Oxley Highway to Kempsey EPBC 2012/6518

Condition 8 Annual Report 2019

Roads and Maritime Services | October 2019

Document control

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Revision history

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Contents

1 Introduction

1.1. Purpose of this document

The purpose of this report is to address EPBC (2012/6518) Approval Condition 8, which requires the preparation of a report addressing compliance with each of the conditions of approval, including implementation of the:

- Biodiversity Offset Management Plan (BOMP)
- Flora and Fauna Management Plans (FFMP)
- Ecological Monitoring Plan (EMP).

This report covers the fifth period from 22 July 2018 to 21 July 2019.

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

- Date of the approval decision under sections 130(1) and 133 of the *Environment Protection and Biodiversity Conservation Act 1999* – 24 January 2015
- Commencement of the action – 22 July 2014
- Expiry of Commonwealth approval – 31 December 2063

1.2. Project staging

The Oxley Highway to Kempsey Pacific Highway Upgrade project has been constructed in three main stages:

- Stage 1: The Sancrox Traffic Arrangement works located about two kilometres north of the Oxley Highway / Pacific Highway intersection. Note that the construction of Stage 1 was completed in November 2015
- Stage 2: Kundabung to Kempsey (K2K) consisting of about 14 kilometres of dual carriageway, commencing north of Barrys Creek near Kundabung (chainage 24,000) and connecting to the Kempsey Bypass at Stumpy Creek (Chainage 37,800). Note that construction of Stage 2 was completed in October 2017
- Stage 3: Oxley Highway to Kundabung (OH2Ku) consisting of about 24 kilometres of dual carriageway, commencing just north of the Oxley Highway / Pacific Highway intersection (chainage 700) and connecting with the Kundabung to Kempsey stage just north of Barrys Creek (chainage 24,000). Note construction of Stage 3 was completed in March 2018.

In addition, there is an ultimate upgrade to the four lane Class M (motorway) standard highway. Due to estimated traffic volumes and availability of funding some sections of the Project will initially be constructed and operated as a Class A (arterial) standard highway. Upgrade of those sections of the Project from Class A to Class M standard will occur when it is warranted by an increase in traffic volumes, and when funding becomes available.

1.3. Modifications to the Conditions of Approval

No modifications to the Conditions of Approval were approved during this reporting period.

2 Conditions of Approval

2.1. Condition 1

Condition 1

The person taking the action must not clear more than 211 hectares of Koala (*Phascolarctos cinerea)* habitat, 232 hectares of Grey-headed Flying-fox (*Pteropus poliocephalus*) habitat, 215 hectares of Spotted-tail Quoll (*Dasyurus maculatus*) habitat and 7.7 hectares of Giant-Barred Frog (*Mixophyes iteratus*) habitat within the project corridor of the proposed action.

Clearing for the three initial stages of the project (refer Section 1.2) is now complete. The clearing quantities for the first three stages against the limits outlined in Condition 1 are detailed in Table 1.

Table 1 Clearing quantities for the first three stages of the project

EPBC Species	Total estimated clearing	Total clearing	EPBC Limit Condition 1
Koala	196.8284	196.7656	211
Grey-headed flying fox	206.9144	206.8258	232
Spotted-tail Quoll	197.0330	196.2896	215
Giant-barred Frog	2.8512	2.8512	7.7

2.2. Condition 2

Condition 2

To assist in mitigating the impacts of the proposal on the Koala, Grey-headed Flying-fox, Spotted-tail Quoll and the Giant-Barred Frog during construction, the person taking the action must prepare and submit a Flora and Fauna Management Plan for each **stage** of the action, for the **Minister**'s written approval prior to **commencement** of each **stage** of the action. The Flora and Fauna Management Plan for each **stage** must be approved by the **Minister** in writing prior to **commencement** of the relevant **stage**. These plans must include:

- **a.** Measures to be implemented to avoid, suppress and control the spread of weeds, plant pathogens and invasive species;
- **b.** Measures to avoid and minimise other indirect impacts that may result from the proposal during and after construction, including erosion and sedimentation;
- **c.** Measures to manage aquatic habitat on-site to at least maintain habitat values for the Giant Barred Frog;
- **d.** A detailed description of the pre-clearance surveys to be undertaken by a **suitably qualified expert** within all areas proposed for disturbance, including: hollow bearing trees, logs, existing culverts and bridges, no earlier than 48 hours prior to the removal of vegetation occurring in that area to ensure that the area is free of the Koala, Giant-Barred Frog, Grey-headed Flying-fox and Spotted-tail Quoll.
- **e.** Measures to relocate and/or ensure the **appropriate care of** individuals of the Koala, Giant-Barred Frog, Grey-headed Flying-fox and Spotted-tail Quoll that are identified during searches referred to in condition 2d; and

Condition 2

f. Clear key milestones, monitoring, performance indicators, corrective actions and timeframes for the completion of all actions outlined in the plan.

A Flora and Fauna Management Plan has been prepared for each stage of the project. As at 21 July 2019, these plans were approved by the Minister on the following dates:

- Stage 1: Sancrox Interchange — 24 June 2014
- Stage 2: Kundabung to Kempsey — 22 October 2014 (Revision 1); 15 November 2016 (Revision 2)
- Stage 3: Oxley Highway to Kundabung — 10 October 2014 (Revision 1); 15 November 2016 (Revision 2)

Construction of these three stages was completed during the last reporting period, along with the requirements of each Flora and Fauna Management Plan. As such the compliance status of the implementation of these plans is no longer being detailed in this report.

2.3. Condition 3

Condition 3

To assist in mitigating the impacts of the proposal on the Koala, Spotted-tail Quoll and the Giant-Barred Frog, the person taking the action must construct and maintain **fauna crossings** and **fencing** in all **areas that are likely to benefit** these species for the duration of the impact of the action.

a. The **fauna crossings** must:
   - **i.** be **effective** for the Koala, Spotted-tail Quoll and/or Giant Barred Frog (the relevant species targeted to use the **fauna crossing**);
   - **ii.** provide dry passage up to a 1 in 100 year Average Recurrence Interval (ARI) event for **dedicated fauna crossings** and up to a one in 1 year 72 hour ARI event for **combined fauna crossings**;
   - **iii.** include a minimum of 11 **dedicated fauna crossings** and 30 **combined fauna crossings** for the project;
   - **iv.** not increase in length more than 10 per cent from the lengths provided in Schedule 2 of this notice, and not reduce in width and height from the values provided in Schedule 2 of this notice without the written consent of the **Minister**;
   - **v.** be bridges in **areas that are likely to benefit** the Giant-Barred Frog.

b. If a change to the **fauna crossing** design is proposed that does not meet the parameters described in Condition 3a), the person taking the action must:
   - **i.** provide evidence to the **Minister** that these will remain **effective** for the Koala, Spotted-tail Quoll or Giant-Barred Frog (as relevant for the **fauna crossing**) for the **Minister's** written approval prior to **commencement** of the **stage** relevant to that fauna crossing; or
   - **ii.** provide written evidence to the **Minister** detailing how the resulting loss in connectivity will be compensated for with increased connectivity for the impacted species. This must be

Condition 3

approved in writing by the **Minister,** prior to **commencement** of **stage 2** and **stage 3**.

c. **Fencing** must be constructed at a minimum the locations identified in Schedule 3 of this notice.

The requirements of this condition were completed during the last reporting period (2017/18). Please refer to the 2017/18 report for further detail on compliance with this condition.

2.4. Condition 4

Condition 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.

The Ecological Monitoring Program for the project was submitted to the Minister in a letter dated 29 April 2014 and approved by the Minister on 10 October 2014. Commencement dates for Stage 2 and Stage 3 were early to mid-November 2014.

An updated Ecological Monitoring Program for the project was submitted to the Minister on 3 May 2016 and approved by the Minister on 11 November 2016.

A third revision of the Ecological Monitoring Program for the project was submitted to the Minister on 3 April 2019. At the date of the approval anniversary for this compliance reporting period, the plan remained under review by the Department.

The compliance status of the implementation of the Ecological Monitoring Program is detailed in Appendix B.

2.5. Condition 5

Condition 5

To compensate for the loss of 240 hectares of threatened species habitat the person taking the action must prepare and submit a Biodiversity Offset Management Plan (**BOMP**) for the **Minister's** written approval within 12 months of approval of the action. The BOMP must be approved in writing by the **Minister** within 12 months of approval of the action. The **BOMP** must include:

a. the identification of the portions of the lands described as the "Proposed Biodiversity Offset Areas" in the Map at Schedule 1 of this notice that are necessary to achieve the outcomes required by the *Environmental Offsets Policy 2012* (or subsequent published revisions). This must include **offset attributes**, **shapefiles**, textual descriptions and maps to clearly define the location and boundaries of the offset area(s);

b. the results of targeted field surveys within the offset sites (undertaken at any ecologically appropriate time of the year) to assess and describe habitat suitability and presence / absence of individuals in relation to the Koala, Grey-headed Flying-fox, Spotted-tail Quoll and Giant Barred frog;

c. an assessment of the baseline population for the Koala, Spotted-tail Quoll, Giant-Barred Frog, and Grey-headed Flying-fox which are detected within the offset area during field surveys;

d. a description of the current **quality** (prior to any management activities) of the offset area(s) identified in Condition 5a with reference to the Koala, Spotted-tail Quoll, Giant-Barred Frog, and Grey-headed Flying-fox;

e. an assessment demonstrating how the offset area(s) achieve the outcomes required by the *Environmental Offsets Policy 2012* (or subsequent published revisions) and user guide;

f. Should the offset sites identified in 5a not be sufficient to achieve the outcomes required by the *Environmental Offsets Policy 2012* (or subsequent published revisions) and user guide, as determined in writing by the **Minister**, the person taking the action must provide further suitable offset sites and include these as part of the **BOMP**;

g. information about the Koala, Grey-headed Flying-fox, Spotted-tail Quoll, Grey-headed Flying-fox, and Giant Barred frog (in relation to ecology, biology and conservation status) to inform appropriate management actions;

h. targeted management actions, regeneration and revegetation strategies to be undertaken on the offset area(s) to improve the ecological quality of these areas for the Koala, Grey-headed Flying-fox, Spotted-tail Quoll and Giant Barred frog

i. clear performance objectives for management actions that will enable maintenance and enhancement of habitat within the offset area, as well as contribute to the better protection of individuals and / or populations of Koala, Spotted-tail Quoll, Giant-Barred Frog, and Grey-headed Flying-fox onsite;

j. anticipated timeframes for achieving performance objectives.

k. performance and completion criteria for evaluating the management of the offset

Condition 5

area, including contingency actions, criteria for triggering contingency actions and a commitment to the implementation of these actions in the event that performance objectives are not met;

l. a program to monitor and report on the effectiveness of these measures, and progress against the performance and completion criteria;

m. details of who would be responsible for monitoring, reviewing, and implementing the **BOMP**.

n. a description of funding arrangements or agreements including work programs and responsible entities;

The approved **BOMP** must be published on the NSW Roads and Maritime Services internet web site, within 1 month of the BOMP being approved.

The approved BOMP must be implemented.

The BOMP was submitted to the Department of the Environment for the approval of the Minister in a letter dated 16 January 2015. Approval from the Minister remains outstanding.

2.6. Condition 6

Condition 6

If an offset site proposed as a part of Condition 5 is already required to be protected as a result of a separate EPBC Act approval, only the management actions which can be demonstrated to be additional to those required for the separate approval, can be considered as an offset for this project. The legal protection of the site and management measures required for a separate approval cannot be considered a part of the offset, in accordance with the *Environmental Offsets Policy 2012* (or subsequent published revisions).

This requirement has been noted as part of the preparation of the BOMP, required under Condition 5.

2.7. Condition 7

Condition 7

Within 12 months of approval of the Biodiversity Offset Management Plan (BOMP), the person taking the action must secure the offset area(s) identified in Condition 5a), under relevant conservation legislation. The legal instrument chosen must be registered on title, and must prevent any future development activities from occurring on the land protected, and ensure the active management of that land for the better protection of matters of national environmental significance for the duration of the impact of the action. Evidence of compliance with this condition must be provided to the **Department** within 30 days after the land(s) have been secured.

Approval from the Minister of the BOMP remains outstanding; as such compliance with this condition is not yet applicable.

2.8. Condition 8

Condition 8

Within three months of every 12 month anniversary of the **commencement** of the action, the person taking the action must publish a report on their website addressing compliance with each of the conditions of this approval, including implementation of the BOMP, Flora and Fauna Management Plans and Ecological Monitoring Plan as specified in the conditions. Documentary evidence providing proof of the date of publication must be provided to the **Department** at the same time as the compliance report is published. Noncompliance with any of the conditions of this approval must be reported to the **Department** within 2 business days of becoming aware of the non-compliance. At any time within the life of this approval the **Minister** may agree, in writing, that further reporting is not required if compliance with all requirements has been demonstrated to the **Minister's** satisfaction.

This report has been prepared to satisfy the requirements of this condition. Evidence of the date of publication will be provided to the Department when this report is published on the Roads and Maritime project website.

The BOMP was submitted to the Department of the Environment for the approval of the Minister in a letter dated 16 January 2015. Approval from the Minister remains outstanding.

Following recent consultation with the Department, Roads and Maritime is prepared to resubmit the BOMP in Q4 of 2019.

A Flora and Fauna Management Plan has been prepared for each stage of the project. As at 21 July 2019, these plans were approved by the Minister on the following dates:

- Stage 1: Sancrox Interchange — 24 June 2014
- Stage 2: Kundabung to Kempsey — 22 October 2014 (Revision 1); 15 November 2016 (Revision 2)
- Stage 3: Oxley Highway to Kundabung — 10 October 2014 (Revision 1); 15 November 2016 (Revision 2)

Construction of Stage 1 was completed in November 2015. Construction of Stage 2 and Stage 3 was completed in October 2017 and March 2018 respectively.

With the exception of the Ecological Monitoring Programs included as Appendices, the Flora and Fauna Management Plans are construction documents and were closed out in the Annual Report submitted to the July 2017 - July 2018 reporting period.

Details of the implementation of the Ecological Monitoring Plan is provided in Section 2

All previous reports, and this report once published, can be found at the following link:

https://www.pacifichighway.nsw.gov.au/document-library/oxley-highway-to-kempsey-upgrade-epbc-compliance-reports

2.9. Condition 9

Condition 9

Within 30 days after the **commencement** of the action, the person taking the action must advise the **Department** in writing of the actual date of **commencement**.

In a letter to the Department, dated 19 August 2014, Roads and Maritime advised the Department of the actual date of commencement, being 22 July 2014.

2.10. Condition 10

Condition 10

The person taking the action must maintain accurate records substantiating all activities associated with or relevant to these conditions of approval, including measures taken to implement the **BOMP,** Ecological Monitoring Plan and Flora and Fauna Management Plans, and make them available upon request to the **Department**. Such records may be subject to audit by the **Department** or an independent auditor in accordance with section 458 of the EPBC Act, or used to verify compliance with the conditions of approval. Summaries of audits will be posted on the **Department's** website. The results of audits may also be publicised through the general media.

Roads and Maritime is maintaining accurate records for all activities relating to the conditions of approval, and the implementation of the BOMP, EMP and FFMPs. The potential audit by the Department is noted.

2.11. Condition 11

Condition 11

Upon the direction of the **Minister**, the person taking the action must ensure that an independent audit of compliance with the conditions of approval is conducted and a report submitted to the **Minister**. The independent auditor must be approved by the **Minister** prior to the **commencement** of the audit. Audit criteria must be approved by the **Minister** and the audit report must address the criteria to the satisfaction of the **Minister**.

The requirements of this condition are noted. A direction from the Minister under Condition 11 has not been received by Roads and Maritime during this reporting period.

2.12. Condition 12

Condition 12

1. If the person taking the action wishes to carry out any activity otherwise than in accordance with the **BOMP**, Ecological Monitoring Plan and Flora and Fauna Management Plans as specified in the conditions, the person taking the action must submit to the **Department** for the **Minister's** written approval a revised version of that Plan. The varied activity shall not commence until the **Minister** has approved the varied Plan in writing. The **Minister** will not approve a varied Plan unless the revised Plan would result in an equivalent or improved environmental outcome over time. If the **Minister** approves the revised Plan, that Plan must be implemented in place of the Plan originally approved.

Roads and Maritime submitted an update to the Ecological Monitoring Plan to the Department for approval on 3 May 2016. The updated Ecological Monitoring Plan was also an appendix of the approved Kundabung to Kempsey and Oxley Highway to Kundabung Flora and Fauna Management plans. The EMP and FFMP updates were approved by the Minister on 15 November 2016.

A third revision of the Ecological Monitoring Program for the project was submitted to the Minister on 3 April 2019. At the date of the approval anniversary for this compliance reporting period, the plan remained under review by the Department.

The BOMP has not yet been approved by the Department, and therefore the requirements of this condition are not yet applicable to this plan.

2.13. Condition 13

Condition 13

1. If the **Minister** believes that it is necessary or convenient for the better protection of listed threatened species and ecological communities to do so, the **Minister** may request that the person taking the action make specified revisions to the **BOMP**, Ecological Monitoring Plan and Flora and Fauna Management Plans, as specified in the conditions and submit the revised **BOMP**, Ecological Monitoring Plan and Flora and Fauna Management Plans for the **Minister's** written approval. The person taking the action must comply with any such request. The revised approved **BOMP**, Ecological Monitoring Plan and Flora and Fauna Management Plans must be implemented. Unless the **Minister** has approved the revised **BOMP**, Ecological Monitoring Plan and Flora and Fauna Management Plans then the person taking the action must continue to implement the **BOMP**, Ecological Monitoring Plan and Flora and Fauna Management Plans originally approved.

Noted.

No requests from the Minister under Condition 13 were received by Roads and Maritime in this reporting period.

2.14. Condition 14

Condition 14

If, at any time after 5 years from the date of this approval, the person taking the action has not **substantially commenced** the action, then the person taking the action must not substantially commence the action without the written agreement of the **Minister**.

Commencement of the action occurred on 22 July 2014.

2.15. Condition 15

Condition 15

Unless otherwise agreed to in writing by the **Minister**, the person taking the action must publish all plans referred to in these conditions of approval on their website. Each plan must be published on the website within 1 month of being approved.

The Flora and Fauna Management Plans for each stage are published at

- https://www.pacifichighway.nsw.gov.au/document-library/sancrox-traffic-arrangement-flora-and-fauna-management-sub-plan
- https://www.pacifichighway.nsw.gov.au/document-library/oxley-highway-to-kundabung-upgrade-construction-environmental-management-plan-0

- https://www.pacifichighway.nsw.gov.au/document-library/kundabung-to-kempsey-upgrade-construction-environmental-management-plan

The Ecological Monitoring Program and reports are published at

- https://www.pacifichighway.nsw.gov.au/document-library/oxley-highway-to-kempsey-upgrade-ecological-monitoring-program-and-reports

3 Ecological Monitoring Plan

Table 2 outlines the monitoring requirements from the Ecological Monitoring Plan, relevant to matters of National Environmental Significance that were required to be conducted during the last reporting period.

This monitoring was conducted in accordance with the timing requirements outlined in Table 2. The results of these monitoring events, including evaluation of the project's compliance with the performance indicators, have been included in Appendix B.

In some instances, monitoring of a particular species or mitigation measure requires several monitoring events throughout the year. In these instances it is considered more informative to wait until all monitoring events have been conducted for that year, before reporting on the results. This allows analysis between seasons, further statistical analysis, etc to be conducted than if individual monitoring events are reported on. Table 2 also details those species/ mitigation measures where further monitoring is to be conducted in the remainder of 2018, and as such a combined report for all of the results for 2018 will be reported on in the 2018/19 annual report.

Table 2 Ecological monitoring requirements during the last reporting period

Species monitored	Timing	Done/ yet to be done	Reporting
Koala	Spring/Summer	Year 3 monitoring (2017) completed. Year 4 monitoring (2018) completed. Year 5 monitoring scheduled for spring 2019 and summer 2019/20.	Year 4 monitoring included in this report
Spotted-tail Quoll	Autumn/winter	Year 4 monitoring (2018) completed. Year 6 monitoring scheduled for autumn/winter 2020.	
Giant Barred Frog	Spring, Summer and Autumn	Year 3 monitoring (2017/18) completed. Year 4 monitoring (2018/19) completed. Spring and autumn surveys were undertaken after suitable rainfall in accordance with the approved EMP. Summer 2019 surveys were not undertaken due to insufficient rainfall. Year 5 monitoring scheduled for spring 2019, summer 2019/20 and autumn 2020.	Year 4 monitoring included in this report
Road kill	Weekly during October (spring), January (summer) and April (autumn)	Construction / post opening – July 2017 – June 2018 completed.	Year 4 monitoring included in this report

Species monitored	Timing	Done/ yet to be done	Reporting
		Year 4 Year 4 monitoring (2018/19) completed. Year 5 monitoring scheduled for October 2019, January 2020 and April 2020.	
Fauna underpasses & fauna fencing	Autumn/spring/summer	Year 4 monitoring (2018/19) completed. Year 6 monitoring scheduled for late autumn 2020, late spring /early summer 2020	One report for Year 4 (first year of operation) to be included in 2018/19 annual report.

Table 3 lists the title of each of the monitoring reports where each of the EPBC reporting requirements in Table 2 have been addressed. These can all be found in Appendix A.

Table 3 EPBC monitoring reports in Appendix A

Species / aspects monitored	Report title in Appendix A
Koala Spring/Summer (Year 4) monitoring	Koala Monitoring 2018
Giant Barred Frog spring, summer and autumn monitoring	Giant Barred Frog Monitoring 2017/2018
Fauna Fence and Road kill monitoring	Fauna Fence and Road kill Monitoring 2018 / 2019
Fauna Underpass monitoring	Fauna Underpass monitoring 2018 / 2019

Clearing has been completed and reported on in previous reports.

All the Ecological Monitoring Program performance measures for the monitoring events listed in Table 3 were met for the 2018/2019 reporting period, except for the following which were not found to be attributed to the project:

- **Koala:**: The performance measure relating to changes in distribution and habitat use has not been met as Koala presence and activity levels appear to have decreased between the baseline, and all following monitoring events. However this apparent decrease has occurred at both control and impact sites. In each of the monitoring surveys undertaken to date, impact sites recorded higher percentages of Koala presence than control sites. In addition, presence and activity levels increased in 2018 compared to previous monitoring years and, in accordance with Lewis (2014), have not decreased from the baseline surveys beyond the recommended 10% tolerance level. As such, results of monitoring undertaken to date indicate that the observed changes in Koala activity/presence across the Project area cannot be directly attributed to the Project and are within the 10% tolerance level.

  It is important to note and as previously advised, one Koala road kill was recorded at Barrys Creek in September 2018 and reported to DoEE at the time. Detailed inspections of the area indicate that the Koala likely accessed the road corridor through a section of fence that had been damaged in flood in March. The breached fauna fence was identified and temporary repairs were immediately undertaken within two days of the road kill being found and permanent works completed on the 19 -21 September 2018.

  This does not result in a non-compliance with the performance indicators of the Ecological Monitoring Program, however is being reported as part of the submission of this report for transparency.

- **Giant Barred Frog:** The performance measure relating to continued presence of Giant Barred Frogs during each survey event where it was identified during baseline surveys was

met for five of the six sites. Giant Barred Frogs were not recorded at Cooperabung reference site during the spring survey, where it was recorded during spring baseline surveys. Giant Barred Frogs were however recorded at this site during autumn 2019 surveys.

- **Giant Barred Frog**: The performance measure relating to changes in density was met for all impact sites except Pipers Creek impact site and Cooperabung Creek impact site. Cooperabung Creek impact, Pipers Creek impact and Cooperabung Creek reference sites all show a decreasing trend in mean records and densities. However, as this decreasing trend is evident at both impact and reference sites, it is not possible to attribute these changes to the Project at this stage.

- **Fauna Underpasses**: Performance measures were partially met for the 2018/2019 underpass monitoring event. Two of the three EPBC listed target species (Koala and Spotted-tailed Quoll) were recorded completing crossings however it was considered that the Giant Barred Frog is unlikely to be detected at the nominated underpass.

Appendix A: Ecological Monitoring Program

Species / mitigation monitored	Report title
Koala	Koala Monitoring 2018
Giant Barred Frog	Giant Barred Frog Monitoring 2018/209
Fauna Fence and Road kill	Fauna Fence and Road kill Monitoring 2018 / 2019
Fauna Underpass	Fauna Underpass Monitoring 2018 / 2019

Koala Monitoring 2018

Year 4 Surveys – Oxley Highway to Kempsey, Pacific Highway Upgrade

Prepared for Roads and Maritime Services

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Cover photograph: Koala scats in Maria River National Park (left) and Koala photographed using underpass in Cairncross State Forest (right).

Executive Summary

Context

This report documents findings from the spring-summer 2018 monitoring period for the Koala, as required for the Oxley Highway to Kempsey (OH2K) Pacific Highway upgrade project (the Project).

Aims

The aim of the Koala monitoring program is to determine whether the Project is having an impact on Koala populations within the study area.

Methods

Each monitoring location was surveyed in accordance with the monitoring method and design specified in the Oxley Highway to Kempsey Pacific Highway Upgrade Ecological Monitoring Program (EMP, RMS 2016). Surveys were undertaken in November and December 2018.

Key Results

- A total of 93 plots across 31 clusters were surveyed in spring-summer 2018. Koalas were found to be present within 16 of the 31 clusters (52%).
- The mean SAT activity level for all plots, measured as the percentage of trees at each plot with scats present, was 2.5% (with a standard deviation of 5.4) and ranged from 0 to 36.7%. This is higher than the mean activity recorded for plots during 2015, 2016 and 2017 surveys (2.0%, 0.7% and 1.8% respectively), but lower than the mean activity recorded during baseline surveys (4.9%).
- Koalas were recorded more frequently at impact sites (67%) than at control sites (38%), which is consistent with results observed in the previous monitoring events.
- Koalas have been recorded using three of the fourteen culverts (located within the vicinity of the monitoring sites) being monitored as part of the Fauna Underpass Monitoring for the Project.
- There was no significant change in the difference between Koala presence at control and impact clusters between 2018 and baseline surveys.
- There was no significant change in the difference between Koala presence at clusters with and without mitigation between 2018 and baseline surveys.
- Average plot activity levels for each treatment type have not decreased from the baseline surveys beyond the recommended 10% tolerance level.

Conclusions

- Performance measures relating to survey requirements have been met.
- Fauna fence has been installed as required by Schedule 3 of the EPBC approval.
- The performance measure relating to changes in distribution and habitat use has not been met as Koala presence and activity levels appear to have decreased between the baseline, and all following monitoring events. However this apparent decrease has occurred at both control and impact sites. In each of the monitoring surveys undertaken to date, impact sites recorded higher percentages of Koala presence than control sites. In addition, presence and activity levels increased in 2018 compared to previous monitoring years and, in accordance with Lewis (2014), have not decreased from the baseline surveys beyond the recommended 10% tolerance level. As such, results of monitoring undertaken to date indicate that the observed changes in Koala activity/presence across the Project area cannot be directly attributed to the Project and are within the 10% tolerance level.

Management Implications

As no significant changes in Koala presence and activity levels from baseline surveys have been detected to date, and as Koalas have been detected using three dedicated fauna underpasses within the Project area, no additional mitigation recommendations have been made at this time.

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1. Introduction

1.1 Context

The Oxley Highway to Kempsey (OH2K) section of the Pacific Highway Upgrade Project (the Project) was approved in 2012 subject to various Ministers Conditions of Approval (MCoA) and a Statement of Commitments (SoC). A subsequent approval with additional conditions of consent (CoA) was granted in 2014 by the Commonwealth Department of Environment (DoE) for Matters of National Environmental Significance (MNES) listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1995* (EPBC Act). The Ecological Monitoring Program (hereafter referred to as the EMP) (RMS 2016) combines these approval conditions and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project. The Koala was identified as requiring mitigation and monitoring during the Project's construction and operational periods.

1.1.1 Legal status

The Koala (*Phascolarctos cinereus*) is listed as vulnerable under both the NSW *Biodiversity Conservation Act* (BC Act 2016) and the Commonwealth EPBC Act. Monitoring of the species is required under the Project's approval.

1.1.2 Monitoring framework

The design, methods and performance indicators that define the Koala monitoring program are specified in the EMP. The monitoring program specifies that monitoring of all sites would occur in Years 1, 2 and 3 (construction phase) once substantial construction had commenced. Following the completion of the Project, monitoring was to continue in Years 4, 5, 6 and 8 (operation phase) or until the mitigation measures can be demonstrated to have been effective for the Koala.

To date, these monitoring events have been conducted and reported on as follows:

- Spring-summer 2015: *Koala Monitoring. Year 1 surveys - Oxley Highway to Kempsey Pacific Highway Upgrade* (Niche 2016)
- Spring- summer 2016: *Koala Monitoring 2016. Year 2 surveys - Oxley Highway to Kempsey Pacific Highway Upgrade* (Niche 2017)
- Spring-summer 2017: *Koala Monitoring 2017. Year 3 surveys - Oxley Highway to Kempsey Pacific Highway Upgrade* (Niche 2018a)
- Spring-summer 2018: Current report.

This report represents the first of the four required operational monitoring reports. Construction monitoring was completed in spring-summer 2017.

1.1.3 Baseline data

In accordance with the EMP, baseline surveys for the Koala were undertaken in 2014 to provide baseline data that could be used to identify changes in habitat use before and after construction of the Project, and determine whether any changes can be reasonably attributed to the Project. Baseline monitoring was conducted by Lewis Ecological prior to the commencement of construction (Lewis 2014). Remote cameras were also opportunistically deployed (targeting other threatened species) in August 2013, while spotlighting and Spot Assessment Technique (SAT) plot surveys were undertaken in spring 2013.

1.1.4 Purpose of this report

This report details the findings obtained from the 2018 monitoring period. As mentioned previously, it represents the first monitoring report for the operational phase of the Project.

The aim of this report is to summarise the methods and results of the spring-summer 2018 monitoring, and to compare the results with the baseline surveys to determine whether performance measures are being met and comment on whether additional measures should be considered.

1.2 Performance Measures

The EMP specifies the following performance measures for the Koala:

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

1.3 Monitoring Timing

Monitoring is to occur during spring-summer.

1.4 Reporting

Annual reporting of monitoring results will include:

- A detailed description of the monitoring methodology
- Results of the monitoring surveys
- Discussion of the 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 NSW Department of Planning and Environment and the NSW Environment Protection Authority.

2. Survey Methodology

2.1 Monitoring Design

In accordance with the baseline monitoring surveys, eight broad areas within a 20 kilometre radius of the Project were surveyed. These eight areas include South Sancrox, North Sancrox, Cairncross State Forest (South), Cairncross State Forest (North), Cooperabung Hill, Mingaletta Road to Smiths Creek, Kundabung Road to North of Pipers Creek and Maria River State Forest. Within each of these areas, three types of monitoring treatments were established:

- Type A: Impact with mitigation. Mitigation plots are located within 500 metres of sufficiently large culverts (>1.8 metres, to allow Koalas to pass under the Highway) that are paired with floppy top fencing.
- Type B: Impact without mitigation. Plots where mitigation has not been proposed or only partial mitigation is proposed. Partial mitigation plots are where only floppy top fencing is present but with obvious openings at interchanges or entry/exit points.
- Type C: Control or reference. These are located in areas at least three kilometres, and often 5-10 kilometres from the Project.

Each treatment type (A, B or C) is represented by a cluster of three SAT plots within each of the eight areas, resulting in nine SAT plots per area giving a total of 72 baseline SAT plots, established by Lewis (2014) (with the exception of Cairncross State Forest (South) that had an additional type B cluster during baseline and Mingaletta to Smiths Creek were no type B cluster was established during baseline). Of these 72 plots, 24 were mitigation (type A), three part mitigation and 21 no mitigation (type B), and 24 were control sites (type C). To ensure a balanced monitoring design between impact plots (mitigated and not mitigated) and control plots, an additional 24 control plots (type C) were established during the first monitoring event in 2015 (Niche 2016). In accordance with the baseline monitoring design these additional 24 control plots were established at least three kilometres from the Project and were grouped in clusters of three plots, one cluster for each of the eight broad areas.

In 2015, eight of the baseline plots had to be relocated to nearby locations because they had been established in the construction site itself or because they were located on private property and access was not possible. Three of the baseline monitoring plots that could not be accessed could not be relocated because there weren't any suitable sites nearby. These three plots were all part of the same cluster (impact, no mitigation) located in the North Sancrox area.

Details of the 96 monitoring plots are presented in Table 1 and the location of the 93 accessible monitoring plots are shown in Figure 1.

Table 1: SAT monitoring plots

Area	Type	Sub category	Data source	Plot name	Easting	Northing
South Sancrox	Impact	No Mitigation	Baseline	1 Sancrox East - Cassegrains	483348	6521736
	Impact	No Mitigation	Baseline	2 Sancrox East - Cassegrains	483455	6521789
	Impact	No Mitigation	Baseline	3 Sancrox East - Cassegrains	483412	6521882
	Impact	Mitigation	Baseline_Niche relocation	1 Sancrox South	483299	6520671
	Impact	Mitigation	Baseline_Niche relocation	2 Sancrox South	483254	6520383
	Impact	Mitigation	Baseline_Niche relocation	3 Sancrox South	483196	6520217
	Control	Control	Baseline	1 Cowarra State Forest	480608	6519056

Area	Type	Sub category	Data source	Plot name	Easting	Northing
	Control	Control	Baseline	2 Cowarra State Forest	480658	6519496
	Control	Control	Baseline	3 Cowarra State Forest	481305	6519136
	Control	New Control	Niche	COWARRA NC1	479706	6518522
	Control	New Control	Niche	COWARRA NC2	479788	6517922
	Control	New Control	Niche	SAT COWARRA NC3	479795	6518227
North Sancrox	Impact*	No Mitigation	Baseline	1 Sancrox North - Expressway Spares	483042	6521731
	Impact*	No Mitigation	Baseline	2 Sancrox North - Expressway Spares	482869	6521683
	Impact*	No Mitigation	Baseline	3 Sancrox North - Expressway Spares	482999	6521818
	Impact	Mitigation	Baseline	1 Fernbank Creek	483101	6523362
	Impact	Mitigation	Baseline	2 Fernbank Creek	483032	6523223
	Impact	Mitigation	Baseline	3 Fernbank Creek	483056	6523123
	Control	Control	Baseline	1 Lake Innes	488124	6518469
	Control	Control	Baseline	2 Lake Innes	488047	6518398
	Control	Control	Baseline	3 Lake Innes	488228	6518390
	Control	New Control	Niche	COWARRA NC3 -SAT COW4	479674	6516436
	Control	New Control	Niche	SAT COW5	479704	6516174
	Control	New Control	Niche	SAT COW6	479667	6515913
Cairncross State Forest (South)	Impact	No Mitigation	Baseline	1 Cairncross State Forest (South)	482428	6526536
	Impact	No Mitigation	Baseline	2 Cairncross State Forest (South)	482385	6526644
	Impact	No Mitigation	Baseline	3 Cairncross State Forest (South)	482393	6526416
	Impact	No Mitigation	Baseline	16 Cairncross State Forest (south)	481655	6527256
	Impact	No Mitigation	Baseline	17 Cairncross State Forest (south)	481590	6527316
	Impact	No Mitigation	Baseline	18 Cairncross State Forest (south)	481637	6527175
	Impact	Mitigation	Baseline	4 Cairncross State Forest (South)	482249	6525930
	Impact	Mitigation	Baseline	5 Cairncross State Forest (South)	482125	6526077
	Impact	Mitigation	Baseline	6 Cairncross State Forest (South)	482488	6526226
	Control	Control	Baseline	1 Limeburners Creek ""The Hatch""	487011	6529909
	Control	Control	Baseline	2 Limeburners Creek ""The Hatch""	487014	6529455
	Control	Control	Baseline	3 Limeburners Creek ""The Hatch""	487035	6528694
	Control	New Control	Niche	SAT PEVI1	476817	6528422
	Control	New Control	Niche	SAT PEVI2	476730	6528225
	Control	New Control	Niche	Cairncross NC1	475996	6528211
Cairncross State Forest (north)	Impact	No Mitigation	Baseline_Niche relocation	7 Cairncross State Forest (North)	481346	6530835
	Impact	No Mitigation	Baseline	8 Cairncross State Forest (North)	481695	6530786
	Impact	No Mitigation	Baseline	9 Cairncross State Forest (North)	481184	6530864
	Impact	Mitigation	Baseline	10 Cairncross State Forest (north)	481238	6530264
	Impact	Mitigation	Baseline	11 Cairncross State Forest (north)	481173	6530319
	Impact	Mitigation	Baseline	12Cairncross State Forest (north)	481438	6530335
	Control	Control	Baseline	13 Cairncross State Forest (Pembrooke)	473751	6528881
	Control	Control	Baseline	14 Cairncross State Forest (Pembrooke)	473464	6528969

Area	Type	Sub category	Data source	Plot name	Easting	Northing
	Control	Control	Baseline	15 Cairncross State Forest (Pembrooke)	473424	6529115
	Control	New Control	Niche	SAT RR1	475284	6532709
	Control	New Control	Niche	SAT RR2	475113	6532603
	Control	New Control	Niche	SAT RR3	474816	6532732
Cooperabung Hill	Impact	No Mitigation	Baseline	1 Cooperabung	482793	6537012
	Impact	No Mitigation	Baseline	2 Cooperabung	482755	6537093
	Impact	No Mitigation	Baseline	3 Cooperabung	482876	6537115
	Impact	Mitigation	Baseline_Niche relocation	4 Cooperabung	482481	6539327
	Impact	Mitigation	Baseline_Niche relocation	5 Cooperabung	482364	6539761
	Impact	Mitigation	Baseline	6 Cooperabung	482364	6538610
	Control	Control	Baseline	1 Cooperabung Hill (Gum Scrub)	475489	6541854
	Control	Control	Baseline	2 Cooperabung Hill (Gum Scrub)	475570	6541903
	Control	Control	Baseline	3 Cooperabung Hill (Gum Scrub)	475838	6541962
	Control	New Control	Niche	SAT FL1	473693	6542127
	Control	New Control	Niche	SAT ST1	473346	6543256
	Control	New Control	Niche	SAT ST2	473682	6542890
Mingaletta to Smiths Creek	Impact	Mitigation	Baseline	1 Mingaletta-Smiths Creek	483304	6543632
	Impact	Mitigation	Baseline	2 Mingaletta-Smiths Creek	483444	6543585
	Impact	Mitigation	Baseline	3 Mingaletta-Smiths Creek	483100	6543670
	Control	Control	Baseline	1 Ballengara State Forest (Gregs Road)	477750	6543274
	Control	Control	Baseline	2 Ballengara State Forest (Gregs Road)	477644	6543623
	Control	Control	Baseline	3 Ballengara State Forest (Gregs Road)	477551	6543709
	Control	New Control	Niche	SAT BR1	477010	6544693
	Control	New Control	Niche	SAT BR2	476890	6544832
	Control	New Control	Niche	SAT BR3	476777	6544973
Kundabung Road to North of Pipers Creek	Impact	No Mitigation	Baseline	1 Kundabung	483095	6549036
	Impact	No Mitigation	Baseline	2 Kundabung	482873	6549112
	Impact	No Mitigation	Baseline	3 Kundabung	483285	6549374
	Impact	Mitigation	Baseline	4 Kundabung	483369	6550655
	Impact	Mitigation	Baseline	5 Kundabung	483331	6550938
	Impact	Mitigation	Baseline	6 Kundabung	483083	6550608
	Control	Control	Baseline	1 Kumbatine National Park	476044	6549609
	Control	Control	Baseline	2 Kumbatine National Park	476165	6549738
	Control	Control	Baseline	3 Kumbatine National Park	475889	6549468
	Control	New Control	Niche	SAT MAC1	476538	6552784
	Control	New Control	Niche	SAT MAC2	476558	6552361
	Control	New Control	Niche	SAT MAC3	476481	6552612
Maria River State Forest	Impact	Part Mitigation	Baseline_Niche relocation	1 Maria River	483074	6554460
	Impact	Part Mitigation	Baseline	2 Maria River	482836	6554330
	Impact	Part Mitigation	Baseline_Niche relocation	3 Maria River	482993	6554024

Area	Type	Sub category	Data source	Plot name	Easting	Northing
	Impact	Mitigation	Baseline	4 Maria River	482886	6552623
	Impact	Mitigation	Baseline	5 Maria River	482754	6552462
	Impact	Mitigation	Baseline	6 Maria River	483135	6552449
	Control	Control	Baseline	1 Maria River National Park	486965	6554366
	Control	Control	Baseline	2 Maria River National Park	486971	6554479
	Control	Control	Baseline	3 Maria River National Park	487004	6554203
	Control	New Control	Niche	SAT CO1	486292	6552230
	Control	New Control	Niche	SAT CO3	486811	6552227
	Control	New Control	Niche	SAT MAR 1	486811	6552454

* could not be surveyed due to private landowner access restrictions.

2.2 Koala Spot Assessment Technique (SAT)

Surveys were undertaken following the SAT methodology (Phillips and Callaghan 2011) in accordance with the EMP monitoring procedure for Koala population monitoring. The SAT method involves a radial assessment of Koala activity within the immediate area surrounding a tree that is known to have been used by the species or is considered to be of importance to the species. The following describes the application of this technique:

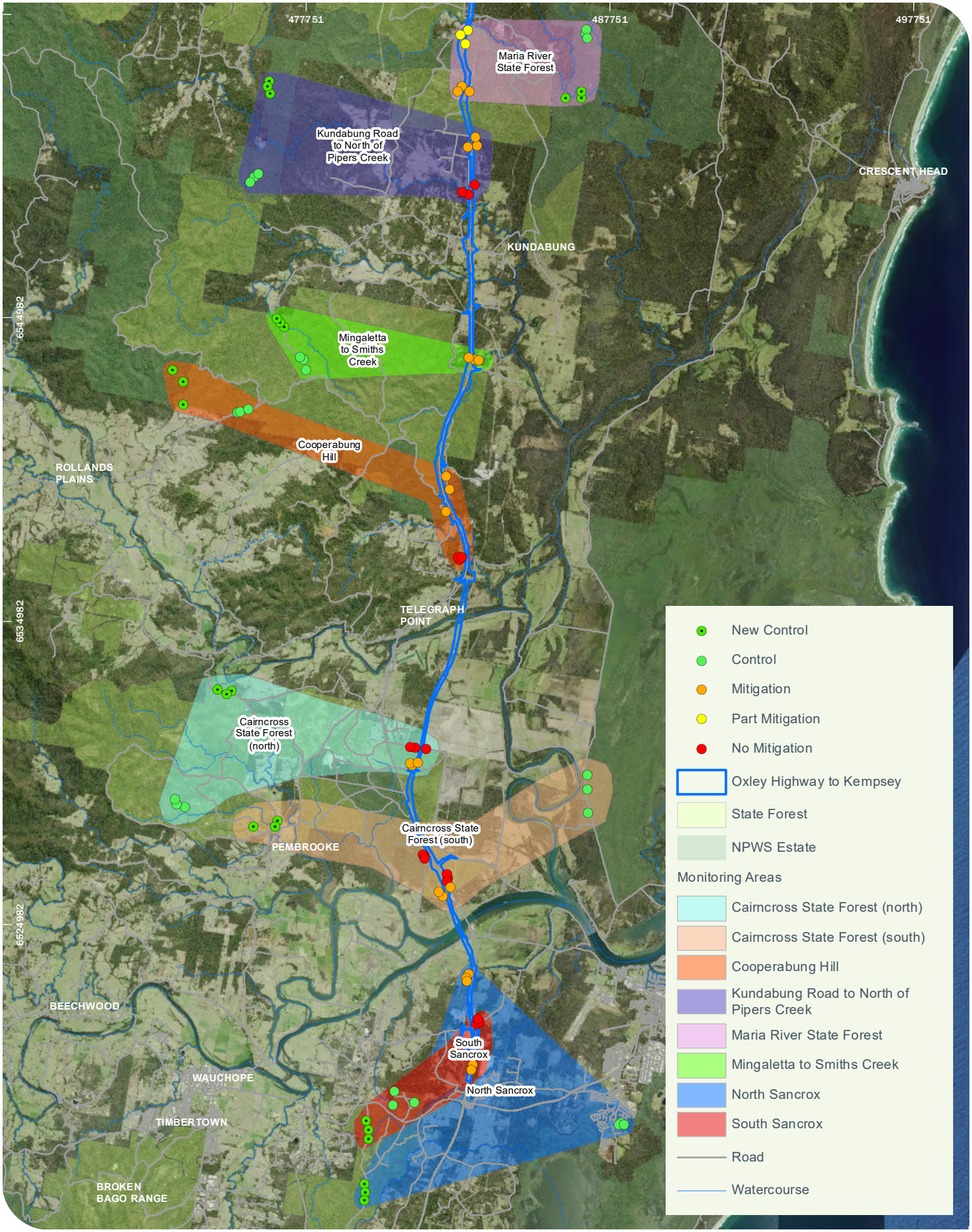
1. Locate and mark a tree that is:
   a) A tree of any species beneath which one or more Koala faecal pellets have been observed; and/or
   b) A tree in which a Koala has been observed; and/or
   c) Any other tree known or considered to be important for Koalas or of interest for other assessment purposes.
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 minutes per tree should be dedicated to the search for faecal pellets. The search should be ended 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. Calculate the activity level of a site as the percentage of surveyed trees within the site (of 30 trees) that have a Koala faecal pellet recorded within its search area. The result is used to assess whether the site supports “Low”, “Medium (normal)” or “High” Koala activity.
5. Record the presence (or absence) of scats, along with a number of other attributes including the species of the tree under which the scat was located.

The selection criteria trees (SCTs) of each plot were marked (tagged) and have been used as the centre tree for the radial searches during each survey event.

2.3 Analysis

General SAT plot presence and activity results are presented for plot, cluster and area. More detailed analyses of impact *vs.* control sites and mitigation *vs.* no mitigation sites were undertaken using cluster presence/absence results. Plots within the same cluster are not independent from each other and therefore cannot be used for most statistical analyses. Between year activity levels were compared using mean plot activity results.

Based on the methods used to collect the data and the location of the plots, it was determined that a Chi-square test was the most suitable statistical test to assess differences in Koala presence between areas, treatments and years. This test compares the proportion of plots with and without Koala scats and so is suitable for presence/absence data. The Chi-square test also allows for analysis of data where sample sizes between categories may differ, as is the case here where there are an unequal number of impact and control sites.



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km
GDA 1994 MGA Zone 56

SAT plot locations

Koala Monitoring: Pacific Highway Upgrade - Oxley Highway to Kempsey

Niche PM: Radika Michniewicz
Niche Proj. #: 1702 PI5.1
Client: Roads and Maritime Services

Figure 1

public_NSW_Imagery:

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3. Results

3.1 SAT Plots

Surveys were undertaken between 6 November 2018 and 17 December 2018. Field data for each SAT plot is presented in Annex 1. The DBH (diameter at breast height) is provided for the marked tree. This tree was used as the SCT for the current monitoring event and will be used as the SCT for all future monitoring events. All of the 93 accessible SAT plots were surveyed across the eight monitoring areas (Figure 1).

3.1.1 Presence/absence

SAT plots

Table 2 provides a summary of presence/absence results for plots and clusters. Graph 1 shows the percentage of plots and clusters with scats present for each monitoring period to date and Graph 2 shows the percentage of clusters within each area with scats present, for each monitoring period to date. Table 3 provides a detailed comparison of the activity level for each plot and presence/absence results of each cluster for each monitoring period to date and Figure 2 shows the SAT cluster presence/absence results for the 2018 monitoring (map reference ID for each cluster is listed in Table 3).

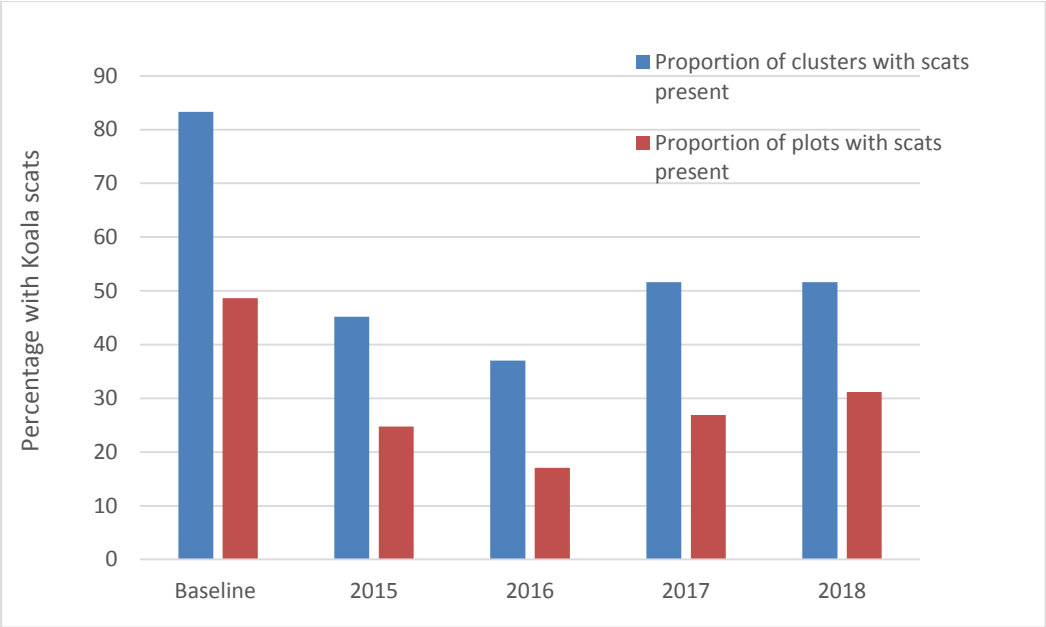
Of the 93 surveyed plots, Koala scats were recorded from 31% (29 of 93) of the individual plots. This is higher than 2015, 2016 and 2017 surveys (25%, 17%, and 27% respectively), but lower than the 49% recorded during baseline surveys. When grouped according to cluster, Koala scats were recorded at 52% of clusters (16 of 31). This is the same as recorded in 2017, higher than recorded in 2015 and 2016 (45% and 37% respectively), but lower than the 83% recorded during baseline surveys. It should be noted that baseline surveys included only 24 (*cf* 31) clusters; if we consider only those clusters in common between baseline and 2018 surveys, scats were recorded at 57 % (13 of 23) of these clusters during the 2018 monitoring.

Of note is the ongoing presence of scats at the 11 plots (located within clusters KUND2, MR1, MR2 and MR4) that were not surveyed in 2016 due to wildfires that resulted in the complete loss of canopy in many areas. Prior to the wildfires, baseline surveys recorded presence at four of these plots (note only eight were surveyed during baseline as three of the 11 are new controls and were not monitored during baseline surveys) and 2015 surveys recorded presence at one of these plots. Since the 2016 wildfires, 2017 and 2018 surveys recorded presence at six and eight of the plots respectively. The substantial canopy regrowth and prevalence of young leaves on the trees in these areas may have encouraged the rapid re-use of these areas by Koalas after the fires and provides ongoing abundant foraging resources.

