Frederickton to Eungai

2019 Annual Ecological Monitoring Report

Roads and Maritime Services | February 2020

NSW GOVERNMENT

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Contents

Introduction

Purpose

This report provides an update on the ecological issues associated with the Frederickton to Eungai Pacific Highway upgrade. This report covers the period of 1 December 2018 to 30 November 2019. This report has been prepared in accordance with the Ecological Monitoring Program: Frederickton to Eungai (Roads and Maritime 2016), for submission to the Department of Planning Industryand Environment and Environment Protection Authority (EPA). This report includes Hairy Joint Grass, *Maundia triglochinoides*, aerial crossing, nest box, fauna underpass and road kill monitoring undertaken in 2019. This report represents the final annual report to be submitted for the operational ecological monitoring for the F2E project in accordance with the approved ecological monitoring program.

Statutory and planning framework

Approval for the Kempsey to Eungai Pacific Highway upgrade was granted by the State Government on 10 July 2008. Kempsey to Eungai Pacific Highway upgrade is being delivered in two stages with Stage One extending from Kempsey to Frederickton and Stage Two extending from Frederickton to Eungai. This report focuses on ecological monitoring associated with Stage Two, known as the Frederickton to Eungai project.

The Kempsey to Eungai Pacific Highway upgrade approval included the requirement to develop an ecological monitoring program:

Prior to the commencement of construction, the Proponent shall develop and implement a Monitoring Program to target the effectiveness of the mitigation measures identified in Condition 2.10(d) for the listed threatened species directly impacted by the project. The program shall include (but not necessarily be limited to) the monitoring of Maundia triglochinoides, Green-thighed Frog, Glossy Black Cockatoo and the Brush-tailed Phascogale. The Program shall be developed in consultation with the DECCW and suitably qualified ecologist(s) and shall include but not necessarily be limited to:

a) the monitoring of threatened species in and adjacent to the project footprint. The methodology shall be decided in consultation with DECCW;

b) an adaptive monitoring program to assess the effectiveness of the mitigation measures identified in Condition 2.10 (d) and allow their modification if necessary. The monitoring program shall include targets against which effectiveness will be measured;

c) monitoring shall be undertaken during construction (for construction-related impacts) and from opening of the project to traffic (for operation/ongoing impacts) until such time as the effectiveness of mitigation measures can be demonstrated to have been achieved over a minimum of three successive monitoring periods, or as otherwise agreed by the Director General in consultation with DECCW;

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

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

f) provision for annual reporting of monitoring results to the Director General and the DECCW, or as otherwise agreed by those agencies.

The Program shall be submitted to the Director General prior to the commencement of construction and shall be updated to incorporate the monitoring methodology for threatened species, once agreed to, in accordance with condition of this approval.

The initial Ecological Monitoring Program: Frederickton to Eungai was approved by the Department of Planning & Environment on 25 July 2013. This was updated in 2016 and approved by the Department of Planning & Environment on 30 June 2016.

The ecological monitoring program includes the provision for annual reporting to the Director General and EPA.

Appendix A Hairy Joint Grass

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Environment and Heritage

Hairy Joint Grass Monitoring 2018/2019

Frederickton to Eungai Pacific Highway Upgrade

Prepared for Roads and Maritime Services

August 2019

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Document control

Project no.:	1702 (6.1)
Project client:	Roads and Maritime Services
Project office:	Port Macquarie
Document description:	Hairy Joint Grass Monitoring 2018/2019
Project Director:	Rhidian Harrington
Project Manager:	Radika Michniewicz
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Internal review:	Radika Michniewicz, Amanda Griffith
Document status:	Rev1
Local Government Area:	Kempsey

Document revision status

Author	Revision number	Internal review	Date issued
Jodie Danvers	D1	Radika Michniewicz	11/07/2019
Jodie Danvers	D2	Radika Michniewicz	24/07/2019
Radika Michniewicz	D3	Amanda Griffith	30/07/2019
Radika Michniewicz	R0		5/08/2019
Radika Michniewicz	R1		2/10/2019

Cover photograph: Site Photo (left) and Hairy Joint Grass (right) at impact plot 1HE autumn 2019.

Executive Summary

Context

This report documents the 2018/2019 monitoring period, the fifth and final monitoring cycle for Hairy Joint Grass (HJG, *Arthraxon hispidus*), as required by the Frederickton to Eungai (F2E) Ecological Monitoring Program (EMP, RMS 2016).

Aims

The aims of this report are to summarise the methods and results of the 2018/2019 monitoring, provide an overall discussion of all monitoring events and determine if performance measures have been met, as per the EMP.

Methods

HJG populations are known to occur at two locations within the Project corridor. In accordance with the EMP, these populations were monitored at four sites, including three potential impact sites and one control site. At each site ten 4 m^2 quadrats were surveyed and the following information was recorded for each quadrat:

- Plant species present and relative cover of all species using the Braun-Blanquet scale
- The extent of flowering and/or seeding HJG
- Signs of disturbance (i.e. cattle), sedimentation and to what extent/area
- A photo taken from a designated photo point.

Key results

During the 2018/2019 monitoring period HJG was recorded at two of the impact sites (1HE and 2HW), but was not recorded at 3CN or 3HN. Flowering/seeding and recruitment was observed at both 1HE and 2HW where the species was detected. The species remained absent from impact site 3HN, where it has never been detected, and from control site 3CN where it has not been recorded since 2016/2017.

Conclusions

A substantial decrease in HJG records and flowering/seeding over successive monitoring events was observed at site 2HW. However this cannot be attributed directly to the Project as the previously identified paired control site could not be accessed subsequent to the first monitoring period.

Management implications

Ongoing monitoring is not recommended for HJG due to the lack of control sites from which conclusions could be drawn. While it is not possible to directly attribute the reduction in presence and cover abundance of HJG to works associated with the Project due to the absence of control sites, it is considered likely that changes in land use associated with the Project have resulted in changes in species composition, habitat suitability and increased competition for HJG. Given the new and ongoing land use and maintenance regime of impact sites will not change, and that concurrent management of adjacent areas within private land is unlikely to occur, management actions are unlikely to be effective in the long term.

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1. Introduction

1.1 Context

As part of the Frederickton to Eungai (F2E) Pacific Highway Upgrade Project (the Project), Roads and Maritime Services (Roads and Maritime) have implemented an Ecological Monitoring Program (hereafter referred to as the 'EMP') in accordance with the Minister for Planning's Condition of Approval (MCoA) No. 3.1. This EMP (RMS 2016) combines the approval conditions provided within the MCoA and Statement of Commitments (SoC), and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project.

Hairy Joint Grass (HJG, *Arthraxon hispidus*) was one threatened species identified as requiring mitigation and monitoring through the course of the Projects' construction and operational period. The monitoring requirements for this species are outlined within the EMP.

1.1.1 Legal status

HJG is listed as vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act) and the New South Wales *Biodiversity Conservation Act* 2016 (BC Act). HJG is in the family Poaceae (grasses) and has a global distribution. The genus *Arthraxon* contains about 25 species and is distributed across parts of Asia, India and Africa. HJG itself is considered an invasive weed in North America. In Australia the species is distributed from around Kempsey northwards.

1.1.2 Monitoring framework

The EMP states the following regarding monitoring:

"Monitoring would commence in the summer-autumn of 2014 and be undertaken three times a year up between the start of summer to the end autumn until 2019." [sic]

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

- *February, April and May 2015*: Niche 2016.
- *December 2015, February and April 2016*: Niche 2017a.
- *December 2016, February and May 2017*: Niche 2017b.
- *December 2017, February and April 2018*: Niche 2018.
- *December 2018, January and April 2019:* current report.

This report therefore represents the fifth and final monitoring report for HJG.

1.1.3 Baseline data

The EMP provides the following baseline data:

"1. Southern population occurs at chainage 24000 and occurred over a mapped extent of 3.71 ha in March 2012 (Richards 2012). The Project will remove approximately 0.55 ha with a further 0.27 ha retained within the Project corridor which may be subject of indirect impacts including weed invasion, sedimentation, changed in hydrology and soil eutrophication. The existing landuse is pasture production for beef and cattle grazing with this area supporting Kikuyu, Paspalum, Carpet Grass and Bladey Grass. Fertilizer applications in the form of super phosphate were historically applied to this area up until about 2007. The western boundary of the mapped extent extends into the North Coast Railway Corridor which contains rank grassland and early successional plants such as Acacia.

2. Northern population occurs at chainage 29500 and occurred over a mapped extent of 2.43 ha in March 2012 (Richards 2012). The Project was re aligned to avoid the majority of this population. Fence line clearing for the Project will remove approximately 0.007 ha. A further 0.027 ha is retained within the Project corridor which may be subject of indirect impacts. The existing landuse is pasture production for beef cattle grazing with this area supporting Paspalum, Carpet Grass and occasionally Kikuyu and White Clover. Fertilizer applications in the form of super phosphate are not known at this location.

At both locations, the plants occur sporadically throughout the mapped extend with Braun-Blanquet scale ranging from r (<<<1(solitary, insignificant cover) to 2 (10-25%) in 2 x 2 m quadrants (4m^2).” [sic]

1.1.4 Purpose of this report

This report complies with the monitoring requirements described within the EMP and details the findings obtained from the fifth and final monitoring event.

The aims of this report are to summarise the methods and results of the 2018/2019 monitoring, provide an overall discussion of all monitoring events and determine if performance measures have been met, as per the EMP.

1.2 Performance measures

The EMP specifies the following performance indicators for HJG:

Indicators of success will focus on the following:

- *Exclusion fencing with signage identifying ‘no go’ zones (during construction)*
- *Sediment control fencing in place and working effectively (during the construction period)*
- *Review of the design of drainage and planning of works (during the construction period)*
- *Flowering and/or seeding is consistent with paired control or previous monitoring results.*

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

- *Breached exclusion fencing (during construction)*
- *No signage identifying the sensitive nature of the location as threatened species habitat (during construction)*
- *A significant (if statistics are used) or substantial difference (i.e. 15% allowance) between the paired monitoring sites or impact only monitoring sites with regard to flowering/seeding and overall extent or recruitment.*

1.3 Monitoring timing

As per the EMP, monitoring was undertaken three times a year, between the start of summer and the end of autumn.

1.4 Reporting

Annual reporting of monitoring results will outline:

- A description of the monitoring methodology employed
- Results of the monitoring surveys
- A discussion of the results, including how the results compare against key performance criteria
- The need for any corrective actions/contingency measures and any general recommendations.

All reports prepared under the EMP will be submitted to the 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 were encountered during the current monitoring period:

- The 3CN control site is considered to be unsuitable to be used in statistical comparisons with the other sites due to the difference in the condition treatment of this site (3CN site is grazed) that may itself result in any differences seen.
- Due to the broad cover abundance range within each Braun-Blanquet score, it is not possible to determine whether a substantial difference has occurred between sites where the Braun-Blanquet Scale score of '3' (i.e. 5-25% cover) or above has been applied, as the percent range exceeds the 15% threshold for detecting change. A smaller percent cover score (e.g. 1-5% increments) should be considered for future monitoring to improve the detectability of change.

2. Survey Methods

2.1 Survey sites

Six monitoring sites were originally identified for HJG monitoring (Lewis 2013). These included three potential impact sites (located within the Project boundary) and a paired control site (located outside of the Project boundary). However, following the completion of the first (February 2015) surveys (where all six sites were monitored), two of the three paired control sites could not be surveyed as landholder agreements for access had not been secured. In accordance with the EMP these two control sites have been removed from the monitoring program. The locations of the four remaining monitoring sites are provided in Figure 1 and detailed in Table 1. Future monitoring of the 3CN control site is subject to landowner agreement (RMS 2016).

