole site	Australian Magpie (adult)	Ch. 29300 Kundabung Road Intersection	483142	6547305	Moist Slopes Forest	During mainline clearing	During Clearing
03-Mar-15	Tuesday	24100-36650	Lewis Ecological Surveys	Whole site	No new fauna found						
04-Mar-15	Wednesday	24100-36650	Lewis Ecological Surveys	Whole site	No new fauna found						
05-Mar-15	Thursday	24100-36650	Lewis Ecological Surveys	Whole site	No new fauna found						
06-Mar-15	Friday	24100-36650	Lewis Ecological Surveys	Whole site	No new fauna found						
09-Mar-15	Monday	24100-36650	Lewis Ecological Surveys	Whole site	European Hare (adult)	Ch. 32550 centre lane	483205	6550504	Moist Gully Forest	During mainline clearing in the middle of the day, suspected individual was flushed	During Clearing

09-Mar-15	Monday	24100-36650	Lewis Ecological Surveys	Whole site	Diamond Python (sub adult)	Ch. 34600 edge of south bound lane	482963	6552531	Moist Slopes Forest	Post 30 days from minor clearing works of mainline	Post Clearing
10-Mar-15	Tuesday	24100-36650	Lewis Ecological Surveys	Whole site	Sugar Glider (adult female)	Ch. 31700 in centre lane and suspect spotlight this individual during pre dawn works around retained habitat trees	483189	6550163	Moist Slopes Forest	During mainline clearing	During Clearing
10-Mar-15	Tuesday	24100-36650	Lewis Ecological Surveys	Whole site	Red-necked Wallaby (adult)	Ch. 32850 in centre lane	483170	6550894	Moist Slopes Forest	During mainline clearing	During Clearing
10-Mar-15	Tuesday	24100-36650	Lewis Ecological Surveys	Whole site	Red-necked Wallaby (adult)	Ch. 34850 in south bound lane	482996	6552974	Moist Slopes Forest	Post 30 days from mainline clearing	Post Clearing
11-Mar-15	Wednesday	24100-36650	Lewis Ecological Surveys	Whole site	White-throated Nightjar (adult)	Ch. 26400 or 200 m south of Gate 5 in south bound lane	483161	6544291	Moist Gully Forest	Post 30 days from mainline clearing	Post Clearing
11-Mar-15	Wednesday	24100-36650	Lewis Ecological Surveys	Whole site	Blue-tongue Lizard (adult)	Ch. 28450 or 200 m north of Smiths Creek	483190	6546387	Moist Floodplain Forest	During mainline clearing	During Clearing
11-Mar-15	Wednesday	24100-36650	Lewis Ecological Surveys	Whole site	Unidentified small mammal	Ch. 34500 opposite construction basin in centre line of road	482908	6552365	Dry Ridgetop Forest	Post 30 days from mainline clearing	Post Clearing

12-Mar-15	Thursday	24100-36650	Lewis Ecological Surveys	Whole site	Australian Magpie (adult)	Ch. 29200 or just south Kundabung Road Intersection	483151	6547192	Moist Slopes Forest	Post 30 days from mainline clearing	Post Clearing
12-Mar-15	Thursday	24100-36650	Lewis Ecological Surveys	Whole site	Red-necked Wallaby (adult)	Ch. 34300 centre of road	482859	6552210	Dry Ridgetop Forest	Post 30 days from mainline clearing	Post Clearing
13-Mar-15	Friday	24100-36650	Lewis Ecological Surveys	Whole site	No new fauna found						
16-Mar-15	Monday	24100-36650	Lewis Ecological Surveys	Whole site	Swamp Wallaby (1 adult)	Ch. 24150 against concrete barriers south bound	482660	6542148	Moist Gully Forest	During construction	During Construction
17-Mar-15	Tuesday	24100-36650	Lewis Ecological Surveys	Whole site	No new fauna found						
18-Mar-15	Wednesday	24100-36650	Lewis Ecological Surveys	Whole site	Northern Brown Bandicoot (adult)	ch. 29340 - Kundabung Road intersection where concrete barriers installed	483141	6547305	Moist Slopes Forest	During mainline clearing	During Clearing
19-Mar-15	Thursday	24100-36650	Lewis Ecological Surveys	Whole site	Blackish Blind Snake (adult)	ch. 27900 - adjacent heavy vehicle checking bay in centre of south bound lane	483191	6545954	Moist Floodplain Forest	During mainline clearing	During Clearing
20-Mar-15	Friday	24100-36650	Lewis Ecological Surveys	Whole site	No new fauna found						

23-Mar-15	Monday	24100-36650	Lewis Ecological Surveys	Whole site	No new fauna found						
24-Mar-15	Tuesday	24100-36650	Lewis Ecological Surveys	Whole site	No new fauna found						
25-Mar-15	Wednesday	24100-36650	Lewis Ecological Surveys	Whole site	Northern Brown Bandicoot (adult)	Ch. 30780 hit in centre of south bound lane with concrete barriers	483165	6548816	Moist Slopes Forest	Post 30 days from mainline clearing	Post Clearing
26-Mar-15	Thursday	24100-36650	Lewis Ecological Surveys	Whole site	No new fauna found						
27-Mar-15	Friday	24100-36650	Lewis Ecological Surveys	Whole site	No new fauna found						
30-Mar-15	Monday	24100-37900	Lewis Ecological Surveys	Whole site	Common Brushtail Possum (adult)	Ch. 26650 north bond lane - concrete barriers in place	483180	6543923	Dry Ridgetop Forest	During construction	During Construction
31-Mar-15	Tuesday	24100-37900	Lewis Ecological Surveys	Whole site	Pacific Black Duck	Ch. 30650 south bond lane with concrete barriers	483162	6548614	Riparian Forest	Post 30 days from mainline clearing	Post Clearing
31-Mar-15	Tuesday	24100-37900	Lewis Ecological Surveys	Whole site	Blackish Blind Snake (adult)	Ch. 36875 north bound	483097	6554698	Riparian Forest	Prior to clearing	Prior to Clearing
01-Apr-15	Wednesday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						
02-Apr-15	Thursday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						

03-Apr-15	Friday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						
06-Apr-15	Monday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						
07-Apr-15	Tuesday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found	Likely to have been frogs but couldn't stop due to K2K safety policy					
08-Apr-15	Wednesday	24100-37900	Lewis Ecological Surveys	Whole site	Eastern Long-necked Turtle (adult)	Ch. 32350 in south bound lane	483197	6550181	Moist Slopes Forest	During mainline clearing	During Clearing
08-Apr-15	Wednesday	24100-37900	Lewis Ecological Surveys	Whole site	Eastern Grey Kangaroo (adult)	Ch. 28050 in edge of south bound lane	483190	6546171	Moist Floodplain Forest	Post 30 days from mainline clearing	Post Clearing
09-Apr-15	Thursday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						
10-Apr-15	Friday	24100-37900	Lewis Ecological Surveys	Whole site	Tawny Frog Mouth (adult)	Ch. 28000 edge of south bound at Heavy Vehicle Checking Bay	483196	6545720	Moist Floodplain Forest	During mainline clearing	During Clearing
13-Apr-15	Monday	24100-37900	Lewis Ecological Surveys	Whole site	Red Fox (1 adult)	Ch. 27300 on corner of Upper Smiths Creek Road	483185	6545286	Moist Slopes Forest	Post 30 days from mainline clearing	Post Clearing
13-Apr-15	Monday	24100-37900	Lewis Ecological Surveys	Whole site	Red Fox (1 adult)	Ch. 24100 at Barrys Creek in southbound emergency breakdown lane with concrete barriers	482602	6542038	Moist Gully Forest	Post 30 days from minor clearing to the mainline	Post Clearing

14-Apr-15	Tuesday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						
15-Apr-15	Wednesday	24100-37900	Lewis Ecological Surveys	Whole site	Tawny Frog Mouth (adult)	Ch. 28100 edge of south bound between Smiths Creek and Heavy Vehicle Checking Bay	483191	6545821	Moist Floodplain Forest	Post 30 days from mainline clearing	Post Clearing
15-Apr-15	Wednesday	24100-37900	Lewis Ecological Surveys	Whole site	Sugar Glider (adult)	Ch. 30750 southbound against concrete barriers	483165	6548816	Moist Slopes Forest	Post 30 days from mainline clearing	Post Clearing
16-Apr-15	Thursday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						
17-Apr-15	Friday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						
20-Apr-15	Monday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						
21-Apr-15	Tuesday	24100-37900	Lewis Ecological Surveys	Whole site	Tawny Frogmouth (adult)	Ch. 32000 north bound	483193	6549981	Moist Slopes Forest	During construction	During Construction
22-Apr-15	Wednesday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						
23-Apr-15	Thursday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						
24-Apr-15	Friday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						

27-Apr-15	Monday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						
28-Apr-15	Tuesday	24100-37900	Lewis Ecological Surveys	Whole site	Red-necked Wallaby (adult)	Ch. 29800 in edge of north bound lane	483149	6547730	Moist Slopes Forest	During construction	During Construction
28-Apr-15	Tuesday	24100-37900	Lewis Ecological Surveys	Whole site	European Hare (adult)	Ch. 30200 centre of south bound	483145	6548331	Moist Slopes Forest	During construction	During Construction
28-Apr-15	Tuesday	24100-37900	Lewis Ecological Surveys	Whole site	European Hare (adult)	Ch. 32300 centre of north bound	483197	6550141	Moist Slopes Forest	During construction	During Construction
29-Apr-15	Wednesday	24100-37900	Lewis Ecological Surveys	Whole site	European Hare (1 adult)	Ch. 32200 in middle of south bound lane	483195	6550040	Moist Slopes Forest	During construction	During Construction
30-Apr-15	Thursday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						
01-May-15	Friday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						
04-May-15	Monday	24100-37900	Lewis Ecological Surveys	Whole site	Lewins Honeyeater x 1 adult	Ch. 24400 edge of north bound in still retained strip of vegetation	482774	6542365	Riparian Forest	Post 30 days from mainline clearing	Post Clearing
04-May-15	Monday	24100-37900	Lewis Ecological Surveys	Whole site	Bush Rat (*Rattus fuscipes*) 1 adult	Ch. 30750 edge of north bound emergency breakdown lane	483164	6548775	Moist Slopes Forest	Post 30 days utility clearing	Post Clearing
05-May-15	Tuesday	24100-37900	Lewis Ecological Surveys	Whole site	Eastern Long-necked Turtle	Ch. 28450 in middle south bound	483171	6546860	Moist Floodplain Forest	During clearing for mainline on western side of the highway	During Clearing

05-May-15	Tuesday	24100-37900	Lewis Ecological Surveys	Whole site	Torresian Crow	Ch. 31100 middle south bound turn in lane into Ravenswood Drive	483169	6549035	Moist Slopes Forest	Post 30 days of utility clearing	Post Clearing
06-May-15	Wednesday	24100-37900	Lewis Ecological Surveys	Whole site	Tawny Frogmouth (1 ad female)	Ch. 25700 (Mobbs Drive intersection)	483167	6543727	Moist Slopes Forest	During construction	During Construction
07-May-15	Thursday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						
08-May-15	Friday	24100-37900	Lewis Ecological Surveys	Whole site	Red-necked Wallaby (1 adult)	Ch. 34100 (Bloodwood Rest Area) north bound centre	482842	6552034	Moist Slopes Forest	Post 30 days minor clearing of the mainline	Post Clearing
11-May-15	Monday	24100-37900	Lewis Ecological Surveys	Whole site	Rabbit (1 adult)	Ch. 25800 in north bound merge lane from Mobbs Drive	483168	6543783	Moist Gully Forest	During construction	During Construction
12-May-15	Tuesday	24100-37900	Lewis Ecological Surveys	Whole site	Swamp Wallaby (1 adult)	Ch. 30300 with animal struck centre south bound lane where concrete barriers occur on eastern side	483155	6548028	Moist Slopes Forest	Post 30 days of Pipers Creek mainline clearing of riparian zone	Post Clearing
13-May-15	Wednesday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						
14-May-15	Thursday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						
15-May-15	Friday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						

18-May-15	Monday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found	Possum reported from 200 m south of Gate 17 on the Saturday but nothing found 48 hrs later	482913	6553311	Dry Ridgetop Forest	During clearing north Gate 17 and associated widening for slip lane	During Clearing
19-May-15	Tuesday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						
20-May-15	Wednesday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						
21-May-15	Thursday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found	Suspect frogs like Striped Marsh Frog but cannot safely access the road					
22-May-15	Friday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found	Suspect frogs like Striped Marsh Frog but cannot safely access the road					
25-May-15	Monday	24100-37900	Lewis Ecological Surveys	Whole site	Eastern Grey Kangaroo (sub adult)	ch.37250 or 100 m north of Kemps Road	483202	6555257	Moist Slopes Forest	Prior to clearing	Prior to Clearing
26-May-15	Tuesday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						
27-May-15	Wednesday	24100-37900	Lewis Ecological Surveys	Whole site	Swamp Wallaby (1 adult)	Ch. 25800 south bound and actually hit at dusk evening before	483198	6543778	Moist Gully Forest	During construction	During Construction
28-May-15	Thursday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						

29-May-15	Friday	24100-37900	Lewis Ecological Surveys	Whole site	Microbat (suspect Gould's Wattled Bat *Chalinolobus gouldi*)	Ch. 27000 but couldn't access. Individual was in centre of bitumen	483185	6545107	Dry Ridgetop Forest	During construction	During Construction
29-May-15	Friday	24100-37900	Lewis Ecological Surveys	Whole site	Swamp Wallaby (1 adult)	Ch. 34700 south bound road verge	483013	6552731	Moist Gully Forest	During construction	During Construction
01-Jun-15	Monday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						
02-Jun-15	Tuesday	24100-37900	Lewis Ecological Surveys	Whole site	Red Fox (1 adult)	ch. 25330 centre of south bound at dawn it was hit	483144	6543331	Moist Gully Forest	Post 30 days mainline clearing at Mingaletta west	Post Clearing
03-Jun-15	Wednesday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						
04-Jun-15	Thursday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						
05-Jun-15	Friday	24100-37900	Lewis Ecological Surveys	Whole site	Macropod remains (couldn't access the area)	ch. 30000 against adjacent concrete barriers on eastern side	483142	6547823	Moist Slopes Forest	During construction	During Construction
05-Jun-15	Friday	24100-37900	Lewis Ecological Surveys	Whole site	European Hare (1 adult)	ch. 31800 centre lane	483196	6550092	Moist Slopes Forest	During construction	During Construction
05-Jun-15	Friday	24100-37900	Lewis Ecological Surveys	Whole site	Red-necked Wallaby (1 adult male)	ch. 33400 north bound lane	483010	6551461	Moist Slopes Forest	Post 30 days clearing of mainline Cut 18 Stage 2	Post Clearing

05-Jun-15	Friday	24100-37900	Lewis Ecological Surveys	Whole site	Eastern Blue Tongue (adult)	Ch. 37675 - Stumpy creek south bound abutment area	483282	6555566	Riparian Forest	Post 30 days clearing for mainline piling works	Post Clearing
08-Jun-15	Monday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						
09-Jun-15	Tuesday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						
10-Jun-15	Wednesday	24100-37900	Lewis Ecological Surveys	Whole site	Tawny Frogmouth (1 ad male)	Edge of north bound breakdown lane 80 mts north of Ravenswood Drive south exit	483170	6549187	Dry Ridgetop Forest	Post 30 days from services clearing	Post Clearing
11-Jun-15	Thursday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						
12-Jun-15	Friday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						
15-Jun-15	Monday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						
16-Jun-15	Tuesday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						
17-Jun-15	Wednesday	24100-37900	Lewis Ecological Surveys	Whole site	Rabbit (1 adult)	South bound lane at ch. 32000	483193	6549978	Moist Slopes Forest	During construction	During Construction
18-Jun-15	Thursday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						

19-Jun-15	Friday	24100-37900	Lewis Ecological Surveys	Whole site	No new fauna found						
22-Jun-15	Monday	24100-37900	Lewis Ecological Surveys	Whole Site	No new fauna found						
23-Jun-15	Tuesday	24100-37900	Lewis Ecological Surveys	Whole Site	Swamp Wallaby (1 adult)	Squashed in centre at ch. 36000	482870	6554091	Moist Slopes Forest	During mainline clearing	During Clearing
24-Jun-15	Wednesday	24100-37900	Lewis Ecological Surveys	Whole Site	No new fauna found						
25-Jun-15	Thursday	24100-37900	Lewis Ecological Surveys	Whole Site	No new fauna found						
26-Jun-15	Friday	24100-37900	Lewis Ecological Surveys	Whole Site	No new fauna found	Wet morning making it difficult to detect small fauna					
29-Jun-15	Monday	24100-37900	Lewis Ecological Surveys	Whole site	Eastern Grey Kangaroo (1 Adult male estimated 65 kg)	Ch. 25600 or 80 m south of Mobbs Dr in the right hand turn lane	483171	6543666	Riparian Forest	During clearing for fauna fence	During Clearing
30-Jun-15	Tuesday	24100-37900	Lewis Ecological Surveys	Whole Site	European Hare (1 adult)	Chainage 30300 but along Rodeo Drive	482879	6547812	Moist Slopes Forest	During clearing for road widening works	During Clearing
01-Jul-15	Wednesday	24100-37900	Lewis Ecological Surveys	Whole Site	European Hare (1 adult)	100 m north of Gate 5 North bound edge of fog line	483187	6544354	Moist Floodplain Forest	During clearing works for fauna fence	During Clearing
02-Jul-15	Thursday	24100-37900	Lewis Ecological Surveys	Whole Site	No new fauna found						

03-Jul-15	Friday	24100-37900	Lewis Ecological Surveys	Whole Site	Northern Brown Bandicoot (1 adult)	150 m north of Wharf Road in north bound edge of fog line	483181	6545502	Moist Gully Forest	During construction	During Construction
03-Jul-15	Friday	24100-37900	Lewis Ecological Surveys	Whole Site	Tawny Frogmouth (1 ad male)	20 m south of Railway Dam Road & Old Coast Road	483027	6554482	Dry Ridgetop Forest	During mainline clearing	During Clearing
03-Jul-15	Friday	24100-37900	Lewis Ecological Surveys	Whole Site	Northern Brown Bandicoot (1 adult)	200 m south of Stumpy Creek ch. 37600	483255	6555481	Moist Slopes Forest	Post 30 days after clearing for piling works at Stumpy Creek	Post Clearing
05-Jul-15	Sunday	24100-37900	Lewis Ecological Surveys	Whole Site	No new fauna found						
06-Jul-15	Monday	24100-37900	Lewis Ecological Surveys	Whole Site	No new fauna found						
07-Jul-15	Tuesday	24100-37900	Lewis Ecological Surveys	Whole Site	No new fauna found						
08-Jul-15	Wednesday	24100-37900	Lewis Ecological Surveys	Whole Site	No new fauna found						
09-Jul-15	Thursday	24100-37900	Lewis Ecological Surveys	Whole Site	No new fauna found						
10-Jul-15	Friday	24100-37900	Lewis Ecological Surveys	Whole Site	No new fauna found						

13-Jul-15	Monday	24100-37900	Lewis Ecological Surveys	Whole Site	Red-necked Wallaby (adult)	Opposite Kundabung Rest Area entrance - centre of north bound - concrete barriers located here.	483146	6547998	Moist Slopes Forest	During construction	During Construction
14-Jul-15	Tuesday	24100-37900	Lewis Ecological Surveys	Whole Site	No new fauna found						
15-Jul-15	Wednesday	24100-37900	Lewis Ecological Surveys	Whole Site	No new fauna found						
16-Jul-15	Thursday	24100-37900	Lewis Ecological Surveys	Whole Site	No new fauna found						
17-Jul-15	Friday	24100-37900	Lewis Ecological Surveys	Whole Site	Southern Boobook	Bloodwood Rest Area in north bound emergency break down lane	482830	6552179	Dry Ridgetop Forest	Post 30 days after second stage clearing of Cut 18	Post Clearing
20-Jul-15	Monday	24100-37900	Lewis Ecological Surveys	Whole Site	No new fauna found	Final survey					

Annex 7: Giant Barred Frog baseline monitoring report

niche
Environment and Heritage

Giant Barred Frog monitoring

Baseline Surveys – Oxley Highway to Kempsey, Pacific Highway Upgrade

Prepared for RMS

August 2015

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Cover photograph: Giant Barred Frog from Cooperabung Creek reference site

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1. Introduction

1.1 Background

As part of Oxley Highway to Kempsey (OH2K) Pacific Highway Upgrade, the Roads and Maritime Services (RMS) have implemented an Ecological Monitoring Program (EMP) (SMEC-Hyder 2015) in accordance with the Minister for Planning's Condition of Approval No. 10, which states that:

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 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, 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 use patterns directly attributable to the construction or operation of the project; and

(f) provision of annual reporting of monitoring results to the Director General and the OEH and DPI, 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).

1.2 Purpose of this report

The aim of this report is to fulfil the annual reporting requirements for the Giant Barred Frog (*Mixophyes iteratus*) as per the 2015 final approved EMP and to satisfy the requirements of MCoA 3.1 and SoC F22, for the baseline (year 0) monitoring survey for the Giant Barred Frog.

1.3 Monitoring framework

The finalised Ecological Monitoring Program (EMP) required three baseline surveys for the Giant Barred Frog to be undertaken in spring, summer and autumn prior to the commencement of construction. The surveys are to cover four impact sites and two control sites.

Monitoring of all sites will continue tri-annually in years 1, 2 and 3 once substantial construction has commenced. Following the completion of the project, monitoring will continue for a further five years, or until the mitigation measures can be demonstrated to be effective. The location of field sites and the techniques employed are summarised in section 2.

The following six performance measures are identified:

- 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.
- Continued presence of Giant Barred Frogs during each survey event in Year 1 – 8 at sites where it was identified during baseline surveys.
- 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).
- 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.

The aim of this report is to summarise the findings of the baseline Giant Barred Frog monitoring survey, including the number of individuals recorded at each site, presence of Chytrid and the prevailing weather conditions.

2. Survey Methods

2.1 Monitoring sites

Monitoring was undertaken in four separate 'treatment' habitats, where the Pacific Highway crosses creek lines known to contain the Giant Barred Frog. These include Cooperabung Creek, Smiths Creek, Pipers Creek and Maria River. Two analogue "control" stream sites, termed reference sites for this study, were also surveyed, being upstream sections of Cooperabung Creek and Pipers Creek.

Each of the six monitoring sites comprise a one kilometre transect surveyed once in each of spring 2013, summer 2014 and autumn 2014 for the baseline survey. The treatment transects extend 450 metres upstream and 550 metres downstream from the Project footprint and are divided into 10 x 100 metre zones. The locations of all monitoring sites are shown on Figure 1, with detailed locations for each transect provided in Annex 1.

2.2 Survey method

The methods used to survey the six transects follow those described in the approved Giant Barred Frog Management Strategy (Lewis 2013). Each one kilometre transect was searched for a minimum of 120 person minutes, but the time required to effectively survey a site depended on access and structure of the vegetation and so total person minutes spent on surveys varied between stream transects. The time of arrival at the start of the survey transect was noted and the survey initiated by listening for vocalisations for 10 minutes. This was followed by calls played intermittently for 15 minutes and then listening for a further 10 minutes. Two or more surveyors then walked slowly down the sides of the stream using headlamps or spotlights to search for Giant Barred Frogs, using reflective eye shine to locate animals in the water or on the banks within 20 metres of the water. Additional call playback followed by periods of listening was undertaken at a minimum of every 50 metres along the transect. Time of finishing was recorded at the end of each transect.

When an animal was located, its position on the transect was recorded and the animal was captured, if possible. Once captured, the frog was checked to see if it had been previously marked with a PIT tag and, if so, the number was recorded. If not, the animal was injected with a PIT tag for permanent identification. At the same time, the animal's sex, weight (in grams), snout vent length (in millimetres), age status (metamorph/juvenile/adult), breeding condition (being the condition of the nuptial pads in males or if females were gravid) were all recorded and each individual was swabbed for the presence of Chytrid fungus.

Tadpole trapping was also undertaken as per the EMP. This consisted of two types of sampling. Dip-netting was undertaken through a series of 10 sweeps with a 20cm diameter dip net completed every 50 metres of stream length. Tadpole trapping was undertaken by placing two standard baitfish traps (~300 millimetres by 200 millimetres) in pools in each of the ten 100m zones (i.e. a total of 20 bait) and all left for a minimum of three hours before being inspected. Numbers and types of tadpoles captured by either method were recorded and then all tadpoles released.

Weather conditions noted through the survey included temperature and humidity (either by windwatch or hygromometer), % cloud cover, broad wind level (scale of 0-3) and moon status. Last 24 hour rainfall was taken from the Bureau of Meteorology station at Telegraph Point (station number 060031). This data was collected to indicate the suitability of the weather conditions at the time of the baseline surveys.

Data for the spring and summer monitoring surveys were provided by Lewis Ecological. The autumn monitoring survey was conducted by Niche Environment and Heritage.

2.3 Water quality

Water quality measurements were conducted by the RMS. Data has yet to be provided.

2.4 Analysis

As per the requirements of the EMP, population estimates of the number of individuals present at each site were undertaken from the available mark-recapture data. As with the Baseline reporting provided by Lewis Ecological after the spring and summer monitoring periods, the Chapman correction of the Lincoln-Petersen Model (hereafter called Chapman) was used order to provide a less variable basic estimate of the population size.

The equation for the Chapman Correction used was:

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

Where:

N = Population Size Estimate

M = The total number of animals captured and marked on the first visit.

C = The total number of animals located on the second visit

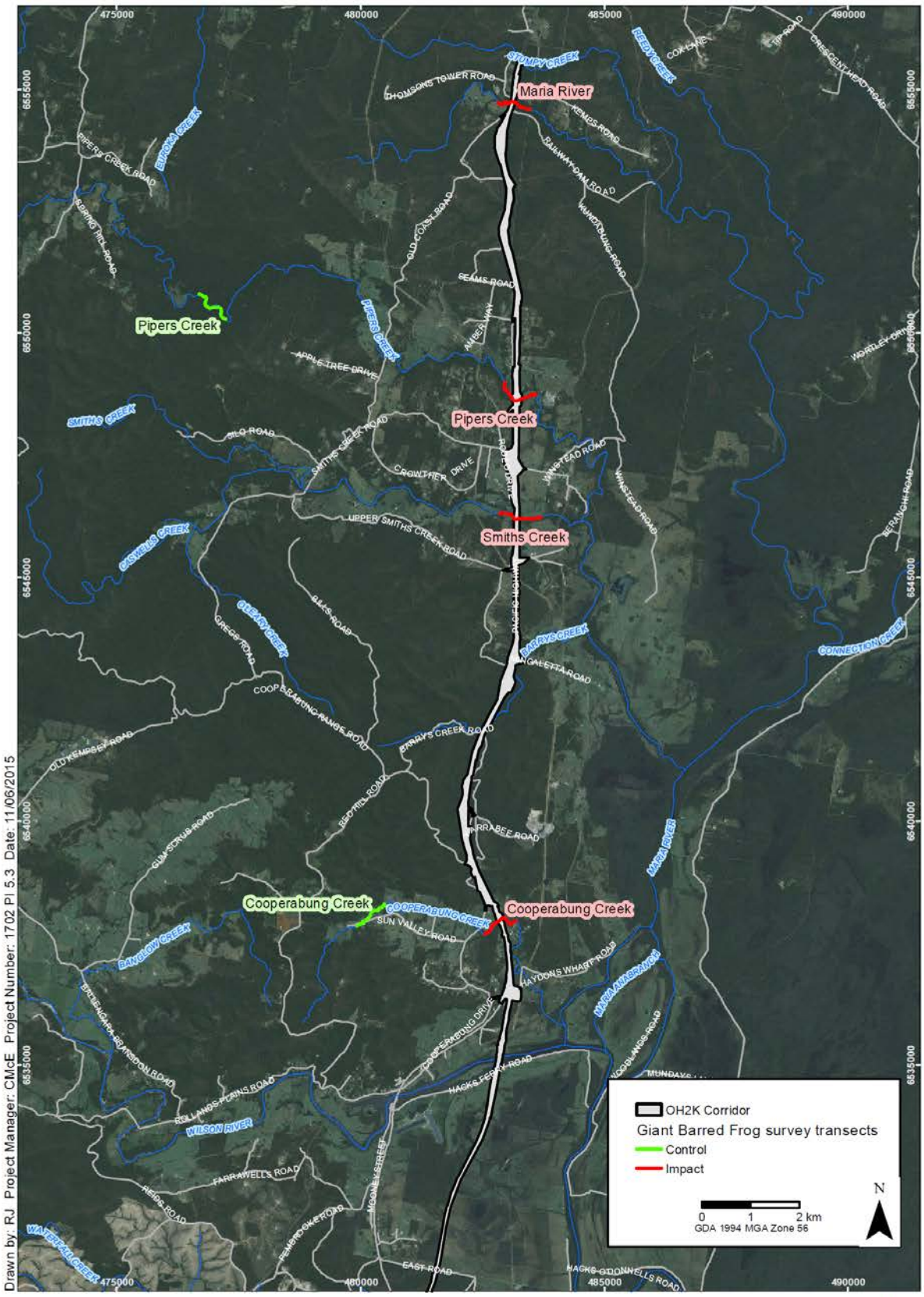
R = The number of animals on the first visit recaptured on the second visit.

A basic estimate of the variance of the population size was also provided using the following formula:

$$\text{Variance } (N) = \frac{(M+1)(C+1)(M-R)(C-R)}{(R+1)(R+1)(R+2)}$$

The Minimum Known to be Alive (MKTBA) was also calculated (see Sutherland 2006) to provide a simple comparative measure of population size. This index is based on the number of new individuals encountered over multiple visits, where any new animals are summed, providing an aggregate total. Limitations of this method are that it does not account for any migration out of the population or any death, so may over-estimate the total population size if counts are completed over a long period of time. However, the same assumptions apply equally for the Chapman method.

Figure 1. Giant Barred Frog survey locations



Site Map

Oxley Highway to Kempsey Giant Barred Frog Survey (PI 5.3)

FIGURE 1

Path: T:\spatial\projects\a1700\a1702_OH2K_Ecology\Maps\PI_5_Ecology_OH2K\PI_53_GiantBarredFrogMonitoring\20150604\1702_OH2K_PI53_GBF.mxd

3. Results

3.1 Streamside search results, including estimated number known to be alive at each site.

Giant Barred Frogs were recorded at all six sites, although two sites did not have active frogs in the autumn 2014 surveys (Table 1). The information clearly demonstrates that the summer surveys provided much greater numbers of frog captures than in spring or autumn. The highest counts obtained in any one survey were at the Cooperabung Creek Reference site, although numbers were still very low even at that site in the autumn survey.

Table 1: Number of Giant Barred Frogs recorded at each site during baseline surveys.

	Cooperabung Creek Impact	Smiths Creek Impact	Pipers Creek Impact	Maria River Impact	Cooperabung Creek Reference	Pipers Creek Reference
Spring	3	10	8	10	20	10
Summer	9	16	9	9	21	13
Autumn	5	2	1	0	6	0
Mean number of frogs per visit	5.67	9.33	6.00	6.33	15.67	7.67
Standard Error (SE)	1.76	4.06	2.52	3.18	4.84	3.93
MKTBA	15	26	14	15	45	23

The population estimates for the Summer (from report by Lewis Ecological) and Autumn periods using the Chapman Estimator for data collected from each of the six sites sampled during the baseline survey period is in provided in Table 2. The Chapman correction reduces variance and so uncertainty for small counts, but the numbers were likely still highly uncertain, especially for the Reference sites given the failure to obtain a significant number of recaptures when larger numbers of frogs were captured.

Table 2: Population estimates based on the Chapman Estimate. (Variance is in brackets)

	Cooperabung Creek Impact	Smiths Creek Impact	Pipers Creek Impact	Maria River Impact	Cooperabung Creek Reference	Pipers Creek Reference
Spring vs Summer 2014	N/A	54 (21)	15.2 (2.94)	NA	118 (51.36)	NA
Summer vs Autumn 2014	15 (20)	44 (630)	9 (0)	9 (0)	89 (3060)	13 (0)
All visits	21 (44)	74 (1800)	17 (0)	19 (0)	189 (14060)	23 (0)

* The all visits data was analysed by comparing the autumn data against the combined spring and summer captures.

The MKTBA estimate was highest at the reference sites (n=23-45) and the Smiths Creek impact site (n=26). The estimates obtained from the remaining impact sites were similar (n=14-15). The raw data for the field surveys are presented in Appendix 1.

3.2 Tadpole trapping

No tadpoles were caught using either sweep netting or tadpole traps during any of the survey periods. Tadpoles were infrequently observed at some sampling sites, although the species could usually not be

confirmed, although 'Barred Frog' tadpoles were detected in the summer monitoring program. The species of tadpoles observed were not confirmed.

3.3 Weather conditions

The weather conditions encountered during the field surveys are summarised in Table 3 below. The surveys in spring and autumn were carried out in relatively cool conditions, however frogs were still recorded.

Table 3: Prevailing weather conditions recorded during the field surveys at the field site

Date	Minimum temperature (C)	Maximum temperature (C)	Water temperature (C)	Humidity (%)	Rainfall (last 24 hours)	Wind Speed
18/9/13	9.7	16	18.5	74	10	0
19/9/13	9	15.7	16.3	83	0.6	0
21/9/13	9.5	14.7	15.3	77	0.0	0
22/9/13	10.6	14.2	14.9	82.5	0.0	0
18/10/13	11	16.6	15	89.5	0.0	0
19/10/13	14.8	18.3	15.5	91	3.0	0
26/1/14	18.6	21.3	19.25	77	0.2	0
27/1/14	19	24.7	20	81.5	0.2	0
28/1/14	23	25	19	80	2.2	0
30/1/14	16.8	18.4	21	87	0.0	0
31/1/14	15.9	23.3	18	79.5	0.2	0
29/4/14	17.8	25.5	N/A	90	2.8	0
30/4/14	18.3	20.3	N/A	88	0.4	1
27/5/14	18.5	26.8	N/A	77	0.0	0
28/5/14	N/A	17.5	N/A	73	0.0	0

3.4 Chytrid Fungus

Sampling during the monitoring surveys failed to detect infections at most sites, however low rates of infection (< 10%) were found for two impact sites during the summer surveys. Chytrid fungus sampling was not carried out in spring and the fungus was not detected infecting any of the frogs swabbed during the autumn monitoring surveys.

3.5 Habitat survey information

Habitat information collected for each site is presented in Appendix 2.

3.6 Water quality

Water quality data is yet to be provided.

3.7 Other observations

Exotic predators or competitors have not been noted during any of the monitoring survey periods. Exotic fish have been notable by their absence. There has been no indication of disturbance of habitat by pigs nor significant evidence of fox or cat activity that may impact on this species.

4. Discussion

Giant Barred Frogs were recorded at all six sites. However the counts varied greatly across the three monitoring periods and the species was not observed at two sites in the autumn 2014 surveys. These data provide the baseline data for the Project and future monitoring of the Giant Barred Frog.

4.1 Population estimates

The use of the Chapman correction provided population estimates with significant variance. This was due to the very small number of recaptures. The MKTBA (Sutherland 2006) provided a simpler data set to work with in regards to population estimates along each transect and can be included in future monitoring reports for comparisons.

Future monitoring should be undertaken late in spring, mid summer and early in autumn (November January and March) to minimise time between samples. This will also enable surveys to, as far as is possible, be carried out with warm evening temperatures to maximise the potential to detect frogs. Research has indicated that the Giant Barred Frog calls little in spring time (Lemckert and Mahony 2008) and with frogs being much less likely to be detected until summer (Lemckert and Morse (1999). This is almost certainly related to air temperatures not being often suitable for Giant Burrowing Frog activity until late in spring or early summer. Koch and Hero (2007) note that air temperatures above 20^{o}C are optimal for this species to undertake surface activity and so be detectable. This temperature threshold was not met in the spring 2013 or autumn 2014 surveys and, although it is recognised that the species is likely to have lower threshold temperatures in the Project area, it is still clear the number of frogs encountered was significantly greater in the comparatively warmer summer sampling period.

4.2 Chytrid sampling

The sampling carried out for Chytrid fungus have indicated that this pathogen is present in the study area, but that its prevalence varies between sites and times of sampling. The presence of Chytrid is expected as it has previously been demonstrated to be widespread along drainages of the east coast of Australia (Kriger and Hero 2007). The data collected provides the baseline in regards to its current prevalence in the impact and control sites.

4.3 Tadpole monitoring

Tadpoles were not collected by either dip-netting or bait trapping. There is no clear guidance in the EMP document (SMEC-Hyder 2013) as to the reason to collect tadpoles nor a performance measure placed against the result and so the lack of success in capturing tadpoles does not impact on the project. Reproduction can and has been concluded to have been successful due to the presence of juvenile and sub-adult frogs at all sites.