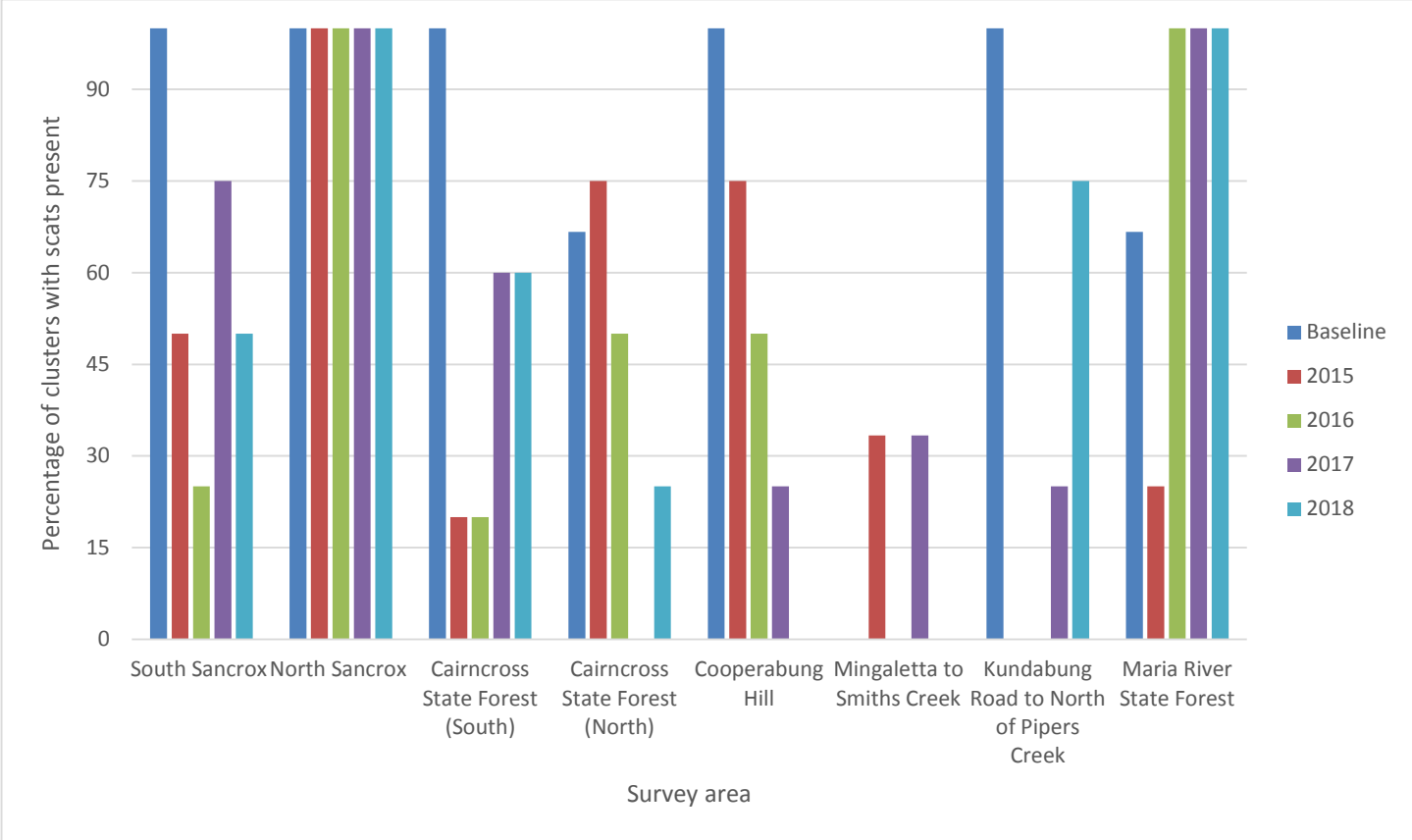
Koala presence was mainly recorded in the northern and southern areas, with activity in the northern area possibly being influenced by regenerating vegetation after the wildfire.

Table 2: Presence/absence results

	Baseline	2015	2016	2017	2018
Number of plots with scats present (n = plots surveyed)	35 (49%, n= 72)	23 (25%, n = 93)	14 (17%, n= 82)	25 (27%, n = 93)	29 (31%, n = 93)
Number of clusters with scats present (n = clusters surveyed)	20 (83%, n= 24)	14 (45%, n = 31)	10 (37%, n= 27)	16 (52%, n = 31)	16 (52%, n = 31)



Graph 1: Percentage of plots and clusters with scats present for each monitoring event to date



Graph 2: Koala presence in areas across all monitoring events

Additional Koala records

There are a number of culverts and bridges along the length of the Project that may provide passage for Koalas (Figure 2). Fourteen of these are being monitored as part of the Fauna Underpass Monitoring component of the Project. Koalas have been detected using three of the dedicated fauna underpasses to date and these are shown on Figure 2. In addition, a Koala was observed during spotlighting surveys undertaken as part of the Yellow-bellied Glider monitoring component of the Project (Figure 2). These records all occur in areas where Koalas were detected during SAT surveys.

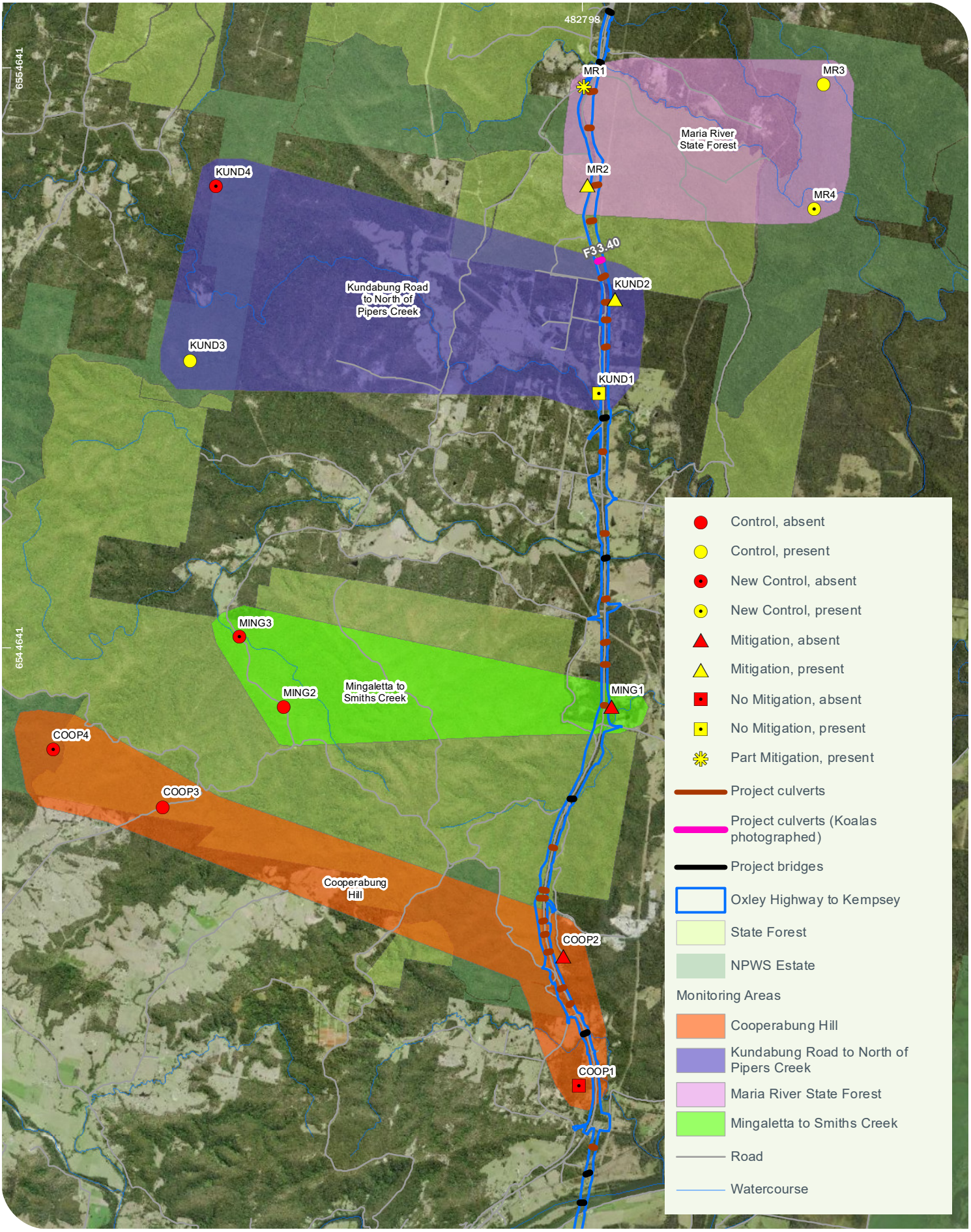
Table 3: SAT plot results baseline – 2018

Area	Type	Data source	Site ID	MapRef	Plot activity (%)				Scat presence (per cluster)				
					Baseline	2015	2016	2017	Baseline	2015	2016	2017	2018
South Sancrox	No Mitigation	Baseline	SANCROX E1	SSAN1	10.0	3.3	0.0	23.3	present	present	absent	present	present
			SANCROX E2		0.0	0.0	0.0	0.0					
			SANCROX E3		0.0	0.0	0.0	0.0					
	Mitigation	Baseline_Niche relocation	SANCROX S1	SSAN2	13.3	0.0	0.0	3.3	present	absent	absent	present	present
			SANCROX S2		3.3	0.0	0.0	0.0					
			SANCROX S3		10.0	0.0	0.0	0.0					
	Control	Baseline	COWARRA SF1	SSAN3	0.0	0.0	0.0	0.0	present	absent	present	absent	absent
			COWARRA SF2		3.3	0.0	0.0	0.0					
			COWARRA SF3		10.0	0.0	6.7	0.0					
	New Control	Niche	SAT COWARRA NC1	SSAN4	-	0.0	0.0	0.0	Not monitored	present	absent	present	absent
			SAT COWARRA NC2		-	3.3	0.0	6.7					
			SAT COWARRA NC3		-	0.0	0.0	3.3					
North Sancrox	No Mitigation	Baseline	SANCROX N1	-	3.3	-	-	-	present	No access	No access	No access	No access
			SANCROX N2		0.0	-	-	-					
			SANCROX N3		0.0	-	-	-					
	Mitigation	Baseline	FERNBANK CK1	NSAN1	33.3	0.0	3.3	16.7	present	present	present	present	present
			FERNBANK CK2		30.0	0.0	6.7	6.7					
			FERNBANK CK3		23.3	6.7	3.3	13.3					
	Control	Baseline	LAKE INNES1	NSAN2	26.7	13.3	0.0	3.3	present	present	present	present	present
			LAKE INNES2		13.3	6.7	3.3	6.7					
			LAKE INNES3		3.3	6.7	0.0	0.0					
	New Control	Niche	SAT COW4	NSAN3	-	10.0	0.0	3.3	Not monitored	present	present	present	present
			SAT COW5		-	0.0	0.0	0.0					
			SAT COW6		-	0.0	3.3	0.0					

Area	Type	Data source	Site ID	MapRef	Plot activity (%)				Scat presence (per cluster)				
					Baseline	2015	2016	2017	Baseline	2015	2016	2017	2018
Cairncross State Forest (South)	No Mitigation	Baseline	CAINCROSS SF1	CCS1	0.0	0.0	0.0	0.0	present	present	absent	absent	absent
			CAINCROSS SF2		3.3	6.7	0.0	0.0					
			CAINCROSS SF3		0.0	3.3	0.0	0.0					
	No Mitigation	Baseline	CAINCROSS SF16	CCS2	0.0	0.0	3.3	3.3	present	absent	present	present	present
			CAINCROSS SF17		0.0	0.0	3.3	0.0					
			CAINCROSS SF18		13.3	0.0	0.0	6.7					
	Mitigation	Baseline	CAINCROSS SF4	CCS3	3.3	0.0	0.0	3.3	present	absent	absent	present	present
			CAINCROSS SF5		3.3	0.0	0.0	0.0					
			CAINCROSS SF6		0.0	0.0	0.0	0.0					
	Control	Baseline	LIMEBURNERS CK1	CCS4	0.0	0.0	0.0	3.3	present	absent	absent	present	absent
			LIMEBURNERS CK2		3.3	0.0	0.0	0.0					
			LIMEBURNERS CK3		0.0	0.0	0.0	3.3					
	New Control	Niche	SAT PEVI1	CCS5	-	0.0	0.0	0.0	Not monitored	absent	absent	absent	present
			SAT PEVI2		-	0.0	0.0	0.0					
			SAT PEVI3		-	0.0	0.0	0.0					
Cairncross State Forest (north)	No Mitigation	Baseline_Niche relocation	CAINCROSS SF7	CCN1	0.0	3.3	0.0	0.0	absent	present	absent	absent	absent
		Baseline	CAINCROSS SF8		0.0	20.0	0.0	0.0					
		Baseline	CAINCROSS SF9		0.0	10.0	0.0	0.0					
	Mitigation	Baseline	CAINCROSS SF10	CCN2	3.3	0.0	0.0	0.0	present	present	present	absent	present
			CAINCROSS SF11		3.3	0.0	3.3	0.0					
			CAINCROSS SF12		6.7	3.3	0.0	0.0					
	Control	Baseline	CAINCROSS SF13	CCN3	6.7	3.3	3.3	0.0	present	present	present	absent	absent
			CAINCROSS SF14		0.0	0.0	0.0	0.0					
			CAINCROSS SF15		0.0	3.3	0.0	0.0					

Area	Type	Data source	Site ID	MapRef	Plot activity (%)				Scat presence (per cluster)				
					Baseline	2015	2016	2017	Baseline	2015	2016	2017	2018
	New Control	Niche	SAT RR1	CCN4	-	0.0	0.0	0.0	Not monitored	absent	absent	absent	absent
			SAT RR2		-	0.0	0.0	0.0					
			SAT RR3		-	0.0	0.0	0.0					
Cooperabung Hill	No Mitigation	Baseline	COOPERABUNG1	COOP1	3.3	3.3	0.0	0.0	present	present	present	absent	absent
			COOPERABUNG2		0.0	23.3	3.3	0.0					
			COOPERABUNG3		10.0	0.0	0.0	0.0					
	Mitigation	Baseline_Niche relocation	COOPERABUNG4	COOP2	0.0	3.3	6.7	0.0	present	present	present	present	absent
		Baseline_Niche relocation	COOPERABUNG5		3.3	3.3	0.0	10.0					
		Baseline	COOPERABUNG6		0.0	0.0	0.0	0.0					
	Control	Baseline	COOP HILL1	COOP3	6.7	0.0	0.0	0.0	present	absent	absent	absent	absent
			COOP HILL2		0.0	0.0	0.0	0.0					
			COOP HILL3		0.0	0.0	0.0	0.0					
	New Control	Niche	SAT FL1	COOP4	-	16.7	0.0	0.0	Not monitored	present	absent	absent	absent
			SAT ST1		-	0.0	0.0	0.0					
			SAT ST2		-	20.0	0.0	0.0					
Mingalletta to Smiths Creek	Mitigation	Baseline	MIN-SMITHS CK1	MING1	0.0	0.0	0.0	0.0	absent	absent	absent	absent	absent
			MIN-SMITHS CK2		0.0	0.0	0.0	0.0					
			MIN-SMITHS CK3		0.0	0.0	0.0	0.0					
	Control	Baseline	BALLENGARA SF1	MING2	0.0	0.0	0.0	0.0	absent	absent	absent	absent	absent
			BALLENGARA SF2		0.0	0.0	0.0	0.0					
			BALLENGARA SF3		0.0	0.0	0.0	0.0					
	New Control	Niche	SAT BR1	MING3	-	6.7	0.0	0.0	Not monitored	present	absent	present	absent
			SAT BR2		-	0.0	0.0	3.3					
			SAT BR3		-	0.0	0.0	0.0					

Area	Type	Data source	Site ID	MapRef	Plot activity (%)				Scat presence (per cluster)				
					Baseline	2015	2016	2017	Baseline	2015	2016	2017	2018
Kundabung Road to North of Pipers Creek	No Mitigation	Baseline	KUNDABUNG 1	KUND1	0.0	0.0	0.0	0.0	present	absent	absent	absent	present
			KUNDABUNG 2		10.0	0.0	0.0	0.0					
			KUNDABUNG 3		0.0	0.0	0.0	0.0					
	Mitigation	Baseline	KUNDABUNG 4	KUND2	33.3	0.0	fire	0.0	present	absent	fire	present	present
			KUNDABUNG 5		13.3	0.0	fire	3.3			fire		
			KUNDABUNG 6		10.0	0.0	0.0	0.0			absent		
	Control	Baseline	KUMBATINE NP1	KUND3	3.3	0.0	0.0	0.0	present	absent	absent	absent	present
			KUMBATINE NP2		0.0	0.0	0.0	0.0					
			KUMBATINE NP3		0.0	0.0	0.0	0.0					
	New Control	Niche	SAT MAC1	KUND4	-	0.0	0.0	0.0	Not monitored	absent	absent	absent	absent
			SAT MAC2		-	0.0	0.0	0.0					
			SAT MAC3		-	0.0	0.0	0.0					
Maria River State Forest	Part Mitigation	Baseline_Niche relocation	MARIA RIVER 1	MR1	0.0	0.0	fire	0.0	present	absent	no access - fire	present	present
		Baseline	MARIA RIVER 2		3.3	0.0	fire	0.0					
		Baseline_Niche relocation	MARIA RIVER 3		6.7	0.0	fire	16.7					
	Mitigation	Baseline	MARIA RIVER 4	MR2	0.0	0.0	fire	6.7	absent	present	no access - fire	present	present
			MARIA RIVER 5		0.0	0.0	fire	0.0					
			MARIA RIVER 6		0.0	3.3	fire	0.0					
	Control	Baseline	MARIA NP1	MR3	0.0	0.0	0.0	3.3	present	absent	present	present	present
			MARIA NP2		10.0	0.0	3.3	0.0					
			MARIA NP3		10.0	0.0	3.3	3.3					
	New Control	Niche	SAT CO1	MR4	-	0.0	fire	6.7	Not monitored	absent	no access - fire	present	present
			SAT CO3		-	0.0	fire	3.3					
			SAT MAR 1		-	0.0	fire	6.7					



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GDA 1994 MGA Zone 56

SAT cluster results 2018 - North

Koala Monitoring: Pacific Highway Upgrade - Oxley Highway to Kempsey

Niche PM: Radika Michniewicz
Niche Proj. #: 1702 PI5.1
Client: Roads and Maritime Services

Figure 2a

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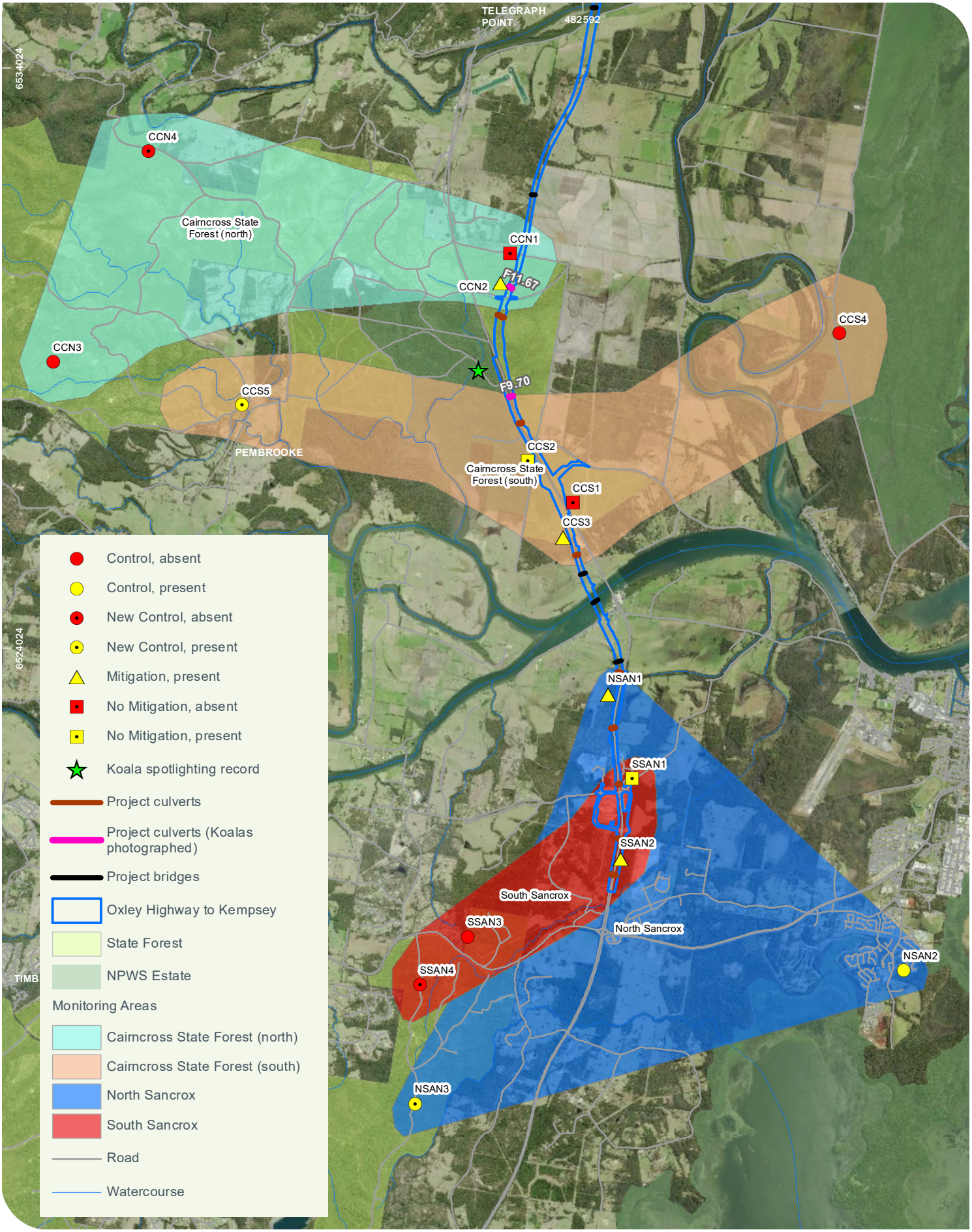

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SAT cluster results 2018 - South

Koala Monitoring: Pacific Highway Upgrade - Oxley Highway to Kempsey

Niche PM: Radika Michniewicz
Niche Proj. #: 1702 PI5.1
Client: Roads and Maritime Services

Figure 2b

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3.1.2 Activity levels

Individual plot activity levels are provided above in Table 3. A summary of the SAT activity level for plots, clusters and areas in all monitoring events is provided in Table 4 and Table 5.

Plot and cluster activity

The mean SAT activity level for all plots, measured as the percentage of trees at each plot with scats present, was 2.5% (standard deviation (SD) of 5.4) and ranged from 0 to 36.7%. This is higher than the mean activity recorded for plots during 2015, 2016 and 2017 surveys (2.0%, 0.7% and 1.8% respectively), but lower than the mean activity during baseline surveys (4.9%).

Considering the activity level within active plots only, i.e. plots where scats were found to be present, the average activity level was 8.0% (SD7.0), which is higher than or equal to the mean activity recorded for active plots during 2015, 2016 and 2017 surveys (8.0%, 4.0%, and 6.8% respectively), but lower than the mean activity recorded for active plots during baseline surveys (10.1%).

The EMP requires interpretation of site activity levels to assess areas as supporting low, medium or high Koala activity. Phillips and Callaghan (2011) used Atlas data to calculate activity levels of sites where Koala scats were recorded. These data were then used to define categories of habitat use in populations of varying densities. The Port Macquarie-Hastings and Kempsey LGAs support a significant Koala population, including a concentrated population in the coastal areas, east of the Pacific Highway and south of Hastings River, as well as pockets of higher density/activity in surrounding areas, including Maria River National Park (BioLink 2013, PMHC 2017). While Phillips and Callaghan (2011) use an arbitrary definition of population densities (low = ≤ 0.1 Koala/hectare), the study area naturally consists of areas of varying densities. Discussions with Port Macquarie-Hastings Council confirmed that population density varies throughout the region and therefore one general population density cannot be attributed to all sites. In addition, as site specific density data is not available for all sites, it is not possible to designate the sites as being low or high density populations according to Phillips and Callaghan. However, in compliance with the EMP, if we consider the habitat use category of Phillips and Callaghan (2011) for low density populations on the east coast, as per the baseline studies (Lewis 2014), using activity levels of SAT plots where scats were recorded, average SAT plot activity has consistency fallen into to the “medium (normal)” use category (3.3% - 12.6%) for populations in an east coast, low density area.

Table 4: Summary of SAT activity results

	Baseline	2015	2016	2017	2018
Average activity per plot (n = plots surveyed)	4.9% (SD8.0, n = 72)	2.0% (SD4.6, n = 93)	0.7% (SD1.6, n = 82)	1.8% (SD4.1, n = 93)	2.5% (SD5.4, n = 93)
Average activity per active plot (n = plots with activity)	10.1% (SD9.0, n = 35)	8.0% (SD6.3 n = 23)	4.0% (SD1.4, n = 14)	6.8% (SD5.3, n = 25)	8.0% (SD7.0, n = 29)
Average activity per cluster (n = plots surveyed)	4.9% (SD6.9, n = 24)	2.0% (SD3.5, n = 31)	0.7% (SD1.1, n = 27)	1.8% (SD2.8, n = 31)	2.5% (SD4.5, n = 31)
Average activity per active cluster (n = active clusters)	5.9% (SD7.1, n = 20)	4.4% (SD4.0, n = 14)	1.9% (SD1.1, n = 10)	3.5% (SD3.0, n = 16)	4.9% (SD5.5, n = 16)
Average activity per area (n = 8)	4.8% (SD4.7)	2.1% (SD2.3)	0.9% (SD0.9)	1.9% (SD2.0)	2.6% (SD3.1)

Area activity

Table 5 and Graph 3 show Koala activity at each of the eight monitoring areas. Area activity is the mean activity of all surveyed plots with the area. As for the 2016 and 2017 monitoring, SAT plot activity was highest at the following locations:

- North Sancrox (4.1%): scats were recorded at all three clusters and at seven of the nine SAT plots.
- Maria River State Forest (9.2%): scats were recorded at all four clusters and at nine of the 12 SAT plots. Three of the four clusters were regenerating after the 2016 wildfires.

To date, activity levels appear to fluctuate across the years within each monitoring area and a definitive increasing or decreasing activity trend is not apparent.

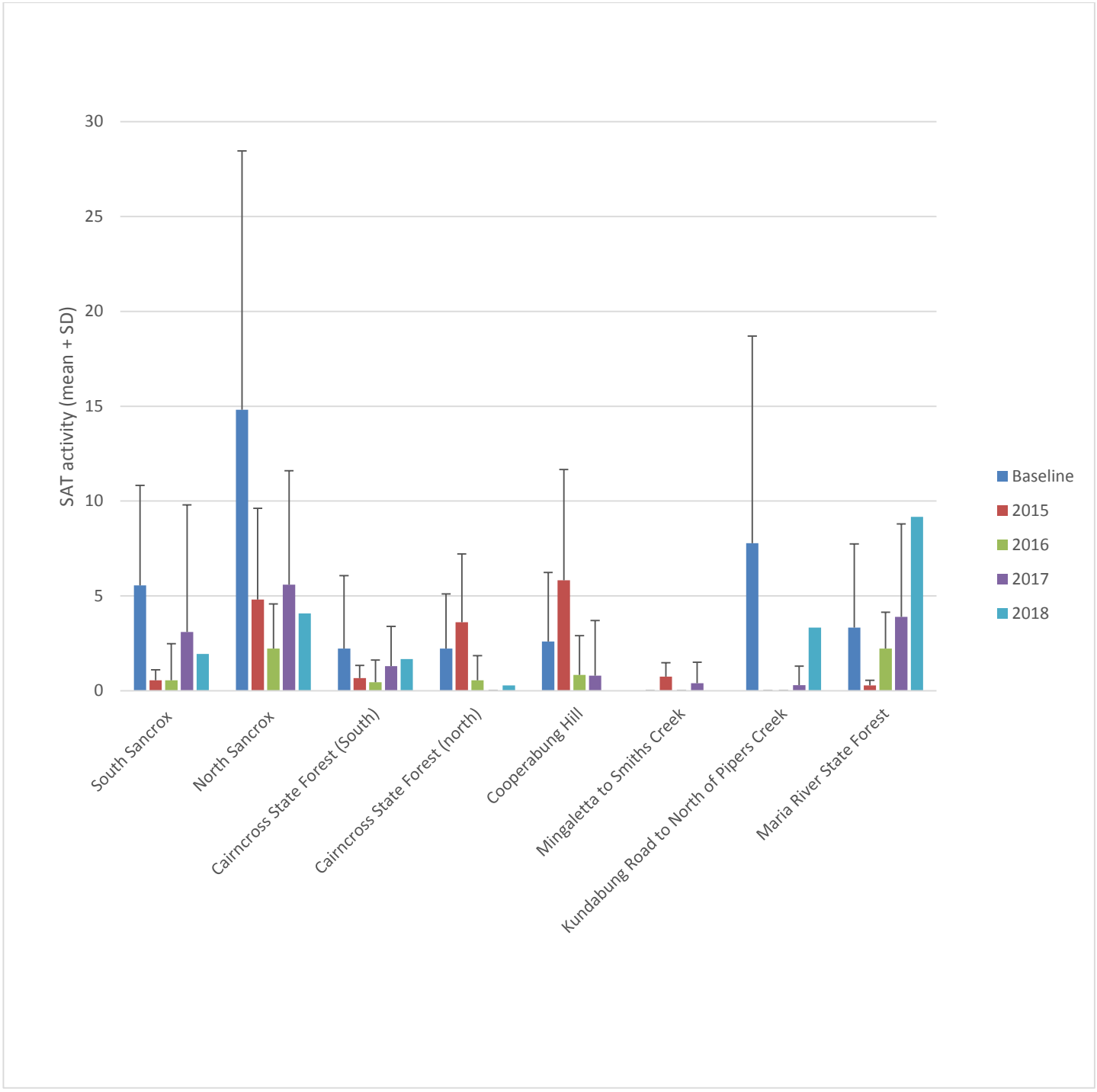
While North Sancrox has previously consistently recorded the highest activity, Maria River State Forest recorded higher activity during 2018 monitoring due to high plot activity in regenerating areas.

Mingaletta to Smiths Creek has generally recorded low activity levels during each monitoring year.

A notable reduction in apparent activity was within the Cooperabung Hill area; no scats were recorded in 2018 but scats have been recorded during each previous monitoring event. 2017 monitoring revealed a similar pattern within the Cairncross State Forest (north) area, whereby no scats were recorded in 2017 after having been recorded during each previous monitoring event. 2018 monitoring again recorded presence in this area.

Table 5: Area activity levels

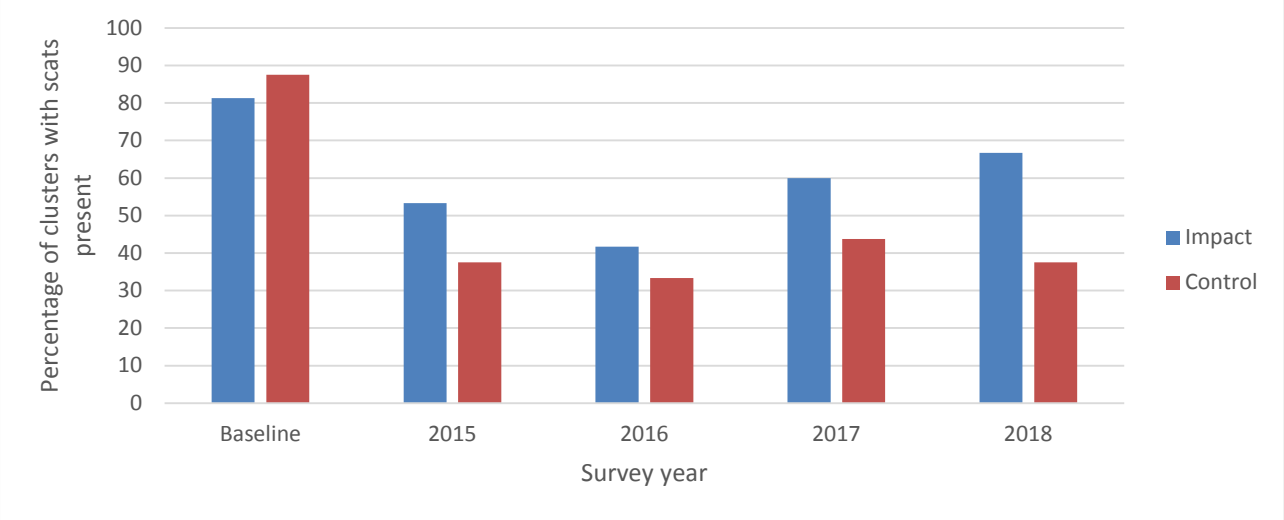
Monitoring Area	Baseline	2015	2016	2017	2018
South Sancrox	5.6% (SD5.3)	0.6% (SD1.3)	0.6% (SD1.9)	3.1% (SD6.7)	1.9% (SD3.0)
North Sancrox	14.8 (SD13.7)	4.8% (SD5.0)	2.2% (SD2.4)	5.6% (SD6.0)	4.1% (SD3.2)
Cairncross State Forest (South)	2.2% (SD3.8)	0.7% (SD1.9)	0.4% (SD1.2)	1.3% (SD2.1)	1.7% (SD2.7)
Cairncross State Forest (North)	2.2% (SD2.9)	3.6% (SD5.9)	0.6% (SD1.3)	0	0.3% (SD1.0)
Cooperabung Hill	2.6% (SD3.6)	5.8% (SD8.8)	0.8% (SD2.1)	0.8% (SD2.9)	0
Mingaletta to Smiths Creek	0	0.7% (SD2.2)	0	0.4% (SD1.1)	0
Kundabung Road to North of Pipers Creek	7.8% (SD10.9)	0	0	0.3% (SD1.0)	3.3% (SD5.9)
Maria River State Forest	3.3% (SD4.4)	0.3% (SD1.0)	2.2% (SD1.9)	3.9% (SD4.9)	9.2% (SD10.6)



Graph 3: Koala activity across the eight monitoring areas

3.2 Impact v Control Cluster Presence/Absence Analysis

A higher percentage of impact clusters had scats present than did control clusters during the 2018 monitoring (67% *cf* 38%) period. This result is the same as that of the previous monitoring years (Graph 4). If we compare the Koala presence/absence results between control and impact clusters there is no significant difference in Koala presence at impact and control clusters between the 2018 surveys and baseline, 2015, 2016 or 2017 surveys ($X^2 = 0.012$, df = 1, $p > 0.05$; $X^2 = 0.425$, df = 1, $p > 0.05$; $X^2 = 0.291$, df = 1, $p > 0.05$; and $X^2 = 0.365$, df = 1, $p > 0.05$ respectively).



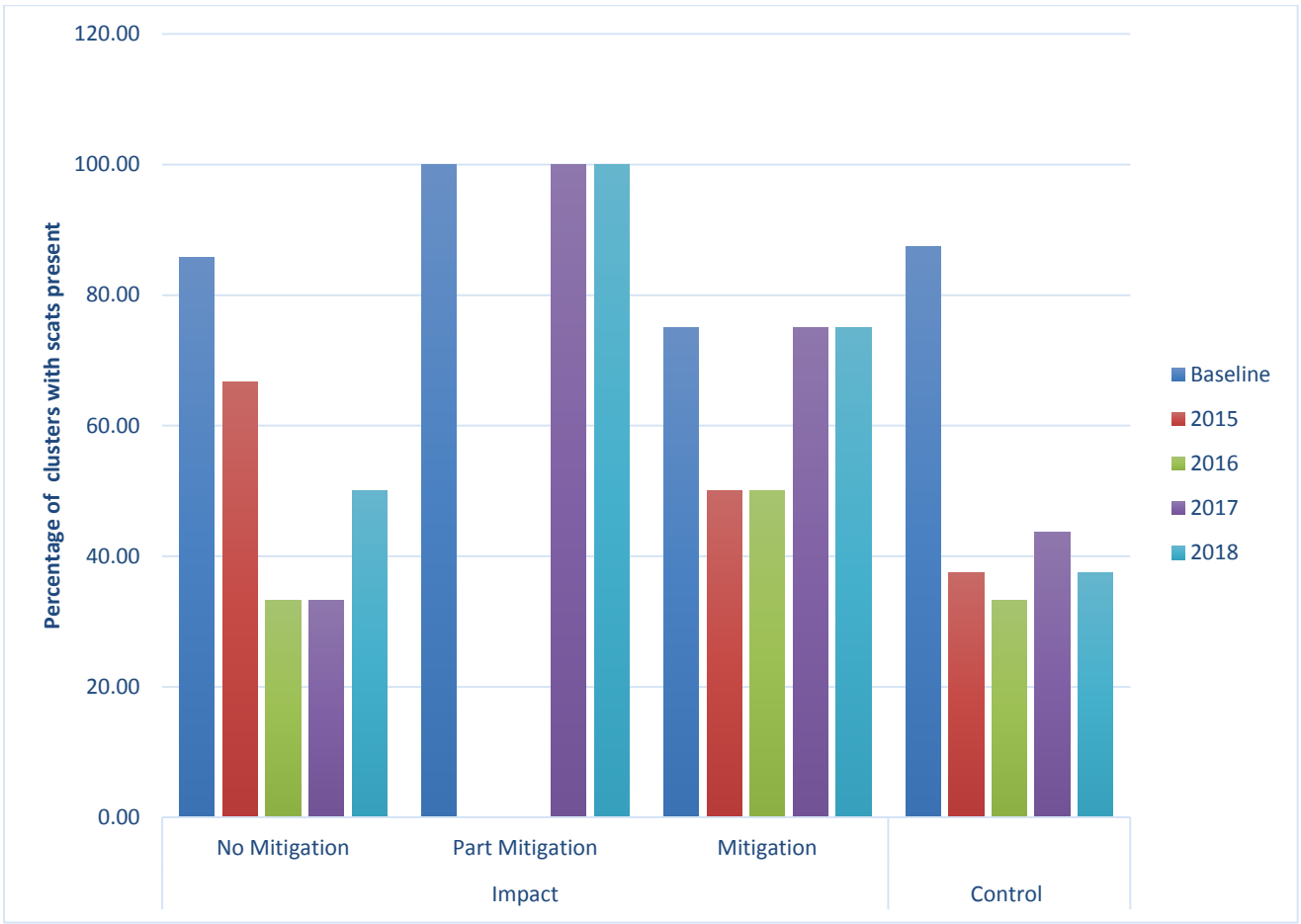
Graph 4: Koala presence at control and impact clusters

3.3 Mitigation v No Mitigation Analysis

3.3.1 Presence/absence analysis

Comparing Koala presence between mitigation and no-mitigation clusters shows no significant difference between the 2018 surveys and baseline, 2015, 2016, or 2017 surveys ($X^2 = 0.024$, df = 1, $p > 0.05$; $X^2 = 0.007$, df = 1, $p > 0.05$; $X^2 = 0.972$, df = 1, $p > 0.05$; and $X^2 = 0.133$, df = 1, $p > 0.05$, respectively). Graph 5 shows the percentage of clusters with scats present within different cluster types. There is no overall apparent trend between impact clusters with mitigation or without mitigation. While mitigation clusters appear to have a higher presence percentage in 2016, 2017 and 2018 than clusters with no mitigation, the presence percentage at clusters with no mitigation is similar to the presence percentage at control clusters during these years. This suggests that any difference is likely site specific and not related to construction activities.

The apparent increase in percentage presence in 2017 and 2018 at mitigation (and part mitigation) clusters is likely due, in part, to the 11 plots that were not surveyed in 2016. Five of these plots are mitigation plots, four of which recorded scats in 2018. In addition, North Sancrox has consistently been recorded as a high activity area and has only a mitigation cluster, without a balancing no-mitigation cluster.



Graph 5: Koala presence and cluster type

3.3.2 Treatment activity analysis

Koala activity (mean activity of plots) for the treatment types is provided in Table 6 and is shown for each area in Graph 6 (mean activity of all plots within each cluster type for each area). When considering all plots, average activity levels have decreased from baseline levels for all treatments, including control plots. When considering only active plots (with scats present), activity levels at control and no-mitigation plots were slighter higher than baseline levels, and activity levels at mitigation plots were slightly lower than baseline levels. The 2018 monitoring plot activity levels were similar among treatments. Lewis 2014 recommends that analyses should:

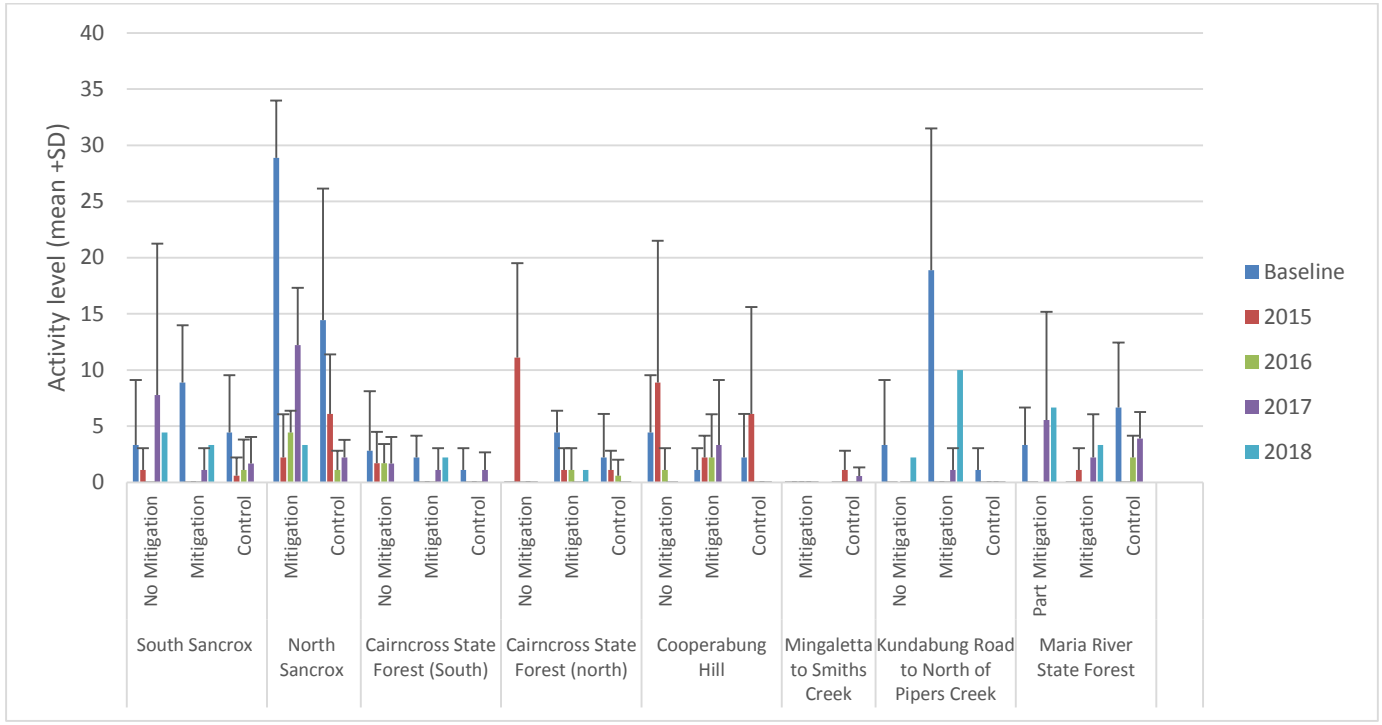
"Ensure any future comparison of Koala activity levels take into account the following baseline data and with a 10% tolerance level to account for variability:

- *Broader study area set at 5% activity;*
- *The three treatment classes of Mitigation set at 8.05%, control reference set at 4.03% and no mitigation set at 2.64%."*

When considering all plots or active plots only, activity levels for each treatment type have not decreased from the baseline surveys beyond the recommended 10% tolerance level. Nor is there a greater than 10% difference between treatment types.

Table 6: Control, mitigation and no mitigation plot activity levels

	Control					Mitigation					No Mitigation				
	Baseline	**2015**	**2016**	**2017**	**2018**	**Baseline**	**2015**	**2016**	**2017**	**2018**	**Baseline**	**2015**	**2016**	**2017**	**2018**
Activity levels of all plots (n = plots surveyed)	4.0 (24) (SD6.4)	1.9 (38) (SD4.5)	0.5 (45) (SD1.4)	1.2 (48) (SD2.1)	2.5 (48) (SD6.4)	8.1 (24) (SD11.0)	0.8 (24) (SD1.8)	1.2 (19) (SD2.3)	2.6 (24) (SD4.7)	2.9 (24) (SD4.5)	2.6 (24) (SD4.2)	3.5 (21) (SD6.6)	0.6 (18) (SD1.3)	2.4 (21) (SD6.2)	2.1 (21) (SD3.7)
Activity levels of active plots (n = active plots)	8.8 (11) (SD6.9)	9.0 (10) (SD5.9)	3.9 (6) (SD1.4)	4.4 (13) (SD1.6)	9.2 (13) (SD9.5)	12.9 (15) (SD11.5)	4.0 (5) (SD1.5)	4.7 (5) (SD1.8)	7.9 (8) (SD5.0)	7.0 (10) (SD4.6)	7.0 (9) (SD3.9)	9.2 (8) (SD8.1)	3.3 (3) (SD0.0)	12.5 (4) (SD9.2)	7.2 (6) (SD3.3)



Graph 6. Mean Koala activity for cluster type within areas (mean ± SD)

3.4 Tree Species Use

A total of 2,790 trees were assessed across the 93 plots (30 at each plot). Koala scats were recorded at 70 (2.5%) of the trees surveyed. Surveyed trees included 31 different tree species. The most commonly surveyed tree species were Tallowwood (*Eucalyptus microcorys*, 20.8%), Coastal Blackbutt (*E. pilularis*, 9.9%), and Pink Bloodwood (*Corymbia intermedia*, 9.1%), together representing 39.8% of all trees surveyed. Koala scats were recorded at 12 (38.7%) different species (Table 7). Considering the percentage of individual tree species where scats were recorded, Koala scats were most commonly recorded beneath Swamp Mahogany (*E. robusta*, 10.7%), Scribbly Gum (*E. signata*, 9.5%), Tallowwood (5.3%), and Thin-leaved Stringybark (*E. eugenioides*, 4.4%). Diameter at breast height for SCTs are provided in Annex 1.

The baseline study (Lewis 2014) suggests comparing activity levels at Tallowwood trees given that they are widespread, are frequently surveyed and yielded relatively high activity scores during baseline surveys (i.e. 9.5%). Use of Tallowwoods (percent of surveyed Tallowwoods with scats) was 2.68%, 0.75%, 4.7% and 5.3% in 2015, 2016, 2017 and 2018, respectively. As such, compared to the baseline surveys, activity at Tallowwood trees has been consistently lower, but has increased during each subsequent monitoring event. This reflects the overall lower activity levels observed since the baseline studies were undertaken.

Table 7: Tree species where scats were recorded – 2018 monitoring

Common name	Species name	Total surveyed	No. with scats	Percent use (%)
Swamp Mahogany	*Eucalyptus robusta*	28	3	10.7
Small-fruited Grey Gum	*Eucalyptus propinqua*	249	4	1.6
Coastal Blackbutt	*Eucalyptus pilularis*	276	8	2.9
Pink Bloodwood	*Corymbia intermedia*	255	4	1.6
Tallowwood	*Eucalyptus microcorys*	581	31	5.3
Forest Oak	*Allocasuarina torulosa*	53	1	1.9
Turpentine	*Syncarpia glomulifera*	195	1	0.5
White Stringy bark	*Eucalyptus globoidea*	145	5	3.5
White Mahogany	*Eucalyptus acmenoides*	49	1	2.0
Thin-leaved Stringybark	*Eucalyptus eugenioides*	68	3	4.4
Red Bloodwood	*Corymbia gummifera*	187	2	1.1
Scribbly Gum	*Eucalyptus signata*	74	7	9.5

3.5 Weather Conditions

Weather conditions during the field surveys were generally warm to hot (maximum temperatures between 22 and 31 degrees) with a few light to moderate rainfall events (Kempsey weather station 059007, Table 8).

Table 8: Weather conditions - 2018 monitoring

Date	Rainfall (mm)	Temp (°C) (max)	Temp (°C) (min)	Wind speed at 9am (km/h)
6/11/2018	0	29.3	18.4	7
9/11/2018	0	22.5	8.9	11
15/11/2018	0.2	30.2	17.7	6
28/11/2018	0.6	29.3	19.0	9
29/11/2018	3.0	27.6	17.8	30
30/11/2018	0	26.9	14.7	6
4/12/2018	0	28.9	12.5	6
5/11/2018	0.6	24.8	16.7	4
6/11/2018	1.8	24.9	16.1	9
7/11/2018	0	26.1	*	11
11/12/2018	0	26.9	16.0	17
12/12/2018	1.4	25.6	18.8	9
13/12/2018	0	29.5	16.1	0
14/12/2018	7.4	31.6	17.6	4
17/12/2018	26.4	29.3	16.8	9

* no data available

4. Discussion

4.1 Performance Measures

A discussion of the 2018 survey results in relation to the performance measures are provided in Table 9.

Table 9: Performance measures

Performance measure	Response
Monitoring is undertaken during baseline surveys and from Year 1 – Year 6 & 8, or until mitigation measures are demonstrated to be effective.	**This performance measure has been met**. To date, SAT plot monitoring has been undertaken during baseline, Year 1 (2015), Year 2 (2016), Year 3 (2017) and Year 4 (2018) of the Project.
Monitoring during Year 1 – Year 6 & 8 is undertaken at the Impact and Control sites where monitoring was undertaken during baseline surveys, subject to ongoing landowner agreement. Where landowner agreement cannot be obtained and the process in Section 3.1.2 of the EMP has been followed, this performance indicator will also be considered to have been met.	**This performance measure has been met**. Monitoring was undertaken at the same sites as surveyed in 2015. In 2015, eight of the baseline plots had to be relocated to nearby locations because they had been established in the construction site itself or because they were located on private property and access was not possible. Also, three of the baseline monitoring plots that could not be accessed could not be relocated because there weren't any suitable sites nearby. These three plots were all part of the same cluster (impact, no mitigation) located in the North Sancrox area. Details of all 96 monitoring plots are presented in Table 1 and the location of the 93 accessible monitoring plots are shown in Figure 1.
Mitigation measures are demonstrated to be effective as defined in the EPBC approval when all monitoring events are considered at Year 8.	Not applicable for Year 4. However, a summary of the efficacy of the mitigation measures to date in relation to treatment Type A: impact with mitigation (sufficiently large culverts and floppy top fencing), indicates: • Three of the fourteen monitored culverts have recorded use by the Koala (Figure 2) • Since commencement of construction (year 1), six Koalas have been recorded as road kill, five during construction and one during operation. The last construction Koala road kill occurred in October 2016, year 2 of the Project (Niche 2018b). The Project became operational in year 4, March 2018 and in September 2018 a Koala road kill occurred at Barry's Creek, between clusters MING1 and COOP2. It was considered most likely that the Koala accessed the road corridor via a flood damaged section of the fauna fence, which has since been repaired.
Fauna fence is installed at a minimum in areas identified in Schedule 3 of the EPBC approval at Year 4.	**This performance measure has been met.** Roads and Maritime have advised that fauna fencing is complete in all areas in accordance with Condition 3c and Schedule 3 of EPBC Approval 2012/6518.
No changes 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.	**This performance measure has not been met.** *Distribution and habitat use* As for previous monitoring years, while the 2018 monitoring results indicate a reduction in the presence and activity of Koalas across the Project area from the baseline surveys, this result is consistent across both the impact and control sites with no significant difference in the proportion of impact and control sites with scats between years. Any observed decrease in Koala presence/activity cannot therefore be directly attributed to disturbance due to the Project. In addition, presence and activity levels increased in 2018 compared to previous monitoring years and, in accordance with Lewis 2014, have not decreased from the baseline surveys beyond the recommended 10% tolerance level. As such, while changes have

Performance measure	Response
	occurred (as specified in the performance measure), these changes cannot be directly attributed to the Project and are within the 10% tolerance level. *Movement patterns and density* SAT plots do not provide any data on individual movement patterns. They also do not provide any data on Koala density, as it is not possible to determine the number of Koalas from scat records.