Table 1: Details of potential impact sites and control site

Monitoring site	Chainage/ Location	Easting	Northing	Site type	Side of Carriageway	No. 2 x 2m Quadrats	Landholder Access Agreement Status
1HE	24000	487175	6576696	potential impact	East	10	Not required
2HW	24000	487173	6576695	potential impact	West	10	Not required
3HN	29500	491349	6580096	potential impact	North	10	Not required
3CN	29500	491261	6580161	control	North	10	Access granted

2.2 Survey method

Monitoring was undertaken in December 2018 (summer 1), January 2019 (summer 2) and April 2019 (autumn). At each site 10 4 m^2 quadrats were surveyed and the following information was recorded for each quadrat:

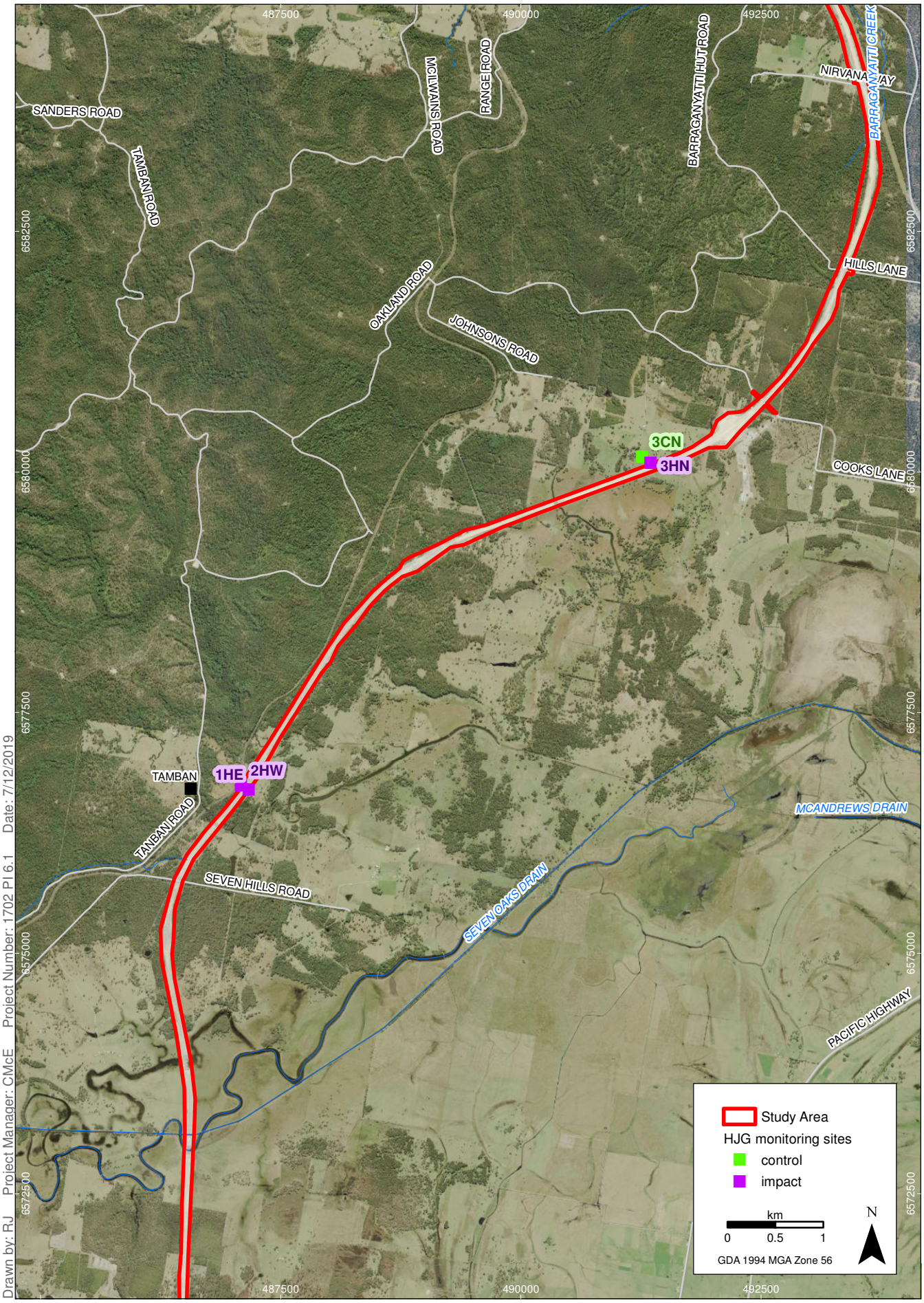
- Plant species present and relative cover of all species using the Braun-Blanquet scale (Table 2)
- The extent of flowering and/or seeding HJG
- Signs of disturbance (i.e. cattle), sedimentation and to what extent/area
- A photo taken from a designated photo point.

Table 2: Braun-Blanquet cover abundance scale used in each 4 m^2 quadrat

Score	Cover Abundance Category
1	1-5% cover – rare
2	1-5% cover – common
3	6-25% cover
4	26-50% cover
5	51-75% cover.
6	76-100% cover

2.3 Analysis of data

Statistical analyses have not been performed due to the lack of paired control sites. In addition, the 3CN control site is considered to be unsuitable to be used in statistical analyses due to the difference in the condition treatment of this site (3CN site is grazed) that may itself result in any differences seen. Instead, the latest monitoring results for each of the four sites were compared with previous monitoring results and assessed for substantial differences (15% allowance) in flowering/seeding and overall extent or recruitment. It should however be noted that due to the broad cover abundance range within each Braun-Blanquet score, it is not possible to determine whether a substantial difference has occurred using the Braun-Blanquet Scale score of '3' (i.e. 5-25% cover) or above between neighbouring scores, as the percent range exceeds the 15% threshold for detecting "substantial change". As such, these scores cannot be used to determine a change. Instead, where appropriate and possible, the difference in the percentage of quadrats recording HJG, flowering/seeding and recruitment has been calculated and used to determine a substantial change between monitoring years.



F2E Hairy Joint Grass Monitoring Locations

Pacific Highway Upgrade – Frederickton to Eungai

FIGURE 1

Imagery: (c) LPI 2014-09-18

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3. Results

3.1 Monitoring results

Field data is provided in Annex 1 and a summary of the results is provided in Table 3, Table 4 and Table 5. Substantial decreases between successive monitoring events (> 15%) are highlighted in bold. Results of photo monitoring are provided in Annex 2.

3.1.1 HJG presence/cover abundance

HJG was recorded at two of the impact sites (1HE and 2HW) during the 2018/2019 monitoring period but was not recorded at impact site 3HN or control site 3CN.

Site 1HE

HJG was recorded within three quadrats during summer 1 surveys and one quadrat during autumn surveys. HJG has been recorded at site 1HE during at least two surveys each monitoring year. Cover abundance and total number of quadrats with HJG (from 0 to 5 quadrats during any one survey) have been consistently low over successive years.

Site 2HW

HJG was recorded within two, two and one quadrat during summer 1, summer 2 and autumn surveys respectively. HJG has been recorded at this site during all monitoring events, with a cover abundance score ranging from 1 (present, uncommon) to 3 (6-20%). Total number of quadrats with HJG has decreased over all the monitoring events: 2014/2015 (n = 25, 83%), 2015/2016 (n = 23, 77%), 2016/2017 (n = 20, 67%), 2017/2018 (n = 9, 30%) and 2018/2019 (n = 5, 17%). **This equates to a substantial decrease (>15%) in the number of quadrats with HJG between the 2014/2015 and 2017/2018 monitoring events and again between the 2016/2017 and 2018/2019 monitoring events.** Graph 2 also illustrates a general decreasing trend in average cover abundance at this site. Substantial decreases observed at site 2HW cannot be attributed directly to the Project as the control site is not available for comparison.

Site 3HN

HJG remained absent from impact site 3HN. The site contained thick introduced grass cover consistent with the results of the previous monitoring periods (see Annex 2).

Site 3CN

While data is not available for all surveys during previous monitoring events due to private property access restrictions, **there has been a substantial decrease in the observed presence of HJG at the control site.** HJG was recorded in only a single quadrat in the 2016/2017 surveys and not at all in the 2017/2018 and current 2018/2019 surveys, compared to at least nine quadrats in each of the previous years' surveys. Site 3CN has been heavily grazed. It is unclear if changes in private land management practices have coincided with the absence of this species from monitoring plots.

Effect of potential competitive species

Clumping and matting of grasses, such as Whisky Grass (*Andropogon virginicus*) and dense growth of grasses such as *Imperata cylindrica* may provide competition with HJG and prevent its growth. Graph 1 and Graph 2 show the average cover abundance score for three dominant species (*I. cylindrica*, *Pterideum esculentum*, and *A. virginicus*) recorded at sites 1HE and 2HW, where HJG is still being recorded. As there is substantial variation in cover abundance scores these graphs act only to illustrate a general trend in average scores. Both *I. cylindrica* and *P. esculentum* have shown an increasing trend in cover abundance at both sites until Year 4;

Year 5 (current monitoring period) showed a slight decrease. *A. virginicus* appears to have decreased in cover abundance from Year 2/3 to the present year at both sites. While cover abundance of HJG has been consistently low at site 1HE, levels have decreased substantially at site 2HW over the course of the monitoring program. It is difficult to determine any interaction effects at site 1HE due to the consistently low cover abundance of the species at that site across all monitoring periods. At site 2HW, while there has been an increase in the cover abundance of two of the three other dominant species at the site, it is not clear if this is related to the observed decrease in HJG.

3.1.2 Flowering/seeding and recruitment

During the 2018/2019 monitoring flowering/seeding and recruitment was observed at both sites 1HE and 2HW where the species was detected. Substantial decreases between successive monitoring events (> 15%) are highlighted in bold.

Site 1HE

Flowering/seeding was recorded in autumn only. Recruitment was observed during all surveys in each of the quadrats where the species was recorded.

Site 2HW

Flowering/seeding was recorded in autumn only. Recruitment was observed during all surveys in each of the quadrats where the species was recorded. Total quadrats recording flowering/seeding has decreased over all monitoring events: 2014/2015 (n = 8, 27%), 2015/2016 (n = 6, 20%), 2016/2017 (n = 2, 7%), 2017/2018 (n = 1, 3%) and 2018/2019 (n =1, 3%). **This equates to a substantial decrease (> 15%) in the flowering/seeding records between the 2014/2015 and 2016/2017 and the 2014/2015 and 2018/2019 monitoring events.** Recruitment at this site also decreased between 2015/2016 (n = 10, 33%) and 2016/2017 (n = 4, 13%) but increased in 2017/2018 (n = 6, 20%) and was similar in 2018/2019 (n = 5, 17%). Substantial decreases observed at site 2HW cannot be attributed directly to the Project as the control site is not available for comparison.

Site 3HN

Flowering/seeding and recruitment has not been recorded at this site during any monitoring event.

Site 3CN

While data is not available for all surveys during previous monitoring events due to private property access restrictions, flowering has been recorded during a single survey at site 3CN in 2015/2016, which resulted in a **substantial decrease in the flowering/seeding recorded between 2015/2016 (n = 8, 27%) monitoring and the 2016/2017 (n = 0), 2017/2018 (n = 0) and 2018/2019 (n = 0) monitoring periods at the control site.** Similarly, recruitment was previously recorded during a single survey in 2015/2016, but has not been recorded since at the control site. These changes relate to the apparent absence of the species from this site since 2015/2016. The land management activities at this site preclude the use of site 3CN as a control site for comparison. As such, observed changes at this site have not been used in the discussion of outcomes at the impact sites.

Table 3: Summary of Hairy Joint Grass monitoring results – presence/abundance

Site	Number of quadrats containing HJG															Cover abundance scores for quadrats with HJG (mean ± se)													
	2014/15			2015/16			2016/17			2017/18			2018/19			2014/15			2015/16			2016/17			2017/18			2018/19		
	Summer 1	Autumn 1	Autumn 2	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Autumn 1	Autumn 2	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn
1HE	1	1	1	0	1	5	4	0	1	1	1	2	3	0	1	2	2	1	0	0.2 ±0.2	1.1 ±0.4	1.5 ±0.3	0	1	3	2	1.5 ±0.5	1.7 ±1.7	0	2
2HW	**9**	**8**	**8**	6	8	9	**8**	**7**	**5**	**5**	**2**	**2**	2	2	1	2.5 ±0.2	1.9 ±0.2	1.1 ±0.2	0.9 ±0.3	2±0.3	2.4 ±0.4	1.9 ±0.1	1.9 ±0.3	1	1.6 ±0.2	1.5 ±0.5	2±0.0	2.5 ±0.5	1.0 ±0.0	2
3HN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3CN	10	ND	ND	9	10	10	1	0	0	0	0	0	0	0	0	1.5 ±0.2	ND	ND	1.7 ±0.3	3.4 ±0.2	2.8 ±0.2	1	0	0	0	0	0	0	0	0

ND = No data due to private property access restrictions.