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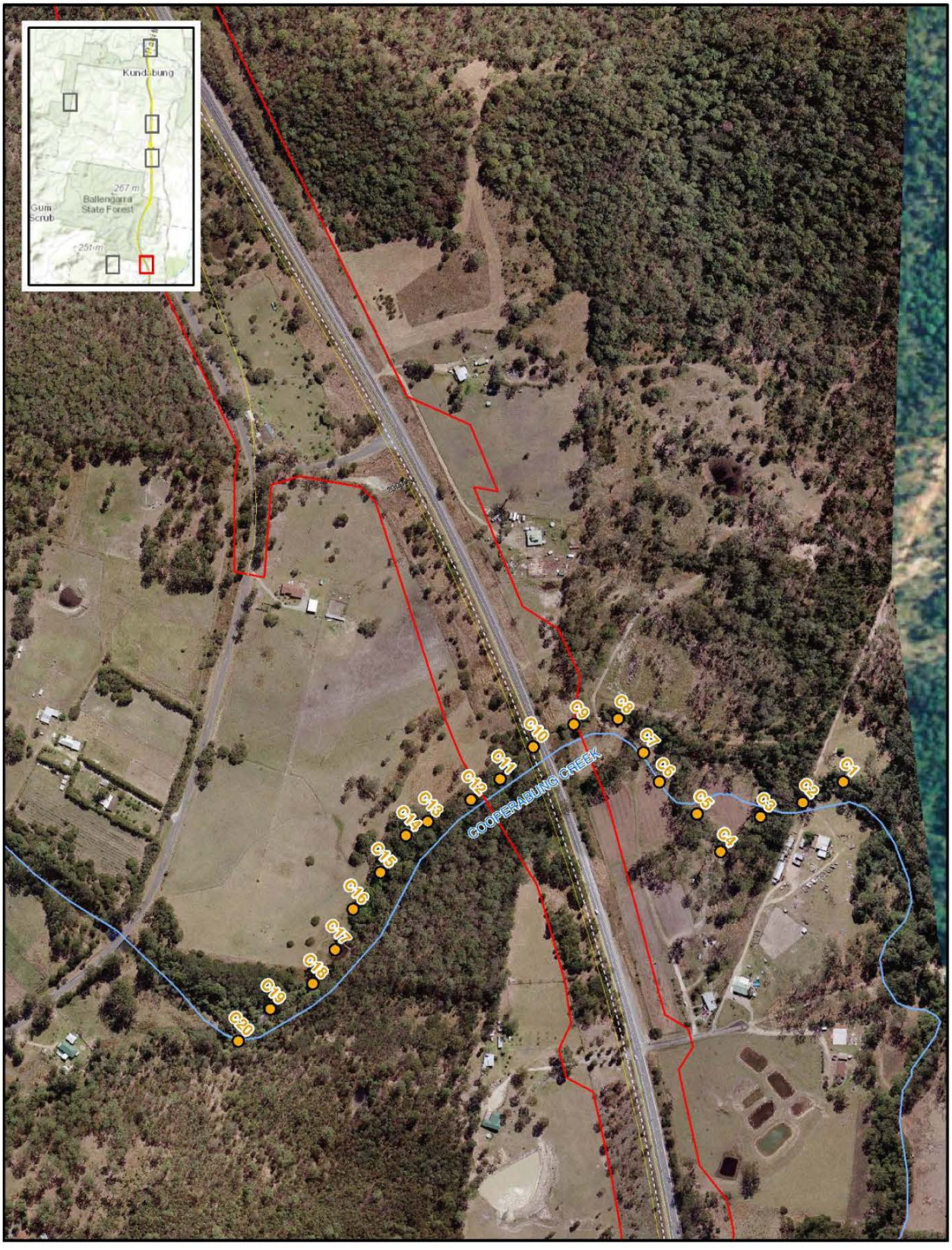
Annex 1 – Detailed transect locations



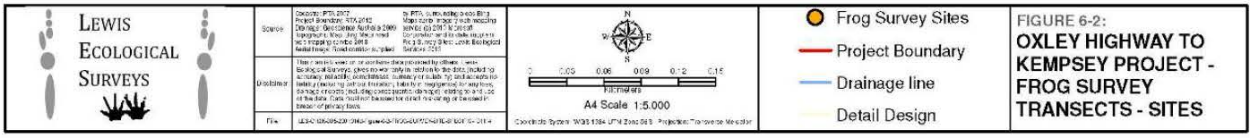


Figure 8 Cooperabung Creek Frog Survey Sites

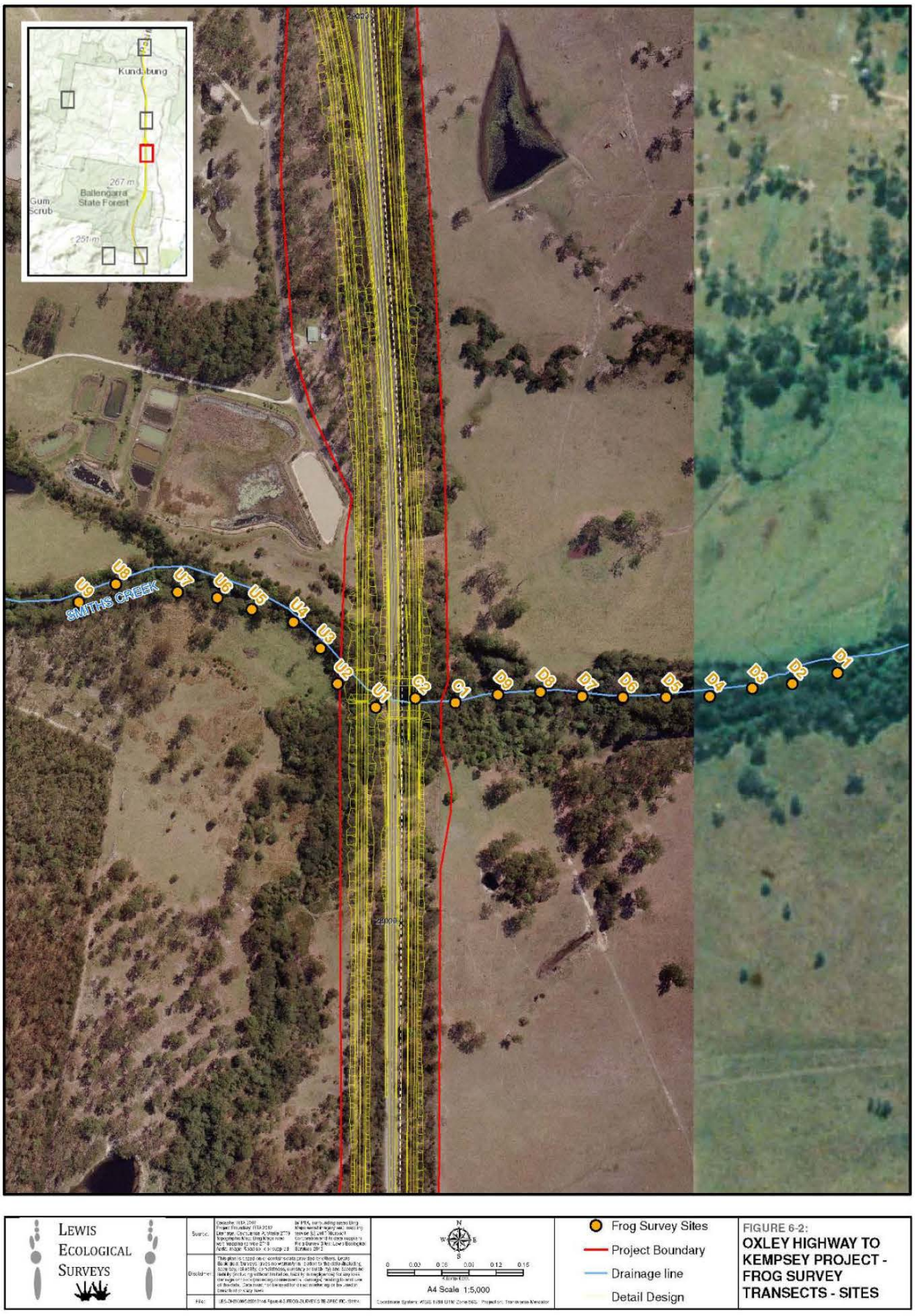


Figure 9 Smiths Creek Frog Survey Sites

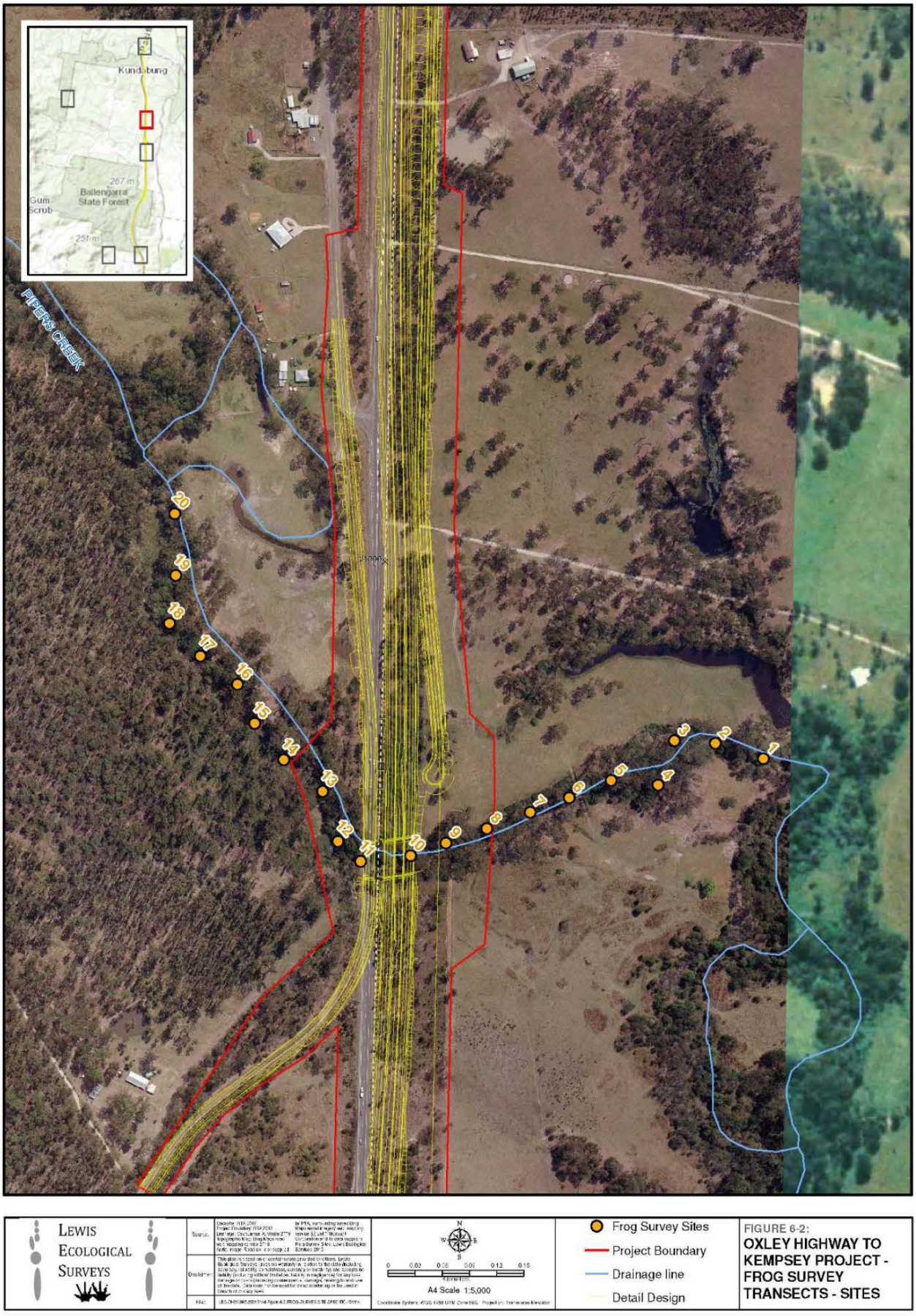


Figure 10 Pipers Creek Frog Survey Sites

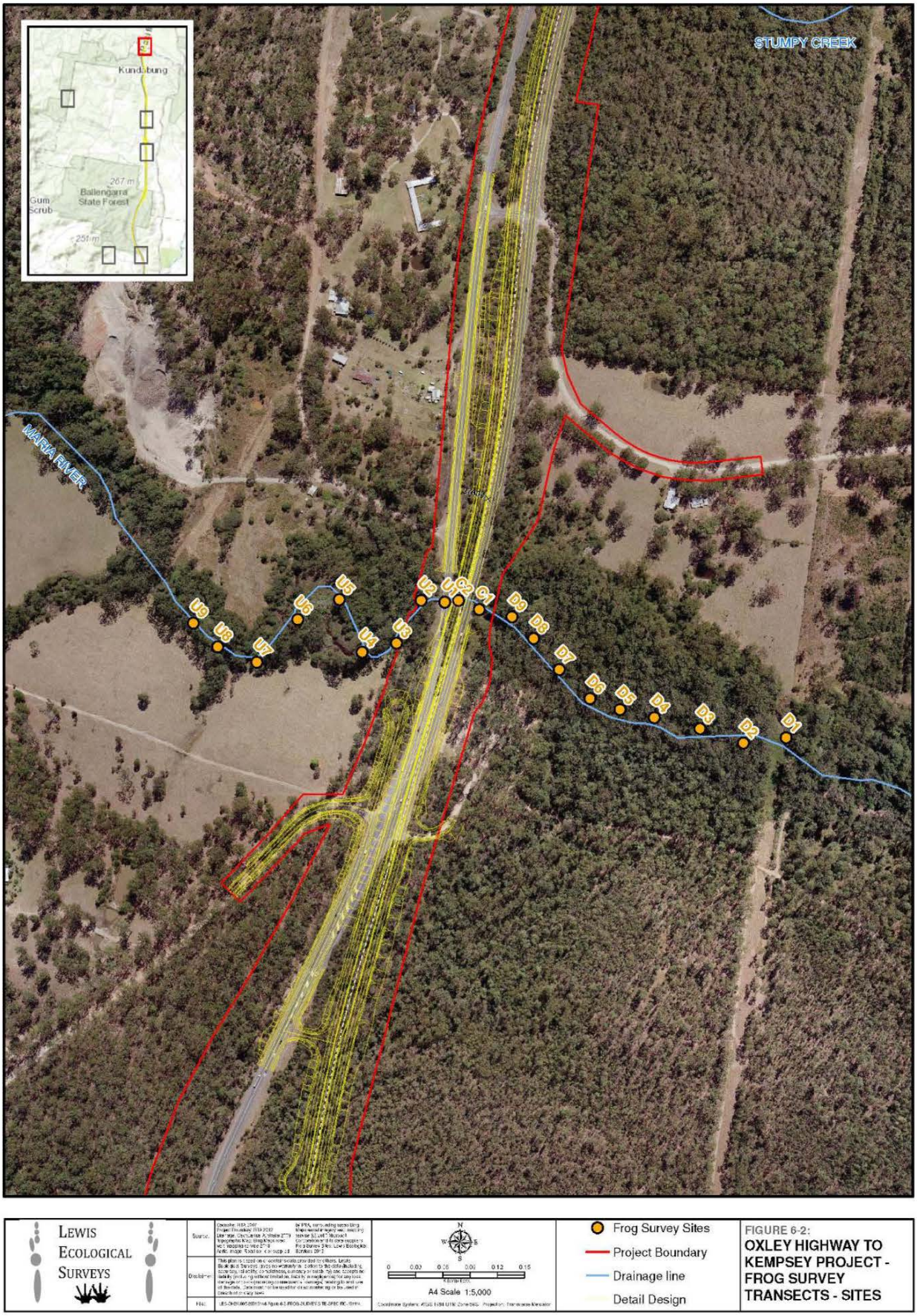


Figure 11 Maria River Frog Survey Sites

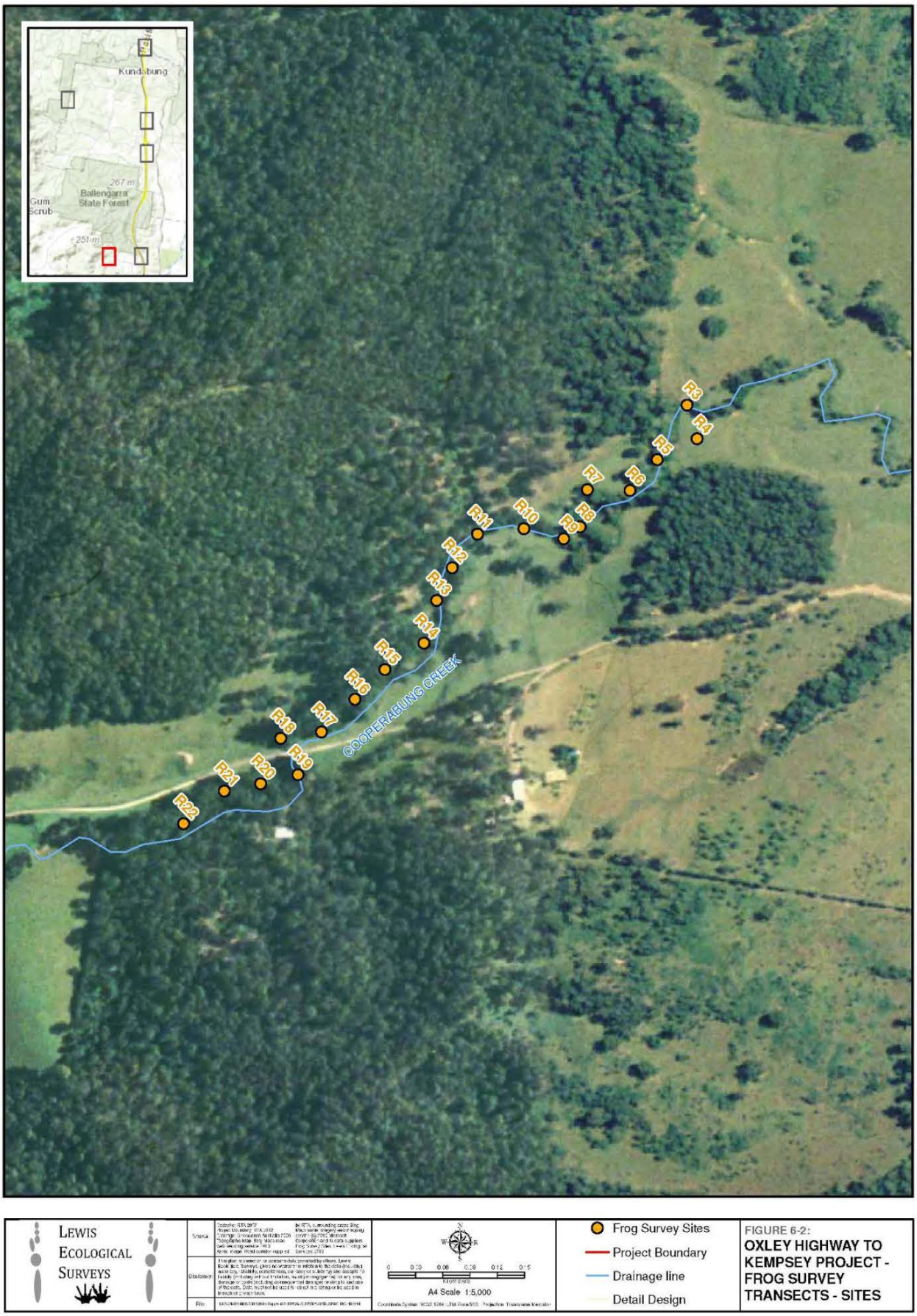


Figure 12 Cooperabung Creek (reference) survey sites

Figure 13 Pipers Creek (reference) survey sites

Annex 2 – Baseline data summary for each monitoring site

Cooperabung Creek Impact

Date and Time of Transect Surveys: Spring - 22nd September 2013 between 1900-2235 hours. Summer – 26th January 2014 between 2125-0220 hours. Autumn – 29th April 2014 between 1930-2150 hours.

Abiotic Conditions: A summary of the prevailing abiotic variables is shown in Table 3.

Table 4. Summary of captures at the Cooperabung Creek impact site

	Spring 2013	Summer 2014	Autumn 2014
Number of frogs recorded	3	9	5
Number of adult males	0	5	1
Number of adult females	1	1	2
Number of subadults	2	1	2
Number of juveniles	0	2	0
Number of recaptures	-	0	2
Number of frogs with Chytrid/ swabbed	NS	0/6	0/5
Number of tadpoles caught in bait traps/nets	0/0	0/0	0/0

Number of Giant Barred Frogs Recorded: Spring - Although no male frogs were recorded/captured they have been previously recorded a further 300 m downstream of the monitoring transect. At the time of the survey male frogs are likely to have been dormant beneath leaf litter and overhanging vegetation on the primary creek bank. **Summer** – Nine Giant Barred Frogs were recorded/captured during the survey. They comprised two juveniles, one sub adult, one female and five males. At the time of the survey, male frogs displayed a range of nuptial pad colours with one frog each exhibiting 'no colour', light nuptials, medium nuptials and three frogs exhibited dark nuptials indicating most males were in a reproductive state to commence breeding. **Autumn** – Five Giant Barred Frogs were recorded/captured during the autumn survey including one male, two females and two subadults. There were two recaptures recorded in this survey, both of which were female. They were distributed across the western half of the study transect. No frogs were located on the eastern side on any occasion.

Evidence of Breeding Recorded: Via the presence of two sub adult frogs in spring, two juveniles and a subadult frog in summer survey and two subadults in autumn.

Zones Inhabited By Giant Barred Frogs: Restricted to zones C10, C11-C13, C15 and C18 which lie within and immediately upstream of the existing carriageway. Both zones C10 and C11 are considered to form part of the construction footprint (see Figure 8). No frogs were recorded on the downstream side of the existing carriageway.

Summer Sampling of Chytrid: Six frogs were swabbed and all tested negative for Chytrid.

Autumn Sampling Chytrid: All five frogs swabbed tested negative for Chytrid..

Giant Barred Frog Tadpoles: No tadpoles were captured. Mixophyes tadpoles were observed in zones C11-C15 (see Figure 8), but the species of Mixophyes could not be determined.

Habitat: Microhabitat within these zones included flood debris as overhang shelter, grass and leaf litter. Frogs were located on litter. Females were occasionally located foraging within Lomandra.

Water Levels: Mean depth 700mm west, 50mm east.

Smiths Creek impact

Date and Time of Transect Surveys: Spring - 22nd September 2013 between 1900-2235 hours. Summer – 26th January 2014 between 2125-0220 hours. Autumn – 29th April 2014 between 2235 and 0010 hours.

Abiotic Conditions: A summary of the prevailing abiotic variables is shown in Table 3.

Table 4. Summary of findings from baseline surveys at the Smiths Creek impact site

	Spring 2013	Summer 2014	Autumn 2014
Number of frogs recorded	10	16	2
Number of adult males	1	4	1
Number of adult females	2	1	0
Number of subadults	7	9	1
Number of juveniles	0	2	0
Number of recaptures	-	2	0
Number of frogs with Chytrid/ swabbed	NS	2/12	0/2
Number of tadpoles caught in bait traps/nets	0/0	0/0	0/0

Number of Giant Barred Frogs Recorded: Spring – Ten Giant Barred Frogs were recorded/captured, consisting mostly of subadults. Seven subadults were recorded along with one male and two females. **Summer** – Sixteen Giant Barred Frogs were recorded/captured during the survey. They comprised two juveniles, nine subadults, one female and four males. At the time of the survey, male frogs displayed a range of nuptial pad colours with one frog each exhibiting 'no colour', light nuptials, medium nuptials and three frogs exhibited dark nuptials. **Autumn** – Two Giant Barred Frogs were recorded/captured during the survey, including one adult and one subadult. There was no colour on the nuptial pads of the male.

Evidence of Breeding Recorded: Seven subadult frogs were recorded in spring, nine subadults and two juvenile frogs in summer and one subadult in autumn.

Zones Inhabited By Giant Barred Frogs: Distributed across the transect.

Summer Sampling of Chytrid: Two out of 12 frogs sampled tested with a positive result for Chytrid.

Autumn Sampling Chytrid: Both frogs tested negative for Chytrid.

Giant Barred Frog Tadpoles: No tadpoles were recorded, but some possible Mixophyes tadpoles were observed in summer scattered across the transect.

Habitat: Microhabitat within these zones included flood debris as overhang shelter, grass and leaf litter.

Water Levels: Mean 800mm.

Pipers Creek impact

Date and Time of Transect Surveys: Spring - 22nd September 2013 between 1900-2235 hours. Summer – 26th January 2014 between 2125-0220 hours. Autumn – 30th April 2014 between 19:30 and 21:50 hours.

Abiotic Conditions: A summary of the prevailing abiotic variables is shown in Table 3.

Table 5. Summary of findings from baseline field surveys at the Pipers Creek impacts site

	Spring 2013	Summer 2014	Autumn 2014
Number of frogs recorded	8	9	1
Number of adult males	3	2	0
Number of adult females	2	5	0
Number of subadults	3	2	0
Number of juveniles	0	0	1
Number of recaptures	-	4	0
Number of frogs with Chytrid/ swabbed	NS	0/8	0/1
Number of tadpoles caught in bait traps/nets	0/0	0/0	0/0

Number of Giant Barred Frogs Recorded: Spring – A total of eight Giant Barred Frogs were recorded/captured, including three adult males, two females and three subadults. **Summer** – Nine Giant Barred Frogs were recorded/captured during the survey. They comprised two subadults, two males and five females. Male frogs displayed a range of nuptial pad colours with one frog each exhibiting 'no colour', light nuptials, medium nuptials and three frogs exhibited dark nuptials indicating most males were in a reproductive state to commence breeding. **Autumn** – One juvenile Giant Barred Frog was recorded.

Evidence of Breeding Recorded: Three sub adult frogs were recorded in spring and two in summer, and one juvenile in the autumn survey.

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

Summer Sampling of Chytrid: Eight frogs were swabbed and tested negative for Chytrid.

Autumn Sampling Chytrid: One frog tested negative for Chytrid.

Giant Barred Frog Tadpoles: No tadpoles were recorded or observed.

Habitat: Microhabitat use included above and partially buried within leaf litter, and on bare ground.

Water Levels: 290mm in the deepest pool.

Maria River impact

Date and Time of Transect Surveys: Spring - 22nd September 2013 between 1900-2235 hours. Summer – 26th January 2014 between 2125-0220 hours. Autumn – 28th May 2014 between 17:10 and 19:40 hours.

Abiotic Conditions: A summary of the prevailing abiotic variables is shown in Table 3.

Table 6. Summary of findings from baseline field surveys at the Maria River impact site

	Spring 2013	Summer 2014	Autumn 2014
Number of frogs recorded	10	9	0
Number of adult males	0	3	0
Number of adult females	6	1	0
Number of subadults	4	1	0
Number of juveniles	0	4	0
Number of recaptures	-	0	0
Number of frogs with Chytrid/ swabbed	NS	0/6	0
Number of tadpoles caught in bait traps/nets	0/0	0/0	0/0

Number of Giant Barred Frogs Recorded: Spring – A total of ten Giant Barred Frogs were recorded/captured during the Spring survey, including six female and four subadults. No males were recorded. **Summer** – Nine Giant Barred Frogs were recorded, comprising three males, one female, one subadult and four juveniles. One adult male and two juveniles were unable to be captured. **Autumn** – No Giant Barred Frogs were recorded.

Evidence of Breeding Recorded: Yes via the presence of four sub adult frogs in spring and one subadult and four juvenile frogs during the summer survey.

Zones Inhabited By Giant Barred Frogs: Giant Barred Frogs were distributed across the study transect.

Summer Sampling of Chytrid: Six frogs were swabbed and tested negative for Chytrid.

Autumn Sampling Chytrid: No Giant Barred Frogs were recorded.

Giant Barred Frog Tadpoles: No tadpoles were recorded.

Habitat: Microhabitat within these zones included flood debris as overhang shelter, grass and leaf litter.

Water Levels: Mean 210 mm.

Cooperabung Creek reference

Date and Time of Transect Surveys: Spring - 22nd September 2013 between 1900-2235 hours. Summer – 26th January 2014 between 2125-0220 hours. Autumn – 27th May 2014 between 19:00 and 21:00 hours.

Abiotic Conditions: A summary of the prevailing abiotic variables is shown in Table 3.

Table 7. Summary of findings from baseline field surveys at the Cooperabung Creek reference site

	Spring 2013	Summer 2014	Autumn 2014
Number of frogs recorded	17	21	6
Number of adult males	4	4	1
Number of adult females	7	4	1
Number of subadults	6	9	4
Number of juveniles	0	4	0
Number of recaptures	-	2	0
Number of frogs with Chytrid/ swabbed	NS	1/10	0/6
Number of tadpoles caught in bait traps/nets	0/0	0/0	0/0

Number of Giant Barred Frogs Recorded: Spring – Seventeen Giant Barred Frogs were recorded/captured, including four adult males, seven females and six subadults. No juveniles were present. **Summer -** Twenty-one Giant Barred Frogs were recorded/captured, consisting of four adult males, four females, nine subadults and four juveniles. Two frogs were recaptures. Male frogs displayed a range of nuptial pad colours. **Autumn** – Six Giant Barred Frogs frogs were recorded/captured consisting of one male, one female and four subadults.

Evidence of Breeding Recorded: Six subadult frogs in spring, nine subadults and four juvenile frogs in summer, and four subadults in autumn.

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

Summer Sampling of Chytrid: One of ten frogs tested was recorded as positive for Chytrid.

Autumn Sampling Chytrid: All six Giant Barred Frogs swabbed tested negative for Chytrid.

Giant Barred Frog Tadpoles: No tadpoles were recorded. Myobatrachid tadpoles were present in most pools in spring, but the species could not be determined.

Habitat: Microhabitat found being used included above and partially buried within leaf litter (some of which included Lomandra shelters), pasture grass, within the undercut of the bank, and on dirt and rock.

Water Levels: 190 – 270 mm.

Pipers Creek reference

Date and Time of Transect Surveys: Spring - 22nd September 2013 between 1900-2235 hours. Summer – 26th January 2014 between 2125-0220 hours. Autumn – 28th May 2014 between 22:00 and 23:55 hours.

Abiotic Conditions: A summary of the prevailing abiotic variables is shown in Table 3.

Table 8. Summary of finding from the baseline field surveys at the Pipers Creek reference site

	Spring 2013	Summer 2014	Autumn 2014
Number of frogs recorded	10	13	0
Number of adult males	4	8	0
Number of adult females	5	5	0
Number of subadults	1	0	0
Number of juveniles	0	0	0
Number of recaptures	-	0	0
Number of frogs with chytrid/ swabbed	NS	0/9	0
Number of tadpoles caught in bait traps/nets	0	0	0

Number of Giant Barred Frogs Recorded: Spring – A total of ten Giant Barred Frogs were recorded in Spring 2013, comprising four adult males, five females and one subadult. **Summer** – Thirteen Giant Barred Frogs were recorded/captured during the survey, including eight adult males and five females. **Autumn** – No Giant Barred Frogs were recorded.

Evidence of Breeding Recorded: One subadult was recorded in Spring 2013.

Zones Inhabited By Giant Barred Frogs: : Located in zones 5,6,7,8, 9,10,13,15, 16 and 19.

Summer Sampling of Chytrid: Nine frogs were swabbed and all tested negative for Chytrid.

Autumn Sampling Chytrid: No Giant Barred Frogs were observed.

Giant Barred Frog Tadpoles: No tadpoles were recorded.

Habitat: Microhabitat microhabitat within these zones included above, partially buried and completely buried within leaf litter, sheltering under Lomandra, and within holes in the bank.

Water Levels: 150 mm to 575 mm.

Annex 3 – Giant Barred Frog microchip data

Site	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
IMPACT SITES													
Cooperabung Creek													
Spring Sample													
1	Male	Sub Adult	Immature	52.4	17.5	000735C1E9	11	North Bank	1.5	First time capture	Observed	Using flood debris as overhang shelter on dirt	Yellowing throat indicating likely to be a male frog once it matures
2	Male	Sub Adult	Immature	54.1	9.75	000735A97E	2	South Bank	2.1	First time capture	Observed	Above litter	Yellowing throat indicating likely to be a male frog once it matures
3	Female	Adult	Not Gravid	95.6	43	000735B40B	3	South Bank	3.7	First time capture	Observed	Above litter	
Summer Sample													
1	Unknown	Juvenile	Immature	38.2	8.25	000735B812	1	North Bank	3.2	First time capture	Observed	Above litter	Swabbed
2	Male	Adult	No Colour	77.7	58.25	0007352F47	12	South Bank	7.3	First time capture	Observed	Above litter	Swabbed
3	Female	Adult	Not Gravid	91	118	000735830E	18	North Bank	6.8	First time capture	Observed	On Grass	Swabbed
4	Male	Adult	Dark Nuptial	69.7	44	0007352816	18	North Bank	5.5	First time capture	Observed	Above litter	Swabbed
5	Male	Adult	Dark Nuptial	68.1	38.25	0007359A50	18	North Bank	2.3	First time capture	Observed	Using flood debris	Swabbed
6	Unknown	Juvenile	Immature	32.5	5.25	0007359E3E	15	South Bank	1.6	First time capture	Observed	Above litter	Swabbed
7	Male	Adult	Moderate Nuptial	73.7	56	0007358413	15	South Bank	3.5	First time capture	Observed	Above litter	Swabbed
8	Male	Adult	Light Nuptial	64.7	33.75	0007359026	12	South Bank	3.8	First time capture	Observed	Above litter	Swabbed
9	Unknown	Juvenile	Immature	40.2	10	0007357F41	10	North Bank	1	First time capture	Observed	On Grass	Swabbed
Autumn Sample													
1	Female	Adult	Not Gravid	89.4	NA	7352F47	13	South bank 5 m from creek above litter		Recapture	Observed	Above Litter	Swabbed

Site	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
2	Female	Adult	Not Gravid	97.4	NA	735B40B	14	South bank 5m from creek half on surface near Lomandra		Recapture	Observed	In Lomandra	Swabbed
3	Male	Adult	No Colour	59.5	NA	76358B7	11	North bank 4 m from creek on slope. No nuptial colouration evident		First time capture	Observed	Above litter	Swabbed
4	Subadult	Subadult	Immature	49.9	NA	7634CB	12	South bank 4 m from creek on slope above litter.		First time capture	Observed	Above litter	Swabbed
5	Subadult	Subadult	Immature	53.9	NA	7634D85	14	South bank 5m from creek half buried in litter at base of tree		First time capture	Observed	Partially Buried	Swabbed
Smiths Creek													
Spring Sample													
1	Unknown	Sub Adult	Immature	39.6	9.5	000735797B	C1	North Bank	1.5	First time capture	Observed	Above Litter	
2	Unknown	Sub Adult	Immature	40.5	10.5	000735A06F	D5	North Bank	1	First time capture	Observed	Above Litter	
3	Unknown	Sub Adult	Immature	46	10.75	000735C27C	D6	North Bank	1	First time capture	Observed	Above Litter	Yellowing underbody indicative of a young male frog
4	Male	Adult	Light Nuptial	74.1	63	0007357455	U6	North Bank	3.5	First time capture	Observed	Partially Buried	
5	Unknown	Sub Adult	Immature	45.1	13.75	000735C206	U6	North Bank	1.5	First time capture	Observed	Above Litter	
6	Unknown	Sub Adult	Immature	41.5	9	00073546CD	U7	North Bank	4	First time capture	Observed	Above Litter	
7	Female	Adult	Not Gravid	117.5	190	00073587DF	U6	North Bank	4	First time capture	Observed	Sheltering beneath Lomandra	
8	Unknown	Sub Adult	Immature	46.2	12	00073564F9	U9	North Bank	3	First time capture	Observed	Above Litter	
9	Female	Adult	Not Gravid	96	149	000735AC9F	U9	North Bank	4.5	First time capture	Observed	Sheltering beneath Lomandra	
10	Unknown	Sub Adult	Immature	45.8	11.75	000735B72A	U8	North Bank	1	First time capture	Observed	On Dirt	
Summer Sample													
1	Unknown	Sub Adult	Immature	55.5	19.75	0007354559	C1	South Bank	8	First time capture	Observed	Above Litter	Probably a male frog. Swabbed

Site	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
2	Male	Adult	No Colour	66.7	33.25	000735B6F8	D6	South Bank	7.5	First time capture	Observed	Above Litter	Swabbed
3	Unknown	Sub Adult	Immature	41.5	9.25	0007356DEB	D5	South Bank	2.3	First time capture	Observed	Above Litter	Swabbed
4	Unknown	Sub Adult	Immature	58.2	27.25	0007353FA9	D2	North Bank	4.1	First time capture	Observed	Above Litter	Probably a male frog. Swabbed
5	Unknown	Juvenile	Immature	36.9	7.75	000735B8C9	D5	North Bank	3	First time capture	Observed	Above Litter	Swabbed
6	Unknown	Juvenile	Immature	36	6.75	000735A09D	D5	North Bank	3.3	First time capture	Observed	Above Litter	Swabbed
7	Male	Adult	Moderate Colour	70.2	44.75	0007358B84	U1	North Bank	3.2	First time capture	Observed	On Log	Swabbed
8	Unknown	Sub Adult	Immature	45.3	12.75	000735C7EC	U3	North Bank	4.4	First time capture	Observed	Above Litter	Swabbed
9	Male	Adult	No Colour	59.6	26.5	0007357443	U5	North Bank	4	First time capture	Observed	Partially buried under litter	Swabbed
10	Unknown	Sub Adult	Immature	46.7	12	0007355C06	U5	North Bank	8.5	First time capture	Observed	Above Litter	Swabbed
11	Unknown	Sub Adult	Immature	56.2	23.75	000735C206	U6	North Bank	9.3	Remained in same zone and same side of creek as spring	Observed	Above Litter	Swabbed
12	Unknown	Sub Adult	Immature	49	15.5	000735CB5C	U7	North Bank	1.3	First time capture	Observed	On Gravel	Swabbed
13	Male	Adult	Moderate Colour	64.6	39	000735C3ED	U8	North Bank	6.2	First time capture	Observed	Above Litter	
14	Unknown	Sub Adult	Immature	43.9	12	7357690	U8	North Bank	2.3	First time capture	Observed	Above Litter	
15	Unknown	Sub Adult	Immature	55.4	18.75	00073564F9	U9	North Bank	3.8	Remained in same zone and same side of creek as spring	Observed	Above Litter	
16	Female	Adult	Gravid	98.7	165	00073542D7	U9	South Bank	7.5	First time capture	Observed	Above Litter	
Autumn Sample													
1	Sub Adult	Sub Adult		49.8	NA	7365DEB	D3	South Bank	10	Recapture	Observed	Above Litter	Swabbed. On litter, under tussock 6m from creek edge
2	Male	Adult	Male with well coloured	62.4	NA	7733CA2	D2	North Bank	4	Observed	Observed	Above Litter	Swabbed. On high bank about 8m from water. On litter at base of tree