5. Recommendations

5.1 Contingency Measures and Recommendations

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those that are considered to be relevant to the Koala monitoring program are listed and discussed in Table 10. No additional mitigation recommendations have been made at this stage based on the following:

- No significant changes from baseline surveys have been detected to date
- Koalas have been detected using three of the dedicated fauna underpasses within the Project area
- Damage to fauna fences has been repaired.

Table 10: Contingency measures

Potential problem	Contingency measure proposed in EMP	Discussion of proposed measure
Decline in presence of target species recorded at Impact sites after the upgrade has been completed, when compared to change in Control sites.	• Investigate cause of decline in consultation with EPA and DoTE within two weeks of results reported by ecologist. • If the cause of the decline is considered most likely attributable to the upgrade of the highway, mitigation measures will be reviewed within two months of the above consultation.	**This contingency measure is not considered relevant.** To date, no significant change has been detected in the difference in Koala presence at control and impact sites between baseline and subsequent monitoring events.

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Annex 1. Koala SAT results – 2018 monitoring

On a number of occasions the marked tree did not correspond with the baseline and 2015 monitoring SCT (selection criteria tree) species. As such, for clarity of results and to facilitate future monitoring, the DBH is provided for the marked tree, and this tree is considered as the "New SCT" for the current and future monitoring events. DBH = diameter at breast height in centimetres (cm), Radial = radial distance of search area from New SCT in metres (m).

Area N	Monitoring area	Treatment	Sub-category	Site_ID	Map ref	Activity	New SCT	DBH (cm)	Radial (m)	Notes
1	South Sancrox	Impact	No Mitigation	SANCROX E1	SSAN1	6.7	Tallowwood	47	20	
1	South Sancrox	Impact	No Mitigation	SANCROX E2		0.0	Thin-leaved Stringybark	34	25	
1	South Sancrox	Impact	No Mitigation	SANCROX E3		6.7	Tallowwood	27	25	
1	South Sancrox	Impact	Mitigation	SANCROX S1	SSAN2	0.0	Blackbutt	46	35	
1	South Sancrox	Impact	Mitigation	SANCROX S2		6.7	Thin-leaved Stringybark	55	40	
1	South Sancrox	Impact	Mitigation	SANCROX S3		3.3	Flooded Gum	58	35	Not tagged
1	South Sancrox	Control	Control	COWARRA SF1	SSAN3	0.0	Small-fruited Grey Gum	55	35	Tag hacked off
1	South Sancrox	Control	Control	COWARRA SF2		0.0	Blackbutt	98	40	
1	South Sancrox	Control	Control	COWARRA SF3		0.0	Small-fruited Grey Gum	33	15	
1	South Sancrox	Control	New Control	SAT COWARRA NC1	SSAN4	0.0	Blackbutt	75	35	
1	South Sancrox	Control	New Control	SAT COWARRA NC2		0.0	Mahogany	53	25	
1	South Sancrox	Control	New Control	SAT COWARRA NC3		0.0	Blackbutt	62	25	
2	North Sancrox	Impact	No Mitigation	SANCROX N1						No access
2	North Sancrox	Impact	No Mitigation	SANCROX N2						No access
2	North Sancrox	Impact	No Mitigation	SANCROX N3						No access
2	North Sancrox	Impact	Mitigation	FERNBANK CK1	NSAN1	3.3	Tallowwood	63	25	
2	North Sancrox	Impact	Mitigation	FERNBANK CK2		0.0	Tallowwood	38	30	
2	North Sancrox	Impact	Mitigation	FERNBANK CK3		6.7	Tallowwood	46	35	
2	North Sancrox	Control	Control	LAKE INNES1	NSAN2	6.7	Tallowwood	72	15	Not tagged
2	North Sancrox	Control	Control	LAKE INNES2		3.3	Swamp Mahogany	117	30	
2	North Sancrox	Control	Control	LAKE INNES3		3.3	Swamp Mahogany	76	20	

Area N	Monitoring area	Treatment	Sub-category	Site_ID	Map ref	Activity	New SCT	DBH (cm)	Radial (m)	Notes
2	North Sancrox	Control	New Control	SAT COW4	NSAN3	3.3	Blackbutt	72	25	
2	North Sancrox	Control	New Control	SAT COW5		0.0	Small-fruited Grey Gum	28	20	
2	North Sancrox	Control	New Control	SAT COW6		10.0	Tallowwood	56	15	
3	Cairncross State Forest (South)	Impact	No Mitigation	CAINCROSS SF1	CCS1	0.0	Tallowwood	33	25	
3	Cairncross State Forest (South)	Impact	No Mitigation	CAINCROSS SF2		0.0	Tallowwood	42	30	
3	Cairncross State Forest (South)	Impact	No Mitigation	CAINCROSS SF3		0.0	Tallowwood	22	30	
3	Cairncross State Forest (south)	Impact	No Mitigation	CAINCROSS SF16	CCS2	0.0	Tallowwood	38	25	
3	Cairncross State Forest (south)	Impact	No Mitigation	CAINCROSS SF17		0.0	Tallowwood	47	25	
3	Cairncross State Forest (south)	Impact	No Mitigation	CAINCROSS SF18		3.3	Tallowwood	53	35	Not tagged
3	Cairncross State Forest (South)	Impact	Mitigation	CAINCROSS SF4	CCS3	6.7	Tallowwood	59	45	
3	Cairncross State Forest (South)	Impact	Mitigation	CAINCROSS SF5		0.0	Tallowwood	64	45	
3	Cairncross State Forest (South)	Impact	Mitigation	CAINCROSS SF6		0.0	Blackbutt	76	25	
3	Cairncross State Forest (South)	Control	Control	LIMEBURNERS CK1	CCS4	0.0	Scribbly Gum	94	45	Not tagged
3	Cairncross State Forest (South)	Control	Control	LIMEBURNERS CK2		0.0	Scribbly Gum	76	40	Not tagged
3	Cairncross State Forest (South)	Control	Control	LIMEBURNERS CK3		0.0	Scribbly Gum	44	50	Not tagged
3	Cairncross State Forest (South)	Control	New Control	SAT PEVI1	CCS5	6.7	Sydney Blue Gum	61	40	
3	Cairncross State Forest (South)	Control	New Control	SAT PEVI2		3.3	Sydney Blue Gum	41	20	
3	Cairncross State Forest (South)	Control	New Control	SAT PEVI3		0.0	Sydney Blue Gum	56	30	
4	Cairncross State Forest (north)	Impact	No Mitigation	CAINCROSS SF7	CCN1	0.0	Blackbutt	67	40	
4	Cairncross State Forest (north)	Impact	No Mitigation	CAINCROSS SF8		0.0	Forest Red Gum	45	30	
4	Cairncross State Forest (north)	Impact	No Mitigation	CAINCROSS SF9		0.0	Blackbutt	65	45	
4	Cairncross State Forest (north)	Impact	Mitigation	CAINCROSS SF10	CCN2	3.3	Swamp Mahogany	33	45	
4	Cairncross State Forest (north)	Impact	Mitigation	CAINCROSS SF11		0.0	Tallowwood	53	45	
4	Cairncross State Forest (north)	Impact	Mitigation	CAINCROSS SF12		0.0	Tallowwood	70	25	
4	Cairncross State Forest (north)	Control	Control	CAINCROSS SF13	CCN3	0.0	Small-fruited Grey Gum	45	25	
4	Cairncross State Forest (north)	Control	Control	CAINCROSS SF14		0.0	Sydney Blue Gum	36	30	

Area N	Monitoring area	Treatment	Sub-category	Site_ID	Map ref	Activity	New SCT	DBH (cm)	Radial (m)	Notes
4	Cairncross State Forest (north)	Control	Control	CAINCROSS SF15		0.0	Sydney Blue Gum	83	30	Not tagged
4	Cairncross State Forest (north)	Control	New Control	SAT RR1	CCN4	0.0	Tallowwood	77	40	
4	Cairncross State Forest (north)	Control	New Control	SAT RR2		0.0	Small-fruited Grey Gum	56	40	
4	Cairncross State Forest (north)	Control	New Control	SAT RR3		0.0	Tallowwood	62	40	
5	Cooperabung Hill	Impact	No Mitigation	COOPERABUNG1	COOP1	0.0	Tallowwood	67	40	
5	Cooperabung Hill	Impact	No Mitigation	COOPERABUNG2		0.0	Small-fruited Grey Gum	49	50	
5	Cooperabung Hill	Impact	No Mitigation	COOPERABUNG3		0.0	Tallowwood	51	35	
5	Cooperabung Hill	Impact	Mitigation	COOPERABUNG4	COOP2	0.0	Tallowwood	34	35	
5	Cooperabung Hill	Impact	Mitigation	COOPERABUNG5		0.0	Tallowwood	25	40	
5	Cooperabung Hill	Impact	Mitigation	COOPERABUNG6		0.0	Tallowwood	69	30	
5	Cooperabung Hill	Control	Control	COOP HILL1	COOP3	0.0	Tallowwood	46	35	
5	Cooperabung Hill	Control	Control	COOP HILL2		0.0	Small Fruited Grey Gum	36	35	
5	Cooperabung Hill	Control	Control	COOP HILL3		0.0	Tallowwood	34	35	
5	Cooperabung Hill	Control	New Control	SAT FL1	COOP4	0.0	Resinifera	39	45	
5	Cooperabung Hill	Control	New Control	SAT ST1		0.0	Mahogany	33	20	
5	Cooperabung Hill	Control	New Control	SAT ST2		0.0	Tallowwood	32	25	
6	Mingaletta to Smiths Creek	Impact	Mitigation	MIN-SMITHS CK1	MING1	0.0	Blackbutt	53	35	
6	Mingaletta to Smiths Creek	Impact	Mitigation	MIN-SMITHS CK2		0.0	Tallowwood	42	20	
6	Mingaletta to Smiths Creek	Impact	Mitigation	MIN-SMITHS CK3		0.0	Small-fruited Grey Gum	57	30	
6	Mingaletta to Smiths Creek	Control	Control	BALLENGARA SF1	MING2	0.0	Tallowwood	37	30	
6	Mingaletta to Smiths Creek	Control	Control	BALLENGARA SF2		0.0	Tallowwood	31	50	
6	Mingaletta to Smiths Creek	Control	Control	BALLENGARA SF3		0.0	Tallowwood	37	45	
6	Mingaletta to Smiths Creek	Control	New Control	SAT BR1	MING3	0.0	Sydney Blue Gum	32	25	
6	Mingaletta to Smiths Creek	Control	New Control	SAT BR2		0.0	Sydney Blue Gum	48	25	
6	Mingaletta to Smiths Creek	Control	New Control	SAT BR3		0.0	Flooded Gum	50	40	
7	Kundabung Road to North of Pipers Creek	Impact	No Mitigation	KUNDABUNG 1	KUND1	0.0	Flooded Gum	47	30	

Area N	Monitoring area	Treatment	Sub-category	Site_ID	Map ref	Activity	New SCT	DBH (cm)	Radial (m)	Notes
7	Kundabung Road to North of Pipers Creek	Impact	No Mitigation	KUNDABUNG 2		6.7	Tallowwood	82	30	
7	Kundabung Road to North of Pipers Creek	Impact	No Mitigation	KUNDABUNG 3		0.0	Pink Bloodwood	38	45	
7	Kundabung Road to North of Pipers Creek	Impact	Mitigation	KUNDABUNG 4	KUND2	13.3	Blackbutt	72	45	
7	Kundabung Road to North of Pipers Creek	Impact	Mitigation	KUNDABUNG 5		16.7	Blackbutt	40	30	
7	Kundabung Road to North of Pipers Creek	Impact	Mitigation	KUNDABUNG 6		0.0	Grey Ironbark	56	25	
7	Kundabung Road to North of Pipers Creek	Control	Control	KUMBATINE NP1	KUND3	0.0	Tallowwood	32	25	
7	Kundabung Road to North of Pipers Creek	Control	Control	KUMBATINE NP2		0.0	Tallowwood	38	25	
7	Kundabung Road to North of Pipers Creek	Control	Control	KUMBATINE NP3		3.3	Tallowwood	44	25	
7	Kundabung Road to North of Pipers Creek	Control	New Control	SAT MAC1	KUND4	0.0	Red Mahogany	82	30	
7	Kundabung Road to North of Pipers Creek	Control	New Control	SAT MAC2		0.0	Spotted Gum	41	35	
7	Kundabung Road to North of Pipers Creek	Control	New Control	SAT MAC3		0.0	Spotted Gum	54	30	
8	Maria River State Forest	Impact	Part Mitigation	MARIA RIVER 1	MR1	6.7	Pink Bloodwood	32	45	
8	Maria River State Forest	Impact	Part Mitigation	MARIA RIVER 2		0.0	Tallowwood	49	25	
8	Maria River State Forest	Impact	Part Mitigation	MARIA RIVER 3		13.3	Tallowwood	26	35	
8	Maria River State Forest	Impact	Mitigation	MARIA RIVER 4	MR2	6.7	Thin-leaved Stringybark	40	20	
8	Maria River State Forest	Impact	Mitigation	MARIA RIVER 5		0.0	Tallowwood	66	25	
8	Maria River State Forest	Impact	Mitigation	MARIA RIVER 6		3.3	Tallowwood	39	40	
8	Maria River State Forest	Control	Control	MARIA NP1	MR3	20.0	Pink Bloodwood	29	40	
8	Maria River State Forest	Control	Control	MARIA NP2		10.0	Tallowwood	58	25	
8	Maria River State Forest	Control	Control	MARIA NP3		36.7	Tallowwood	31	25	
8	Maria River State Forest	Control	New Control	SAT CO1	MR4	10.0	White Stringybark	62	35	
8	Maria River State Forest	Control	New Control	SAT CO3		0.0	Blackbutt	67	40	
8	Maria River State Forest	Control	New Control	SAT MAR 1		3.3	Tallowwood	76	35	

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Giant Barred Frog Monitoring 2018/2019

Oxley Highway to Kempsey, Pacific Highway Upgrade

Prepared for Roads and Maritime Services

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Cover photograph: Giant Barred Frog (Photo: Matthew Stanton)

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Executive summary

Context

This report documents findings of the second (spring 2018) and third (autumn 2019) operational monitoring surveys for the Giant Barred Frog (*Mixophyes iteratus*), as required for the Oxley Highway to Kempsey (OH2K) Pacific Highway Upgrade Project (the Project), and specified in the Oxley Highway to Kempsey (OH2K) Ecological Monitoring Program (EMP, RMS 2019a). Summer 2019 surveys were not undertaken due to insufficient rainfall. The NSW Roads and Maritime Services (Roads and Maritime) is required to manage and monitor the effectiveness of biodiversity mitigation measures implemented as part of the Project. The Giant Barred Frog is one of the threatened species identified as requiring mitigation and monitoring throughout the course of the construction and operational periods of the Project.

Aims

The aim of the Giant Barred Frog monitoring program is to determine, through evaluation of the performance indicators outlined in the EMP, if the Project is having an impact on the species and whether corrective actions are required.

Methods

Six sites (two reference and four impact) were monitored. Each site consists of a one kilometre transect along the creek line, divided into 10 x 100 metre zones. Each monitoring location was surveyed in accordance with the monitoring method and design specified in the EMP. Surveys were undertaken after a sufficient rainfall trigger event (> 10 millimetres within a 24 hour period) and involved passive listening, call playback (upon arrival and at intervals during searches), active searching (within 20 metres of each creek bank) and habitat surveys within each of the 100 metre zones.

Key results

Surveys were undertaken on the 15 – 17 October 2018 (spring), and 11 – 13 March 2019 (autumn) after suitable rainfall. Summer 2019 surveys were not undertaken due to insufficient rainfall. A total of 72 Giant Barred Frogs were recorded during the 2018/2019 monitoring period and 28.6% (n = 20) of those captured were recaptures. Frogs were recorded at all sites during all seasons with the exception of Cooperabung Creek reference site where no frogs were recorded during the spring surveys.

All sites showed evidence of breeding via presence of juveniles or sub-adults, gravid females or reproductive males during at least one survey event.

Chytrid fungus was detected at Cooperabung Creek reference site during the 2018/2019 monitoring period, however is considered to be present at all monitoring sites, where it has been detected previously.

All sites had at least one water quality parameter for one or more monthly results for which the median downstream value exceeded the 80th percentile of the upstream value.

Conclusions

Performance measures relating to undertaking monitoring have to date been met.

The performance measure relating to continued presence of Giant Barred Frogs during each survey event where it was identified during baseline surveys was met for five of the six sites. Giant Barred Frogs were not recorded at Cooperabung reference site during the spring survey, where it was recorded during spring baseline surveys. Giant Barred Frogs were however recorded at this site during autumn 2019 surveys.

The performance measure relating to changes in density was met for all impact sites except Pipers Creek impact site and Cooperabung Creek impact site. Cooperabung Creek impact, Pipers Creek impact and Cooperabung Creek reference sites all show a decreasing trend in mean records and densities. However, as this decreasing trend is evident at both impact and reference sites, it is not possible to attribute these changes to the Project at this stage.

The water quality performance measure was met for all parameters. Values above the 80th percentile trigger value were not considered to be attributable to construction activities.

Management implications

Given the variable nature of annual mean records among sites, the absence of summer survey records from the current monitoring period, the evidence of a decreasing trend at a reference site and the lack of a distinct difference between impact and reference sites, it is not possible to attribute observed changes to the Project. As such, it is recommended that monitoring continue as per the EMP.

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1. Introduction

1.1 Context

The Oxley Highway to Kempsey (OH2K) section of the Pacific Highway Upgrade Project (the Project) was approved in 2012 subject to various Ministers Conditions of Approval (MCoA) and a Statement of Commitments (SoC). A subsequent approval with additional conditions of consent (CoA) was granted in 2014 by the Commonwealth Department of Environment (DoE) for Matters of National Environmental Significance (MNES) listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1995* (EPBC Act). The Ecological Monitoring Program (hereafter referred to as the EMP) (RMS 2019a) combines these approval conditions and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project. The Giant Barred Frog (*Mixophyes iteratus*) was one threatened species identified as requiring mitigation and monitoring through the course of the Project's construction and operational period.

1.1.1 Legal status

The Giant Barred Frog is listed as endangered under the New South Wales *Biodiversity Conservation Act 2016* (BC Act) and Commonwealth EPBC Act. Monitoring of the species is required under the Project's approval.

1.1.2 Monitoring framework

The design, methods and performance indicators that define the Giant Barred Frog monitoring program are specified in the EMP and Giant Barred Frog Management Strategy (GBFMS, Lewis 2013). Where there are discrepancies between the EMP and the GBFMS, the EMP takes precedence (Section 1.2 RMS 2019a).

The EMP required monitoring of the Giant Barred Frog three times a year (spring, summer and autumn) in years 1, 2 and 3 once substantial construction commenced. Following completion of the Project, surveys are to be undertaken for five consecutive years, in spring, summer and autumn of Year 4, 5, 6, 7 and 8 (operational phase) or until mitigation measures can be demonstrated to have been effective. To date, these monitoring events have been undertaken and reported as follows:

- Construction phase monitoring:
  - *Autumn 2015*: Niche 2015a
  - *Spring 2015, summer and autumn 2016*: Niche 2016
  - *Spring 2016, summer and autumn 2017*: Niche 2017
  - *Spring 2017, summer 2018*: Niche 2018.
- Operational phase monitoring:
  - *Autumn 2018:* Niche 2018
  - *Spring 2018, (summer 2019 insufficient rainfall) and autumn 2019*: current report.

This report addresses the second (spring 2018), third (summer 2019) and fourth (autumn 2019) survey events of operational phase monitoring of the Project. Summer 2019 surveys were not undertaken due to insufficient rainfall. This report therefore represents the fifth of nine monitoring reports for the Giant Barred Frog. The next round of operational monitoring will commence in spring 2019.

Water quality monitoring is also being conducted within Giant-Barred Frog habitat and potential habitat. Water quality monitoring commenced prior to construction, continued during construction and will continue for three years during the operational phase. Water monitoring results for the Giant Barred Frog impact sites are included in this report.

1.1.3 Baseline data

The EMP specifies the following regarding the Giant Barred Frog:

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

The EMP lists six sites to be monitored:

- Four impact sites: Cooperabung Creek, Smiths Creek, Pipers Creek, and Maria River.
- Two reference sites: Sun Valley Road (where it crosses Cooperabung Creek), and Old Coast Road (where it crosses Pipers Creek).

Baseline surveys (Niche 2015b) recorded a total of 152 Giant Barred Frogs, at all six monitoring sites in spring and summer and at four sites in autumn. Frogs were absent from the Maria River impact site and Pipers Creek reference site during the autumn 2014 baseline survey.

1.1.4 Purpose of this report

The purpose of this report is to summarise the methods and results of the 2018/2019 monitoring and determine if performance measures are being met, as per the EMP.

1.2 Performance Measures

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

1.3 Monitoring Timing

Monitoring is to occur three times a year: spring, summer and autumn. Monitoring is to occur in the middle of the season, within one week of rainfall of 10 millimetres within a 24 hour period.

1.4 Reporting

As per the EMP, annual reporting of monitoring results will include:

- Detailed description of monitoring methodology
- 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 NSW Department of Planning, Industry and Environment (DPIE; previously the NSW Department of Planning and Environment) and the NSW Environment Protection Authority (EPA).

1.5 Limitations

The following limitations to the monitoring procedure were encountered:

- As reported in Niche 2017, increasing density of Lantana (*Lantana camera*) at a number of sites, notably Maria River impact site and Pipers Creek impact site, is hampering survey efforts. Safe navigation of the creek lines has become difficult due to low visibility and steep creek banks. Giant Barred Frogs have become difficult to detect and impossible to access in areas due to this Lantana growth.
- Summer 2019 surveys were not undertaken due to insufficient rainfall.

2. Methodology

2.1 Monitoring Sites

Monitoring was undertaken at the four impact and two reference sites. Each site consists of a one kilometre transect along the creek line.

Where possible, impact site transects extend 450 metres upstream and 450 metres downstream of the Project footprint (assumes Project boundary width of 100 metres) and are divided into 10 x 100 metre zones, resulting in four to five zones downstream of the Project footprint, one within the Project footprint, and four to five upstream of the Project footprint. As for previous monitoring events, the Cooperabung Creek impact site was not surveyed for the full kilometre as access agreements with landowners could not be obtained for the final downstream zone, and for the first two upstream zones.

The two reference sites are located several kilometres upstream of the Project footprint within Cooperabung Creek and Pipers Creek.

The location of all monitoring sites is shown in Figure 1, with detailed locations for each site transect provided in Figure 2 to Figure 7.

2.2 Giant Barred Frog Survey Method

Surveys were undertaken in accordance with the EMP after sufficient rainfall events.

A two hour minimum search time, using two ecologists, at each site was employed, however access and movement difficulties due to dense vegetation often resulted in increased survey time. Surveys involved passive listening, call playback (upon arrival and at intervals during searches), active searching (within 20 metres of creek bank) and habitat surveys. In accordance with the EMP, the following habitat data was collected within each of the 100 metre zones:

- Overstorey vegetation cover (OS, expressed as a cover percentage out of 100%)
- Shrub cover (expressed as a cover percentage out of 100%)
- Ground cover (expressed as a cover percentage out of 100%)
- Leaf litter cover (expressed as a cover percentage out of 100%)
- Bare soil/earth (expressed as a cover percentage out of 100%)
- Presence of cattle (based on hoof marks, manure and whether it is recent or aged evidence)
- Number of pools and riffles within the zone
- Approximate depth of the deepest pool within the zone
- Number of breaches in frog fencing, if applicable.

The position of all observed Giant Barred Frogs was recorded and, where possible, individuals were captured. Captured individuals were checked for recapture status and fitted with a Passive Integrated Transponder (PIT) tag if the individual was previously unknown. In accordance with the EMP, the following data were collected for captured individuals:

- Location according to demarcated survey zone
- Distance from stream edge
- Sex (male, female, unknown)
- Breeding condition with:
    - Males assessed on the colouration of their nuptial pads (i.e. no colour, light, moderate, dark)

- Females based on whether they are gravid or not gravid (egg bearing).
- Snout-vent length (millimetres)
- Weight (grams).

A swab sample to test for the presence of Chytrid fungus was also undertaken during the 2018/2019 surveys, however this is no longer a requirement of the EMP, as Chytrid fungus has been detected at all sites, and will not be undertaken in future surveys.

Temperature and humidity (either by windwatch or hygrometer), % cloud cover and broad wind level (scale of 0-3 where 0 = no wind) were recorded for each survey. Rainfall (millimetres) within the previous 24 hours was recorded from the Port Macquarie Airport (BOM Station No. 060183), Maria River (BOM Station No. 560003) and Kundabung AWS (Roads and Maritime Station No. RMSN3AWS).

2.3 Water Quality

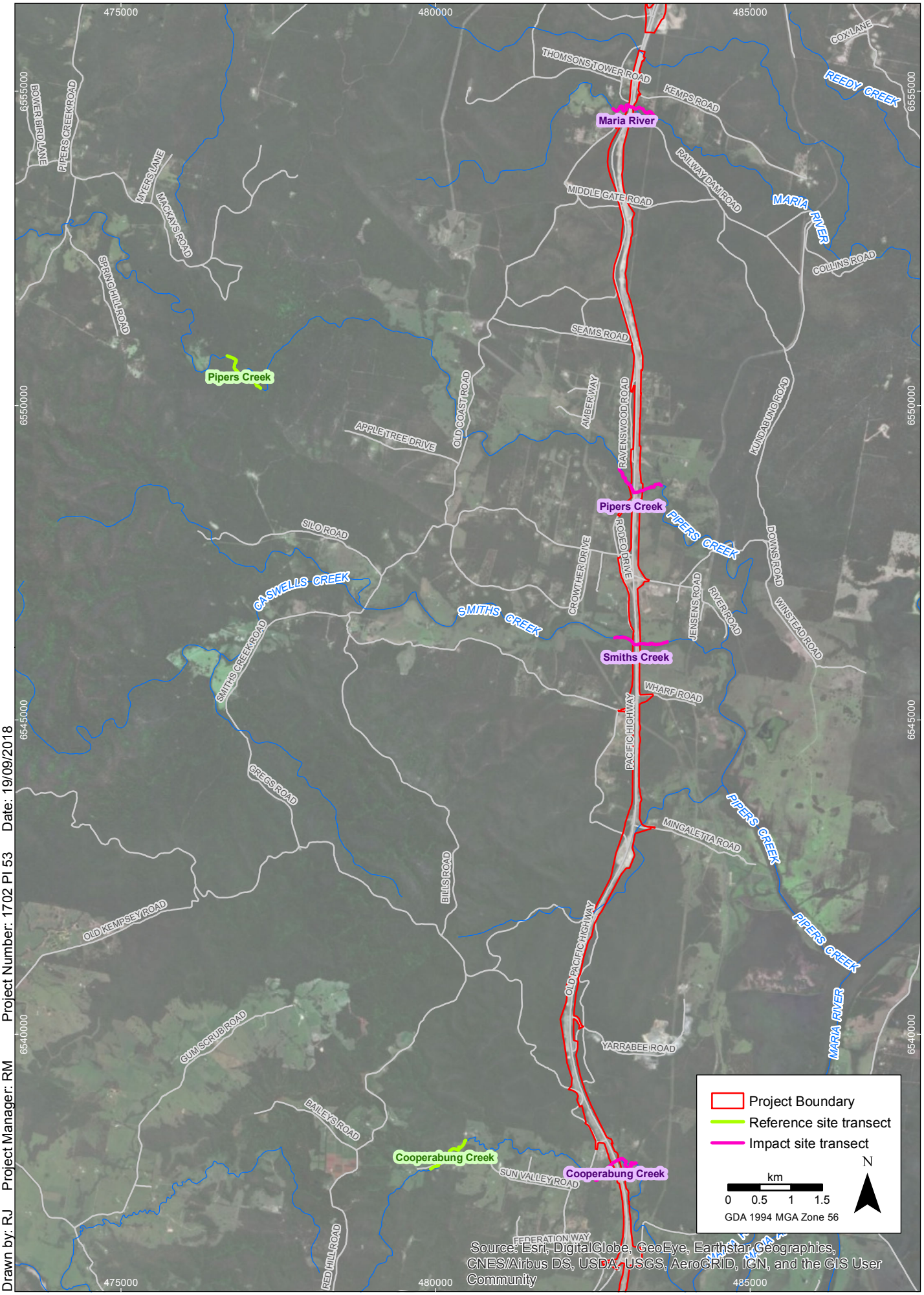
Water quality monitoring was undertaken by Roads and Maritime between 30 March 2018 and 29 March 2019 (RMS 2019b). RMS (2019) presents results from the first operational water quality monitoring period and this report summarises water quality data from both upstream and downstream sites for Cooperabung Creek, Smiths Creek, Pipers Creek, and Maria River.

The median water quality value for downstream sites was compared with the site specific trigger values developed for the upstream site based on: the 80th percentile and, where relevant, the 20th percentile (where parameters have a lower acceptable limit e.g. EC, DO, pH, NTU), as well as the ANZECC default trigger values for physical and chemical stressors for south-east Australian slightly disturbed, freshwater ecosystems. Trigger values were derived from 24 sampling events up to and including the month indicated, where data was available.

2.4 Analysis

The Minimum Number Known Alive (MNA) (see Sutherland 2006) was calculated for each of the sites. The MNA is based on the number of new individuals encountered over multiple visits, where any new animals are summed, providing an aggregate total. As this method does not account for any migration out of the population or any death, it may over-estimate the total population size if counts are completed over a long period of time. As baseline studies commenced in 2013 it is possible that considering cumulative records over these last five years may overestimate the actual population. Data is provided for the annual new captures and a cumulative MNA over the years is also provided, however this data should be approached with caution, as the lifespan of the Giant Barred Frog may not extend beyond four or five years (Michael Mahony unpublished data).

Changes in Giant Barred Frog density within the zones and distribution along transects across the years were investigated by considering mean annual records within each specific zone. In addition, movement of individuals between zones was examined for recaptured frogs.



Drawn by: RJ Project Manager: RM Project Number: 1702 PI 53 Date: 19/09/2018

Giant Barred Frog Monitoring Sites: overview

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FIGURE 1

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Drawn by: RJ Project Manager: RM Project Number: 1702 PI 5.3 Date: 08/08/2018

Giant Barred Frog monitoring: Cooperabung Creek impact site

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FIGURE 2

Imagery: (c) DigitalGlobe

Giant Barred Frog monitoring: Smiths Creek impact site

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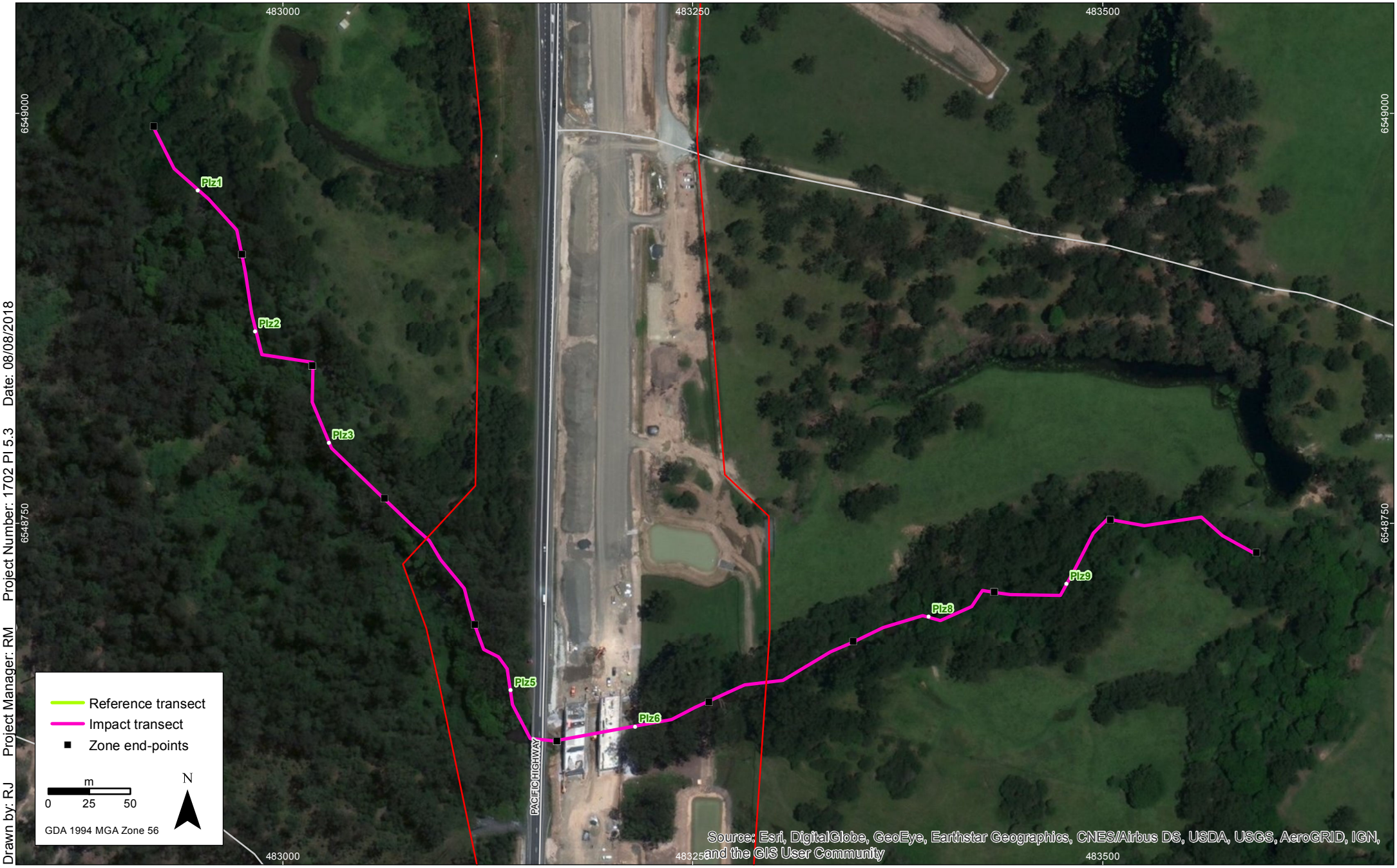
FIGURE 3

Imagery: (c) DigitalGlobe



Giant Barred Frog monitoring: Pipers Creek impact site

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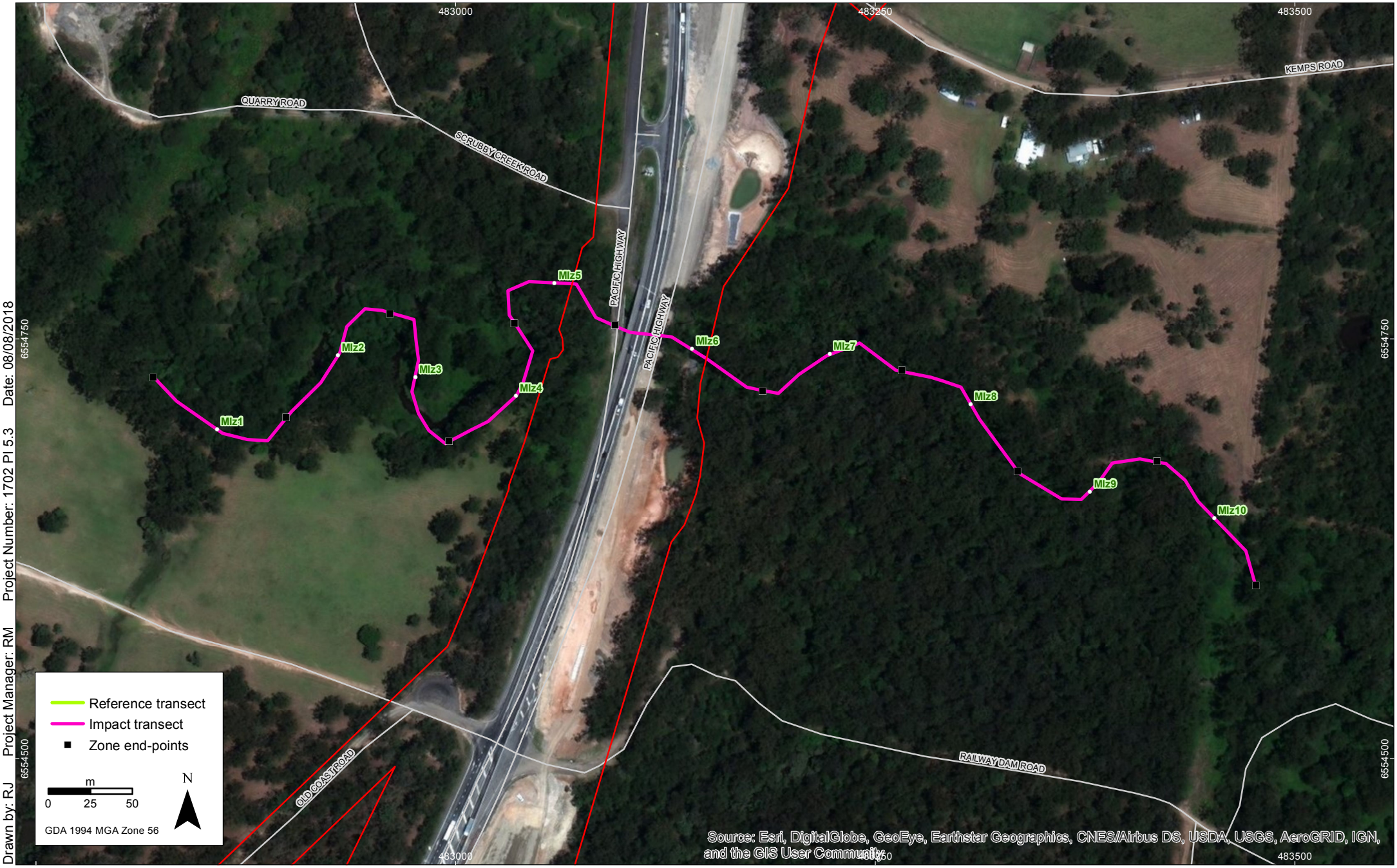
FIGURE 4

Imagery: (c) DigitalGlobe



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Giant Barred Frog monitoring: Maria River impact site

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FIGURE 5

Imagery: (c) DigitalGlobe

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Giant Barred Frog monitoring: Cooperabung Creek reference site

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FIGURE 6

Imagery: (c) DigitalGlobe

Giant Barred Frog monitoring: Pipers Creek reference site

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FIGURE 7

Imagery: (c) DigitalGlobe

3. Results

3.1 2018/2019 Giant Barred Frog Monitoring Results

Field data are presented in Annex 1 and Annex 2. Survey dates and trigger rainfall events measured at Port Macquarie Airport (060183) weather station were as follows:

- 15 - 17 October 2018 (spring): 33.6 millimetres recorded on the 11th October 2019 prior to surveys
- 11 – 13 March 2019 (autumn): 32 millimetres recorded on the 10th March 2019 prior to surveys.

There was insufficient rainfall during December 2018, January and February 2019 to trigger summer surveys.

3.1.1 Survey results

A total of 72 Giant Barred Frogs were recorded in spring and autumn during the 2018/2019 monitoring surveys. Frogs were recorded at all sites during autumn surveys and at five of the six sites during spring surveys (Table 1). Of the 72 frogs recorded, 70 were captured, of which 20 were recaptures (28.6%). Frogs were recorded at all sites during all seasons with the exception of Cooperabung Creek reference site where no frogs were recorded during the spring surveys. Pipers Creek reference site recorded the greatest mean number of frogs.

The cumulative MNA is highest at the Pipers Creek reference site (MNA = 165) and Smiths Creek reference site (MNA = 112). As mentioned in Section 2.4, this estimate of MNA is likely an overestimate of the population as calculation of the MNA does not take dispersal or deaths into account.

Table 1: Giant Barred Frogs recorded at each site during 2018/2019 surveys

	Cooperabung Creek impact	Smiths Creek impact	Pipers Creek impact	Maria River impact	Cooperabung Creek reference	Pipers Creek reference
Spring (2018)	3	13	2	2	0	9
Autumn (2019)	1	3	3	3	3	30
Mean number of frogs per visit	2.0	8.0	2.5	2.5	1.5	19.5
Standard Error (SE)	1.4	7.1	1.0	1.0	2.1	14.8
New captures	2	10	5	4	1	28
Cumulative MNA	53	112	45	92	73	165

3.1.2 Evidence of breeding

Table 2 presents records of breeding evidence. All sites showed evidence of breeding via the presence of juveniles or sub-adults, gravid females or reproductive males during at least one survey event during 2018/2019.

Table 2: Breeding evidence records 2018/2019

		Juveniles	Sub-adults	Gravid females	Nuptial pads
Cooperabung Creek impact	Spring	1			2
	Autumn	1			
Maria River impact	Spring			1	
	Autumn	1			2
Pipers Creeks impact	Spring			1	
	Autumn			1	
Smiths Creek impact	Spring	2	1	2	2
	Autumn			3	
Cooperabung Creek reference	Spring				
	Autumn		1	1	
Pipers Creek reference	Spring				7
	Autumn	4	2	2	9

3.1.3 Weather conditions

The prevailing weather conditions encountered during the field surveys are summarised in Table 3 (Port Macquarie Airport (BOM Station No. 060183)). Additional details of the prevailing micrometeorological conditions at the six sites during the field surveys are presented in Annex 1.

Table 3: Weather conditions: spring 2018 and autumn 2019

Date	Min temp (˚C)	Max temp (˚C)	Humidity (%)	Rainfall 24 hours (mm)	Rainfall 7 days (mm)	Rainfall 30 days (mm)
15/10/2018	15.1	21.1	90	7.8	52.8	91.2
16/10/2018	17.7	23.6	76	5.6	58.2	96.8
17/10/2018	18.5	24.0	89	15.4	73.6	112.2
11/03/2019	21.7	31.2	65	0	34.4	89.2
12/03/2019	17.7	31.5	97	0	34.4	87.4
13/03/2019	17.6	27.8	77	0	34.4	87.4

3.1.4 Chytrid fungus

Chytrid fungus sampling was carried out during all monitoring events. Table 4 presents current and previous monitoring event results. During the current monitoring period Chytrid fungus was detected during autumn at Cooperabung Creek reference site only. Chytrid fungus was not detected during the spring monitoring surveys at any of the sites. Chytrid fungus was not detected at the remaining five sites during the 2018/2019 monitoring period, however it has been previously detected at these sites during either baseline surveys or previous monitoring events. It is presumed that once present, this pathogen will remain at a location on a permanent basis. Chytrid fungus is therefore considered to be present at all monitoring sites.

Table 4: Chytrid fungus detection/presence at each site for all surveys conducted to date

	Cooperabung Creek impact	Smiths Creek impact	Pipers Creek impact	Maria River impact	Cooperabung Creek reference	Pipers Creek reference
Baseline	not detected	**detected**	not detected	not detected	**detected**	not detected
2015/2016	not detected	not detected	**detected**	**detected**	not detected	**detected**
2016/2017	**detected**	not detected	not detected	not detected	**detected**	**detected**
2017/2018	not detected	**detected**	not detected	not detected	not detected	not detected
2018/2019	not detected	not detected	not detected	not detected	**detected**	not detected

3.1.5 Habitat use

Habitat information collected for each site is presented in Annex 1. Microhabitat use was highly variable. Frogs were recorded on and buried within leaf litter, using flood debris as shelter, within the creeks, on rocks and under logs and vegetation.

No frogs were found to have breached the frog fences at any sites (i.e. observed on the wrong side of the fence).

3.2 Comparison with Previous Surveys

As previously mentioned, the summer survey was not undertaken due to insufficient rainfall.

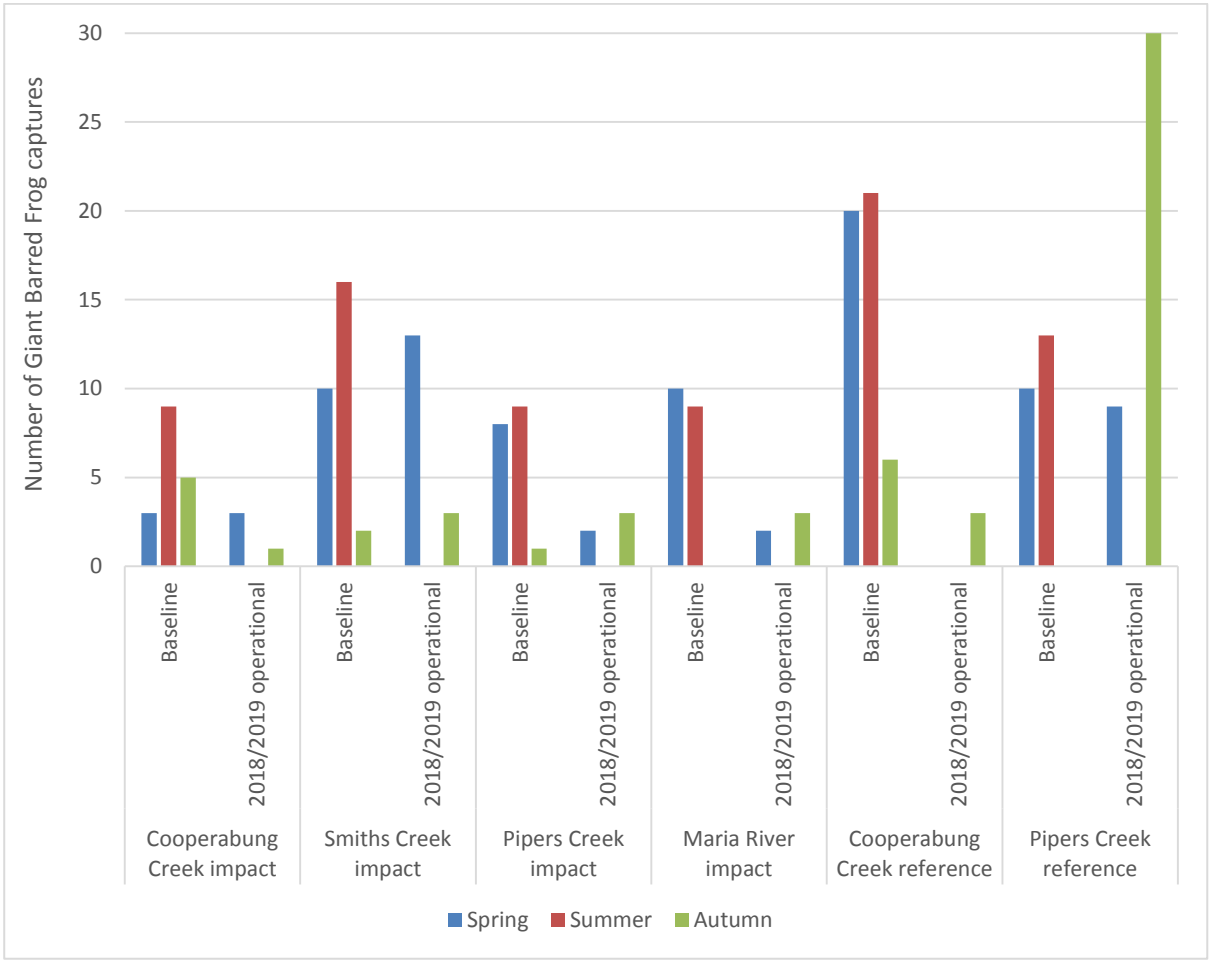
3.2.1 Baseline and 2018/2019 surveys

Graph 1 presents the Giant Barred Frog records for baseline and the 2018/2019 operational monitoring surveys.

Baseline surveys recorded the Giant Barred Frog at all six monitoring sites in spring and summer and at four sites in autumn. Giant Barred Frogs were not recorded at the Maria River impact site and Pipers Creek reference site during the autumn 2014 baseline survey.

The 2018/2019 monitoring recorded Giant Barred Frogs at five monitoring sites in spring and at all six sites in autumn. Giant Barred Frogs were not recorded at Cooperabung Creek reference site during the spring 2018 surveys, where it was recorded during the spring baseline surveys.

Giant Barred Frogs were therefore recorded during all 2018/2019 surveys at the two sites (one impact site) where they were not recorded during the autumn baseline surveys (Pipers Creek reference site and Maria River impact site), however they were not recorded at the Cooperabung Creek reference site in the spring survey, where they were recorded during baseline surveys.



Graph 1: Giant Barred Frog records: baseline and 2018/2019 monitoring

3.2.2 Annual mean records

The mean number of records each year for each site is shown in Graph 2.