Table 4: Flowering/seeding and recruitment

Site	Flowering/seeding (no. of quadrats)															Recruitment (no. of quadrats)													
	2014/15			2015/16			2016/17			2017/18			2018/19			2014/15			2015/16			2016/17			2017/18			2018/19		
	Summer 1	Autumn 1	Autumn 2	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Autumn 1	Autumn 2	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn
1HE	0	1	0	0	0	1F	0	0	0	0	0	2F	0	0	1	0	0	0	0	0	1	0	0	0	1	1	2	3	0	1
2HW	0	**8**	0	0	0	6S	**1F**	0	**1F**	0	0	**1F**	0	0	1	0	0	3	**6**	0	**4**	**1**	**3**	0	2	2	2	2	2	1
3HN	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3CN	0	ND	ND	0	0	8S	0	0	0	0	0	0	0	0	0	0	ND	ND	0	0	3	0	0	0	0	0	0	0	0	0

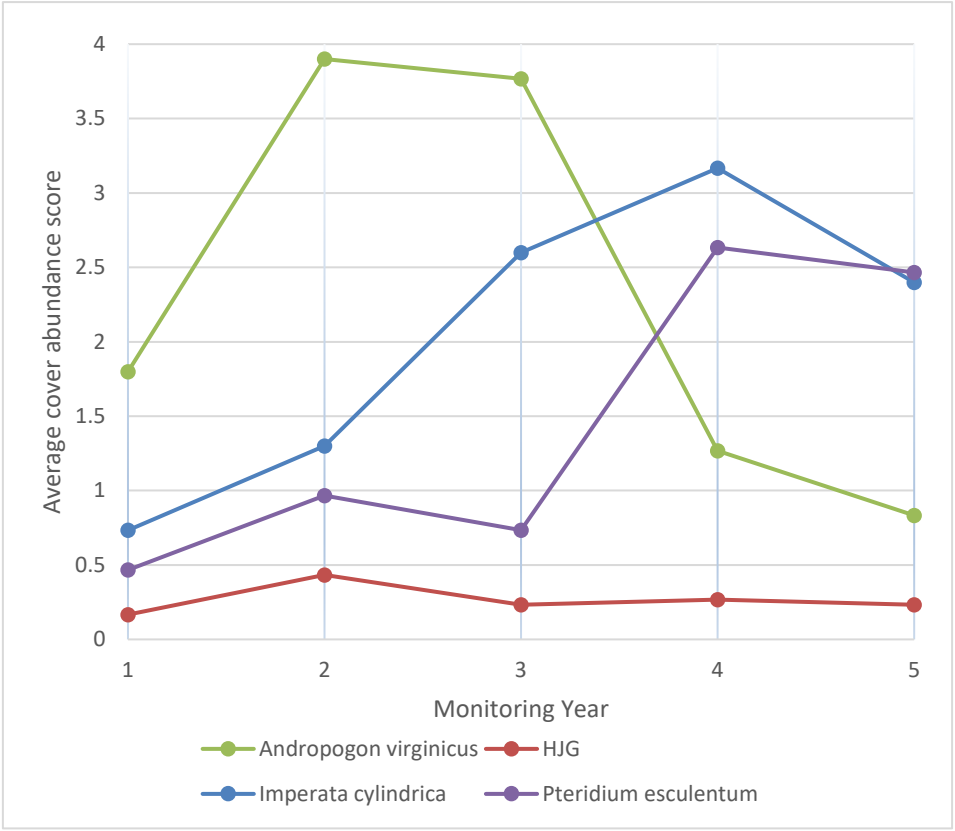
S=Seeding, F=Flowering, ND = No data due to private property access restrictions.

Table 5: Summary of quadrat results

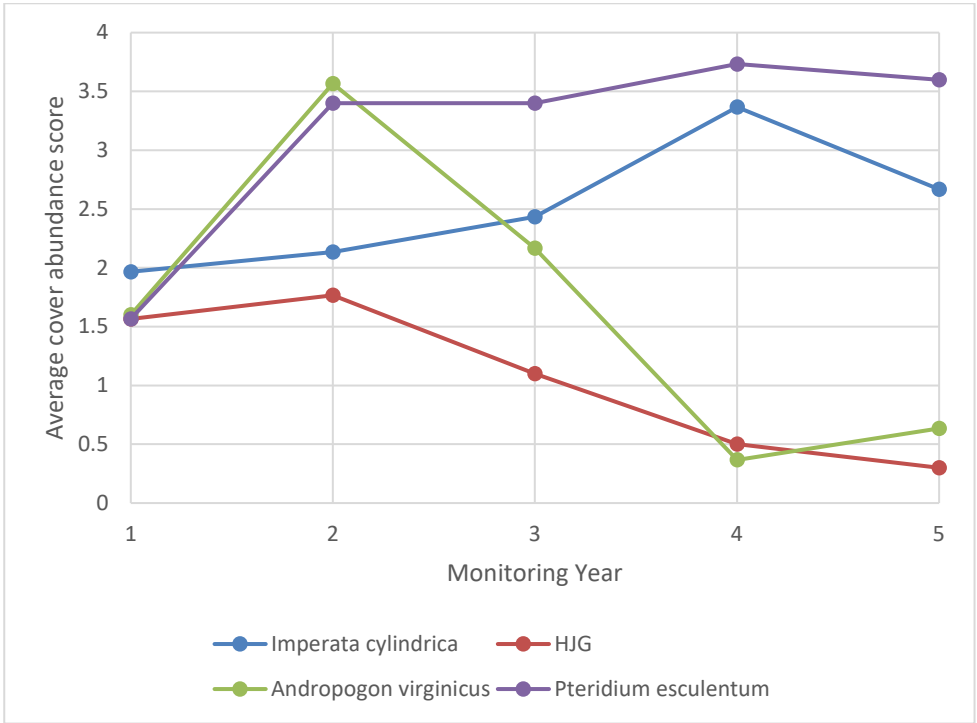
Site	Percent of quadrats with HJG					Percent of quadrats with flowering/seeding					Percent of quadrats with recruitment				
	2014/15	2015/16	2016/17	2017/18	2018/19	2014/15	2015/16	2016/17	2017/18	2018/19	2014/15	2015/16	2016/17	2017/18	2018/19
1HE	10% (3)	20% (6)	17% (5)	13% (4)	13% (4)	3% (1)	3% (1)	0% (0)	7% (2)	3% (1)	0% (0)	3% (1)	0% (0)	13% (4)	13% (4)
2HW	**83%** (25)	77% (23)	**67%** (20)	**30%** (9)	**17%** (5)	**27**% (8)	20% (6)	**7%** (2)	**3%** (1)	**3%** (1)	10% (3)	**33%** (10)	**13%** (4)	20% (6)	17% (5)
3HN	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)	0% (0)
3CN	100% (10)*	**97%** (29)	**3%** (1)	0% (0)	0% (0)	0% (0)	**27%** (8)	**0%** (0)	0% (0)	0% (0)	0% (0)	10% (3)	0% (0)	0% (0)	0% (0)

(n) = number of quadrats; * = only summer 1 surveys undertaken due to access restrictions

Graph 1: Average annual cover abundance of dominant species at impact site 1HE



Graph 2: Average annual cover abundance of dominant species at impact site 2HW



4. Discussion

4.1 Performance measures

A discussion of the 2018/2019 monitoring results in relation to the performance measures is provided in Table 6. As discussed previously (Section 2.3), the 3CN control site is considered unsuitable for use in statistical comparisons due to the difference in the management of this site (3CN site is grazed) that may itself result in any differences seen. As such control site 3CN has been excluded from the discussion of performance indicators. Instead, the latest monitoring results for each of the four sites are compared with previous monitoring results and assessed for substantial differences (15% allowance) in flowering/seeding and overall extent or recruitment.

Table 6: Indicators of success

Indicators of success	Discussion
Exclusion fencing with signage identifying 'no go' zones (during construction).	This performance indicator no longer applies as the construction period is complete and this section of the highway is now operational.
Sediment control fencing in place and working effectively (during the construction period).	This performance indicator no longer applies as the construction period is complete and this section of the highway is now operational.
Review of the design of drainage and planning of works (during the construction period).	This performance indicator no longer applies as the construction period is complete and this section of the highway is now operational.
Flowering and/or seeding is consistent with paired control or previous monitoring results.	**This performance indicator has been met for all sites except Site 2HW.** At site 2HW total quadrats with flowering/seeding plants has decreased with each monitoring event, with a substantial decrease observed between the 2014/2015 and 2016/2017 monitoring events, and also between the 2017/2018 and 2018/2019 monitoring events. Substantial decreases observed at site 2HW cannot be attributed directly to the Project as the control site is not available for comparison.

Table 7: Signs of the habitat protection procedure not working

Signs of habitat protection procedure not working	Discussion
Breached exclusion fencing (during construction).	This performance indicator no longer applies as the construction period is complete and this section of the highway is now operational.
No signage identifying the sensitive nature of the location as threatened species habitat (during construction).	This performance indicator no longer applies as the construction period is complete and this section of the highway is now operational.
A significant ($p<0.05$) or substantial difference (i.e. 15% allowance) between the paired monitoring sites or impact only monitoring sites with regard to flowering/seeding and overall extent or recruitment.	Comparisons between control and impact sites cannot be made due to the sites being exposed to different treatments which may confound the results (see Section 2.3). Comparisons between impact sites are similarly not suitable due to differences in site treatments and ecological variables. Comparison between monitoring events at the same sites has therefore been used to detect differences in HJG presence/seeding and recruitment over time. To this end, this performance indicator of unsuccessful mitigation has not been met for sites 1HE and 3HN (i.e. there was no substantial difference in presence, flowering/seeding or recruitment between successive surveys) **however it has been met for Site 2HW.** There were substantial decreases in the number of quadrats in which HJG was recorded and the flowering/seeding for 2HW between the 2014/2015 and the 2016/2017, 2017/2018 and 2018/2019 monitoring events. Recruitment increased in 2017/2018, however decreased slightly from 2017/2018 to 2018/2019. Substantial decreases in HJG observed at site 2HW cannot be attributed directly to the Project as the control site is not available for comparison.

5. Recommendations/Discussion

As stated previously, control site 3CN has not been used for impact-control statistical comparisons within monitoring events. Likewise, overall seasonal trends observed for control site 3CN cannot be used to identify non-impact related trends due to the differences in land use between this site and the impact sites and the lack of other control sites. As such, recommendations provided below are based only on within-site data and comparisons.

5.1 Contingency measures

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those that are considered to be relevant to the HJG monitoring program are listed and discussed in Table 8.

Table 8: Potential problems and contingency measures proposed for HJG

Potential Problem	Contingency Measures proposed in EMP	Relevance of contingency measure
Residual area of HJG impacted by construction works (i.e. clearing, habitat damage), sedimentation	Review the exclusion fencing Review extent of signage used to demarcate the habitat protection zone Review clearing procedures	This is no longer relevant as construction is complete.
Significant difference ($p < 0.05$ level) in flowering/seeding and/or extent of relative cover between control sites and treatment sites, or over consecutive monitoring events with impact only monitoring sites.	Review drainage (local hydrological patterns) Review the need for additional management such as mowing and removal of mulch.	**These contingency measures are considered relevant to Site 2HW only**. Substantial decreases were found for the HJG quadrat records and flowering/seeding between successive monitoring events at this site.

5.2 Recommendations

The recommendations provided in Table 9 aim to address the outcome of the final monitoring results with reference to all previous monitoring events.

The EMP states that "*Monitoring shall be undertaken during construction (for construction-related impacts) and from opening of the project to traffic (for operation/ongoing impacts) until such time as the effectiveness of mitigation measures can be demonstrated to have been achieved over a minimum of three successive monitoring periods, or as otherwise agreed by the Director-General in consultation with DECCW*".

Site 2HW has shown progressive substantial reductions in the presence of HJG. However, ongoing monitoring of this site (and others) would be futile given the lack of control sites for comparison. Ongoing monitoring is therefore not recommended for HJG.

Previous recommendations aimed to enhance existing populations by managing the competitive influence of invasive species, targeting weeds and over abundant native species (Niche 2017b). However Roads and Maritime concluded, with the support of the EPA, that localised weeding would be ineffective in the long-term due to the presence of such species immediately adjacent and their high likelihood of re-establishment. While Roads and Maritime proposed to "*to review the ongoing monitoring before consideration to any actions would be taken*", it is still considered that the above localised management of weeds and over abundant native species would be ineffective in the long term. .

While slashing was undertaken at site 3CN in September 2015 to encourage HJG recruitment (Niche 2016) with the support of NSW EPA, HJG had not previously been recorded at this site, the success of slashing cannot therefore be deduced from this action.

Table 9: Recommendations

Relevant contingency measure	Application	Discussion of contingency measures
Review drainage (local hydrological patterns).	Site 2HW	Local drainage cannot be changed at the site.
Review the need for additional management such as mowing and removal of mulch.	Site 2HW	Without concurrent management of the area immediately adjacent to site 2HW, management actions are unlikely to be effective in the long term.

5.3 Discussion

The construction of the Project has resulted in changes in land use at the impact sites due to shifting of boundary fences, altered grazing regimes and maintenance/slashing regimes, resulting in dense grassy growth, dense Bracken (*Pteridium esculentum*) growth and newly shaded areas in locations.