Site	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
			nuptial pads										
3	Subadult			NA	NA	735BA08	D2	South	13	Observed	Observed	Above Litter	
										Observed			
Piper's Creek													
Spring Sample													
1	Unknown	Sub Adult	Immature	48.2	16	000735C107	4	South bank	3.9	First time capture	Observed	Above litter	
2	Unknown	Sub Adult	Immature	56	21.5	000735B231	4	North Bank	2.7	First time capture	Observed	Above litter	
3	Unknown	Sub Adult	Immature	53.5	19	0007356DF2	4	North Bank	2.9	First time capture	Observed	Above litter	
4	Male	Adult	Dark Nuptials	83.9	86	000735BFCC	18	South bank	5.8	First time capture	Observed	Above litter	
5	Male	Adult	Light Nuptials	81	82.5	000735BCBE	18	South bank	7.3	First time capture	Observed	Above litter	
6	Male	Adult	No Colour	66	36.5	0007353695	18	South bank	8.4	First time capture	Observed	Above litter	Some yellowing spots not recorded at other locations. This frog deemed very light very its size and possible unhealthy or feeling the effects of a long dry spring
7	Male	Adult	Moderate Nuptials	75.6	56	0007358A4C	17	South bank	5.2	First time capture	Observed	Above litter	Some yellowing spots not recorded at other locations
8	Female	Adult	Not Gravid	66.6	41	0007358DDC	17	South bank	6.2	First time capture	Observed	Above litter	Some yellowing spots not recorded at other locations
Summer Sample													
1	Female	Adult	Not Gravid	63.8	31	000735B231	4	North Bank	5	Remained in same zone and same side of creek but 2.3 m further from water	Observed	Partially buried under litter	Swabbed
2	Unknown	Sub Adult	Immature	58.9	28	000735C107	4	Centre Island	2.7	Remained in same zone and same side of creek	Observed	Above litter	Swabbed
3	Female	Adult	Not Gravid	64.1	38	0007356DF2	4	North Bank	5	Remained in same zone and same	Observed	Above litter	Swabbed

Site	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
										side of creek			
4	Male	Adult	Moderate Nuptials	63.6	32	000735BA08	10	North Bank	2.3	First time capture	Observed	Above Litter	Swabbed
5	Unknown	Sub Adult	Immature	53	18	00073585C3	12	South Bank	2.1	First time capture	Observed	On Bare Ground	Swabbed
6	Female	Adult	Gravid	99.9	181	0007354BC4	13	North Bank	1	First time capture	Observed	Above Litter	Swabbed
7	Female	Adult	Gravid	94.3	132	0007359B0F	15	South Bank	6	First time capture	Observed	Above Litter	Swabbed
8	Female	Adult	Not Gravid	78.8	64	0007358DDC	17	South Bank	2.3	Same zone and side of creek but closer to water	Observed	Partially buried under litter	Swabbed
Autumn Sample													
1	Juvenile	Juvenile	Immature	35	NA	7635041	D3	South Bank	5	First time capture	Observed	Above litter	Swabbed. Small juvenile at base of tree again about 5m from water
Maria River													
Spring Sample													
1	Unknown	Sub Adult	Immature	49.2	19.75	00073531A8	U9	North Bank	3.5	First time capture	Observed	Above Litter	
2	Female	Adult	Not Gravid	96.6	145	000735B70C	U1	North Bank	3	First time capture	Observed	Above Litter	
3	Female	Adult (young)	Not Gravid	77.8	67.5	00073579A3	U1	North Bank	3.2	First time capture	Observed	Using Undercut of Bank	
4	Sub Adult	Sub Adult	Immature	57.8	28.5	7357806	U1	North Bank	3.7	First time capture	Observed	Sheltering beneath lantana	Predict this will be a male frog once it matures
5	Female	Adult	Not Gravid	99.2	148	0007357A85	U1	South Bank	2.6	First time capture	Observed	Part Buried Under Litter	
6	Female	Adult	Not Gravid	85.6	83	000735974B	D8	South Bank	7.8	First time capture	Observed	Above Litter	
7	Male	Sub Adult	No Colour	59.9	30	0007356F68	D6	North Bank	2.4	First time capture	Observed	Above Litter	
8	Female	Adult	Not Gravid	90.4	103	000735BEBE	D5	North Bank	13.3	First time capture	Observed	Above Litter	
9	Male	Sub Adult	No Colour	59.9	27	00073531B0	D5	South Bank	1.8	First time capture	Observed	Under Vines	

Site	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
10	Female	Adult	Not Gravid	99.8	147	000735508E	D4	South Bank	1.9	First time capture	Observed	Above Litter	
Summer Sample													
1	Male	Adult	Light Nuptials	64.6	38	000735B2F4	U1	North Bank	2	First time capture	Observed	Above Litter	Swabbed
2	Unknown	Juvenile	Immature	38.2	8.5	000735BE05	U1	North Bank	0.8	First time capture	Observed	Above Litter	Swabbed
3	Unknown	Sub Adult	Immature	49.4	13	7359976	U1	North bank	1.5	First time capture	Observed	Above Litter	Swabbed
4	Male	Adult	No data	No data	No data	No data	D3	No data	No data	No data	Calling	Under Litter	Could not be captured
5	Female	Adult	Not Gravid	94.4	158	000735D09C	U2	South Bank	3	First time capture	Observed	On Dirt	Swabbed
6	Unknown	Juvenile	Immature	37.4	11	000735AEE9	U8	North Bank	0.3	First time capture	Observed	On dirt using hole in bank	Swabbed
7	Male	Adult	Light Nuptials	75.8	70	000735B020	U9	North Bank	3	First time capture	Observed	Part buried under litter	Swabbed
8	Unknown	Juvenile	Immature	No data	No data	No data	D8	North Bank	No Data	No Data	Observed	Above Litter	Could not be captured
9	Unknown	Juvenile	Immature	No data	No data	No data	D8	South Bank	No Data	No Data	Observed	Above Litter	Could not be captured
Autumn Sample													
0	None recorded												
REFERENCE SITES													
Cooperabung Creek													
Spring Sample													
1	Male	Adult	Dark Nuptial	70.8	50.5	000735C3DB	15	North Bank	3.1	First time capture	Call response	Above Litter	
2	Male	Adult	Light Nuptial	74.4	64	0007359C3A	15	North Bank	4.1	First time capture	Observed	Above Litter	
3	Male	Adult	Light Nuptial	71.9	63.5	00073588FF	14	North Bank	1.9	First time capture	Observed	Above Litter	
4	Unknown	Sub Adult	Immature	50.3	21.5	0007356F32	14	North Bank	2.1	First time capture	Observed	Above Litter	
5	Female	Adult	Not Gravid	110.6	142.5	00073576C7	13	North Bank	8.5	First time capture	Observed	Above Litter	

Site	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
6	Unknown	Sub Adult	Immature	44.9	13.5	00073599EE	11	South bank	2.6	First time capture	Observed	On Pasture Grass	
7	Male	Adult	Moderate Nuptial	71.2	61.5	000735A504	10	South bank	1.2	First time capture	Call response	Above Litter	
8	Female	Adult	Not Gravid	97	132.5	000735613C	9	North Bank	2.8	First time capture	Observed	Above Litter	
9	Female	Adult	Not Gravid	96.6	141	0007359F76	5	South bank	1.3	First time capture	Observed	Above Litter	
10	Female	Adult	Not Gravid	97.7	124	00073546F4	9	South bank	7.2	First time capture	Observed	On Pasture Grass	
11	Female	Adult	Not Gravid	94	132	0007353E49	17	North Bank	5.9	First time capture	Observed	Above Litter	
12	Unknown	Sub Adult	Immature	54.9	25.5	0007359659	17	North Bank	0.9	First time capture	Observed	Above Litter	
13	Female	Adult	Part Gravid	97.2	147	00073530F3	18	North Bank	3.3	First time capture	Observed	Above Litter	
14	Male	Sub Adult	Immature	57.9	28.5	0007359D56	20	South bank	3.1	First time capture	Observed	Above Litter	Yellow underbody indicating probably a young sub adult male
15	Female	Adult	Part Gravid	98	172	000735ADC9	20	South bank	2.4	First time capture	Observed	Above Litter	
16	Male	Sub Adult	Immature	58.3	28.5	0007353F6E	22	North Bank	5.7	First time capture	Observed	Above Litter	
17	Male	Sub Adult	Immature	53.7	22.5	0007358D13	19	South bank	3.2	First time capture	Observed	Above Litter	Yellow underbody indicating probably a young sub adult male
Summer Sample													
1	Unknown	Sub adult	Immature	44.9	13.5	0007357B14	16	South Bank	0.5	First time capture	Observed	Above Litter using Lomandra shelter Site	Swabbed
2	Female	Adult	Not Gravid	91.7	130	0007359D67	15	North Bank	1	First time capture	Observed	Partially Buried Under Litter	Swabbed
3	Unknown	Juvenile	Immature	40.1	10	0007357BBC	15	North Bank	0.3	First time capture	Observed	Above Litter	Swabbed
4	Male	Adult	Light Nuptials	73.6	61	000735C59A	15	South Bank	0.7	First time capture	Observed	On Dirt	Swabbed
5	Male	Adult	Light Nuptials	75.5	62	0007359C3A	15	South Bank	1.1	Same zone but changed side of creek and closer to water	Observed	On Rock	Swabbed
6	Unknown	Sub adult	Immature	45	13.5	0007352C3A	14	North Bank	0	First time capture	Observed	Above Litter at Waters Edge	Swabbed

Site	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
7	Unknown	Sub adult	Immature	45	14	0007359E7B	11	North Bank	0.3	First time capture	Observed	Using Bank Undercut	
8	Unknown	Sub adult	Immature	45.6	14.5	000735A74D	8	North Bank	2.6	First time capture	Observed	On Grass	
9	Unknown	Juvenile	Immature	37.3	9	000735A4D1	8	North Bank	2.9	First time capture	Observed	On Grass	
10	Female	Adult	Not Gravid	95.7	123	0007359F76	7	South Bank	4.2	Moved 2 zones upstream	Observed	On Grass	Swabbed
11	Male	Adult	Dark Nuptials	74.1	57.5	00073535CD	7	South Bank	3.6	First time capture	Observed	On Grass	Swabbed
12	Unknown	Sub Adult	Immature	48.5	17	0007359D2A	5	South Bank	1.4	First time capture	Observed	Above Litter	
13	Female	Adult	Not Gravid	78.7	68	00073563EA	3	South Bank	1.4	First time capture	Observed	Partially Buried Under Litter	Swabbed
14	Male	Adult	Moderate Nuptials	65.9	40.25	000735B0E5	3	North Bank	5	First time capture	Observed	On Grass	Swabbed
15	Female	Adult	Not Gravid	68.7	38.75	000735C733	3	South Bank	0.8	First time capture	Observed	Using Bank Undercut	
16	Unknown	Sub Adult	Immature	47.5	18	000735C584	15	South Bank	1.9	First time capture	Observed	Above Litter	
17	Unknown	Sub Adult	Immature	41.7	12.5	000735BD28	17	South Bank	1.2	First time capture	Observed	On Grass	
18	Unknown	Juvenile	Immature	39.7	10	000735B42E	19	North Bank	2.7	First time capture	Observed	Above Litter	
19	Unknown	Sub Adult	Immature	43.5	13	000735A858	19	North Bank	3	First time capture	Observed	Above Litter	
20	Unknown	Juvenile	Immature	39.5	11.25	7354212	22	North Bank	2.4	First time capture	Observed	Above Litter	
21	Unknown	Sub Adult	Immature	40.6	11.25	000735546E	22	South Bank	0.7	First time capture	Observed	Above Litter	
Autumn Sample													
1	Male	Adult	No Colour	57 mm	40g	0007625883	NA	NA	NA	First time capture			
2	Subadult	Subadult		66 mm	49g	000735C584	NA	NA	NA	Recapture			
3	Female	Adult		81 mm	67g	00076345E4	NA	NA	NA	First time capture			
4	Subadult	Subadult		31 mm	19g		NA	NA	NA	First time capture			Too small to process data

Site	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
5	Subadult	Subadult		63 mm	37g	0007635734	NA	NA	NA	First time capture			
6	Subadult	Subadult		35 mm	29g	NA	NA	NA	NA	First time capture			To small to process data
Piper's Creek (Boonie Corner Road)													
Spring Sample													
1	Female	Adult	Not Gravid	93	130	000735AE22	16	North bank	1.1	First time capture	Observed	Partially buried under litter @ 1910 hrs	
2	male	Adult	Medium Nuptials	77.8	60	0007359C08	16	North bank	1.4	First time capture	Observed	Partially buried under litter/moss	
3	male	Adult	Light Nuptials	67.6	39	0007359F7C	19	North bank	2	First time capture	Observed	Shelter beneath Lomandra fronds	
4	Unknown	Sub Adult	Immature	44	13.5	7352736	9	North bank	2.1	First time capture	Observed	Partially buried under litter	Yellowing underbody indicative of a young male
5	Female	Adult	Not Gravid	89.2	98	7358076	7	North bank	3.3	First time capture	Observed	Above litter	Missing right hand - photographed
6	male	Adult	Dark Nuptials	77.8	68	0007355C05	7	North bank	1.1	First time capture	Observed	Under litter	Just eye of frog protruding
7	Female	Adult	Not Gravid	97.6	148	0007355ED1	7	Southbank	2.1	First time capture	Observed	Partially buried under litter	
8	male	Adult	Dark Nuptials	78.1	57	7358100	6	Southbank	0.9	First time capture	Observed	Above litter	
9	Female	Adult	Not Gravid	113.1	153	0007354E33	5	Southbank	2.1	First time capture	Observed	Above litter	
10	Female	Adult	Not Gravid	91.2	117	00073525A5	7	North bank	1.1	First time capture	Observed	Partially buried under litter and Lomandra	
Summer Sample													
1	Male	Adult	Dark Nuptials	64.9	37	000735C44D	7	South Bank	4	First time capture	Observed	Partially Buried Under Litter	Swabbed
2	Male	Adult	Moderate Nuptials	72.8	57	7355572	6	North Bank	2.5	First time capture	Observed	Partially Buried Under Litter	Swabbed
3	Female	Adult	Not Gravid	61.7	27	7352335	6	South Bank	0.5	First time capture	Observed	Above Litter	Swabbed
4	Female	Adult	Not Gravid	66.1	41	00073593EC	6	South Bank	4	First time capture	Observed	Above Litter	Swabbed
5	Male	Adult	Moderate Nuptials	76.1	74	00073555B9	8	North Bank	1.5	First time capture	Observed	Partially Buried Under Litter	Swabbed

Site	Sex	Age	Reproductive Status	Length	Weight	Pit Tag Code	Zone	Side of Creek	Distance to water	Bearing & Distance from last capture	Activity	Microhabitat	Notes
6	Male	Adult	Moderate Nuptials	74.1	55	7357086	9	North Bank	2	First time capture	Observed	Partially Buried Under Litter	Swabbed
7	Female	Adult	Gravid	98.6	178	00073573F1	10	North Bank	1.5	First time capture	Observed	Using hole in bank	Swabbed
8	Male	Adult	Moderate Nuptials	76	68	00073529AE	13	South Bank	1	First time capture	Observed	Partially Buried Under Litter	Swabbed
9	Male	Adult	Dark Nuptials	73.7	52	000735CA5F	15	South Bank	2.5	First time capture	Observed	Above Litter	Swabbed
10	Female	Adult	Gravid	96	165	7356674	19	South Bank	3.6	First time capture	Observed	Above Litter	Swabbed
11	Female	Adult	Gravid	94.6	141	0007356F20	19	South Bank	5	First time capture	Observed	Above Litter	Swabbed
12	Male	Adult	No Data	No Data	No Data	No Data	6	No Data	No Data	No Data	Call Response	No Data	Frog could not be captured
13	Male	Adult	No Data	No Data	No Data	No Data	18	No Data	No Data	No Data	Call Response	No Data	Frog could not be captured
Autumn Sample													
0	None recorded												

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Annex 8: Squirrel Glider monitoring report (Niche 2015)

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Environment and Heritage

Squirrel Glider Monitoring

Baseline Autumn 2014 Surveys – Oxley Highway to Kempsey Pacific Highway Upgrade

Prepared for RMS

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Cover photograph: Squirrel Glider observed in Coastal Banksia at Forster, photo- C McLean

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1. Introduction

As part of Oxley Highway to Kempsey (OH2K) Pacific Highway Upgrade, the Roads and Maritime Services (Roads and Maritime) have implemented an Ecological Monitoring Program (EcMP) in accordance with the Minister for Planning's Condition of Approval (MCoA) No. 10, which states that:.

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 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, 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 use patterns directly attributable to the construction or operation of the project; and

(f) provision of annual reporting of monitoring results to the Director General and the OEH and DPI, 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).

The aim of this report is to fulfil the annual reporting requirements as per the approved EcMP and to satisfy the requirements of MCoA 3.1 and SoC F22, for the Autumn baseline monitoring survey for the Squirrel Glider.

An important point to note that the Squirrel Glider has not been recorded within the impact area of the Upgrade (Hyder 2014). Only suitable habitat has been identified and so it is unclear as to what the extent of this species inhabits the areas chosen for monitoring. No monitoring points had been chosen prior to these monitoring works and eight sites were chosen to provide basic statistical rigour to allow a valid monitoring program to be developed to assess the question of impacts of the road and success of mitigation. The areas monitored were included due to a perceived suitability as habitat for the Squirrel Glider based on vegetation present and its extent and level of connectivity in the landscape.

The Ecological Monitoring Program requires one baseline survey to be undertake in Autumn 2014, providing information on the population prior to the commencement of construction. Monitoring will then continue to be carried out again once in years 4, 6 and 8 of the project.

The location of field sites and the techniques employed are summarised in Section 2.

The following performance measures are identified in the Ecological Monitoring Program for the Squirrel Glider:

- Monitoring is undertaken before and after construction of the upgrade.
- Monitoring is undertaken at Control and Impact sites.
- Squirrel Glider populations are maintained at Impact sites where it was identified during baseline surveys; there is no significant difference in any population declines between Impact and Control sites after completion of the Project.

The aim of this report is to summarise the findings of the baseline field surveys, the number of individuals recorded at each site and the prevailing weather conditions. The report also aims to assess the likely value of the current monitoring program and any improvements that may be considered to the program and its overall value in the context of the management of the species along the Upgrade.

2. Survey Methods

Monitoring sites were paired at four separate locations (i.e. a control and treatment site occurred at each location). These were located at Cairncross State Forest, Barry's Creek, Mingaletta Road and Maria River and the site locations are shown on Figure 1. In general treatment locations were located approximately 100 – 200 metres from the proposed alignment, while control locations were located approximately 20 - 50 metres from the proposed alignment.

Sampling occurred between 26th and 30th May 2014. A grid of 20 arboreal Elliott B traps were mounted on brackets approximately three metres above the ground across an area of approximately two hectares, with a distance of at least 50 metres occurring between traps. Traps were baited with a mixture of rolled oats, peanut butter and honey, while the trap host tree was sprayed with a mixture of brown sugar and water, via a pressure sprayer, to a height of 10 metres. Traps were checked at dawn each morning and the sugar water was reapplied to the host trees. Traps were in place for four consecutive nights, representing a trap effort of 80 trap nights per site and a total of 640 trap nights amongst the four paired locations.

Table 1: Weather conditions encountered during the field surveys

Date	Minimum temperature	Maximum temperature	Rainfall
26/5/14	10.5	24.4	0
27/5/14	12.7	25.8	0
28/5/14	14.5	24.0	0
29/5/14	6.5	22.3	0
30/5/14	8.7	20.3	1.6

3. Results

No Squirrel Gliders were captured during these surveys and, in fact, no specifically arboreal marsupials, were captured at any of the sites during the field surveys. The only captures were of the Brown Antechinus (*Antechinus stuartii*) which was captured at 16 times at 6 of the 8 sites and the Black Rat (*Rattus rattus*) which was captured twice and at only just one site (see Table 3).

Table 2: Captures recorded at each site.

	27/05/2104	28/05/2014	29/05/2014	30/05/2014
Cairncross State Forest treatment			1 x *A. stuartii*	
Cairncross State Forest control		1 x *A. stuartii*	2 x *A. stuartii*	2 x *A. stuartii*
Barry's Creek treatment				
Barry's Creek control				1 x *A. stuartii*
Mingaletta Road treatment			1 x *A. stuartii*	3 x *A. stuartii*
Mingaletta Road control		1 x *A. stuartii*		1 x *A. stuartii*
Maria River treatment		1 x *A. stuartii*	1 x *A. stuartii* 1 X *R. rattus*	1 x *A. stuartii* 1 X *R. rattus*
Maria River control				

4. Discussion

The very clear problem arising from this baseline monitoring program is the no Squirrel Gliders were captured at any site. Hence there is no baseline population to compare against to determine if there has been change. This may likely reflect a true absence of the Squirrel Gliders in all of the monitoring sites as the species has not actually ever been recorded within the monitoring areas (Hyder 2014). The choice of sites was based on the presence of appropriate habitat in areas of connected intact land.

However, while no Squirrel Gliders were captured during the surveys, their occurrence at any or all of the sites, even in moderate densities cannot be entirely discounted for a number of reasons. Arboreal trapping success rates using the prescribed methods are often very low, with success of around 5% and at times less than 1% being reported elsewhere (see Smith and Murray 2003, Winning and King 2007). Subsequently a trapping effort of 80 trap nights per site may reasonably result in a failure to capture a glider during any single monitoring period.

Recent research works completed by Niche on the Squirrel Glider at Forster compared the efficacy in detecting this species via arboreal trapping and spotlighting. At a number of sites where both techniques were used Squirrel Gliders were detected only by spotlighting and not by trapping. At one site trapping occurred over 14 consecutive nights (representing 168 trap nights) without any gliders being captured. This was despite the fact that gliders were recorded on the site and in close proximity to the traps as a result of spotlighting surveys undertaken at the same time. Similar results occurred in Goldingay and Sharp (2004) who concluded that the probability of detecting a Squirrel Glider via trapping was lower than detecting one via spotlighting, although this may depend on the habitat being surveyed.

Consequently a major limitation of this monitoring program is the use of only a single, four night trapping period to determine baseline population levels or even presence of the species. Ideally as shown by Goldingay and Sharp (2004) and Niche, multiple methods are recommended in order to effectively survey for the Squirrel Glider. These may include the use of arboreal trapping, monitoring of nesting boxes and also spotlighting and a combination of all methods may be required to effectively understand the size and status of any resident population.

Another significant implication of the lack of captures is that, even if animals are captured in subsequent events, the data collected is unlikely to allow a very useful assessment of population changes and so determine with any confidence if the road has impacted the species or if mitigation is being effective. If the populations are in very low densities such that single gliders are captured on each site every now and then, then the counts will provide no statistical power to detect changes. If population densities vary more greatly and numbers rise and fall in cycles, then the large variations in counts between monitoring periods will similarly result in very poor sensitivity of analyses such that the level of data provided on population size will be insufficient to provide any knowledge on population size or meet the objectives of the monitoring program to be able to conclude whether the population has changed in size.

Based on the absence of records to date, it is recommended that an initial more intensive trapping program be implemented to determine with some confidence if a population is present at any or all of the currently monitored sites. If no populations are present on the impact sites, as is suggested during baseline surveys, then the continued monitoring for this species should cease as there is no practical use in continuing. While additional trapping may increase costs in the short term, if it is determined that Squirrel Glider monitoring is no longer required then this would represent an overall cost saving to the RMS. Should the Squirrel Glider

turn up after the program is terminated then the unexpected finds procedure would be used to manage this species.

If populations are recorded on any of the impact sites, then the monitoring program can be re-focused onto those sites to ensure that resources are directed into locations where the Squirrel Glider is present.

The available information indicates that if a more intensive survey was to be conducted, then it should include repeat spotlighting of each of the monitoring sites for a minimum of 1 person hour per site. Increasing trapping effort to 200 trap nights per site (50 traps per site for four nights) would provide clear evidence as to whether the Squirrel Glider is present and can be trapped. The trapping/spotlighting success obtained can ultimately be used to determine the intensity of any future monitoring so that meaningful results can be obtained to test if the populations are being impacted by the Upgrade.

5. References

Goldingay, R. L., & Sharpe, D. J. (2004). How effective is spotlighting for detecting the squirrel glider? Wildlife Research, 31(4), 443-449.

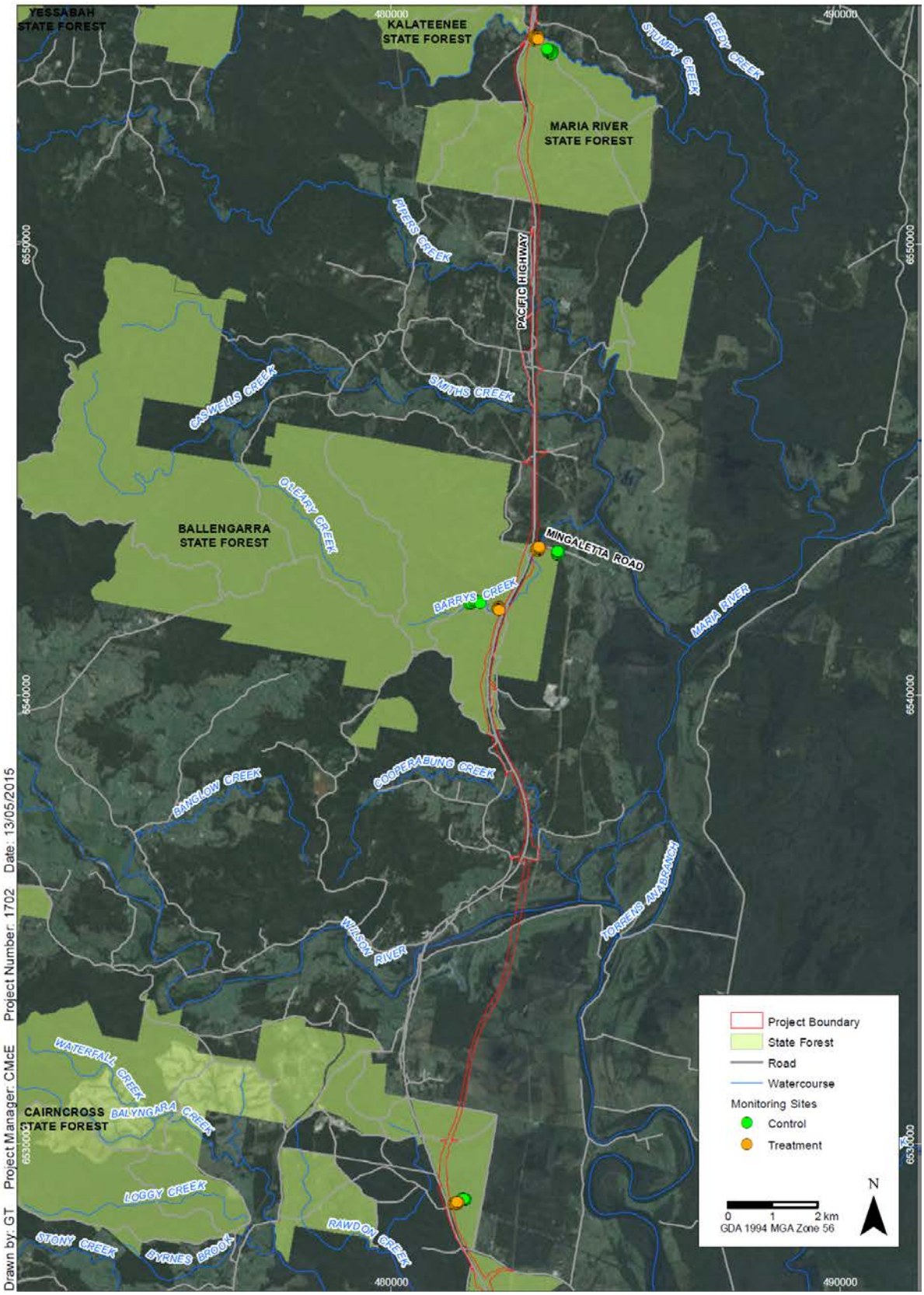
Hyder (2014). Oxley Highway to Kempsey Pacific Highway Upgrade—Ecological Monitoring Program Hyder Consulting Pty Ltd

Smith, A. P., & Murray, M. (2003). Habitat requirements of the squirrel glider (*Petaurus norfolcensis*) and associated possums and gliders on the New South Wales central coast. Wildlife Research, 30(3), 291-301.

Winning, G, & King, J. (2008). A new trap design for capturing squirrel gliders and sugar gliders. Australian Mammalogy, 29(2), 245-249.

Annex 1 Figures

Figure 1: Location of Squirrel Glider survey sites



Niche Environment and Heritage

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Annex 9: Microbat Roost Boxes Monitoring

Ref: 2431415d:BatBoxMonitoringWinter2014

22nd August 2014

McConnell Dowell Constructors (Aust) Pty Ltd
Level 7, Tower B
799 Pacific Highway
Chatswood NSW 2067

Attention: Vince Chaplin/James Hamilton/Jamie Crawford

Re: Monitoring Of Bat 75 Boxes for Winter Period 2014

Please find within a summary as a registered output for completing the winter bat box monitoring for K2K on the 20-21st August 2014 and within 24 hours of the variation being granted approval.

In summary, all 75 micro bat boxes were located and inspected for signs of bats or any other fauna inhabiting them. Four boxes (5.3%) are currently inhabited by micro bats comprising two species; Lesser Long-eared Bat (*Nyctophilus geoffroyi*) and Gould's Long-eared Bat (*Nyctophilus gouldi*). Both of these species are not currently listed as threatened species pursuant to state (*TSC* Act) and commonwealth (*EPBC* Act) legislation. Another eight boxes (10.6%) showed signs of being used by either *Antechinus* or Feather-tail Glider given the boxes had leaf nests constructed within them.

The ecological habits of the two recorded Long-eared Bats are best described as a 'fluttering' species of coastal forests and woodlands and generally forage in the lower part of the canopy. They will roost at a variety of heights in tree hollows and beneath exfoliating bark and are therefore not an unexpected find. With regard to the micro bat management plan I don't believe Long-eared Bats to have been much of an issue associated with bridges and culverts on the K2K project as these bats tend to roost beneath bark or in tree hollows. In that capacity, the boxes given their current positioning are perhaps providing more of a temporal roost resource linked with the forecast loss of tree hollows (i.e. functioning like the micro bat boxes identified for use in the nest box plan).

One important factor that I did notice was the boxes haven't been installed as per the micro bat plan. The plan specifically provides for two mounting options and given all boxes have been tree mounted the following directions are most relevant, "*For tree mounted roosts, the following considerations must be satisfied:*

1. *Every attempt made to install >2 m above ground and ideally 3-4 m;*
2. *Overhanging >100 mm of surface water;*
3. *Beneath tree canopy to reduce solar radiation;*
4. *Recipient tree considered robust and in good health (i.e. healthy tree canopy and unexposed roots); and*
5. *Consideration is given to installing a number of boxes to provide a number of thermoregulatory options. For example, painting some boxes in different colours or positioning the boxes with differing aspects (i.e. one on southern side of a tree another on the northern side").*

Not one of the 75 checked boxes have been installed overhanging water. In this capacity, it makes it difficult as the author of the micro bat management strategy to now have confidence that the boxes have been given the greatest possible chance of being used by the target species (i.e. Southern Myotis). This matter will need to be forwarded onto the RMS for them to consider how they might manage under-performing boxes and the performance measures within the micro bat plan itself. To illustrate my point, I have included two example pictures. Plate 1 (left) is a black coloured box to address thermoregulatory considerations and has been placed on the north side of the tree which is correct. However, in this position the bat box dose not hang above the water and there are several trees on the southern side of Pipers Creek that are more suitable and would have allowed the box to face north to capture the winter sun (that's why it's painted black) and overhanging the water. The role of evaporation and humidity can play an

important role in the way bats tend to select their roosts and it is this reason why bats are often found using bridges and culverts with water in them. Plate 1 (right) illustrates a bat box being installed around shrubby vegetation. Shrubs such as this tend to provide access points for predators (i.e. small python) and are therefore less likely to be inhabited by micro bats. It also makes it more difficult for bats to enter and exit the box due to the obstruction of clear passage from the leaves and branches.

Plate 1-1. Example of poor implementation of the microbat management plan. Left - Box not overhanging water and should have been ideally placed on the south bank facing north. Right – Box installed low and with shrubby vegetation growing around its entrance making it more likely for predation events and impeding fly way to and from the box.

Some maintenance and management of the boxes was performed during the monitoring and included one box (133) that was laying on the ground being relocated to a more suitable location around 8 m to the east and closer to overhanging an existing pool in Barrys Creek. At other times, the vegetation was trimmed or pulled out of the way to increase the suitability of the box as a roost site and the aspect was also changed on several boxes to improve their overall suitability. For example, bat boxes installed on sloping tree trunks were repositioned so they faced in a more vertical manor to allow the bats to fall from the roost before taking flight. In the installed position, this was not possible.

I have attached an excel spreadsheet as an addendum file to this letter report which detailed the specifics of each box and this should be used for each successive seasonal monitoring event.

Kind Regards

Ben Lewis
Director
Lewis Ecological Surveys
(ACN – 166970378)

Lewis Ecological Surveys Record Number	Monitoring Episode	Season	Date Recorded	Box Number	Bats Recorded	Species Name	Common Name	Number	Comments
35	1	Winter	20.08.2014	2	No	-	-	-	Placed in inappropriate location, not over water
34	1	Winter	20.08.2014	3	No	-	-	-	Placed in inappropriate location , not over water
36	1	Winter	20.08.2014	4	No	-	-	-	Placed in inappropriate location, not over water
39	1	Winter	20.08.2014	5	No	-	-	-	
41	1	Winter	20.08.2014	6	No	-	-	-	
40	1	Winter	20.08.2014	7	No	-	-	-	
38	1	Winter	20.08.2014	8	No	-	-	-	
37	1	Winter	20.08.2014	9	Yes	*Nyctophilus geoffroyi*	Lesser Long-eared Bat	3	
73	1	Winter	20.08.2014	10	No	-	-	-	Box placed in inappropriate position within the foliage of an adjacent Acacia
74	1	Winter	20.08.2014	11	No	-	-	-	
72	1	Winter	20.08.2014	12	No	-	-	-	
75	1	Winter	20.08.2014	13	No	-	-	-	
71	1	Winter	20.08.2014	14	No	-	-	-	
70	1	Winter	20.08.2014	15	No	-	-	-	
29	1	Winter	20.08.2014	16	No	-	-	-	
30	1	Winter	20.08.2014	17	Yes	*Nyctophilus geoffroyi*	Lesser Long-eared Bat	2	
33	1	Winter	20.08.2014	18	No	-	-	-	Repositioned to face SSE
32	1	Winter	20.08.2014	19	No	-	-	-	
31	1	Winter	20.08.2014	20	No	-	-	-	
28	1	Winter	20.08.2014	21	No	-	-	-	

48	1	Winter	20.08.2014	22	No	-	-	-	
49	1	Winter	20.08.2014	23	No	-	-	-	
50	1	Winter	20.08.2014	24	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
46	1	Winter	20.08.2014	25	No	-	-	-	Difficult to inspect design. Leaves in box, Possible Antechinus or Feather-tailed Glider
45	1	Winter	20.08.2014	26	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
47	1	Winter	20.08.2014	27	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
53	1	Winter	20.08.2014	28	No	-	-	-	Location might be in clearance area
51	1	Winter	20.08.2014	29	No	-	-	-	Location might be in clearance area
44	1	Winter	20.08.2014	30	No	-	-	-	
20	1	Winter	21.08.2014	31	No	-	-	-	Difficult to inspect design
42	1	Winter	20.08.2014	32	No	-	-	-	
43	1	Winter	20.08.2014	35	No	-	-	-	
19	1	Winter	21.08.2014	36	No	-	-	-	
21	1	Winter	21.08.2014	37	No	-	-	-	
22	1	Winter	21.08.2014	38	No	-	-	-	
57	1	Winter	20.08.2014	46	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
55	1	Winter	20.08.2014	47	No	-	-	-	
54	1	Winter	20.08.2014	49	No	-	-	-	
63	1	Winter	20.08.2014	50	No	-	-	-	
56	1	Winter	20.08.2014	51	No	-	-	-	

58	1	Winter	20.08.2014	52	No	-	-	-	
59	1	Winter	20.08.2014	53	No	-	-	-	
62	1	Winter	20.08.2014	54	No	-	-	-	
61	1	Winter	20.08.2014	55	No	-	-	-	
60	1	Winter	20.08.2014	56	No	-	-	-	
66	1	Winter	21.08.2014	57	No	-	-	-	
67	1	Winter	21.08.2014	58	No	-	-	-	
64	1	Winter	21.08.2014	59	No	-	-	-	
68	1	Winter	21.08.2014	61	No	-	-	-	
69	1	Winter	21.08.2014	62	No	-	-	-	
65	1	Winter	21.08.2014	63	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
23	1	Winter	21.08.2014	64	No	-	-	-	
26	1	Winter	21.08.2014	65	No	-	-	-	
24	1	Winter	21.08.2014	66	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
25	1	Winter	21.08.2014	67	No	-	-	-	
27	1	Winter	21.08.2014	68	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
10	1	Winter	20.08.2014	95	No	-	-	-	Difficult to inspect design
15	1	Winter	20.08.2014	96	No	-	-	-	
14	1	Winter	20.08.2014	97	No	-	-	-	Half fallen off, repositioned facing SSW
13	1	Winter	20.08.2014	98	No	-	-	-	
11	1	Winter	20.08.2014	99	No	-	-	-	Difficult to inspect design
16	1	Winter	20.08.2014	100	No	-	-	-	
12	1	Winter	20.08.2014	101	No	-	-	-	

1	1	Winter	20.08.2014	130	Yes	*Nyctophilus gouldi*	Gould's Long-eared Bat	2	
3	1	Winter	20.08.2014	131	No	-	-	-	
7	1	Winter	20.08.2014	132	No	-	-	-	
6	1	Winter	20.08.2014	133	No	-	-	-	Box had fallen off the tree. Relocated to adjacent Paperbark tree. E: 0483287, N: 6543380
8	1	Winter	20.08.2014	134	No	-	-	-	
4	1	Winter	20.08.2014	135	No	-	-	-	
5	1	Winter	20.08.2014	136	Yes	*Nyctophilus gouldi*	Gould's Long-eared Bat	1	located in the space closest to the tree
2	1	Winter	20.08.2014	137	No	-	-	-	
9	1	Winter	20.08.2014	138	No	-	-	-	
17	1	Winter	20.08.2014	139	No	-	-	-	
18	1	Winter	20.08.2014	140	No	-	-	-	
52	1	Winter	20.08.2014	28B	No	-	-	-	Location might be in clearance area, repositioned facing SW overslope and water

Ref: 2431415d:BatBoxMonitoringSpring2014

19th November 2014

McConnell Dowell OHL Joint Venture
205 Rodeo Drive
Kundabung, NSW 2441
Attention: James Hamilton/Jamie Crawford

Re: K2K Bat Box Monitoring –Episode 2 (Spring 2014)

Please find within, a summary of the Kundabung to Kempsey Bat Box Monitoring – Episode 2 as a registered output for your records in delivering the construction related component of the Ecological Monitoring Plan (SMEC-Hyder Joint Venture 2014) and associated Micro Bat Management Strategy (Lewis 2013).