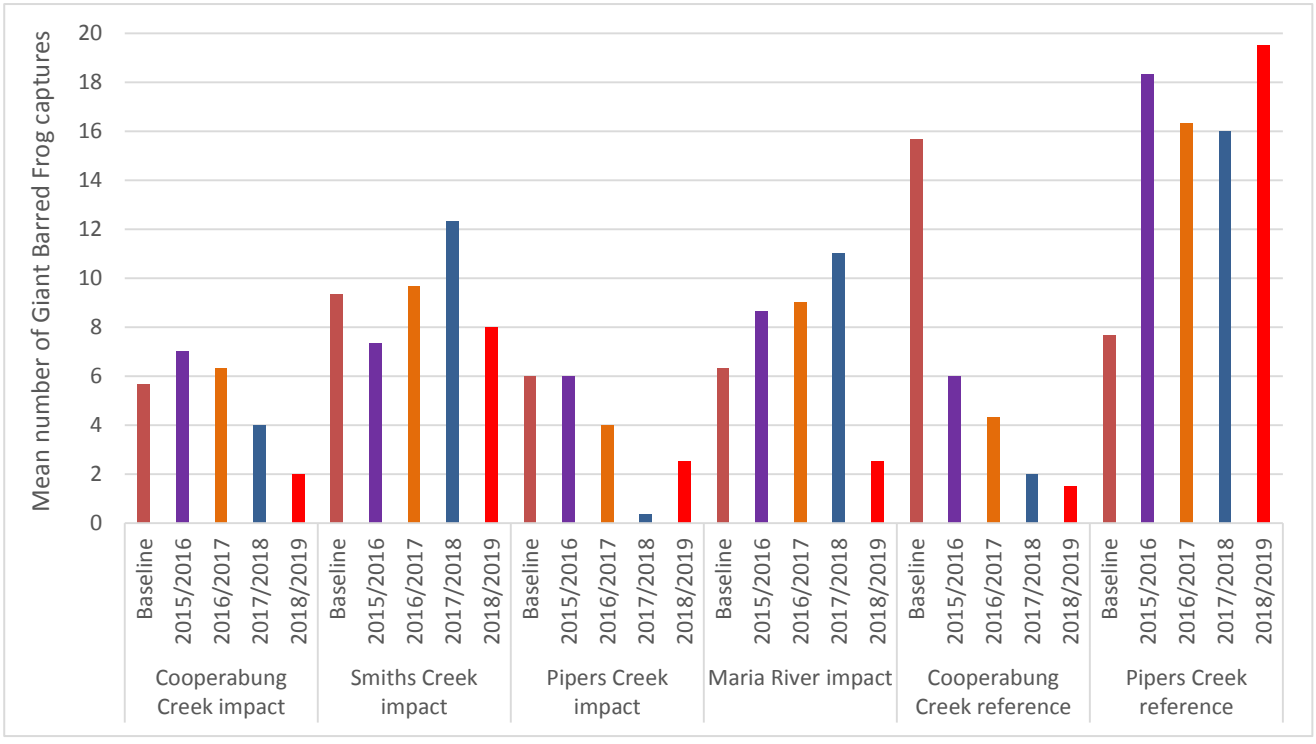
The mean number of Giant Barred Frogs recorded at Cooperabung Creek impact site and Cooperabung Creek reference site has decreased annually since 2015/2016 and baseline, respectively. Pipers creek impact site showed a similar annual decrease, however the mean number of Giant Barred Frogs recorded increased at this site in the current monitoring period.

The mean number of Giant Barred Frogs recorded at Smiths Creek impact site and Maria River impact site has increased annually since 2015/2016 and baseline respectively, however the mean number of Giant Barred Frogs recorded decreased substantially at both these sites in the current monitoring period.

The mean number of Giant Barred Frogs recorded at Pipers Creek reference site decreased in the current monitoring period, however there is no apparent annual trend at this site.

The mean number of Giant Barred Frogs recorded during the current monitoring period decreased from the previous monitoring event at all sites excluding Pipers Creek impact site. It should be noted that the greatest number of Giant Barred Frogs are generally recorded in the summer surveys of each monitoring cycle. The absence of the summer survey period is likely to have resulted in lower mean records for the current monitoring period.

Given the variable nature of annual mean records among sites, the absence of summer survey records from the current monitoring period, the evidence of a decreasing trend at a reference site and the lack of a distinct difference between impact and reference sites, it is not possible to attribute observed changes to the Project.



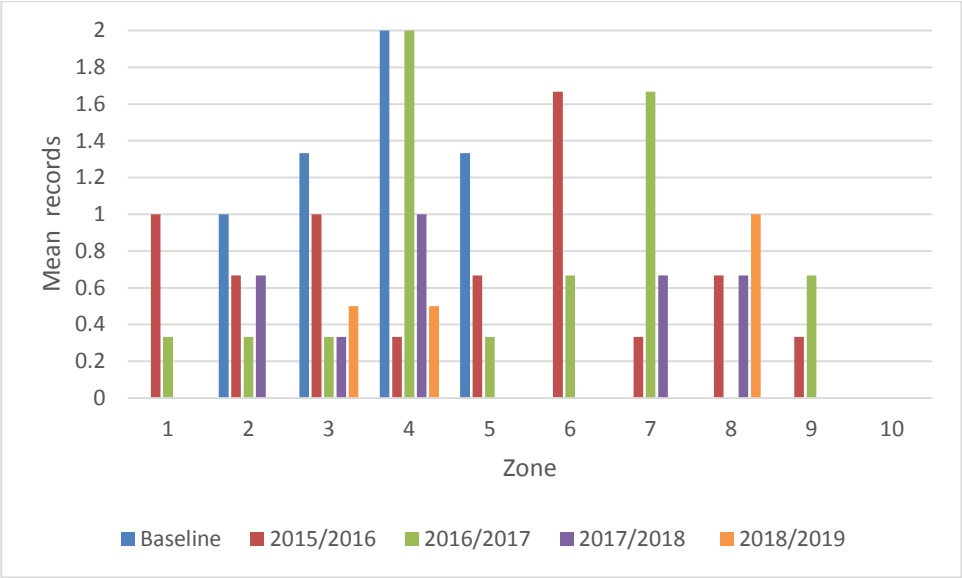
Graph 2: Mean annual Giant Barred Frog records by site

3.3 Density and Distribution

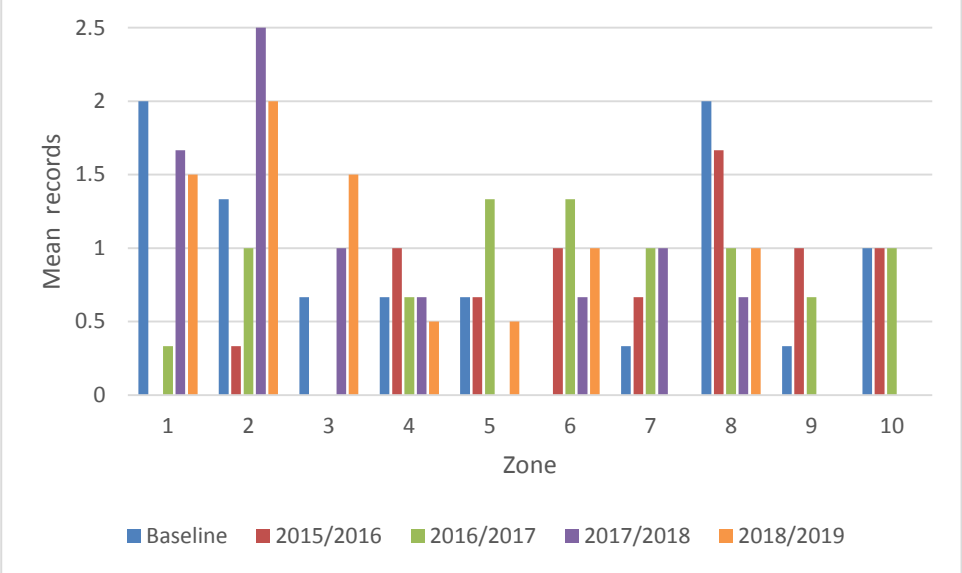
Graph 3 - Graph 8 present the density (*annual mean number of Giant Barred Frog records per zone*) and distribution of Giant Barred Frog records along the survey transect for each site and each monitoring period. Figure 8 - Figure 13 show the total number of captures within each zone over all monitoring periods.

The density of Giant Barred Frogs has been considered as the *mean number of records per year per zone* (Graph 3 to Graph 8). While the zones may vary in size slightly due to the nature of the creek's bank formation and the non-linear nature of the creek line, the zones themselves are consistent between years. As such comparisons can be made within the same zone between years to help identify trends in changing frog numbers. There is no consistent trend evident at any site for frogs to be found in any particular zone. Density appears to be highly variable across the years and along the transect and there is no evidence of lower frog densities within zones 5 and 6, i.e. under the carriageway and immediately adjacent.

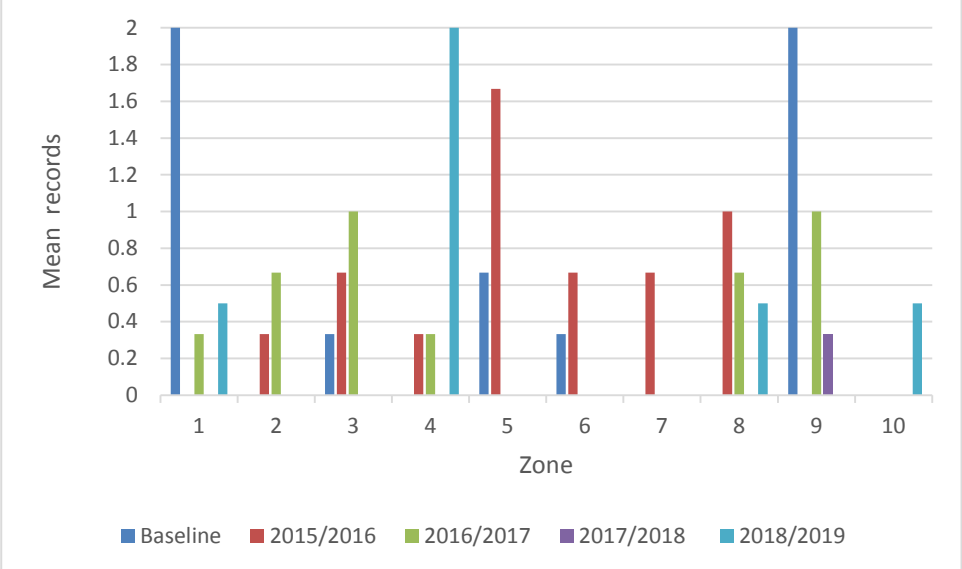
Figure 8 - Figure 13 show all capture records (i.e. cumulative records), whereby capture records (including recaptures) are shown as count ranges, where larger circles indicate larger frog counts. While density data indicates that frog distribution along the transects varies from year to year, when considering all years, frogs mostly appear to be using the entire length of the transect and there is no evidence of frogs being recorded only in one particular zone. In addition, there is no evidence of frogs being absent from zones 5 and 6. While capture frequencies within zones directly under the carriageway consistently fall into the lower range category (1-7 frogs), the low capture frequency range occurs regularly along the transects and at all sites.



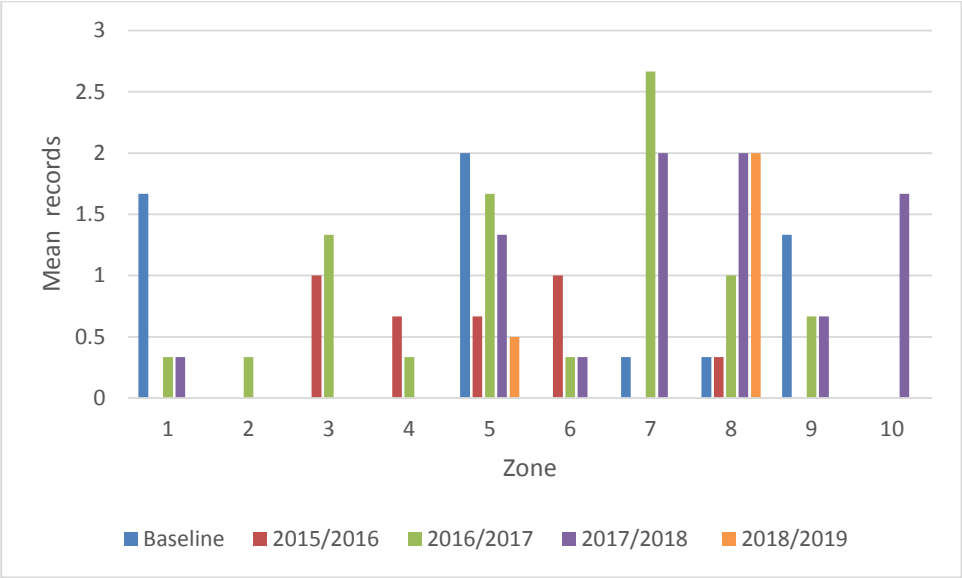
Graph 3: Cooperabung Creek impact site: mean number of Giant Barred Frogs per zone



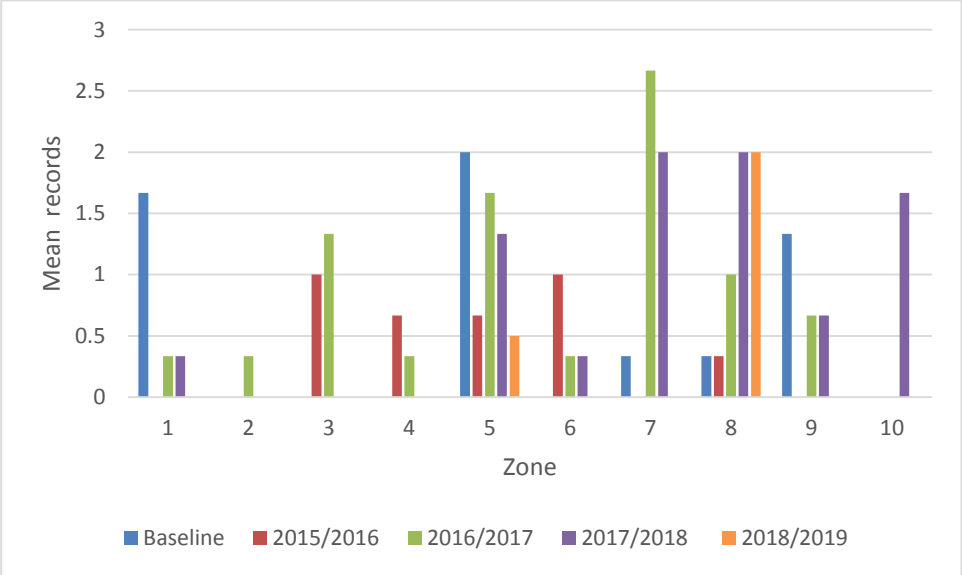
Graph 4: Smiths Creek impact site: mean number of Giant Barred Frogs per zone



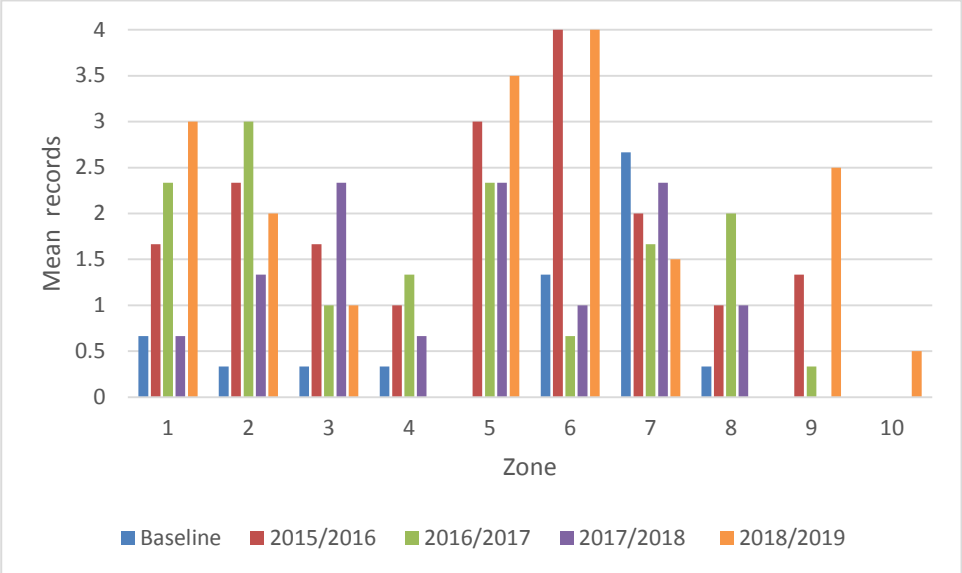
Graph 5: Pipers Creek impact site: mean number of Giant Barred Frogs per zone



Graph 6: Maria River impact site: mean number of Giant Barred Frogs per zone



Graph 7: Cooperabung Creek reference site: mean number of Giant Barred Frogs per zone



Graph 8: Pipers Creek reference site operational: mean number of Giant Barred Frogs per zone

Giant Barred Frog capture distribution: Cooperabung Creek impact site

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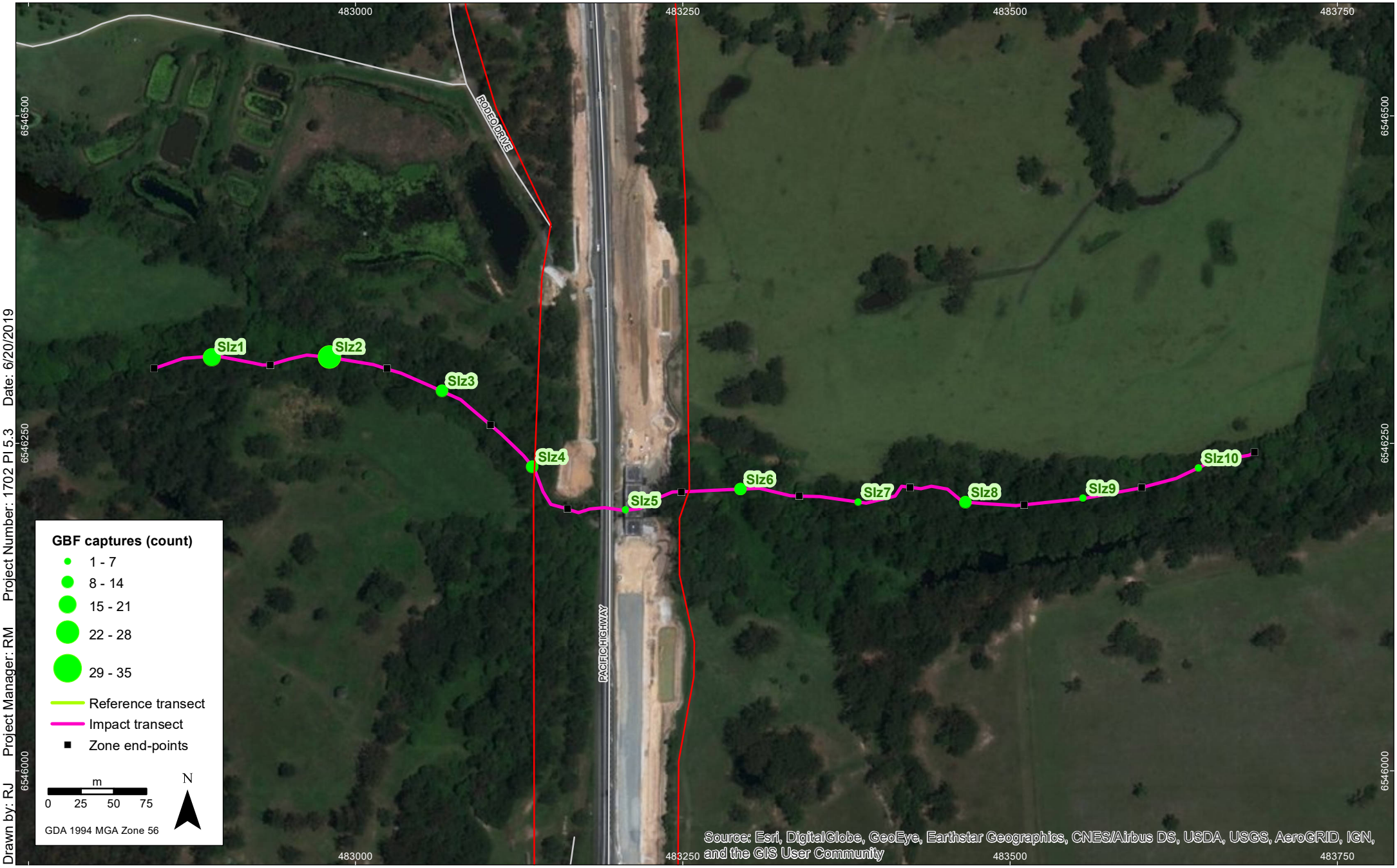
FIGURE 8

Imagery: (c) DigitalGlobe



Giant Barred Frog capture distribution: Smiths Creek impact site

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FIGURE 9

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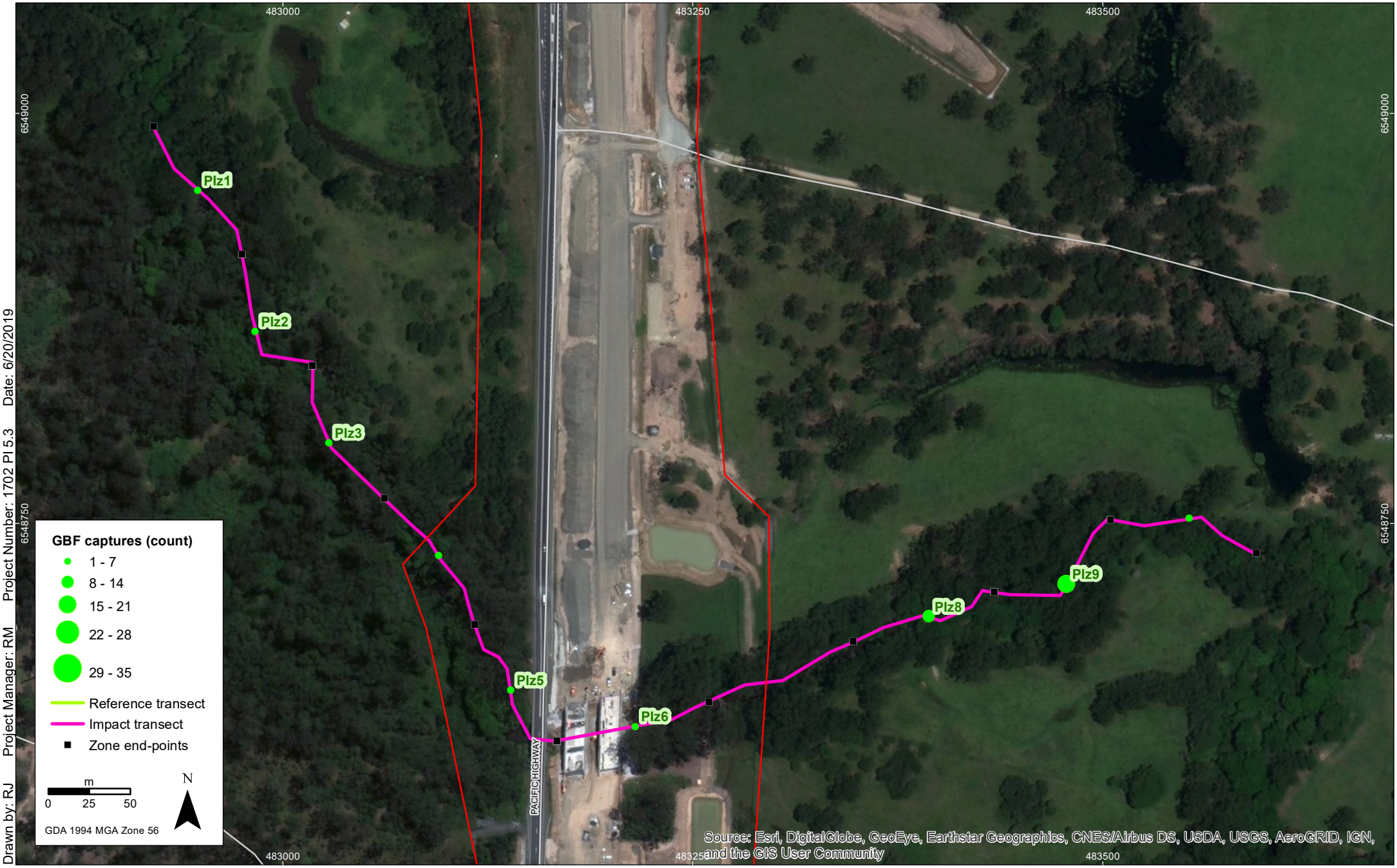

Giant Barred Frog capture distribution: Pipers Creek impact site

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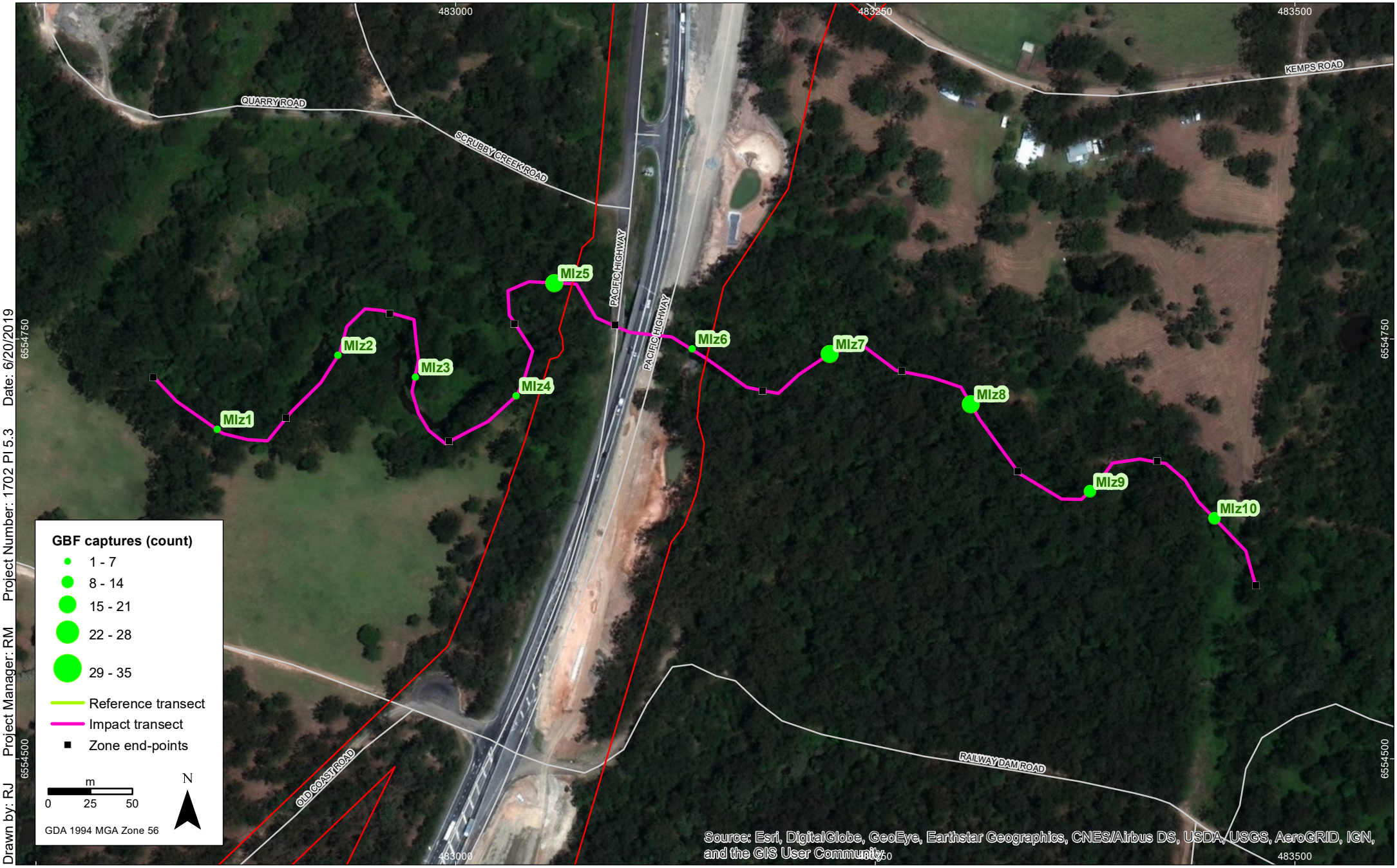
FIGURE 10

Imagery: (c) DigitalGlobe



Giant Barred Frog capture distribution: Maria River impact site

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FIGURE 11

Imagery: (c) DigitalGlobe

Giant Barred Frog capture distribution: Cooperabung Creek reference site

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FIGURE 12

Imagery: (c) DigitalGlobe

Giant Barred Frog capture distribution: Pipers Creek reference site

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FIGURE 13

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Imagery: (c) DigitalGlobe

3.4 Movement

Recapture data of PIT-tagged individuals was used to determine movements along the transects, and notably, past the midpoint of the transect i.e. from one side of the carriageway to the other at the impact sites. It should be noted that this analysis does not imply that individuals that have not been found on opposite sides of the carriageway have not traversed at some time. Graph 9 - Graph 14 show the movement patterns of individual recaptured Giant Barred Frogs at each site and the data is summarised for each site below. As reference sites by their nature do not traverse the carriageway, a transect midpoint has been included to provide an indication of movements along the transects and permit comparison between reference and impact sites. The reference midpoint was chosen as the arbitrary midpoint location to provide similar recapture circumstances to the impact sites (i.e. equal zones on either side). It should however be noted that comparisons made between impact and reference sites do not take into account other potentially confounding factors such as site specific population ecology. Capture order is indicated by the numbers beside each capture point and a single capture point indicates recaptures within the same zone (order not indicated).

A total of 81 individuals have been recaptured on at least one occasion over all monitoring events. Of these, 48 recaptures have occurred at the impact sites. Fifteen (31%) of these individuals from impact sites have been captured on both sides of the carriageway over successive monitoring events. Of the 33 recaptures at the reference sites, 12 (36%) have been captured on both sides of the midpoint over successive monitoring events.

Cooperabung Creek impact site: Ten Giant Barred Frogs have been recaptured over all monitoring periods. Of these individuals, four (40%) have been captured on both sides of the carriageway, including one individual (ID#7) that traversed on at least two occasions.

Smiths Creek impact site: Eighteen frogs have been recaptured over all monitoring periods. Of these individuals, four (22%) have been captured on both sides of the carriageway.

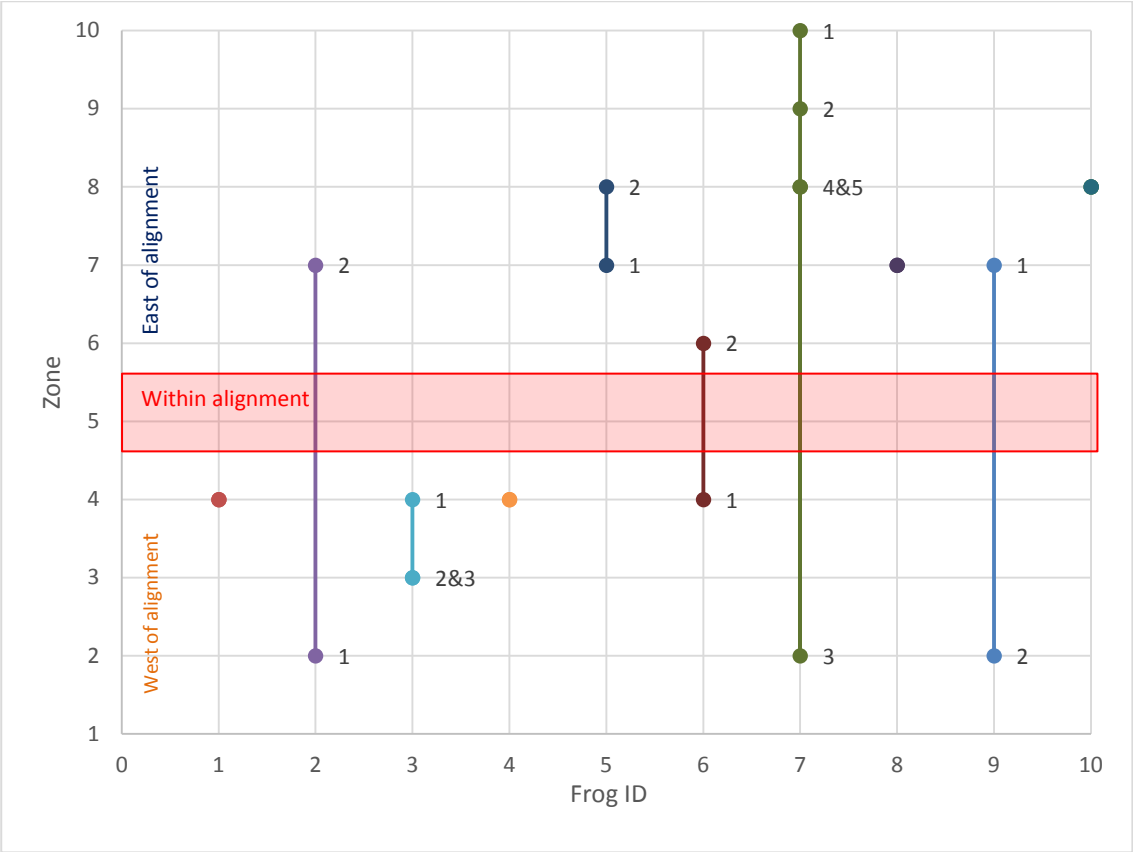
Pipers Creek impact site: Eleven Giant Barred Frogs have been recaptured over all monitoring periods. Of these individuals, three (27%) have been captured on both sides of the carriageway.

Maria River impact site: Nine Giant Barred Frogs have been recaptured over all monitoring periods. Of these individuals, four (44%) have been captured on both sides of the carriageway.

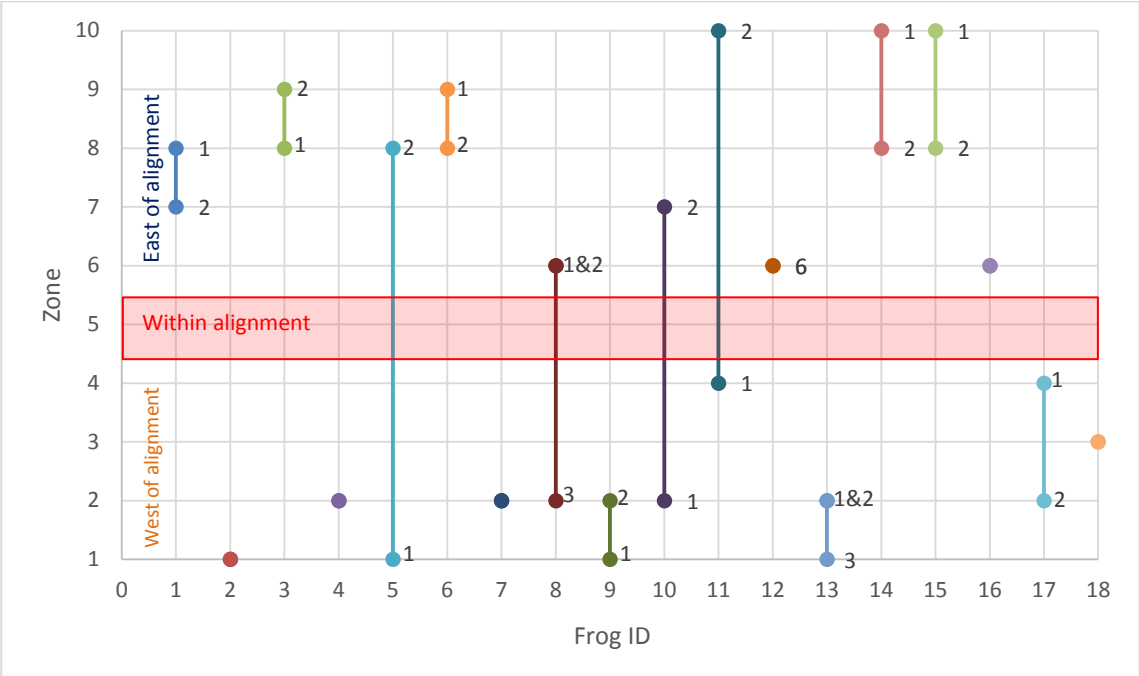
Cooperabung Creek reference site: Nine Giant Barred Frogs have been recaptured over all monitoring periods. Of these individuals, two (22%) have been captured on both sides of the transect midpoint.

Pipers Creek reference site: Twenty-four Giant Barred Frogs have been recaptured over all monitoring periods. Of these individuals, ten (42%) have been captured on both sides of the transect midpoint.

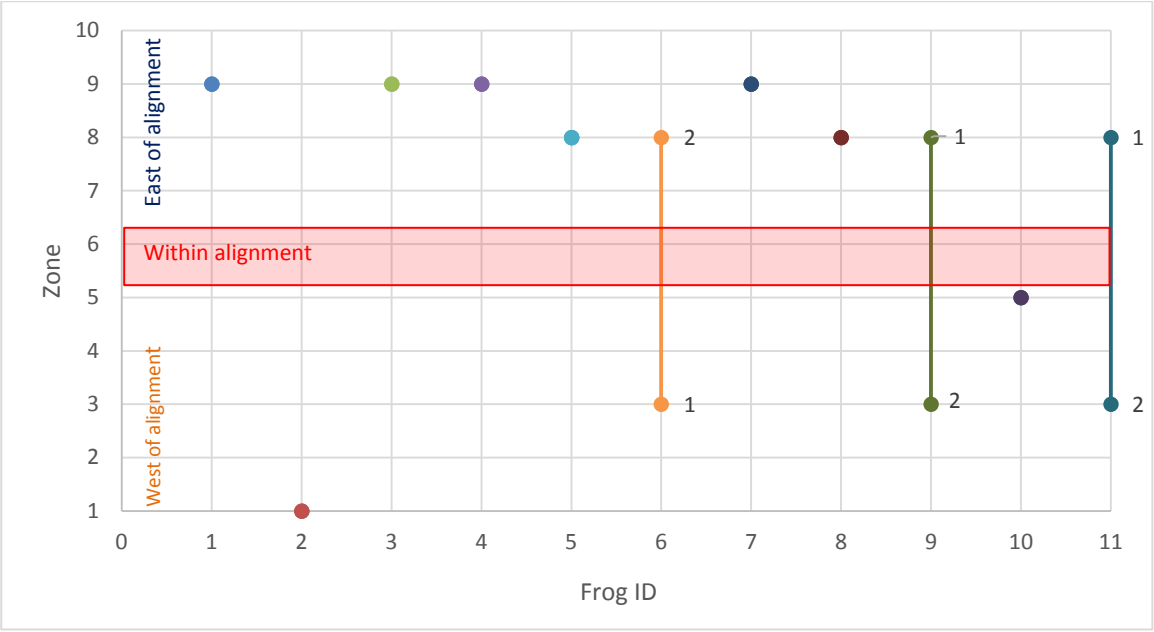
At the impact sites, while the monitored waterways continue uninterrupted under the carriageway, there is a distinct change in streamside vegetation within the area immediately under the carriageway. Under the carriageway at all impact sites, streamside vegetation ranges from completely absent to very limited, represented by small clumps of shrubs and/or *Lomandra* spp. The streamside habitat in these areas is limited to the large rocks and boulders deposited during construction of the Project. Despite this abrupt change in streamside habitat immediately under the carriageway, a number of Giant Barred Frogs have been recorded traversing the carriageway. The percentage of Giant Barred Frogs found to have traversed the impact site midpoints do not appear to differ substantially from the percentage of Giant Barred Frogs found to have traversed the reference site midpoints.



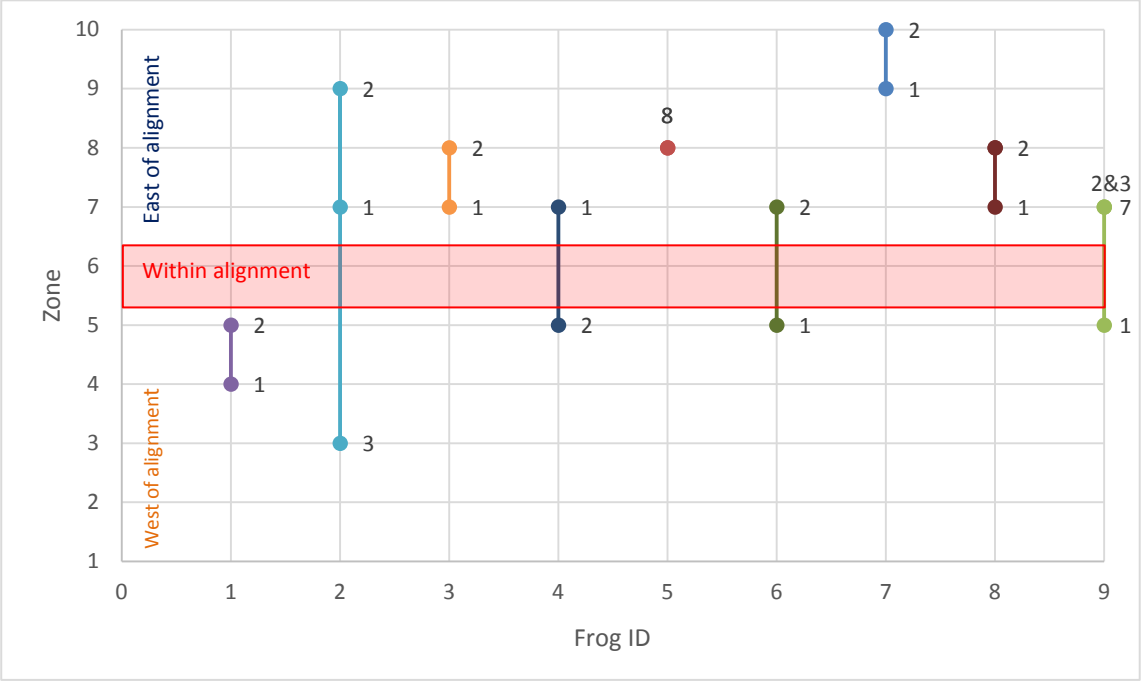
Graph 9: Cooperabung Creek impact site: recapture movement patterns



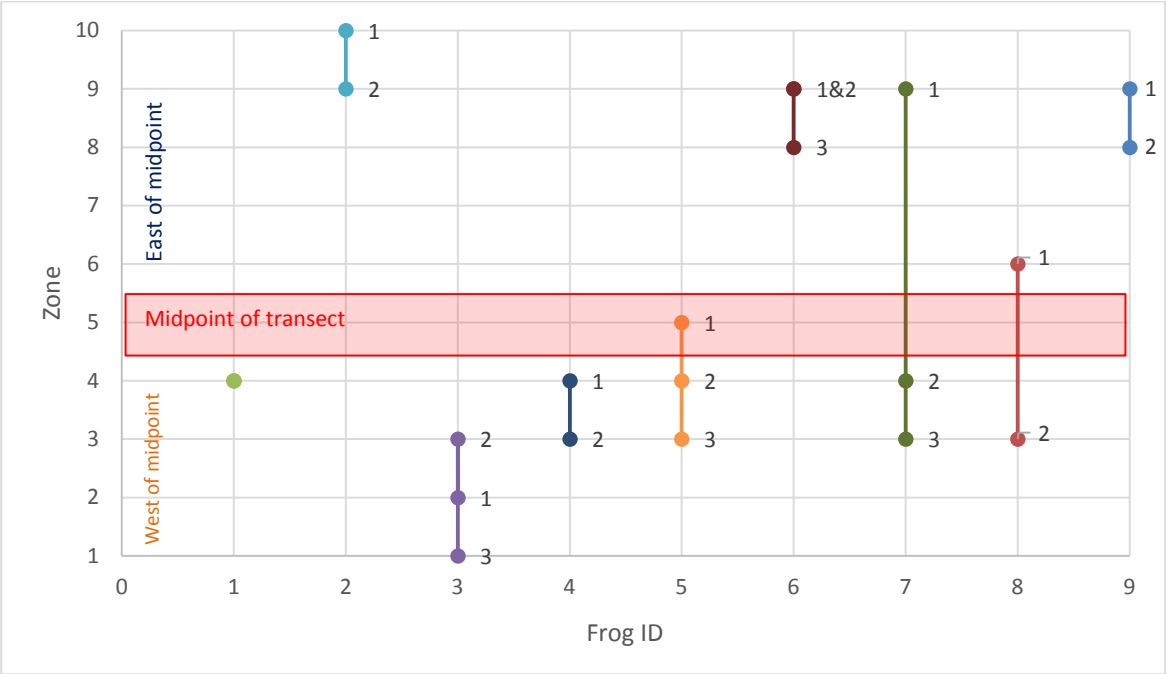
Graph 10: Smiths Creek impact site: recapture movement patterns



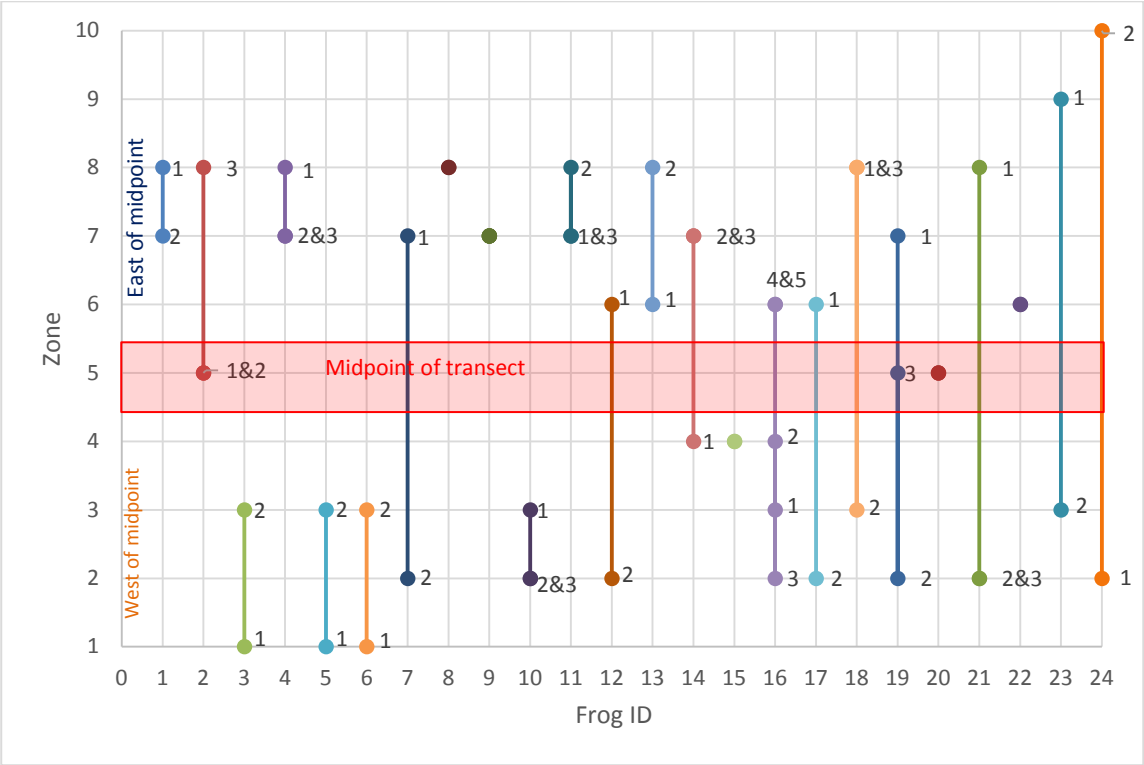
Graph 11: Pipers Creek impact site: recapture movement patterns



Graph 12: Maria River impact site: recapture movement patterns



Graph 13: Cooperabung Creek reference site: recapture movement patterns



Graph 14: Pipers Creek reference site: recapture movement patterns

3.5 Water Quality

Water quality monitoring was undertaken by Roads and Maritime. Data included in this report represents the first operational monitoring period, from 30 March 2018 to 29 March 2019 (RMS 2019b). Presented here is a summary of the data collected for Cooperabung Creek, Smiths Creek, Pipers Creek and Maria River, for the purpose of assessing the water quality in relation to desired parameters and the water quality performance measures specified in the EMP. Annex 3 presents data extracted from the water quality reports. It shows only those sampling results where the calculated median downstream value exceeded (was above the 80th percentile) or was below (below the 20th percentile) desired threshold values of the upstream site.

3.5.1 Parameters

Table 5 presents the number of occasions downstream median values were greater than the 80th percentile, and of these, the number that exceeded the ANZECC trigger value. All sites had at least one parameter for one or more monthly results, for which the median downstream value exceeded the 80th percentile of the upstream value. These are discussed below.

Electrical conductivity: Downstream median values were higher than the upstream trigger values throughout the 12 months at all sites except Maria River. These values, while slightly elevated, were well within ANZECC guideline trigger values. According to RMS 2019b, the greater differences between upstream and downstream values occurred when there was no visible flow, sample points persisting as isolated ponds, or in some cases dry upstream conditions at the time of sampling. At Smiths Creek elevated nutrients/sediments is likely associated with agricultural activities and Project construction works. Continued vegetation growth and landscaping will likely reduce sediments entering the waterway.

Dissolved oxygen: Downstream median values were regularly below or above the calculated upstream 80th and 20th percentile trigger value. At Cooperabung Creek and Smiths Creek the variability coincided with algae outbreaks and both these sites were noted as having little to no flow or existing as isolated ponds. The water quality monitoring report considered impacts attributable to construction to be negligible.

pH: Downstream median values were generally within, or close to, the calculated upstream 80th and 20th percentile trigger values. pH levels were within the default ANZECC trigger value range for all but one instance at Smiths Creek. The water quality monitoring report considered impacts to be unrelated to construction.

Turbidity: Downstream turbidity was variable throughout the year and for sites. With 80th percentile values being exceeded on one occasion at Cooperabung Creek and Maria River and on five occasions at Smiths Creek. The ANZECC upper limit default trigger value was exceeded at Smith Creek on one occasion. At Smiths Creek, differences between upstream and downstream values coincided with shallow isolated ponds and algae growth. The water quality monitoring report considered impacts attributable to the Project to be negligible or minor.

Nitrogen and Phosphorus: Downstream nitrogen and phosphorus values were variable throughout the year and for sites. Levels were generally consistent within upstream and downstream ranges. However, elevated levels were recorded at Smiths Creek, Pipers Creek and Maria River with samples above the ANZECC trigger value. Differences between upstream and downstream was generally when the sampling points persisted as isolated ponds. The water quality monitoring report considered impacts attributable to construction to be negligible.

Metals: There was limited variation in the level of metals with the exception of aluminium, chromium, iron, manganese and zinc. Levels were generally consistent with upstream values. Differences between upstream and downstream values was generally when the sampling points persisted as isolated ponds. The water quality monitoring report considered elevated metal parameters unlikely to be attributable to construction related activities.

The water quality monitoring report suggested that results were not inconsistent with the variability and levels experienced during the pre-construction monitoring.

Table 5: Triggered water quality parameters per site

Parameter	Number of samples where downstream median value > 80th % (# downstream value exceeds ANZECC trigger/range)			
	Cooperabung Creek	Smiths Creek	Pipers Creek	Maria River
Temperature ˚C	2	2	2	3
Electrical Conductivity uS/cm	5	3 (1)	3	0
Dissolved oxygen %	2	3	4	0
pH	2	2	2	1
Turbidity (NTU)	1	5 (1)	0	1 (1)
Total suspended solids mg/L	3	4	0	1
Aluminium mg/L	1 (2)	2 (3)	1 (1)	1 (5)
Arsenic mg/L	0	0	0	0
Cadmium mg/L	0	0	0	0
Chromium mg/L	0	0	0	1 (1)
Copper mg/L	0	0	0	0
Iron mg/L	1	1	2	0
Lead mg/L	0	0	0	0
Manganese mg/L	2	2	0	0
Mercury mg/L	0	0	0	0
Nickel mg/L	0	0	0	0
Silver mg/L	0	0	0	0
Zinc mg/L	2 (2)	0 (3)	2 (2)	3 (4)
Total nitrogen mg/L	0	2 (2)	3 (2)	1 (5)
Total phosphorus mg/L	0	4 (3)	3	4 (1)

4. Discussion

4.1 Performance Measures

A summary of Year 1 (2015/2016), Year 2 (2016/2017), Year 3 (2017/2018) and Year 4 (2018/2019) survey results in relation to the performance measures is provided in Table 6.