While it is not possible to directly attribute the reduction in presence and cover abundance of HJG to works associated with the Project due to the absence of control sites, it is considered likely that changes in land use associated with the Project have resulted in changes in species composition, habitat suitability and increased competition for HJG. Given the new and ongoing land use and maintenance regime of impact sites will not change, and that concurrent management of adjacent areas within private land is unlikely to occur, management actions are unlikely to be effective in the long term.

6. References

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Impact site 1HE (*Exotic species) (numbers represent Braun-Blanquet scale cover abundance scores: 1 = present but uncommon; 2 = <5%; 3 = 6-20%; 4 = 21-50%; 5 = 51-75%; 6 = >75%)

Species	Summer 1 (December 2018)										Summer 2 (January 2019)											Autumn (April 2019)								
Quadrat	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
*Anagallis arvensis**										1						1														1
*Andropogon virginicus**	3	4	4																	2				3			3	3		3
Arthraxon hispidus			2			1				2												2								
Carex sp.																1	1	2	1	1										
Casuarina glauca	3	1			3	3	3				1	1			1								3				1	1		2
Centaurium spicatum		1																												
Centella asiatica	1		1																1									2		1
*Cirsium vulgare**			1	1												1														
*Conyza bonariensis**			2	3											1							2	1				1			
*Cyperus brevifolius**																														1
Cyperus sp.*	1																													
Dianella longifolia				1																										
Dichelachne micrantha												1																		
Dichondra repens		1		1																					1		2	1		
Echinopogon ovatus				1													1	2												
Entolasia marginata					1																	2	2			2				
Geranium solanderi																									1					
Glycine clandestina					1		1							1													1			
Glycine tabacina	1		1															1												
Hibbertia scandens							1						1								3									
Hydrocotyle peduncularis	1																													1
*Hypochaeris radicata**			1																											
Imperata cylindrica				4			4	4		4	3	4	3	5	5	4	3		2	3	3	3	2	5	3	3	3		2	

Species	Summer 1 (December 2018)										Summer 2 (January 2019)											Autumn (April 2019)									
Quadrat	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Microlaena stipoides	3	3	3	3	3	3	3	3	4	3	2	1	3	3	2	2	3	3	3	2	3	3	2	3	2		2	3	3	4
Oplismenus aemulus								4	2	3						1	3	3							2				2	1
Oxalis exilis				1	2					1						1	2	1	1									1		1
Pandorea pandorana																			1											
*Pennisetum clandestinum**	3	3																												
*Plantago lanceolata**	2	2	2	1								1				1				1				1				1		2
Pteridium esculentum			3	1		4		3	4	4		2	4	4	2	4	5	5	5		2	4	3	2	5	5			3	
*Senecio madagascariensis**	1		2	2											1	1				1										
*Setaria pumila**																					2									
*Sida rhombifolia**						1	1															2								
*Solanum mauritianum**	1	1																								1				
*Solanum nigrum**					1														1			1								
*Sonchus oleraceus**																				1										
*Verbena rigida**	2	4		2	3		4	4	4	3	3	3	2	2	2		3	3	3		2			2	3	3	2	3	4	2
Viola hederacea																											2			
Veronica sp.																3														

Impact site 2HW (*Exotic species) (numbers represent Braun-Blanquet scale cover abundance scores: 1 = present but uncommon; 2 = <5%; 3 = 6-20%; 4 = 21-50%; 5 = 51-75%; 6 = >75%)

Species	Summer 1 (December 2018)										Summer 2 (January 2019)											Autumn (April 2019)								
Quadrat	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
*Andropogon virginicus**	3											3		2	3				1		4				3					
Arthraxon hispidus				2	3							1			1										2					
Calochlaena dubia																			4						3			2		
Carex sp.											1			1																
Casuarina glauca								1		1				1						3			1					1	1	
Centella asiatica																							1							
Commelina cyanea																		1					1		1		1	1		
Convolvulus sp.							1	2		1										1									1	
*Conyza bonariensis**				1	2		1								3			1							1		1			
*Conyza canadensis**			2																											
*Cyperus brevifolius**						1																								
Dichelachne micrantha																			1											
Dichondra repens	1	1	2	2	2				2						1										2	1	1			
Echinopogon ovatus																						1							2	
Glycine tabacina																								1	1		1	1		
*Hypochaeris radicata**				2																										
Imperata cylindrica		4	4	4	3	3	3	3	5	3		4	3	1		3	5	3	3			3	3	3		4	4	3	3	3
*Lantana camara**																											1			
Microlaena stipoides	3	3	2	3	2	3	3	2	3	2	3	3			2				3	3	2	2	2	2	3	3	3	2	3	2
Oplismenus aemulus				2	2	1									1								2							2
Paspalum dilatatum																					2					3	1			2
*Plantago lanceolata**				1	3	1						1			1										2					2
Pteridium esculentum	1	4	4	4	4	4	4	4	4	4	4	4	5	3	3	4	3	4	4	4	1	4	3	4	3	3	4	5	3	3
*Senecio madagascariensis**					1																									
*Setaria pumila**																									3				2	

Species	Summer 1 (December 2018)										Summer 2 (January 2019)											Autumn (April 2019)								
Quadrat	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
*Sporobolus fertilis**															3										2					
Sonchus oleraceus																												1		
*Verbena bonariensis**																		3												
*Verbena rigida**	4	3	3	3	3	4	3		3	4	4	3	2	4		3	3	2	3	3	4	3	4	3	4	4	3			4

Impact site 3HN (*Exotic species) (numbers represent Braun-Blanquet scale cover abundance scores: 1 = present but uncommon; 2 = <5%; 3 = 6-20%; 4 = 21-50%; 5 = 51-75%; 6 = >75%)

Species	Summer 1 (December 2018)										Summer 2 (January 2018)											Autumn (April 2018)								
Quadrat	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
*Andropogon virginicus**					3																									3
Arthraxon hispidus																														
*Axonopus fissifolius**													3		3						2				2	3			3	
Carex spp.																				3										
Centella asiatica														2											2		1			
Commelina cyanea																					1									
*Conyza bonariensis**													2																	
*Cyperus brevifolius**						1																								
Hydrocotyle peduncularis	2	2	2	2		2	2	2	2	2	3	2	3	2	2	2	2	3	2	2	1	2								
*Hypochaeris radicata**								2																						
Juncus continuus		1				2	1		1		2	2	2					1	2	1		1		1		1				
Juncus usitatus	1	1	1	1	1		1	2		2																				
Medicago polymorpha	4	4		4	4	4	4	3	4	4	3	3	3	3	3	3	3	3	3	3	2	3	3	3	2	3	3	3	3	3
Paspalidium distans								3																						
Paspalum dilatatum	3	3	3	2	4	3			3	3	3	3	4	3	4	3	3	4		3	2		2	2	3	3	3	2	3	
*Pennisetum clandestinum**										3			3	3						4				3	5				3	3
*Plantago lanceolata**	2			2	3	2		2	1	2							2	2					1		1					
Pratia purpurascens																						2								
Ranunculus inundatus		1				1		2																						
*Rumex crispus**																											1			
*Senecio madagascariensis**						1		2		2				2													2		2	2
*Setaria pumila**	3	4	4	4	3	4	4	3		4	5	4	3	4	5	3	3	4	3	3	4	4	5	5	2	3	4	2		
Unknown Grass											4	4	3	4		5	5	3	4	3								5		4

Control site 3CN (*Exotic species) (numbers represent Braun-Blanquet scale cover abundance scores: 1 = present but uncommon; 2 = <5%; 3 = 6-20%; 4 = 21-50%; 5 = 51-75%; 6 = >75%)

Species	Summer 1 (December 2018)										Summer 2 (January 2019)											Autumn (April 2019)								
Quadrat	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Arthraxon hispidus																														
Aria sp.						1																								
*Axonopus fissifolius**	2	2	2	2	3				2	2	2	3	3	2	3	3	3	3	3	3	2	4	4	3	2	3	3	3	2	3
Centella asiatica					1				1	2																	2	1	1	
Commelina cyanea		2										1																		
*Conyza bonariensis**																					2									
Cynodon dactylon						2	2	2	2									3							1	2				
*Cyperus eragrostis**									1																				1	
Echinpogon ovatus	1																													
Geranium solanderi																								2						
*Hypochaeris radicata**	2			1	1			1	2	2	1			1	1	2	2		1	2	2		2		1	1	2	1	1	
Imperata cylindrica																														
Juncus continuus			1		2	2		2	2	1	1				1		1	1	1		1					1			1	
Juncus usitatus	2	1	2	2	2	3			2	2			1													1		1		
Melaleuca quinquenervia							3						1				1													
Microlaena stipoides	1																													
Parsonsia straminea							1																							
Paspalum dilatatum			1						2		2		4	3	3	4	3	4	4	4	5	5		4	4	4	4	4	5	2
*Pennisetum clandestinum**	5	5	5	6	5	5	5	5	6	5	5	5	5	5	5	4	4	4	4	4		3	4	4	3		2	3	3	4
Persicaria sp.																														
*Plantago lanceolata**	1	2	2		2	2		2	2	3	2	1		2	2	2	2	2	2	3	3	1	2	2	5	2	2	2	1	2
Ranunculus inundatus						1																			1					
*Senecio madagascariensis**				1	1					1																		1	1	
*Setaria pumila**	2							2													2	2			2			2		3

Species	Summer 1 (December 2018)										Summer 2 (January 2019)											Autumn (April 2019)								
Quadrat	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
*Sida rhombifolia**											1	2																		
*Solanum nigrum**																					1									1
*Sporobolus fertilis**										1																1	1		2	
*Trifolium repens**	2	2	2	1	3	2	2	2	2	3		1	1	2	2	1	2	2		2		1	2	1	2					2

Annex 2. Photo monitoring

Site 1HE photo monitoring

Year	Summer 1	Summer 2	Autumn
2018/19			
2017/18			

Year	Summer 1	Summer 2	Autumn
2016/17			
2015/16			

Site 2HW photo monitoring

Year	Summer 1	Summer 2	Autumn
2018/19			
2017/18			

Year	Summer 1	Summer 2	Autumn
2018/17			
2015/16			

Site 3HN photo monitoring

Year	Summer 1	Summer 2	Autumn
2018/19			
2017/18			

Year	Summer 1	Summer 2	Autumn
2016/17			
2015/16			

Site 3CN photo monitoring

Year	Summer 1	Summer 2	Autumn
2018/19			Not Available
2017/18			

Year	Summer 1	Summer 2	Autumn
2016/17			
2015/16			

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Appendix B *Maundia triglochinodes*

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Environment and Heritage

Maundia triglochinoides Monitoring 2018/2019

Frederickton to Eungai Pacific Highway Upgrade

Prepared for Roads and Maritime Services

August 2019

Document control

Project no.:	1702 (6.2)
Project client:	Roads and Maritime Services
Project office:	Port Macquarie
Document description:	*Maundia triglochinoides* Monitoring 2018/2019
Project Director:	Dr Rhidian Harrington
Project Manager:	Radika Michniewicz
Authors:	Jodie Danvers
Internal review:	Radika Michniewicz, Luke Baker, Amanda Griffith
Document status:	Rev1
Local Government Area:	Kempsey

Document revision status

Author	Revision number	Internal review	Date issued
Jodie Danvers	D1	Radika Michniewicz	11/7/19
Jodie Danvers	D2	Radika Michniewicz	29/7/19
Radika Michniewicz	D3	Amanda Griffith	6/8/2019
Radika Michniewicz	R0		7/8/2019
Radika Michniewicz	R1		2/10/2019

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Locations

Sydney
Central Coast
Illawarra
Armidale
Newcastle
Mudgee
Port Macquarie
Brisbane
Cairns

Cover photographs: Maundia triglochinoides impact site MI08

Executive Summary

Context

This report documents results of the 2018/2019 monitoring period (including December 2018, January 2019 and April 2019), which is the fifth and final monitoring cycle for *Maundia triglochinoides* (Maundia), as required by the Frederickton to Eungai (F2E) Ecological Monitoring Program (EMP, RMS 2016).

Aims

The aims of this report are to summarise the methods and results of the 2018/2019 monitoring, provide a discussion of all monitoring events and determine if performance measures have been met, as per the EMP.

Methods

The 2018/2019 monitoring methodology is consistent with the methods developed and used in 2016 which includes collection of data within a 50 metre (m) x 2 m belt transect (i.e. 100 m^2) within *Maundia triglochinoides* habitat at each site.

Five paired impact-control and six impact-only monitoring sites were surveyed in accordance with the monitoring method specified in the EMP. In addition, three reference sites have been included in the monitoring program.