Monitoring for episode 2 was performed on the 14th and 17th November 2014 in accordance with Lewis Ecological Surveys Safe Work Method Statement Version 3. At this time, no clearing had been undertaken nor had any construction works commenced apart from the micro bat exclusion process consistent with the approved micro bat management strategy.

All 75 of the Roads and Maritime installed bat boxes were located and inspected for signs of bats or any other fauna inhabiting them. On this occasion, none of the boxes were found to contain bats which differs from the winter monitoring (Episode 1) where four of the boxes (5.3%) were inhabited by two species of bat (Lewis 2014). Other types of fauna shows signs of using the boxes with 13 (17.3%) recording leaf nests constructed by either the Brown Antechinus (*Antechinus stuartii*), a small scansorial dasyurid, or the Feather-tail Glider (*Acrobates pygmaeus*) which is the world's smallest gliding marsupial. This uptake by non-target native species represents a 6.5% increase from Episodes 1 where eight boxes (10.6%) showed evidence of this in late August (Lewis 2014). Seven (53.8%) of these 13 boxes were the wedge shape design despite it comprising only 22.6% (n=17) of all boxes installed. At this initial stage of monitoring this could be attributed to a couple of factors, firstly, the boxes have not been installed in a manner consistent with the micro bat management strategy to improve their uptake, and secondly, the wedge shape design may not be entirely suitable when designing a bat specific bat box. This first point was drawn to the attention of the Joint Venture following monitoring of Episode 1 and as yet there has been no directive provided to amend or address the poor installation of the Roads and Maritime installed bat boxes. The details of this were provided for monitoring Episode 1 and need not be repeated again.

With regard to maintenance of the boxes a number of them required some form of vegetation trimming to improve their suitability as potential bat roosts whilst Bat Box 56 showing signs of recent termite uptake between the tree and the back of the box. We will continue to monitor this during the next round of monitoring schedule for mid to late summer and report on it then.

Please also find an attached excel spreadsheet as an addendum file to this letter report which detailed the specifics of each box. Should you have any questions or queries please contact me at your convenience.

Kind Regards

Ben Lewis (Principal Ecologist)
Lewis Ecological Surveys
(ACN – 166970378)

References

Lewis Ecological Surveys (2013). *Pacific Highway Upgrade: Oxley Highway to Kempsey Microchiropteran Bat Management Strategy.*
Prepared for Roads and Maritime Services by Lewis Ecological Surveys.

Lewis, B. (2014). Monitoring of Bat 75 Boxes for Winter Period 2014. Letter Report to McConnell Dowell Constructors (Aust) Pty Ltd.

SMEC-Hyder (2014). Oxley Highway to Kempsey Pacific Highway Upgrade: Ecological Monitoring Program. Prepared for RMS.

Lewis Ecological Surveys Record Number	Monitoring Episode	Season	Date Recorded	Box Number	Bats Recorded	Species Name	Common Name	Number	Comments
48	2	Spring	17/11/2014	2	No	-	-	-	
49	2	Spring	17/11/2014	3	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
50	2	Spring	17/11/2014	4	No	-	-	-	
45	2	Spring	17/11/2014	5	No	-	-	-	
44	2	Spring	17/11/2014	6	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
43	2	Spring	17/11/2014	7	No	-	-	-	
46	2	Spring	17/11/2014	8	No	-	-	-	
47	2	Spring	17/11/2014	9	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
75	2	Spring	14/11/2014	10	No	-	-	-	
73	2	Spring	14/11/2014	11	No	-	-	-	
72	2	Spring	14/11/2014	12	No	-	-	-	
74	2	Spring	14/11/2014	13	No	-	-	-	
71	2	Spring	17/11/2014	14	No	-	-	-	
70	2	Spring	17/11/2014	15	No	-	-	-	
22	2	Spring	17/11/2014	16	No	-	-	-	
21	2	Spring	17/11/2014	17	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
19	2	Spring	17/11/2014	18	No	-	-	-	
18	2	Spring	17/11/2014	19	No	-	-	-	
20	2	Spring	17/11/2014	20	No	-	-	-	
23	2	Spring	17/11/2014	21	No	-	-	-	

36	2	Spring	14/11/2014	22	No	-	-	-	
38	2	Spring	14/11/2014	23	No	-	-	-	
39	2	Spring	14/11/2014	24	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
34	2	Spring	14/11/2014	25	No	-	-	-	
35	2	Spring	14/11/2014	26	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
37	2	Spring	14/11/2014	27	No	-	-	-	
41	2	Spring	17/11/2014	28	No	-	-	-	
40	2	Spring	17/11/2014	29	No	-	-	-	
51	2	Spring	17/11/2014	30	No	-	-	-	
11	2	Spring	17/11/2014	31	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
52	2	Spring	17/11/2014	32	No	-	-	-	
53	2	Spring	17/11/2014	35	No	-	-	-	
9	2	Spring	17/11/2014	36	No	-	-	-	
10	2	Spring	17/11/2014	37	No	-	-	-	
12	2	Spring	17/11/2014	38	No	-	-	-	
26	2	Spring	17/11/2014	46	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
25	2	Spring	17/11/2014	47	No	-	-	-	
24	2	Spring	17/11/2014	49	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
33	2	Spring	17/11/2014	50	No	-	-	-	
27	2	Spring	17/11/2014	51	No	-	-	-	

28	2	Spring	17/11/2014	52	No	-	-	-	
29	2	Spring	17/11/2014	53	No	-	-	-	
32	2	Spring	17/11/2014	54	No	-	-	-	
30	2	Spring	17/11/2014	55	No	-	-	-	
31	2	Spring	17/11/2014	56	No	-	-	-	Termites starting to eat the back
5	2	Spring	17/11/2014	57	No	-	-	-	
6	2	Spring	17/11/2014	58	No	-	-	-	
8	2	Spring	17/11/2014	59	No	-	-	-	
4	2	Spring	17/11/2014	61	No	-	-	-	
3	2	Spring	17/11/2014	62	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
7	2	Spring	17/11/2014	63	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
13	2	Spring	17/11/2014	64	No	-	-	-	
16	2	Spring	17/11/2014	65	No	-	-	-	
14	2	Spring	17/11/2014	66	No	-	-	-	
15	2	Spring	17/11/2014	67	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
17	2	Spring	17/11/2014	68	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
64	2	Spring	17/11/2014	95	No	-	-	-	
65	2	Spring	17/11/2014	96	No	-	-	-	
65	2	Spring	17/11/2014	97	No	-	-	-	
69	2	Spring	17/11/2014	98	No	-	-	-	
67	2	Spring	17/11/2014	99	No	-	-	-	
63	2	Spring	14/11/2014	100	No	-	-	-	
68	2	Spring	14/11/2014	101	No	-	-	-	

54	2	Spring	14/11/2014	130	No	-	-	-	
58	2	Spring	14/11/2014	131	No	-	-	-	
62	2	Spring	14/11/2014	132	No	-	-	-	
59	2	Spring	14/11/2014	133	No	-	-	-	
61	2	Spring	14/11/2014	134	No	-	-	-	
56	2	Spring	14/11/2014	135	No	-	-	-	
57	2	Spring	14/11/2014	136	No	-	-	-	
55	2	Spring	14/11/2014	137	No	-	-	-	
60	2	Spring	14/11/2014	138	No	-	-	-	
2	2	Spring	17/11/2014	139	No	-	-	-	
1	2	Spring	17/11/2014	140	No	-	-	-	
42	2	Spring	17/11/2014	28B	No	-	-	-	

Ref: 2431415d:BatBoxMonitoringSummer2015

20th February 2015

McConnell Dowell OHL Joint Venture
205 Rodeo Drive
Kundabung, NSW 2441
Attention: James Hamilton/Jamie Crawford

Re: K2K Bat Box Monitoring –Episode 3 (Summer 2015)

Please find within, a summary of the Kundabung to Kempsey Bat Box Monitoring – Episode 3 as a registered output for your records in delivering the construction related component of the Ecological Monitoring Plan (SMEC-Hyder Joint Venture 2014) and associated Micro Bat Management Strategy (Lewis 2013). Monitoring for Episode 3 was performed on the 21st of January and the 17th February 2015 in accordance with Lewis Ecological Surveys Safe Work Method Statement Version 3. This was the first monitoring episode to take place since the clearing and grubbing program commenced in November 2014.

All 75 of the Roads and Maritime installed bat boxes were located and inspected for signs of bats or any other fauna inhabiting them. On this occasion, five of the boxes were inhabited by two species of bat (6.6% of all boxes deployed) known as the Gould's Long-eared Bat (*Nyctophilus gouldi*) and Lesser Long-eared Bat (*Nyctophilus geoffroyi*). Both of these species were recorded during monitoring episode one and are considered wide ranging and common across Australia. There was no evidence of any of the target species (i.e. Southern Myotis *Myotis macropus*) recorded during this round of monitoring.

With regard to bat box occupancy rates, this round of monitoring was an increase from the spring monitoring (Episode 2) where none of the bat boxes were being used by bats and is slightly higher though comparable to the winter monitoring (Episode 1) where four (5.3%) of the boxes were inhabited by bats (Lewis 2014a, Lewis 2014b). The variation in these occupancy rates could be attributed to a number of factors, the most obvious here being the clearing works where hundreds of hollow bearing trees have now been removed or simply the environmental variables associated with seasonality and the recent high rainfall combined with the shelter qualities of the boxes themselves.

Monitoring during Episode 3 also recorded a continuation in the use of the bat boxes by other types of native fauna referred to here as non target species. On this occasion, 15 (20.0%) of the bat boxes contained leaf nests constructed by either the Brown Antechinus (*Antechinus stuartii*), a small scansorial dasyurid, or the Feather-tail Glider (*Acrobates pygmaeus*) which is the world's smallest gliding marsupial. Since the monitoring began in August 2014 there has been a continuing upwards trend on the use of boxes by non target species with Episode 1 reporting 10.6%, Episode 2 increased to 17.3% and now it sits at 20% (Lewis 2014a, Lewis 2014b). This confirms that bat boxes themselves provide an alternative den/roost resource and therefore contribute to the required quantities of nest boxes outlined in the Nest Box Plan of Management for the Oxley Highway to Kempsey Upgrade. With regard to the different bat box designs it is the wedge shape bat box that is continuing to provide a disproportionally high rate of occupancy for non target species with five (33.3%) of the 15 boxes being used despite this design only comprising 22.6% (n=17) of all boxes installed.

The uptake of nest boxes by non-target species could be attributed to a couple of factors which have been discussed in previous summaries of the bat box monitoring program (Lewis 2014a, Lewis 2014b). Firstly, the boxes have not been installed in a manner consistent with the micro bat management strategy to improve their uptake by the target species, and secondly, the wedge shape design may not be entirely suitable when designing a bat specific bat box. This first point was drawn to the attention of the Joint Venture following monitoring of Episode 1 (Lewis 2014a) and as yet there has been no directive provided to amend or address the poor installation of the Roads and Maritime installed bat boxes. The details of this were provided for monitoring Episode 1 (Lewis 2014a) and need not be repeated again.

With regard to maintenance of the boxes, termites on Bat Box 56 now appear dormant and at present the box shows no obvious structural damage that limits its functionality. Bat Box 54 now has some termite tunnels within the structure and the extent of this damage will be evaluated and reported on during the next round of monitoring schedule for mid to late autumn.

Please also find an attached excel spreadsheet as an addendum file to this letter report which detailed the specifics of each box. Should you have any questions or queries please contact me at your convenience.

Kind Regards

Ben Lewis (Principal Ecologist)
Lewis Ecological Surveys
(ACN – 166970378)

References

Lewis Ecological Surveys (2013). *Pacific Highway Upgrade: Oxley Highway to Kempsey Microchiropteran Bat Management Strategy.* Prepared for Roads and Maritime Services by Lewis Ecological Surveys.

Lewis, B. (2014a). Monitoring of Bat 75 Boxes for Winter Period 2014. Letter Report to McConnell Dowell Constructors (Aust) Pty Ltd.

Lewis, B. (2014b). Monitoring of Bat 75 Boxes for Spring Period 2014. Letter Report to McConnell Dowell Constructors (Aust) Pty Ltd.

SMEC-Hyder (2014). Oxley Highway to Kempsey Pacific Highway Upgrade: Ecological Monitoring Program. Prepared for RMS.

Lewis Ecological Surveys Record Number	Monitoring Episode	Season	Date Recorded	Box Number	Bats Recorded	Species Name	Common Name	Number	Comments
34	3	Summer	21/01/2015	2	No	-	-	-	
35	3	Summer	21/01/2015	3	No	-	-	-	
36	3	Summer	21/01/2015	4	No	-	-	-	
31	3	Summer	21/01/2015	5	No	-	-	-	
30	3	Summer	21/01/2015	6	No	-	-	-	
29	3	Summer	21/01/2015	7	Yes	*Nyctophilus geoffroyi*	Lesser Long-eared Bat	-	*N. geoffroyi* X1
32	3	Summer	21/01/2015	8	No	-	-	-	
33	3	Summer	21/01/2015	9	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
1	3	Summer	21/01/2015	10	No	-	-	-	
2	3	Summer	21/01/2015	11	No	-	-	-	
4	3	Summer	21/01/2015	12	No	-	-	-	
3	3	Summer	21/01/2015	13	No	-	-	-	
5	3	Summer	21/01/2015	14	No	-	-	-	
6	3	Summer	21/01/2015	15	No	-	-	-	
48	3	Summer	21/01/2015	16	No	-	-	-	
49	3	Summer	21/01/2015	17	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
50	3	Summer	21/01/2015	18	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider, mostly open (old)
51	3	Summer	21/01/2015	19	No	-	-	-	
52	3	Summer	21/01/2015	20	No	-	-	-	
53	3	Summer	21/01/2015	21	No	-	-	-	

17	3	Summer	21/01/2015	22	Yes	*Nytophorus gouldi*	Gould's Long-eared Bat	-	*Nytophorus* sp. X 9 (4 were *N. gouldi*)
18	3	Summer	21/01/2015	23	No	-	-	-	
20	3	Summer	21/01/2015	24	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
21	3	Summer	21/01/2015	25	No	-	-	-	
22	3	Summer	21/01/2015	26	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
19	3	Summer	21/01/2015	27	No	-	-	-	
25	3	Summer	21/01/2015	28	No	-	-	-	
23	3	Summer	21/01/2015	29	No	-	-	-	
28	3	Summer	21/01/2015	30	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
9	3	Summer	17/02/2015	31	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
27	3	Summer	21/01/2015	32	Yes	*Nytophorus gouldi*	Gould's Long-eared Bat	-	*Nytophorus gouldi* x 1
26	3	Summer	21/01/2015	35	No	-	-	-	
7	3	Summer	17/02/2015	36	No	-	-	-	
8	3	Summer	17/02/2015	37	No	-	-	-	
10	3	Summer	17/02/2015	38	No	-	-	-	
9	3	Summer	21/01/2015	46	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
8	3	Summer	21/01/2015	47	No	-	-	-	
7	3	Summer	21/01/2015	49	No	-	-	-	
12	3	Summer	21/01/2015	50	No	-	-	-	
10	3	Summer	21/01/2015	51	No	-	-	-	

16	3	Summer	21/01/2015	52	Yes	*Nytophorus gouldi*	Gould's Long-eared Bat	-	*Nytophorus* sp. X 22 (one was *N. gouldi* with photo)
15	3	Summer	21/01/2015	53	No	-	-	-	
11	3	Summer	21/01/2015	54	No	-	-	-	Termite starting to build a nest
13	3	Summer	21/01/2015	55	No	-	-	-	
14	3	Summer	21/01/2015	56	No	-	-	-	
3	3	Summer	17/02/2015	57	No	-	-	-	
4	3	Summer	17/02/2015	58	No	-	-	-	
6	3	Summer	17/02/2015	59	No	-	-	-	
2	3	Summer	17/02/2015	61	No	-	-	-	
1	3	Summer	17/02/2015	62	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
5	3	Summer	17/02/2015	63	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
11	3	Summer	17/02/2015	64	No	-	-	-	
13	3	Summer	17/02/2015	65	No	-	-	-	
15	3	Summer	17/02/2015	66	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
12	3	Summer	17/02/2015	67	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
14	3	Summer	17/02/2015	68	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
55	3	Summer	21/01/2015	95	No	-	-	-	
54	3	Summer	21/01/2015	96	No	-	-	-	
57	3	Summer	21/01/2015	97	No	-	-	-	
58	3	Summer	21/01/2015	98	No	-	-	-	
59	3	Summer	21/01/2015	99	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
56	3	Summer	21/01/2015	100	No	-	-	-	
60	3	Summer	21/01/2015	101	No	-	-	-	

46	3	Summer	21/01/2015	130	No	-	-	-	
43	3	Summer	21/01/2015	131	No	-	-	-	
39	3	Summer	21/01/2015	132	No	-	-	-	
40	3	Summer	21/01/2015	133	No	-	-	-	
44	3	Summer	21/01/2015	134	No	-	-	-	
41	3	Summer	21/01/2015	135	No	-	-	-	
42	3	Summer	21/01/2015	136	Yes	*Nytophorus gouldi*	Gould's Long-eared Bat	-	*Nytophorus gouldi* x 1
47	3	Summer	21/01/2015	137	No	-	-	-	
45	3	Summer	21/01/2015	138	No	-	-	-	
37	3	Summer	21/01/2015	139	No	-	-	-	
38	3	Summer	21/01/2015	140	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
24	3	Summer	21/01/2015	28B	No	-	-	-	

Ref: 2431516d:BatBoxMonitoringAutumn2015

17th April 2015

McConnell Dowell OHL Joint Venture
Kundabung Road
Kundabung, NSW 2441
Attention: James Hamilton

Re: Kundabung to Kempsey Bat Box Monitoring – Episode 4 (Autumn 2015)

Please find within, a summary of the Kundabung to Kempsey Bat Box Monitoring – Episode 4 as a registered output for your records in delivering the construction related component of the Ecological Monitoring Plan (SMEC-Hyder Joint Venture 2014) and associated Micro Bat Management Strategy (Lewis 2013a). Monitoring for Episode 4 was performed between the 14th and 16th April 2015 in accordance with Lewis Ecological Surveys Safe Work Method Statement Version 4. This was the second monitoring episode to take place since the clearing and grubbing program commenced in November 2014.

All 75 of the Roads and Maritime installed bat boxes were located and inspected for signs of bats or any other fauna inhabiting them. On this occasion, no bats were detected roosting in any of the bat boxes. This result is partly attributed to how the bat boxes have been installed and no corrective action has been performed to rectify the problem which has been identified since monitoring episode 1 in late August 2014 (Lewis 2014a). Future monitoring is likely to continue to produce disappointing results until the problem is rectified.

With regard to bat box occupancy rates, this round of monitoring represents a decline from the previous winter and summer monitoring when both periods recorded 5.3% and 6.6% occupancy rates (Lewis 2014a, Lewis 2015). The current result is the same as the spring monitoring (i.e. Episode 2) indicating that bats may only periodically use the bat boxes as a short term respite following the initial clearing phase or simply as a seasonal roost resource for species like Gould's Long-eared Bat (*Nyctophilus gouldi*) and Lesser Long-eared Bat (*Nyctophilus geoffroyi*) at other times of the year.

Monitoring during Episode 4 also recorded a continuation in the use of the bat boxes by other types of native fauna referred too here as non target species. On this occasion, 13 (17.3%) of the bat boxes contained leaf nests constructed by either the Brown Antechinus (*Antechinus stuartii*), a small scansorial dasyurid, or the Feather-tail Glider (*Acrobates pygmaeus*) which is the world's smallest gliding marsupial. Since the monitoring began in August 2014, there has been a continuing upwards trend on the use of boxes by non target species with Episode 1 reporting 10.6%, Episode 2 increased to 17.3% and Episode 3 to 20%, however, the uptake now appears to have stabilised around 17-20% or one in every five boxes. This confirms that bat boxes themselves provide an alternative den/roost resource and therefore contribute to the required quantities of nest boxes outlined in the Nest Box Plan of Management for the Oxley Highway to Kempsey Upgrade (Lewis 2013b). With regard to the different bat box designs, the wedge shape bat box continues to provide a disproportionally high rate of occupancy for non target species with six (46.2%) of the 13 boxes being used despite this design only comprising 22.6% (n=17) of all boxes installed.

The uptake of nest boxes by non-target species could be attributed to a couple of factors which have been discussed in previous summaries of the bat box monitoring program (Lewis 2014a, 2014b, 2015). Firstly, the boxes have not been installed in a manner consistent with the micro bat management strategy to improve their uptake by the target species, and secondly, the wedge shape design may not be entirely suitable when designing a bat specific bat box.

With regard to maintenance of the boxes, termites on Bat Box 54 and 56 both now appear dormant and at present the box shows no obvious structural damage that limits its functionality. These boxes will be evaluated and reported on during the next round of monitoring schedule for mid to late winter.

Please also find an attached excel spreadsheet as an addendum file to this letter report which detailed the specifics of each box. Should you have any questions or queries please contact me at your convenience.

Kind Regards

Ben Lewis (Principal Ecologist)
Lewis Ecological Surveys
(ACN – 166970378)

References

Lewis, B.D. (2013a). *Pacific Highway Upgrade: Oxley Highway to Kempsey Microchiropteran Bat Management Strategy.* Prepared for Roads and Maritime Services by Lewis Ecological Surveys.

Lewis, B.D (2013b). Oxley Highway to Kempsey: Nest Box Plan of Management. Report prepared for SMEC-Hyder Joint Venture by Lewis Ecological Surveys. ©

Lewis, B. (2014a). Kundabung to Kempsey Bat Box Monitoring: Episode 1 Winter Period 2014. Letter Report to McConnell Dowell Constructors (Aust) Pty Ltd.

Lewis, B. (2014b). Kundabung to Kempsey Bat Box Monitoring: Episode 2 Spring Period 2014. Letter Report to McConnell Dowell Constructors (Aust) Pty Ltd.

Lewis, B. (2015). Kundabung to Kempsey Bat Box Monitoring: Episode 3 Autumn Period 2015. Letter Report to McConnell Dowell Constructors (Aust) Pty Ltd.

SMEC-Hyder (2014). Oxley Highway to Kempsey Pacific Highway Upgrade: Ecological Monitoring Program. Prepared for RMS.

Lewis Ecological Surveys Record Number	Monitoring Episode	Season	Date Recorded	Box Number	Bats Recorded	Species Name	Common Name	Number	Comments
55	4	Autumn	16/04/2015	2	No	-	-	-	
56	4	Autumn	16/04/2015	3	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
57	4	Autumn	16/04/2015	4	No	-	-	-	
52	4	Autumn	16/04/2015	5	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
51	4	Autumn	16/04/2015	6	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
50	4	Autumn	16/04/2015	7	No	-	-	-	
53	4	Autumn	16/04/2015	8	No	-	-	-	
54	4	Autumn	16/04/2015	9	No	-	-	-	
8	4	Autumn	14/04/2015	10	No	-	-	-	
7	4	Autumn	14/04/2015	11	No	-	-	-	
5	4	Autumn	14/04/2015	12	No	-	-	-	
6	4	Autumn	14/04/2015	13	No	-	-	-	
4	4	Autumn	14/04/2015	14	No	-	-	-	
3	4	Autumn	14/04/2015	15	No	-	-	-	
10	4	Autumn	14/04/2015	16	No	-	-	-	
11	4	Autumn	14/04/2015	17	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
14	4	Autumn	14/04/2015	18	No	-	-	-	
13	4	Autumn	14/04/2015	19	No	-	-	-	
12	4	Autumn	14/04/2015	20	No	-	-	-	
9	4	Autumn	14/04/2015	21	No	-	-	-	

41	4	Autumn	15/04/2015	22	No	-	-	-	
43	4	Autumn	15/04/2015	23	No	-	-	-	
44	4	Autumn	15/04/2015	24	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
46	4	Autumn	15/04/2015	25	No	-	-	-	
45	4	Autumn	15/04/2015	26	No	-	-	-	
42	4	Autumn	15/04/2015	27	No	-	-	-	
49	4	Autumn	15/04/2015	28	No	-	-	-	
47	4	Autumn	15/04/2015	29	No	-	-	-	
59	4	Autumn	15/04/2015	30	No	-	-	-	
69	4	Autumn	15/04/2015	31	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
58	4	Autumn	15/04/2015	32	No	-	-	-	
60	4	Autumn	15/04/2015	35	No	-	-	-	
68	4	Autumn	15/04/2015	36	No	-	-	-	
67	4	Autumn	15/04/2015	37	No	-	-	-	
66	4	Autumn	15/04/2015	38	No	-	-	-	
32	4	Autumn	14/04/2015	46	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
33	4	Autumn	14/04/2015	47	No	-	-	-	
34	4	Autumn	14/04/2015	49	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
38	4	Autumn	15/04/2015	50	No	-	-	-	Inside the clearing limit
31	4	Autumn	14/04/2015	51	No	-	-	-	

39	4	Autumn	15/04/2015	52	No	-	-	-	
40	4	Autumn	15/04/2015	53	No	-	-	-	
37	4	Autumn	14/04/2015	54	No	-	-	-	
36	4	Autumn	14/04/2015	55	No	-	-	-	
35	4	Autumn	14/04/2015	56	No	-	-	-	
73	4	Autumn	15/04/2015	57	No	-	-	-	
74	4	Autumn	15/04/2015	58	No	-	-	-	
71	4	Autumn	15/04/2015	59	No	-	-	-	
70	4	Autumn	15/04/2015	61	No	-	-	-	
75	4	Autumn	15/04/2015	62	No	-	-	-	
72	4	Autumn	15/04/2015	63	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
65	4	Autumn	15/04/2015	64	No	-	-	-	
64	4	Autumn	15/04/2015	65	No	-	-	-	
63	4	Autumn	15/04/2015	66	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
62	4	Autumn	15/04/2015	67	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
61	4	Autumn	15/04/2015	68	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
29	4	Autumn	14/04/2015	95	No	-	-	-	
28	4	Autumn	14/04/2015	96	No	-	-	-	
27	4	Autumn	14/04/2015	97	No	-	-	-	
24	4	Autumn	14/04/2015	98	No	-	-	-	
25	4	Autumn	14/04/2015	99	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
30	4	Autumn	14/04/2015	100	No	-	-	-	
26	4	Autumn	14/04/2015	101	No	-	-	-	

22	4	Autumn	14/04/2015	130	No	-	-	-	
17	4	Autumn	14/04/2015	131	No	-	-	-	
21	4	Autumn	14/04/2015	132	No	-	-	-	
18	4	Autumn	14/04/2015	133	No	-	-	-	
19	4	Autumn	14/04/2015	134	No	-	-	-	
16	4	Autumn	14/04/2015	135	No	-	-	-	
15	4	Autumn	14/04/2015	136	No	-	-	-	
23	4	Autumn	14/04/2015	137	No	-	-	-	
20	4	Autumn	14/04/2015	138	No	-	-	-	
1	4	Autumn	14/04/2015	139	No	-	-	-	
2	4	Autumn	14/04/2015	140	No	-	-	-	
48	4	Autumn	15/04/2015	28B	No	-	-	-	

Ref: 2431516d:BatBoxMonitoringWinter2015

25th July 2015

McConnell Dowell OHL Joint Venture
Kundabung Road
Kundabung, NSW 2441
Attention: James Hamilton

Re: Kundabung to Kempsey Bat Box Monitoring – Episode 5 (Winter 2015)

Please find within, a summary of the Kundabung to Kempsey Bat Box Monitoring – Episode 5 as a registered output for your records in delivering the construction related component of the Ecological Monitoring Plan (SMEC-Hyder Joint Venture 2014) and associated Micro Bat Management Strategy (Lewis 2013a). Monitoring for Episode 5 was performed between the 6th and 17th July and represents the third monitoring episode to have taken place since the clearing and grubbing program commenced in November 2014.

All 75 of the Roads and Maritime installed bat boxes were located and inspected for signs of micro bats or any other fauna inhabiting them. On this occasion, two bat boxes were relocated from the clearing footprint at approximate ch. 36450 to a more suitable location closer to the drainage. They include:

- Bat Box 50 (Slot Box Design) with new location details of Easting-483051.77 Northing-6554308.88 where it has been installed 3.5 m up in a Paperbark overhanging the water;
- Bat Box 56 (Black wedge box) with new location details of Easting-483071.36 Northing-6554342.94 where it now located 3.5 m up in a Paperbark, also overhanging the water.

Both of the updated locations have been transcribed in the attached excel working sheet and were recorded in GDA94 format.

Micro bats were recorded inhabiting five (6.7%) of the 75 boxes comprising two species of Long-eared Bat; Lesser Long-eared Bat (*Nyctophilus geoffroyi*) and Gould's Long-eared Bat (*Nyctophilus gouldi*). Both of these species are not currently listed as threatened species pursuant to state (*TSC* Act 1995) and commonwealth (*EPBC* Act 1999) legislation. Both species have been previously recorded using the installed boxes and the repeated seasonal use of Bat Box 9 at Smiths Creek would suggest some level of roost fidelity.

With regard to bat box occupancy rates, this round of monitoring represents an increase from the previous autumn monitoring and is comparable to the past winter and summer monitoring episodes which recorded occupancy rates of 5.3% and 6.6% respectively (Figure 1-1). The results suggest some forest dwelling bats will readily occupy these artificial roost sites, however, the key target species such as the Southern Myotis (*Myotis macropus*) and Bent-wing Bats (*Miniopterus spp*.) may be more reluctant. One of the more plausible reasons for this is the placement of the boxes over dry land as opposed to water so as to align with the approved micro bat management strategy (i.e. Lewis 2013a; Lewis 2014a,b). The Southern Myotis is known to utilise these bat box designs when they are suspended over water which appears to be an important determinant in their roost site selection. The water itself is thought to increase the localised humidity at the roost site and this can prevent the wings of bats from drying out. Having water beneath the roost site is also thought to reduce the predation risk of the roost site thus making it more attractive to micro bats.

Another interesting aspect of the monitoring to date is the absence of micro bats use the bat boxes during the spring and autumn months. During the spring period, Long-eared Bats are normally breeding and probably take up residence in larger voids used as maternity roosts. It is unclear why micro bats are absent during the autumn monitoring, and perhaps a more definitive explanation will be forthcoming at the end of the monitoring program.

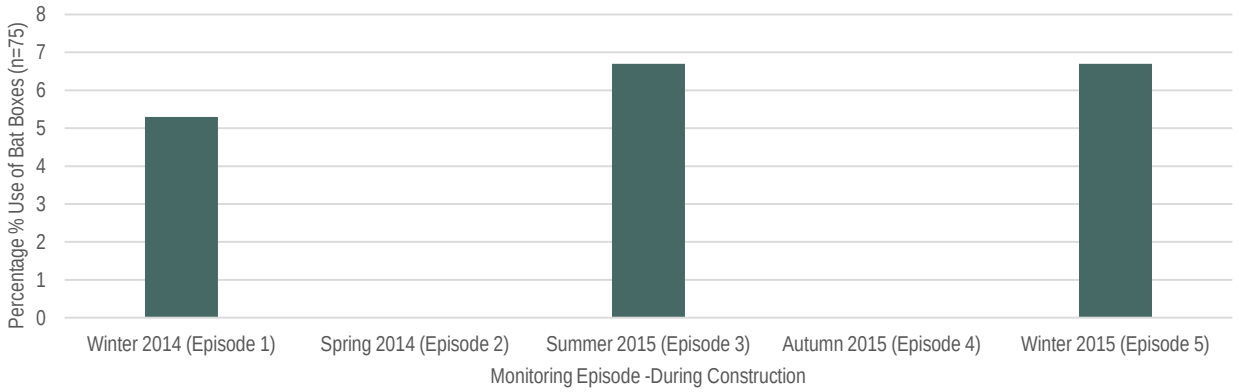

Figure 1-1. Micro bat occupancy rates over the five monitoring episodes.

Monitoring during Episode 5 also recorded a continuation in the use of the bat boxes by other types of native fauna referred too here as non target species. On this occasion, 17 (22.6%) of the bat boxes contained leaf nests constructed by either the Brown Antechinus (*Antechinus stuartii*), a small scansorial dasyurid, or the Feather-tail Glider (*Acrobates pygmaeus*) which is the world's smallest gliding marsupial. It should be noted that no direct observations of these two species were made but rather their constructed nests of leaves. Since the monitoring began in August 2014, there has been a continuing upwards trend on the use of boxes by non target species with Episode 1 reporting 10.6%, Episode 2 increased to 17.3%, Episode 3 to 20%, Episode 4 17.3% and now an incremental increase to 22.6% (Lewis 2014 a,b; Lewis 2015 a,b; Figure 1-2). This confirms that bat boxes themselves provide an alternative den/roost resource and therefore contribute to the required quantities of nest boxes outlined in the Nest Box Plan of Management for the Oxley Highway to Kempsey Upgrade (Lewis 2013b).

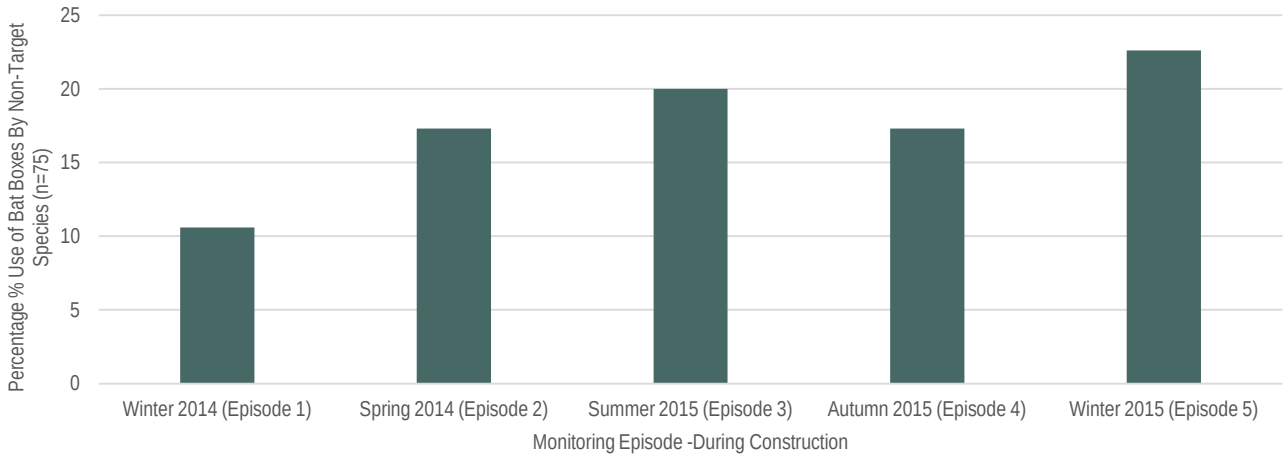

Figure 1-2. Occupancy rates of non target species over the five monitoring episodes.

With regard to the maintenance of the bat boxes, termites on both box number 54 and 56 remain dormant and at present the box shows no obvious structural damage that would limit its functionality. Continual evaluation of this will be required to ensure the boxes remain in a functional state during the remainder of the construction program.

Please also find an attached excel spreadsheet as an addendum file to this letter report which detailed the specifics of each box. Should you have any questions or queries please contact me at your convenience.

Kind Regards

Ben Lewis (Principal Ecologist)
Lewis Ecological Surveys

Plate 1-1. Gould's Long-eared Bat (*Nyctophilus gouldi*) inhabiting a green coloured slot design box from Barrys Creek area.

References

Lewis, B.D. (2013a). *Pacific Highway Upgrade: Oxley Highway to Kempsey Microchiropteran Bat Management Strategy.* Prepared for Roads and Maritime Services by Lewis Ecological Surveys.

Lewis, B.D (2013b). Oxley Highway to Kempsey: Nest Box Plan of Management. Report prepared for SMEC-Hyder Joint Venture by Lewis Ecological Surveys. ©

Lewis, B. (2014a). Kundabung to Kempsey Bat Box Monitoring: Episode 1 Winter Period 2014. Letter Report to McConnell Dowell Constructors (Aust) Pty Ltd.

Lewis, B. (2014b). Kundabung to Kempsey Bat Box Monitoring: Episode 2 Spring Period 2014. Letter Report to McConnell Dowell Constructors (Aust) Pty Ltd.

Lewis, B. (2015a). Kundabung to Kempsey Bat Box Monitoring: Episode 3 Summer Period 2015. Letter Report to McConnell Dowell Constructors (Aust) Pty Ltd.

Lewis, B. (2015b). Kundabung to Kempsey Bat Box Monitoring: Episode 4 Autumn Period 2015. Letter Report to McConnell Dowell Constructors (Aust) Pty Ltd.

SMEC-Hyder (2014). Oxley Highway to Kempsey Pacific Highway Upgrade: Ecological Monitoring Program. Prepared for RMS.