Table 6: Performance measures and discussion of results.

Performance measure	Discussion
Monitoring is undertaken during baseline surveys and Years 1 – 8 or until monitoring can demonstrate that mitigation measures are effective.	**This performance measure has been met for Baseline, Year 1 (2015/2016), Year 2 (2016/2017), Year 3 (2017/2018) and Year 4 (2018/2019)**. Giant Barred Frog monitoring has been undertaken at all six sites according to the EMP to date. Summer 2018/2019 surveys were not undertaken due to insufficient rainfall.
Monitoring during Year 1 – 8 is undertaken at the Impact and Control sites where baseline monitoring was undertaken, subject to landowner agreement.	**This performance measure has been met for Baseline, Year 1 (2015/2016), Year 2 (2016/2017), Year 3 (2017/2018) and Year 4 (2018/2019)**. Giant Barred Frog monitoring has been undertaken at all six baseline sites, where landowner agreement permitted.
Continued presence of Giant Barred Frogs during each survey event in Year 1 – 8 at sites where it was identified during baseline surveys, subject to access due to landowner agreement.	**This performance measure has been met for all sites in Year 1 (2015/2016), 5 of 6 sites in Year 2 (2016/2017), Year 3 (2017/2018) and Year 4 (2018/2019).** Baseline: Giant Barred Frogs were recorded at all six monitoring sites in spring and summer and at four sites in autumn. Giant Barred Frogs were not recorded at the Maria River impact site and Pipers Creek reference site during the autumn 2014 baseline survey. Year 1 (2015/2016): Giant Barred Frogs were detected at all six sites during all surveys. Year 2 (2016/2017): Giant Barred Frogs were detected at all six sites in spring and summer and five sites in autumn. Not recorded at Pipers Creek impact site during the autumn 2017 survey where it was detected during baseline surveys. Year 3 (2017/2018): Giant Barred Frogs were detected at all six sites in spring and five sites in summer and autumn. Not recorded at Pipers Creek impact site during summer and autumn 2018 where it was detected during baseline surveys. Year 4 (2018/2019): Giant Barred Frogs were detected at five sites in spring and all six sites in autumn. Not recorded at Cooperabung Creek reference site during spring 2018 where it was detected during baseline surveys. Giant Barred Frogs have been recorded at all six sites on at least one occasion during each monitoring period.
Mitigation measures are effective as defined in the EPBC approval when all monitoring events are considered at Year 8.	This performance measure is not yet applicable. Initial results (review of movement patterns of re-captured individuals showing records along the creek on either side of the carriageway) indicate that Giant Barred Frogs are moving underneath the road. It is unknown if they used the underpasses, however, no breaches of the frog fencing were observed during surveys.
Median values of all downstream water quality monitoring at GBF habitat or potential habitat locations during construction and operation (Year 1 – 6) is less than the 80th percentile value of the upstream site (where 80th percentile is the value at which median values at the downstream site are above 80% of the recorded background water quality records), where this change is found to be attributable to construction or operation.	**This performance measure has been met for all parameters at all sites.** Whilst values at all sites have exceeded the 80th percentile on one or more occasion, impacts potentially attributable to construction were considered negligible or minor. Variability at some sites was a result of extensive algae outbreaks and low water flows. RMS (2019b) in referring to relevant waterways states "*while exceedances have occurred they have tended to be smaller and less frequent. …As noted previously, these changes are considered to be unrelated to the project activities / changes, but rather other land use activities within the catchment. At other locations e.g. SW7, SW9 and SW11 extensive algae outbreaks and very low flows have resulted in variability, particularly with respect to dissolved oxygen and electrical conductivity".*

Performance measure	Discussion
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.	**This performance measure has been met for all sites except Pipers Creek impact site and Cooperabung Creek impact site.** The number and location of Giant Barred Frogs recorded varied between season and year at all sites. Cooperabung Creek impact, Pipers Creek impact and Cooperabung Creek reference sites all show a decreasing trend in mean records and densities. However, as this decreasing trend is evident at both impact and reference sites, it is not possible to attribute these changes to the Project at this stage. Within-year movement patterns that would permit comparison between baseline and subsequent monitoring events is not possible due to lack of data (surveys and captures are too infrequent), however, assessment of movement patterns of recaptured individuals over all surveys show that 31% of recaptured frogs have been found to traverse from one side of the carriageway to the other.

5. Recommendations

5.1 Contingency Measures

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those that are considered relevant to the Giant Barred Frog monitoring program are listed and discussed in Table 7.

Table 7: Contingency measures

Potential problem	Contingency measure proposed in EMP	Discussion of proposed measure
Decline in presence of target species recorded at Impact sites after the upgrade has been completed, when compared to change in Control sites.	The cause of the decline in populations at impacts sites will be investigated in consultation with EPA and DoTE within two weeks of results reported by ecologist. If the cause of decline is considered most likely attributed to the upgrade of the highway (and not another event such as bushfire), mitigation measures, such as the location and types of fauna crossings and fauna fencing will be reviewed within two months of the above consultation being completed.	The mean number of Giant Barred Frogs recorded during the current monitoring period was lower compared to the previous monitoring event at all sites excluding Pipers Creek impact site. It should be noted that the greatest number of Giant Barred Frogs are generally recorded in summer each monitoring cycle. The absence of the summer survey period is likely to have resulted in lower mean records for the current monitoring period. It is not possible to attribute observed changes in Giant Barred Frog presence/abundance at the sites to the Project for the following reasons: • The variable nature of annual mean records among sites • The absence of summer survey records from the current monitoring period • The evidence of a decreasing trend at a reference site • The lack of a distinct difference between impact and reference sites. The apparent reduction in Giant Barred Frog numbers, however, is noted and will be considered in future monitoring events. **This contingency measure is not yet considered relevant**.

5.2 Recommendations

A summary of those performance indicators that were not met in the 2018/2019 monitoring period, recommended corrective actions and general recommendations are provided in Table 8.

Table 8: Recommendations

Performance measure	Action
Continued presence of Giant Barred Frogs during each survey event in Year 1 – 8 at sites where it was identified during baseline surveys, subject to access due to landowner agreement.	**This performance measure has been met for 5 of 6 sites in Year 4 (2018/2019).** Giant Barred Frogs were not recorded at Cooperabung Creek reference site during spring 2018 survey, where it was detected during baseline surveys. However it was recorded during the autumn 2019 surveys at this site. As this is a reference site it is recommended that monitoring continue as per the EMP.
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.	**This performance measure has been met for all sites except Pipers Creek impact site and Cooperabung Creek impact site.** As discussed in Table 6, Cooperabung Creek impact, Pipers Creek impact and Cooperabung Creek reference sites all show a decreasing trend in mean records and densities. However, as this decreasing trend is evident at both impact and reference sites, it is not possible to attribute these changes to the Project at this stage. It is recommended that monitoring continue as per the EMP.

References

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

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

Niche (2015a). Giant Barred Frog monitoring: 2015 Autumn survey – Oxley Highway to Kempsey, Pacific Highway Upgrade. Report prepared for Roads and Maritime Services by Niche Environment and Heritage Pty Ltd.

Niche (2015b). Giant Barred Frog monitoring: Baseline Surveys – Oxley Highway to Kempsey, Pacific Highway Upgrade. Report prepared for Roads and Maritime Services by Niche Environment and Heritage Pty Ltd.

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RMS (2019a). Oxley Highway to Kempsey Pacific Highway Upgrade Ecological Monitoring Program. Roads and Maritime Update to report prepared by SMEC Hyder Joint Venture, August 2019.

RMS (2019b). Oxley Highway to Kempsey Upgrade Project Operational water quality monitoring report - 30 March 2018 to 29 March 2019. Roads and Maritime Services NSW.

Sutherland, W. (2006). Ecological Census Techniques: a Handbook, Cambridge University Press, Cambridge.

Annex 1 – 2018/2019 data summary for each monitoring site

Cooperabung Creek impact site

Table 9: Summary of surveys and prevailing abiotic variables: Cooperabung Creek impact site

Date	Time		Air temp. °C	Water temp. °C	Humidity %	Stream depth (cm)	Wind (0-3, 0= no wind)	Cloud cover %	Rain (0-3, 0= no rain)
15/10/2018	Start	12:35am	17	17	80	40	0	100	0
	Finish	2:45am	19	17	95	20	0	100	2
12/03/2019	Start	1:15am	22.2	23	64	40	0	0	0
	Finish	3:20am	22.3	23	71	0	0	0	0

Table 10: Habitat details: Cooperabung Creek impact site

Zone	OS %	Sh %	G %	LL %	BE %	Cattle	Pools	Riffles	DoP (cm)	FB	EF	Frogs detected
5	60	10	40	15	40	N	1	0	35			0
4	70	10	40	25	30	Y	1	0	60			1
3	80	15	60	10	5	Y	1	1	20			1
2	30	20	45	5	40	Y	2	1	80			0
6	65	40	70	10	20	N	1	0	40			0
7	60	50	35	5	30	Y	1	0	50			0
8	80	30	50	10	10	Y	1	0	20			2
9	70	20	70	10	10	Y	1	0	40			0
1												
10												

OS = overstorey cover, Sh = Shrub cover, G = Ground cover, LL = leaf litter cover, BE = bare earth, DoP = depth of deepest pool, FB = fence breach, EF = exotic fish

Table 11: Summary of captures: Cooperabung Creek impact site

	Spring 2018	Autumn 2019
Number of frogs recorded	3	1
Number of adult males	2	0
Number of adult females	0	0
Number of sub-adults	0	0
Number of juveniles	1	1
Number of recaptures	2	0
Number of frogs with Chytrid/ swabbed	0/3	0/0

Habitat: Microhabitat within these zones included flood debris as overhang shelter, grass and leaf litter. Frogs were located on litter, in Lomandra and at the base of a tree.

Smiths Creek impact site

Table 12: Summary of surveys and prevailing abiotic variables: Smiths Creek impact site

Date	Time		Air temp. °C	Water temp. °C	Humidity %	Stream depth (cm)	Wind (0-3, 0= no wind)	Cloud cover %	Rain (0-3, 0= no rain)
17/10/2018	Start	9:30pm	20	19	99	50	1	100	1
	Finish	1:30am	20	19	99	50	1	100	3
11/03/2019	Start	10:20pm	23	23	68	20	0	10	0
	Finish	12:30am	22	23	75	10	0	0	0

Table 13: Habitat details: Smiths Creek impact site

Zone	OS %	Sh %	G %	LL %	BE %	Cattle	Pools	Riffles	DoP (cm)	FB	EF	Frogs detected
1	70	5	80	85	15	Y	2	2	50			3
2	90	60	85	85	15	Y	2	2	80			4
3	80	10	40	40	50	Y	1	0	100			3
4	45	50	80	85	10	Y	1	0	50			1
5	30	40	70	30	20	N	1	0	50			1
6	70	10	80	85	15	N	1	1	200			2
7	45	50	100	80	0	N	1	0	200			
8	40	10	90	95	0	N	1	0	200			2
9	90	15	80	80	0	N	1	1	200			
10	75	15	10	10	90	N	1	0	200			

OS = overstorey cover, Sh = Shrub cover, G = Ground cover, LL = leaf litter cover, BE = bare earth, DoP = depth of deepest pool, FB = fence breach, EF = exotic fish

Table 14: Summary of captures: Smiths Creek impact site

	Spring 2018	Autumn 2019
Number of frogs recorded	13	3
Number of adult males	3	0
Number of adult females	3	3
Number of sub-adults	1	0
Number of juveniles	2	0
Number of recaptures	5	1
Number of frogs with Chytrid/ swabbed	0/13	0/3

Habitat: Microhabitat within these zones included bare ground, shrubs, grass and leaf litter.

Pipers Creek impact site

Table 15: Summary of surveys and prevailing abiotic variables: Pipers Creek impact site

Date	Time		Air temp. °C	Water temp. °C	Humidity %	Stream depth (cm)	Wind (0-3, 0= no wind)	Cloud cover %	Rain (0-3, 0= no rain)
16/10/2018	Start	11:00pm	19	17	90	100	0	100	3
	Finish	1:48am	19	17	87	100	0	100	1
13/03/2019	Start	11:35pm	22.8	23	99	50	0	100	1
	Finish	2:21am	24.4	23	95	40	0	80	1

Table 16: Habitat details: Pipers Creek impact site

Zone	OS %	Sh %	G %	LL %	BE %	Cattle	Pools	Riffles	DoP (cm)	FB	EF	Frogs detected
1	35	55	70	40	20	N	1	0	100+			1
2	70	50	80	80	10	N	1	0	100+			
3	80	60	80	70	10	N	1	0	100+			1
4	85	20	70	60	10	N	1	0	100+			1
5	55	20	60	50	5	N	1	0	100+			
6	20	100	100	80	0	N	1	0	100+			
7	50	15	40	5	25	Y	2	2	100+			
8	50	20	30	15	55	Y	2	2	100+			1
9	85	10	25	10	60	Y	2	1	100+			
10	20	50	75	50	25	Y	1	0	100+			1

OS = overstorey cover, Sh = Shrub cover, G = Ground cover, LL = leaf litter cover, BE = bare earth, DoP = depth of deepest pool, FB = fence breach, EF = exotic fish

Table 17: Summary of captures: Pipers Creek impact site

	Spring 2018	Autumn 2019
Number of frogs recorded	2	3
Number of adult males	1	2
Number of adult females	1	1
Number of sub-adults	0	0
Number of juveniles	0	0
Number of recaptures	0	0
Number of frogs with Chytrid/ swabbed	0/2	0/3

Habitat: Microhabitat use included leaf litter, grass and on bare ground at tree base.

Maria River impact site

Table 18: Summary of surveys and prevailing abiotic variables: Maria River impact site

Date	Time		Air temp. °C	Water temp. °C	Humidity %	Stream depth (cm)	Wind (0-3, 0= no wind)	Cloud cover %	Rain (0-3, 0= no rain)
16/10/2018	Start	7:30pm	21	17	95	50	1	100	2
	Finish	10:30pm	19	17	95	50	0	100	3
13/03/2019	Start	7:30pm	24.9	23	72	40	0	100	1
	Finish	11:09pm	23.8	23	98	40	1	100	2

Table 19: Habitat details: Maria River impact site

Zone	OS %	Sh %	G %	LL %	BE %	Cattle	Pools	Riffles	DoP (cm)	FB	EF	Frogs detected
1	80	50	5	80	20	N	unk	unk	unk			
2	50	5	10	50	50	N	unk	unk	unk			
3	20	100	100	80	0	N	unk	unk	unk			
4	30	100	90	90	5	N	unk	unk	unk			
5	40	60	50	100	0	N	unk	unk	unk			1
6	90	80	15	100	5	N	unk	unk	unk			
7	70	75	80	40	15	N	unk	unk	unk			
8	80	65	90	60	5	N	unk	unk	unk			5
9	40	80	25	90	0	Y	unk	unk	unk			
10		100										

OS = overstorey cover, Sh = Shrub cover, G = Ground cover, LL = leaf litter cover, BE = bare earth, DoP = depth of deepest pool, FB = fence breach, EF = exotic fish

Table 20: Summary of captures: Maria River impact site

	Spring 2018	Autumn 2019
Number of frogs recorded	2	3
Number of adult males	1	2
Number of adult females	1	0
Number of sub-adults	0	0
Number of juveniles	0	1
Number of recaptures	0	0
Number of frogs with Chytrid/ swabbed	0/1	0/3

Habitat: Microhabitat within these zones included under logs and leaf litter. Lantana is very abundant along both side of the river banks and is the dominant vegetation from MIz1 to MIz5.

Cooperabung Creek reference site

Table 21: Summary of surveys and prevailing abiotic variables: Cooperabung Creek reference site

Date	Time		Air temp. °C	Water temp. °C	Humidity %	Stream depth (cm)	Wind (0-3, 0= no wind)	Cloud cover %	Rain (0-3, 0= no rain)
17/10/2018	Start	7:30pm	21	19	99	15	0	100	1
	Finish	9:00pm	20	19	99	30	0	100	2
11/03/2019	Start	7:45pm	26	24	63	0	0	5	0
	Finish	9:53pm	25	24	63	0	0	10	0

Table 22: Habitat details: Cooperabung Creek reference site

Zone	OS %	Sh %	G %	LL %	BE %	Cattle	Pools	Riffles	DoP (cm)	FB	EF	Frogs detected
1	1	70	20	40	60	10	Y	3	4			
2	2	50	15	20	30	20	Y	4	4			
3	3	80	30	30	60	5	Y	3	4			
4	4	15	20	10	40	5	Y	4	5			
5	5	95	50	20	80	15	Y	2	3			
6	6	95	10	50	90	10	Y	3	3			
7	7	50	15	10	5	80	Y	4	6			
8	8	20	5	70	20	5	Y	3	3			2
9	9	90	5	40	80	10	Y	3	4			1
10	10	85	15	20	50	40	Y	3	3			

OS = overstorey cover, Sh = Shrub cover, G = Ground cover, LL = leaf litter cover, BE = bare earth, DoP = depth of deepest pool, FB = fence breach, EF = exotic fish

Table 23: Summary of captures: Cooperabung Creek reference site

	Spring 2018	Autumn 2019
Number of frogs recorded	0	3
Number of adult males		0
Number of adult females		2
Number of sub-adults		0
Number of juveniles		1
Number of recaptures		2
Number of frogs with Chytrid/ swabbed	0/0	1/3

Habitat: Microhabitat found being used included grass and leaf litter.

Pipers Creek reference site

Table 24: Summary of surveys and prevailing abiotic variables: Pipers Creek reference site

Date	Time		Air temp. °C	Water temp. °C	Humidity %	Stream depth (cm)	Wind (0-3, 0= no wind)	Cloud cover %	Rain (0-3, 0= no rain)
15/10/2018	Start	7:31pm	18	17	99	10	1	100	2
	Finish	12:00pm	17	17	95	40	1	100	3
12/03/2019	Start	7:50pm	28	24	53	30	0	80	0
	Finish	12:30pm	22.8	24	67	10	0	75	0

Table 25: Habitat details: Pipers Creek reference site

Zone	OS %	Sh %	G %	LL %	BE %	Cattle	Pools	Riffles	DoP (cm)	FB	EF	Frogs detected
1	80	5	20	50	30	N	1	1	80			6
2	60	60	5	40	70	N	2	2	40			4
3	95	70	80	60	5	N	3	2	60			2
4	60	30	95	50	10	N	2	2	20			
5	40	20	60	40	20	N	2	2	40			6
6	95	30	75	30	15	N	1	1	40			8
7	90	65	80	25	25	N	2	1	25			3
8	80	10	90	50	10	N	2	1	50			
9	95	60	60	10	20	N	2	2	40			5
10	80	20	70	20	20	N	2	1	40			1

OS = overstorey cover, Sh = Shrub cover, G = Ground cover, LL = leaf litter cover, BE = bare earth, DoP = depth of deepest pool, FB = fence breach, EF = exotic fish

Table 26: Summary of captures: Pipers Creek reference site

	Spring 2018	Autumn 2019
Number of frogs recorded	9	30
Number of adult males	8	18
Number of adult females	1	6
Number of sub-adults	0	0
Number of juveniles	0	6
Number of recaptures	5	5
Number of frogs with Chytrid/ swabbed	0/8	0/14

Habitat: Microhabitat within these zones included within leaf litter, sheltering under Lomandra, and on the creek bed.

Annex 2 - Giant Barred Frog individual capture data

L = length (mm); W = weight (g); DW = distance to water (m); S = swabbed for Chytrid fungus; Z = Zone; U = unknown; M = male; F = female; J = juvenile

Site type	Location	Season	Sex	Age	Reproductive status	L	W	DW	Pit_Tag_Co	Capture status	S	Z	Activity	Microhabitat
impact	Cooperabung Ck	spring	Unk	Juv	juvenile	42	12	1	not tagged	first time	Y	3	sitting	base of tree
impact	Cooperabung Ck	spring	M	adult	light nuptials	73	70	1.5	00079205FF	recapture	Y	8	calling	leaf litter
impact	Cooperabung Ck	spring	M	adult	light nuptials	80	65	1	000791EBBD	recapture	Y	8	calling	Lomandra
impact	Cooperabung Ck	autumn1	Unk	Juv	unk	unk	20	10	not tagged	first time	N	4	sitting	on stick in veg
impact	Maria River	spring	F	adult	possibly gravid	139	163	2	0007A3DE53	first time	Y	5	sitting	leaf litter
impact	Maria River	spring	M	adult	calling			unk	not tagged	uncaptured	N	8	calling	unk
impact	Maria River	autumn1	M	adult	light nuptials	68	47	10	0007A38CA4	first time	Y	8	calling	leaf litter
impact	Maria River	autumn1	M	adult	light nuptials	67	44	5	0007A3AB40	first time	Y	8	calling	leaf litter
impact	Maria River	autumn1	Unk	Juv	unk	47	15	15	not tagged	first time	Y	8	sitting	under log
impact	Pipers Ck	spring	F	adult	gravid	94	135		0007A2E861	first time	Y	1	sitting	base of tree
impact	Pipers Ck	spring	M	adult	no nuptials	79	78		0007A0D205	first time	Y	4	sitting	base of tree
impact	Pipers Ck	autumn1	F	adult	lightly gravid	104	144	25	0007A2E987	first time	Y	3	sitting	grass
impact	Pipers Ck	autumn1	M	adult	no nuptials	80	62	2.5	0007A3ED0F	first time	Y	8	sitting	creek bed rock
impact	Pipers Ck	autumn1	M	adult	no nuptials	81	60	3	0007A3F2B3	first time	Y	10	sitting	leaf litter
impact	Smiths Ck	spring	Unk	Juv	juvenile	48	16	5.0	not tagged	first time	Y	1	sitting	leaf litter
impact	Smiths Ck	spring	Unk	Juv	juvenile	49.0	20.0	8.0	not tagged	first time	Y	1	sitting	leaf litter
impact	Smiths Ck	spring	Unk	Sub-adult	sub-adult	68.0	42	10.0	0007A0EFB8	first time	Y	1	sitting	bare ground
impact	Smiths Ck	spring	F	adult	gravid	101.0	174.0	12.0	00077E6A5F	recapture	Y	2	sitting	under shrubs
impact	Smiths Ck	spring	M	adult	light nuptials	85	80	15	00079FED7C	first time	Y	3	sitting	lantana and litter
impact	Smiths Ck	spring	M	adult	moderately dark nuptials	80	67	25	0007A0CE0B	recapture	Y	3	sitting	bare ground

Site type	Location	Season	Sex	Age	Reproductive status	L	W	DW	Pit_Tag_Co	Capture status	S	Z	Activity	Microhabitat
impact	Smiths Ck	spring	F	adult	possibly gravid	63	123.0	4.0	0007A3B459	first time	Y	3	sitting	leaf litter
impact	Smiths Ck	spring		adult		86.0	108		00079F8F77	first time	Y	4	sitting	
impact	Smiths Ck	spring	Unk	adult	unk	90	109	25	0007A0E973	first time	Y	5	sitting	raised tier of underpass in revegetation area
impact	Smiths Ck	spring	M	adult	no nuptials	69	63	3	0007A01C1A	recapture	Y	6	sitting	leaf litter near fallen timber
impact	Smiths Ck	spring	F	adult	unk	94	126	30	00079EA3F1	first time	Y	6	sitting	
impact	Smiths Ck	spring	Unk	adult	unk	150	96	2	0007D1E298	recapture	Y	8	sitting	
impact	Smiths Ck	spring	Unk	adult	unk	87	146	2	00079EA483	recapture	Y	8	sitting	grass
impact	Smiths Ck	autumn1	F	adult	lightly gravid	89	132	15	0007A39284	first time	Y	2	sitting	base of tree
impact	Smiths Ck	autumn1	F	adult	lightly gravid	91	143	20	0007A3BC0A	first time	Y	2	sitting	base of tree
impact	Smiths Ck	autumn1	F	adult	moderately gravid	94	125	5	0007A09A12	recapture	Y	2	buried	leaf litter
reference	Cooperabung Ck	autumn1	F	adult	lightly gravid	96	159	25	00076345D6	recapture	Y	8	sitting	grass
reference	Cooperabung Ck	autumn1	F	adult	non-gravid	89	127	15	00077E7E2D	recapture	Y	8	sitting	grass
reference	Cooperabung Ck	autumn1	Unk	Juv	sub-adult	45	16	2	not tagged	first time	Y	9	sitting	leaf litter
reference	Pipers Ck	spring	F	adult	non-gravid	90	135	15	000791EC0D	recapture	Y	5	sitting	leaf litter
reference	Pipers Ck	spring	M	adult	light nuptials	72	60	1.5	000791EA9A	recapture	Y	6	calling	leaf litter
reference	Pipers Ck	spring	M	adult	light nuptials	71	65	3	000791EC31	recapture	Y	6	calling	leaf litter
reference	Pipers Ck	spring	M	adult	dark nuptials	75	72	5	0007D261CD	first time	Y	9	calling	leaf litter
reference	Pipers Ck	spring	M	adult	light nuptials	70	50	2	0007A3DF2B	first time	Y	9	calling	leaf litter
reference	Pipers Ck	spring	M	adult	light nuptials	77	50	1	0007A3C6FA	first time	Y	9	calling	leaf litter
reference	Pipers Ck	spring	M	adult	light nuptials	75	75	4	0007920736	recapture	Y	9	sitting	leaf litter
reference	Pipers Ck	spring	M	adult	light nuptials	unk	unk	2	not tagged	uncaptured	N	9	sitting	leaf litter
reference	Pipers Ck	spring	M	adult	unk	77	61	12	900118001374700	recapture	Y	10	sitting	leaf litter

Site type	Location	Season	Sex	Age	Reproductive status	L	W	DW	Pit_Tag_Co	Capture status	S	Z	Activity	Microhabitat
reference	Pipers Ck	autumn1	M	adult	dark nuptials	72	53	2	0007A3DCBF	first time	Y	1	sitting	ck bed rocks
reference	Pipers Ck	autumn1	M	adult	light nuptials	68	50	5	0007A38B2A	first time	Y	1	sitting	Lomandra
reference	Pipers Ck	autumn1	M	adult	light nuptials	68	60	5	0007A3B0B2	first time	Y	1	calling	under log
reference	Pipers Ck	autumn1	M	adult	no nuptials	70	52	10	0007A3AB67	first time	Y	1	sitting	leaf litter
reference	Pipers Ck	autumn1	M	adult	no nuptials	79	70	10	0007A3F00E	first time	Y	1	sitting	leaf litter
reference	Pipers Ck	autumn1	F	adult	non-gravid	92	116	5	0007A3AB34	first time	Y	1	sitting	log
reference	Pipers Ck	autumn1	M	adult	dark nuptials	71	49	2	0007A3E1C0	first time	Y	2	sitting	Lomandra
reference	Pipers Ck	autumn1	F	adult	lightly gravid	90	130	10	0007A3D9D0	first time	Y	2	sitting	Lomandra
reference	Pipers Ck	autumn1	M	adult	no nuptials	80	59	5	00077E7D76	recapture	N	2	sitting	leaf litter
reference	Pipers Ck	autumn1	Unk	Juv		48	20	15	000791EB93	first time	N	2	sitting	leaf litter
reference	Pipers Ck	autumn1	M	adult	lightly gravid	74	60	5	0007A3DF2B	recapture	Y	3	sitting	Lomandra
reference	Pipers Ck	autumn1	F	adult	no nuptials	90	133	0.5	0007923BFA	recapture	Y	3	sitting	ck bed
reference	Pipers Ck	autumn1	M	adult	no nuptials	79	57	2	0007A394CB	first time	Y	5	sitting	ck bed
reference	Pipers Ck	autumn1	M	adult	no nuptials	72	52	1	0007A391A3	first time	Y	5	sitting	ck bed
reference	Pipers Ck	autumn1	F	adult	no nuptials	97	154	20	0007A005DF	first time	Y	5	sitting	base of tree
reference	Pipers Ck	autumn1	Unk	Juv	unk	36	8	1.5	not tagged	first time	N	5	sitting	ground
reference	Pipers Ck	autumn1	Unk	Juv	unk	46	16	1	not tagged	first time	N	5	sitting	ck bed
reference	Pipers Ck	autumn1	Unk	Juv	unk	40	10	1	not tagged	first time	Y	5	sitting	rocks
reference	Pipers Ck	autumn1	M	adult	dark nuptials	78	61	8	000791EBA3	recapture	N	6	sitting	ck bed
reference	Pipers Ck	autumn1	M	adult	light nuptials	71	46	1	0007A3D0EF	first time	N	6	sitting	Lomandra
reference	Pipers Ck	autumn1	M	adult	light nuptials	63	44	10	0007A2EC07	first time	N	6	calling	leaf litter
reference	Pipers Ck	autumn1	M	adult	light nuptials	69	42	5	0007A38893	first time	N	6	sitting	ck bed
reference	Pipers Ck	autumn1	M	adult	light nuptials	76	58	10	0007A3F17D	first time	N	6	calling	leaf litter
reference	Pipers Ck	autumn1	M	adult	no nuptials	62	34	10	0007A3E2CE	first time	N	6	sitting	Lomandra
reference	Pipers Ck	autumn1	M	adult	no nuptials	78	64	2	000791EC31	recapture	N	6	sitting	leaf litter

Site type	Location	Season	Sex	Age	Reproductive status	L	W	DW	Pit_Tag_Co	Capture status	S	Z	Activity	Microhabitat
reference	Pipers Ck	autumn1	F	adult	non-gravid	96	129	5	0007A3F040	first time	N	6	sitting	ck bed rocks
reference	Pipers Ck	autumn1	F	adult	non-gravid	95	146	12	0007A384E5	first time	N	6	sitting	bare ground
reference	Pipers Ck	autumn1	M	adult	no nuptials	75	60	4	0007A39819	first time	N	7	sitting	under leaf
reference	Pipers Ck	autumn1	Unk	Juv	sub-adult	50	12	6	not tagged	first time	N	7	sitting	tree base
reference	Pipers Ck	autumn1	Unk	Juv	sub-adult	40	8	5	not tagged	first time	N	7	sitting	leaf litter

Annex 3 - Water Quality data (extracted from RMS 2019b)

Table 27: Triggered water quality parameters: Cooperabung Creek

Parameter	ANZECC trigger value	Median downstream site value (Upstream 20th % - 80th % trigger range) Values in black = < 20th % Values in red = > 80th % Shaded cells = outside/above ANZECC trigger											
		April 2018	May 2018	June 2018	July 2018	August 2018	September 2018	October 2018	November 2018	December 2018	January 2019	February 2019	March 2019
Temperature ˚C	NA		18.4 (19.0-23.7)	13.6 (19.0-23.7)	12.4 (19.0-23.7)	12.0 (17.1-23.7)	16.0 (16.3-23.3)			24.3 (16.3-23.6)	25.6 (16.3-23.6)		
Electrical Conductivity uS/cm	125 – 2200		396.0 (216-348)	191.5 (216.6-348.0)		378.0 (223.8-348.0)	461.0 (223.8-348.0)			305.0 (206.6-301.4)	504.0 (206-6-309.8)		
Dissolved oxygen %	85 – 110	72.0 (36.4-82.4)	75.0 (36.4-82.4)	83.3 (36.4-82.0)	84.1 (36.4-83.5)	63.3 (36.4-80.0)	71.7 (36.4-83.5)	76.9 (36.4-85.3)	47.1 (35.1-85.3)	55.5 (35.0-83.5)	62.7 (35.0-83.5)		
pH	6.5 – 8		7.4 (6.7-7.3)		7.3 (6.7-7.2)		6.6 (6.7-7.2)		6.6 (6.7-7.2)				
Turbidity (NTU)	6 – 50		7.6 (9.2-21.7)			3.3 (8.0-28.8)	5.5 (8.0-28.8)	31.1 (8.0-28.8)					
Total suspended solids mg/L	-			8 (5-7)				10 (5-7)	9 (5-7)				
Aluminium mg/L	0.055		0.03 (0.02-0.10)	0.38 (0.02-0.12)			0.01			0.08 (0.01-0.10)			
Arsenic mg/L	0.024												
Cadmium mg/L	0.0002												
Chromium mg/L	0.001												
Copper mg/L	0.0014												
Iron mg/L	ID		0.33 (0.36-0.94)				0.20 (0.35-0.83)			1.13 (0.35-1.06)			
Lead mg/L	0.0034												
Manganese mg/L	1.9						0.488 (0.034-0.266)			0.601 (0.034-0.363)			
Mercury mg/L	0.0006												
Nickel mg/L	0.011												

Parameter	ANZECC trigger value	Median downstream site value (Upstream 20th % - 80th % trigger range) Values in black = < 20th % Values in red = > 80th % Shaded cells = outside/above ANZECC trigger											
Silver mg/L													
Zinc mg/L	0.008		0.039 (0.005-0.013)				0.052 (0.005-0.009)						
Total nitrogen mg/L	0.5					0.1 (0.2-0.4)	0.1 (0.2-0.4)			0.1 (0.2-0.5)	0.1 (0.2-0.5)		
Total phosphorus mg/L	0.05												

ID = insufficient representative data (ANZECC)

Table 28: Triggered water quality parameters: Smiths Creek

Parameter	ANZECC trigger value	Median downstream site value (Upstream 20th % - 80th % trigger range) Values in black = < 20th % Values in red = > 80th % Shaded cells = outside/above ANZECC trigger											
		April 2018	May 2018	June 2018	July 2018	August 2018	September 2018	October 2018	November 2018	December 2018	January 2019	February 2019	March 2019
Temperature ˚C	NA		16.5 (17.1-23.7)	13.3 (17.1-23.7)	10.5 (17.1-23.7)	11.5 (15.6-23.7)					24.0 (13.6-23.6)		24.6 (13.6-23.5)
Electrical Conductivity uS/cm	125 – 2200	179.0 (202.2-300.4)	202.0 (202.2-300.4)	174.5 (197.2-300.4)				188.0 (195.2-290.2)	174.0 (176.4-262.2)		306.0 (192.4-262.0)	573.0 (192.4-271.4)	2580.0 (192.4-323.6)
Dissolved oxygen %	85 – 110	68.7 (31.7-73.5)	59.3 (31.7-66.2)	86.1 (37.1-66.2)	86.0 (31.7-67.3)	86.1 (31.7-74.4)	61.2 (31.7-74.4)	67.8 (31.7-75.2)	36.8 (31.7-75.2)	30.4 (26.0-75.2)	6.1 (26.0-75.2)	36.1 (23.1-75.2)	63.0 (23.1-75.2)
pH	6.5 – 8					7.7 (6.9-7.4)				6.8 (7.0-7.4)		7.6 (7.0-7.4)	
Turbidity (NTU)	6 – 50		7.8 (11.0-20.2)	22.0 (11.3-20.8)	5.5 (10.2-20.8)	6.1 (11.0-20.8)	4.9 (10.6-20.8)	46.4 (10.6-20.8)		25.1 (10.9-20.8)		62.9 (10.9-20.5)	49.5 (10.9-22.8)
Total suspended solids mg/L	-									10 (5-9)	16 (5-7)	14 (5-7)	33 (5-6)
Aluminium mg/L	0.055		0.08 (0.02-0.12)	0.23 (0.02-0.12)						0.09 (0.02-0.08)			
Arsenic mg/L	0.024												
Cadmium mg/L	0.0002												
Chromium mg/L	0.001												
Copper mg/L	0.0014												
Iron mg/L	ID									1.41 (0.44-1.19)			
Lead mg/L	0.0034												
Manganese mg/L	1.9			0.007 (0.012-0.391)						0.984 (0.017-0.499)			1.569 (0.037-0.578)
Mercury mg/L	0.0006												
Nickel mg/L	0.011												
Silver mg/L													

Parameter	ANZECC trigger value	Median downstream site value (Upstream 20th % - 80th % trigger range) Values in black = < 20th % Values in red = > 80th % Shaded cells = outside/above ANZECC trigger											
Zinc mg/L	0.008						0.010 (0.005-0.011)			0.009 (0.005-0.011)			0.012 (0.005-0.012)
Total nitrogen mg/L	0.5		0.1 (0.2-0.6)		0.2 (0.3-0.6)	0.1 (0.2-0.6)						0.6 (0.2-0.5)	1.7 (0.2-0.5)
Total phosphorus mg/L	0.05				0.01 (0.02-0.05)					0.04 (0.01-0.03)	0.08 (0.01-0.04)	0.07 (0.01-0.03)	0.38 (0.01-0.03)

ID = insufficient representative data (ANZECC)

Table 29: Triggered water quality parameters: Pipers Creek

Parameter	ANZECC trigger value	Median downstream site value (Upstream 20th % - 80th % trigger range) Values in black = < 20th % Values in red = > 80th % Shaded cells = outside/above ANZECC trigger											
		April 2018	May 2018	June 2018	July 2018	August 2018	September 2018	October 2018	November 2018	December 2018	January 2019	February 2019	March 2019
Temperature ˚C	NA		16.7 (17.1-23.8)	12.9 (17.1-23.8)	10.6 (17.1-23.8)	10.4 (15.8-23.8)					24.6 (13.9-24.1)		24.0 (13.9-23.9)
Electrical Conductivity uS/cm	125 – 2200	216.0 (252.8-430.2)		197.0 (211.2-430.2)			405.5 (211.2-383.2)					500.0 (210.8-361.6)	519.5 (210.8-413.2)
Dissolved oxygen %	85 – 110	51.0 (37.9-71.5)	43.5 (37.5-68.0)	73.2 (37.5-64.5)	74.0 (37.5-65.5)	79.0 (37.5-68.0)	80.0 (37.5-75.7)	66.7 (37.9-75.7)	23.1 (37.9-73.0)	25.5 (36.1-73.0)	39.6 (34.4-73.0)	24.4 (33.1-73.0)	75.8 (34.4-76.7)
pH	6.5 – 8					7.7 (6.9-7.5)			6.9 (7.0-7.5)				7.6 (7.1-7.5)
Turbidity (NTU)	6 – 50					8.8 (11.8-57.5)	7.7 (12.3-57.5)						
Total suspended solids mg/L	-												
Aluminium mg/L	0.055			0.27 (0.03-0.24)						0.06 (0.03-0.19)			
Arsenic mg/L	0.024												
Cadmium mg/L	0.0002												
Chromium mg/L	0.001												
Copper mg/L	0.0014												
Iron mg/L	ID		0.95 (0.43-0.69)				0.19 (0.41-0.69)			1.94 (0.41-0.69)			0.31 (0.35-0.69)
Lead mg/L	0.0034												
Manganese mg/L	1.9			0.014 (0.036-0.188)						0.663 (0.037-0.263)			
Mercury mg/L	0.0006												
Nickel mg/L	0.011												
Silver mg/L													

Parameter	ANZECC trigger value	Median downstream site value (Upstream 20th % - 80th % trigger range) Values in black = < 20th % Values in red = > 80th % Shaded cells = outside/above ANZECC trigger											
Zinc mg/L	0.008						0.009 (0.005-0.008)						0.030 (0.005-0.009)
Total nitrogen mg/L	0.5			0.6 (0.2-0.5)		0.1 (0.3-0.5)		0.5 (0.2-0.4)			0.6 (0.2-0.4)		
Total phosphorus mg/L	0.05									0.03 (0.01-0.02)	0.04 (0.01-0.03)	0.03 (0.01-0.02)	

ID = insufficient representative data (ANZECC)

Table 30: Triggered water quality parameters: Maria River

Parameter	ANZECC trigger value	Median downstream site value (Upstream 20th % - 80th % trigger range) Values in black = < 20th % Values in red = > 80th % Shaded cells = outside/above ANZECC trigger											
		April 2018	May 2018	June 2018	July 2018	August 2018	September 2018	October 2018	November 2018	December 2018	January 2019	February 2019	March 2019
Temperature ˚C	NA			13.4 (17.4-23.6)	10.9 (17.4-23.6)	11.3 (16.3-23.6)				23.0 (13.0-22.8)	24.8 (13.0-22.5)		24.5 (13.0-22.5)
Electrical Conductivity uS/cm	125 – 2200	184.0 (204.8-470.0)	194.0 (202.6-470.0)					166.5 (184.4-342.2)		146.5 (184.4-298.4)	183.0 (184.4-322.2)		106.0 (179.8-322.2)
Dissolved oxygen %	85 – 110	19.2 (23.8-67.0)	8.1 (22.3-67.0)	41.8 (22.3-67.0)	43.2 (22.3-67.0)	58.4 (22.3-67.0)	43.2 (22.3-67.4)	46.2 (22.3-56.5)	13.2 (22.3-52.5)	12.5 (22.3-52.5)	3.4 (22.3-52.9)		45.1 (22.3-53.3)
pH	6.5 – 8	6.4 (6.7-7.3)			6.7 (6.8-7.3)	7.4 (6.8-7.3)	6.7 (6.8-7.3)	6.6 (6.8-7.3)	6.6 (6.8-7.2)				
Turbidity (NTU)	6 – 50					11.3 (16.1-51.2)	8.5 (14.6-51.2)	12.9 (13.3-47.4)			61.4 (13.2-38.8)		
Total suspended solids mg/L	-										32 (5-11)		
Aluminium mg/L	0.055		0.11 (0.05-0.32)	0.25 (0.05-0.26)			0.06 (0.05-0.21)			0.12 (0.05-0.20)			0.20 (0.05-0.15)
Arsenic mg/L	0.024												
Cadmium mg/L	0.0002												
Chromium mg/L	0.001												0.002 (0.001)
Copper mg/L	0.0014												
Iron mg/L	ID												
Lead mg/L	0.0034												
Manganese mg/L	1.9			0.070 (0.083-0.208)									
Mercury mg/L	0.0006												
Nickel mg/L	0.011												
Silver mg/L													

Parameter	ANZECC trigger value	Median downstream site value (Upstream 20th % - 80th % trigger range) Values in black = < 20th % Values in red = > 80th % Shaded cells = outside/above ANZECC trigger											
Zinc mg/L	0.008			0.010 (0.005-0.009)			0.013 (0.005-0.012)			0.011 (0.005-0.012)			0.020 (0.005-0.016)
Total nitrogen mg/L	0.5	0.6 (0.5-0.8)	0.4 (0.5-0.8)	0.6 (0.5-0.8)	0.4 (0.5-0.8)	0.3 (0.5-0.8)	0.4 (0.5-0.8)	0.6 (0.5-0.8)	0.7 (0.5-0.8)		2.2 (0.5-0.8)		
Total phosphorus mg/L	0.05					0.01 (0.02-0.04)			0.05 (0.02-0.04)	0.04 (0.02-0.03)	0.20 (0.02-0.03)		0.05 (0.02-0.03)

ID = insufficient representative data (ANZECC), DNS = Did not sample

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Fauna Fence and Road Kill Monitoring 2018/2019

Oxley Highway to Kempsey, Pacific Highway Upgrade

Prepared for Roads and Maritime Services

August 2019

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Brisbane
Cairns

Cover photograph: Standard fauna fence with Lace monitor (left), frog fence with Green Tree Snake (right).

Executive summary

Context

This report documents findings of the 2018/2019 monitoring period, which includes the first of three monitoring periods for the fauna fence and the first of four operational monitoring periods for road kill, as required by the Oxley Highway to Kempsey (OH2K) Ecological Monitoring Program (EMP, RMS 2016).

Aims

The aim of the fauna fence and road kill monitoring program is to determine if purpose built fauna fences are stopping fauna from crossing the road, thereby reducing road kill. The aims of this report are to summarise the methods and results of the 2018/2019 monitoring period and determine if performance measures are being met and provide corrective actions where required, as per the EMP.

Methods

Monitoring of the fauna fences involved surveying the fence lines on foot identifying breaches, damage and maintenance issues. The following sections of fencing were surveyed:

- 200 metres north and south of the underpass on both sides of the carriageway where it adjoins a fauna underpass monitored as part of the fauna underpass monitoring component of the Project
- The entire length of frog and phascogale fencing
- Searches for threatened frogs on both sides of the entire length of frog fencing.

Road kill monitoring was undertaken along the entire length of the Project. Surveys involved observations made from a vehicle travelling at approximately 80 km/h. Road kill fauna observed on the road and within three metres of the road verge were recorded using a GPS.

Key Results

The key results of the 2018/2019 fauna fence and road kill monitoring were:

- A number of maintenance issues were identified including vegetation encroachments, fallen trees, gaps underneath the fence caused by environmental factors i.e. water or erosion, platting or netting lifting and detached Phascogale panels.
- No fence breaches (evident passage by fauna) were recorded during the fauna fence monitoring, however a Koala was recorded as road kill in September 2018.
- No threatened frog species were identified during targeted surveys, fence monitoring or road kill surveys.
- There were a total of 45 road kill records in spring, 27 in summer and 20 in autumn. Birds, medium ground dwelling mammals and large ground dwelling mammals were the most commonly recorded fauna groups.
- Of the 59 road kill records (excluding birds) from the 2018/2019 monitoring period, 26 (44%) records were within and 33 (56%) records were outside fenced areas. The rate of road kill in unfenced areas (6.4 kilometres; 5.16 records/kilometre) was higher than the rate in fenced areas (30.6 kilometres; 0.85 records/kilometre).
- Of the 59 road kill records (excluding birds) there were four road kill records within 200 metres of any aerial crossing during the 2018/2019 road kill surveys. The rate of road kill within 200 metres of aerials crossings (5.2 kilometres; 0.77 records/kilometre) was substantially lower than outside this boundary (31.8 kilometres; 1.73 records/kilometre).

- Of the 59 road kill records (excluding birds) 24 occurred within 200 metres of underpasses. The rate of road kill within 200 metres of fauna underpasses/bridges (19.2 kilometres; 1.25 records/kilometre) was slightly lower than the rate outside this boundary (17.8 kilometres; 1.96 records/kilometre).
- The overall average weekly road kill rate has decreased from baseline (8.0) to 2018/2019 (7.7) for the same three seasons.

Conclusions

All performance measures for both the fauna fence and road kill monitoring were met for the 2018/2019 monitoring period:

- There were no records of Giant Barred Frog or Green-thighed Frog road kill
- Rates of road kill were lower within fenced areas compared to unfenced areas
- Incidence of road kill has reduced from baseline
- Roads and Maritime have advised that fauna fencing is complete
- Rates of road kill were lower in proximity to underpasses and aerial crossings.

Management Implications

Given that all performance measures were met and that contingency measures were addressed as required, there are no recommendations based on the outcomes of the 2018/2019 monitoring period.

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1. Introduction

1.1 Context

The Oxley Highway to Kempsey (OH2K) section of the Pacific Highway Upgrade Project (the Project) was approved in 2012 subject to various Ministers Conditions of Approval (MCoA) and a Statement of Commitments (SoC). A subsequent approval with additional conditions of consent (CoA) was granted in 2014 by the then Commonwealth Department of Environment (DoE) for Matters of National Environmental Significance (MNES) listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1995* (EPBC Act). The Ecological Monitoring Program (hereafter referred to as the EMP) (RMS 2016) combines these approval conditions and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project.

Fauna fences were installed to prevent fauna crossing the road surface, thereby reducing road kill and guiding animals towards safe wildlife crossing structures (underpasses and aerial crossing structures). The fauna fence and road kill are to be monitored to assess their effectiveness in reducing fauna road kill, as required by the EMP.

1.1.1 Monitoring framework

The design, methods and performance indicators that define the fauna fence and road kill monitoring program are specified in the EMP.

Fauna fence

The EMP requires fauna fence monitoring to occur in Years 4, 6 and 8 (operational phase). This report represents the first of three reports required for the fauna fence monitoring – Year 4 autumn 2018 and spring/summer 2018/2019.

Road kill

Road kill monitoring was required for baseline, during clearing, during construction and upon completion of the Project (operational) in Years 4, 5, 6 and 8. The road kill monitoring framework provided within the EMP and the reporting status to date is shown in Table 1. The 2018/2019 monitoring period represents the first operational monitoring period and includes spring (October 2018), summer (January 2019) and autumn (April 2019). This report represents the first of four reports required for the operational phase monitoring.

Table 1: Road kill monitoring

Project Phase	Monitoring event: report	Timing of survey	Location
Baseline	*spring 2013, summer 2014, autumn 2014:* Niche 2015	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	*November 2014- July 2015*: Niche 2015	Daily	Portion of existing highway adjacent to clearing operations
One month following clearing operations			
For the duration of construction	*8 August 2015 – 22 July 2016*: Niche 2016a *27 July 2016 – 28 July 2017*: Niche 2017a *4 August 2017 – March 29 2018*: Niche 2018	Weekly (Note: as the opening of the Project occurred in three stages, weekly monitoring of the Project continued in the unopened sections of the Project to satisfy construction monitoring requirements.)	Entire length of existing highway in Project area

Project Phase	Monitoring event: report	Timing of survey	Location
Within one month of opening of the Project	Twelve week post-opening periods were as follows: • Ku2K: from 3 November 2017 • OH2Ku Stage 1: from 17 November 2017 • OH2Ku Stage 2: from 30 March 2018 All in Niche 2018.	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)	Year 4: • Spring (October 2018) • Summer (January 2019) • Autumn (April 2019) Current report.	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

1.1.2 Background data

The fauna fence aims to prevent animals crossing the road surface and to guide animals towards safe fauna crossing structures. Three types of fauna fencing has been installed as per the EMP as follows:

- Standard floppy-top fencing: *Permanent floppy top fencing will comprise of a heavily galvanised, floppy-top mesh fauna fence. Mesh one metre wide will be attached to the base of the fauna fencing and laid over the ground away from the carriageway to provide an effective barrier to burrowing animals. The mesh must be pinned to the ground with metal pins every metre without any gaps between the mesh and the ground. Fauna exclusion fencing at underpass entrances will have wide angled openings to encourage usage by fauna and must have a minimum length of 200 metres of fauna fencing on each side of the underpass and on each side of the carriageway or road*.
- Frog fencing:
  - *Giant Barred Frog fencing is to be at least 900 millimetres in height and will comprise of gauze size 30-40 millimetres to prevent frogs from moving through the fence, yet allow for the flow of overland water. The gauze will include a small return of not less than 150 millimetres on the ground.*
  - *Green-thighed Frog fencing is to comprise of 500 millimetres high neoprene rubber sheeting (>4 millimetre thickness) including a small rubber return of not less than 100 millimetres on the ground. The fence must consist of a hot dip galvanized pressed sheet metal or powder coated aluminium pressed sheet mounted on a galvanized star picket*. This fencing was unsuccessful and has since been replaced. Roads and Maritime removed the neoprene sheeting and replaced it with vermin-proof mesh, as approved on the Pacific Highway Upgrade between Woolgoolga and Ballina. These frog fencing replacement works were completed in November 2018.
  - Where both frog species occur in association the frog fencing must account for both morphologies.
- Phascogale fencing: *Phascogale fencing is attached to floppy top fauna fencing. At the base of floppy top fauna fences, a second layer of mesh is installed to 200 millimetres above ground level height, offset from the first layer of mesh to create maximum opening size of 25 millimetres. Above 200 millimetres, 600 millimetre hot dip galvanised pressed steel sheet or powder coated aluminium pressed sheet are affixed to the floppy top fauna fencing.*

Standard fauna fencing was installed within State Forests, where the Project traverses regional corridors, between dual carriageway bridges and culverts and on the outside of all spill containment / water quality treatment basins. Targeted threatened species fauna fencing was installed in areas of known or high potential habitat with high risk of fauna accessing the carriageway.