Key results

Cover Abundance

Maundia was recorded at each of the sites as follows during the 2018/2019 monitoring period:

- On at least one occasion at three of the five paired impact sites and at four of the five paired control sites
- At all three reference sites
- On at least one occasion at five of the six impact-only sites
- Maundia was not detected at MI03E, MI06, MC06 and MI10 during the 2018/2019 monitoring period.

Recruitment and Flowering/Seeding

Recruitment was recorded at the following:

- At three paired impact sites and four of the paired control sites
- At Reference sites 11 and 12
- At three of the impact-only sites
- Flowering was recorded at two of the five paired impact sites and at three of the paired control sites, at Reference site 12, and at two of the six impact-only monitoring sites.

Conclusions

The performance measure relating to consistent flowering between paired control or nearest reference site was met for all impact sites. However, the performance measure of consistent flowering in relation to previous monitoring was met for six of the 11 impact sites. There were no obvious negative trends at impact sites compared to control sites over the years. As such, the observed changes cannot be confidently or solely attributed to the Project. Others factors that may account for the observed changes in Maundia populations over time and in relation to the paired sites include: the close proximity of paired impact-control sites which may negate their independence; differences in land use and management practices (notably presence of cattle) between the sites.

Management implications

The majority of the observed changes and differences in Maundia populations cannot be confidently or directly attributed to the Project due to environmental factors or natural variations and fluctuations. Ongoing monitoring is therefore not recommended for Maundia.

At site MI05/MC05 recommendations have been made to establish an area that is inaccessible to drainage works and cattle trampling via reparation of boundary fencing and Salvinia control.

At site MI10/MC10 the topography of the land within and adjacent to MI10 was altered considerably to provide for floodwater runoff, creating an altered landscape. While it is not possible to attribute differences between MI10 and MC10 directly to the Project due to differences in land use and vegetation structure, it is considered likely that the changed topography and landscape caused by the engineering design for floodwater runoff has altered the land within and adjacent to MI10 so that it is unlikely to provide suitable habitat for Maundia.

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1. Introduction

1.1 Context

As part of the Frederickton to Eungai (F2E) Pacific Highway Upgrade Project (the Project), Roads and Maritime Services (Roads and Maritime) have implemented an Ecological Monitoring Program (hereafter referred to as the EMP) in accordance with the Minister for Planning's Condition of Approval (MCoA) No. 3.1. This EMP (RMS 2016) combines the approval conditions provided within the MCoA and Statement of Commitments (SoC), and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project.

Maundia triglochinoides (Maundia) was one threatened species identified as requiring mitigation and monitoring through the course of the Projects' construction and operational period. The monitoring requirements for this species are outlined within the EMP.

1.1.1 Legal status

Maundia is listed as vulnerable on the New South Wales *Biodiversity Conservation Act* 2016 (BC Act). Monitoring of the species is required under the Project's approval.

1.1.2 Monitoring framework

The EMP states the following regarding monitoring:

"Monitoring would commence in the summer of Year 2014 and be undertaken three times a year up until Year 2019 of the Project."

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

- *February, April, May 2015*: Niche 2016.
- *December 2015, February, April 2016*: Niche 2017a.
- *December 2016, February, May 2017*: Niche 2017b.
- *December 2017, February 2018, April 2018*: Niche 2018.
- *December 2018, January 2019, April 2019*: current report.

This report therefore documents the 2018/2019 monitoring period (including December 2018, January 2019 and April 2019), which is the fifth and final monitoring cycle for Maundia.

1.1.3 Baseline data

The EMP provides the following background information for the Maundia populations within and adjacent to the Project in relation to the known locations:

"*Maundia triglochinoides populations are known from at least 36 locations within the vicinity (i.e. <2 km) of the Project extending from CH14200 to CH31100 (Lewis 2013). Combined, this mapped extent was estimated at 29.86 ha in March-August 2012. Individual location data is provided in Appendix A (Table A1 and A2)*".

No data detailing relative cover abundance (i.e. Braun Blanquet scores), incidence of flowering/ seeding or recruitment was provided as part of this baseline information.

1.1.4 Purpose of this Report

This report complies with the monitoring requirements described within the approved EMP and details the findings obtained from the fifth and final monitoring event. This report therefore represents the last of five required reports.

The aims of this report are to summarise the methods and results of the 2018/2019 monitoring, provide a discussion of all monitoring events and determine if performance measures have been met, as per the EMP.

1.2 Performance measures

The approved EMP specifies the following performance measures for Maundia:

Indicators of success will focus on the following:

- *Exclusion fencing in place with signage identifying these as 'no go' zones (during construction).*
- *Sediment control fencing in place (during construction).*
- *Flowering and/or seeding is consistent with paired control and/or nearest reference site.*
- *Flowering and/or seeding at impact site is consistent with previous monitoring results.*

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

- *Breached exclusion fencing (during construction).*
- *No signage in place identifying the sensitive nature of the location as threatened species habitat (during construction).*
- *A significant (if statistics are used) or substantial difference (i.e. 15% allowance) between paired monitoring sites (those within and those outside of the Project Area boundary) with regard to flowering/seeding and overall extent or recruitment that cannot be attributed to environmental factors.*
- *A significant (if statistics are used) or substantial difference (15% allowance) between impact monitoring sites over subsequent monitoring events that cannot be attributed to environmental factors.*

1.3 Monitoring timing

The monitoring program specifies that monitoring surveys commence in the summer of Year 2014 (construction phase) and be undertaken three times a year between the beginning of summer and the end of autumn until Year 2019 (operational phase) of the Project.

1.4 Reporting

Annual reporting of monitoring results will outline:

- A description of the monitoring methodology employed
- Results of the monitoring surveys
- A discussion of the results, including how the results compare against key performance criteria
- The need for any corrective actions/contingency measures and any general recommendations.

All reports prepared under the EMP will be submitted to the 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 were encountered during the current monitoring period:

- Other site-specific environmental variables, including shade, soil quality, water temperature, width of the habitat at each monitoring site, flora competition or water flow rate, that may impact upon the population were not recorded as part of the monitoring program.
- Between-year comparisons for cover extent were limited to a range estimate derived from the Braun-Blanquet scale in 2014/2015 surveys.

2. Survey Methods

2.1 Survey sites

Five paired impact-control sites and six impact-only sites were monitored. Each paired site includes one impact location within the Project boundary and one control location outside the Project boundary. Due to access restrictions (Niche 2016), the revised EMP (RMS 2016) excluded control sites MC03E, MC03W, MC04, MC07, MC08 and MC09 from the program. These locations are to be monitored via an impact site only. Site locations are shown in Figure 1, Figure 2 and Figure 3, with details provided in Table 1.

Table 1: Monitoring sites

Site	Chainage (Location)	Easting	Northing	Paired Control plot for potential impact plot	Easting of Control Plot	Northing of Control Plot
MI01	15360 (East)	487671	6568746	MC01 100 m downstream	487723	6568775
MI02	17360 (East)	486650	6570499	MC02 50 m downstream	486727	6570489
MI03E	19200 (East)	486461	6572090	Impact only	n/a	n/a
MI03W	19200 (West)	486546	6572155	Impact only	n/a	n/a
MI04	19950 (West)	486484	6572948	Impact only	n/a	n/a
MI05	20100 (East)	496604	6573123	MC05 100 m downstream	496604	6573123
MI06	20850 (East)	486531	6573953	MC06 100 m downstream	486564	6573899
MI07	23800 (East)	487058	6576563	Impact only	n/a	n/a
MI08	24425 (East)	487403	6577089	Impact only	n/a	n/a
MI09	24450 (West)	487352	6577162	Impact only	n/a	n/a
MI10	30275 (South)	492027	6580246	MC10 50 – 100 m downstream	491981	6580190

n/a = not applicable; m = metres

All sites were surveyed during the three monitoring events in 2018/2019. Three external reference sites (Table 2) were also surveyed. These sites are independent of the Project area with the purpose of comparative monitoring of Maundia populations in the broader area. It is assumed that any change detected at these sites would be unrelated to the impacts of road construction or operation. Due to access restrictions (Niche 2016), the revised EMP (RMS 2016) excluded site 13- Old Stock Dam from future monitoring, and the previous Site 14 (Tamban Road) has become the "new" Site 13 in the EMP. For comparative purposes across monitoring/reporting events, reports continue to refer to this site as Site 14 (Tamban Road).

Table 2: Reference sites

Site	Easting	Northing	Reference site name
11	490652	6581695	Cols Causeway
12	484393	6571941	Collombatti-Tamban Road
14	486641	6576627	Tamban Road

2.2 Survey method

As per the modified methodology in Niche 2016, the 2018/2019 monitoring was undertaken within a 50 metre (m) x 2 m belt transect (i.e. 100 m^2) within Maundia habitat at each site. Cover abundance was recorded as percent cover using 5% increments to be able to identify a "substantial difference" (i.e. 15% difference, as per the EMP) between paired monitoring sites. This modified methodology was presented in Niche 2016 and allows for improved data collection and analysis whilst still complying with the EMP. The modified methodology is consistent with the Native Vegetation Interim Standard (NVIS) for estimating number of stems and percent cover of plant species along a transect. Every two metres, a 2 m x 2 m quadrat was established along the transect (i.e. at 0 m to 2 m, 2 m to 4 m etc.), where the number of Maundia individuals, flowering, seeding and percent cover were recorded. The following data was collected at each of the monitoring quadrats:

- Number of Maundia individuals
- The extent of flowering or seeding
- Signs of recruitment (i.e. recruiting individuals)
- Percent cover of Maundia using 5% increments
- Average water depth
- Signs of disturbance (i.e. cattle) and to what extent/area
- Photo from installed specific photo point.

Where a 50 m belt transect could not be achieved due to site geometry or boundary limitations, the transect was extended as far as possible and recorded.

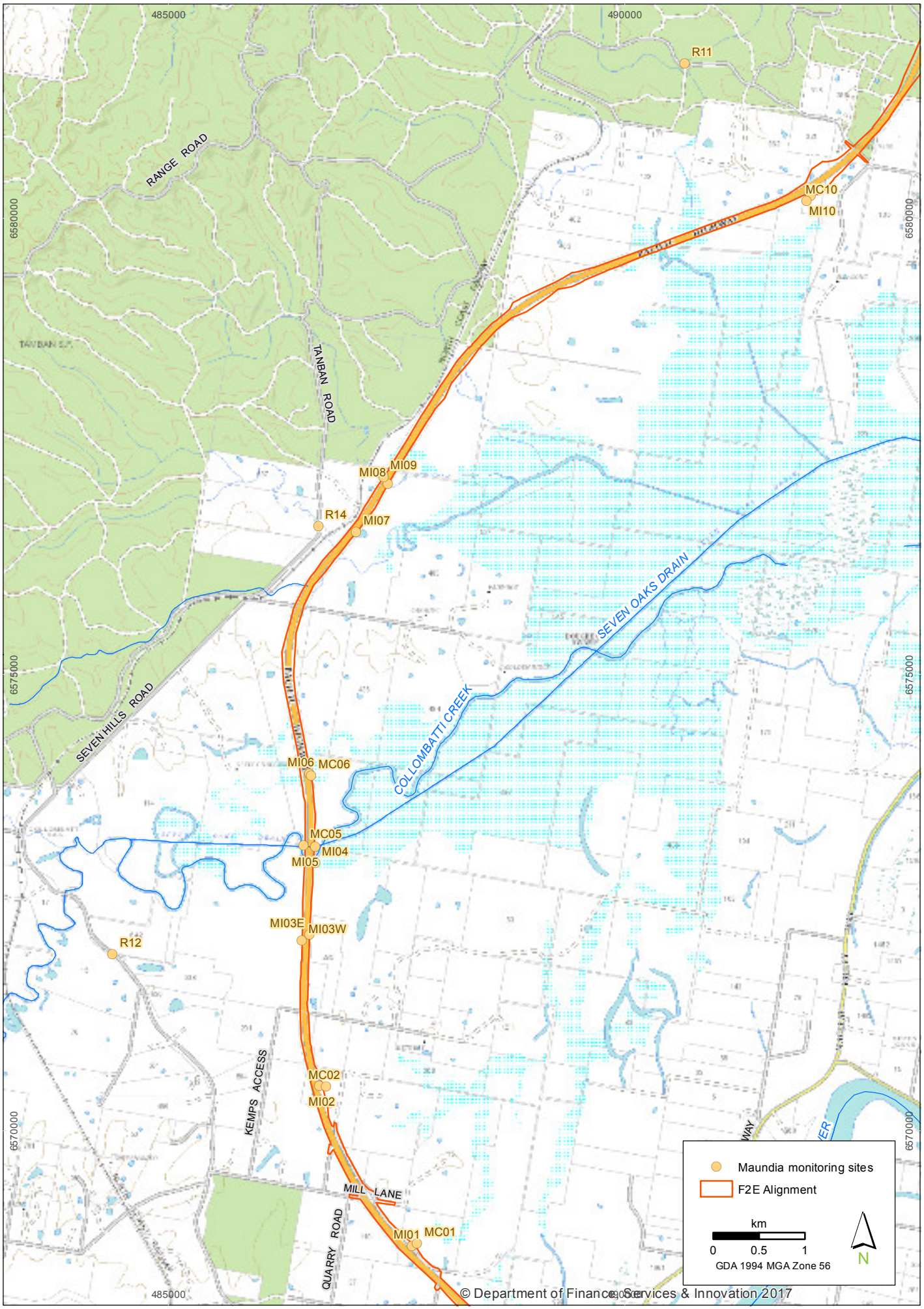
2.3 Analysis

The EMP specifies the following approach to the data analysis.