Lewis Ecological Surveys Record Number	Monitoring Episode	Season	Date Recorded	Box Number	Bats Recorded	Species Name	Common Name	Number	Comments
55	4	Winter	09.07.2015	2	No	-	-	-	
56	4	Winter	09.07.2015	3	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
57	4	Winter	09.07.2015	4	No	-	-	-	
52	4	Winter	09.07.2015	5	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
51	4	Winter	09.07.2015	6	No	-	-	-	
50	4	Winter	09.07.2015	7	No	-	-	-	
53	4	Winter	09.07.2015	8	No	-	-	-	
54	4	Winter	09.07.2015	9	Yes	*Nyctophilus geoffroyi*	Lesser Long-eared Bat	5	Box has been previously used by this species. Suggest some seasonal site fidelity
8	4	Winter	10.07.2015	10	No	-	-	-	
7	4	Winter	10.07.2015	11	No	-	-	-	
5	4	Winter	10.07.2015	12	No	-	-	-	
6	4	Winter	10.07.2015	13	No	-	-	-	
4	4	Winter	10.07.2015	14	No	-	-	-	
3	4	Winter	10.07.2015	15	No	-	-	-	
10	4	Winter	10.07.2015	16	No	-	-	-	
11	4	Winter	10.07.2015	17	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
14	4	Winter	10.07.2015	18	No	-	-	-	
13	4	Winter	10.07.2015	19	No	-	-	-	
12	4	Winter	10.07.2015	20	No	-	-	-	
9	4	Winter	10.07.2015	21	No	-	-	-	
41	4	Winter	11.07.2015	22	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider

43	4	Winter	11.07.2015	23	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
44	4	Winter	11.07.2015	24	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
46	4	Winter	11.07.2015	25	No	-	-	-	
45	4	Winter	11.07.2015	26	No	-	-	-	
42	4	Winter	11.07.2015	27	No	-	-	-	
49	4	Winter	11.07.2015	28	No	-	-	-	
47	4	Winter	11.07.2015	29	No	-	-	-	
59	4	Winter	17.07.2015	30	No	-	-	-	
69	4	Winter	17.07.2015	31	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
58	4	Winter	17.07.2015	32	No	-	-	-	
60	4	Winter	17.07.2015	35	No	-	-	-	
68	4	Winter	17.07.2015	36	No	-	-	-	
67	4	Winter	17.07.2015	37	No	-	-	-	
66	4	Winter	17.07.2015	38	No	-	-	-	
32	4	Winter	17.07.2015	46	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
33	4	Winter	17.07.2015	47	Yes	*Nyctophilus geoffroyi*	Lesser Long-eared Bat	3	
34	4	Winter	17.07.2015	49	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
38	4	Winter	17.07.2015	50	No	-	-	-	Relocated to the driange line 30 m to the east in a Paperbark: Easting-483051.77 Northing-6554308.88
31	4	Winter	17.07.2015	51	No	-	-	-	
39	4	Winter	17.07.2015	52	No	-	-	-	

40	4	Winter	17.07.2015	53	No	-	-	-	
37	4	Winter	17.07.2015	54	No	-	-	-	
36	4	Winter	17.07.2015	55	No	-	-	-	
35	4	Winter	17.07.2015	56	No	-	-	-	Relocated to the driange line 30 m to the east in a Paperbark: Easting-483071.36 Northing-6554342.94
73	4	Winter	17.07.2015	57	No	-	-	-	
74	4	Winter	17.07.2015	58	No	-	-	-	
71	4	Winter	17.07.2015	59	No	-	-	-	
70	4	Winter	17.07.2015	61	Yes	*Nyctophilus geoffroyi*	Lesser Long-eared Bat	1	
75	4	Winter	17.07.2015	62	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
72	4	Winter	14.07.2015	63	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
65	4	Winter	14.07.2015	64	No	-	-	-	
64	4	Winter	14.07.2015	65	No	-	-	-	
63	4	Winter	14.07.2015	66	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
62	4	Winter	14.07.2015	67	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
61	4	Winter	14.07.2015	68	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
29	4	Winter	14.07.2015	95	No	-	-	-	
28	4	Winter	14.07.2015	96	No	-	-	-	
27	4	Winter	14.07.2015	97	No	-	-	-	
24	4	Winter	14.07.2015	98	No	-	-	-	
25	4	Winter	14.07.2015	99	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
30	4	Winter	14.07.2015	100	No	-	-	-	
26	4	Winter	14.07.2015	101	No	-	-	-	
22	4	Winter	06.07.2015	130	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider

17	4	Winter	06.07.2015	131	No	-	-	-	
21	4	Winter	06.07.2015	132	No	-	-	-	
18	4	Winter	06.07.2015	133	Yes	*Nyctophilus gouldi*	Gould's Long-eared Bat	3	
19	4	Winter	06.07.2015	134	No	-	-	-	
16	4	Winter	06.07.2015	135	No	-	-	-	
15	4	Winter	06.07.2015	136	No	-	-	-	
23	4	Winter	06.07.2015	137	No	-	-	-	Leaves in box, Possible Antechinus or Feather-tailed Glider
20	4	Winter	06.07.2015	138	No	-	-	-	
1	4	Winter	06.07.2015	139	No	-	-	-	
2	4	Winter	06.07.2015	140	Yes	*Nyctophilus geoffroyi*	Lesser Long-eared Bat	2	
48	4	Winter	06.07.2015	28B	No	-	-	-	

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16 July 2014

Cc Grant Fletcher

Dear Nathan,

RE: Winter 2014 bat box inspection – event #1.

On 3 and 4 June 2014 Sandpiper ecologists, Dr Brendan Taylor and Mr Tom Welch, inspected 83 bat boxes installed as part of the Oxley Highway to Kempsey Microbat Management Strategy (Lewis 2014). Bat boxes were installed by RPS (2013). The inspection was undertaken using a purpose built nest box (or pole) camera attached to a 9m extension pole. The nest box camera is used in preference to visual inspection via a ladder or a tree climber. The use of tree climbers is problematic as they are generally not qualified to identify or handle bats and there are safety concerns about using ladders. If bats are detected, and closer inspection is required for identification, then a ladder is used, under controlled conditions, to access the box. The pole camera generally provides good visibility of the box and can be manipulated to inspect confined sections.

No bats were recorded during the inspection. The wire on Box No. 103 was loose and appears to have been stretched but otherwise all boxes were in good repair. A *Eucalypt* spp leaf nest, probably belonging to a feathertail glider (Acrobates pygmaeus), was recorded in Box No. 128.

One noted limitation was restricted visibility within wedge-shaped boxes that have a narrow <15mm entrance. The entrance was too narrow to enable access by the pole camera. Visibility in these boxes was restricted to the floor and partial view of internal roof. In future inspections a bore-scope will be used to inspect wedge-shaped boxes that cannot otherwise be inspected. The next inspection is scheduled for spring 2014.

If you have any questions regarding the information provided please contact me on 0401 195 480.

Yours Faithfully,

Dr David Rohweder
Managing Director, Senior Ecologist

Biodiversity Survey
Project Management
Impact Assessment
Ecological Monitoring
Specialist Surveys

References

RPS (2013). Pacific Highway Upgrade: Oxley Highway to Kempsey Microchiropteran roost box installation. Report prepared for NSW RMS.

Lewis, B. D. (2014). Pacific Highway Upgrade Oxley Highway to Kempsey Microbat Strategy. Report prepared for NSW RMS.

Table 1: Results of winter 2014 bat box inspection – event #1. FtG = feathertail glider; pr = probable

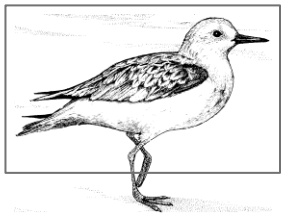
Date	RPS ID no.	Chainage	Box no.	Species	Condition	Comments
4-6-2014	46	1000	150	Nil	Good	
4-6-2014	46	1000	151	Nil	Good	Wedge; slit ~15mm.
4-6-2014	46	1000	152	Nil	Good	
4-6-2014	46	1000	89	Nil	Good	Appears 69 on box
4-6-2014	46	1000	90	Nil	Good	Wedge; slit ~15mm.
4-6-2014	46	1000	94	Nil	Good	
4-6-2014	46	1000	93	Nil	Good	
4-6-2014	46	1000	92	Nil	Good	
4-6-2014	46	1000	91	Nil	Good	Floor & ~15mm slit; partial view of roof
4-6-2014	49	1000	112	Nil	Good	Floor & ~15mm slit; partial view of roof
4-6-2014	49	1000	113	Nil	Good	
4-6-2014	49	1000	114	Nil	Good	
4-6-2014	45	1300	149	Nil	Good	
4-6-2014	45	1300	146	Nil	Good	
4-6-2014	45	1300	148	Nil	Good	
4-6-2014	45	1300	147	Nil	Good	
4-6-2014	50	1300	111	Nil	Good	Floor & ~15mm slit; partial view of roof
4-6-2014	50	1300	109	Nil	Good	
4-6-2014	50	1300	110	Nil	Good	Wedge; slit ~15mm.
4-6-2014	44	1550	86	Nil	Good	Wedge; slit ~15mm.
4-6-2014	44	1550	85	Nil	Good	
4-6-2014	44	1550	84	Nil	Good	Floor & ~15mm slit; partial view of roof
4-6-2014	44	1550	88	Nil	Good	
4-6-2014	44	1550	87	Nil	Good	
4-6-2014	51	1700	102	Nil	Good	
4-6-2014	51	1700	107	Nil	Good	Floor & ~15mm slit; partial view of roof
4-6-2014	51	1700	106	Nil	Good	
4-6-2014	51	1700	108	Nil	Good	Wedge; slit ~15mm.
4-6-2014	51	1700	103	Nil	Wire stretched/loose	Re-tightened
4-6-2014	51	1700	104	Nil	Good	
4-6-2014	47	3600	115	Nil	Good	
4-6-2014	47	3600	120	Nil	Good	
4-6-2014	47	3600	118	Nil	Good	Floor & ~15mm slit; partial view of roof
4-6-2014	47	3600	117	Nil	Good	Wedge; slit ~15mm.
4-6-2014	47	3600	116	Nil	Good	Floor & ~15mm slit; partial view of roof
4-6-2014	47	3600	119	Nil	Good	
3-6-2014	48	3800	39	Nil	Good	

Table 1 cont.

Date	RPS ID no.	Chainage	Box no.	Species	Condition	Comments
3-6-2014	48	3800	40	Nil	Good	Wedge; slit ~15mm.
3-6-2014	48	3800	41	Nil	Good	
3-6-2014	48	3800	42	Nil	Good	Wedge; slit ~15mm.
3-6-2014	48	3800	43	Nil	Good	
3-6-2014	48	3800	44	Nil	Good	
3-6-2014	48	3800	45	Nil	Good	
3-6-2014	48	3800	48	Nil	Good	
3-6-2014	48	3800	156	Nil	Good	
3-6-2014	48	3800	33	Nil?	Good	Floor & ~15mm slit; partial view of roof
3-6-2014	31	18200	78	Nil	Good	
3-6-2014	31	18200	79	Nil	Good	
3-6-2014	31	18200	80	Nil	Good	
3-6-2014	31	18200	81	Nil	Good	
3-6-2014	31	18200	82	Nil	Good	
3-6-2014	31	18200	83	Nil	Good	
3-6-2014	33	19650	122	Nil	Good	
3-6-2014	33	19650	121	Nil	Good	
3-6-2014	33	19650	127	Nil	Good	
3-6-2014	33	19650	129	Nil	Good	
3-6-2014	33	19650	124	Nil	Good	
3-6-2014	33	19650	125	Nil	Good	
3-6-2014	33	19650	126	Nil?	Good	Floor & ~15mm slit; partial view of roof
3-6-2014	33	19650	128	Euc leaves-FtG(pr)	Good	Floor & ~15mm slit; partial view of roof
3-6-2014	57	21550	142	Nil	Good	
3-6-2014	57	21550	123	Nil	Good	
3-6-2014	57	21550	141	Nil	Good	
3-6-2014	57	21550	144	Nil	Good	
3-6-2014	57	21550	145	Nil	Good	
3-6-2014	57	21550	143	Nil	Good	
3-6-2014	57	21550	1	Nil	Good	
3-6-2014	15	23700	153	Nil	Good	
3-6-2014	15	23700	154	Nil	Good	
3-6-2014	15	23700	155	Nil	Good	
3-6-2014	15	23700	157	Nil	Good	
3-6-2014	15	23700	158	Nil	Good	
3-6-2014	15	23700	159	Nil?	Good	Floor & ~15mm slit; partial view of roof
3-6-2014	15	23700	73B	Nil	Good	
3-6-2014	15	23700	69	Nil	Good	
3-6-2014	15	23700	70	Nil?	Good	Floor & ~15mm slit; partial view of roof

Table 1 cont.

Date	RPS ID no.	Chainage	Box no.	Species	Condition	Comments
3-6-2014	15	23700	72	Nil?	Good	Floor & ~15mm slit; partial view of roof
3-6-2014	13	23700	71	Nil	Good	
3-6-2014	13	23900	73A	Nil	Good	
3-6-2014	13	23900	74	Nil	Good	Wedge; slit ~15mm.
3-6-2014	13	23900	76	Nil?	Good	Floor & ~15mm slit; partial view of roof
3-6-2014	13	23900	77	Nil	Good	
3-6-2014	13	23900	75	Nil	Good	



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5 December 2014

Cc Nathan Russell

Dear Grant,

RE: Spring 2014 bat box inspection – event #2.

On 24---26 September and 20 November 2014, My Nick Priest and Mr Tom Welch, inspected 83 bat boxes installed as part of the Oxley Highway to Kempsey Microbat Management Strategy (MMS; Lewis 2014). Bat boxes were installed by RPS (2013). At the same time 39 boxes installed within 50m of the upgrade, and therefore contrary to the MMS, were relocated to >50m from the upgrade (refer SES 2014 for further discussion).

The inspection was undertaken using a purpose built nest box (or pole) camera attached to a 9m extension pole. The nest box camera is used in preference to visual inspection via a ladder or a tree climber. The use of tree climbers is problematic as they are generally not qualified to identify or handle bats and there are safety concerns about using ladders. If bats are detected, and closer inspection is required for identification, then a ladder is used, under controlled conditions, to access the box. The pole camera generally provides good visibility of the box and can be manipulated to inspect confined sections.

No bats were recorded during the inspection and all boxes were in good condition (Table 1). Potential feathertail glider dens (i.e. small amount of eucalypt leaf) were recorded in box numbers 128 and 149.

One noted limitation was restricted visibility within wedge---shaped boxes that have a narrow <15mm entrance. The entrance was too narrow to enable access by the pole camera. Visibility in these boxes was restricted to the floor and partial view of internal roof. In future inspections a bore---scope will be used to inspect wedge---shaped boxes that cannot otherwise be inspected. The next inspection is scheduled for summer 2015.

If you have any questions regarding the information provided please contact me on 0401 195 480.

Yours Faithfully,

Dr David Rohweder
Senior Ecologist

Biodiversity Survey

Project Management

Impact Assessment

Ecological Monitoring

Specialist Surveys

References

Lewis, B. D. (2013). Oxley Highway to Kempsey Michrochiropteran Bat Management Strategy. Report prepared for NSW Roads and Maritime Services.

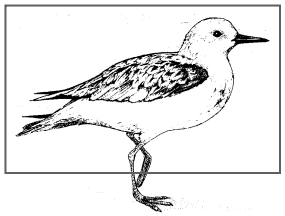
RPS (2013). Pacific Highway Upgrade: Oxley Highway to Kempsey Microchiropteran roost box installation. Report prepared for NSW RMS.

Sandpiper Ecological Surveys (2014). Memorandum: OH2Ku Microchiropteran Bat Management Strategy. Prepared for Lend Lease Engineering.

Table 1: Results of the OH2Ku winter and spring 2014 bat box surveys.

RPS ID no.	Chainage	Box no.	Winter 2014				Spring 2014			
			Date (2014)	Result	Comment	Condition	Date (2014)	Result	Comment	Condition
46	1000	150	4---6	Nil	---	Good	20/11	Nil		Good
46	1000	151	4---6	Nil		Good	20/11	Nil		Good
46	1000	152	4---6	Nil	---	Good	20/11	Nil		Good
46	1000	89	4---6	Nil	Appears 69 on box	Good	20/11	Nil		Good
46	1000	90	4---6	Nil		Good	20/11	Nil		Good
46	1000	94	4---6	Nil	---	Good	20/11	Nil		Good
46	1000	93	4---6	Nil	---	Good	20/11	Nil		Good
46	1000	92	4---6	Nil	---	Good	20/11	Nil		Good
46	1000	91	4---6	Nil		Good	20/11	Nil		Good
49	1000	112	4---6	Nil		Good	24---26/9	Nil	Relocated	Good
49	1000	113	4---6	Nil	---	Good	24---26/9	Nil	Relocated	Good
49	1000	114	4---6	Nil	---	Good	24---26/9	Nil	Relocated	Good
45	1300	149	4---6	Nil	---	Good	20/11	Bark in top cnr		Good
45	1300	146	4---6	Nil	---	Good	20/11	Nil		Good
45	1300	148	4---6	Nil	---	Good	20/11	Nil		Good
45	1300	147	4---6	Nil	---	Good	20/11	Nil		Good
50	1300	111	4---6	Nil		Good	24---26/9	Nil	Relocated	Good
50	1300	109	4---6	Nil	---	Good	24---26/9	Nil	Relocated	Good
50	1300	110	4---6	Nil		Good	24---26/9	Nil	Relocated	Good
44	1550	86	4---6	Nil		Good	20/11	Nil		Good
44	1550	85	4---6	Nil	---	Good	20/11	Nil		Good
44	1550	84	4---6	Nil		Good	20/11	Nil		Good
44	1550	88	4---6	Nil	---	Good	20/11	Nil		Good
44	1550	87	4---6	Nil	---	Good	20/11	Nil		Good
51	1700	102	4---6	Nil	---	Good	24---26/9	Nil	Relocated	Good
51	1700	107	4---6	Nil		Good	24---26/9	Nil	Relocated	Good
51	1700	106	4---6	Nil	---	Good	24---26/9	Nil	Relocated	Good
51	1700	108	4---6	Nil		Good	24---26/9	Nil	Relocated	Good
51	1700	103	4---6	Nil	Re---tightened	Wire stretched/loose	24---26/9	Nil	Relocated	Good
51	1700	104	4---6	Nil	---	Good	24---26/9	Nil	Relocated	Good
47	3600	115	4---6	Nil	---	Good	24---26/9	Nil	Relocated	Good
47	3600	120	4---6	Nil	---	Good	24---26/9	Nil	Relocated	Good
47	3600	118	4---6	Nil		Good	24---26/9	Nil		Good
47	3600	117	4---6	Nil		Good	24---26/9	Nil, mud wasp		Good
47	3600	116	4---6	Nil		Good	24---26/9	Nil		Good
47	3600	119	4---6	Nil	---	Good	24---26/9	Nil, mud wasp		Good
48	3800	39	3---6	Nil	---	Good	24---26/9	Nil	Relocated	Good
48	3800	40	3---6	Nil		Good	24---26/9	Nil	Relocated	Good
48	3800	41	3---6	Nil	---	Good	24---26/9	Nil	Relocated	Good
48	3800	42	3---6	Nil		Good	24---26/9	Nil	Relocated	Good
48	3800	43	3---6	Nil	---	Good	24---26/9	Nil	Relocated	Good
48	3800	44	3---6	Nil	---	Good	24---26/9	Nil	Relocated	Good
48	3800	45	3---6	Nil	---	Good	24---26/9	Nil	Relocated	Good
48	3800	48	3---6	Nil	---	Good	24---26/9	Nil	Relocated	Good
48	3800	156	3---6	Nil	---	Good	24---26/9	Nil	Relocated	Good

48	3800	33	3---6	Nil?		Good	24---26/9	Nil	Relocated	Good
31	18200	78	3---6	Nil	---	Good	24---26/9	Nil	Relocated	Good
31	18200	79	3---6	Nil	---	Good	24---26/9	Nil	Relocated	Good
31	18200	80	3---6	Nil	---	Good	24---26/9	Nil	Relocated	Good
31	18200	81	3---6	Nil	---	Good	24---26/9	Nil	Relocated	Good
31	18200	82	3---6	Nil	---	Good	24---26/9	Nil	Relocated	Good
31	18200	83	3---6	Nil	---	Good	24---26/9	Nil		Good
33	19650	122	3---6	Nil	---	Good	24---26/9	Nil	Relocated	Good
33	19650	121	3---6	Nil	---	Good	24---26/9	Nil	Relocated	Good
33	19650	127	3---6	Nil	---	Good	24---26/9	Nil		Good
33	19650	129	3---6	Nil	---	Good	24---26/9	Nil		Good
33	19650	124	3---6	Nil	---	Good	24---26/9	Nil		Good
33	19650	125	3---6	Nil	---	Good	24---26/9	Nil		Good
33	19650	126	3---6	Nil?		Good	24---26/9	Nil	Relocated	Good
33	19650	128	3---6	Euc leaves		Good	24---26/9	Euc. Leaves		Good
57	21550	142	3---6	Nil	---	Good	24---26/9	Nil		Good
57	21550	123	3---6	Nil	---	Good	24---26/9	Nil		Good
57	21550	141	3---6	Nil	---	Good	24---26/9	Nil		Good
57	21550	144	3---6	Nil	---	Good	24---26/9	Nil		Good
57	21550	145	3---6	Nil	---	Good	24---26/9	Nil		Good
57	21550	143	3---6	Nil	---	Good	24---26/9	Nil		Good
57	21550	1	3---6	Nil	---	Good	24---26/9	Nil	Relocated	Good
15	23700	153	3---6	Nil	---	Good	24---26/9	Nil	---	Good
15	23700	154	3---6	Nil	---	Good	24---26/9	Nil	---	Good
15	23700	155	3---6	Nil	---	Good	24---26/9	Nil	---	Good
15	23700	157	3---6	Nil	---	Good	24---26/9	Nil	---	Good
15	23700	158	3---6	Nil	---	Good	24---26/9	Nil	---	Good
15	23700	159	3---6	Nil?		Good	24---26/9	Nil		Good
15	23700	73B	3---6	Nil	---	Good	24---26/9	Nil	Relocated	Good
15	23700	69	3---6	Nil	---	Good	24---26/9	Nil	Relocated	Good
15	23700	70	3---6	Nil?		Good	24---26/9	Nil	Relocated	Good
15	23700	72	3---6	Nil?		Good	24---26/9	Nil	Relocated	Good
13	23700	71	3---6	Nil	---	Good	24---26/9	Nil	Relocated	Good
13	23900	73A	3---6	Nil	---	Good	24---26/9	Nil	Relocated	Good
13	23900	74	3---6	Nil		Good	24---26/9	Nil		Good
13	23900	76	3---6	Nil?		Good	24---26/9	Nil		Good
13	23900	77	3---6	Nil	---	Good	24---26/9	Nil	---	Good
13	23900	75	3---6	Nil	---	Good	24---26/9	Nil	---	Good



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Biodiversity Survey

Project Management

Impact Assessment

Ecological Monitoring

Specialist Surveys

Grant Fletcher
Environmental Manager
Lend Lease Engineering
OH2K Pacific Highway Upgrade
grant.fletcher@lendlease.com

18 May 2015

Cc Nathan Russell

Dear Grant,

RE: Summer and autumn 2015 bat box inspection (event #3&4) and bat box relocation.

Summer (January) and Autmn (May) 2015 bat box inspection

As part of the Oxley Highway to Kundabung (OH2Ku) upgrade, 83 microbat roost boxes (bat boxes) were installed at various locations adjacent to the alignment during 2013 (RPS 2013). The Oxley Highway to Kempsey (OH2Ke) Microbat Management Strategy (MMS; Lewis 2014) requires that seasonal inspections of bat boxes be undertaken for two years during construction. The first two inspections were conducted in winter 2014 and spring 2014. The following is a report on results of the third and fourth first year inspections conducted in summer and autumn 2015.

Seventy one of the 83 bat boxes were inspected on 29 and 30 January 2015. The remaining 12 boxes at Mel Properties land (chainage 1000-1550), which were taken down after the spring 2014 inspection, were re-installed after the summer inspection (refer below). As per previous monitoring, inspections were undertaken using a purpose-built camera attached to an extendable pole. The summer inspection revealed three long-eared bats (*Nyctophilus* sp.) roosting within the rear chamber of a slotted box (box 141) at chainage 21550 (Table 1). By comparison, no roosting microbats were detected during the spring 2014 or autumn 2015 inspections. One long-eared bat (Nyctophilus spp) was recorded in Box No. 85 on 5 May 2015, the day before the formal monitoring event. In summer and autumn three boxes (boxes 33, 128, 126) featured eucalypt leaf material most likely attributed to feathertail gliders. All boxes were in good repair. In autumn 2015 11 boxes contained insect material, mostly wasp and hornet nests.

Bat box relocation

Further to our previous advice (Sandpiper 2014), bat boxes positioned within 100m of the alignment are contrary to the MMS and require relocation. In previous correspondence (Sandpiper 2014) we recommended that the exclusion distance of 100m be reduced to 50m as noise and vibration impacts on tree roosts would be low at that distance. Accordingly, 39 bat boxes at 10 locations were relocated to outside 50m of the alignment after the spring 2014 inspection (Tables 1 & 2). A further 12 boxes from Mel Properties land (chainage 1000-1550), which required relocation, were installed <50m from alignment because of site and property constraints. A draft noise and vibration plan has been prepared to manage potential construction impacts on those boxes. The remaining 32 boxes did not require relocation and were left in their original position.

Discussion

As evident from the results presented above, very few of the bat boxes installed by RPS (RPS 2013) were done so in accordance with the MMS. Firstly, 61% of boxes were installed too close (i.e. <100m) to the alignment. Secondly, few if any of the boxes were installed overhanging >100mm of water. While acknowledging the second point, we followed the RPS box installation approach during the relocation process in order to maintain consistency of method. The number of nest boxes installed at some locations did not reflect the results of the targeted microbat surveys. Lewis (2014) recommended that bat boxes be installed adjacent to High Conservation Value (HCV) roosts only, yet during installation many boxes were installed adjacent to Low Conservation Value sites. For example, RPS (2013) installed 30 bat roost boxes, or 19% of total boxes, between chainages 1000 and 1700 to compensate for the removal of one culvert (no. 510067) that contained a single eastern horseshoe bat (Rhinalophus megaphylus) during targeted summer and winter surveys (Lewis 2013).

If you have any questions regarding the information provided please contact me on 0429 460 338.

Yours Faithfully,

Dr Brendan Taylor
Senior Ecologist

References

Lewis, B. D. (2013). Oxley Highway to Kempsey Michrochiropteran Bat Management Strategy. Report prepared for NSW Roads and Maritime Services.

RPS (2013). Pacific Highway Upgrade: Oxley Highway to Kempsey Microchiropteran roost box installation. Report prepared for NSW RMS.

Sandpiper Ecological Surveys (2014). Memorandum: OH2Ku Microchiropteran Bat Management Strategy. Prepared for Lend Lease Engineering.

Table 1: Results of spring 2014 and summer and autumn 2015 microbat box inspections. FtG = feathertail glider; A'chinus = Antechinus sp.; Pr = probable

RPS ID no.	Chainage	Box no.	2014 Spring			2015 Summer (29 & 30 January)			Autumn 2015 (6 May)		
			Species/Signs	Condition	Comments	Species/Signs	Condition	Comments			
46	1000	150	Nil	Good	Taken down	Not installed		Relocated 26/2/15	Nil	Good	
46	1000	151	Nil	Good	Taken down	Not installed		Relocated 26/2/15	Nil	Good	
46	1000	152	Nil	Good	Taken down	Not installed		Relocated 26/2/15	Nil	Good	
46	1000	89	Nil	Good	Taken down	Not installed		Relocated 26/2/15	Nil	Good	
46	1000	90	Nil	Good	Taken down	Not installed		Relocated 26/2/15	Nil	Good	
46	1000	94	Nil	Good	Taken down	Not installed		Relocated 26/2/15	Nil	Good	
46	1000	93	Nil	Good	Taken down	Not installed		Relocated 26/2/15	Nil	Good	
46	1000	92	Nil	Good	Taken down	Not installed		Relocated 26/2/15	Nil	Good	
46	1000	91	Nil	Good	Taken down	Not installed		Relocated 26/2/15	Nil	Good	
49	1000	112	Nil	Good	Relocated	Nil	Good	Insect material	Nil	Good	
49	1000	113	Nil	Good	Relocated	Nil	Good	Insect material	Nil	Good	Insect material
49	1000	114	Nil	Good	Relocated	Nil	Good		Nil	Good	
45	1300	149	Bark in top cnr-A'chinus(Pr)	Good	Not moved	Nil	Good	Insect material	Nil	Good	
45	1300	146	Nil	Good	Taken down	Not installed		Relocated 26/2/15	Nil	Good	
45	1300	148	Nil	Good		Nil	Good		Nil	Good	
45	1300	147	Nil	Good		Nil	Good		Nil	Good	
50	1300	111	Nil	Good	Relocated	Nil	Good		Nil	Good	
50	1300	109	Nil	Good	Relocated	Nil	Good		Nil	Good	
50	1300	110	Nil	Good	Relocated	Nil	Good		Nil	Good	
44	1550	86	Nil	Good		Nil	Good		Nil	Good	
44	1550	85	Nil	Good		Nil	Good		Nil	Good	1 *Nyctophilus* spp 5/5/15
44	1550	84	Nil	Good		Nil	Good		Nil	Good	
44	1550	88	Nil	Good	Taken down	Not installed		Relocated 26/2/15	Nil	Good	
44	1550	87	Nil	Good	Taken down	Not installed		Relocated 26/2/15	Nil	Good	
51	1700	102	Nil	Good	Relocated	Nil	Good		Nil	Good	
51	1700	107	Nil	Good	Relocated	Nil	Good		Nil	Good	
51	1700	106	Nil	Good	Relocated	Nil	Good		Nil	Good	

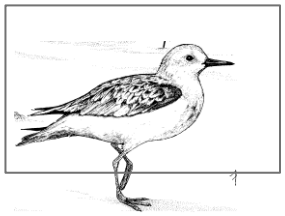
51	1700	108	Nil	Good	Relocated	Nil	Good		Nil	Good	
51	1700	103	Nil	Good	Relocated	Nil	Good		Nil	Good	
51	1700	104	Nil	Good	Relocated	Nil	Good		Nil	Good	
47	3600	115	Nil	Good	Relocated	Nil	Good		Nil	Good	
47	3600	120	Nil	Good	Relocated	Nil	Good		Nil	Good	
47	3600	118	Nil	Good		Nil	Good		Nil	Good	Insect material
47	3600	117	Nil, mud wasp	Good		Nil	Good	Insect material	Nil	Good	
47	3600	116	Nil	Good		Nil	Good		Nil	Good	
47	3600	119	Nil, mud wasp	Good		Nil	Good	Insect material	Nil	Good	Insect material
48	3800	39	Nil	Good	Relocated	Nil	Good		Nil	Good	Insect material
48	3800	40	Nil	Good	Relocated	Nil	Good	Insect material	Nil	Good	
48	3800	41	Nil	Good	Relocated	Nil	Good		Nil	Good	
48	3800	42	Nil	Good	Relocated	Nil?	Good		Nil	Good	
48	3800	43	Nil	Good	Relocated	Nil	Good		Nil	Good	
48	3800	44	Nil	Good	Relocated	Nil?	Good		Nil	Good	
48	3800	45	Nil	Good	Relocated	Nil	Good		Nil	Good	Insect material
48	3800	48	Nil	Good	Relocated	Nil	Good		Nil	Good	
48	3800	156	Nil	Good	Relocated	Nil	Good		Nil	Good	
48	3800	33	Nil	Good	Relocated	Nil	Good	Euc leaves-FtG(pr)	Nil	Good	Leaf material
31	18200	78	Nil	Good	Relocated	Nil	Good		Nil	Good	
31	18200	79	Nil	Good	Relocated	Nil	Good		Nil	Good	
31	18200	80	Nil	Good	Relocated	Nil	Good		Nil	Good	
31	18200	81	Nil	Good	Relocated	Nil	Good		Nil	Good	
31	18200	82	Nil	Good	Relocated	Nil	Good		Nil	Good	
31	18200	83	Nil	Good		Nil	Good		Nil	Good	
33	19650	122	Nil	Good	Relocated	Nil	Good		Nil	Good	Insect material
33	19650	121	Nil	Good	Relocated	Nil	Good		Nil	Good	
33	19650	127	Nil	Good		Nil	Good		Nil	Good	
33	19650	129	Nil	Good		Nil	Good		Nil	Good	
33	19650	124	Nil	Good		Nil	Good		Nil	Good	
33	19650	125	Nil	Good		Nil	Good	Insect material	Nil	Good	Insect material

33	19650	126	Nil	Good	Relocated	Nil	Good	Euc leaves-FtG(pr)	Nil	Good	Feathertail nest
33	19650	128	Euc leaves-FtG(pr)	Good		Nil	Good	Euc leaves-FtG(pr)	Nil	Good	Feathertail nest
57	21550	142	Nil	Good		Nil	Good		Nil	Good	
57	21550	123	Nil	Good		Nil	Good		Nil	Good	
57	21550	141	Nil	Good		Nyctophilus sp. x3	Good	bats in closest chamber to tree	Nil	Good	
57	21550	144	Nil	Good		Nil	Good		Nil	Good	
57	21550	145	Nil	Good		Nil	Good		Nil	Good	Insect material
57	21550	143	Nil	Good		Nil	Good				
57	21550	1	Nil	Good	Relocated	Nil	Good		Nil	Good	Insect material
15	23700	153	Nil	Good		Nil	Good		Nil	Good	
15	23700	154	Nil	Good		Nil	Good		Nil	Good	Insect material
15	23700	155	Nil	Good		Nil	Good		Nil	Good	
15	23700	157	Nil	Good		Nil	Good		Nil	Good	
15	23700	158	Nil	Good		Nil	Good		Nil	Good	
15	23700	159	Nil	Good		Nil?	Good		Nil	Good	
15	23700	73B	Nil	Good	Relocated	Nil	Good		Nil	Good	
15	23700	69	Nil	Good	Relocated	Nil	Good		Nil	Good	
15	23700	70	Nil	Good	Relocated	Nil	Good		Nil	Good	
15	23700	72	Nil	Good	Relocated	Nil	Good		Nil	Good	
13	23700	71	Nil	Good	Relocated	Nil	Good		Nil	Good	
13	23900	73A	Nil	Good	Relocated	Nil	Good		Nil	Good	
13	23900	74	Nil	Good		Nil?	Good		Nil	Good	
13	23900	76	Nil	Good		Nil?	Good		Nil	Good	
13	23900	77	Nil	Good		Nil	Good		Nil	Good	Insect material
13	23900	75	Nil	Good		Nil	Good		Nil	Good	

Table 2: Position of relocated microbat nest boxes. na = not applicable (i.e. box not requiring relocation)

RPS ID no.	Chainage	Box no.	Location of relocated nest boxes			
			Easting	Northing	Tree species	Aspect
46	1000	150	483209	6520177	P. Bloodwood	E
46	1000	151	483196	6520080	P. Bloodwood	N
46	1000	152	483196	6520080	Turpentine	NW
46	1000	89	483198	6520136	Wh. Stringybark	ESE
46	1000	90	483210	6520140	P. Bloodwood	W
46	1000	94	483200	6520168	P. Bloodwood	N
46	1000	93	483203	6520118	Turpentine	NNW
46	1000	92	483200	6520158	Tallowwood	W
46	1000	91	483209	6520176	P. Bloodwood	S
49	1000	112	483006	6520072	Pnk b'wood	NE
49	1000	113	483014	6520093	Tallow wood	N
49	1000	114	483011	6520089	Wh mahog	NE
45	1300	149	na	na	na	na
45	1300	146	483247	6520371	Turpentine	E
45	1300	148	na	na	na	na
45	1300	147	na	na	na	na
50	1300	111	483006	6520385	Turpentine	NE
50	1300	109	483100	6520400	Blackbutt	NE
50	1300	110	483047	6520392	Pnk b'wood	E
44	1550	86	na	na	na	na
44	1550	85	na	na	na	na
44	1550	84	na	na	na	na
44	1550	88	483274	6520597	Wh. Stringybark	E
44	1550	87	483282	6520590	Melaleuca spp	NNE
51	1700	102	483073	6520808	Melaleuca spp.	NW
51	1700	107	483089	6520792	Melaleuca spp.	NE
51	1700	106	483071	6520792	Melaleuca spp.	W
51	1700	108	483093	6520797	Melaleuca spp.	W
51	1700	103	483062	6520798	Melaleuca spp.	NW
51	1700	104	483105	6520823	Tallow	W
47	3600	115	482945	6522669	Tallow	NE
47	3600	120	483009	6522658	Tallow	N
47	3600	118	na	na	na	na
47	3600	117	na	na	na	na
47	3600	116	na	na	na	na
47	3600	119	na	na	na	na
48	3800	39	483339	6522898	Melaleuca qu.	NW
48	3800	40	483326	6522892	Melaleuca qu.	N
48	3800	41	483289	6522827	Melaleuca qu.	N
48	3800	42	483311	6522860	Melaleuca qu.	NW

48	3800	43	483288	6522815	Sw mahog	N
48	3800	44	483289	6522806	Melaleuca qu.	N
48	3800	45	483284	6522806	Melaleuca qu.	N
48	3800	48	483299	6522842	Melaleuca qu.	NW
48	3800	156	483309	6522814	Sw mahog	E
48	3800	33	483300	6522857	Melaleuca qu.	NW
31	18200	78	482847	6536590	Casuarina	NE
31	18200	79	482830	6536580	Casuarina	NW
31	18200	80	482867	6536606	Casuarina	W
31	18200	81	482864	6536617	Casuarina	W
31	18200	82	482867	6536583	Casuarina	NW
31	18200	83	na	na	na	na
33	19650	122	482725	6537882	Unid spp	NE
33	19650	121	482732	6537911	Unid spp	NE
33	19650	127	na	na	na	na
33	19650	129	na	na	na	na
33	19650	124	na	na	na	na
33	19650	125	na	na	na	na
33	19650	126	482725	6537888	Unid spp	NW
33	19650	128	na	na	-	na
57	21550	142	na	na	Bloodwood	na
57	21550	123	na	na	Bloodwood	na
57	21550	141	na	na	Tallow	na
57	21550	144	na	na	-	na
57	21550	145	na	na	-	na
57	21550	143	na	na	-	na
57	21550	1	482295	6539697	Sf grey gum	N
15	23700	153	na	na	na	na
15	23700	154	na	na	na	na
15	23700	155	na	na	na	na
15	23700	157	na	na	na	na
15	23700	158	na	na	na	na
15	23700	159	na	na	na	na
15	23700	73B	482339	6541780	Brushbox	NW
15	23700	69	482356	6541811	Turpentine	NE
15	23700	70	482357	6541811	Brushbox	NE
15	23700	72	482342	6541797	Turpentine	NW
13	23700	71	482351	6541801	Sf grey gum	N
13	23900	73A	482487	6542055	Brushbox	NW
13	23900	74	na	na	na	na
13	23900	76	na	na	na	na
13	23900	77	na	na	na	na
13	23900	75	na	na	na	na



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Grant Fletcher
Environmental Manager Lend
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OH2K Pacific Highway Upgrade
grant.fletcher@lendlease.com

18 August 2015

Cc Nathan Russell

Dear Grant,

RE: Winter 2015 bat box inspection (event #5).