1.1.3 Purpose of this report

This report documents findings of the 2018/2019 monitoring period, which includes the first of three monitoring periods for the fauna fence and the first of four operational monitoring periods for road kill. The aims of this report are to summarise the methods and results of the 2018/2019 monitoring and determine if performance measures are being met, as per the EMP.

1.2 Performance Measures

The EMP specifies the following performance measures for fauna fence monitoring:

- *No records of Giant Barred Frog or Green-thighed Frog road kill on the main carriageways directly adjacent to installed frog fencing in any monitoring event during Years 4, 6 & 8*
- *Lower rates of road kill in proximity to fauna fencing than in sections of the upgrade not near fauna fencing during all monitoring events (Year 4, 6 & 8)*
- *Reduced incidence of road kill from baseline conditions*
- *Fauna exclusion fencing is installed at a minimum in the locations identified in Schedule 3 of the EPBC approval at Year 4.*

The EMP specifies the following performance measures for road kill monitoring:

- *Lower rates of road kill in proximity (i.e. areas of the main carriageways within areas adjacent to installed fauna fencing, and within 100 metres 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.*

1.3 Monitoring Timing

Fauna Fence monitoring is to be undertaken in Years 4, 6 and 8 of the Project's operational phase. Fauna fence monitoring is to occur in late autumn and late spring/early summer and searches for threatened frogs is to be undertaken in spring and summer.

Operational road kill monitoring is required weekly for four weeks during October (spring), January (summer) and April (autumn) in Years 4, 5, 6 and 8.

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 Secretary of the Department of Planning and Environment and the Environment Protection Authority.

1.5 Limitations

- As rainfall determines the movement of threatened frogs, searches for threatened frogs were undertaken following rainfall in spring. However, the lack of rainfall during summer 2018/2019 resulted in searches being undertaken during a dry period, when it is considered unlikely that frogs would have been mobile and hence exposed to road crossing risks, which may have impacted results.
- Identification and detection of road kill was limited to what can be observed whilst travelling at 80km/hr as it was not considered safe to stop on the operational highway. As such:
    - Some road kill fauna were identified to the vertebrate group level only.
    - Some records were classified as 'unknown' as road kill fauna could not be identified as a result of extensive collision damage.
    - It is possible that small fauna such as frogs, snakes, small mammals and birds have been under-counted as small-sized road kill fauna have the potential to be partially or wholly removed by scavenger animals, resulting in impossible identification from the vehicle.
- Due to their small size and cryptic nature, frogs and smaller reptiles are difficult to detect within the underpasses using the current survey methods and thus if present, may have gone undetected.
- Safety issues prevent the removal of road kill following each survey and therefore, despite efforts, road kill may have been recorded multiple times over the four weekly surveys resulting in double-counting and 'unknown' records as the condition of the animal deteriorated.

2. Methodology

2.1 Monitoring Sites

Monitoring of the fauna fence involved surveys of the following sections of fencing:

- 200 metres north and south of the underpass and on both sides of the carriageway where it adjoins one of the 14 fauna underpasses monitored as part of the fauna underpass monitoring component of the Project
- The entire length of frog and phascogale fencing
- Searches for threatened frogs on both sides of the entire length of frog fencing.

Road kill monitoring was undertaken along the entire length of the Project.

2.2 Survey Methods

Surveys were undertaken in accordance with the EMP and are outlined below.

2.2.1 Fauna fence inspections

The first monitoring of the fauna fence was undertaken in autumn 2018 in its entirety and the second monitoring event was undertaken in late spring 2018 in conjunction with fauna underpass monitoring and in summer 2019 for the remainder of the fencing. Surveys involved inspection of the fauna fence on foot for 200 metres north and south of the monitored underpasses and on both sides of the carriageway. The entire length of phascogale and frog fence was surveyed as well as the edge of the highway in proximity to fencing where possible and safe to do so. Possible breaches, damage and maintenance issues, such as impinging vegetation growth, were noted and their location recorded.

2.2.2 Frog searches

Searches for threatened frogs were undertaken on both sides of the frog fence in spring 2018 and summer 2018/2019 to identify the presence of any frogs that may have breached the frog fence. Surveys were timed to follow rainfall in order to coincide with frog movement where possible. Table 2 shows the rainfall recorded by Bureau of Meteorology (BOM) weather stations prior to surveys. It should be noted that summer surveys for threatened frogs were undertaken during a particularly dry period.

Table 2: Threatened frog survey dates and 24 hour rainfall

Date	Season	Previous 24hr rainfall Kempsey Airport (mm)	Previous 24hr rainfall Port Macquarie Airport (mm)	Previous 24hr rainfall Telegraph Point (mm)
08/11/2018	spring	25	28	7.2
26/02/2018	summer	1.4	4	4.6

2.2.3 Road kill surveys

Road kill surveys of the entire Project were undertaken once a week for four weeks during October 2018 (spring), January 2019 (summer) and April 2019 (autumn). These surveys involved observations made from a vehicle travelling at approximately 80 km/hr. Road kill fauna observed on the road and within three metres of the road verge were recorded by the passenger. Due to the safety issues associated with the operational highway, it was not possible to stop the vehicle to closer inspect or remove road kill. Road kill records were grouped into general fauna groups for analysis.

2.3 Analysis

Weekly road kill rates were calculated to compare changes in rates of road kill between years. An analysis of the number of road kill events (excluding bird records) that occurred within or outside of fenced sections of the Project was undertaken by calculating a *road kill per kilometre* rate. A similar analysis was undertaken to compare road kill rates within 200 metres of fauna crossings. Fauna crossing zones were created by grouping fauna crossings that occurred within 400 metres of each other (i.e. their 200 metre boundary overlapped) and included 200 metres north and south of the crossing/s. The road kill records that occurred within the zones were compared to road kill records outside of the zones. Aerial crossings and underpasses (including bridges and culverts) were analysed separately.

3. Results

Detailed survey results for the 2018/2019 monitoring are presented in Annex 1 and Annex 2.

3.1 Fence Inspections

Fauna fence inspection results are provided in Annex 1.

3.1.1 Maintenance

A number of maintenance issues were identified during the 2018/2019 monitoring. Maintenance is required in relation to vegetation encroachments, fallen trees, gaps underneath the fence caused by environmental factors i.e. water or erosion, platting or netting lifting and detached phascogale panels.

Of particular note, problems with the neoprene frog fence were identified in autumn 2018 and reported to Roads and Maritime. These issues have since been rectified by Roads and Maritime. Roads and Maritime removed the neoprene sheeting and replaced it with vermin-proof mesh, as approved on the Pacific Highway Upgrade between Woolgoolga and Ballina. These frog fencing replacement works were completed in November 2018.

3.1.2 Possible breaches

No signs of possible fence breaches by fauna were recorded during the 2018/2019 fence monitoring, however a Koala (*Phascolarctos cinereus*) was recorded as road kill in September 2018. This record is discussed further in Section 3.3.4. While no fauna was recorded on the highway-side of the fauna fence during fence inspections, undertaking maintenance to address identified gaps and ensure secure fastening of the base netting should prevent breaches from occurring.

3.2 Threatened Frog Searches

Diurnal searches for threatened frogs were undertaken on the 8 November 2018 (spring) and 26 February 2019 (summer). No threatened frog species were identified during targeted surveys, fence monitoring or road kill surveys. A single dead frog was found during the spring surveys which could not be identified due to its deteriorated condition, however it was determined from colouration and size as unlikely to be either the threatened Giant Barred Frog (*Mixophyes iteratus*) or Green-thighed Frog (*Litoria brevipalmata*).

It should be noted that summer surveys for threatened frogs were undertaken during a particularly dry period. It was intended that surveys would be done following periods of substantial rainfall, where frogs were likely to have been more mobile. However the EMP specifies surveys be undertaken in summer. As such, surveys were undertaken as late as possible in summer (while waiting for optimal conditions), however substantial rain had not fallen by this time. It is therefore considered that conditions were not optimal to determine the effectiveness of the frog fence by searching for road kill at this time as the frogs were unlikely to have been very active.

3.3 Road Kill Surveys

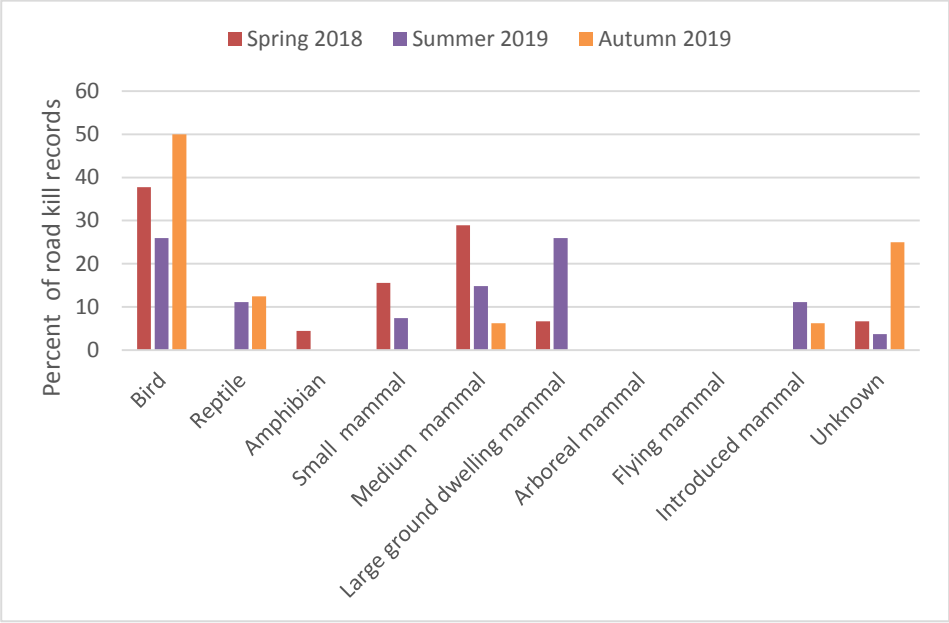
Road kill results are provided in Annex 2. The distribution of road kill records is in shown in Figure 1 and Figure 2.

3.3.3 Total alignment

Fauna categories for analysis were defined as follows:

- Arboreal mammals
- Flying mammals (i.e. bats)
- Introduced mammals
- Small mammals
- Medium mammals
- Large ground dwelling mammals
- Amphibians
- Reptiles
- Birds
- Unknown

There were a total of 45 road kill records in spring, 27 in summer and 20 in autumn. The percentage of road kill records for each category for the current monitoring period is presented in Graph 1. Combining spring, summer and autumn results, birds (35.9% of road kill, n =33), medium ground dwelling mammals (20.7% of road kill, n = 19), and large ground dwelling mammals (12.0%, n = 11), were the most commonly recorded fauna groups.



Graph 1: 2018/2019 road kill records

3.3.4 Threatened fauna

There was one record of threatened fauna identified as road kill that occurred outside of the 2018/2019 road kill and fauna fence surveys. A road kill Koala was observed on the 16 September 2018 by Roads and Maritime within a fenced area of the highway on the northbound left lane near Barry's Creek (Figure 2, map section 3). The individual likely entered the carriageway through a flood damaged section of the fauna fence which was immediately addressed with temporary repairs by Roads and Maritime and permanent works completed on the 19 -21 September 2018. Table 3 lists the threatened species identified as road kill throughout the Project to date. The baseline monitoring report (Lewis 2014) states that, based on baseline Koala road kill records, "*the baseline count for road kill should be set at 1 individual per 8 weeks*". Koala road kill has therefore not increased from the baseline count.

Table 3: Threatened species road kill

Monitoring type (report)	Monitoring period	Threatened species identified as road kill (number recorded)
Baseline (Lewis 2014)	2013-2014	Koala (1*) Grey-headed Flying Fox (2)
Clearing (Niche 2015)	2014-2015	Koala (4) Grey-headed Flying Fox (1) Masked Owl (2) Spotted-tail Quoll (1)
Construction (Niche 2016b)	2015-2016	Koala (3)
Construction (Niche 2017b)	2016-2017	Koala (2)
Construction (Niche 2018)	2017-2018	Nil
Operational (current)	2018-2019	Koala (1)

* = An additional three Koala road kill were recorded between August 2013 and February 2014, outside of the monitoring period.

3.3.5 Fauna fence

A total of approximately 30,600 metres (82.7%) of the 37,000 metres of the Project is fenced with a minimum of standard fauna fence (data provided by Roads and Maritime).

An analysis of the number of road kill events (excluding the bird records) that occurred either within or outside of fenced sections of the Project (considering those road kill observations made at the edge of a fenced area, or in an area where fencing was present on one side of the carriageway only, to be outside) was undertaken. Of the 59 road kill records (excluding birds) from the 2018/2019 monitoring period, 26 (44%) records were within and 33 (56%) records were outside fenced areas. Considering the data with regard to fencing along the highway, calculation of a *road kill per kilometre* rate (excluding birds) showed the rate of road kill in unfenced areas (6.4 kilometres; 5.16 records/kilometre) to be substantially higher than the rate in fenced areas (30.6 kilometres; 0.85 records/kilometre).

3.3.6 Fauna crossings

The performance indicator for road kill refers to lower rates of road kill "*within 100 metres of rope bridges and fauna underpasses"*. However the EMP identifies "*high rates of fauna road strike mortality within 200 metres of fauna underpasses*" as a potential problem for fauna fences for which contingency measures have been provided. An analysis of road kill within 200 metres of fauna crossings has therefore been undertaken in order to address the trigger for contingency measures. It is considered that this analysis is sufficient to address the performance indicator, as it extends the range within which road kill rates should be lower. As discussed in Section 2.3 fauna crossing zones were created by grouping fauna crossings that occurred within 400 metres of each other (i.e. their 200 metre boundary overlapped). The road kill records that occurred within these zones were compared to road kill records outside of the zones. Aerial crossings and underpasses (including bridges and culverts) were analysed separately.

Aerial crossings

There are 18 aerial crossings along the entire length of the Project that fall into nine separate zones. Both rope bridges and glider pole crossings were considered in this analysis. The Project consists of 5,176 metres that fall within 200 metres of an aerial crossing, and therefore 31,824 metres outside of these zones. Of the 59 road kill records (excluding birds) from the 2018/2019 monitoring period there were four road kill records within 200 metres of any aerial crossing during the 2018/2019 road kill surveys. Calculation of a *road kill per kilometre* rate (excluding birds) showed the rate of road kill within 200 metres of aerials crossings (5.2 kilometres; 0.77 records/kilometre) to be substantially lower than outside this boundary (31.8 kilometres; 1.73 records/kilometre).

Underpasses

There are 42 culverts and 12 bridge areas throughout the Project that are considered to provide fauna passage under the carriageway, which fall into 39 separate zones. The Project consists of 19,175 metres that fall within 200 metres of an underpass/bridge, and therefore 17,825 metres outside of these zones. Of the 59 road kill records (excluding birds) from the 2018/2019 monitoring period 24 occurred within 200 metres of underpasses, while the remaining 35 occurred outside this boundary. Calculation of a *road kill per kilometre* rate (excluding birds) found the rate of road kill within 200 metres of fauna underpasses/bridges (19.2 kilometres; 1.25 records/kilometre) to be slightly lower than the rate outside this boundary (17.8 kilometres; 1.96 records/kilometre).

3.3.7 Comparison with baseline and previous monitoring

Baseline surveys were undertaken prior to the commencement of construction for 12 weeks in spring 2013, summer 2014 and autumn 2014. Monitoring took place weekly for four weeks in each of the seasons as required by the EMP. Baseline surveys recorded 96 animals as road kill during the three monitoring events, representing 33 species and an average weekly road kill for spring, summer and autumn of 9.5, 11.8 and 3.3 respectively.

The average weekly road kill for all monitoring periods is presented in Table 4.

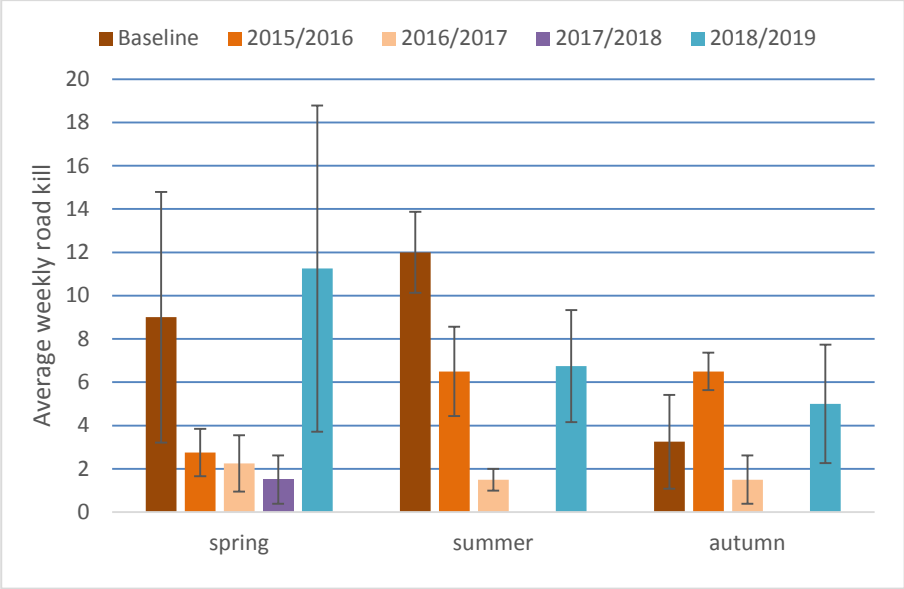
In order to compare the results of the baseline surveys with that of subsequent monitoring periods, the average weekly road kill for the four survey weeks undertaken in each season of the baseline surveys (spring (October), summer (January), autumn (May)), was compared to the same four weeks of each subsequent monitoring event. While spring and autumn weekly road kill rates were higher in the 2018/2019 monitoring period (11.3 in spring, 5.0 in autumn) than during baseline (9.5 in spring, 3.3 in autumn), summer weekly road kill rates were lower in the 2018/2019 monitoring period (6.8) compared to baseline (11.8). The overall average weekly road kill rate decreased from baseline of 8.0 to 7.7 for the same three seasons.

Graph 2 shows the seasonal average weekly road kill for each of the same four week periods for all monitoring events. Winter has been excluded from the graph as winter surveys were not undertaken during baseline surveys and do not form part of the operational road kill monitoring.

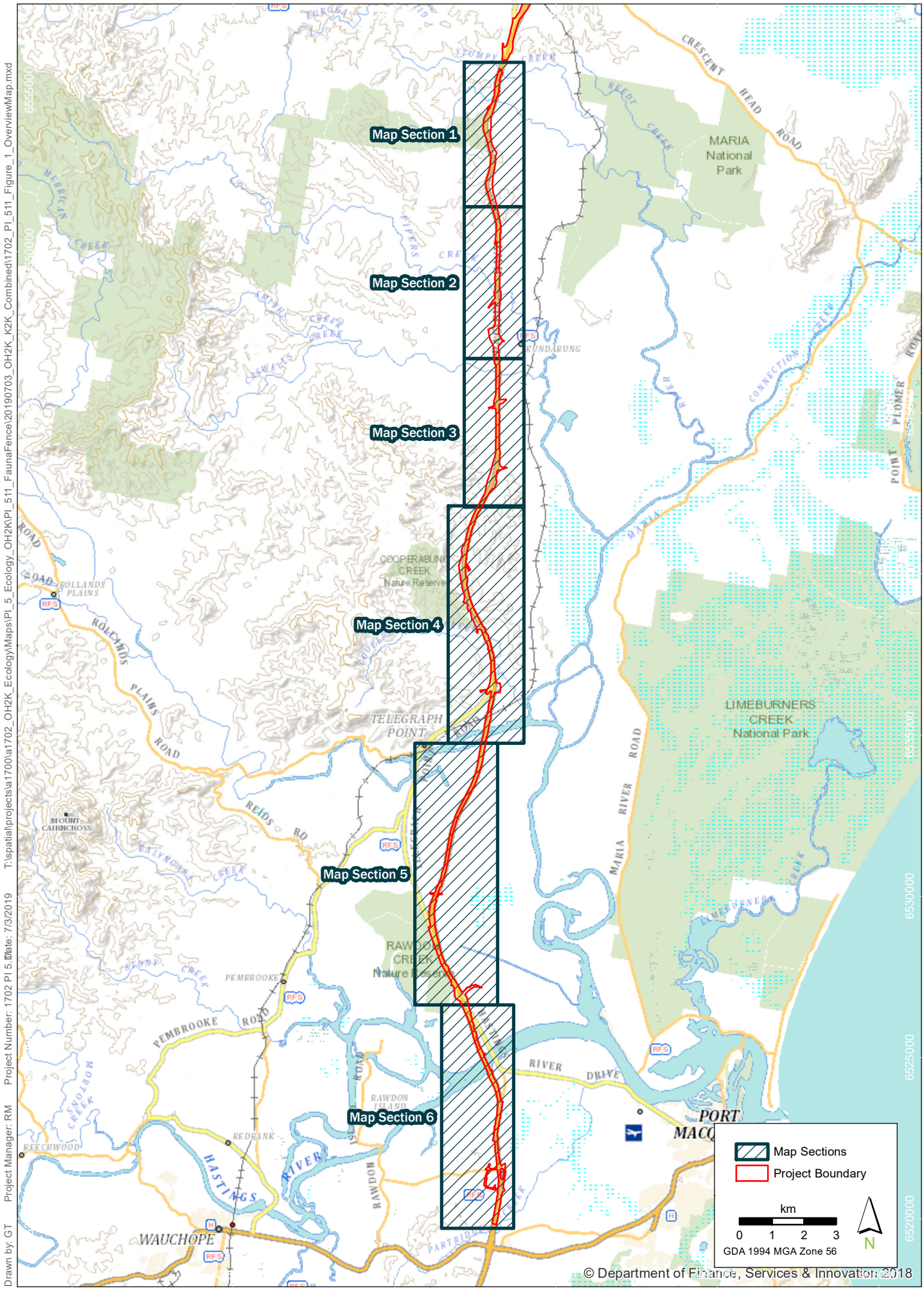
Table 4: Weekly road kill rates for monitoring undertaken along the entire Project alignment

Monitoring period		Spring (n)	Summer (n)	Autumn (n)	Winter (n)	Annual (n)
Baseline	**2013/2014**	9.5 (4)	11.8 (4)	3.3 (4)	No surveys	8.0 (12)
Construction phase	**2015/2016 (all surveys)**	4.2 (13)	5.8 (14)	6.7 (13)	4.1 (12)	5.0 (52)
	2015/2016 (4 weeks)	2.75 (4)	6.5 (4)	6.5 (4)	3.0 (4)	
	2016/2017 (all surveys)	3.3 (13)	2.6 (13)	2.0 (12)	2.2 (14)	2.3 (52)
	2016/2017 (4 weeks)	4.0 (4)	1.5 (4)	1.5 (4)	2.5 (4)	
	2017/2018 (all surveys)	2.9 (9)	No surveys*	No surveys*	3.3 (4)	3.0 (13)
	2017/2018 (4 weeks)	1.5 (4)	No surveys*	No surveys*	3.3 (4)	
12-week post-opening	**2017/2018 (all sections combined)**					4.5 (12)
Operational	**2018/2019**	11.3 (4)	6.8 (4)	5.0 (4)	No surveys	7.7 (12)

n = number of survey weeks; * = construction partially complete



Graph 2: Average (±SD, n = 4) weekly road kill in spring, summer and autumn



Fauna Fence and Road Kill Monitoring – Overview

Oxley Highway to Kempsey Pacific Highway Upgrade - PI 5.11 Fauna Fencing

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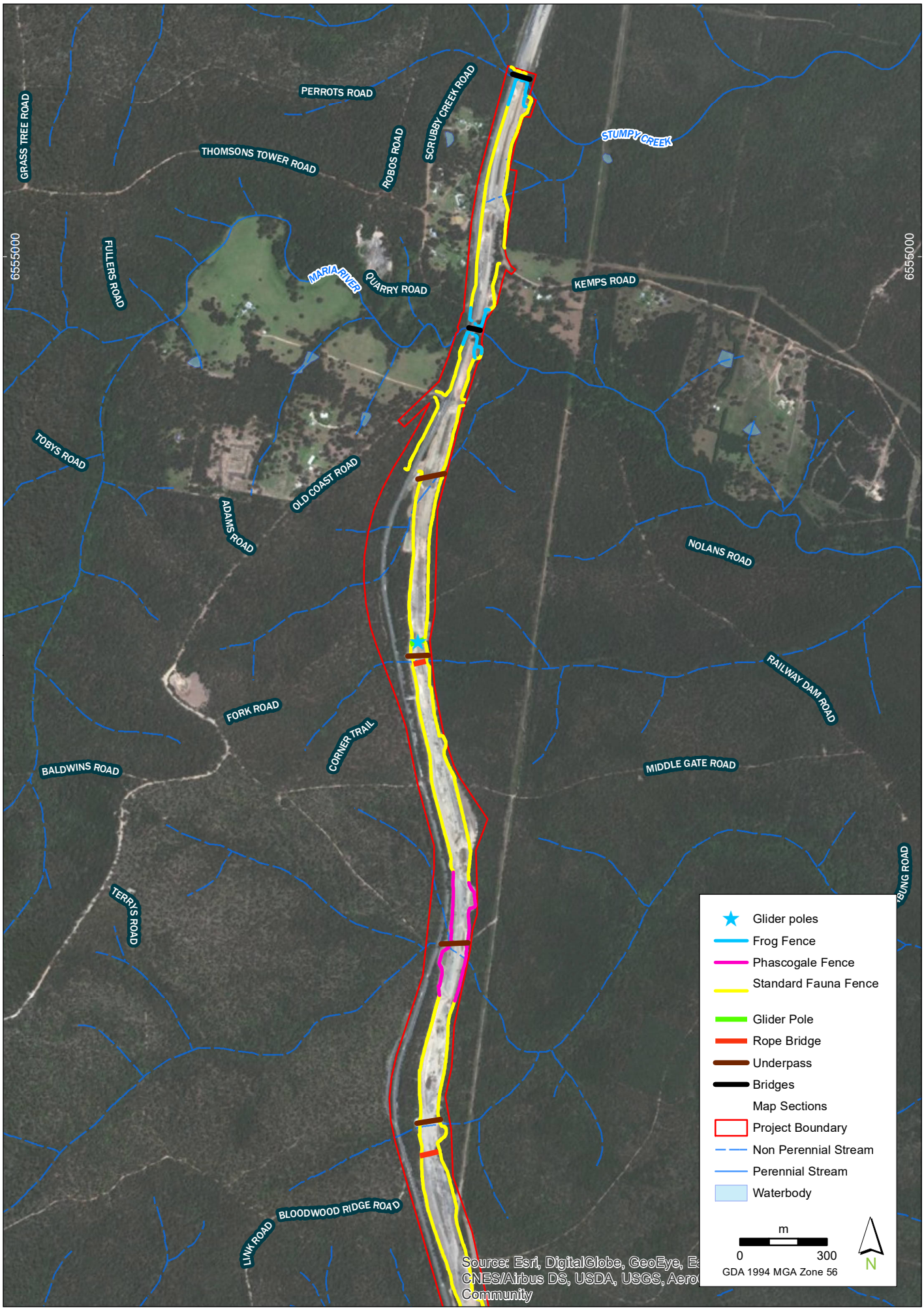
FIGURE 1

Imagery: (c) DigitalGlobe 25/11/2015



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Fauna Fence and Road Kill Monitoring - Map Section 1

Oxley Highway to Kempsey Pacific Highway Upgrade - PI 5.11 Fauna Fencing

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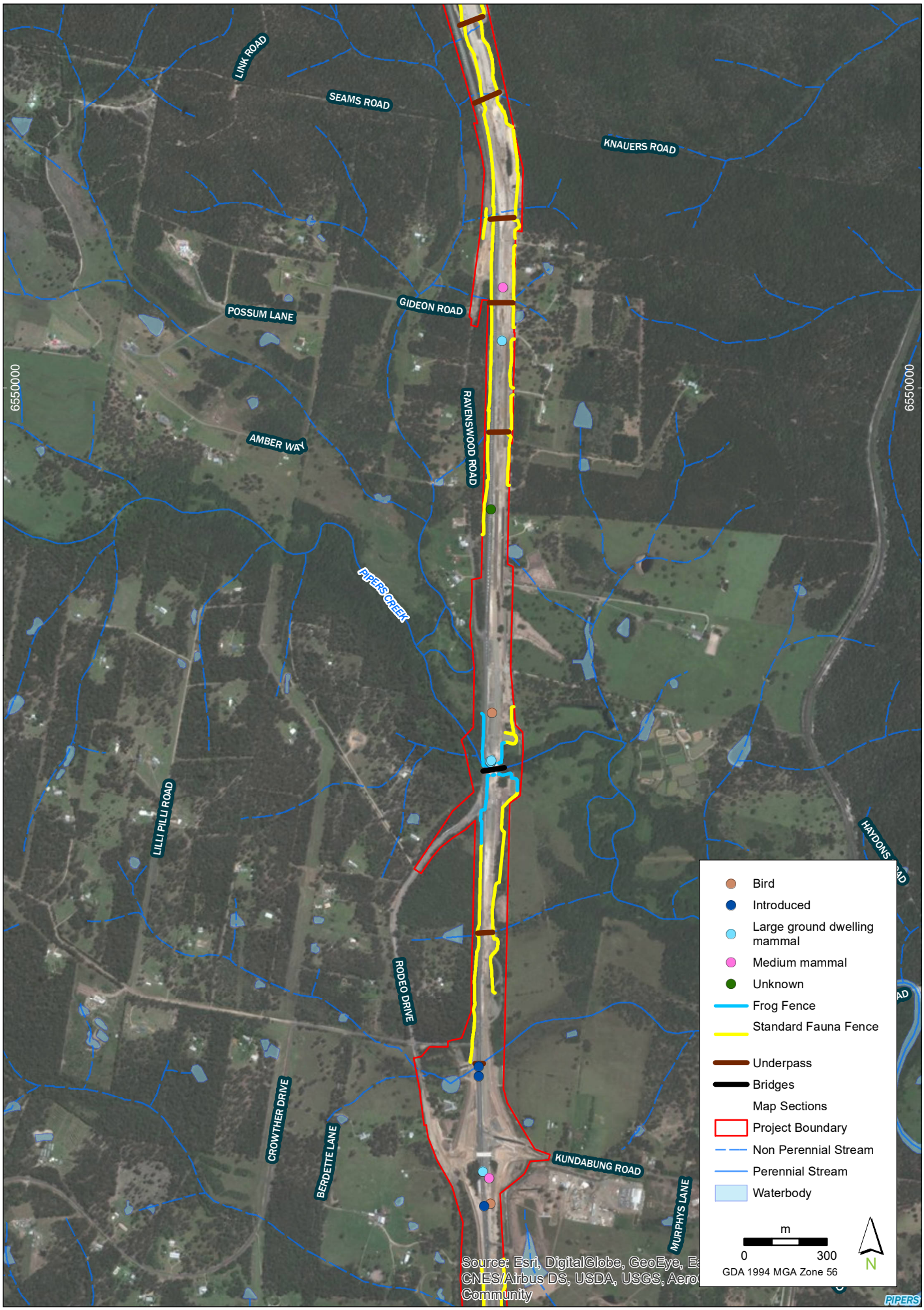
FIGURE 2.1

Imagery: (c) DigitalGlobe 25/11/2015



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Fauna Fence and Road Kill Monitoring - Map Section 2

Oxley Highway to Kempsey Pacific Highway Upgrade - PI 5.11 Fauna Fencing

FIGURE 2.2

Imagery: (c) DigitalGlobe 25/11/2015

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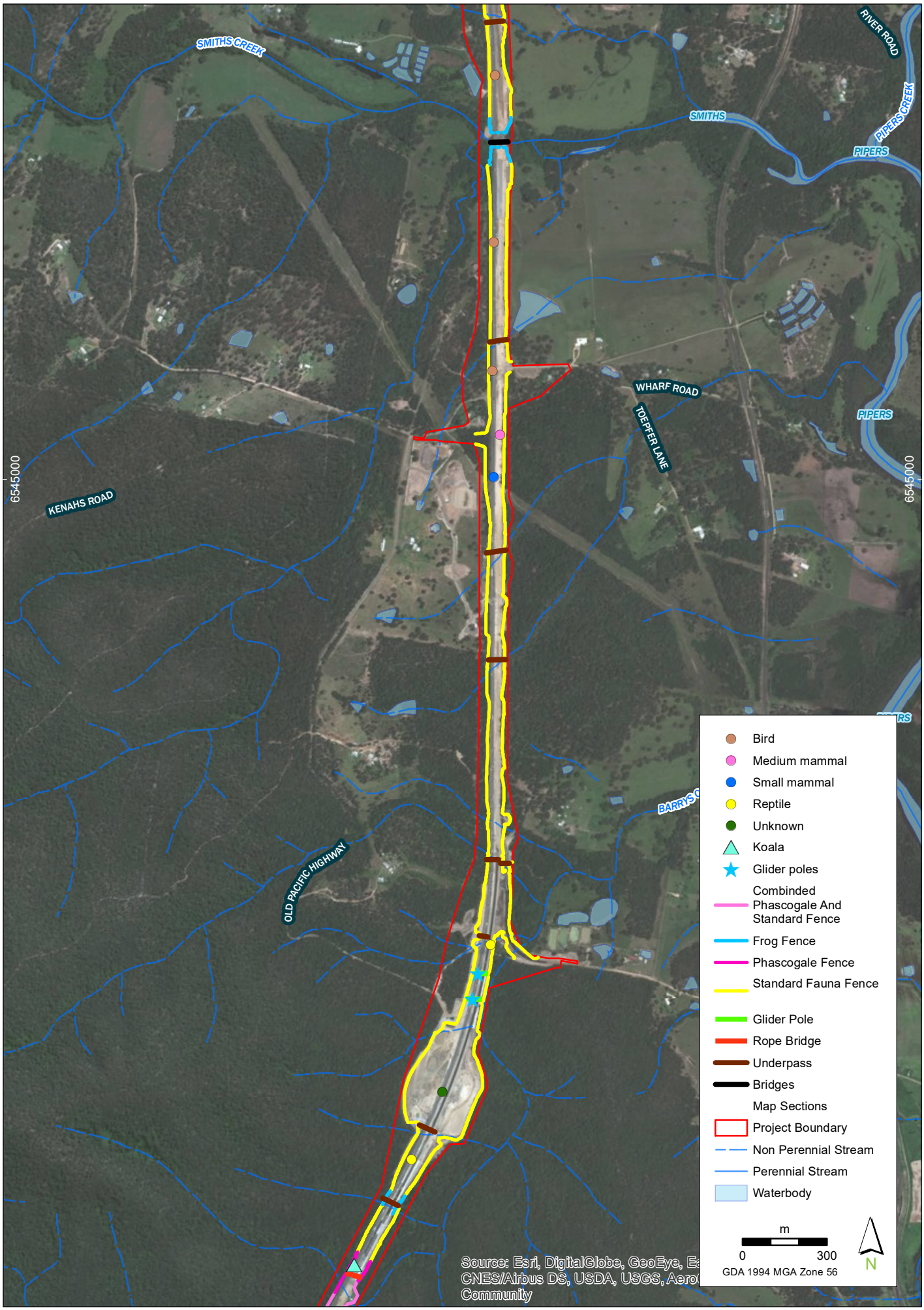

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Fauna Fence and Road Kill Monitoring - Map Section 3

Oxley Highway to Kempsey Pacific Highway Upgrade - PI 5.11 Fauna Fencing

FIGURE 2.3

Imagery: (c) DigitalGlobe 25/11/2015

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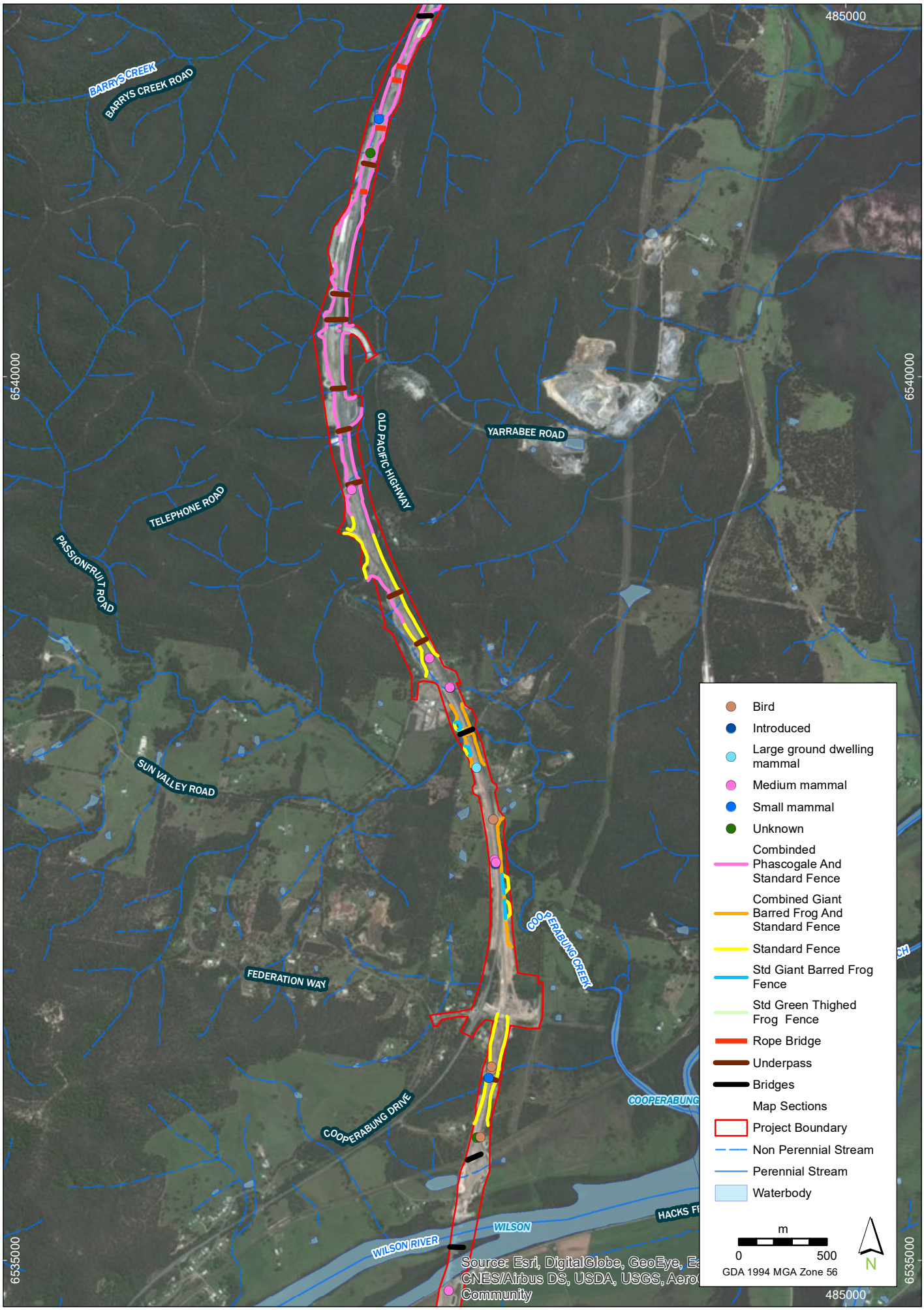

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Fauna Fence and Road Kill Monitoring - Map Section 4

Oxley Highway to Kempsey Pacific Highway Upgrade - PI 5.11 Fauna Fencing

FIGURE 2.4

Imagery: (c) DigitalGlobe 25/11/2015

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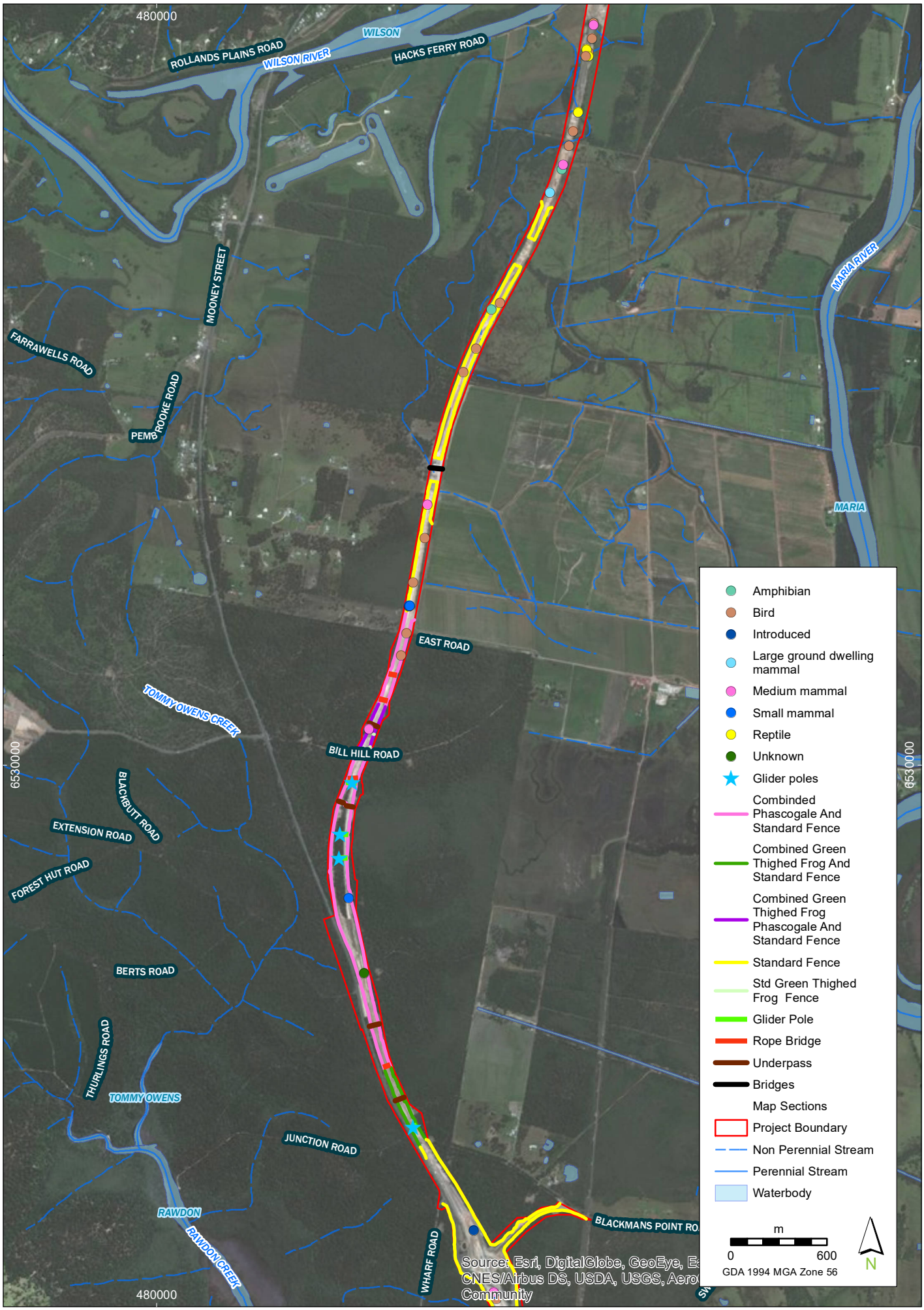

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Fauna Fence and Road Kill Monitoring - Map Section 5

Oxley Highway to Kempsey Pacific Highway Upgrade - PI 5.11 Fauna Fencing

FIGURE 2.5

Imagery: (c) DigitalGlobe 25/11/2015

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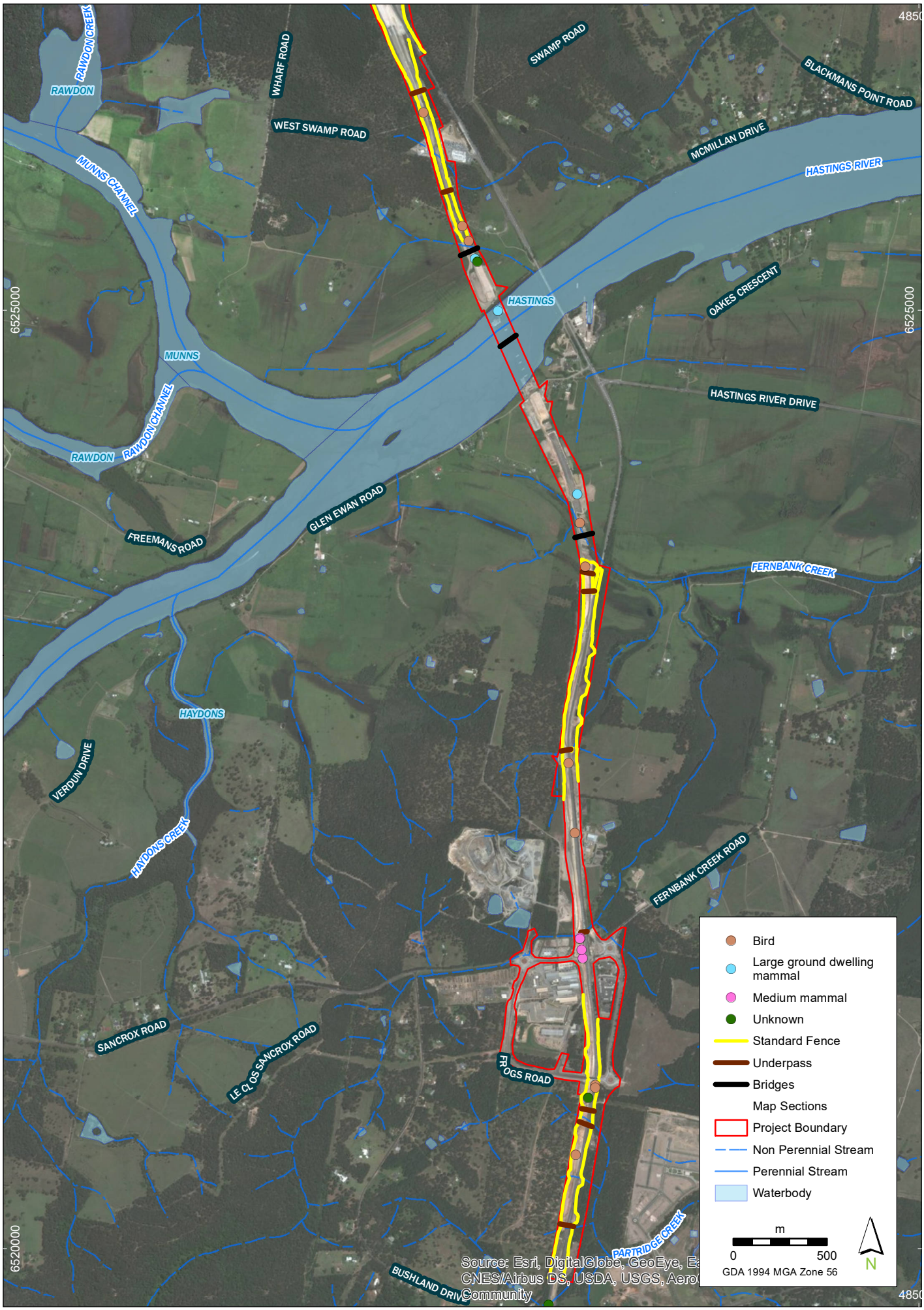

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Fauna Fence and Road Kill Monitoring - Map Section 6

Oxley Highway to Kempsey Pacific Highway Upgrade - PI 5.11 Fauna Fencing

FIGURE 2.6

Imagery: (c) DigitalGlobe 25/11/2015

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4. Discussion

4.1 Performance Measures

4.1.1 Fauna fence

A summary of 2018/2019 survey results in relation to the fauna fence performance measures are provided in Table 5.

Table 5: Indicators of success for fauna fencing

Performance measure	Discussion
No records of Giant Barred Frog or Green-thighed Frog road kill on the main carriageways directly adjacent to installed frog fencing in any monitoring event during Years 4, 6 & 8.	**This performance measure has been met.** No Giant Barred Frog or Green-thighed Frog road kill were recorded.
Lower rates of road kill in proximity to fauna fencing than in sections of the upgrade not near fauna fencing during all monitoring events (Year 4, 6 & 8).	**This performance measure has been met.** Of the 59 road kill records (excluding birds) from the 2018/2019 monitoring period, 26 (44%) records were within and 33 (56%) records were outside fenced areas. The rate of road kill in unfenced areas (5.16 records/kilometre) was higher than the rate in fenced areas (0.85 records/kilometre).
Reduced incidence of road kill from baseline conditions.	**This performance measure has been met.** The overall average weekly road kill rate has decreased slightly from baseline (8.0) to 2018/2019 (7.7) for the same three seasons.
Fauna fence is installed at a minimum in areas identified in Schedule 3 of the EPBC approval at Year 4.	**This performance measure has been met.** Roads and Maritime have advised that all fauna fencing as identified in Schedule 3 of the EPBC approval has been installed.

4.1.2 Road kill

A summary of 2018/2019 survey results in relation to the road kill performance measures are provided in Table 6.

Table 6: Performance measures for road kill monitoring

Performance measure	Discussion
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.	**This performance measure has been met.** As discussed in 3.3.6, road kill within 200 metres of fauna crossings was analysed. *Fauna fence*: Of the 59 road kill records (excluding birds) 26 (44%) records were within and 33 (56%) records were outside fenced areas. The rate of road kill in unfenced areas (5.16 records/kilometre) was higher than the rate in fenced areas (0.85 records/kilometre). *Aerial crossing 200 metre boundary*: Of the 59 road kill records (excluding birds) there were four road kill records within 200 metres of any aerial crossing during the 2018/2019 road kill surveys. The rate of road kill within 200 metres of aerials crossings (0.77 records/kilometre) was substantially lower than outside this boundary (1.73 records/kilometre). *Underpass 200 metre boundary*: Of the 59 road kill records (excluding birds) 24 occurred within 200 metres of underpasses, while the remaining 35 occurred outside. The rate of road kill within 200 metres of fauna underpasses/bridges (1.25 records/kilometre) was lower than the rate outside this boundary (1.96 records/kilometre).

Performance measure	Discussion
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.	**This performance measure has been met.** The overall average weekly road kill rate has decreased slightly from baseline (8.0) to 2018/2019 (7.7) for the same three seasons.
Fauna exclusion fencing is installed at a minimum in the locations identified in Schedule 3 of the EPBC approval at Year 4.	**This performance measure has been met.** Roads and Maritime have advised that all fauna fencing as identified in Schedule 3 of the EPBC approval has been installed.

5. Recommendations

5.1 Contingency Measures and Recommendations

The EMP lists potential problems and contingency measures for the Project's mitigation measures. Those that are related to the fauna fence monitoring program are listed and discussed in Table 7.