"*For those sites subject to paired impact, control monitoring, a paired t test or a non-parametric equivalent (i.e. Mann Whitney) will be used to explore the usefulness of statistics in comparing the data set*."

Despite the existence of statistical tests that can analyse non-parametric data, most statistical tests assume that you have a sample of independent observations (including Mann Whitney), meaning that observations must be independent in space and time. Many of the paired impact-control sites established in the EMP are spatially close to each other and are considered unlikely to be independent. Control sites are located downstream of their paired impact site and would also be subject to upstream impacts. This lack of independence means that the use of statistical analyses for these data is not appropriate and a substantial difference (i.e. 15% allowance) (as per the performance measures provided in the EMP) has been used as the basis for identifying changes.

In addition, land use and management practices may vary between control and impact sites, such as exposure to grazing. Differences in land use and management may influence any observed changes.



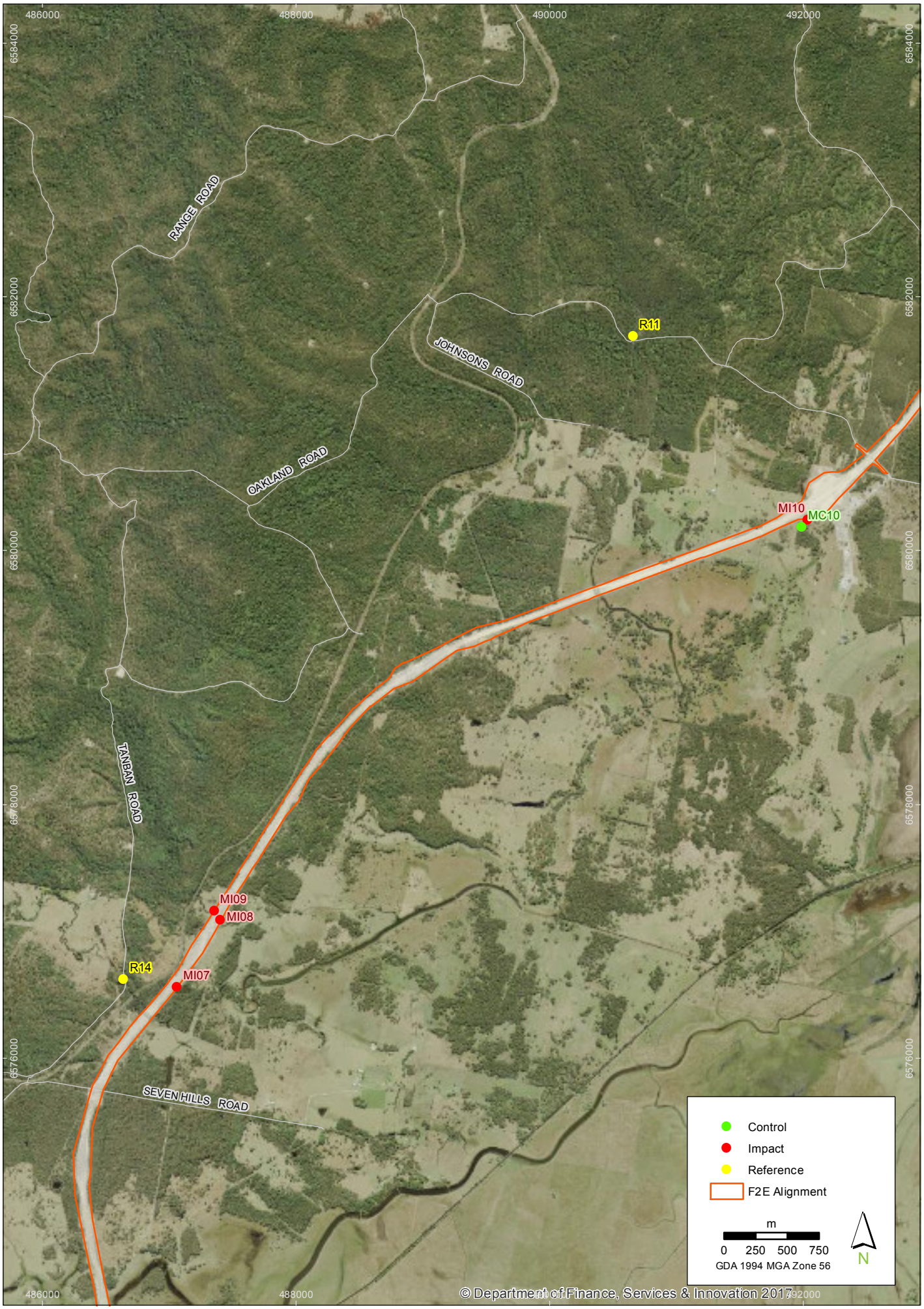
Drawn by: RJ Project Manager: RM Project Number: 1702 PI6.2 Date: 24/05/2018 T:\spatial\projects\a1700\a1702_OH2K_Ecology\Maps\PI_6_EcolMonit_F2E\PI_62_Maundia\20181702_PI_62_Figure_1_Overview.mxd

F2E Maundia monitoring locations: Overview

Pacific Highway Upgrade: Frederickton to Eungai

FIGURE 1

niche Environment and Heritage



F2E Maundia monitoring locations: Northern section

Pacific Highway Upgrade: Frederickton to Eungai

niche Environment and Heritage

FIGURE 2

Imagery: (c) LPI 2014-09-18

Drawn by: RJ Project Manager: RM Project Number: 1702 PI6.2 Date: 24/05/2018 T:\spatial\projects\a1700\a1702_OH2K_Ecology\Maps\PI_6_EcolMonit_F2E\PI_62_Maundia\20181702_PI_62_Figure_3_Sth.mxd

F2E Maundia monitoring locations: Southern section

Pacific Highway Upgrade: Frederickton to Eungai

niche Environment and Heritage

FIGURE 3

Imagery: (c) LPI 2014-09-18

3. Results

Monitoring was undertaken in December 2018 (summer 1), January 2019 (summer 2) and April 2019 (autumn). Results summarising Maundia presence (% cover), recruitment (% of Maundia considered to be recruiting individuals) and flowering (% of Maundia individuals observed to be flowering) for each of the sites are presented in Table 3 and Table 4. Field data is provided in Annex A. Photo monitoring results are presented in Annex B.

3.1 Percent cover 2018/2019

There were no substantial differences (> 15%) observed in the percent cover between paired impact-control sites and between impact-only and reference sites.

Paired impact-control sites

Maundia was recorded on at least one occasion at three of the five paired impact sites and at four of the five paired control sites during the 2018/2019 monitoring period. As in 2017/2018, Maundia was not detected at MI06 and MI10 during the 2018/2019 monitoring period. Monitoring results were as follows:

- MI01 / MC01: A substantial difference in percent cover extent was not recorded between the impact and control site within any survey or annually. Over the three surveys the average percent cover was 7% at the control site *vs* <1% at the impact site.
- MI02 / MC02: A substantial difference in cover extent was not recorded between the impact and control site within any survey or annually. Over the three surveys the average percent cover was 12% at the control site *vs* 8% at the impact site.
- MI05 / MC05: A substantial difference in cover extent was not recorded between the impact and control site within any survey or annually**.** Over the three surveys the average percent cover was 7% at the control site *vs* >1% at the impact site. Maundia was not detected in the autumn surveys at either site after having been detected during both summer surveys. These sites were subject to earthworks associated with private land management prior to the final 2018/2019 survey (autumn 2019), which resulted in the removal of soil from the drainage channel where Maundia was previously recorded. These earthworks extended from within private land where MC05 is located into the road reserve where MI05 is located. The earthworks were found to be a funded action undertaken by the Seven Oaks Drainage Union (the Union) and will be an ongoing activity. This is discussed further in Table 9.
- MI06 / MC06: A substantial difference in percent cover was not recorded as Maundia was not detected at the impact or the control site.
- MI10 / MC10: Maundia was not detected at the impact site however a substantial difference in cover extent was not recorded as the annual average percent cover at the control site was low (<1%).

Impact-only sites and reference sites

Maundia was recorded at all three reference sites during at least one of the 2018/2019 monitoring surveys and on at least one occasion at five of the six impact-only sites. Results were as follows:

- Reference site 12 is the nearest reference site to impact-only sites MI03E, MI03W and MI04. Site 12 had an annual average percent cover of 11%, *cf* 0%, 1% and <1% at the impact sites respectively. There was no substantial difference in the average percent cover between the impact-only sites MI03E, MI03W and MI04 and Reference site 12.
- Reference site 14 is the nearest reference site to impact-only sites MI07, MI08 and MI09. Site 14 had an annual average percent cover of < 1%, *cf* <1%, 1% and 2% at the impact sites respectively.

There was no substantial difference in the average percent cover between the impact-only sites MI07, MI08 and MI09 and Reference site 14.

3.2 Recruitment 2018/2019

Substantial differences (> 15%) in the percentage of recruitment between paired impact-control sites and between impact-only and references sites are highlighted in bold.

Paired impact-control sites

A substantial difference in recruitment between control and impact sites was recorded at two paired impact-control sites (MI01/MC01 and MI10/MC10). Results were as follows:

- **MI01 / MC01: A substantial difference was recorded between the control and impact site. The annual average was 24% at the control *cf* 6% at the impact site.** MI01 has a high level of dense vegetation including *Persicaria* sp. and exotic perennial grasses, whilst MC01 is exposed to cattle grazing. These differences in land use and floristics may result in varying levels of Maundia presence and detection of recruitment. It is therefore not possible to attribute differences directly to the Project.
- MI02 / MC02: Recruitment was observed at both the control and impact site, however a substantial difference was not recorded (11% *cf* 13%).
- MI05 / MC05: Recruitment was observed at the control site but not the impact site, however the difference was not substantial (0% *cf* 10%).
- MI06 / MC06: Recruitment was not recorded at the impact or control site.
- **MI10 / MC10: A substantial difference was recorded between the control and impact site. The annual average was 25% at the control *cf* 0% at the impact site (Maundia was absent).** MI10 and MC10 have a distinctly different vegetation structure and site use. MC10 has a dense canopy cover over an open swampy ground cover and is exposed to cattle grazing while MI10 is open with limited canopy and dense ground cover including *Persicaria* sp. and exotic perennial grasses. These differences in land use and vegetation structure may result in varying levels of Maundia presence and detection of recruitment. It is therefore not possible to attribute differences directly to the Project.

Impact-only sites and reference sites

Recruitment was observed at Reference sites 11 and 12 but not at Reference site 14. Recruitment was observed at three of the impact-only sites. Results were as follows:

- Reference site 12 is the nearest reference site to impact-only sites MI03E, MI03W and MI04. **Reference site 12 recorded an annual average recruitment of 25%. Recruitment was not observed at MI03E or MI04.** MI03W had an annual average recruitment of 57%.
- Reference site 14 is the nearest reference site for impact-only sites MI07, MI08 and MI09. Recruitment was not recorded at Reference site 14. Likewise impact-only site MI07 showed no signs of recruitment while recruitment was observed during at least one survey at impact-only sites MI08 and MI09.

3.3 Flowering/Seeding 2018/2019

There were no substantial differences (> 15%) observed in the percentage of flowering/seeding individuals between paired impact-control sites and between impact-only and reference sites.

Paired impact-control sites

Flowering was recorded at two of the five paired impact sites and at three of the paired control sites. Results were as follows:

- MI01 / MC01: Flowering was recorded at both impact and control sites during the December 2018 surveys only, at a similarly low level.
- MI02 / MC02: Flowering was not recorded at the impact or control site.
- MI05 / MC05: Flowering was recorded at the control site during January 2019 surveys (5.8%) while no flowering was recorded at the impact site.
- MI06 / MC06: Flowering was not recorded at the impact or control site.
- MI10 / MC10: Flowering was recorded at the control site during January 2019 surveys (1.3%), while no flowering was recorded at the impact site.