Winter 2015 bat box inspection

As part of the Oxley Highway to Kundabung (OH2Ku) upgrade, 83 microbat roost boxes (bat boxes) were installed at various locations adjacent to the alignment during 2013 (RPS 2013). The Oxley Highway to Kempsey (OH2Ke) Microbat Management Strategy (MMS; Lewis 2014) requires that seasonal inspections of bat boxes be undertaken for two years during construction. Previous inspections have been conducted in winter and spring 2014 and summer and autumn 2015. The following is a report on results of the fifth inspection and first inspection of year two conducted in July 2015.

All bat boxes were inspected by two ecologists on 10 July 2015. As per previous monitoring, inspections were undertaken using a purpose---built camera attached to an extendable pole. No roosting microbats were recorded during the winter 2015 survey (Table 1). All boxes were in good repair.

If you have any questions regarding the information provided please contact me on 0429 460 338.

Yours Faithfully,

Dr David Rohweder
Senior Ecologist

Biodiversity Survey

Project Management

Impact Assessment

Ecological Monitoring

Specialist Surveys

References

Lewis, B. D. (2013). Oxley Highway to Kempsey Michrochiropteran Bat Management Strategy. Report prepared for NSW Roads and Maritime Services.

RPS (2013). Pacific Highway Upgrade: Oxley Highway to Kempsey Microchiropteran roost box installation. Report prepared for NSW RMS.

Table 1: Results of spring 2014 and summer, autumn and winter 2015 microbat box inspections. FtG = feathertail glider; A'chinus = Antechinus sp.; Pr = probable

RPS ID no.	Chainage	Box no.	2014 Spring	2015 Summer (29 & 30 January)	Autumn 2015 (6 May)	Winter 2015 (10 July)		
			Species/Signs	Species/Signs	Species/Signs	Species/Signs	Box condition	Comments
46	1000	150	Nil	Not installed	Nil	Nil	Good	
46	1000	151	Nil	Not installed	Nil	Nil	Good	
46	1000	152	Nil	Not installed	Nil	Nil	Good	
46	1000	89	Nil	Not installed	Nil	Nil	Good	
46	1000	90	Nil	Not installed	Nil	Nil	Good	Spider nest/webs
46	1000	94	Nil	Not installed	Nil	Nil	Good	
46	1000	93	Nil	Not installed	Nil	Nil	Good	
46	1000	92	Nil	Not installed	Nil	Nil	Good	
46	1000	91	Nil	Not installed	Nil	Nil	Good	
49	1000	112	Nil	Nil	Nil	Nil	Good	Mud wasp nest
49	1000	113	Nil	Nil	Nil	Nil	Good	Insect material?
49	1000	114	Nil	Nil	Nil	Nil	Good	
45	1300	149	Bark in top cnr---A'chinus(Pr)	Nil	Nil	Nil	Good	Insect material?
45	1300	146	Nil	Not installed	Nil	Nil	Good	
45	1300	148	Nil	Nil	Nil	Nil	Good	
45	1300	147	Nil	Nil	Nil	Nil	Good	
50	1300	111	Nil	Nil	Nil	Nil	Good	
50	1300	109	Nil	Nil	Nil	Nil	Good	
50	1300	110	Nil	Nil	Nil	Nil	Good	
44	1550	86	Nil	Nil	Nil	Nil	Good	
44	1550	85	Nil	Nil	Nil	Nil	Good	
44	1550	84	Nil	Nil	Nil	Nil	Good	
44	1550	88	Nil	Not installed	Nil	Nil	Good	
44	1550	87	Nil	Not installed	Nil	Nil	Good	
51	1700	102	Nil	Nil	Nil	Nil	Good	Spider nest
51	1700	107	Nil	Nil	Nil	Nil	Good	
51	1700	106	Nil	Nil	Nil	Nil	Good	
51	1700	108	Nil	Nil	Nil	Nil	Good	
51	1700	103	Nil	Nil	Nil	Nil	Good	
51	1700	104	Nil	Nil	Nil	Nil	Good	
47	3600	115	Nil	Nil	Nil	Nil	Good	
47	3600	120	Nil	Nil	Nil	Nil	Good	
47	3600	118	Nil	Nil	Nil	Nil	Good	Mud wasp nest

47	3600	117	Nil, mud wasp	Nil	Nil	Nil	Good	
47	3600	116	Nil	Nil	Nil	Nil	Good	
47	3600	119	Nil, mud wasp	Nil	Nil	Nil	Good	Mud wasp nest
48	3800	39	Nil	Nil	Nil	Nil	Good	
48	3800	40	Nil	Nil	Nil	Nil	Good	
48	3800	41	Nil	Nil	Nil	Nil	Good	
48	3800	42	Nil	Nil	Nil	Nil	Good	
48	3800	43	Nil	Nil	Nil	Nil	Good	Mud wasp nest
48	3800	44	Nil	Nil	Nil	Nil	Good	
48	3800	45	Nil	Nil	Nil	Nil	Good	Mud wasp nest
48	3800	48	Nil	Nil	Nil	Nil	Good	
48	3800	156	Nil	Nil	Nil	Nil	Good	
48	3800	33	Nil	Nil	Nil	Nil	Good	Leaf material
31	18200	78	Nil	Nil	Nil	Nil	Good	
31	18200	79	Nil	Nil	Nil	Nil	Good	
31	18200	80	Nil	Nil	Nil	Nil	Good	
31	18200	81	Nil	Nil	Nil	Nil	Good	
31	18200	82	Nil	Nil	Nil	Nil	Good	
31	18200	83	Nil	Nil	Nil	Nil	Good	
33	19650	122	Nil	Nil	Nil	Nil	Good	
33	19650	121	Nil	Nil	Nil	Nil	Good	
33	19650	127	Nil	Nil	Nil	Nil	Good	
33	19650	129	Nil	Nil	Nil	Nil	Good	
33	19650	124	Nil	Nil	Nil	Nil	Good	
33	19650	125	Nil	Nil	Nil	Nil	Good	
33	19650	126	Nil	Nil	Nil	Nil	Good	Leaf material
33	19650	128	Euc leaves--- FtG(pr)	Nil	Nil	Nil	Good	Leaf material
57	21550	142	Nil	Nil	Nil	Nil	Good	
57	21550	123	Nil	Nil	Nil	Nil	Good	
57	21550	141	Nil	Nyctophilus sp. x3	Nil	Nil	Good	
57	21550	144	Nil	Nil	Nil	Nil	Good	
57	21550	145	Nil	Nil	Nil	Nil	Good	Mud wasp nest
57	21550	143	Nil	Nil		Nil	Good	
57	21550	1	Nil	Nil	Nil	Nil	Good	
15	23700	153	Nil	Nil	Nil	Nil	Good	Mud wasp nest
15	23700	154	Nil	Nil	Nil	Nil	Good	Spider nest
15	23700	155	Nil	Nil	Nil	Nil	Good	
15	23700	157	Nil	Nil	Nil	Nil	Good	
15	23700	158	Nil	Nil	Nil	Nil	Good	

15	23700	159	Nil	Nil	Nil	Nil	Good	
15	23700	73B	Nil	Nil	Nil	Nil	Good	Mud wasp nest
15	23700	69	Nil	Nil	Nil	Nil	Good	
15	23700	70	Nil	Nil	Nil	Nil	Good	
15	23700	72	Nil	Nil	Nil	Nil	Good	
13	23700	71	Nil	Nil	Nil	Nil	Good	
13	23900	73A	Nil	Nil	Nil	Nil	Good	
13	23900	74	Nil	Nil?	Nil	Nil	Good	
13	23900	76	Nil	Nil?	Nil	Nil	Good	
13	23900	77	Nil	Nil	Nil	Nil	Good	
13	23900	75	Nil	Nil	Nil	Nil	Good	

Annex 10: Sancrox Interchange Post Clearing Fauna Management Report (Ferrovial Agroman Australia 2015)

Post Clearing Fauna Management Report

Project:

Pacific Highway Upgrade - Sancrox Interchange

Client:

Ferrovial Agroman Australia

July 2015

Document Status

Version	Purpose	Author	Reviewed By	Approved By	Date
Rev 1	Draft	Will Steggall	Jason Berrigan	Erin Davies	19/02/2015
Rev 2	Final	Will Steggall	Jason Berrigan	Erin Davies	01/07/2015

Document Control

Copy No.	Date	Type/Via	Issued to	Name	Purpose
1	19/02/2015	Electronic/ Email	Ferrovial Agroman	Brenden Bale	Client Copy
2	19/02/2015	Electronic/ Email	Naturecall	Chantal Sergeant	File Copy
3	01/07/2015	Electronic/ Email	Ferrovial Agroman	Tim Haydon	Client Copy
4	01/07/2015	Electronic/ Email	Naturecall	Chantal Sergeant	File Copy

Project Number: EC730

Our Document Reference: EC730-BEC-REP-0007-FASancroxInterchgPtCR-rev2.0

Contents

List of Tables

1.0 Introduction

1.1. Background

Biodiversity Australia Pty Ltd Trading as Naturecall Environmental (hereafter referred to as 'Naturecall') was commissioned by Ferrovial Agroman Australia ('the client') to act as the Project Ecologist on the first stage of the Oxley Highway to Kempsey upgrade of the Pacific Highway: the Sancrox interchange. The Sancrox interchange works will include building local service roads and a bridge over the Pacific Highway at Sancrox about 600 metres south of the existing Sancrox Road intersection.

Ecological assessment, monitoring, management and reporting forms a key part of the project, as detailed in the following specifications which form part of the contract with the NSW Roads and Maritime Services (RMS):

a) Environmental Protection (Management System) - QA Specification G36 for HW10 Pacific Highway Upgrade, Oxley Highway to Kempsey, Sancrox Traffic Arrangement – Addendum 3 (RMS 2013).
    - Section 6.9 Flora
    - Section 6.10 Fauna
    - Section 6.19 Pests and Diseases

b) Clearing and Grubbing - QA Specification G40 for HW10 Pacific Highway Upgrade, Oxley Highway to Kempsey, Sancrox Traffic Arrangement (RMS 2012).
    - Section 2.4 Clearing
    - Section 2.6 Post Clearing Report.
    - Section 5.0. Disposal of Materials
    - Miscellaneous services.

The QA Specification G40 requires that after completion of clearing, a Post Clearing Fauna Management Report is to be provided detailing the following:

- An assessment of habitat and handling of fauna.
- Information on clearing operations, dates, procedures, areas.
- Live animal sightings, captures, any releases or injured/shocked wildlife.
- Any dead animals located.
- Photographs of rescued fauna

This report provides the required data for the Sancrox Interchange clearing area including the service roads, overpass abutments, roundabouts and ancillary sites.

2.0 Clearing and Habitat/Fauna Methodology Data

2.1. Data on Clearing Operations

2.1.1. Clearing Procedures

The QA specifications required a two-stage clearing procedure to be undertaken by the clearing contractor. This entailed removal of non-habitat trees in the first stage, and removal of habitat trees (generally hollow-bearing trees) no less than 24 hours after completion of stage 1 clearing.

A two stage clearing process was required in accordance with the G40. First stage clearing was undertaken by a bulldozer which cleared undergrowth and non-habitat trees. Habitat trees were later removed by a bulldozer which was at times assisted by an excavator.

2.1.2. Clearing Dates

The main phase of clearing was undertaken over roughly 9 weeks from the 23rd July to 25th September, with most occurring between 23rd July to 11th August 2014 when the service roads and abutments were cleared. All of the habitat trees were removed during this period.

The quarry road was cleared from 21-22 August and 24-25 September 2014. The northeastern roundabout at the Cassegrain Winery entrance was cleared from 17-19 September.

Dewatering was undertaken at the site of a new culvert on the quarry access road on 2-3 February 2015. Fencelines along Service Road 3 were cleared from 17-23 February 2015.

2.2. Clearing Monitoring and Fauna Handling Methodology

2.2.1. Pre-clearing Surveys

The G40 required a two stage pre-clearing survey.

The first stage involved marking and mapping of habitat trees and large hollow-logs for stage 2 clearing management. Habitat trees consisted of hollow-bearing trees and also primary preferred Koala browse species (Schedule 2 of SEPP 44 Koala Habitat Protection). The latter were to be offered for forage and cage furniture to the Port Macquarie Koala Hospital and Billabong Wildlife Park. Large hollow-logs were also marked and individually identified for inspection during removal and potential relocation.

At no less than 24hrs before scheduled clearing, a thorough habitat search was made by 1-2 ecologists. This consisted of a visual search for bird nests in all stratums, roosting nocturnal birds or fauna (eg Koalas), and fauna under decorticating bark; and targeted survey for terrestrial fauna such as reptiles and frogs within coarse woody debris and leaf litter via raking and turning over logs and debris. This was to enable capture and relocation of any fauna outside the clearing envelope; establish

temporary buffer zones (if required due to key lifecycle stage); or advanced fauna rescue measures (if required) such as egg collection. Terrestrial habitat searches were also intended to create a disturbance to encourage fauna to evacuate the site and hence minimise potential mortality risk during clearing.

A final walk-through on the morning of scheduled clearing to ensure no fauna had re-entered the clearing envelope comprised the second stage of pre-clearing surveys. This generally involved final raking of leaf litter, moving logs, and checking all trees for roosting fauna for 30-60 minutes before clearing commenced. This was periodically repeated during the working day to ensure no fauna re-entered the clearing envelope (eg Koalas), or had been buried in debris or injured while attempting to flee. The dates for pre-clearing surveys and clearing supervision are shown in the following table:

Table 1: Location and dates of pre-clearing surveys and clearing supervision

Pre-clearing Surveys			Clearing Supervision	
Location	**Dates**	**Personnel**	**Dates**	**Personnel**
Service Road 1	21/07/14 to 28/07/14	Matthew Bailey and Nathan Boyd	24/07/14 to 25/07/14 and 31/07/14	Matthew Bailey and Nathan Boyd
HF Hands access road	30/07/14 and 12/08/14	Nathan Boyd	12/08/14	Nathan Boyd
West abutment	24/07/14 to 28/07/14	Matthew Bailey and Nathan Boyd	29/07/14 to 30/07/14	Matthew Bailey and Nathan Boyd
East abutment and southeast roundabout	04/08/14 to 05/08/14	Matthew Bailey and Nathan Boyd	05/08/14 to 06/08/14	Matthew Bailey and Nathan Boyd
Service Road 3	01/08/14 to 08/08/14	Matthew Bailey and Nathan Boyd	01/08/14 to 08/08/14	Matthew Bailey and Nathan Boyd
Auxiliary site 3 access road	04/08/14	Will Steggall	04/08/14	Will Steggall
Auxiliary site 3	12/08/14 to 13/08/14 and 18/08/14	Nathan Boyd	12/08/14 to 13/08/14 (Stage 1) and 18/08/14 (Stage 2)	Nathan Boyd
Quarry Road	21/08/14 to 22/08/14 and 24/09/14 to 25/09/14	Nathan Boyd	21/08/14 to 22/08/14 and 24/09/14 to 25/09/14	Nathan Boyd

Cassegrain intersection	17/09/14 to 19/09/14	Nathan Boyd and Will Steggall	17/09/14 to 19/09/14	Nathan Boyd and Will Steggall
Service Road 3 fencelines	17/02/15 to 23/02/15	Nathan Boyd	17/02/15 to 23/02/15	Nathan Boyd
Quarry Road De-watering	NA	NA	02/02/15 to 03/02/15	Will Steggall
Fernbank Creek Road	05/05/2015	Nathan Boyd	05/05/15	Nathan Boyd

2.2.2. Clearing Monitoring

The G40 required a qualified ecologist to be present during both stages of clearing. The primary objective was to ensure fauna welfare issues were addressed, and to direct recycling of habitat components where practical.

Stage 1 clearing monitoring predominantly involved an ecologist standing at a safe distance from tree felling, and constantly monitoring the ground around the machines, vegetation at the clearing front, and adjacent vegetation for fauna either displaced by the work or at risk. Any fauna sighted which needed rescue or buffers would initiate a stop-work procedure previously agreed between the ecologist and plant operators for OH&S and practicality; and implementation of the appropriate action eg temporary stop to enable search, rescue and relocation.

Stage 2 clearing monitoring focused on supervision of habitat tree and log removal, primary hollow-bearing trees and hollow-logs. This required an agreed procedure between the ecologist and plant operator for felling, and then inspecting the tree and all hollows eg turning over trees with hollows facing the ground and a chainsaw operator to cut sections to allow rescue.

Monitoring was also undertaken during de-watering activities in February 2015. This involved rescuing and relocating native aquatic species from pools of water that were drained with pumps.

2.3. Site Habitat

The site habitat generally consisted of modified dry sclerophyll forest dominated by Tallowwood, Bloodwood, White Stringybark and Blackbutt. The understorey ranged from open (e.g. in the west) to dense and dominated primarily by Black Oak, Cheese Tree and young eucalypts. The habitat on site has been subject to various levels of disturbance including logging, clearing, underscrubbing, grazing by goats, road construction/maintenance and weed invasion.

No bush rock occurred on site, however a few large logs were located and flagged for subsequent relocation. Leaf litter was generally shallow and dry, however some dense accumulations occurred under large canopy trees and in areas with a dense understorey.

Several aquatic habitat features are present on the site which consisted of small creeks, roadside drains and ephemeral drainage depressions with scours.

A number of hollow-bearing trees were present throughout the site, especially along Service Road 3 in

the east.

3.0 Results

3.1. Fauna Rescues and Relocations

3.1.1. Pre Clearing Survey

Pre-clearing surveys did not find and relocate any live fauna, however a dead Feathertail Glider (*Acrobates pygmaeus*) was found during a walk-through on the morning of 29th July in an adjacent powerline easement near the western overpass abutment (Photo 4). It was indeterminable if the glider was fatally injured by clearing (unlikely given distance from clearing area) or had been killed via other means eg dropped by a passing predator.

3.1.2. Clearing Monitoring

3.1.2.1 Stage 1 – Non-habitat Trees

Despite areas of dense groundcover and undergrowth present in the clearing area, no fauna were observed or rescued during the removal of non-habitat trees and the undergrowth.

No fauna, bird nests or possum dreys were identified in any tree which was felled.

3.1.2.2 Stage 2 – Habitat trees

As mentioned in the pre-clearance report undertaken by Naturecall, 66 potential and actual hollow bearing trees were identified and flagged within the clearing limit. Some of these had been previously flagged for the Oxley Highway to Kundabung upgrade works. These were monitored by an ecologist at the time of clearing.

Habitat trees were brought down as slowly and gently as practically possible by the bulldozer, and checked by the supervising ecologist immediately after felling. This resulted in the capture of 4 Lace Monitors (*Varanus varius*), 1 Blackish Blind Snake (*Ramphotyphlops nigrescens*) and a den containing a family of Sugar Gliders (*Petaurus breviceps*). These are shown in Photos 1-3 and 6-7 in Appendix 1. None of these animals appeared to be injured aside from one Lace Monitor which had some blood around its mouth from an abrasion but was otherwise fine. All captured fauna were successfully released into adjacent habitat offsite by the ecologist. The location of fauna releases and habitat log relocations is shown in Figure 1 below.

In addition, hives of native stingless bees (*Trigona carbonaria*) were found in two trees (Photo 5). These were given to local native bee enthusiasts for rehabilitation and relocation.

The number of actual hollows contained in the trees and their location, aperture size, depth and any evidence of usage were recorded by the ecologists after they were felled. Table 1 below provides this habitat tree data and the capture/release information of fauna. This information will be used to determine whether nest boxes are required for Sancrox Interchange project, based on the approved

OH2K Nest Box Plan.

3.1.2.3. De-watering

A number of native and non-native fish were captured with a small scoop net during de-watering at the culvert construction site on the quarry access road. Four native species were identified, these being the Longfinned Eel (*Anguilla reinhardtii*), Striped Gudgeon (*Gobiomorphus australis*), Firetail Gudgeon (*Hypseleotris galii*) and Empire Gudegon (*Hypseleotris compressa*). Photos are provided in Appendix 1.

The eel was promptly relocated to the creek outside the works area. The rescued fish were placed in a holding tank until a few were gathered and then relocated to the creek. The re-location points are shown in Figure 2.

Figure 1: Location of release and relocation points

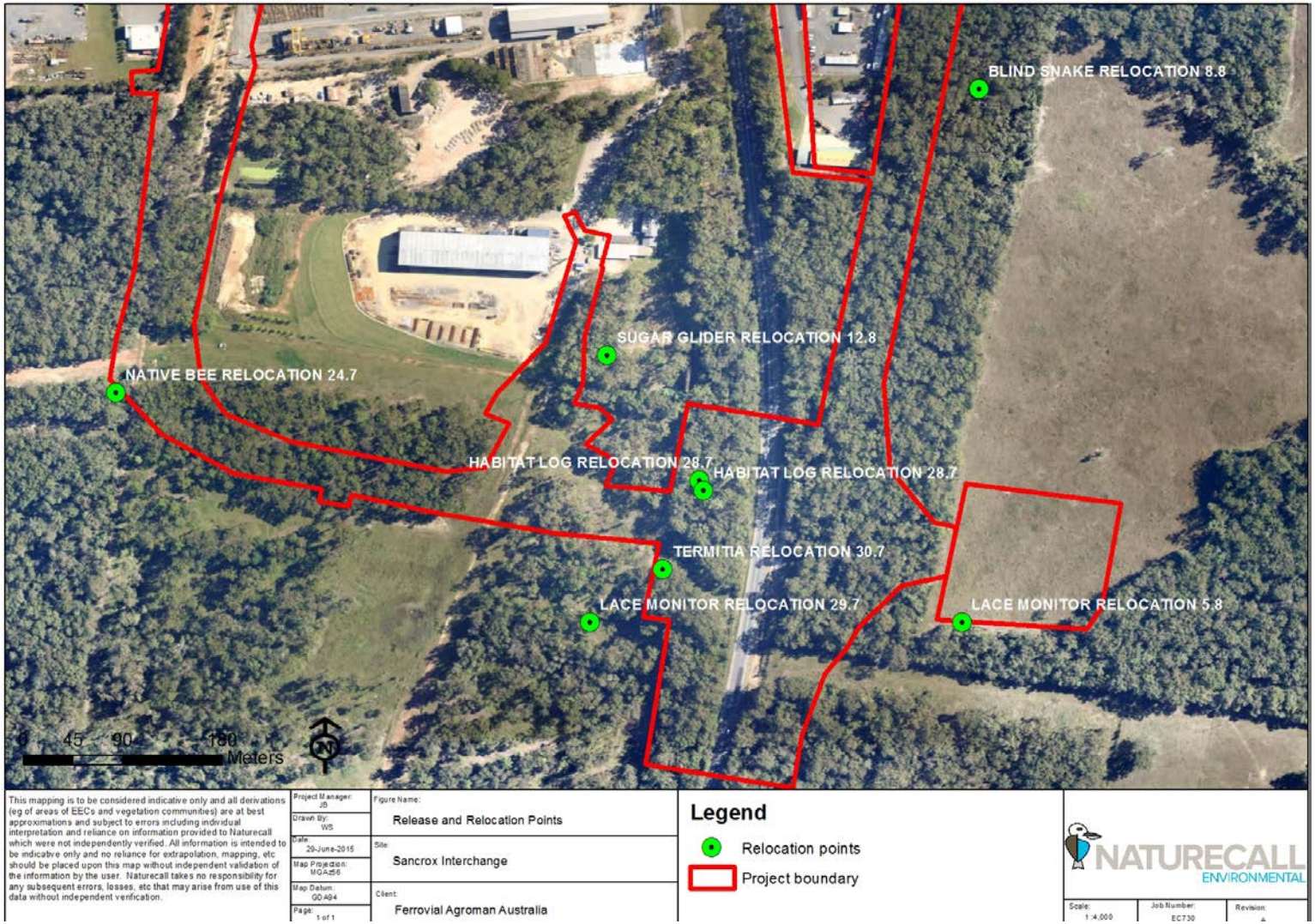

Figure 2: Release points for fish

Table 2: Hollow-bearing tree clearing monitoring data

Tree ID#	Date	Species	Latitude	Longitude	Diameter (cm)	Depth (cm)	Location in Tree	Evidence of Usage	Fauna detected	Release location	Live/ Dead
EH 1	6/08/2014	*Stag*	-31.446438	152.82446	nil	nil	nil	nil	nil	N/A	N/A
EH 2	6/08/2014	*Eucalyptus globoidea*	-31.446433	152.82458	nil	nil	nil	nil	nil	N/A	N/A
EH3	5/08/2014	*E. globoidea*	-31.446465	152.82457	nil	nil	nil	Fire scar	nil	N/A	N/A
EH 4	6/08/2014	*E. globoidea*	-31.446479	152.82458	8	15	Branch	nil	nil	N/A	N/A
EH 5	5/08/2014	*Corymbia gummifera*	-31.446630	152.82462	6	15	Branch	Yes- leaf nest	nil	N/A	N/A
EH 6	5/08/2014	*E. microcorys*	-31.446758	152.82482	6	800	Trunk	nil	nil	N/A	N/A
					15	800	Trunk	nil	nil	N/A	N/A
EH 7	5/08/2014	*Syncarpia glomulifera*	-31.446680	152.82493	4	45	Trunk	Trunk fissure	nil	N/A	N/A
EH8	5/08/2014	*E. acmenoides*	-31.446751	152.82504	10/6/30 multiple	546	Branch	Lace monitor	Lace Monitor	-31.44724; 152.82558	Live
					10	210	Branch	nil	nil	N/A	N/A

EH9	5/08/2014	*C. gummifera*	-31.446794	152.82504	nil	nil	nil	nil	nil	N/A	N/A
EH 10	5/08/2014	*C. gummifera*	-31.446902	152.82502	nil	nil	nil	nil	nil	N/A	N/A
EH 11	5/08/2014	*S. glomulifera*	-31.446533	152.82502	25	300	Trunk	nil	nil	N/A	N/A
EH 12	6/08/2014	*C. gummifera*	-31.446494	152.82498	nil	nil	nil	nil	nil	N/A	N/A
EH13	5/08/2014	*C. gummifera*	-31.445771	152.82486	30	40	Branch	nil	nil	N/A	N/A
EH 14	5/08/2014	*C. gummifera*	-31.445751	152.82485	nil	nil	nil	Lace Monitor	Lace Monitor	-31.44724; 152.82558	Live
EH 15	6/08/2014	*E. globoidea*	-31.445771	152.82485	nil	nil	nil	nil	nil	N/A	N/A
EH 16	5/08/2014	Stag	-31.445981	152.82463	15	77	Branch	Lace monitor	Lace Monitor	-31.44724; 152.82558	Live
					10	5	Branch	nil	nil	N/A	N/A
					7	120	Branch	nil	nil	N/A	N/A
					12	30	Branch	nil	nil	N/A	N/A
					23	230	Branch	nil	nil	N/A	N/A
					29	120	Branch	nil	nil	N/A	N/A
					30	15	Branch	nil	nil	N/A	N/A

					28	220	Trunk	nil	nil	N/A	N/A
					15	46	Branch	nil	nil	N/A	N/A
					23	180	Branch	nil	nil	N/A	N/A
					9	100	Branch	nil	nil	N/A	N/A
					19	280	Branch	nil	nil	N/A	N/A
					19	130	Branch	nil	nil	N/A	N/A
EH 17	5/08/2014	*E. globoidea*	-31.446268	152.82473	6	10	Trunk	nil	nil	N/A	N/A
EH 18	6/08/2014	*E. pilularis*	-31.446850	152.82418	nil	nil	nil	nil	nil	N/A	N/A
EH 19	6/08/2014	*E. globoidea*	-31.446240	152.82423	nil	nil	nil	Termitaria	nil	N/A	N/A
EH 20	6/08/2014	*E. globoidea*	-31.445940	152.82427	nil	nil	nil	Termitaria	nil	N/A	N/A
EH 21	5/08/2014	*C. gummifera*	-31.445475	152.82444	nil	nil	nil	nil	nil	N/A	N/A
EH 22	6/08/2014	*E. globoidea*	-31.446999	152.82459	nil	nil	nil	nil	nil	N/A	N/A
EH 23	5/08/2014	*E. globoidea*	-31.446667	152.82525	nil	nil	nil	nil	nil	N/A	N/A
EH 24	6/08/2014	*C. gummifera*	-31.445304	152.82504	nil	nil	nil	nil	nil	N/A	N/A
EH 25	6/08/2014	Stag	-31.444880	152.82475	15	400	trunk	Trunk fissure	nil	N/A	N/A

					5	150	Branch	Basal scar	nil	N/A	N/A
EH 26	6/08/2014	*C. gummifera*	-31.443807	152.82515	7	10	Trunk	Termitaria	nil	N/A	N/A
					10	40	Branch	nil	nil	N/A	N/A
EH 27	6/08/2014	*E. globoidea*	-31.443225	152.82528	15	45	Branch	Native bees nest	nil	N/A	N/A
EH 28	8/08/2014	*E. globoidea*	-31.442967	152.82528	5	10	Branch	nil	nil	N/A	N/A
EH 29	7/08/2014	*E. propinqua*	-31.442839	152.82535	60	1800	Trunk	Whole tree hollow/snake	Blackish Blind Snake	-31.44289; 152.82572	Live
EH 30	7/08/2014	*C. gummifera*	-31.442497	152.82543	nil	nil	nil	nil	nil	N/A	N/A
EH 31	7/08/2014	*E. globoidea*	-31.442338	152.82528	5	29	Branch	nil	nil	N/A	N/A
EH 32	6/08/2014	*E. globoidea*	-31.442207	152.8254	15	8	trunk	nil	nil	N/A	N/A
EH 33	6/08/2014	*C. gummifera*	-31.442140	152.82525	nil	nil	nil	nil	nil	N/A	N/A
EH 34	7/08/2014	*E. globoidea*	-31.442081	152.82542	nil	nil	nil	nil	nil	N/A	N/A
EH 35	8/8/20104	Stag	-31.441677	152.82559	8	15	Branch	nil	nil	N/A	N/A
EH 36	8/08/2014	*E. microcorys*	-31.441576	152.8254	3	5	Branch	nil	nil	N/A	N/A
EH 37	8/08/2014	*E. globoidea*	-31.441432	152.82556	10	30	Branch	Trunk fissure	nil	N/A	N/A

EH38	6/08/2014	Stag	-31.441158	152.82537	Termitaria	0	0	nil	nil	N/A	N/A
					11	14	Branch	nil	nil	N/A	N/A
Han 001	12/08/2014	*E. globoidea*	CH20	CH20	nil	nil	Trunk	Termitaria	nil	N/A	N/A
Han 002	12/08/2014	*E. globoidea*	CH60	CH60	25	1300	Trunk	nil	nil	N/A	N/A
Han 003	12/08/2014	*E. globoidea*	CH60	CH60	nil	nil	Trunk	Termitaria	nil	N/A	N/A
Han 004	12/08/2014	*E. microcorys*	CH100	CH100	nil	nil	Trunk	Termitaria	nil	N/A	N/A
Han 005	12/08/2014	*E. globoidea*	CH120	CH120	8	50	Trunk	Leaf nest- Sugar gliders	Sugar Gliders	-31.44505; 152.82270	Live
Han 006	12/08/2014	*E. globoidea*	CH160	CH160	6	11	Branch	nil	nil	N/A	N/A
WH1(H53)	29/07/2014	*C. gummifera*	-31.446300	152.8238	15	20	Trunk	nil	nil	N/A	N/A
					7	30	Limb	nil	nil	N/A	N/A
					10	30	Limb	nil	nil	N/A	N/A
					16	130	Limb	nil	nil	N/A	N/A
					17	140	Limb	nil	nil	N/A	N/A
WH3(H52)	29/07/2014	*E. microcorys*	-31.446300	152.8236	Termitaria			Termitaria	nil	N/A	N/A

WH4(H54)	29/07/2014	*C. gummifera*	-31.446500	152.8235	14 to 7	170	Limb	Lace Monitor	Lace Monitor	-31.44724; 152.82255	Live
					4	8	limb	nil	nil	N/A	N/A
					4	8	limb	nil	nil	N/A	N/A
					7	12	limb	nil	nil	N/A	N/A
WH5	29/07/2014	*E. pilularis*	-31.446400	152.8235	nil	nil	nil	nil	nil	N/A	N/A
WH6	29/07/2014	*E. globoidea*	-31.446100	152.8237	7 in termitaria	220	Limb	Fibrous nesting material, termitaria with limb protruding	nil	N/A	N/A
WH7	30/07/2014	*E. globoidea*	-31.445700	152.8238	4	10	trunk	nil	nil	N/A	N/A
					4	6	Limb	nil	nil	N/A	N/A
					4	7	Limb	nil	nil	N/A	N/A
WH10	25/07/2014	*C. gummifera*	-31.446004	152.82171	nil	nil	nil	nil	nil	N/A	N/A
WH11	25/07/2014	*E. pilularis*	-31.446287	152.8209	nil	nil	nil	nil	nil	N/A	N/A
WH12	31/07/2014	*E. globoidea*	-31.446202	152.8206	6	15	Limb	nil	nil	N/A	N/A
WH13	25/07/2014	*E. globoidea*	-31.445978	152.82031	25	180	Trunk	Nil, flying insects(Midgees)	nil	N/A	N/A

					50	150	Trunk	Nil, basal fire scar opening, termites	nil	N/A	N/A
					5	13	Limb	Nil	nil	N/A	N/A
					3	8	Limb	Nil	nil	N/A	N/A
WH14	25/07/2014	*E. globoidea*	-31.445894	152.82016	7	30	Trunk	nil, partial termitaria	nil	N/A	N/A
WH16	24/07/2014	*E. globoidea*	-31.445342	152.81936	6	70	Limb	nil	nil	N/A	N/A
					8 in termitaria	Shattered	Branch/Trunk	Native Bee hive present	nil	N/A	N/A
WH17	24/07/2014	*E. globoidea*	-31.445337	152.81906	8	n/a	Limb	nil, blocked with termitaria, uninhabitable	nil	N/A	N/A
					6	n/a	Limb	nil, blocked with termitaria, uninhabitable	nil	N/A	N/A
WH18	31/07/2014	*E. pilularis*	-31.444060	152.81915	4	10	Limb	nil	nil	N/A	N/A
					3	6	Limb	nil	nil	N/A	N/A
					6	15	Limb	nil	nil	N/A	N/A
WH19	31/07/2014	*E. globoidea*	-31.443465	152.81929	nil	nil	nil	nil	nil	N/A	N/A

WH21	31/07/2014	*C. gummifera*	-31.442025	152.81929	nil	nil	nil	nil	nil	N/A	N/A
Unmarked	28/07/2014	Habitat logs. 3 relocated	-31.446169	152.82347				nil	nil	N/A	N/A
Unmarked	29/07/2014	Stag			nil	nil	nil	nil, potential microbat roost	nil	N/A	N/A
Unmarked	30/07/2014	*C. gummifera*	-31.446300	152.8237	20 internal, 8 cm entrance	350	trunk	nil- shattered on impact no salvage value	nil	N/A	N/A
NH 1	21/08/2014	*E. tereticornis*	-31.440693	152.81972	nil	nil	nil	nil	nil	N/A	N/A
NH 2	21/08/2014	Stag	-31.440366	152.81978	15	37	limb	nil	nil	N/A	N/A
					5	14	limb	nil	nil	N/A	N/A
					45	1200	trunk	nil	nil	N/A	N/A
NH 4	22/08/2014	Stag	-31.440345	152.81995	24	56	trunk	nil	nil	N/A	N/A
NH 5	22/08/2014	*C. gummifera*	-31.439292	152.82055	nil	nil	nil	nil	nil	N/A	N/A

3.2. Fauna Injuries and Mortalities

No mortalities were recorded from the few fauna species that were captured during the clearing operations.

As previously mentioned, pre-clearing surveys did however detect a single Feathertail Glider (Photo 4) which was found dead on 29/7/14 on open ground near the western overpass abutment.

The only injury noted was on a Lace Monitor which had some blood around its mouth but examination showed no serious injury.

3.3. Habitat Salvage

3.3.1. Koala Foliage and Gunyas

A number of Tallowwoods that were previously identified to have value for local Koala rehabilitation organisations were salvaged during the main clearing period. Each morning before clearing commenced, a clearing contractor felled a Tallowwood with high salvage value, cut off the foliage, and sectioned the limbs to the specified sizes. These were loaded into a vehicle and taken to Billabong Wildlife Park nearby.

The Port Macquarie Koala Hospital was contacted for their interest in salvaging foliage and limbs during the clearing phase, however they were unable to collect any materials, and Ferrovial Agroman staff did not have the available resources to transport salvaged foliage and limbs to the Koala Hospital. The Hospital advised that collection of forage is limited by its palatability which rapidly declines after cutting.