Given that all performance measures were met and that contingency measures were addressed as required, there are no recommendations based on the outcomes of the 2018/2019 monitoring period.

Table 7: Contingency measures for fauna fencing

Potential problems	Contingency measure	Discussion of proposed measure
Breach in fauna fencing. High rates of fauna road strike mortality within 200 metres 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.	Road kill rates were lower in proximity to underpasses. There were no recorded possible breaches during 2018/2019 fauna fence surveys. One Koala road kill was recorded within a fenced area by Roads and Maritime in September 2018. The breached fauna fence was identified and temporary repairs were immediately undertaken within two days of the road kill being found and permanent works completed on the 19 -21 September 2018. **This contingency measure is not considered relevant.**
	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.	**These contingency measures were relevant during the 2018/2109 monitoring period and implemented as required.**
	Permanent repair to occur as soon as possible and within two months of the breach being identified.	**This contingency measure was relevant during the 2018/2109 monitoring period and implemented as required.** Permanent repairs to the fauna fence were completed within five days of the identified breach.

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Niche (2016b). OH2K Pacific Highway Upgrade. Annual Ecological Monitoring Report 2016. Prepared by Niche Environment and Heritage Pty Ltd for Roads and Maritime Services, Port Macquarie, NSW.

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Annex 1 – Fauna fence survey data

Table 8: 2018/2019 fauna fence inspection results

SOC = side of carriageway, E = East, W = West, STD FF = Standard Fauna Fence, m = metres

Season	Date	Section	SOC	Fence type	Easting	Northing	Observation / maintenance required
Autumn	12/04/2018	OH2Ku	E	STD FF	483236	6520739	South East of underpass 1.62. Vegetation clearing required at 200 m.
Autumn	07/05/2018	OH2Ku	E	STD FF	483241	6523502	South East of underpass 4.46. Requires vegetation clearing - inaccessible and pressing on fence in locations.
Autumn	07/05/2018	OH2Ku	E	STD FF	483241	6523502	North East of underpass 4.46. Inner fauna fence - requires vegetation removal from 100 m as inaccessible.
Autumn	12/04/2018	OH2Ku	E	STD FF	482336	6526166	South East of underpass 7.26. Some vegetation removal at 200 m.
Autumn	16/05/2018	OH2Ku	E	Frog	481609	6527827	Grass encroaching on frog fence.
Autumn	16/05/2018	OH2Ku	E	Phascogale	481431	6528298	Missing Phascogale mesh/wire and also section where mesh doesn't meet ground at rocky drainage line.
Autumn	16/05/2018	OH2Ku	E	Phascogale	481345	6528539	Large gap created due to opening angle of gate.
Autumn	16/05/2018	OH2Ku	E	Phascogale	481301	6528734	Gap at back of Phascogale panel due to undulations.
Autumn	16/05/2018	OH2Ku	E	Phascogale	481301	6528863	Top edge of Phascogale panel not attached.
Autumn	16/05/2018	OH2Ku	E	Phascogale	481207	6529190	Phascogale panel lifted and bent at corner of gate and overhang of gate opening not secured.
Autumn	16/05/2018	OH2Ku	E	STD FF (Phascogale)	481185	6529270	Vine growing over fence -clearing required.
Autumn	16/05/2018	OH2Ku	E	STD FF (Phascogale)	481298	6530041	Mesh lifting creating potential digging channel/gap.
Autumn	16/05/2018	OH2Ku	E	Frog + Phascogale	481298	6530070	Attachment issues and gaps created.
Autumn	16/05/2018	OH2Ku	E	Phascogale	481374	6530204	Height of Phascogale panel insufficient in places between underpass and Bill Hill Rd.
Autumn	16/05/2018	OH2Ku	E	Phascogale	481565	6530822	Gap under Phascogale wire.
Autumn	18/05/2018	OH2Ku	E	Frog+STD FF	483077	6537054	Fencing for Frog incomplete.
Autumn	16/05/2018	OH2Ku	E	Frog+STD FF	482887	6537988	Fence not completely finished at Cooperabung bridge.
Autumn	12/04/2018	OH2Ku	E	STD FF	482442	6538846	60 m of fence lying flat - ground securing has failed and fencing incomplete - base mesh missing.
Autumn	16/05/2018	OH2Ku	E	Phascogale	482199	6539727	Gap underneath Phascogale wire in rocky area near underpass.
Autumn	16/05/2018	OH2Ku	E	Phascogale	482170	6539800	Fauna escape under construction near Yarrabee Rd.
Autumn	16/05/2018	OH2Ku	E	Phascogale	482152	6540030	Gap under Phascogale wire.
Autumn	16/05/2018	OH2Ku	E	Phascogale	482150	6540231	Rocky drainage has created gap under Phascogale wire.
Autumn	16/05/2018	OH2Ku	E	Phascogale	482499	6541737	No Phascogale fence on gate.
Autumn	16/05/2018	OH2Ku	E	Phascogale	482648	6541995	No fine Phascogale mesh at sediment basin drain.
Autumn	16/05/2018	OH2Ku	E	Phascogale	482621	6542015	No Phascogale fence on gate and panel detached on adjacent fence.
Autumn	16/05/2018	OH2Ku	E	Frog	482621	6542015	Neoprene frog fence fallen down at end.
Autumn	16/05/2018	OH2Ku	E	Phascogale	482682	6542085	No Phascogale fence at sediment basin drain. Vegetation removal required locally.
Autumn	16/05/2018	Ku2K	E	Phascogale	482705	6542132	No Phascogale fence on gate.
Autumn	31/05/2018	Ku2K	E	Frog	482867	6542413	Gap at corner- mesh not joined. Mesh raised above ground over sealed drain pipe immediately to the north.

Season	Date	Section	SOC	Fence type	Easting	Northing	Observation / maintenance required
Autumn	31/05/2018	Ku2K	E	Frog	482867	6542425	Fine frog mesh does not continue to end of metal return – frog fencing incomplete?
Autumn	12/04/2018	Ku2K	E	STD FF	483144	6544340	Gap under the fence.
Autumn	31/05/2018	Ku2K	E	Frog	483249	6546156	Neoprene join detached.
Autumn	31/05/2018	Ku2K	E	Frog	483243	6546162	Neoprene join detached.
Autumn	31/05/2018	Ku2K	E	Frog	483243	6546162	Neoprene fencing fallen down at corner.
Autumn	31/05/2018	Ku2K	E	Frog + STD FF	483243	6546162	Vegetation clearing required south from this point.
Autumn	31/05/2018	Ku2K	E	Frog	483232	6546172	Neoprene fencing down.
Autumn	31/05/2018	Ku2K	E	Frog	483221	6546234	Gaps, tears and frog fence down north from Smiths Creek bridge.
Autumn	31/05/2018	Ku2K	E	STD FF	483246	6546262	Fauna fence falling over near gate.
Autumn	31/05/2018	Ku2K	E	Frog	483252	6546275	Tear at top of neoprene and gap underneath.
Autumn	31/05/2018	Ku2K	E	Frog	483251	6546276	Grass control required.
Autumn	31/05/2018	Ku2K	E	Frog	483213	6548651	Gap at corner - mesh needs screws and securing over rocks.
Autumn	12/04/2018	Ku2K	E	STD FF	483279	6550235	Gaps under fence at drainage line.
Autumn	12/04/2018	Ku2K	E	STD FF	483193	6551276	Gap under gate (no bottom mesh).
Autumn	12/04/2018	Ku2K	E	STD FF	483167	6551493	Vegetation encroaching on fence.
Autumn	31/05/2018	Ku2K	E	Phascogale	483105	6552634	Phascogale panels need to be attached to fauna fence at top and bottom to minimise gaps between the fauna fence and the panels. This applies to entire length of Phascogale fencing to the northern point and to the southern point on both sides of the highway.
Autumn	12/04/2018	Ku2K	E	STD FF	482971	6554238	South East of underpass 36.4. Vegetation removal from 100 metres onwards.
Autumn	12/04/2018	Ku2K	E	STD FF	482971	6554238	North East of underpass 36.4. Substantial vegetation removal required.
Autumn	31/05/2018	Ku2K	E	Frog	483137	6554744	Gap under neoprene.
Autumn	31/05/2018	Ku2K	E	Frog	483127	6554768	Neoprene coming away from screws.
Autumn	31/05/2018	Ku2K	E	Frog	483146	6554773	Tear in neoprene.
Autumn	31/05/2018	Ku2K	E	Frog	483302	6555584	Vegetation control required. Gap at fence between mesh and neoprene.
Autumn	31/05/2018	Ku2K	E	Frog	483300	6555605	Gap at corner.
Autumn	31/05/2018	Ku2K	MID (bridge)	Frog	483190	6546183	Mesh not attached to return.
Autumn	12/04/2018	OH2Ku	W	STD FF	483125	6520124	South West of underpass 1.04. Substantial vegetation removal required from 50 m onwards - fence not accessible.
Autumn	12/04/2018	OH2Ku	W	STD FF	483169	6520608	Gap under fence.
Autumn	12/04/2018	OH2Ku	W	STD FF	483181	6520666	Gap under fence.
Autumn	12/04/2018	OH2Ku	W	STD FF	483202	6520765	Gap under fence in drainage line.
Autumn	16/05/2018	OH2Ku	W	Frog	481506	6527889	Fence lifting creating gap underneath, pegs lifted.
Autumn	16/05/2018	OH2Ku	W	Frog	482831	6528112	Vegetation removal required along entire section, fence inaccessible.
Autumn	16/05/2018	OH2Ku	W	Phascogale	481374	6528259	Gaps under Phascogale mesh/wire. Numerous gaps to underpass due to ground being uneven.
Autumn	16/05/2018	OH2Ku	W	Phascogale	481088	6529550	A number of Phascogale panels not properly secured creating gaps for approximately 50 m.
Autumn	16/05/2018	OH2Ku	W	Phascogale	481191	6529886	Phascogale panels detached heading north to Bill Hill Rd.
Autumn	16/05/2018	OH2Ku	W	Phascogale	481248	6530093	No Phascogale panel on gate on northern side Bill Hill Rd.
Autumn	16/05/2018	OH2Ku	W	Frog	481262	6530125	Gap in the return fold.

Season	Date	Section	SOC	Fence type	Easting	Northing	Observation / maintenance required
Autumn	16/05/2018	OH2Ku	W	Phascogale	481299	6530178	Phascogale panel detached.
Autumn	16/05/2018	OH2Ku	W	Phascogale	481305	6530195	Height of Phascogale panel above frog return insufficient from this point to the underpass in places.
Autumn	16/05/2018	OH2Ku	W	Phascogale	481324	6530261	Phascogale fencing does not continue to underpass.
Autumn	16/05/2018	OH2Ku	W	Frog	481356	6530319	Gap under frog mesh.
Autumn	16/05/2018	OH2Ku	W	Phascogale	481445	6530596	Gap under Phascogale wire due to rocky drainage.
Autumn	16/05/2018	OH2Ku	W	Phascogale	481509	6530822	Gap under Phascogale wire.
Autumn	16/05/2018	OH2Ku	W	Phascogale	481510	6530844	Gap under Phascogale wire.
Autumn	17/05/2018	OH2Ku	W	Frog+STD FF	482866	6537849	Vegetation removal required north and south, fence inaccessible.
Autumn	16/05/2018	OH2Ku	W	Frog+STD FF	482849	6537912	Fence down, flood damage.
Autumn	17/05/2018	OH2Ku	W	Phascogale	482455	6538673	Grassy drainage channel creating gap under Phascogale wire.
Autumn	17/05/2018	OH2Ku	W	Phascogale	482422	6538722	Vegetation control required.
Autumn	17/05/2018	OH2Ku	W	Phascogale	482418	6538753	Gap under Phascogale wire.
Autumn	17/05/2018	OH2Ku	W	Phascogale	482418	6538762	Concrete drainage channel - no Phascogale mesh at bottom.
Autumn	17/05/2018	OH2Ku	W	Phascogale	482370	6538867	Gap under Phascogale and fauna fence at gate.
Autumn	16/05/2018	OH2Ku	W	Phascogale	482187	6539334	Vegetation removal required. Phascogale wire doesn't meet ground in adjacent concrete drainage channels.
Autumn	16/05/2018	OH2Ku	W	Phascogale	482092	6539925	Gap under Phascogale wire.
Autumn	16/05/2018	OH2Ku	W	Phascogale	482085	6539973	No Phascogale wire on gate.
Autumn	16/05/2018	OH2Ku	W	Phascogale	482047	6540286	Gap under Phascogale wire in drainage channel.
Autumn	16/05/2018	OH2Ku	W	Phascogale	482092	6540567	Fine mesh at base of panel missing.
Autumn	16/05/2018	OH2Ku	W	STD FF (Phascogale)	482101	6540580	Mesh overhang of gate opening insufficient resulting in a gap.
Autumn	16/05/2018	OH2Ku	W	Phascogale	482209	6540680	Gaps behind panels due to undulations. Two sections within 10 m.
Autumn	16/05/2018	OH2Ku	W	Phascogale	482136	6540860	Vegetation removal required within 100 m north.
Autumn	16/05/2018	OH2Ku	W	Phascogale	482266	6541222	Fencing incomplete.
Autumn	16/05/2018	OH2Ku	W	Phascogale	482319	6541414	Gap in Phascogale fence, incomplete?
Autumn	16/05/2018	OH2Ku	W	STD FF (Phascogale)	482383	6541578	Bottom mesh appears torn away. Possibly due to tractor movement.
Autumn	16/05/2018	OH2Ku	W	STD FF (Phascogale)	482394	6541613	Missing bottom mesh leaving gap. Approximately 20 m north.
Autumn	16/05/2018	OH2Ku	W	STD FF + Phascogale	482437	6541749	Fencing incomplete or damaged.
Autumn	16/05/2018	Ku2K	W	STD FF	482639	6542130	Damage to base mesh to 50 m north. Possible flooding debris.
Autumn	31/05/2018	Ku2K	W	Frog	482786	6542438	Join in neoprene not holding.
Autumn	31/05/2018	Ku2K	W	Frog	482808	6542454	Neoprene does not reach ground at the north and south side of underpass (frogs can pass directly through fence mesh).
Autumn	31/05/2018	Ku2K	W	Frog	482804	6542477	Neoprene has begun tearing at the connection point to metal return.
Autumn	12/04/2018	Ku2K	W	STD FF	483173	6544197	Encroaching saplings to be removed.
Autumn	12/04/2018	Ku2K	W	STD FF	483198	6544361	North West of underpass 26.4 there are no pegs in base mesh/wire.
Autumn	31/05/2018	Ku2K	W	Frog	483146	6548399	Grass clearing required north and south.
Autumn	31/05/2018	Ku2K	W	Frog	483155	6548699	Gap at corner - mesh not joined.
Autumn	12/04/2018	Ku2K	W	STD FF	483210	6550308	South West of underpass 32.35. Branches fallen over fence and vegetation to be cleared.
Autumn	12/04/2018	Ku2K	W	STD FF	483210	6550308	South West of underpass 32.35. Pegs lifting.

Season	Date	Section	SOC	Fence type	Easting	Northing	Observation / maintenance required
Autumn	12/04/2018	Ku2K	W	STD FF	483210	6550308	North West of underpass 32.35. Vegetation clearing required.
Autumn	12/04/2018	Ku2K	W	STD FF	483210	6550308	North West of underpass 32.35. Bottom mesh not pegged or pegs lifting.
Autumn	12/04/2018	Ku2K	W	STD FF	483110	6551323	South West of underpass 36.4. Corner not secured, directly south of underpass.
Autumn	12/04/2018	Ku2K	W	STD FF	483110	6551323	South West of underpass 36.4. Vegetation removal required in numerous locations.
Autumn	12/04/2018	Ku2K	W	STD FF	483110	6551323	North West of underpass 36.4. Vegetation removal required immediately north of underpass.
Autumn	12/04/2018	Ku2K	W	STD FF	483110	6551323	North West of underpass 36.4. Pegs lifting.
Autumn	31/05/2018	Ku2K	W	Phascogale	482989	6552491	Gap at corner - not joined.
Autumn	31/05/2018	Ku2K	W	STD FF (Phascogale)	483002	6552547	No bottom mesh on gate to pond.
Autumn	31/05/2018	Ku2K	W	Phascogale	483009	6552595	No panel or mesh on drainage rock channel.
Autumn	31/05/2018	Ku2K	W	Phascogale	483038	6552645	Phascogale panels need to be attached to fauna fence at top and bottom to minimise gaps between the faun fence and the panels. This applies to entire length of Phascogale fencing to the northern point and to the southern point on both sides of the highway.
Autumn	31/05/2018	Ku2K	W	STD FF	483035	6552670	Fauna fence lifting at base due to steep bank eroding.
Autumn	16/05/2018	OH2Ku	W	Frog + Phascogale	481315	6530174	The installation Frog + Phascogale fence has resulted in a gap between the two parts that could act as a danger to small fauna getting trapped.
Spring/Summer	24/01/2019	OH2Ku	ALL	Frog	482874	6538007	Frog fence overgrown - extensive vegetation removal required north, south, east and west of bridge.
Spring/Summer	31/10/2018	OH2Ku	E	STD FF	483108	6519861	Vegetation removal required south from this point.
Spring/Summer	31/10/2018	OH2Ku	E	STD FF	483286	6523604	Vegetation removal required along both fence lines - adjacent to highway and on the western side of Winery Drive.
Spring/Summer	31/10/2018	OH2Ku	E	STD FF	482382	6526123	Base wire not attached to fence, leaving a gap.
Spring/Summer	31/10/2018	OH2Ku	E	STD FF	482306	6526354	Some shrub removal required.
Spring/Summer	24/01/2019	OH2Ku	E	Frog	481034	6527738	Frog fence low in locations - from 200 mm. Does not fulfil EMP and Green-thighed Frog Management Strategy specification (height of 500 mm for the neoprene rubber (replaced by vermin proof mesh) including a minimum return of 100 mm on the ground).
Spring/Summer	24/01/2019	OH2Ku	E	Frog	481632	6527829	Vegetation clearing required.
Spring/Summer	24/01/2019	OH2Ku	E	Phascogale	481534	6527940	Vegetation clearing required northward.
Spring/Summer	24/01/2019	OH2Ku	E	Phascogale	481506	6528002	End of combined Frog/Phascogale fence. There is no Phascogale fence north of this point where it is mapped.
Spring/Summer	24/01/2019	OH2Ku	E	Phascogale	481452	6528124	Start of Phascogale Fence. Determine if Phascogale fence required to continue south to meet Frog fence.
Spring/Summer	24/01/2019	OH2Ku	E	Phascogale	481307	6530047	Base of fauna fence lifting excessively.
Spring/Summer	24/01/2019	OH2Ku	E	Frog+Phascogale	481371	6530235	Vegetation removal required south.
Spring/Summer	24/01/2019	OH2Ku	E	Frog+Phascogale	481380	6530256	Vegetation removal required north and south.
Spring/Summer	24/01/2019	OH2Ku	E	Phascogale	481504	6530578	Vegetation removal required north and south.
Spring/Summer	24/01/2019	OH2Ku	E	Phascogale	481602	6530855	Vegetation removal required north and south.
Spring/Summer	24/01/2019	OH2Ku	E	Frog	483074	6537034	Vegetation clearing suggested to pre-empt overgrowth of fence.
Spring/Summer	30/10/2018	OH2Ku	E	STD FF	482474	6538793	Base netting does not come to the end of the fence at the underpass, creating a gap at the underpass.
Spring/Summer	22/01/2019	OH2Ku	E	Phascogale	482194	6539700	Vegetation removal required southward.

Season	Date	Section	SOC	Fence type	Easting	Northing	Observation / maintenance required
Spring/Summer	22/01/2019	OH2Ku	E	Phascogale	482264	6539796	Sheet metal panel missing.
Spring/Summer	22/01/2019	OH2Ku	E	Phascogale	482165	6539962	Vegetation clearing required both north and south of culvert.
Spring/Summer	22/01/2019	OH2Ku	E	Phascogale	482183	6540520	Dense weed - removal required.
Spring/Summer	22/01/2019	OH2Ku	E	Phascogale	482238	6540829	Vegetation removal required.
Spring/Summer	22/01/2019	OH2Ku	E	Phascogale	482291	6541020	Continued vegetation removal required.
Spring/Summer	22/01/2019	OH2Ku	E	Phascogale	482329	6541188	Extensive grass removal required southward.
Spring/Summer	22/01/2019	OH2Ku	E	Phascogale	482557	6541827	Sapling removal required.
Spring/Summer	22/01/2019	Ku2K	E	Phascogale	482701	6542091	Vegetation clearing required.
Spring/Summer	22/01/2019	Ku2K	E	Phascogale	482694	6542134	Vegetation and grass removal required in the area.
Spring/Summer	22/01/2019	Ku2K	E	STD FF	482817	6542348	Sapling removal required.
Spring/Summer	22/01/2019	Ku2K	E	Frog	483247	6546153	Grass covering frog fence - removal required.
Spring/Summer	22/01/2019	Ku2K	E	Frog	483227	6546196	Numerous gaps between rocks and fauna fence and between fauna fence and frog fence - frog fence needs to be attached or weighted down and gaps filled.
Spring/Summer	22/01/2019	Ku2K	E	Frog	483245	6546271	Grass covering frog fence - removal required.
Spring/Summer	23/01/2019	Ku2K	E	Frog	483267	6548592	Intermittent grass clearing required.
Spring/Summer	23/01/2019	Ku2K	E	Frog	483209	6548647	Frog fence overgrown - extensive clearing required.
Spring/Summer	30/10/2018	Ku2K	E	STD FF	483260	6550317	Base wire has come away from the main fence, leaving a gap between the two.
Spring/Summer	23/01/2019	Ku2K	E	Phascogale	483090	6552553	Vegetation encroaching of fence - clearing required.
Spring/Summer	31/10/2018	Ku2K	E	STD FF	483011	6554237	Top of fence is not curved/bent inwards - check integrity.
Spring/Summer	31/10/2018	Ku2K	E	STD FF	482971	6554238	North East underpass 36.4. North of underpass to 100 metres - vegetation clearing required on the highway side of the fauna fence.
Spring/Summer	22/01/2019	Ku2K	E	Frog	483308	6555588	Grass removal required in area.
Spring/Summer	31/10/2018	OH2Ku	W	STD FF	483042	6519948	Large branch fallen over fence.
Spring/Summer	24/01/2019	OH2Ku	W	Frog	481466	6527980	Clearing of vegetation from entire length frog fence required.
Spring/Summer	24/01/2019	OH2Ku	W	Frog+Phascogale	481448	6528023	Phascogale sheeting too narrow (0.15 m) over the top of the frog fence? Both east and west of culvert.
Spring/Summer	24/01/2019	OH2Ku	W	Phascogale	481373	6528255	Vegetation removal required south.
Spring/Summer	24/01/2019	OH2Ku	W	Phascogale	481300	6530191	Phascogale sheeting too narrow (0.15 m) over the top of the frog fence? Both east and west of culvert.
Spring/Summer	24/01/2019	OH2Ku	W	Frog+Phascogale	481347	6530326	Vegetation clearing required.
Spring/Summer	24/01/2019	OH2Ku	W	Frog+Phascogale	481395	6530435	Vegetation clearing required in area.
Spring/Summer	24/01/2019	OH2Ku	W	STD FF (Phascogale)	481495	6530720	Base wires of standard fauna fence deformed and pulled away from main fauna fence.
Spring/Summer	24/01/2019	OH2Ku	W	Phascogale	481517	6530866	Vegetation removal required northward.
Spring/Summer	24/01/2019	OH2Ku	W	Frog	482861	6537923	No frog fence around pipe culvert - check design and determine if required.
Spring/Summer	24/01/2019	OH2Ku	W	Frog	482845	6537961	Fence damaged from fallen tree - tree removed.
Spring/Summer	24/01/2019	OH2Ku	W	Phascogale	482421	6538734	Tree trimming and vegetation clearing required south to end of Phascogale fence.
Spring/Summer	24/01/2019	OH2Ku	W	Phascogale	482363	6538854	Trees fallen over fauna fence in multiple locations.
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482184	6539365	Tree growth into fence - removal required southward.
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482165	6539456	Grass removal required in area.

Season	Date	Section	SOC	Fence type	Easting	Northing	Observation / maintenance required
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482170	6539497	Tree growing into fence - removal required.
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482131	6539660	Vegetation on highway side of fence growing over and weighing down fauna fence – remove.
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482094	6539920	Vegetation growth through fauna fence - removal required.
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482040	6540259	Tree down over fence, fence damaged.
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482091	6540403	Vegetation encroaching on fence - removal required northward.
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482100	6540515	Grass encroaching on fence - removal required.
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482102	6540576	No overhanging wire cover at base of gate.
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482127	6540841	Sapling growth in and around fence panels northward - removal required.
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482195	6540987	Tree down over fence, fence damaged.
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482221	6541022	Vegetation removal required northward.
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482238	6541185	Vegetation and grass removal required in the area.
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482447	6541750	Grass removal required northward.
Spring/Summer	22/01/2019	OH2Ku	W	Phascogale	482565	6541999	Vegetation and grass removal required northward.
Spring/Summer	22/01/2019	Ku2K	W	Phascogale	482599	6542076	Grass removal required.
Spring/Summer	22/01/2019	Ku2K	W	Frog	483180	6546183	Fence/gate maintenance appears to be incomplete - fencing not completely attached leaving a gap under the fauna fence and frog fence does not extend to end of fauna fence.
Spring/Summer	22/01/2019	Ku2K	W	Frog	483181	6546220	Frog fence mesh incompletely attached leaving a section of the fauna fence with no frog fence.
Spring/Summer	22/01/2019	Ku2K	W	Frog	483175	6546279	Grass covering frog fence - removal required.
Spring/Summer	23/01/2019	Ku2K	W	Frog	483149	6548416	Grass clearing required.
Spring/Summer	23/01/2019	Ku2K	W	Frog	483158	6548810	Branches and vegetation hanging over fence - clearing required.
Spring/Summer	30/10/2018	Ku2K	W	STD FF	483130	6551147	Gap at drainage line - base wire not properly covering to edges.
Spring/Summer	30/10/2018	Ku2K	W	STD FF	483097	6551238	Base wires has come away from the main fence, leaving a gap between the two.
Spring/Summer	30/10/2018	Ku2K	W	STD FF	483079	6551281	Gap between the fence and the drainage line.
Spring/Summer	23/01/2019	Ku2K	W	Phascogale	483005	6552612	Panel has detached and is hanging off.
Spring/Summer	23/01/2019	Ku2K	W	Phascogale	483038	6552693	Panel needs to be attached to fauna fence at top and bottom to prevent gaps - both east and west of culvert.
Spring/Summer	31/10/2018	Ku2K	W	STD FF	482919	6554226	The end of the fauna fence is not properly secured at the underpass, leaving a gap on both north and south sides.
Spring/Summer	31/10/2018	Ku2K	W	STD FF	482890	6554283	Tree fallen onto fence.
Spring/Summer	22/01/2019	Ku2K	W	Frog	483253	6555573	Vegetation removal required northward.

Annex 2 – Road kill survey data

Table 9: 2018/2019 road kill monitoring results

Season	Date	Latitude	Longitude	Species	Native/Introduced	Assigned vertebrate group
Spring	03/10/2018	-31.439694	152.82315	Medium Mammal	Unknown	Medium mammal
Spring	03/10/2018	-31.399989	152.814449	Magpie	Native	Bird
Spring	03/10/2018	-31.394468	152.811939	Bird of prey	Native	Bird
Spring	03/10/2018	-31.394114	152.811776	Small Mammal	Unknown	Small mammal
Spring	03/10/2018	-31.355429	152.80628	Small Mammal	Unknown	Small mammal
Spring	03/10/2018	-31.354099	152.806569	Bird	Unknown	Bird
Spring	03/10/2018	-31.313033	152.820438	Unknown	Unknown	Unknown
Spring	03/10/2018	-31.309557	152.821279	Kookaburra	Native	Bird
Spring	03/10/2018	-31.294135	152.820458	Kangaroo	Native	Large ground dwelling mammal
Spring	03/10/2018	-31.248635	152.821532	Unknown	Unknown	Unknown
Spring	03/10/2018	-31.180668	152.823946	Medium Mammal	introduced	Medium mammal
Spring	03/10/2018	-31.227617	152.823727	Medium Mammal	Unknown	Medium mammal
Spring	03/10/2018	-31.290037	152.818886	Medium Mammal	Native	Medium mammal
Spring	03/10/2018	-31.322596	152.818473	Bird of prey	Native	Bird
Spring	03/10/2018	-31.324246	152.81815	Bird of prey	Native	Bird
Spring	03/10/2018	-31.328696	152.817107	Bird of prey	Native	Bird
Spring	03/10/2018	-31.330826	152.816361	Frog	Native	Amphibian
Spring	03/10/2018	-31.351604	152.807325	Bird of prey	Native	Bird
Spring	03/10/2018	-31.356945	152.806128	Owl	Native	Bird
Spring	03/10/2018	-31.376089	152.803312	Unknown	Unknown	Unknown
Spring	03/10/2018	-31.406148	152.816966	Bird	Native	Bird
Spring	03/10/2018	-31.418339	152.823037	Kangaroo	Native	Large ground dwelling mammal
Spring	03/10/2018	-31.434624	152.822861	Owl	Native	Bird
Spring	11/10/2018	-31.439719	152.823147	Medium Mammal	Unknown	Medium mammal
Spring	11/10/2018	-31.394209	152.81177	Small Mammal	Unknown	Small mammal
Spring	11/10/2018	-31.355398	152.80629	Rodent	Unknown	Small mammal
Spring	11/10/2018	-31.30939	152.821328	Bird	Native	Bird
Spring	11/10/2018	-31.228975	152.823479	Small Mammal	Unknown	Small mammal
Spring	11/10/2018	-31.290025	152.818872	Medium Mammal	Unknown	Medium mammal
Spring	11/10/2018	-31.296763	152.821443	Bird	Native	Bird
Spring	11/10/2018	-31.322703	152.818457	Medium Mammal	Unknown	Medium mammal
Spring	11/10/2018	-31.330579	152.816451	Medium Mammal	Unknown	Medium mammal
Spring	11/10/2018	-31.37187	152.802294	Small Mammal	Unknown	Small mammal
Spring	18/10/2018	-31.349704	152.807512	Bandicoot	Native	Medium mammal
Spring	18/10/2018	-31.338699	152.811732	Frog	Native	Amphibian
Spring	26/10/2018	-31.440664	152.823291	Medium Mammal	Introduced	Medium mammal

Season	Date	Latitude	Longitude	Species	Native/Introduced	Assigned vertebrate group
Spring	26/10/2018	-31.440267	152.823239	Medium Mammal	Introduced	Medium mammal
Spring	26/10/2018	-31.394103	152.811782	Medium Mammal	Unknown	Medium mammal
Spring	26/10/2018	-31.355391	152.806327	Rodent	Unknown	Small mammal
Spring	26/10/2018	-31.342243	152.809868	Bird	Native	Bird
Spring	26/10/2018	-31.209512	152.823127	Kangaroo	Native	Large ground dwelling mammal
Spring	26/10/2018	-31.209731	152.823373	Medium Mammal	Introduced	Medium mammal
Spring	26/10/2018	-31.32952	152.816852	Bird of prey - Owl	Native	Bird
Spring	26/10/2018	-31.340913	152.810736	Duck	Native	Bird
Spring	26/10/2018	-31.358196	152.805756	Bird of prey	Native	Bird
Summer	08/01/2019	-31.407016	152.817317	Macropod	Native	Large ground dwelling mammal
Summer	08/01/2019	-31.409504	152.818604	Wallaby	Native	Large ground dwelling mammal
Summer	08/01/2019	-31.431274	152.82253	Kookaburra	Native	Bird
Summer	08/01/2019	-31.324086	152.818008	Turtle	Native	Reptile
Summer	08/01/2019	-31.299061	152.821552	Fox	Introduced	Introduced
Summer	08/01/2019	-31.288528	152.81766	Medium Mammal	Unknown	Medium mammal
Summer	08/01/2019	-31.279915	152.813042	Medium Mammal	Unknown	Medium mammal
Summer	08/01/2019	-31.221445	152.823501	Raven	Native	Bird
Summer	08/01/2019	-31.206409	152.822982	Fox	Introduced	Introduced
Summer	08/01/2019	-31.196149	152.823451	Kangaroo	Native	Large ground dwelling mammal
Summer	08/01/2019	-31.338355	152.812289	Owl	Native	Bird
Summer	15/01/2019	-31.450106	152.822892	Magpie	Native	Bird
Summer	15/01/2019	-31.309979	152.821134	Echidna	Native	Small mammal
Summer	15/01/2019	-31.261002	152.814707	Small Mammal	Unknown	Small mammal
Summer	15/01/2019	-31.225569	152.823452	Bird	Unknown	Bird
Summer	15/01/2019	-31.196121	152.823423	Kangaroo	Native	Large ground dwelling mammal
Summer	15/01/2019	-31.407161	152.817465	Unknown	Unknown	Unknown
Summer	22/01/2019	-31.298814	152.821501	Medium Mammal	Unknown	Medium mammal
Summer	22/01/2019	-31.206084	152.822984	Fox	Introduced	Introduced
Summer	22/01/2019	-31.243936	152.823333	Turtle	Unknown	Reptile
Summer	22/01/2019	-31.327601	152.817446	Turtle	Unknown	Reptile
Summer	29/01/2019	-31.459087	152.820882	Wallaby	Native	Large ground dwelling mammal
Summer	29/01/2019	-31.419732	152.823177	Bird	Unknown	Bird
Summer	29/01/2019	-31.29898	152.821577	Medium Mammal	Unknown	Medium mammal
Summer	29/01/2019	-31.196102	152.823483	Kangaroo	Native	Large ground dwelling mammal
Summer	29/01/2019	-31.182392	152.823913	Kangaroo	Native	Large ground dwelling mammal
Summer	29/01/2019	-31.210555	152.823423	Black bird	Unknown	Bird
Autumn	05/04/2019	-31.324452	152.818144	Lizard	Native	Reptile
Autumn	05/04/2019	-31.262736	152.814192	Mammal	Unknown	Unknown
Autumn	05/04/2019	-31.187902	152.823474	Unknown	Unknown	Unknown
Autumn	12/04/2019	-31.324446	152.817935	Bird of prey	Native	Bird
Autumn	12/04/2019	-31.446777	152.823985	Magpie	Native	Bird

Season	Date	Latitude	Longitude	Species	Native/Introduced	Assigned vertebrate group
Autumn	12/04/2019	-31.210655	152.823178	Fox	Introduced	Introduced
Autumn	12/04/2019	-31.250807	152.820384	Lace Monitor	Native	Reptile
Autumn	18/04/2019	-31.421827	152.823479	Magpie	Native	Bird
Autumn	18/04/2019	-31.216111	152.823561	Bird	Unknown	Bird
Autumn	18/04/2019	-31.194548	152.823516	Bird	Unknown	Bird
Autumn	18/04/2019	-31.312986	152.820635	Bird	Unknown	Bird
Autumn	18/04/2019	-31.32346	152.818352	Bird of prey	Native	Bird
Autumn	18/04/2019	-31.446879	152.823987	Magpie	Native	Bird
Autumn	18/04/2019	-31.457338	152.821342	Small unknown	Unknown	Unknown
Autumn	18/04/2019	-31.447363	152.823579	Unknown	Unknown	Unknown
Autumn	28/04/2019	-31.362348	152.803642	Echidna	Native	Medium mammal

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Fauna Underpass Monitoring 2018/2019

Oxley Highway to Kempsey, Pacific Highway Upgrade

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Illawarra
Armidale
Newcastle
Mudgee
Port Macquarie
Brisbane
Cairns

Cover photograph: Koala recorded in F11.67 (left) and Common Brushtail Possum using fauna furniture in F34.72 (right) during late spring/summer surveys.

Executive summary

Context

This report documents findings of the 2018/2019 monitoring period, the first of three monitoring periods for the fauna underpasses, as required for the Oxley Highway to Kempsey (OH2K) Pacific Highway Upgrade Project (the Project), and specified in the Oxley Highway to Kempsey (OH2K) Ecological Monitoring Program (EMP, RMS 2016).

Aims

The aim of the fauna underpass monitoring program is to determine whether fauna are using the underpass structures to complete crossings under the Pacific Highway. The aim of this report is to determine if the Project is meeting the performance indicators of success for the mitigation measure, and provide corrective actions where required.

Methods

Fourteen underpasses were surveyed in accordance with the monitoring method specified in the EMP, specifically:

- Two remote cameras were placed within each underpass and left to record for 60 consecutive days
- 10 hair tube traps were placed in and around the entrance to each underpass for 14 consecutive nights
- Sand plots were established in combined fauna underpasses and monitored for eight consecutive nights
- Scat searches were conducted within underpasses and adjoining habitat during sand plot surveys and camera deployment and retrieval.

Key Results

The key results of the 2018/2019 fauna underpass monitoring were as follows:

- All but one of the required fauna groups (frogs), were recorded using eleven of the fourteen underpasses; frogs were the only absent group at all underpasses. The remaining three underpasses (F1.62, C4.46 and F21.24) had records of all but two of the required fauna groups, with frogs and either arboreal mammals, macropods or reptiles, respectively, the absent groups.
- Two of the three EPBC listed target threatened species, the Koala and Spotted-tailed Quoll were recorded. The Giant Barred Frog was not recorded using the underpasses.
- Non-EPBC target species, the Green-thighed Frog and Brush-tailed Phascogale were not recorded using any underpasses. Indicator species for the Brush-tailed Phascogale were recorded at all underpasses. However, no frogs were recorded at any underpass to date.
- Two of the three cover-dependent/low mobility species fauna groups, reptiles and small ground-dwelling mammals, were recorded at the majority of underpasses. Frogs were not recorded.
- Non-native predators including cats, dogs and foxes, were detected at all of the fourteen monitored underpasses. Seven of the 14 monitored underpasses showed high use by non-native predators, F1.04, F1.62, F26.40, C32.35, F33.40, F34.72 and C36.40.
- The 2018/2019 average weekly road kill decreased slightly from that recorded during baseline monitoring: 10.4 to 9.0. Three road kill records were within 200 metres of monitored underpasses.

Conclusions

Performance measures were partially met for the 2018/2019 underpass monitoring event. Two of the three EPBC listed target species (Koala and Spotted-tailed Quoll) were recorded completing crossings however it was considered that the Giant Barred Frog is unlikely to be detected at the nominated underpass. An assessment regarding sufficient crossing frequency of EPBC target species could not be undertaken to the detail specified in the EMP, however the use of the underpasses by fauna, as measured and monitored according to the EMP, can indicate whether the underpasses allow for the opportunity for movement within home ranges, dispersal and/or re-colonisation. This has been met at three underpasses for Koalas and one underpass for the Spotted-tailed Quoll. The performance indicators for non-EPBC target species were also partially met: indicator species for the Brush-tailed Phascogale were recorded at all underpasses; indicator species for the Green-thighed Frog were not recorded; and cover-dependent and low mobility fauna were recorded at the majority of underpasses for two of the three relevant fauna groups, with frogs not recorded at any underpass. The performance indicator requiring a reduced incidence of road kill from baseline monitoring was met.

Management Implications

This report presents the results of the first of three monitoring events, as such continued monitoring as per the EMP is recommended. While specific recommendations have not been made, the following considerations may assist the program in meeting its performance measures:

- Consideration could be given to extending the camera monitoring period to increase the opportunity for detecting EPBC species.
- The likelihood of detecting the Green-thighed Frog and other amphibians using current survey methods is low. Consider undertaking targeted frog surveys during/following suitable weather conditions to determine the use of underpasses by amphibians.
- Consider consulting with Local Land Services concerning control methods for foxes and dogs in the area, focusing on those underpasses where they have been recorded, notably, F1.04, F1.62, F26.40, F33.40, F34.72 and C36.40.

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1. Introduction

1.1 Context

The Oxley Highway to Kempsey (OH2K) section of the Pacific Highway Upgrade Project (the Project) was approved by the NSW Department of Environment and Planning in 2012 subject to various Ministers Conditions of Approval (MCoA) and a Statement of Commitments (SoC). A subsequent approval with additional conditions of consent (CoA) was granted in 2014 by the Commonwealth Department of Environment (DoE) for Matters of National Environmental Significance (MNES) listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1995* (EPBC Act). The Ecological Monitoring Program (hereafter referred to as the EMP) (RMS 2016) combines these approval conditions and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project.

Fauna underpasses were installed to reduce the impacts on fauna, facilitate movement and maintain habitat connectivity for native fauna. These structures are to be monitored to assess their effectiveness in facilitating fauna movement**,** as required by the EMP.

1.1.1 Monitoring framework

The design, methods and performance indicators that define the fauna underpass monitoring program are specified in the EMP. The EMP specifies that monitoring be undertaken at 14 underpasses, including 10 dedicated fauna underpasses and four combined drainage/fauna culverts.

The EMP requires monitoring to occur in autumn and late spring/early summer in Years 4, 6 and 8 (operational phase) of the Project. The EMP specifies that additional monitoring may be required if underpasses are determined to be ineffective.

This report represents the first of three reports required for the underpass monitoring – Year 4 autumn 2018 and spring/summer 2018/2019.

1.1.2 Background data

Underpass selection

The Project includes over 50 underpasses that may facilitate the passage of fauna, including bridges, dedicated fauna underpasses and combined drainage/fauna culverts. The EMP specifies that 14 underpasses be monitored based on the following criteria:

- All dedicated fauna underpasses will be monitored.
- Combined underpasses that are 50 metres or more in length, and located in proximity to intact native vegetation (fauna habitat) will be monitored.
- No combined culverts that are located in cleared, disturbed or modified areas will be monitored.
- No combined culverts that are located within 600 metres of another monitored underpass will be monitored.
- No incidental underpasses will be monitored (small culverts that are not intended to allow for the passage of fauna but may be used incidentally by small fauna).

Indicator species

The EMP provides a list of indicator and target (threatened) species to determine the successful use of fauna crossing structures. These species are those that have been previously recorded in proximity to the Project or are known to occur in the Project area and were considered as being potentially adversely affected by the Project. Section 2.2.4 of the EMP states:

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

Table 1 lists the five fauna groups that are to be used to assess the effectiveness of the underpasses, as well as the indicator and target species for each of the five groups.

Table 1: Indicator species for fauna crossings (from Table 5 of the EMP)

Fauna group	Indicator species (known from area)	Target (threatened) species
Frogs	*Litoria* sp., *Limnodynastes* sp., *Crinia* sp., Giant Barred Frog	Green-thighed Frog, Giant Barred Frog
Small ground-dwelling mammals	Antechinus, rodents and bandicoots, Echidna, Spotted-tailed Quoll	Spotted-tailed Quoll, Brush-tailed Phascogale
Arboreal mammals	Brushtail Possum, Ringtail Possum	Brush-tailed Phascogale
Koala	Koala	Koala
Macropods	Swamp Wallaby, Red-necked Wallaby, Eastern Grey Kangaroo	N/A

1.1.3 Purpose of this report

This report details the findings obtained from the first operational monitoring event for the fauna underpasses. The aims of this report are to summarise the methods and results of the 2018/2019 monitoring and determine if performance measures are being met, as per the EMP.

1.2 Performance Measures

The EMP specifies the following performance measures for fauna underpasses:

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

1.3 Monitoring Timing

Monitoring is to be undertaken in Years 4, 6 and 8 of the Project's operational phase. Monitoring is to occur in late autumn and late spring/early summer each monitoring year for a minimum of 60 days. The timing of monitoring coincides with breeding seasons and dispersal periods for target species, shown in Table 2.

Table 2: Breeding seasons and likely dispersal periods of threatened target species (from Table 13 of the EMP)

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

1.4 Reporting

Annual reporting of monitoring results will include:

- Detailed description of monitoring methodology
- 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 Secretary of the Department of Planning and Environment and the Environment Protection Authority.

1.5 Limitations

- Due to their small size and cryptic nature, frogs and smaller reptiles are difficult to detect within the underpasses using the current survey methods and thus if present, may have gone undetected.
- The EMP requires installation of sand plots at combined underpasses, which serve as combined drainage/fauna culverts. It was considered that sand plots established across the active drainage channel of the culvert would likely wash away. In consultation with Roads and Maritime it was therefore determined that sand plots would be established across the entire width of the underpass only if the drainage channel was not inundated with water.
- The EMP requires an assessment of the effectiveness of the underpasses for species listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (hereafter referred to as EPBC species) based on "*Complete safe crossing of the crossing by the targeted EPBC species at sufficient frequency to ensure that habitat connectivity is maintained or improves from baseline conditions, and ongoing population viability by providing opportunity for species dispersal and re-colonisation*". The EMP does not define what "*sufficient frequency*" would be and baseline crossing frequencies are unknown and therefore cannot be used to assess the success of the underpasses. In addition, this monitoring program does not provide a means of measuring dispersal and re-colonisation of species or population viability. The limitations of the EMP with regards to this performance measure is discussed in detail in Table 11.

2. Methods

2.1 Monitoring Sites

Monitoring was undertaken at 14 underpasses, including 10 dedicated fauna underpasses and four combined drainage/fauna culverts. Table 3 lists the fauna groups nominated in Table 12 of the EMP and shows the relevance of each of these groups at each of the underpasses (as specified in Table 12 of EMP). Target species (non-EPBC and EPBC listed species) have also been considered separately to their related fauna group as Table 12 of the EMP specifically nominates individual target species at certain underpasses. While the Brush-tailed Phascogale was not specifically nominated within Table 12 of the EMP, it is listed in Table 13 of the EMP as a species targeted by underpasses and has therefore been included separately as a non-EPBC target species. Underpass F34.72 was erroneously omitted from Table 12 in the EMP; the text states all dedicated underpasses are to be monitored, therefore, after consultation with Roads and Maritime, F34.72 was included in the monitoring. Fauna groups were therefore not nominated for F34.72 within the EMP. For the purpose of assessment, fauna groups/species nominated for the two closest underpasses (F33.40 and C36.4) have been included here as a guide for F34.72. The location of each monitored underpass is shown in Figure 1 and Figure 2.

Table 3: Monitored fauna underpasses and target species (adapted from Table 12 of the EMP).

	Indicator Species	F1.04	F1.62	C4.46	C7.26	F9.70	F11.67	F20.54	F21.24	F22.32	F26.40	C32.35	F33.40	F34.72*	C36.40
Fauna group/species (target threatened species)															
Frogs (Green-thighed Frog)	*Litoria* sp., *Limnodynastes* sp., *Crinia* sp., Giant Barred Frog	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Small ground-dwelling mammals (Brush-tailed Phascogale)	*Antechinus* spp, rodents and bandicoots, Echidna, Spotted-tail Quoll	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Arboreal mammals (Brush-tailed Phascogale)	Brushtail Possum, Ringtail Possum		✓	✓	✓	✓	✓			✓			✓	✓	✓
Macropods	Swamp Wallaby, Red-necked Wallaby, Eastern Grey Kangaroo	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Reptiles		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Non-EPBC target species															
Green-thighed Frog	*Litoria* sp., *Limnodynastes* sp., *Crinia* sp., Giant Barred Frog												✓		✓
Brush-tailed Phascogale+	*Antechinus* spp, rodents and bandicoots, Echidna, Spotted-tail Quoll, Brushtail Possum, Ringtail Possum														
EPBC target species															
Giant Barred Frog	Giant Barred Frog														✓
Koala	Koala	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Spotted-tail Quoll	Spotted-tail Quoll				✓	✓	✓	✓	✓	✓	✓		✓	✓	✓

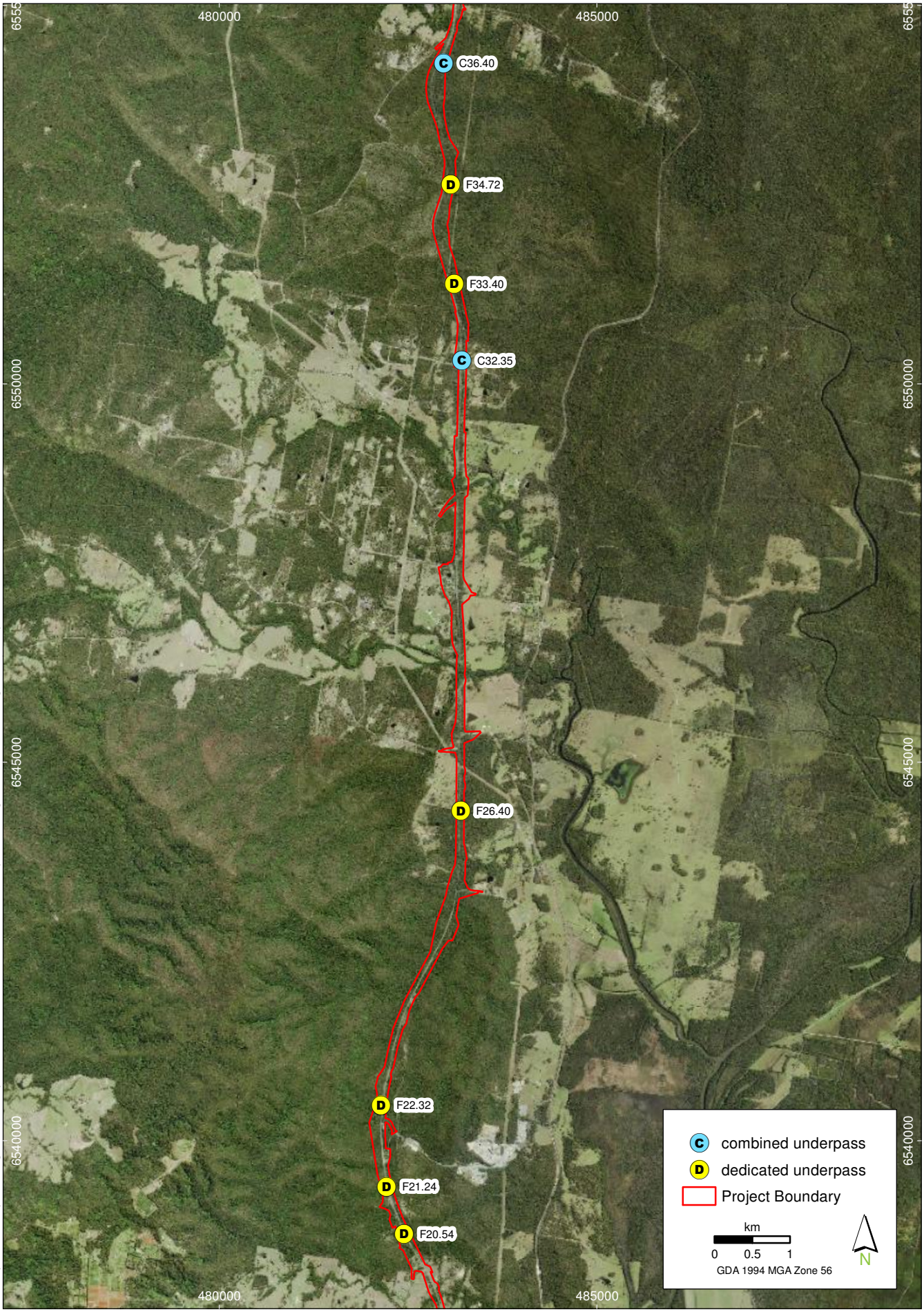
+ The Brush-tailed Phascogale was not specifically nominated at any underpass in Table 12 of the EMP.