Impact-only sites and reference sites

Flowering was recorded at Reference site 12 and at two of the six impact-only monitoring sites. Results were as follows:

- Reference site 12 is the nearest reference site to impact-only sites MI03E, MI03W and MI04. Reference site 12 recorded an annual average flowering of 1%. Flowering was not observed at MI03E, MI03W and MI04.
- Reference site 14 is the nearest reference site to impact-only sites MI07, MI08 and MI09. Flowering was not recorded at Reference site 14. Likewise flowering was not observed at impact-only site MI07 while flowering was observed at impact-only sites MI08 (10%) and MI09 (9%).

Table 3: Summary of Maundia presence, recruitment and flowering

Site name	Design	*Maundia triglochinoides* flowering and (recruitment) % of Maundia individuals				*Maundia triglochinoides* percent cover in 100 m^2 (%)			
		December 2018	January 2019	April 2019	Average	December 2018	January 2019	April 2019	Average
MI01	Impact	4 (0)	0 (8)	0 (11)	1 (**6**)	1.2	0.7	0.4	<1
MC01	Control	3 (19)	0 (13)	0	1 (**24**)	10.2	11.4	0.3	7
MI02	Impact	0 (6)	0 (17)	0 (9)	0 (11)	9.3	8.7	6.0	8
MC02	Control	0 (12)	0 (12)	0 (14)	0 (13)	22.5	6.6	8.0	12
MI03E	Impact	0 (0)	0 (0)	0 (0)	0 (**0**)	0	0	0	0
MI03W	Impact	0 (45)	0 (56)	0 (69)	0 (57)	1.4	1.3	0.6	1
MI04	Impact	0 (0)	0 (0)	0 (0)	0 (**0**)	0.1	0	0	<1
MI05	Impact	0 (0)	0 (0)	0 (0)	0 (0)	0.02	0.02	0	<1
MC05	Control	0 (10)	5.8 (20)	0 (0)	2 (10)	12.6	7.9	0	7
MI06	Impact	0 (0)	0 (0)	0 (0)	0 (0)	0	0	0	0
MC06	Control	0 (0)	0 (0)	0 (0)	0 (0)	0	0	0	0
MI07	Impact	0 (0)	0 (0)	0 (0)	0 (0)	0.5	1.1	0	<1
MI08	Impact	26.1 (0)	4 (5)	0 (0)	10 (2)	2.6	0.7	0.02	1
MI09	Impact	23.4 (0)	3.7 (8)	0 (29)	9 (12)	4	1.8	0.08	2
MI10	Impact	0 (0)	0 (0)	0 (0)	0 (**0**)	0	0	0	0
MC10	Control	0 (10.1)	1.3 (17.9)	0 (46.5)	<1 (**25**)	0.3	0.3	0.2	<1

Table 4: Maundia results for reference monitoring sites

Site Name	Design	*Maundia triglochinoides* flowering and (recruitment) % of Maundia individuals				*Maundia triglochinoides* percent cover in 100 m^2 (%)			
		December 2018	January 2019	April 2019	Average	December 2018	January 2019	April 2019	Average
R11	Reference	0 (6.4)	0 (36.9)	0 (64.2)	0 (36)	11.4	1.2	0.4	4
R12	Reference	0.5 (13)	2.9 (25)	0 (38)	1 (**25**)	17.3	12.4	2.1	11
R14	Reference	0 (0)	0 (0)	0 (0)	0 (0)	0.04	0	0	<1

3.4 Successive monitoring event assessment

A summary of previous monitoring events for all sites is provided in Table 5. Averages were calculated for the three monitoring surveys for each monitoring event. Substantial decreases in percent cover, recruitment and flowering/seeding over successive monitoring events (> 15%) are highlighted in bold. Where control/nearest reference sites were substantially higher than the paired impact site within any one monitoring year, cells are shaded orange. It should be noted that the low level or absence of water at all sites during the 2018/2019 monitoring permitted observations of recruitment where previously this was not possible due to water depth.

Table 5: Summary of Maundia results

	Average Maundia % cover 100m^2					Average flowering (%)					Average recruitment (%)				
Year	**1#**	**2***	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
MI01	6-25 (3)	2 (3)	1 (3)	2 (3)	<1 (3)	1 (1)	0	6 (1)	6 (1)	1 (1)	<1 (1)	0	0	0	6 (2)
MC01	6-25 (3)	6 (3)	12 (3)	16 (3)	7 (3)	1 (1)	0	1 (1)	4 (1)	1 (1)	<1 (1)	Y (1)	<1 (1)	Y (1)	24 (3)
MI02	6-25 (3)	**44** (3)	**26** (3)	16 (3)	**8** (3)	6 (3)	**33** (2)	**<1** (1)	**<1** (2)	**0**	23 (2)	Y (1)	0	Y (1)	11 (3)
MC02	6-25 (3)	**34** (3)	**10** (3)	31 (3)	**12** (3)	1 (1)	**15** (3)	**<1** (1)	**2** (2)	**0**	3 (2)	Y (1)	1 (1)	Y (2)	13 (3)
MI03E	1-5 (3)	4 (2)	<1 (1)	<1 (1)	0	0	9 (1)	0	0	0	2 (1)	0	2 (1)	Y (1)	0
MI03W	1-5 (3)	11 (3)	7 (3)	9 (3)	1 (3)	3 (1)	**36** (2)	**0**	**1** (2)	0	3 (2)	Y (2)	2 (1)	<1 (1)	57 (3)
MI04	0	**24** (2)	14 (3)	12 (2)	**<1** (1)	0	3 (2)	<1 (2)	4 (1)	0	0	Y	3 (2)	0	0
MI05	0-5 (1)	<1 (3)	<1 (1)	<1 (1)	<1 (2)	0	14 (1)	0	0	0	0	Y (1)	0	Y (1)	0
MC05	0-5 (1)	3 (3)	6 (3)	12 (3)	7 (2)	0	0	6 (1)	9 (1)	2 (1)	0	0	6 (2)	0	10 (2)
MI06	1-5 (2)	1 (1)	0	0	0	3 (2)	Y (1)	0	0	0	<1 (1)	0	0	0	0
MC06	0-5 (2)	<1 (1)	<1 (1)	0	0	1 (1)	**17** (1)	**0**	0	0	0	Y (1)	0	0	0
MI07	0	<1 (1)	0	<1 (1)	<1 (2)	0	**33** (1)	0	**0**	**0**	0	Y (1)	0	0	0
MI08	0	<1 (2)	<1 (2)	3 (3)	1 (3)	0	**28** (1)	**12** (1)	**8** (2)	**10** (2)	0	Y (1)	0	0	2 (1)
MI09	0	2 (3)	3 (3)	2 (3)	2 (3)	0	**39** (2)	**18** (2)	**2** (2)	**9** (2)	0	Y (1)	0	Y (1)	12 (2)
MI10	0-5 (1)	<1 (1)	0	0	0	0	33 (1)	0	0	0	0	0	0	0	0
MC10	1-5 (3)	7 (3)	4 (3)	4 (3)	<1 (3)	0	0	0	0	<1 (1)	3 (1)	Y (1)	7 (2)	Y (2)	25 (3)
R11	1-5 (3)	**21** (3)	10 (3)	15 (3)	**4** (3)	0	0	<1 (1)	0	0	0	0	1 (2)	<1 (2)	36 (3)
R12	26-50 (3)	**21** (3)	**4** (3)	2 (3)	11 (3)	0	<1 (1)	0	0	1 (2)	<1 (1)	Y (3)	<1 (1)	20 (1)	25 (3)
R14	0-5 (3)	1 (3)	<1 (2)	<1 (3)	<1 (1)	0	0	0	0	0	0	Y (1)	0	0	0

= cover extent derived from Braun-Blanquet cover abundance scale. * = average based on two surveys where 100 m^2 transect data available, but (n) reflects all three surveys. (n) = number of surveys recorded. Y = recorded but no number or % available. Note that recruitment is only shown for where recruitment was observed. Sites where it could not be determined are shown as 0. Year 1 = 2014/2015; 2 = 2015/2016; 3 = 2016/2017; 4 = 2017/2018; 5 = 2018/2019.

4. Discussion

4.1 Performance measures

A summary of the 2018/2019 survey results in relation to the performance indicators is provided in Table 6 and Table 7.

Table 6: Performance indicators of successful mitigation

Performance indicators of success	Discussion
Exclusion fencing with signage identifying these as 'no go' zones (during construction)	This performance indicator is no longer applicable due to the road now being operational.
Sediment control fencing in place (during construction)	This performance indicator is no longer applicable due to the road now being operational.
Flowering and/or seeding is consistent with paired control and/or nearest reference site	**This performance indicator has been met by all impact sites.** There were no substantial differences (> 15%) observed in the percentage of flowering/seeding individuals between paired impact-control sites and between impact-only and reference sites during 2018/2019 monitoring. When considering all monitoring events, there were no years where the percentage of flowering individuals was substantially higher at paired control or nearest reference sites than at impact sites.
Flowering and/or seeding at impact sites is consistent with previous monitoring results	**This performance indicator has been met by all but five (MI02, MI03W, MI07, MI08 and MI09) of the 11 impact sites**. MI02, MI03W, MI07 and MI08 recorded a substantial decrease between 2015/2016 and subsequent monitoring events. Higher levels of flowering in general were observed in 2015/2016 for impact and control sites, with similar substantial decreases in flowering observed at control sites. As such, decreases in flowering from 2015/2016 cannot be directly attributed to the Project. MI09 recorded a substantial decrease between 2015/2016 and 2016/2017 and again between 2016/2017 and 2017/2018. However, during 2018/2019 flowering increased to within 15% of 2016/2017 levels and the decrease observed from 2015/2016 levels may be attributed to the general decrease in flowering observed at both control and impact sites. The absence of flowering at the nearest reference site removes the ability to compare observed trends, however, it should be noted that current flowering levels have either increased from or remain consistent with the first surveys at these sites. The differences between the percent of individuals flowering could be attributed to a number of factors, such as differing abiotic conditions across years, and varying annual weather conditions which may impact water flow, depth, turbidity, pH, nutrients, and temperature. Given the species grows in warm conditions, these variables may impact upon the flowering times. Given there is no clear negative trend at impact sites compared to control sites, and that observed changes may be the result of site-specific environmental conditions, there is no clear evidence to suggest the Project is affecting the flowering or seeding of Maundia in the Project area.

Table 7: Performance indicators of unsuccessful mitigation

Performance indicators of unsuccessful mitigation	Discussion
Breached exclusion fencing (during construction).	This performance indicator is no longer applicable due to the road now being operational.
No signage in place identifying the sensitive nature of the location as threatened species habitat (during construction).	This performance indicator is no longer applicable due to the road now being operational.
A significant (if statistics are used) or substantial difference (i.e. 15% allowance) between paired monitoring sites with regard to flowering/seeding and overall extent or recruitment that cannot be attributed to environmental factors.	**This performance indicator of unsuccessful mitigation has not been met.** **Flowering/seeding:** When considering all monitoring events, there were no years where the percentage of flowering individuals was substantially higher at control/nearest reference sites than at paired impact sites. **Recruitment**: When considering all monitoring events, recruitment was observed to be substantially higher at a control/nearest reference than at its paired impact site on one occasion at paired sites MI01/MC01 and MI10/MC10 and on one occasion at Reference site 12 and MI03E and MI04. These occurrences were all in the current 2018/2019 monitoring period. The higher recruitment levels at the paired control/nearest reference sites relate to the higher (not substantial) percent cover at these sites. Maundia has consistently recorded low recruitment at MI03E and MI04, fluctuating between 0 and 3%. These fluctuations in observed recruitment may be due to both natural variability, seasonality and visibility of recruiting individuals and cannot therefore be confidently attributed to the Project. Despite being substantially lower than its paired control site, recruitment at MI01 increased in 2018/2019 from previous monitoring years, similarly potentially reflecting the extent of Maundia and natural fluctuations in recruitment. Recruitment has not been observed at MI10 during any survey, while it has been consistently recorded at MC10. While the non-independent nature and different land management practices of the paired sites preclude inferences regarding cause, MI10 is discussed further below. **Percent cover:** When considering all monitoring events, percent cover was observed to be substantially higher at control/nearest reference sites than at impact sites only at Reference site 12 compared to MI03E, MI03W, MI04 in 2014/2015 and MI03E in 2015/2016. Given these substantial differences were in the first and second year of monitoring when Reference site 12 recorded particularly high percent cover (after which it decreased substantially), and that baseline values are not known, it is difficult to make a statement regarding the likely impact of the Project at these sites. MI03E and MI03W have consistently recorded low cover extent, which may therefore represent the baseline state of this species at these sites. Maundia was absent from MI04 in 2015/2016 but has since been recorded during each monitoring event. It is therefore not possible to confidently attribute these differences between Reference site 12 and MI03E, MI03W and MI04 in 2014/2015 (and 2015/2016) to the Project.
A significant (if statistics are used) or substantial difference (15% allowance) between impact monitoring sites over subsequent monitoring events that cannot be attributed to environmental factors.	**This performance indicator of unsuccessful mitigation has not been met, however MI10 is discussed further.** **Flowering/seeding**: • MI02, MI03W, MI07 and MI08 recorded a substantial decrease between 2015/2016 and subsequent monitoring events. Higher levels of flowering in general were observed in 2015/2016 for impact and control sites, with similar substantial decreases in flowering observed at control sites. As such, decreases in flowering from 2015/2016 cannot be directly attributed to the Project. • MI09 recorded a substantial decrease between 2015/2016 and 2016/2017 and again between 2016/2017 and 2017/2018. However, during 2018/2019 flowering increased to within 15% of 2016/2017 levels and the decrease observed from 2015/2016 levels may be attributed to the general decrease in flowering observed at both control and impact sites.