3.3.2. Logs and Hollow Trees

Three large habitat logs were salvaged near the western overpass abutment on 28th July and relocated into adjacent habitat by an excavator under supervision of the ecologist (Photo 6).

Only two hollow-bearing tree sections were salvaged and relocated to nearby habitat outside the project area as most of the trees with potential to be salvaged, shattered when they hit the ground or had to be dissected to enable thorough searches.

4.0 Recommendations and Conclusions

The site habitat generally consisted of regrowth open forest with varying density of understorey cover, and patchy to open groundcover; to agricultural woodland. All of the site's forest has been previously logged or almost completely cleared, and used for grazing.

The limited undergrowth and connectivity was a significant limitation on the occurrence of small groundcover-dependant species, hence a key reason why no such fauna were observed.

No fauna or bird nests, possum dreys, etc, were identified during the pre-clearing surveys, and this is predominantly attributed to the significant disturbance history of the general area which has resulted in simplified and low quality habitats for fauna; and the low productivity of the site vegetation (evidenced by the vegetation). The high exposure of most of the site habitat and noise from adjacent industrial areas, the quarry, and the highway, coupled with the effects of local fragmentation, may have also attributed to the lack of fauna detected. These results are consistent with previous studies of the surrounding habitat, and parts of the project area (eg Darkheart 2000).

The 2 stage clearing method required by RMS appeared to be very effective in this project, as very few fauna were captured during habitat tree removal, especially so considering the apparent number of hollows identified (Table 1). However, as acknowledged in the literature, an aperture does not alone indicate a habitat hollow, and other factors affect use eg internal configuration. Hence no all hollows observed can be assumed to be habitable at any point in time. The disturbance history, limited diversity of vegetation communities and fragmentation may have also had a strong bearing on both diversity and abundance of arboreal mammals. Season (ie non-breeding) is also likely to have been a key influence.

The dominant method of clearing utilised however (ie bulldozer) is generally not preferred as it increases the risk of injury to fauna when trees are felled (higher impact with the ground), especially stags and dead limbs which can shatter on impact with the ground. This also reduces the potential for good hollows to be salvaged and relocated eg habitat logs. Clearing works should consider the greater use of a harvester head on an excavator. This attachment allows trees (and limbs) up to a certain diameter (and hence safe working weight) to be cut and lowered to the ground in a controlled manner, thereby reducing risk of injury and mortality of fauna.

Despite the relative abundance of trees marked during pre-clearing works, a relatively small number of Tallowwoods were harvested for their foliage and limbs. These were only supplied to the Billabong Wildlife Park and not the Port Macquarie Koala Hospital which was originally intended. In future, a better level of communication, liaison and an agreed action plan with such organisations should be established prior to clearing to ensure Koala food trees to be removed can be fully utilised.

Overall, it is considered that the majority of the measures were implemented effectively as fauna mortalities and injures were evidently minimised during clearing.

5.0 References

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Appendix 1: Photos

Photo 1: Blackish Blind Snake in rotting stag

Photo 2: Lace Monitor captured during clearing

Photo 3: Lace Monitor being released

Photo 4: Feathertail Glider found dead from unknown means

Photo 5: Native bee hive found in hollow

Photo 6: Relocated habitat logs including former Squirrel Glider den

Photo 7: Rescued Sugar Gliders

Photo 8: Longfinned Eel

Photo 9: Striped Gudgeon

Photo 10: Gudgeons in holding tank

Annex 11: Maundia Habitat Protection Monitoring (Niche 2015)

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Environment and Heritage

OH2K Pacific Highway Upgrade

Maundia triglochinoides Monitoring 2015

Prepared for RMS

2 October 2015

Document control

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Cover photograph: Maundia triglochinoides; flowers, inflorescence and habit (photo by: Mr Mark Aitkens)

Executive summary

Context

This report documents the 2015 monitoring period for *Maundia triglochinoides* as required for the Oxley Highway to Kempsey (OH2K) Pacific Highway upgrade project (the Project).

Aims

The monitoring program design for *Maundia triglochinoides* has the purpose of determining if the Project is having an impact upon avoided populations of this species.

Methods

The location of monitoring sites was to be determined during completion of the Projects detailed design (Hyder 2014). Three paired 'impact - control' monitoring sites were identified to Niche by RMS staff in February 2015. Each monitoring location was surveyed in accordance with the monitoring method specified in Hyder (2014).

Key results

Maundia triglochinoides was determined to be present at one monitoring location within the Project boundary. No data exists to demonstrate that the species was present at the other monitoring locations previously. Where observed, the species is at a high abundance in a relatively small area. Flowering and seed set was evident at this site. Management controls (protection fencing) were found to be in place. The monitoring data currently indicates that lifecycle processes for *Maundia triglochinoides* are persisting during the construction phase currently occurring adjacent to the known location of this species.

Conclusions

General compliance with performance indicators 1 and 2 as specified in the *Maundia triglochinoides* monitoring program has been achieved to prevent further unauthorised habitat loss (i.e. fencing and signage to protect the locations of *Maundia triglochinoides* within the Project boundary). Limitations in the data obtained and in monitoring design and method have prevented the use of statistical analyses to assess the Projects impact.

Management implications

Access to private lands for the purposes of monitoring was and is expected to remain problematic. This has necessitated moving one monitoring point (although the point still looks across the same area). It is considered likely that no *Maundia triglochinoides* exists at two of the three paired impact-control monitoring locations. However, monitoring at these locations should be continued to provide some certainty. The management implications of the survey work to date is that it is unlikely that meaningful statistical analyses can be undertaken in relation to this monitoring program as it stands. The focus on this program should be on careful management of the known location where *Maundia triglochinoides* occurs within the Project boundary. More detailed assessments of this location are likely to be helpful in this regard.

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1. Introduction

1.1 Context

The Oxley Highway to Kempsey section of the Pacific Highway Upgrade Project (the "Project") was approved in 2012 and is subject to various Ministers Conditions of Approval (MCoA) and Statement of Commitments (SoC). This approval outlines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project. *Maundia triglochinoides* was one threatened plant species identified as requiring mitigation and monitoring outcomes through the course of the Projects' construction and post construction period.

Legal Status

Maundia triglochinoides is listed as vulnerable on the New South Wales *Threatened Species Conservation Act* (TSC Act 1995). Monitoring of the species is required under the Project approval. The design, methods and performance indicators for this monitoring is specified in the approved Ecological Monitoring Plan (EMP) for the Project (Hyder 2014).

Monitoring Framework

The Project MCoA and SoC require the RMS to manage and monitor the effectiveness of the biodiversity mitigation measures implemented as part of the project. This includes *Maundia triglochinoides* and monitoring is to be performed in accordance with the Ecological Monitoring Program (Hyder 2014).

Monitoring is to be performed in accordance with the EMP (see Section 4.10).

The CFFMSP (Lend Lease 2014) states:

> "*Maundia triglochinoides* was recorded in three locations in the Project corridor. The Project will directly impact two of these populations, with 0.1 ha within the Project clearing footprint and an additional 0.38 hectares to be impacted by shading beneath the proposed twin bridge over Fernbank Creek.
>
> The location of threatened flora species in relation to the Project is shown on the Sensitive Area Plans included at Appendix A6 of the CEMP".

The following management and monitoring guidance was provided for *Maundia triglochinoides* in the CFFMSP (FF16 in Table 5-1):

> "A specific Environmental Work Method Statement shall be developed for all works within and adjacent to known populations of *Maundia triglochinoides*. This EWMS will include but not be limited to:
>
> - Specific methodologies for the construction of the twin bridges over Fernbank Creek.
> - Installation of sediment retention and protective fencing with sensitive area signage where works are within 100m of populations of or potential habitat for *Maundia triglochinoides*.
> - Installation of exclusion fencing and signage around all populations of *Maundia triglochinoides* to be retained adjacent to the Project and in Fernbank Creek below the bridge.
> - Implementation of any specific weed controls measures required.
>
> Populations of *Maundia triglochinoides* will be monitored in accordance with the approved Ecological Monitoring Program for the project".

Baseline Data

Three distinct potential sub-populations of *Maundia triglochinoides* have been previously recorded in the Project boundary (Hyder 2014):

- Fernbank Creek (Ch. 4,450-5,080)
- Wilson River Floodplain – canal (Ch. 13,900-14,100)
- Wilson River Floodplain – wetlands (Ch. 15,890).

Hyder (2014) details extent data for *Maundia triglochinoides* within the Project corridor (i.e. habitat area including area directly impacted by the Project (concept design)).

1.2 Project objectives

The Project objectives for *Maundia triglochinoides* are specified in the Project's SoC and MCoA, as listed in Table 1-1.

Table 1-1. Project SoC and MCoA relevant to the monitoring program

Objective	Reference Number	Commitment	Timing
Avoid or protect individual threatened plant species where possible.	SoC F9 MCoA B31(b)	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.	Pre-construction and construction.
Determine effectiveness of flora and fauna mitigation measures.	SoC F21 MCoA B10	An *adaptive* monitoring program will be developed and implemented 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 six years after construction completion.	Pre-construction, construction and operation.

1.3 Performance measures

The approved EMP specifies the following performance indicators for *Maundia triglochinoides* (Hyder 2014).

Success (protection of retained populations) is indicated by:

- Exclusion fencing with signage identifying these as 'no go' zones.
- Sediment control fencing in place.
- 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 in place identifying the sensitive nature of the location as threatened species habitat.
- A significant (if statistics are used) or substantial difference (i.e. 15% allowance) between paired monitoring sites with regard to flowering/seeding and overall extent or recruitment.

1.4 Reporting

Annual reporting of monitoring results will outline:

- Detailed description of monitoring methodology employed.
- Results of the monitoring period.
- 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 EMP will be submitted to the Director General of the Department of Planning and Infrastructure and the Environment Protection Authority.

1.5 Limitations

Monitoring locations

The Project EMP (Hyder 2014) states the following with reference to locating *Maundia triglochinoides* monitoring sites:

> "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".

Monitoring sites were first inspected by Niche in February 2015 immediately following a RMS escort to those sites. These sites coincide with *Maundia triglochinoides* incidence recorded by the SMEC Hyder JV during the preparation of the Project EMP (Hyder 2014).

Analysis

The Project EMP (Hyder 2014) states the following with reference to analysing *Maundia triglochinoides* monitoring data:

> "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."

No analysis is possible as this is the first monitoring event.

2. Methods

2.1 Project Area

The Project is located north from the Oxley Highway intersection with the Pacific Highway at Port Macquarie on the mid-north coast of New South Wales. An overview of the Project boundary and monitoring sites is provided in Figure 1.

2.2 Monitoring design

Three paired 'impact-control' monitoring sites have been established for the monitoring of Maundia triglochinodes within the Project boundary. The location of these is shown in Figure 1, with details provided in Table 2-1.

Measurements collected at each of the monitoring sites included the following parameters:

- Current extent of cover using the Braun-Blanquet scale (20m X 20m quadrat or 400 m^2). The monitoring area extends from the installed monitoring marker point into the water body, with the marker point located midway along the quadrat boundary.
- Average water depth was estimated for the quadrat (water staff have not been able to be put in place with no access to land granted).
- The extent of flowering or seeding (per cent of total number of observed plants within quadrat).
- Signs of recruitment (per cent of total number of observed plants within quadrat).
- Signs of disturbance (i.e. cattle) and to what extent/area.
- Specific photo point installed.

The installation of permanent photo points at site 1 and site 2 'control' sites remain outstanding. Site 1 photo point was moved to coincide with a publically accessible vantage point having effectively the same view of the control site located within adjoining private property. Site 2 was not re-installed during the May monitoring event due to severe inclement weather at the time. This remains a task for the spring monitoring event.

Table 2-1. Paired 'Impact –Control' monitoring sites

Site	Chainage (Location)	Description	Easting of Impact Plot	Northing of Impact Plot	Easting of Control Plot	Northing of Control Plot
1	4,450 - 5,080	Hastings River floodplain	483251	6523788	483113	6523992
2	13,900 – 14,100	Wilson River floodplain	481919	6532555	481900	6532520
3	15,890	Wilson River drainage channel	482762	6534479	482775	6534886

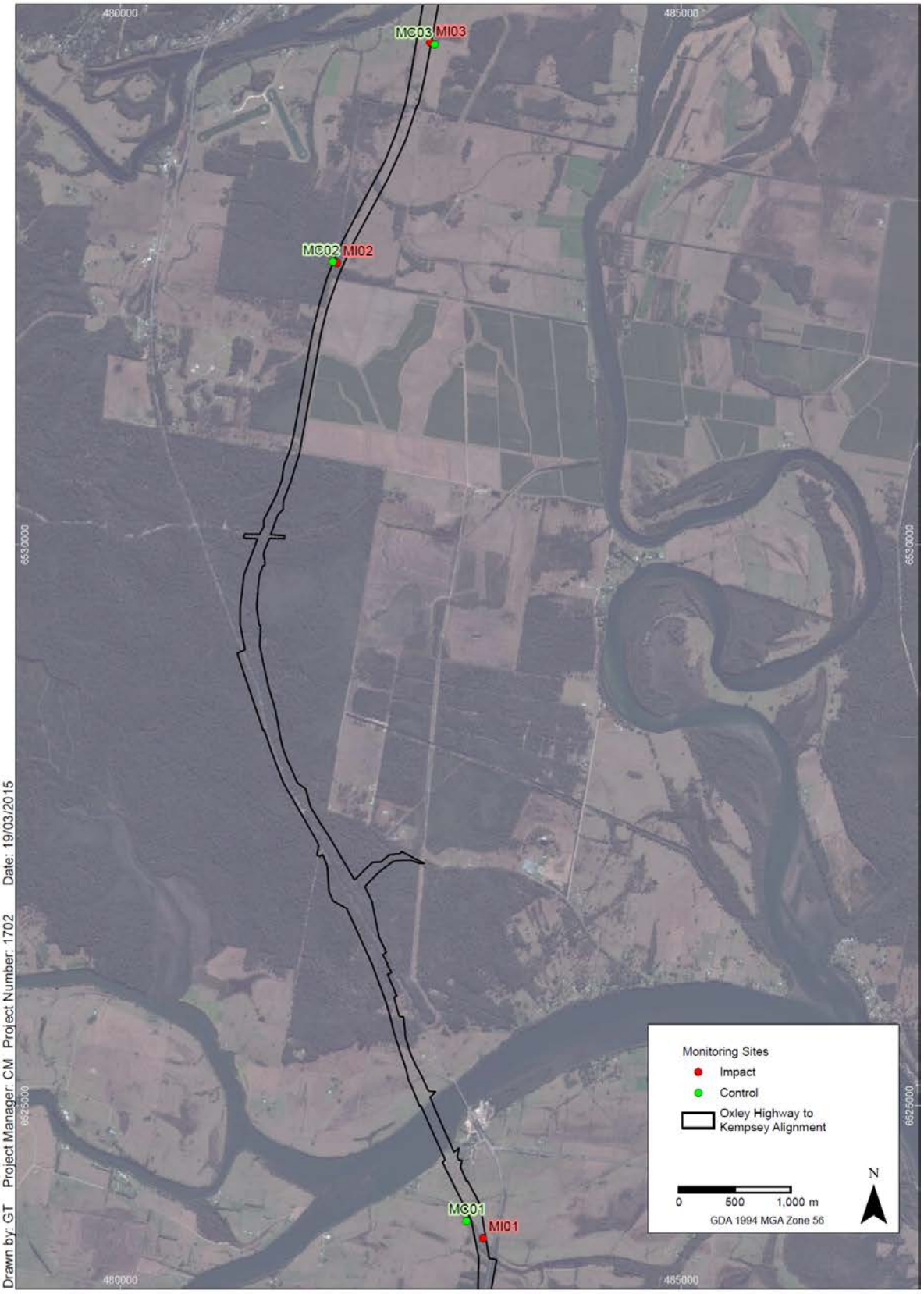
2.3 Method

Measurements collected at each of the monitoring sites included the following parameters:

- Current extent of cover using the Braun-Blanquet scale (20m X 20m quadrat or 400 m^2). The monitoring area extends from the installed monitoring marker point into the water body, with the marker point located midway along the quadrat boundary.
- Average water depth was estimated for the quadrat.
- The extent of flowering or seeding (per cent of total number of observed plants within quadrat).
- Signs of recruitment (per cent of total number of observed plants within quadrat).
- Signs of disturbance (i.e. cattle) and to what extent/area.
- Specific photo point installed.

The installation of permanent photo points at site 1 and site 2 'control' sites remain outstanding. Site 1 photo point was moved to coincide with a publically accessible vantage point having effectively the same view of the control site located within adjoining private property. Site 2 was not re-installed during the May monitoring event due to severe inclement weather at the time. This remains a task for the spring monitoring event.

Figure 1 Paired 'Control – Impact' monitoring sites



OH2K Maundia Monitoring Locations Site Plan (Overview)

Pacific Highway Upgrade - Oxley Highway to Kempsey & Frederickton to Eungai

FIGURE 1

Path: T:\spatial\projects\a1700\a1702_OH2K_Ecology\Maps\PI_5_Ecology_OH2K\PI_516_Maundia_Monitoring\1702_PI_516_Figure_1_Overview.mxd

The Braun-Blanquet scale used in this monitoring program is provided in Table 2-2.

Table 2-2: Braun-Blanquet cover abundance scale used in each 400m^2 quadrat

Score	Cover Abundance Category
1	1-5% cover - rare
2	1-5% cover - common
3	6-25% cover
4	26-50% cover
5	51-75% cover
6	76-100% cover

The scale specified in Table 2-2 is a standard used frequently in flora assessments.

2.4 Analyses

Hyder (2014) specifies the following approach to the data analysis.

> "A significant (if statistics are used) or substantial difference (i.e. 15% allowance) between paired monitoring sites".

Statistical tests used to analyse monitoring data would consider the usefulness of a paired t-test or a non parametric equivalent (e.g. Mann Whitney). In the first monitoring period (this report) the utility of statistical tests and other potential measures for monitoring change would be investigated and reported.

3. Results

Results are reported below for each of the performance indicators pertaining to *Maundia triglochinoides* that require assessment in the EMP. Refer detailed results in Annex 1.

3.1 Performance indicator 1 - Exclusion fencing and signage for 'no go' zones

Fencing and signage was found to have been in place installed across the two monitoring events (February and May. The fencing and signage was deemed to be effective and intact.

3.2 Performance indicator 2 - Sedimentation fencing / protection in place

Sediment and erosion control fencing was installed at all the impact sites.

3.3 Performance indicator 3 - Flowering, seeding and recruitment

Access to control site 1 was not secured for the 2015 monitoring period. Notwithstanding, observations from the Project boundary were possible, thus allowing for some data collection for this access impaired site. The only site which was found to have *Maundia triglochinoides* was impact site 1. Flowering and seeding were observed at this site in the first monitoring period. The second monitoring period was late in the flowering / seed period for this species and thus no flowering or seeding was observed.

The data collected from the sites was imported into the program G-MAV and a Cochran's test used to test for normality. This test determined that the data was non-normal ($P< 0.01$) and transformations (log, √ and constant) did not normalise the data. Use of a non-parametric test was also not applied as the paired sites are considered potentially non-independent. A 15% difference overall was found among the paired sites (mean = 0 and mean = 1) respectively for sites outside of the development footprint and those inside (across the whole survey period). However, no temporal difference in the data was found (each site recorded the same score at each of the three observations undertaken across the summer to autumn survey period). Therefore the data is highly skewed, but no significant temporal changes were determined.

4. Discussion

4.1 Contingencies

As required by MCoA B10(e), the EMP describes contingencies for potential problems identified in the construction and post construction period. No specific contingency measures were defined for *Maundia triglochinoides* within the EMP. It is recommended that the RMS develop contingency measures for *Maundia triglochinoides.*

4.2 Plan review

Project MCoA B10(a) states:

> "An adaptive monitoring program will be developed and implemented 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 three years after construction completion."

Below are points that could be considered for the purpose of improving the monitoring program.

Design and Analysis

A statistical analysis of the data was not performed because paired impact-control sites may not be independent. Site independence is a fundamental assumption required by all statistical analyses. Additionally, the dataset is non-normal and could not be normalised with standard transformations. Therefore the use of statistical analyses for this data is not appropriate.

A >15% difference among paired sites was determined from this observation period (however, no difference among the three survey times of this period was found). Therefore, no temporal change was detected within this time period (summer to autumn 2014-15).

The paired impact-control sites established in the EMP are spatially close to each other and changes to hydrology (for example) will likely impact many of these pairs simultaneously.

Establishing additional monitoring sites in independent locations is an option that could be pursued to correct this issue.

Observations to date have found *Maundia triglochinoides* present at only one of the six designated monitoring locations. There is no evidence that the species was present previous to these observations at all sites. Therefore the current monitoring has a very limited capacity to detect decline (it can only detect this at one site). The design could be altered to maximise monitoring of the single location where *Maundia triglochinoides* occurs. This would involve spatially replicated sampling of this location.

Methods

There are methodological issues with the approved EMP in how species abundance, flowering/ seeding and recruitment are measured (Hyder 2014). Measurements are made using the Braun-Blanquet scale, but the scoring in this scale is very coarse (i.e. a score of 3 indicates a cover of between 5-25%). The threshold for a potential impact is set at 15% (but a score of 3 may not detect a 15% change). The scoring of abundance could be altered to be in raw percentages (at 5% intervals). This change would overcome the inconsistency between scoring coarseness and the threshold for impact detection.

Additionally, we recommend that quadrats could be marked more thoroughly in the field (to aid observers in examining the same exact area each time). Niche will work to implement this in upcoming survey times (use of additional markers; use of site photos in the field to visually cue the observer etc.).

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Morrison, D.A. (2002). How to improve statistical analysis in parasitology research publications. *International Journal for Parasitology* 32: 1065-1070.

Hyder (2014). Oxley Highway to Kempsey Pacific Highway Upgrade: Ecological Monitoring Program. Prepared by SMEC Hyder Joint Venture for the Roads and Maritime Service, Sydney.

Annex 1 Monitoring Data - 2015

Site	Design	Easting	Northing	Inspection Date		Camera point installed		Maundia present		Braun-Blanquet Score		Water Depth (mm)		Flowering/ Seeding		Recruitment	
				Feb	May	Feb	May	Feb	May	Feb	May	Feb	May	Feb	May	Feb	May
MI01	impact	483251	6523788	26/02/2015	1/05/2015	Y	N*	N	Y	0	2	200	n/r	nil	nil	nil	nil
MC01	control	483113	6523992	26/02/2015	1/05/2015	Y	N*	N	N	0	0	200	n/r	nil	nil	nil	nil
MI02	impact	481919	6532555	26/02/2015	1/05/2015	Y	Y	N	N	0	0	500	n/r	nil	nil	nil	nil
MC02	control	481900	6532520	26/02/2015	1/05/2015	Y	N	N	N	0	0	500	n/r	nil	nil	nil	nil
MI03	impact	482762	6534479	18/02/2015	1/05/2015	Y	Y	N	N	0	0	100	n/r	nil	nil	nil	nil
MC03	control	482775	6534486	18/02/2015	1/05/2015	Y	Y	N	N	0	0	100	n/r	nil	nil	nil	nil
MC11	Ref	490652	6581695	n/a	29/04/2015	Y	Y	Y	Y	2	2	Unk	500	nil	nil	nil	nil
MC12	Ref	484393	6571941	n/a	29/04/2015	Y	Y	Y	Y	3	3	Unk	400	nil	nil	nil	<1%
MC13	Ref	487600	6577150	n/a	n/a	Y	Unk	Y	Unk	2	Unk	Unk	Unk	nil	Unk	nil	Unk.
MC14	Ref	486641	6576627	n/a	29/04/2015	Y	Y	Y	Y	1	1	Unk	500	nil	nil	nil	nil

n/r = not recorded

Unk = unknown

Y = Yes

N = No

* = Marker knocked over and requires replacement

Site	Design	Easting	Northing	Inspection Date		Compliance with Mitigation Measures	
				Feb	May	Feb	May
MI01	impact	483251	6523788	26/02/2015	1/05/2015	Yes	Yes
MC01	control	483113	6523992	26/02/2015	1/05/2015	n/a	n/a
MI02	impact	481919	6532555	26/02/2015	1/05/2015	Yes	Yes
MC02	control	481900	6532520	26/02/2015	1/05/2015	n/a	n/a
MI03	impact	482762	6534479	18/02/2015	1/05/2015	Yes	Yes
MC03	control	482775	6534486	18/02/2015	1/05/2015	n/a	n/a

n/a = not applicable

Annex 2 Photographs

OH2K Maundia Monitoring Summer 2014/15

Site ID	Photo
MI01	
MC01	
MI02	

Site ID	Photo
MC02	
MI03	
MC03	

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OH2K Pacific Highway Upgrade

Giant Barred Frog Monitoring, Autumn 2015

Prepared for RMS

13 October 2015

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Authors:	Mr Mark Aitkens
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Cover photograph: Mixophyes iteratus at Maria River (photo by: Mr Mark Aitkens)

Executive summary

Context

This report documents findings from the Autumn 2015 monitoring period for Giant Barred Frog (*Mixophyes iteratus*) as required for the Oxley Highway to Kempsey (OH2K) Pacific Highway upgrade project (the Project).

Aims

The Giant Barred Frog monitoring program has the purpose of determining if the Project is having an impact upon avoided populations and habitat of this species.

Methods

The Giant Barred Frog and its habitat is widely distributed within and outside the Project boundary. Six monitoring sites are identified (two reference and four impact monitoring sites). Each monitoring location was surveyed in accordance with the monitoring method and design specified in SMEC-Hyder (2015) and Lewis Ecological Surveys (2013).

Key results

A total of 28 Giant Barred Frogs were observed across the six monitoring locations. A varied number of individuals were observed at each site ranging from a single adult female at Cooperabung Creek (reference) to numerous juveniles at Pipers Creek (reference). The only 'recapture' was at Cooperabung Creek (reference). No tadpoles were caught in the trapping/ netting surveys, although, numerous native fish species were repetitively captured using these methods. Evidence of recruitment was noted at five sites (i.e. juveniles). The monitoring data currently indicates that lifecycle processes for Giant Barred Frog are persisting although it is not possible to determine if recruitment is in decline or not. Chytrid fungus sampling has detected the presence of this pathogen within both impact and reference sites, although the incidence of positive tests was very low.

Conclusions

There is evidence of compliance with performance indicators (i.e. persistence of Giant Barred Frog individuals and lifecycles). Chytrid testing has located infections at two sites where it was previously not recorded: Pipers Creek and Cooperabung Creek. Assessments and any potential actions will not be clearly definable until the data from all three required seasonal monitoring periods are combined.

Management implications

No specific management recommendations additional to those specified in the EMP are presented in this report.

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1. Introduction

1.1 Context

The Oxley Highway to Kempsey section of the Pacific Highway Upgrade Project (the "Project") was approved in 2012 subject to various Ministers Conditions of Approval (MCoA) and Statement of Commitments (SoC). A subsequent approval with additional conditions of consent (CoA) was granted in 2014 by the Department of Environment (DoE) for matters of national environmental significance listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1995 (EPBC Act). Combined, these approvals outline the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project. The Giant Barred Frog was identified as requiring mitigation and monitoring outcomes through the course of the Projects' construction and post construction period.

Legal Status

Giant Barred Frog is listed as endangered on the New South Wales *Threatened Species Conservation Act* (TSC Act 1995) and Commonwealth EPBC Act. Monitoring of the species is required under the Project approval.

Monitoring Framework

The Project MCoA, SoC and EPBC Act CoA require the RMS to manage and monitor the Giant Barred Frog. Management is to be performed in accordance with the Construction Environmental Management Plan (CEMP) and Construction Flora and Fauna Management Sub-Plans (CFFMSP) for the Oxley Highway to Kundabung section (Lend Lease 2014) and Kundabung to Kempsey section (McConnell Dowell OHL JV 2014). Appended to these sub-plans is the Giant Barred Frog Management Strategy (Lewis Ecological Surveys 2013); an important component of the species management and monitoring framework.

The design, methods and performance indicators that define the Giant Barred Frog monitoring program are specified in the approved Ecological Monitoring Plan (EMP) (SMEC-Hyder 2015) and Giant Barred Frog Management Strategy (Lewis Ecological Surveys 2013).

Baseline Data

Four distinct Giant Barred Frog sub-populations have been recorded in the Project area (SMEC-Hyder 2015). Known 'impact' sites within the Project area are listed below:

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

Baseline data is provided in Niche (2015) for these 'impact' sites. In addition, baseline data for two reference sites (Cooperabung Creek and Pipers Creek) is also provided in Niche (2015). The purpose of this data is to enable before and after comparisons / analysis, and thus determine if there has been any change in Giant Barred Frog populations within the impact sites.

Purpose of this Report

This report details the data obtained from the first monitoring period post the baseline surveys, which were conducted as part of the Giant Barred Frog management Strategy (Lewis Ecological Surveys 2013). It represents the first monitoring report for the construction phase of the Project.

1.2 Project objectives

The Project objectives for the Giant Barred Frog are specified in the MCoA, SoC and EPBC Act CoA and are listed in Table 1-1.

Table 1-1. Project MCoAs, SoCs and EPBC Act CoAs for the Giant Barred Frog

Objective	Reference Number	Commitment	Timing
Management of Giant Barred Frog and its habitat	MCoA B31(b)(v)	Management Strategy for the Giant Barred Frog	Pre-construction and operation.
Determine effectiveness of flora and fauna mitigation measures.	SoC F21 MCoA 10	An adaptive monitoring program will be developed and implemented 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 six years after construction completion.	Pre-construction, construction and operation.
Prevention of wildlife mortality	SoC F19	Fauna exclusion fencing (e.g. floppy-top fencing) will be erected along the Proposal at appropriate locations to direct fauna movement towards wildlife crossing structures.	Construction.
Habitat protection	EPBC FF6 and FF34	The limits of clearing are to be clearly marked on all relevant work plans and protective fencing erected to mark these limits (i.e. 'no go' areas). Fencing will be installed 5 days prior to vegetation clearing activities occurring. Riparian and aquatic habitat (including known GBF habitat) will be protected from construction works through the installation of protective fencing prior to works commencing in the vicinity.	Construction.
Habitat protection and enhancement	EPBC FF10	Revegetation/rehabilitation of all areas disturbed as part of the Project (that do not form part of permanent pavement or structures) will be undertaken progressively during construction to maintain and enhance key habitat areas in order to minimise the impact on Koala, Grey-headed Flying Fox, Spotted-tail Quoll and Giant Barred Frogs.	Construction.
Prevent harm to flora and fauna species including the Giant Barred Frog	EPBC FF38	The spread of bacteria, viruses and diseases such as *Phytophthora cinnamomi*, amphibian chytrid fungus, myrtle rust and beak and feather disease will be addressed using the processes described in the Weed and Pathogen Management Plan.	Construction.

In addition, MCoA 31b (IX) states the following requirement for each Construction Flora and Fauna Management Sub-Plan (DoP 2012) prepared for the Project:

"Mechanism for the monitoring, review and amendment of this Sub-Plan"

In reference to the Giant Barred Frog, this MCoA was initially interpreted as being relevant to the pre-construction (i.e. baseline survey) and operational phases of the Project. However, with the addition of the EPBC Act CoA, the requirement to monitor, review and amend the Construction Flora and Fauna Management Sub-Plan was widened to include the construction phase of the Project. Thus, monitoring works specified in the Giant Barred Frog Management Strategy (i.e. pre-construction and operation) have been broadened to include the construction period (i.e. annual spring, summer and autumn monitoring surveys).

1.3 Performance measures

The approved EMP (SMEC-Hyder 2015) and Construction Flora and Fauna Management sub-plans (Lend Lease 2014, McDonnell Dowell OHL JV 2014) specify the following performance indicators for the Giant Barred Frog.

- Continued presence of Giant Barred Frogs during each survey event in Year 1 – 8 at sites where it was identified during baseline surveys.
- 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).
- 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.

1.4 Monitoring timing

The approved EMP (SMEC-Hyder 2015) states the following monitoring timing for the Giant Barred Frog:

- 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.

Monitoring is to be performed thrice yearly in spring, summer and autumn with a monitoring event ideally conducted in that order (i.e. spanning two calendar years). This monitoring event constitutes the autumn season only and will be treated as a single monitoring event for 2015. The upcoming 2015 spring and summer monitoring events would combine with the 2016 autumn monitoring survey to form the 2016 monitoring year.

1.5 Reporting

Annual reporting of monitoring results will outline:

- Detailed description of monitoring methodology employed.
- Results of the monitoring period.

- 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 EMP will be submitted to the Director General of the Department of Planning and Infrastructure and the Environment Protection Authority.

1.6 Limitations

Monitoring timing

The Project EMP (RMS 2013) stipulates a triannual monitoring program (i.e. spring, summer and autumn) for at least eight years spanning the construction and post construction periods. The results presented in this report represent the first post-baseline monitoring event for 2015 (i.e. autumn). The data will be included with future spring and summer monitoring to provide a comparison with the baseline data.

Analysis

Analysis has been limited to a simple comparison of survey results with mean baseline datasets and qualitative analysis of demographic data. The consideration of performance measures has been limited to:

- Continued presence at sites surveyed in the baseline survey.
- 'Distribution' and, to a lesser extent, habitat usage.

Densities and movement patterns will be analysed after spring and summer data are available, although caution will be exercised as these data do not fit with the single "activity season" as covered through a single spring to autumn survey.

Habitat and water quality data will also be analysed against baseline data when the full range of seasonal data is available.

2. Methods

2.1 Project Area

The Project is located north from the Oxley Highway intersection with the Pacific Highway at Port Macquarie on the mid-north coast of New South Wales.

2.2 Monitoring design

Four impact and two reference monitoring sites have been established for monitoring the Projects impact on the Giant Barred Frog. The location of these is shown in Figure 1, with details provided in Tables 2-1 and 2-2.

Table 2-1. Impact monitoring sites

Site	Easting (start)	Northing (Start)	Easting (end)	Northing (end)
Cooperabung Creek	483189	6537953	482547	6537678
Smiths Creek	483686	6546224	482848	6546302
Pipers Creek	483594	6548729	482945	6548999
Maria River	483472	6554600	482819	6554726

Table 2-2. Reference monitoring sites

Site	Easting (start)	Northing (start)	Easting (end)	Northing (end)
Cooperabung Creek	480480	6538315	479925	6537854
Pipers Creek	477226	6550293	476690	6550799

These are independent of the Project and have the purpose of monitoring Giant Barred Frog populations not impacted by the Project. It is assumed that any change detected at these sites would be indicative of 'natural' variance unrelated to the impacts of road construction or operation and so provides a comparison with any changes detected at the impact sites.

2.3 Methods

A variety of detection methods were performed to sample for the Giant Barred Frog at each of the monitoring sites, as described in the following sections. Monitoring surveys was conducted in accordance with the *Hygiene protocol for the control of disease in frogs* (DECC 2008).

2.3.1 Detection

Call playback

The time of arrival at the start of the survey transect was noted and the survey initiated with a 10 minute listening period followed by a 15 minute call playback and a further 10 minutes of listening. Call playbacks (five minutes) were then undertaken at a maximum of every 50 metres along the length of the transect.

Spotlighting

Each monitoring site comprises a one kilometre riparian transect, which was searched by spotlight for a minimum of 120 person minutes. However, the time required to effectively survey a site depended on access and structure of the vegetation and so total person minutes spent on surveys varied between stream transects. Two or more surveyors walked slowly down the sides of the stream using headlamps or

spotlights to search for Giant Barred Frogs, using reflective eye shine to locate animals in the water or on the banks within 20 metres of the water. Additional call playback was undertaken at a maximum of every 50 metres along the transect. Time of finishing was recorded at the end of each transect.

Trapping and dip-netting

Tadpole trapping was undertaken in order to determine if tadpoles were present in the streams being surveyed and so indicate reproductive success. Dip-netting was undertaken at each site and consisted of a series of 10 sweeps with a dip net every 50 metres of stream in an attempt to catch any tadpoles present.

Tadpole trapping was undertaken using one standard baitfish trap (~300 millimetres by 200 millimetres) deployed every 100m along each transect and left for a minimum three hours (i.e. a total of 10 bait traps in each of the ten 100m zones). The traps were then inspected and numbers and types of tadpoles captured were recorded and then all tadpoles released.