*Nominated fauna groups/species are based on the two closest underpasses and proximity of recorded Green-thighed Frog habitat.

2.2 Survey Method

Surveys were undertaken in accordance with the EMP. At each underpass the following survey techniques were used:

- Two motion-detecting cameras were installed in the middle of each underpass, one facing along the fauna furniture and one facing along the ground, where possible. Cameras were left operating for 60 days in autumn and late spring/early summer.
- Sand plots at least one metre wide were established across the entire width of the raised cement footpath at each end of combined underpasses as drainage channels were inundated at the time of monitoring. Sand plots were monitored for eight nights in each monitoring period. Each morning plots were checked, any tracks recorded and plots raked clean.
- Ten hair-tubes were attached to fauna furniture (where possible) or placed along the ground within each underpass and in adjoining habitat. Hair tubes were baited with a mixture of peanut butter, honey and oats and left for a minimum of 14 consecutive nights in each monitoring period. Hair samples were sent to Barbara Triggs ('Dead Finish') for analysis, and were identified to species level where possible.
- Scat searches were undertaken within underpasses and adjoining habitat during sand plot surveys and camera deployment and retrieval.



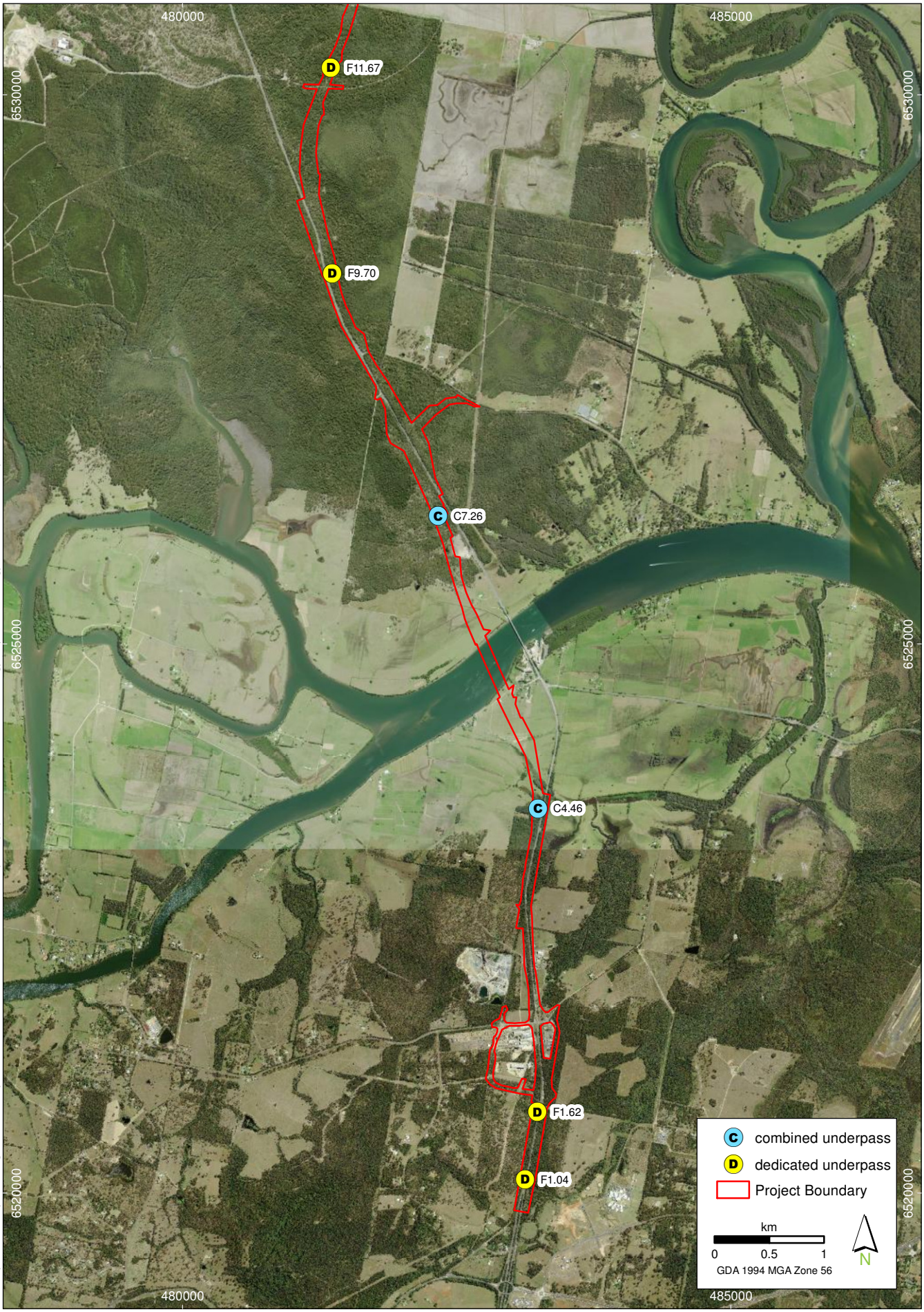
Drawn by: GT Project Manager: RM Project Number: 1702 PI 5.9 Date: 6/6/2019 T:\SpatialWorking\a1702\1702_PI_59_Figure_1_UnderpassLocations_North2.mxd

Fauna Underpass Locations - North

Oxley Highway to Kempsey - PI 5.9 Fauna Underpass Monitoring

FIGURE 1

Imagery: (c) LPI 2013



Fauna Underpass Locations - South

Oxley Highway to Kempsey - PI 5.9 Fauna Underpass Monitoring

niche Environment and Heritage

FIGURE 2

Imagery: (c) LPI 2013

3. Results

3.1 2018/2019 Monitoring Summary

Detailed field data are provided in Annex 1 and Annex 2. Results of the different survey methods were combined to provide an overall assessment of the use of the monitored underpasses.

3.1.1 Monitoring periods

The 2018/2019 monitoring periods were as follows:

- Autumn 2018: 27 March 2018 – 29 May 2018
- Late spring/early summer 2018/2019: 21 November 2018 – 24 January 2019.

Hair tube surveys were undertaken in the first two weeks of the monitoring period. Sand plots were monitored for eight nights in autumn (7 – 15 May 2018) and late spring (21 – 29 November 2018). As the deployment periods were longer than the minimum 60 days, different species that had not been recorded within the 60 day monitoring period were considered as value adding data and included in the assessment of underpass use by fauna groups.

A number of issues including camera malfunctions, battery depletion and camera tampering and theft were encountered during the monitoring periods. Camera details, including monitoring dates and durations, for autumn and spring/summer surveys are provided in Annex 1.

3.1.2 Remote cameras

Table 4 provides a summary of the fauna records for the monitored underpasses. Cameras captured a total of 975 fauna records over the two monitoring periods. A proportion (8.6%) of records were unidentified, which were mostly partial and/or unclear images. Of those records that were identified, 54.1% were identified as native fauna.

Table 4: 2018/2019 camera fauna record summary

Underpass	# fauna records	# natives	# non native	# unidentified	# introduced predator	% native	% introduced predator
F1.04	98	26	64	8	52	26.5	53.1
F1.62	60	9	37	14	26	15.0	43.3
C4.46	76	57	14	5	11	75.0	14.5
C7.26	55	42	13	0	7	76.4	12.7
F9.70	100	16	53	31	21	16.0	21.0
F11.67	56	44	8	4	1	78.6	1.8
F20.54	77	54	21	2	16	70.1	20.8
F21.24	35	26	8	1	7	74.3	20.0
F22.32	112	87	22	3	9	77.7	8.0
F26.40	93	51	41	1	34	54.8	36.6
C32.35	20	14	6	0	6	70.0	30.0
F33.40	54	18	26	10	19	33.3	35.2
F34.72	121	71	46	4	42	58.7	34.7
C36.40	18	12	5	1	5	66.7	27.8
TOTALS	975	527	364	84	256	54.1	26.3

3.2 Native Fauna Use of Underpasses

Results of the different survey methods were combined to provide an overall assessment of the use of monitored underpasses. While a specific means of determining a "*complete safe crossing*" by targeted EPBC species is not specified in the EMP, it is considered that animals captured on remote cameras within the underpass are using the underpass to complete successful crossings. Table 5 shows the use of underpasses by fauna groups and target species. Shaded squares indicate the underpasses where fauna groups/target species were nominated (Table 3). All but one of the required fauna groups (frogs), were recorded using eleven of the fourteen underpasses; frogs were the only absent group at all underpasses. The remaining three underpasses (F1.62, C4.46 and F21.24) had records of all but two of the required fauna groups, with frogs and either arboreal mammals, macropods or reptiles, respectively, the absent groups. A summary of the use of underpasses by the respective fauna groups is as follows:

- Frogs: not recorded at any underpass.
- Small ground-dwelling mammals: recorded at all nominated underpasses; represented by rodents, antechinus, bandicoots, the Echidna and the Spotted-tailed Quoll.
- Arboreal mammals: recorded at seven of the nine nominated underpasses, and at two additional underpasses; represented by the Brushtail Possum and the Koala.
- Macropods: recorded at 13 of the 14 nominated underpasses (excluding C4.46); represented by the Eastern Grey Kangaroo and Swamp Wallaby.
- Reptiles: recorded at 13 of the 14 nominated underpasses (excluding F21.24); represented predominantly by the Eastern Water Dragon and Lace Monitor.

Table 5: Native fauna use of underpasses – autumn 2018 and spring/summer 2018/2019

	Indicator Species	F1.04	F1.62	C4.46	C7.26	F9.70	F11.67	F20.54	F21.24	F22.32	F26.40	C32.35	F33.40	F34.72*	C36.40
Fauna group/species (target threatened species)															
Frogs (Green-thighed Frog)	*Litoria* sp., *Limnodynastes* sp., *Crinia* sp., Giant Barred Frog														
Small ground-dwelling mammals (Brush-tailed Phascogale)	*Antechinus* spp, rodents and bandicoots, Echidna, Spotted-tail Quoll	Y (3)	Y (3)	Y (3)	Y (2)	Y (2)	Y (3)	Y (4)	Y (3)	Y (5)	Y (3)	Y (1)	Y (3)	Y (3)	Y (2)
Arboreal mammals (Brush-tailed Phascogale)	Brushtail Possum, Ringtail Possum	Y (1)		Y (1)	Y (1)	Y (1)	Y (1)			Y (1)		Y (1)		Y (1)	Y (1)
Macropods	Swamp Wallaby, Red-necked Wallaby, Eastern Grey Kangaroo	Y (1)	Y (1)		Y (1)	Y (1)	Y (2)	Y (2)	Y (1)	Y (2)	Y (2)	Y (1)	Y (1)	Y (1)	Y (1)
Reptiles		Y (2)	Y (1)	Y (1)	Y (2)	Y (3)	Y (1)	Y (2)		Y (1)	Y (1)	Y (1)	Y (3)	Y (2)	Y (2)
Non-EPBC target species															
Green-thighed Frog	*Litoria* spp., *Limnodynastes* spp., *Crinia* spp., Giant Barred Frog														
Brush-tailed Phascogale+	*Antechinus* spp, rodents and bandicoots, Echidna, Spotted-tail Quoll, Brushtail Possum, Ringtail Possum														
EPBC target species															
Giant Barred Frog	Giant Barred Frog														
Koala (Koala)	Koala					Y	Y						Y		
Spotted-tail Quoll	Spotted-tail Quoll														Y

+ The Brush-tailed Phascogale was not specifically nominated at any underpass in Table 12 of the EMP. *Nominated fauna groups/species are based on the two closest underpasses. (#) = number of different species detected.

3.3 EPBC Target Species

Three of the five target threatened species (Table 1) are listed under the EPBC Act, including the Koala (*Phascolarctos cinereus*), Giant Barred Frog (*Mixophyes iteratus*) and Spotted-tailed Quoll (*Dasyurus maculatus*). These species were specifically nominated as target species at all, one and 10 of the underpasses respectively. Two of these species were recorded using four underpasses during the 2018/2019 monitoring period; the Koala was detected using F9.70, F11.67 and F33.40, and the Spotted-tailed Quoll was detected using C36.40. Details of these records are provided in Table 6 and discussed below. The Giant Bared Frog was not detected using any underpass.

The Koala was detected on a single occasion at three of the 14 nominated underpasses during the spring/summer monitoring period, with all individuals heading in an easterly direction. All three underpasses are dedicated fauna underpasses with installed fauna furniture (rails and refuge poles) targeted specifically at Koalas. However all three individuals were recorded on the ground. Underpasses used were all similar in width (3 metres), height (2.4-3 metres) and length (38-49 metres) and all three connect State Forest habitat on either side of the road.

The Spotted-tailed Quoll was detected using a nominated combined drainage/fauna culvert heading in a westerly direction on the raised fauna footpath. The underpass provides connectivity of habitat from Maria River State Forest in the east linked indirectly to the northern tip of Kumbatine National Park in the west. The western side of the underpass opens to a lightly re-vegetated median area that is separated from the open woodland of Kumbatine National Park by a local two-lane road.

The Giant Barred Frog was specifically nominated as a species that may 'possibly' (RMS 2016) use C36.40. Given the constructed state of C36.40, the intermittent water flow within the underpass and in the drainage line connecting to the underpass, and the absence of habitat within the underpass to facilitate movement (including shelter such as leaf litter, vegetation, rocks and logs), it is considered unlikely that this species would use this underpass. The nearest baseline record is from Maria River, approximately 500 metres to the north (Lewis 2014).

As mentioned, it is considered that animals captured on remote cameras within the underpass are using the underpass to complete successful crossings. Koalas have therefore been recorded completing safe crossings at three of the 14 underpasses at which it is a target species, and the Spotted-tail Quoll has been recorded completing a safe crossing at one of 10 underpasses at which it is a target species.

Table 6: Recorded EPBC species in underpasses

Season	Underpass	Date	Time	Species	Position	Direction
Autumn	C36.40	28/05/2018	2:43:37	Spotted-tailed Quoll	Ground	West
Spring/summer	F33.40	23/11/2018	5:41:47	Koala	Ground	East
Spring/summer	F11.67	24/11/2018	23:16:54	Koala	Ground	East
Spring/summer	F9.70	16/12/2018	11:06:19	Koala	Ground	East

3.4 Non-EPBC Target Species

Non-EPBC target threatened species include the Green-thighed Frog (*Litoria brevipalmata*) and Brush-tailed Phascogale (*Phascogale tapoatafa*).

3.4.1 Presence of indicator species

The Green-thighed Frog was specifically nominated as a species that may 'possibly' (RMS 2016) use F33.40 and C36.40. Indicator species for this target species include those species listed within the frog fauna group, however no amphibians were detected at any of the underpasses during the 2018/2019 monitoring periods. F33.40 is located approximately 150 metres (western side of carriageway) and 250 metres (eastern side of carriageway) south of Green-thighed Frog ponds constructed as part of the Project's mitigation requirements for this species, in proximity to a site where the species was recorded during targeted surveys (Site 16, Lewis 2013). However, no Green-thighed Frogs have been recorded at these ponds during the two monitoring events undertaken by Niche as part of the Project's Green-thighed Frog pond monitoring in 2016/2017 and 2018/2019 (Niche 2017a; Niche 2018a). It should be noted that it is unlikely that, if present, individuals from the identified Site 16 population would travel the required distance to F33.40 (Lemckert and Slatyer 2002). C36.40 is within 400 metres of a targeted survey site (Site 17, exact location not provided; Lewis 2013) identified as a likely location for the species and visited during targeted surveys. However, no Green-thighed Frogs were recorded at this site during the targeted surveys. It is therefore considered unlikely that Green-thighed Frogs use C36.40 or F33.40.

Indicator species for the Brush-tailed Phascogale include those species included in the small ground-dwelling mammal fauna group and the arboreal mammal fauna group. While the Brush-tailed Phascogale was not specifically nominated at individual underpasses, for the purpose of assessment, it is assumed that this species is a general target at all underpasses where the small ground-dwelling mammals and/or arboreal mammal fauna groups have been nominated, i.e. at all underpasses. Representatives of the small ground-dwelling fauna group were detected at all underpasses with at least one indicator species at any underpass and representatives of the arboreal mammal group were recorded at seven of the nine nominated underpasses. It is therefore considered that indicator species for the Brush-tailed phascogale have recorded use at all relevant underpasses.

3.4.2 Presence of cover-dependant/low mobility species

Cover dependent fauna, or fauna with low mobility, was not defined within the EMP. As such it has been assumed to include animals whose size is likely to limit dispersal ability and increase predation/exposure risk, i.e. smaller terrestrial fauna species, which have a reduced ability to disperse and greater vulnerability to exposure and predation compared to larger, more mobile species. Cover-dependent and low mobility fauna has been interpreted as including individuals from three fauna groups: frogs, reptiles and small ground-dwelling mammals.

As discussed, at least one indicator species from the small ground-dwelling mammal fauna group were recorded at all nominated underpasses, represented by rodents, antechinus, bandicoots, the Echidna and the Spotted-tailed Quoll; and reptiles were recorded at 13 of the 14 nominated underpasses (excluding F21.24), represented predominantly by the Eastern Water Dragon and Lace Monitor.

Frogs were not recorded using the underpasses. This lack of detection could be attributed to the survey methods and weather conditions at the time of surveys. Hair tubes, remote cameras and limited opportunistic surveys are generally not very effective at detecting small, and often cryptic, amphibian species.

3.5 Use of underpasses by non-native predators

Non-native predators including cats, dogs and foxes, were detected at all of the fourteen monitored underpasses. Table 7 shows the non-native predators recorded using each underpass and the percentage of all identified fauna records that were non-native predators.

Based on previous underpass monitoring outcomes (Sandpiper Ecological 2015, Sandpiper Ecological 2017) and in consultation with North Coast Local Land Services (Biosecurity Manager, *pers. comm.* 2017), it was considered that visitation by non-native predators equating to greater than 25% of visitations to the underpass or visitations by non-native predators on more than 25% of the days monitored, constitutes high use by non-native predators.

Seven of the 14 monitored underpasses showed high use by non-native predators. The highest use was recorded at F1.04, F1.62 and F26.40, with visitation by non-native predators accounting for 53.1%, 43.3% and 36.6% of visitations respectively; the majority of which were Foxes. The exotic predators recorded within C32.35, F33.40 were predominantly Cats, while F34.72 had high visitation by Dogs.

Table 7: Exotic predator use of underpasses

	F1.04	F1.62	C4.46	C7.26	F9.70	F11.67	F20.54	F21.24	F22.32	F26.40	C32.35	F33.40	F34.72	C36.40
Fox (*Vulpes vulpes*)	47	22	8	1	13	0	2	0	4	22	0	2	0	0
Cat (*Felis catus)*	5	4	3	6	8	1	6	5	4	5	6	15	16	3
Dog (*Canis familiaris/dingo*)	0	0	0	0	0	0	8	2	1	7	0	2	26	2
% of visitations	**53.1**	**43.3**	14.5	12.7	21.0	1.8	20.8	20.0	8.0	**36.6**	**30.0**	**35.2**	**34.7**	**27.8**

Bold indicates visitation rate by exotic predators > 25% of all visitations.

3.6 Road Kill

3.6.1 Weekly road kill rate

As part of the road kill monitoring component of the Project, road kill surveys were undertaken in October 2018 (spring) and January 2019 (summer), involving weekly surveys of the entire length of the Project for four weeks in each season. Detailed reporting of these surveys is presented in Niche 2019a. There were a total of 72 road kill records for the spring and summer road kill monitoring events, including 45 in spring and 27 in summer. Baseline surveys recorded 83 animals as road kill during the spring (36 records) and summer (47 records) monitoring events. Table 8 shows a comparison between the average weekly road kill for baseline and the 2018/2019 monitoring events. While spring weekly road kill rates were higher in the 2018/2019 monitoring period (11.3) than during baseline (9.5), summer weekly road kill rates were lower in the 2018/2019 monitoring period (6.8) compared to baseline (11.8) and the overall average weekly road kill rate has decreased from baseline.

3.6.2 Within 200 metres of monitored fauna underpasses

Table 9 shows the road kill records within 200 metres of monitored underpasses during 2018/2019 and baseline monitoring events. There were a total of three road kill records within 200 metres of monitored underpasses during spring and summer 2018/2019 road kill surveys. Two of these records were within 200 metres of C32.35. Baseline road kill surveys recorded five road kill within 200 metres of monitored underpasses including F1.04, F34.72, F22.32 and C7.26.

3.6.3 Threatened species road kill

Table 10 lists the threatened species identified as road kill throughout the Project to date. One Koala was identified as road kill in September 2018 (outside of the monitoring period), within a fenced area of the highway on the northbound left lane near Barry's Creek. The individual likely entered through a flood damaged section of the fauna fencing, which was immediately addressed with temporary repairs by RMS and permanent works completed on the 19 -21 September 2018. No other target species were identified as road kill during the 2018/2019 monitoring period. However it should be noted that road kill surveys are undertaken from a vehicle travelling at 80 kilometres per hour, without an opportunity to stop due to safety restrictions. The ability to positively identify small fauna (including frogs and small ground-dwelling mammals) is therefore highly limited.

The baseline monitoring report (Lewis 2014) states that, based on baseline Koala road kill records, "*the baseline count for road kill should be set at 1 individual per 8 weeks*". Koala road kill has therefore not increased from the baseline count.

Table 8: Average weekly road kill rate comparison

Monitoring period		Spring (n)	Summer (n)	2018/2019 (n)
Baseline	**2013/2014**	9.0 (4)	11.8 (4)	10.4 (8)
Operational	**2018/2019**	11.3 (4)	6.8 (4)	9.0 (8)

n = number of surveys

Table 9: Road kill within 200 metres of monitored fauna underpasses

Event	Season	Species	Native/Introduced	Fauna category	Underpass	Distance (metres)
2018/2019	Spring	Medium Mammal	unknown	Medium ground dwelling mammal	C32.35	136.8
2018/2019	Summer	Medium Mammal	unknown	Medium ground dwelling mammal	F21.24	31.9
2018/2019	Summer	Kangaroo	native	Large ground dwelling mammal	C32.35	54.3
Baseline	Autumn	Brushtail Possum	native	Arboreal Mammal	F1.04	67.0
Baseline	Spring	Lace Monitor	native	Reptile	F34.72	77.8
Baseline	Spring	Koala	native	Arboreal Mammal	F22.32	117.3
Baseline	Summer	Eastern Grey Kangaroo	native	Large ground dwelling mammal	C7.26	150.4
Baseline	Summer	Red-necked Wallaby	native	Large ground dwelling mammal	F22.32	150.5

Table 10: Threatened species road kill to date

Monitoring type (report)	Monitoring period	Threatened species identified as road kill (number recorded)
Baseline (Lewis 2014)	2013-2014	• Koala (1*) • Grey-headed Flying Fox (2)
Clearing (Niche 2015)	2014-2015	• Koala (4) • Grey-headed Flying Fox (1) • Masked Owl (2) • Spotted-tail Quoll (1)
Construction (Niche 2016)	2015-2016	• Koala (3)
Construction (Niche 2017b)	2016-2017	• Koala (2)
Construction (current)	2017-2018	Nil
Operational	2018-2019	• Koala (1)

* = An additional three Koala road kill were recorded between August 2013 and February 2014, outside of the monitoring period.

4. Discussion

4.1 Performance Measures

A summary and discussion of the 2018/2019 fauna underpass monitoring results in relation to the performance measures is provided in Table 11.

Table 11: Performance measures

Performance measure	Discussion
Complete safe crossing of the crossing by the targeted EPBC species at sufficient frequency to ensure that habitat connectivity is maintained or improves from baseline conditions, and ongoing population viability by providing opportunity for species dispersal and re-colonisation when all monitoring events are considered at Year 8.	**This performance measure cannot be assessed to the level specified in the EMP due to lack of data**. The crossing frequency required to determine effective habitat connectivity each EPBC species and baseline crossing frequencies are unknown. As such, it is not possible to determine if fauna are crossing with 'sufficient frequency' and therefore it is not possible to use this metric to assess the success of the underpasses. In addition, the monitoring program does not provide a means of measuring dispersal and re-colonisation of species. The role of habitat connectivity in species genetic diversity and population viability is broad, complex, population and species-specific, and beyond the scope of this monitoring program. For example, a larger wider-ranging species may require habitat connectivity over a much broader area to ensure population viability due to the broader distribution of resources when compared to a smaller species with smaller home range areas. The use of the underpasses by fauna, as measured and monitored according to the EMP, can only indicate that the underpasses allow for the opportunity for movement within home ranges, dispersal and/or re-colonisation. This has been met at three underpasses for Koalas and one underpass for the Spotted-tailed Quoll. Monitoring in years 4, 6 and 8 permits the reporting of the frequency of use of underpasses by EPBC target species within specific monitoring periods. These frequencies may be used within the framework of the monitoring program to identify changes in use, for example as species become more familiar with the crossings or seasonal differences. In addition, direction of travel may be used to identify any directional trends over the three prescribed monitoring years. Beyond this, large-scale conclusions cannot be drawn based on the monitoring results. To date, two target EBPC species (Koala and Spotted-tailed Quoll) have been recorded during the 2018/2019 monitoring. The Koala was recorded using three underpasses, each on a single occasion. These events all occurred within the second (spring/summer) monitoring event, which may reflect a developed familiarity with the crossings or the movement seasonality of this species. The Spotted-tailed Quoll was detected using one underpass on a single occasion. The Giant Barred Frog was not detected at the nominated C36.40 and is considered unlikely to be detected at this underpass given the lack of suitable aquatic habitat. Giant Barred Frog monitoring for the Project has however shown that this species is traversing the Pacific Highway within the monitored waterways under bridges (Niche 2018b).
For non-EPBC species, recorded presence of indicator species from nominated classes during underpass monitoring.	**This performance measure has been met for one of the two non-EPBC target threatened species.** Indicator species (small ground-dwelling mammals and/or arboreal mammals) for the Brush-tailed Phascogale were recorded using all underpasses. Indicator species for the Green-thighed Frog were not recorded using the two underpasses where this species was nominated. It is noted that the EMP states that this species may 'possibly' use these underpasses. However it is considered unlikely that the Green-thighed Frog uses the nominated underpasses (F33.40 and C36.40) due to the distance of the identified population from F33.40 and the absence of baseline records in proximity to C36.40.
For non-EPBC species, recorded presence of cover-dependent species or fauna species with low mobility during underpass monitoring.	**This performance measure has been met at the majority of underpasses for two of the three relevant fauna groups.** Cover-dependent and low mobility fauna has been interpreted as including individuals from three fauna groups: frogs, reptiles and small ground-dwelling mammals. • Frogs were not recorded at any underpass. • Reptiles were recorded at 13 of the 14 nominated underpasses (excluding F21.24). • Small ground-dwelling mammals were recorded at all nominated underpasses.
Reduced incidence of road kill from baseline conditions.	**This performance measure has been met.** The annual average weekly road kill rate has decreased slightly from baseline to 2018/2019 operational monitoring (10.4 in baseline *cf.* 9.0 in 2018/2019).

5. Recommendations

5.1 Contingency Measures

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those that are related to the underpass monitoring program are listed and discussed in Table 12.

Table 12: Contingency measures

Potential problem	EMP contingency measure	Discussion of proposed measure
No recorded presence of indicator species from the nominated classes in underpasses.	Commence review/modification of fauna furniture associated with underpasses within two weeks of results reported by ecologist.	Four of the five fauna groups have been detected at the majority of monitored underpasses. Frogs have not been detected using any underpass, however monitoring methods do not favour their detection. Continued monitoring, as per the EMP, will add to the number of records at each underpass. **This contingency measure is not considered relevant at this stage**
No recorded presence of cover- dependent species or fauna species with low mobility in underpasses.	Commence review/modification of habitat (i.e. vegetation composition and structure; type and abundance of natural habitat features) adjoining the underpass within two weeks of results reported by ecologist.	Two of the three relevant fauna groups have been detected using the majority of underpasses. Frogs have not been detected using any underpass, however monitoring methods do not favour their detection. Continued monitoring, as per the EMP, will add to the number of records at each underpass. **This contingency measure is not considered relevant at this stage**
Increased incidence of road kill from baseline conditions, in proximity to underpasses, particularly target species.	Commence review/modification of frequency and/or timing of monitoring periods within two weeks of results reported by ecologist.	Overall annual weekly road kill rates have decreased slightly in 2018/2019 compared to baseline monitoring. 2018/2019 monitoring recorded three road kill within 200 metres of monitored underpasses (F21.24 and C32.35) and baseline monitoring recorded five road kill within 200 metres of four different underpasses (F1.04, F34.72, F22.32 and C7.26). There has not been an increase in road kill in proximity to monitored underpasses. One target species (the Koala) was recorded as road kill during the 2018/2019 monitoring period, which does not represent an increase from previous target species road kill records. The baseline monitoring report (Lewis 2014) states that, based on baseline Koala road kill records, "*the baseline count for road kill should be set at 1 individual per 8 weeks*". Koala road kill has therefore not increased from the baseline count. **This contingency measure is not considered relevant.**
Inferior results compared to baseline surveys for the EPBC species, relevant to reference site monitoring.	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.	Comparison of underpass records with EPBC species reference site monitoring may be undertaken only at a superficial level due to the different means of data collection of the different monitoring components. Koalas were recorded along the entire length of the Project during baseline surveys (Lewis 2014). The Koala was recorded using three underpasses in areas where the Koala had recorded presence during baseline surveys (Niche 2019b). Ongoing monitoring of the underpasses may provide additional data regarding use of underpasses by the Koala along the length of the Project. The Spotted-tailed Quoll was not recorded during baseline surveys (Niche 2018c) but was recorded using one nominated underpass during the 2018/2019 fauna underpass monitoring. The Giant Barred Frog has been recorded traversing the Project under constructed bridges at locations where it was recorded during baseline surveys (Niche 2018b), but not using the nominated underpass, which is considered unlikely to provide suitable habitat for this species. **This contingency measure is not considered relevant.**

5.2 Recommendations

This report presents the results of the first of three monitoring events, as such continued monitoring as per the EMP is recommended and is likely to increase the number of species detected. While specific recommendations have not been made, the considerations provided in Table 13 may assist the program in meeting its performance measures.

Table 13: Recommendations

Problem identified	Discussion/Recommendations and actions
Absence of use of the fauna underpasses by key target EBPC species	• Consideration could be given to extending the camera monitoring period to increase the opportunity for detecting EPBC species. • The likelihood of detecting the Green-thighed Frog and other amphibians using current survey methods is low. Consider undertaking targeted frog surveys during/following suitable weather conditions to determine the use of underpasses by amphibians.
Absence of some fauna groups from select underpasses.	
Lack of evidence of use by frog species.	
High visitation/usage rates by exotic predators	Non-native predators including cats, dogs and foxes, were detected at all of the fourteen monitored underpasses. Seven of the 14 monitored underpasses showed high use by non-native predators, F1.04, F1.62, F26.40, C32.35, F33.40, F34.72 and C36.40. • Consider consulting with Local Land Services concerning control methods for foxes and dogs in the area, focusing on those underpasses where these fauna have been recorded, notably, F1.04, F1.62, F26.40, F33.40, F34.72 and C36.40.

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Annex 1 – Camera Results

Table 14: 2018/2019 remote camera records – F1.04, F1.62, C4.46, C7.26, F9.70, F11.67 and F20.54

Underpass	F1.04		F1.62		C4.46		C7.26		F9.70		F11.67		F20.54	
Fauna group / Species	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**
Small ground-dwelling mammals														
Antechinus sp.				Y (1)		Y (6)								Y (1)
Bandicoot	Y (1)	Y (1)				Y (2)						Y (9)		Y (17)
Northern Brown Bandicoot (*Isoodon macrourus*)														Y (4)
Long-nosed Bandicoot (*Perameles nasuta*)												Y (4)		Y (3)
Echidna (*Tachyglossus aculeatus*)								Y (2)			Y (1)	Y (2)		
Spotted-tailed Quoll (*Dasyurus maculatus*)*														
Rattus fuscipes										Y (1)				
Rattus spp.	Y (8)		Y (12)		Y (4)				Y (6)	Y (24)				Y (2)
Rodent/Marsupial	Y (2)	Y (2)	Y (4)		Y (1)				Y (1)					
Arboreal mammals														
Brushtail Possum		Y (2)			Y (5)	Y (35)			Y (1)			Y (11)		
Common Brushtail Possum (*Trichosurus vulpecula*)						Y (1)			Y (1)					
Koala														
Koala (*Phascolarctos cinereus*)*										Y (1)		Y (1)		
Macropods														
Eastern Grey Kangaroo (*Macropus giganteus*)	Y (1)	Y (3)	Y (3)				Y (1)	Y (2)		Y (7)	Y (1)			Y (11)
Macropod sp.							Y (1)							

Underpass	F1.04		F1.62		C4.46		C7.26		F9.70		F11.67		F20.54	
Fauna group / Species	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**
Swamp Wallaby (*Wallabia bicolor*)														Y (1)
Wallaby											Y (1)			Y (5)
Reptiles														
Blue-tongue Lizard (*Tiliqua scincoides*)														
Eastern Water Dragon (*Intellagama lesueurii*)		Y (4)		Y (3)		Y (7)		Y (31)		Y (2)				Y (4)
Lace Monitor (*Varanus varius*)		Y (9)						Y (5)		Y (1)		Y (14)		Y (5)
Snake										Y (1)				
Other														
Microbat														Y (3)
Unk Mammal	Y (1)									Y (1)				
Rattus rattus			Y (11)		Y (2)	Y (1)	Y (2)	Y (4)	Y (10)	Y (22)			Y (3)	Y (2)
Raven (*Corvus* sp.)					Y (1)									
Wood Duck (*Chenonetta jubata*)														
Fox (*Vulpes vulpes*)	Y (36)	Y (11)	Y (22)		Y (8)			Y (1)	Y (9)	Y (4)			Y (2)	
Hare (*Lepus europeaus*) / Rabbit (*Oryctolagus cuniculus)*		Y (5)										Y (1)		
Cat (*Felis catus*)	Y (5)		Y (4)		Y (3)		Y (4)	Y (2)	Y (8)		Y (1)		Y (1)	Y (5)
Wild Dog (*Canis lupus*)													Y (7)	Y (1)

Y = detected; (n) = number of records; * = EPBC target species

Table 15: 2018/2019 remote camera records – F21.24, F22.32, F26.40, C32.35, F33.40, F34.72 and C36.40

Underpass	F21.24		F22.32		F26.40		C32.35		F33.40		F34.72		C36.40	
Fauna group / Species	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**
Small ground-dwelling mammals														
Antechinus sp.				Y (1)		Y (2)					Y (2)			
Bandicoot		Y (16)		Y (32)	Y (1)	Y (2)		Y (1)		Y (1)			Y (1)	Y (1)
Northern Brown Bandicoot (*Isoodon macrourus*)		Y (2)		Y (2)						Y (3)				
Long-nosed Bandicoot (*Perameles nasuta*)		Y (3)												
Echidna (*Tachyglossus aculeatus*)														
Spotted-tailed Quoll (*Dasyurus maculatus*)*													Y (1)	
Rattus sp.		Y (1)	Y (2)	Y (1)						Y (8)				
Rodent/Marsupial				Y (1)	Y (1)				Y (1)	Y (1)	Y (4)			
Arboreal mammals														
Brushtail Possum				Y (9)				Y (1)				Y (14)		
Common Brushtail Possum (*Trichosurus vulpecula*)				Y (1)								Y (2)		
Koala														
Koala (*Phascolarctos cinereus*)*										Y (1)				
Macropods														
Grey Kangaroo (*Macropus giganteus*)				Y (4)	Y (1)	Y (1)				Y (1)		Y (17)		Y (4)
Macropod sp.					Y (6)	Y (2)								
Swamp Wallaby (*Wallabia bicolor*)				Y (2)	Y (1)	Y (4)								
Wallaby	Y (1)	Y (4)		Y (4)	Y (18)		Y (2)							
Reptiles														
Blue-tongue Lizard (*Tiliqua scincoides*)										Y (1)				

Underpass	F21.24		F22.32		F26.40		C32.35		F33.40		F34.72		C36.40	
Fauna group / Species	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**	**autumn**	**spring/ summer**
Eastern Water Dragon (*Intellagama lesueurii*)								Y (7)	Y (7)			Y (6)	Y (1)	Y (1)
Lace Monitor (*Varanus varius*)				Y (28)		Y (12)				Y (4)	Y (6)	Y (24)	Y (1)	Y (2)
Other														
Microbat				Y (2)			Y (1)							
Rattus rattus		Y (1)	Y (12)	Y (1)	Y (5)				Y (6)	Y (1)	Y (4)			
Unk Mammal			Y (1)											
Raven (*Corvus* sp.)														
Wood Duck (*Chenonetta jubata*)								Y (2)						
Fox (*Vulpes vulpes*)			Y (4)		Y (19)	Y (3)			Y (2)					
Hare (*Lepus europeaus*) / Rabbit (*Oryctolagus cuniculus)*						Y (2)								
Cat (*Felis catus*)	Y (4)	Y (1)		Y (4)	Y (2)	Y (3)	Y (5)	Y (1)	Y (7)	Y (8)	Y (10)	Y (6)	Y (3)	
Wild Dog (*Canis lupus*)	Y (1)	Y (1)		Y (4)	Y (7)					Y (2)	Y (22)	Y (4)	Y (2)	

Y = detected; (n) = number of records; * = EPBC target species

Table 16: Autumn 2018 camera details

Underpass	Camera	Operating for entire period (Y/N)	Install date	Retrieve date	Operational days	Location	Direction facing (E/W)	Number of fauna records	Note
F1.04	423	No	27/03/2018	29/05/2018	58	top	W	0	Last photo triggered 25/05/2018
F1.04	449	Yes	27/03/2018	29/05/2018	60+	bottom	W	61	
F1.62	445	Yes	27/03/2018	29/05/2018	60+	top	E	27	
F1.62	432	Yes	27/03/2018	29/05/2018	60+	bottom	W	29	
C4.46	428	Yes	27/03/2018	29/05/2018	60+	both	E/W	14	
C4.46	415	No	08/05/2018	29/05/2018	unk	bottom	W	10	Deployed late due to unfinished underpass
C4.46	435	No	27/03/2018	07/05/2018	unk	top	W	0	Malfunction collected 7/5 and replaced 8/5.
C7.26	447	No	27/03/2018	29/05/2018	48	top	W	3	Last photo false trigger on the 15/5/19
C7.26	443	Yes	27/03/2018	29/05/2018	60+	bottom	E	5	
F9.7	430	Yes	27/03/2018	31/05/2018	60+	top	E	19	
F9.7	425	Yes	27/03/2018	31/05/2018	60+	bottom	E	17	
F11.67	431	Yes	27/03/2018	31/05/2018	60+	bottom	E	4	
F11.67	174	No	27/03/2018	31/05/2018	56	top	E	0	Last photo triggered 23/05/2018
F20.54	426	Yes	27/03/2018	31/05/2018	60+	top	W	4	
F20.54	433	Yes	27/03/2018	31/05/2018	60+	bottom	E	10	
F21.24	399	Yes	27/03/2018	31/05/2018	60+	bottom	E	6	
F21.24	398	Yes	27/03/2018	31/05/2018	60+	top	E	0	
F22.32	424	Yes	27/03/2018	31/05/2018	60+	bottom	W	7	
F22.32	440	No	27/03/2018	31/05/2018	52	top	E	12	Last photo triggered 19/05/2018
F26.4	400	Yes	28/03/2018	31/05/2018	60+	bottom	E	55	
F26.4	436	No	28/03/2018	31/05/2018	30	top	E	5	Camera malfunction
C32.35	444	Yes	28/03/2018	31/05/2018	60+	bottom	W	5	
C32.35	438	Yes	28/03/2018	31/05/2018	60+	bottom	E	3	
F33.4	60	No	28/03/2018	31/05/2018	unk	bottom	W	9	Camera malfunction

Underpass	Camera	Operating for entire period (Y/N)	Install date	Retrieve date	Operational days	Location	Direction facing (E/W)	Number of fauna records	Note
F33.4	397	Yes	28/03/2018	31/05/2018	60+	top	E	14	
F34.72	65	Yes	28/03/2018	31/05/2018	60+	bottom	E	42	
F34.72	401	Yes	28/03/2018	31/05/2018	60+	top	E	6	
C36.4	67	No	28/03/2018	31/05/2018	30	bottom	E	2	Camera malfunction
C36.4	175	Yes	28/03/2018	31/05/2018	60+	bottom	W	6	

Table 17: Spring/summer 2018/2019 camera details

Underpass	Camera #	Operating for entire period (Y/N)	Install date	Retrieve date	Operational days	Location	Direction facing (E/W)	Number of fauna records	Notes
F1.04	174	Y	31/10/2018	23/11/2018	60+	top	W	1	Malfunction. Replaced batteries 23/11/18
F1.04	400	Y	31/10/2018	23/01/2019	60+	bottom	W	36	
F1.62	448	Y	31/10/2018	23/01/2019	60+	top	W	4	
F1.62	379	N	31/10/2018	stolen	Stolen	bottom	W	0	
C4.46	446	Y	31/10/2018	23/01/2019	60+	top	W	48	Middle culvert
C4.46	166	Y	31/10/2018	23/01/2019	60+	bottom	W	4	Middle culvert
C7.26	370	Y	31/10/2018	23/01/2019	60+	top	W	34	23/11/18 batteries replaced
C7.26	436	Y	31/10/2018	23/01/2019	60+	bottom	W	13	
F9.7	386	Y	30/10/2018	24/01/2019	60+	top	E	51	Camera was moved (11/11/18) to face wall. Repositioned 23/11/18.
F9.7	175	Y	30/10/2018	24/01/2019	60+	bottom	E	13	Camera was moved (11/11/18) to face wall. Repositioned 23/11/18.
F11.67	179	N	30/10/2018	24/01/2019	unk	top	E	0	23/11/18 battery change and lowered camera sensitivity due to excessive false triggers. Camera malfunction taking constant photos.
F11.67	383	Y	30/10/2018	24/01/2019	60+	bottom	E	52	
F20.54	374	Y	30/10/2018	24/01/2019	60+	top	E	10	
F20.54	428	Y	30/10/2018	24/01/2019	60+	bottom	E	53	
F21.24	415	Y	31/10/2018	22/01/2019	60+	top	W	1	
F21.24	431	Y	31/10/2018	22/01/2019	60+	bottom	W	28	
F22.32	423	Y	30/10/2018	22/01/2019	60+	top	W	13	
F22.32	369	Y	30/10/2018	22/01/2019	60+	bottom	W	80	
F26.4	173	Y	30/10/2018	24/01/2019	60+	top	E	3	
F26.4	440	Y	30/10/2018	24/01/2019	60+	bottom	E	30	

Underpass	Camera #	Operating for entire period (Y/N)	Install date	Retrieve date	Operational days	Location	Direction facing (E/W)	Number of fauna records	Notes
C32.35	445	Y	30/10/2018	23/01/2019	60+	bottom	E	2	
C32.35	176	Y	30/10/2018	23/01/2019	60+	bottom	W	10	
F33.4	376	Y	30/10/2018	23/01/2019	60+	top	E	5	
F33.4	411	Y	30/10/2018	23/01/2019	60+	bottom	E	26	
F34.72	441	Y	30/10/2018	23/01/2019	60+	top	E	15	
F34.72	398	Y	30/10/2018	23/01/2019	60+	bottom	E	58	
C36.4	416	Y	31/10/2018	16/01/2019	60+	bottom	E	8	Possibly not functioning prior to 22/11
C36.4	372	Y	31/10/2018	16/01/2019	60+	bottom	W	1	Possibly not functioning prior to 22/11

Annex 2 – Field Data

Table 18: Sand plot survey results - autumn 2018 and spring 2018/2019

Species	C7.26	C4.46	C32.35	C36.40
Fox	Y	Y	Y	
Rodent	Y	Y	Y	Y
Bird		Y		
Cat		Y	Y	Y
Brushtail Possum	Y	Y		Y
Bandicoot			Y	
Lace Monitor				Y
Water Dragon	Y	Y	Y	Y
Skink/Small Lizard				Y
Macropod				Y
Reptile	Y	Y		Y
Mammal				Y
Unknown		Y		Y

Y = detected

Table 19: Tracks and scats results - autumn 2018 and spring 2018/2019

Underpass	F1.04		F1.62		C4.46		C7.26		F9.70		F11.67		F20.54		C32.35		C36.40	
Fauna group/Species	**A**	**S**	**A**	**S**	**A**	**S**	**A**	**S**	**A**	**S**	**A**	**S**	**A**	**S**	**A**	**S**	**A**	**S**
Bandicoot					T													
Macropod		T						T			T	T			T			T
Microbat						C, I	C								C		C	
Rodent					C,T		C		C									
Reptile						I		T							C		C	C
Dog	T											T		T				
Deer	T	T	T															
Cat															T			

S = spring/summer, A = autumn, I = observed, C = scat, T = track

Table 20: Species detected by hair tube surveys

Underpass	F1.04		F1.62		C4.46		C7.26		F11.67		F20.54		F21.54		F26.40		C32.35		F33.40		F34.72	
Species	**A**	**S**	**A**	**S**	**A**	**S**	**A**	**S**	**A**	**S**	**A**	**S**	**A**	**S**	**A**	**S**	**A**	**S**	**A**	**S**	**A**	**S**
Rattus sp.							Y										Y					
Rodent	Y								Y		Y		Y		Y		Y		Y			
Macropod			Y																			
Trichosurus sp.						Y												Y				Y

S = spring/summer, A = autumn, Y = detected

Table 21: Hair tube results - autumn 2018 and spring 2018/2019

Season	Underpass	Location	# of tubes	Deploy date	Retrieve date	Tubes with hair (samples sent for ID)	Species ID definite	Species ID probable
autumn	1.04	underpass	6	27/03/2018	12/04/2018	2	One hair	Rodent
autumn	1.04	adjacent	4	27/03/2018	12/04/2018	1	One hair-no ID	
autumn	1.62	underpass	6	27/03/2018	12/04/2018	0		
autumn	1.62	adjacent	4	27/03/2018	12/04/2018	2	One hair	Macropod
autumn	4.46	underpass	6	Fauna furniture incomplete - hair tubes not deployed				
autumn	4.46	adjacent	4	Fauna furniture incomplete - hair tubes not deployed				
autumn	7.26	underpass	6	27/03/2018	12/04/2018	1	One hair-no ID	
autumn	7.26	adjacent	4	27/03/2018	12/04/2018	1	Two rodent hairs	*Rattus* sp.
autumn	9.7	underpass	6	27/03/2018	12/04/2018	1	One hair-no ID	
autumn	9.7	adjacent	4	27/03/2018	12/04/2018	0		
autumn	11.67	underpass	6	27/03/2018	12/04/2018	1	One hair	Rodent
autumn	11.67	adjacent	4	27/03/2018	12/04/2018	1	One hair-no ID	
autumn	20.54	underpass	6	27/03/2018	12/04/2018	1	One hair	Rodent
autumn	20.54	adjacent	4	27/03/2018	12/04/2018	0		
autumn	21.24	underpass	6	27/03/2018	12/04/2018	1	One hair	Rodent
autumn	21.24	adjacent	4	27/03/2018	12/04/2018	0		
autumn	22.32	underpass	6	27/03/2018	12/04/2018	1	One hair-no ID	
autumn	22.32	adjacent	4	27/03/2018	12/04/2018	0		
autumn	26.4	underpass	6	28/03/2018	12/04/2018	1	One hair	Rodent
autumn	26.4	adjacent	4	28/03/2018	12/04/2018	1	One hair	Rodent
autumn	32.35	underpass	6	28/03/2018	12/04/2018	1	Two fine hairs	Rodent
autumn	32.35	adjacent	4	28/03/2018	12/04/2018	1	Two rodent hairs	*Rattus* sp.
autumn	33.4	underpass	6	28/03/2018	12/04/2018	1	One hair	Rodent
autumn	33.4	adjacent	4	28/03/2018	12/04/2018	1	One hair-no ID	
autumn	34.72	underpass	6	28/03/2018	12/04/2018	0		
autumn	34.72	adjacent	4	28/03/2018	12/04/2018	1	One hair-no ID	
autumn	36.4	underpass	6	28/03/2018	12/04/2018	1	One hair-no ID	
autumn	36.4	adjacent	4	28/03/2018	12/04/2018	0		
spring/summer	1.04	underpass	6	31/10/2018	19/11/2018	0		
spring/summer	1.04	adjacent	4	31/10/2018	19/11/2018	0		
spring/summer	1.62	underpass	6	31/10/2018	19/11/2018	0		
spring/summer	1.62	adjacent	4	31/10/2018	19/11/2018	0		
spring/summer	4.46	underpass	6	31/10/2018	19/11/2018	1	*Trichosurus* sp.	*T. vulpecula*
spring/summer	4.46	adjacent	4	31/10/2018	19/11/2018	4	*Trichosurus* sp.	*T. vulpecula*
spring/summer	7.26	underpass	6	31/10/2018	19/11/2018	0		
spring/summer	7.26	adjacent	4	31/10/2018	19/11/2018	0		
spring/summer	9.7	underpass	6	30/10/2018	19/11/2018	0		
spring/summer	9.7	adjacent	4	30/10/2018	19/11/2018	0		
spring/summer	11.67	underpass	6	30/10/2018	19/11/2018	0		

Season	Underpass	Location	# of tubes	Deploy date	Retrieve date	Tubes with hair (samples sent for ID)	Species ID definite	Species ID probable
spring/summer	11.67	adjacent	4	30/10/2018	19/11/2018	0		
spring/summer	20.54	underpass	6	30/10/2018	19/11/2018	0		
spring/summer	20.54	adjacent	4	30/10/2018	19/11/2018	0		
spring/summer	21.24	underpass	6	31/10/2018	19/11/2018	0		
spring/summer	21.24	adjacent	4	31/10/2018	19/11/2018	0		
spring/summer	22.32	underpass	6	30/10/2018	19/11/2018	0		
spring/summer	22.32	adjacent	4	30/10/2018	19/11/2018	0		
spring/summer	26.4	underpass	6	30/10/2018	19/11/2018	0		
spring/summer	26.4	adjacent	4	30/10/2018	19/11/2018	0		
spring/summer	32.35	underpass	6	30/10/2018	19/11/2018	0		
spring/summer	32.35	adjacent	4	30/10/2018	19/11/2018	1	Few hairs	*Trichosurus* sp.
spring/summer	33.4	underpass	6	30/10/2018	19/11/2018	0		
spring/summer	33.4	adjacent	4	30/10/2018	19/11/2018	0		
spring/summer	34.72	underpass	6	31/10/2018	19/11/2018	5	*Trichosurus* sp.	*T. vulpecula*
spring/summer	34.72	adjacent	4	31/10/2018	19/11/2018	3	*Trichosurus* sp.	*T. vulpecula*
spring/summer	36.4	underpass	6	31/10/2018	19/11/2018	0		
spring/summer	36.4	adjacent	4	31/10/2018	19/11/2018	0		

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