Water quality

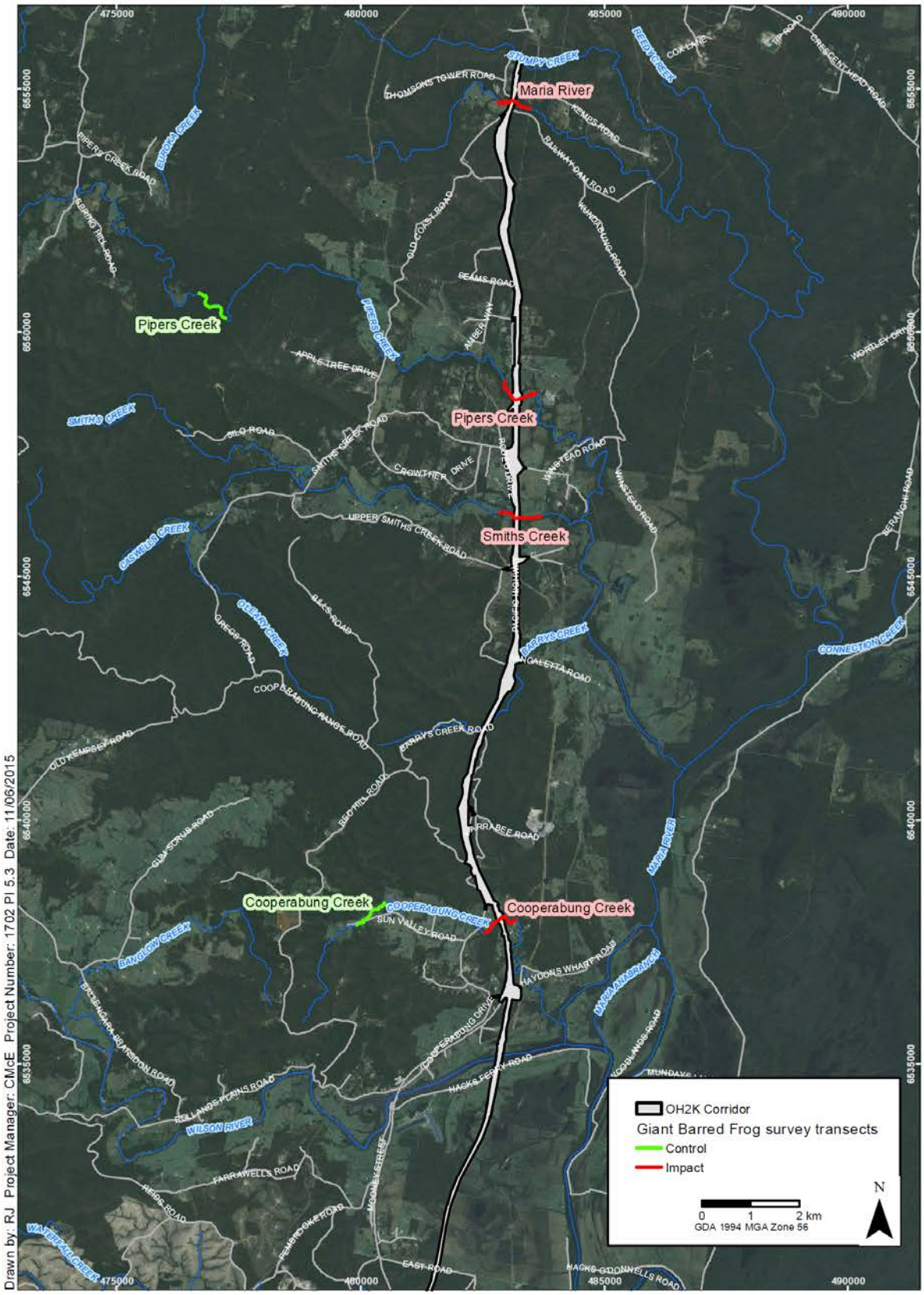
Water quality will be included when the data is made available and including that from the 2015 spring and summer periods.

2.3.2 Chytrid sampling

Each individual captured during the monitoring survey was swabbed for the presence of Chytrid fungus. This involved handling frog individuals in an unused plastic bag thereby preventing skin to skin contact. Sterile swabs were smeared over the body surface for at least 20 seconds taking care to sample all parts of the frog with particular attention to the ventral surface and sent for analysis. Unusual skin characteristics were also noted (see Plate 1 for 'skin barnacles' observed on some frogs).

Plate 1. Skin 'barnacles' observed on some Giant Bared Frog specimens

Figure 1 Impact and Reference monitoring sites



Site Map

Oxley Highway to Kempsey Giant Barred Frog Survey (PI 5.3)

FIGURE 1

Path: T:\spatial\projects\a1700\a1702_OH2K_Ecology\Maps\PI_5_Ecology_OH2K\PI_53_GiantBarredFrogMonitoring\20150604\1702_OH2K_PI53_GBF.mxd

2.3.3 Data collection

Morphometric

When an animal was located, its position on the transect was recorded and the animal was captured, if possible. Once captured, the frog was checked to see if it had been previously marked with a PIT tag and, if so, the number was recorded. At the same time, the animal's sex, weight (in grams), snout vent length (in millimetres), age status (juvenile/sub adult, adult), breeding condition (being the condition of the nuptial pads in males or if females were gravid) and general health were all recorded.

The frogs were also swabbed to

Weather

Weather conditions noted through the survey included temperature and humidity (either by windwatch or thermometer), % cloud cover, broad wind level (scale of 0-3) and moon status. Last 24 hour rainfall was taken from the Bureau of Meteorology station at Port Macquarie. This data was collected to indicate the suitability of the weather conditions at the time of the survey.

Water levels

Water levels were recorded at the deepest pool in each 100 m section of each transect and the deepest point overall recorded.

Additional information

Additional anecdotal information was collected on the presence of introduced fish, feral predators and/or notable changes to important elements of the habitat were also recorded.

2.4 Analysis

Baseline data was preciously collected by Lewis Ecological Surveys and Niche Environment and Heritage and analysed by Niche Environment and Heritage (Niche 2015). Analysis involved population estimates using the Lincoln-Peterson (L-P) method with the Chapman correction and Minimum Known to be Alive (MKTBA). This baseline data will be compared with the combined construction phase monitoring results for autumn spring and summer to evaluate the performance of the management strategy.

3. Results

Results are reported below for the autumn 2015 Giant Barred Frog monitoring survey.

3.1 Incidence

Giant Barred Frogs surveys were undertaken between the 10th and 13th of May 2015 and frogs were recorded at all six sites (Table 3-1). The highest counts obtained in any one survey were at the Pipers Creek reference site. The distribution of Giant Barred Frogs observed during the monitoring survey is shown in Figure 2 to Figure 7.

Table 3-1. Giant Barred Frog count at each site during the autumn 2015 monitoring survey and baseline population estimates

	Cooperabung Creek Impact	Smiths Creek Impact	Pipers Creek Impact	Maria River Impact	Cooperabung Creek Reference	Pipers Creek Reference
May 2015 count	8	3	4	5	1	11
Mean number of frogs per visit during the Baseline surveys[1]	5.67	9.33	6.00	6.33	15.67	7.67
Standard Error (SE)[1]	1.76	4.06	2.52	3.18	4.84	3.93
MKTBA[1]	15	26	14	15	45	23

Only one Giant Barred Frog was recaptured during the monitoring survey (Cooperabung Creek reference). This was a large female frog with PIT identification number 0007356F32.

3.2 Morphometrics

Morphometric data for the 28 Giant Barred Frogs examined during the monitoring period is provided in Annex 1. All age classes were evident for all sites, with the exception of Cooperabung Creek reference where only one adult frog was observed.

3.3 Weather conditions

Weather conditions for the survey periods are provided in Table 2.

Table 3-2. Weather conditions on nights of autumn monitoring program

Date	Minimum temperature (C)	Maximum temperature (C)	Humidity (%)	Rainfall (last 24 hours)	Wind Speed
11/5/15	6.8	25.7	67	0.0	0
12/5/15	6.1	23.2	68	0.0	0
13/5/15	8.6	20.8	47	0.2	1
14/5/15	9.0	18.7	66	0.0	1

3.4 Water levels

The water levels recorded for each transect were:

- Cooperabung Creek impact = 650 mm

[1] Baseline dataset (Niche 2015)

- Smiths Creek Impact = 750 mm
- Pipers Creek Impact = 280 mm
- Maria River Impact = 210 mm
- Cooperabung Reference = 250 mm
- Pipers Creek Reference = 575 mm

3.5 Chytrid fungus

Three positive and two equivocal tests were returned for the 28 samples recovered from the autumn 2015 monitoring period (see Annex 1 for details). Positive Chytrid fungus tests were at the following sites:

- Pipers Creek impact
- Pipers Creek reference
- Cooperabung reference.

Equivocal tests were returned for the Cooperabung Creek and Smiths Creek impact sites.

3.6 Anecdotal observations

There were no important anecdotal observations to come out of the Autumn 2015 monitoring surveys. There were no indications of feral predator activity or disturbances created by other feral species such as pigs. The overall habitat condition remained the same at the canopy and midstorey levels and stream conditions showed little sign of change. The only observation of note at this time was that there appears to be an increase in the extent of some introduced plant species that may be providing greater shading of the banks and possible coverage of native ground covers. Lantana remains the most serious problem, although this species is known to form used habitat for the Giant Barred Frog in other locations. A more thorough understanding of the potential growth and impacts of weeds will be undertaken on completion of the full range of 2015/2016 surveys.

3.7 Mitigation

Frog fences were inspected at each of the impact sites and were noted to be installed at all sites.

General Chytrid washdown facilities and instructions are located at the Smiths Creek site, which is the only site previously recorded to have the fungus.

Figure 2 Cooperabung Creek Impact

Figure 3 Smiths Creek Impact

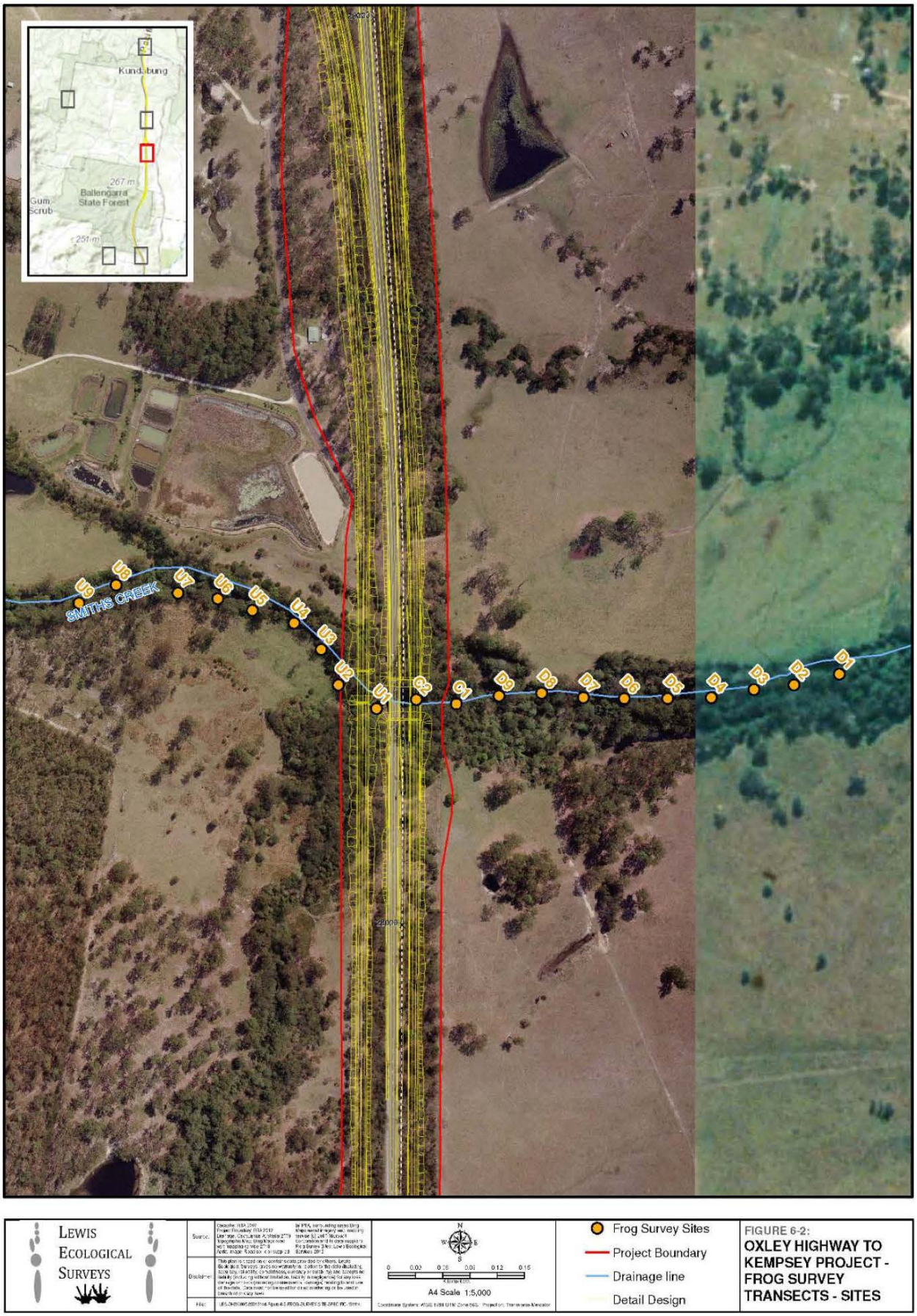


Figure 4 Pipers Creek Impact

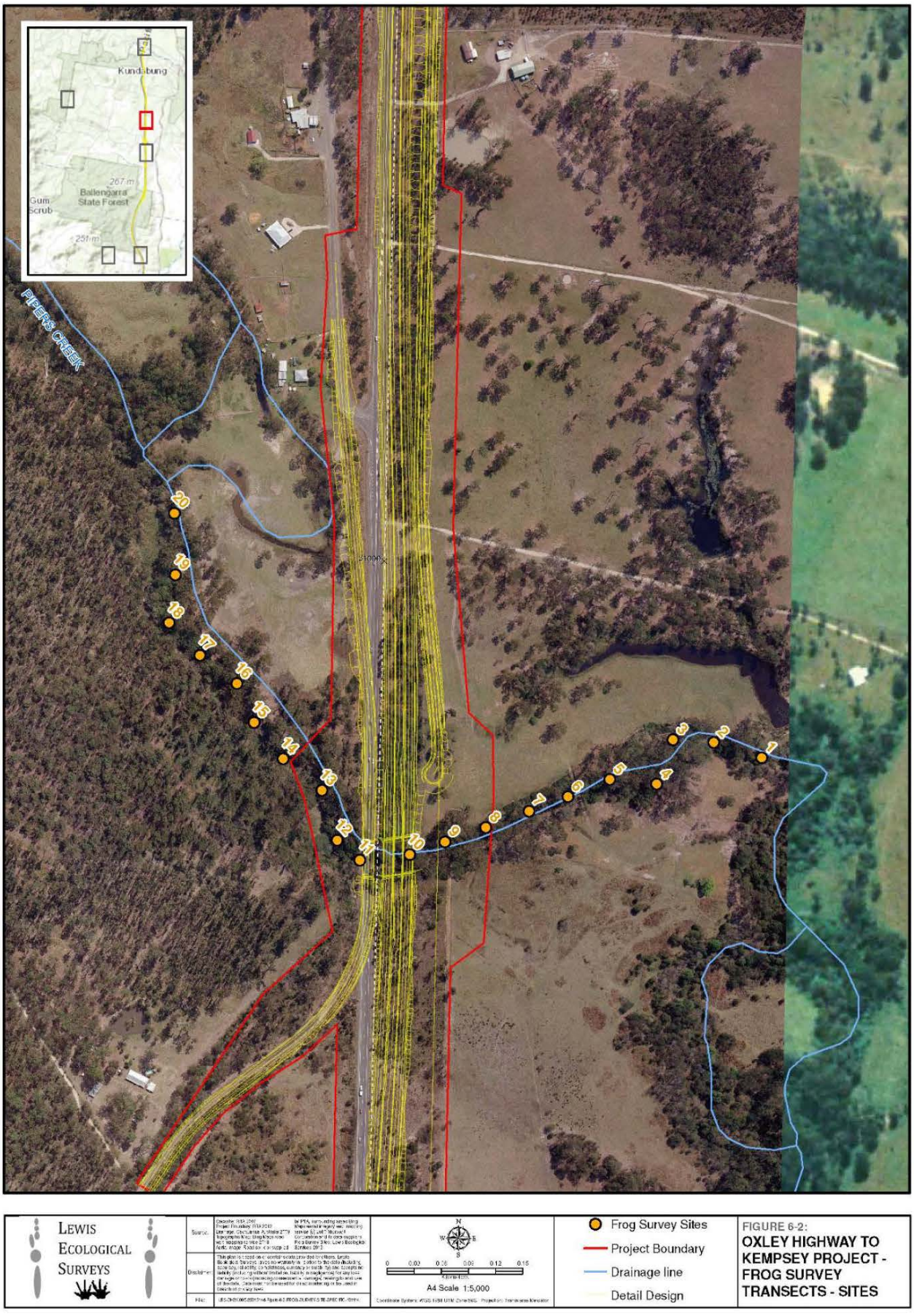


Figure 5 Maria River Impact

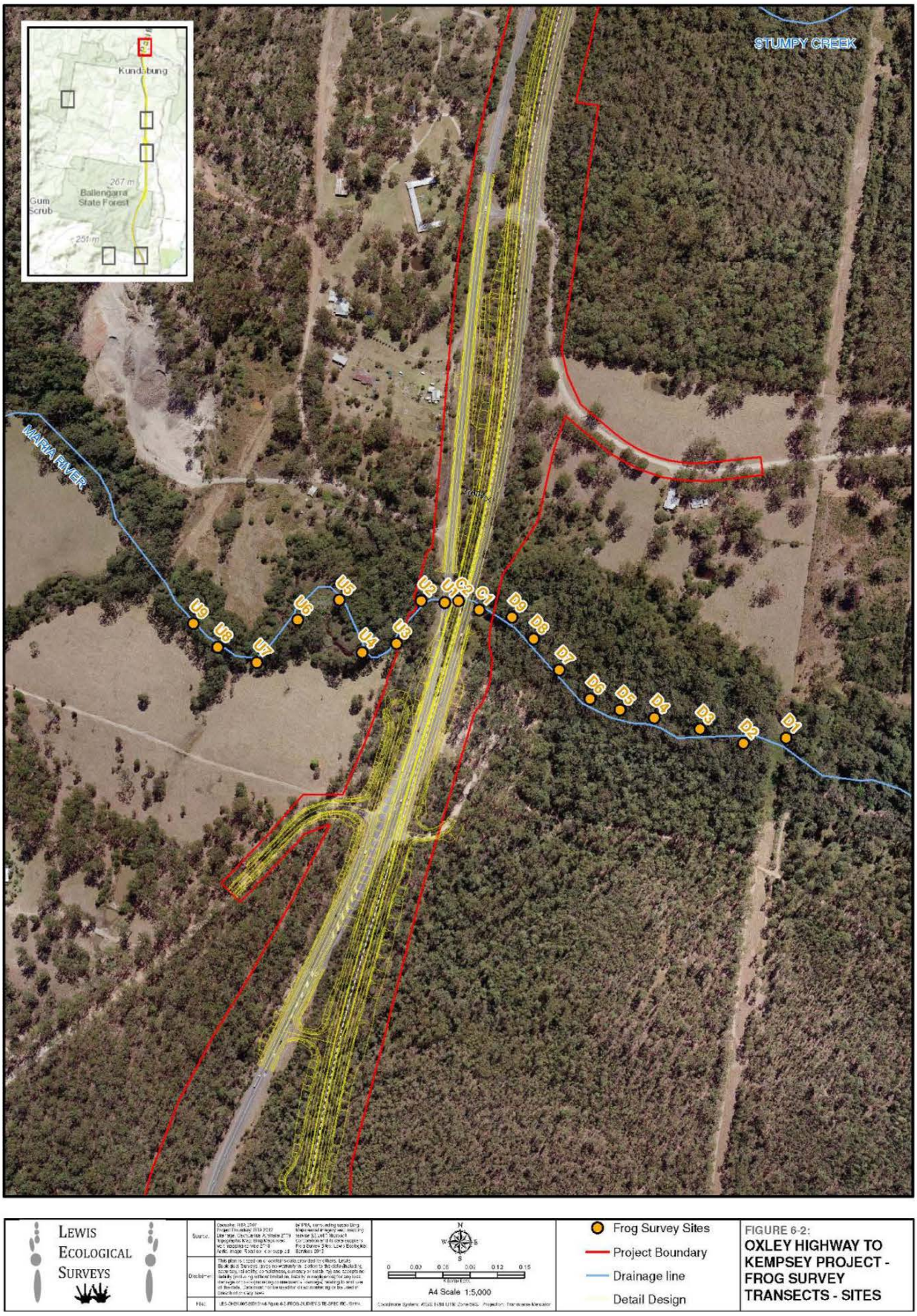


Figure 6 Cooperabung Creek Reference

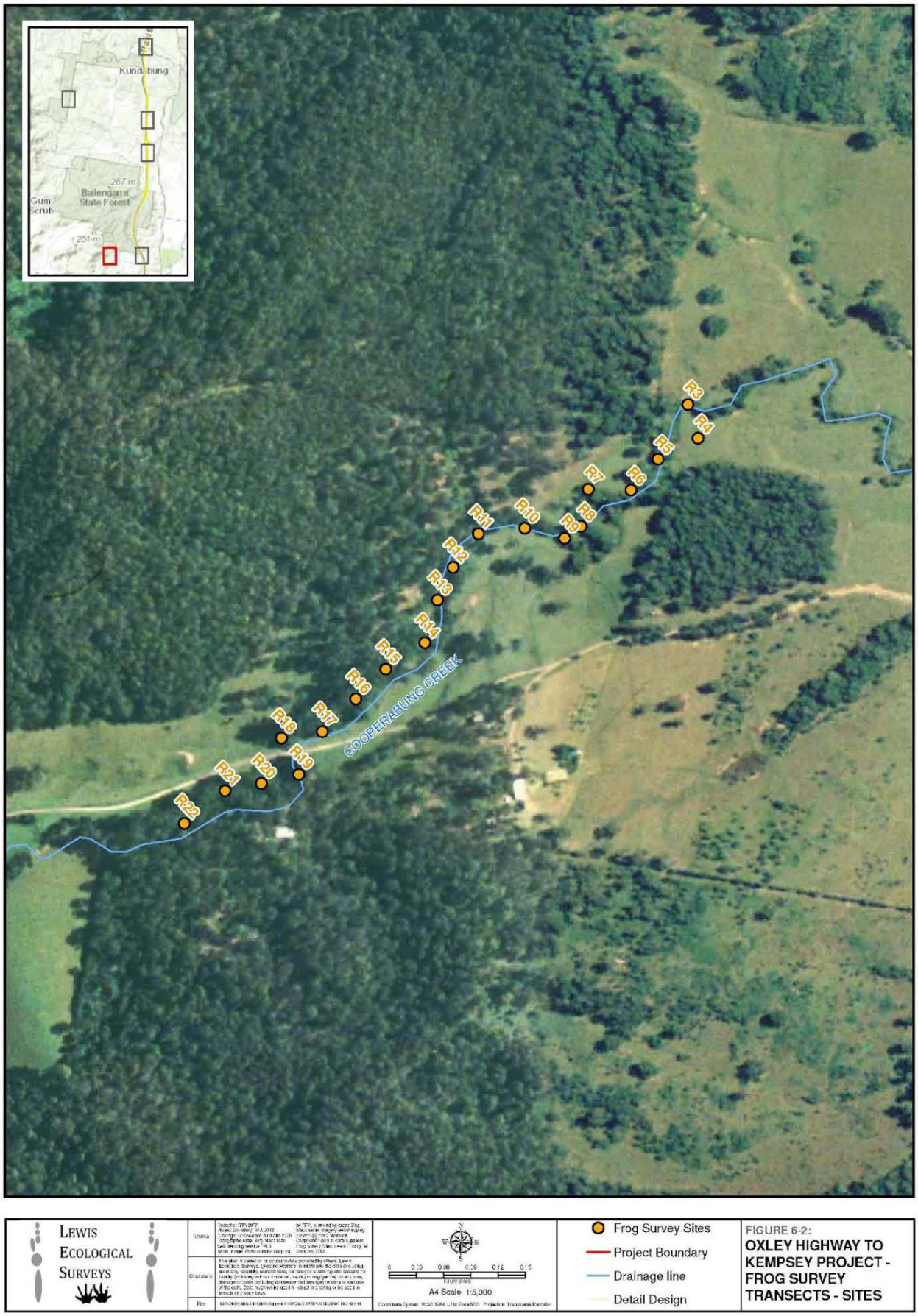
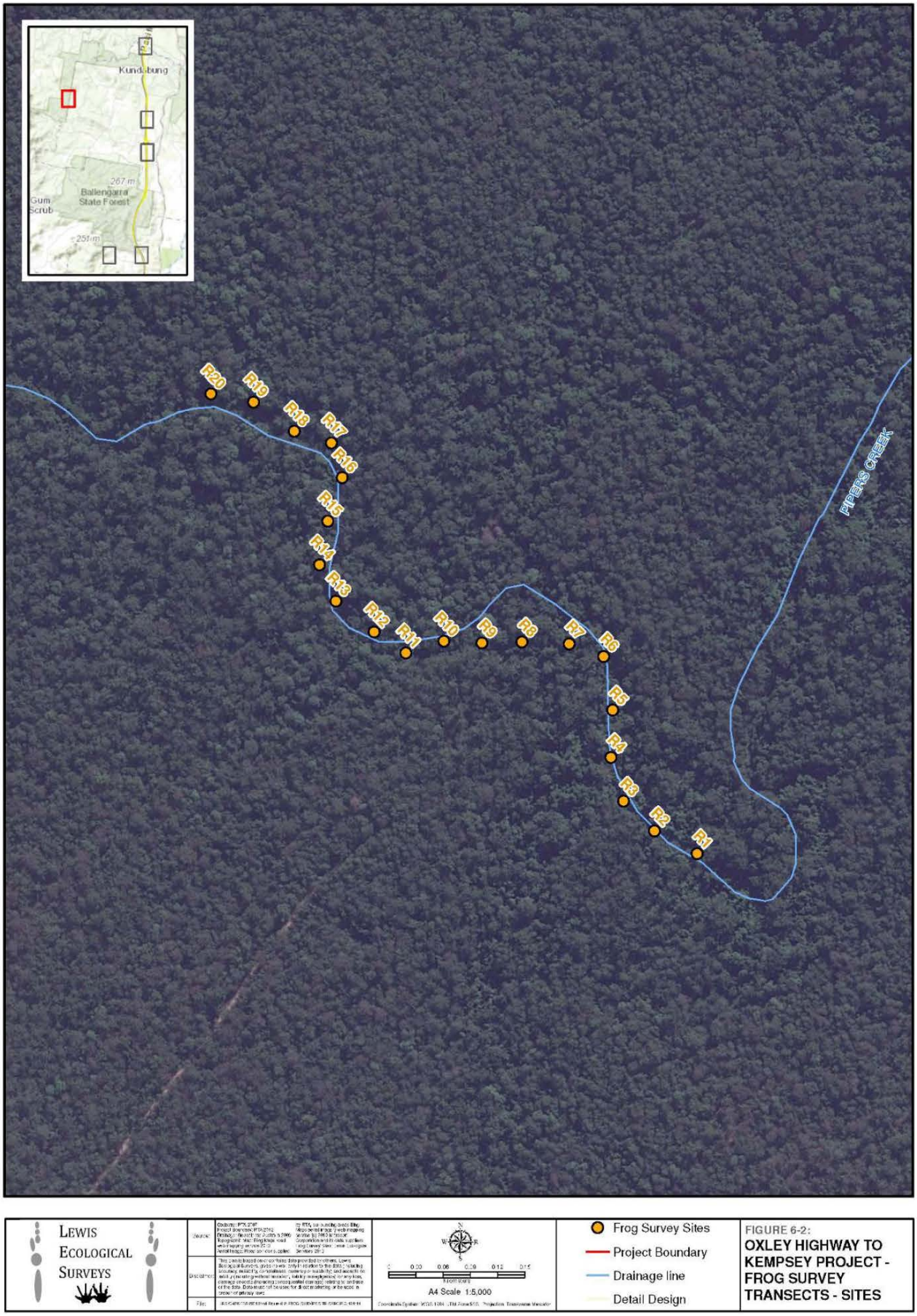


Figure 7 Pipers Creek Reference



4. Discussion

4.1 Performance measures

4.1.1 Continued presence

The continued presence of Giant Barred Frogs during each survey event in Year 1 – 8 at sites where it was identified during baseline surveys is a performance measure that can be evaluated annually through the monitoring program. Results show that the Giant Barred Frog remains present at each of the impact and reference monitoring sites. It is considered that the Project has met this performance measure for the autumn 2015 monitoring period.

4.1.2 Effectiveness of mitigation measures

This performance indicator is to be assessed at the end of the monitoring period (i.e. year 8). Notwithstanding, site observations indicate that frog fencing has been installed. Fauna crossings are yet to be installed and, as such, cannot be performance assessed at this stage of the monitoring program.

The presence of "new" records of the Chytrid fungus at Pipers Creek as well as the equivocal results at two other sites provides unclear information on the potential "introduction" of the disease by the road construction. The positive result at the upstream reference site indicates that the disease may quite possibly have been present within these areas prior to any construction and simply was not recorded in previous testing. This would fit with the results of Kriger and Hero (2007) which found the fungus to be present in all catchments sampled and the sampling effort has been relatively low. However, the available data does not allow any real conclusions to be drawn on the subject. Continued monitoring of Chytrid infection rates will provide a better understanding of the situation.

4.1.3 Water quality

Water quality will be analysed when the data can be combined for three surveys to provide a proper comparison with the baseline data set.

4.1.4 No changes in densities, distribution, habitat use and movement patterns

The Project is to demonstrate that there is 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. The data from only one single late autumn monitoring event does not yet allow any meaningful assessment of changes in these factors.

4.2 Contingencies

The EMP describes contingencies for potential problems identified in the construction and post construction period. Table 4-1 summarises the proposed actions to be undertaken where a potential problem has been detected. No actions are required to be taken at this time.

Table 4-1: Mitigation measures, potential problems, contingency measures and proposed action matrix (SMEC-Hyder 2015)

Mitigation Measure	Potential Problem	Contingency Measures	Proposed Action
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.	None. Fauna fencing is in intact and operating as intended.
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.	None. Fauna fencing is in intact and operating as intended.
Baseline Surveys Before, After, Control Impact (BACI) design (specifically the Koala, Spotted-	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 OEH and DoTe within two weeks of results reported by ecologist. If the cause of decline is considered most likely attributed to the	None. BACI design not able to be implemented due to single sample period only.

Mitigation Measure	Potential Problem	Contingency Measures	Proposed Action
tail Quoll, Giant Barred Frog, Yellow-bellied Glider, Brush-tailed Phascogale)		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.	

References

Kriger, K.M. & Hero, J.M. (2007). Large-scale seasonal variation in the prevalence and severity of chytridiomycosis. Journal of Zoology 271: 352-359.

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MacDonnell Dowell OHL JV (2014). Construction Flora and Fauna Management Sub-Plan: Kundabung to Kempsey. Prepared by MacDonnell Dowell OHL JV for the Roads and Maritime Service, Sydney.

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Annex 1 Monitoring data - 2015

Table A1-1. Demographic data for the Cooperabung Creek impact site

	Spring 2014	Summer 2014	Autumn 2015
Number of frogs recorded	n/a	n/a	8
Number of adult males	n/a	n/a	2#
Number of adult females	n/a	n/a	0
Number of subadults	n/a	n/a	4
Number of juveniles	n/a	n/a	2
Number of recaptures	n/a	n/a	0
Percentage of swabbed frogs with chytrid	n/a	n/a	0/8
Number of tadpoles caught in bait traps	n/a	n/a	0

n/a = no monitoring event performed
= sex not determined. Assumed to be male.

Table A1-2. Morphometric data for the Cooperabung Creek impact site

Giant Barred Frog Identifier	Distance from stream (m)	Sex	Breeding condition	Snout-vent (mm)	Weight (grams)	Chytrid	Condition
CC01	4	sub	non	45	16	neg (0)	Good. Yellow cream throat
CC02	2	sub	non	44	9	neg (0)	Good. Yellow cream throat
CC03	3	sub	non	63	38	neg (0)	Good. Yellow cream belly white throat
CC04	2	sub	non	59	25	neg (0)	Good. Yellow cream belly white throat
CC05	0.5	J	non	42	10	equ (1)	Good. Yellow cream throat
CC06	3	A	non	71	46	neg (0)	Good. Very cream ventral surface
CC07	5	A	non	70	38	neg (0)	Good. Very cream ventral surface
CC08	10	J	non	38	8	neg (0)	Good. Yellow cream belly white throat

sub = sub adult A = adult (non-sexed) J = Juvenile M = Male F = Female neg = negative equ = equivocal pos = positive

Table A1-3. Demographic data for the Smiths Creek impact site

	Spring 2014	Summer 2014	Autumn 2015
Number of frogs recorded	n/a	n/a	3
Number of adult males	n/a	n/a	0
Number of adult females	n/a	n/a	2
Number of subadults	n/a	n/a	1
Number of juveniles	n/a	n/a	0
Number of recaptures	n/a	n/a	0
Percentage of swabbed frogs with chytrid	n/a	n/a	0/3
Number of tadpoles caught in bait traps	n/a	n/a	0

n/a = no monitoring event performed
= sex not determined. Assumed to be male.

Table A1-4. Morphometric data for the Smiths Creek impact site

Giant Barred Frog Identifier	Distance from stream (m)	Sex	Breeding condition	Snout-vent (mm)	Weight (grams)	Chytrid	Condition
SC01	1	sub	non	50	16	neg (0)	Good. Pale spots on dorsal surface.
SC02	2	A	non	89	90	equ (1)	Yellow in groin & belly, cream throat
SC03	12	A	non	73.5	87	neg (0)	Good. Pale spots on dorsal surface.

sub = sub adult A = adult (non-sexed) J = Juvenile M = Male F = Female neg = negative equ = equivocal pos = positive

Table A1-5. Demographic data for the Pipers Creek impacts site

	Spring 2014	Summer 2014	Autumn 2015
Number of frogs recorded	n/a	n/a	4
Number of adult males	n/a	n/a	0
Number of adult females	n/a	n/a	2
Number of subadults	n/a	n/a	2
Number of juveniles	n/a	n/a	0
Number of recaptures	n/a	n/a	0
Percentage of swabbed frogs with chytrid	n/a	n/a	1/4
Number of tadpoles caught in bait traps	n/a	n/a	0

n/a = no monitoring event performed
= sex not determined. Assumed to be male.

Table A1-6. Morphometric data for the Pipers Creek impact site

Giant Barred Frog Identifier	Distance from stream (m)	Sex	Breeding condition	Snout-vent (mm)	Weight (grams)	Chytrid	Condition
PC01	12	F	non	99.6	120	neg (0)	Good. Fat (early indication of gravid?)
PC02	12	F	non	78.4	89	neg (0)	Good. Yellow cream belly white throat
PC03	5	sub	non	47.4	20	neg (0)	Pale ventral barnacles dorsal surface
PC04	3	sub	non	59.1	47	pos (3)	Cream ventral barnacles dorsal surface

sub = sub adult A = adult (non-sexed) J = Juvenile M = Male F = Female neg = negative equ = equivocal pos = positive

Table A1-7. Demographic data for the Maria River impact site

	Spring 2014	Summer 2014	Autumn 2015
Number of frogs recorded	n/a	n/a	5*
Number of adult males	n/a	n/a	0
Number of adult females	n/a	n/a	1
Number of subadults	n/a	n/a	0
Number of juveniles	n/a	n/a	1
Number of recaptures	n/a	n/a	0
Percentage of swabbed frogs with chytrid	n/a	n/a	0/2
Number of tadpoles caught in bait traps	n/a	n/a	0

n/a = no monitoring event performed
* = total count includes three individuals that were not captured and measured due to safety issues
# = sex not determined. Assumed to be male.

Table A1-8. Morphometric data for the Maria River impact site

Giant Barred Frog Identifier	Distance from stream (m)	Sex	Breeding condition	Snout-vent (mm)	Weight (grams)	Chytrid	Condition
MR01	10	sub	non	45	15	neg (0)	Good. Yellow cream belly white throat
MR02	15	F	non	89	125	neg (0)	Good. Yellow cream belly white throat barnacles dorsal surface

sub = sub adult A = adult (non-sexed) J = Juvenile M = Male F = Female neg = negative equ = equivocal pos = positive

Table A1-9. Demographic data for the Cooperabung Creek reference site

	Spring 2014	Summer 2014	Autumn 2015
Number of frogs recorded	n/a	n/a	1
Number of adult males	n/a	n/a	0
Number of adult females	n/a	n/a	1
Number of subadults	n/a	n/a	0
Number of juveniles	n/a	n/a	0
Number of recaptures	n/a	n/a	1
Percentage of swabbed frogs with chytrid	n/a	n/a	1/1
Number of tadpoles caught in bait traps	n/a	n/a	0

n/a = no monitoring event performed

Table A1-10. Morphometric data for the Cooperabung Creek reference site

Giant Barred Frog Identifier	Distance from stream (m)	Sex	Breeding condition	Snout-vent (mm)	Weight (grams)	Chytrid	Condition
0007356F32	0.5	F	non	84	135	pos (3)	Good. Yellow cream belly white throat barnacles dorsal surface

sub = sub adult A = adult (non-sexed) J = Juvenile M = Male F = Female neg = negative equ = equivocal pos = positive

Table A1-11. Demographic data for the Pipers Creek reference site

	Spring 2014	Summer 2014	Autumn 2015
Number of frogs recorded	n/a	n/a	11
Number of adult males	n/a	n/a	2#
Number of adult females	n/a	n/a	2
Number of subadults	n/a	n/a	6
Number of juveniles	n/a	n/a	1
Number of recaptures	n/a	n/a	0
Percentage of swabbed frogs with chytrid	n/a	n/a	1/11
Number of tadpoles caught in bait traps	n/a	n/a	0

n/a = no monitoring event performed
* = total count includes three individuals that were not captured and measured due to safety issues
# = sex not determined. Assumed to be male.

Table A1-12. Morphometric data for the Pipers Creek reference site

Giant Barred Frog Identifier	Distance from stream (m)	Sex	Breeding condition	Snout-vent (mm)	Weight (grams)	Chytrid	Condition
PR01	3	sub	non	48	14	neg (0)	Good. Yellow cream throat
PR02	15	F	non	85	70	neg (0)	Good. Yellow cream throat
PR03	6	M	non	66	34	neg (0)	Good. Yellow cream belly white throat
PR04	10	sub	non	45	14	neg (0)	Good. Yellow cream belly white throat
PR05	10	F	non	93	119	neg (0)	Good. Yellow cream throat
PR06	5	sub	non	51	14	pos (3)	Good. Very cream ventral surface
PR07	5	sub	non	50	17	neg (0)	Good. Very cream ventral surface
PR08	1	J	non	36	6	neg (0)	Good. Yellow cream belly white throat
PR09	5	sub	non	50	20	neg (0)	Good. Very cream ventral surface
PR10	5	sub	non	51	20	neg (0)	Good. Very cream ventral surface
PR11	12	M	non	68	40	neg (0)	Good. Yellow cream belly white throat

sub = sub adult A = adult (non-sexed) J = Juvenile M = Male F = Female neg = negative equ = equivocal pos = positive

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