Performance indicators of unsuccessful mitigation	Discussion
	Recruitment: • There have been no substantial decreases in observed recruitment between successive years at any site. **Percent cover**: • There was a substantial decrease at MI02 and MC02 between 2015/2016 and successive monitoring events. As this substantial decrease was observed at both the impact site and its paired control site, these changes cannot be confidently attributed to the Project. • There was a substantial decrease at MI04 between 2015/2016 and successive monitoring events. The nearest reference site, Reference site 12 also experienced a substantial decrease between 2015/2016 and successive monitoring events. As this substantial decrease was observed at both the impact site and its paired control site, these changes cannot be confidently attributed to the Project. Given there is no clear negative trend at impact sites compared to control sites, and that observed changes may be the result of site-specific environmental conditions, there is no clear evidence to suggest the Project is affecting the flowering or seeding of Maundia in the Project area. **MI10** cannot be classified as recording substantial decreases due to the initial low levels, however Maundia has not been recorded at the impact site since 2015/2016, while it continues to be recorded at the paired control site, albeit at low levels. In addition, its paired control site showed signs of recruitment in the current monitoring period.

5. Recommendations/Discussion

5.1 Contingency measures

The EMP lists potential problems and contingency measures for various components of the monitoring program. Those that are considered to be relevant to the Maundia monitoring program are listed and discussed in Table 8. Sites where substantial differences are considered as likely attributable to environmental factors or natural variations and fluctuations, as discussed in Table 6 and Table 7, have not been considered below.

Table 8: Potential problems and contingency measures proposed in the EMP

Potential Problem	Contingency Measure proposed in EMP	Relevance of contingency measure
Residual area of Maundia impacted by construction works (i.e. clearing, habitat damage, sedimentation, scouring).	Review the exclusion fencing Review extent of signage used to demarcate the habitat protection zone Review clearing procedures	While construction is complete, Maundia habitat was damaged and Maundia individuals were removed during drainage maintenance works undertaken by the Seven Oaks Drainage Union. **Review of existing fencing of Roads and Maritime property boundaries is therefore considered relevant.**
Significant difference ($p<0.05$ level) in flowering/seeding and/or extent of relative cover between control sites (adjacent road corridor) and treatment sites (habitat protection zones within road corridor) or within impact-only monitoring sites.	Review drainage (local hydrological patterns)	As discussed in Table 6 and Table 7, the majority of substantial differences cannot be directly attributed to the Project. However, while **MI10** cannot be classified as recording substantial decreases due to the initial low levels, Maundia has not been recorded at the impact site since 2015/2016, while it continues to be recorded at the paired control site, albeit at low levels. In addition, its paired control site showed signs of recruitment in the current monitoring period. **This contingency measure is therefore considered relevant for the final 2018/2019 monitoring event and is discussed further in Table 9.**

5.2 Recommendations

The recommendations provided in Table 9 aim to address the outcome of the final monitoring results with reference to all previous monitoring events. As discussed in Table 6 and Table 7, the majority of the observed changes and substantial differences cannot be confidently or directly attributed to the Project due to environmental factors or natural variations and fluctuations. It should also be noted that due to the proximity of paired impact-control sites, and thereby lack of independence, as well as varying land use and management practices (notably presence of cattle) at most sites, it is generally not possible to attribute differences in Maundia populations solely to the Project.

The EMP states that "*Monitoring shall be undertaken during construction (for construction-related impacts) and from opening of the project to traffic (for operation/ongoing impacts) until such time as the effectiveness of mitigation measures can be demonstrated to have been achieved over a minimum of three successive monitoring periods, or as otherwise agreed by the Director-General in consultation with DECCW*". It is considered that ongoing monitoring of the Maundia sites would serve no purpose as it is likely that natural fluctuations and differences in land management across the sites would continue to confound the results. Ongoing monitoring is therefore not recommended for Maundia. Recommendations have instead been made to potentially provide opportunities for Maundia recruitment.

Previous recommendations aimed to enhance existing populations by managing the competitive influence of invasive species, targeting weeds and over abundant native species (Niche 2017b). However Roads and Maritime concluded, with the support of the EPA, that localised weeding would be ineffective in the long-term due to the presence of such species upstream and their high likelihood of re-establishment. While Roads and Maritime proposed to "*to review the ongoing monitoring before consideration to any actions would be taken*", it is still considered that the above localised management of weeds and over-abundant native species would be ineffective in the long term, but they may provide the short-term opportunity for recruitment and growth of Maundia.

Table 9: Recommendations

Relevant contingency measure	Application	Recommendations
Review drainage (local hydrological patterns)	MI10/MC10	The current land use practices and local environment/habitat differ considerably between these two sites. MC10 is situated within a Melaleuca swamp forest that is exposed to grazing and MI10 is mostly open with a dense grassy groundcover situated within a drainage line that is discontinuous with MC10, separated by a raised gravel track that serves as a powerline access trail. The Project design established a series of pipes under the gravel track to create an even distribution of floodwater runoff into the adjacent land. Insufficient flow however resulted in excess flood waters in adjacent private lands. As such a pipe was removed and a causeway was created along the gravel track to improve flow. The engineering design for floodwater runoff in this area cannot be altered.
Review of existing fencing of Roads and Maritime property boundaries	MI05/MC05	The earthworks were found to be a funded action undertaken by the Union and will be an ongoing activity. As such, recommendations for amelioration of this site have not been made. However, it is recommended that Roads and Maritime engage with the Union to: • Discuss historical and ongoing management actions • Discuss the potential impact on the local Maundia plants. Outside the impact site Maundia is present under the adjacent bridge (Pacific Highway), beyond the area of works of the Union. There is therefore the opportunity to establish an area that is inaccessible to drainage works and cattle trampling that may act as a source of recruitment for downstream sites. It is therefore recommended that: • The current damaged and ineffective fence be replaced • Salvinia control be undertaken to reduce competition.

5.3 Discussion

During construction, the topography of the land within and adjacent to MI10 was altered considerably to provide for floodwater runoff, creating an altered landscape. While it is not possible to attribute differences between MI10 and MC10 directly to the Project due to differences in land use and vegetation structure, it is considered likely that the changed topography and landscape caused by the engineering design for floodwater runoff has altered the land within and adjacent to MI10 so that it is unlikely to provide suitable habitat for Maundia.

6. References

Lewis, B.D. (2013). Pacific Highway Upgrade Frederickton to Eungai: Translocation investigation for *Maundia triglochinoides*. Report prepared for Roads and Maritime Services by Lewis Ecological Surveys

Niche (2016). Frederickton to Eungai Pacific Highway Upgrade *Maundia triglochinoides* Monitoring 2015, Prepared for Roads and Maritime Services, Sydney.

Niche (2017a). Frederickton to Eungai Pacific Highway Upgrade *Maundia triglochinoides* Monitoring 2016, Prepared for Roads and Maritime Services, Sydney.

Niche (2017b). *Maundia triglochinoides* Monitoring 2016/2017. Frederickton to Eungai Pacific Highway Upgrade. Prepared for Roads and Maritime Services, Sydney.

Niche (2018). *Maundia triglochinoides* Monitoring 2017/2018. Frederickton to Eungai Pacific Highway Upgrade. Prepared for Roads and Maritime Services, Sydney.

RMS (2016). Frederickton to Eungai Pacific Highway Upgrade Ecological Monitoring Program. Roads and Maritime Update to report prepared by Lewis Ecological Surveys, May 2016.

Annex A. 2018/2019 monitoring results

Site Name	Design	Inspection Date			Maundia Present			% Maundia cover average cover in 100 m^2			Water Depth (mm)			% Flowering/ Seeding			Recruitment %			Signs of disturbance		
		Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn
F2E MI01	impact	11/12/2018	29/01/2019	16/04/2019	Y	Y	Y	1.2	0.7	0.39	150	200	200	4.00	0.00	0.00	0	8	11	Nil	Nil	Nil
F2E MC01	control	11/12/2018	29/01/2019	16/04/2019	Y	Y	Y	10.2	11.4	0.34	200	0	50	3.00	0.00	0.00	19	13	40	Nil	Cattle	Cattle
F2E MI02	impact	12/12/2018	30/01/2019	16/04/2019	Y	Y	Y	9.3	8.7	5.96	0	0	100	0.00	0.00	0.00	6	17	9	Nil	Nil	Nil
F2E MC02	control	12/12/2018	30/01/2019	16/04/2019	Y	Y	Y	22.5	6.6	8.00	200	0	200	0.00	0.00	0.00	12	12	14	Nil	Nil	Nil
F2E MI03E	impact	11/12/2018	29/01/2019	16/04/2019	N	N	N	0.0	0.0	0.00	0	0	0	0.00	0.00	0.00	0	0	0	Cattle	Cattle	Cattle

Site Name	Design	Inspection Date			Maundia Present			% Maundia cover average cover in 100 m^2			Water Depth (mm)			% Flowering/ Seeding			Recruitment %			Signs of disturbance		
		Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn
F2E MI03W	impact	11/12/2018	29/01/2019	16/04/2019	Y	Y	Y	1.4	1.3	0.56	0	0	0	0.00	0.00	0.00	45	56	69	Nil	Nil	Nil
F2E MI04	impact	11/12/2018	29/01/2019	16/04/2019	Y	N	N	0.1	0.0	0.00	300	0	0	0.00	0.00	0.00	0	0	0	Cattle	Cattle	Cattle
F2E MI05	impact	12/12/2018	30/01/2019	16/04/2019	Y	Y	N	0.02	0.02	0.00	300	0	0-50	0.00	0.00	0.00	0	0	0	Cattle	Cattle	Earthworks
F2E MC05	control	12/12/2018	30/01/2019	16/04/2019	Y	Y	N	12.6	7.9	0.00	300	0	0-50	0.00	5.80	0.00	10	20	0	Cattle	Cattle	Earthworks
F2E MI06	impact	11/12/2018	30/01/2019	15/04/2019	N	N	N	0.0	0.0	0.00	0	0	0	0.00	0.00	0.00	0	0	0	Cattle	Cattle	Cattle
F2E MC06	control	11/12/2019	30/01/2019	15/04/2019	N	N	N	0.0	0.0	0.00	0	0	0	0.00	0.00	0.00	0	0	0	Cattle	Cattle	Cattle

Site Name	Design	Inspection Date			Maundia Present			% Maundia cover average cover in 100 m^2			Water Depth (mm)			% Flowering/ Seeding			Recruitment %			Signs of disturbance		
		Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn
F2E MI07	impact	11/12/2018	30/01/2019	16/04/2019	Y	Y	N	0.5	1.1	0.00	150	0	0	0.00	0.00	0.00	0	0	0	Nil	Cattle	Nil
F2E MI08	impact	10/12/2018	30/01/2019	16/04/2019	Y	Y	Y	2.6	0.7	0.02	200	100	0	26.10	4.00	0.00	0	5	0	Nil	Nil	Nil
F2E MI09	impact	10/12/2018	30/01/2019	16/04/2019	Y	Y	Y	4.0	1.8	0.08	250	250	0	23.40	3.70	0.00	0	8	29	Nil	Nil	Nil
F2E MI10	impact	10/12/2018	30/01/2019	15/04/2019	N	N	N	0.0	0.0	0.00	0	0	0	0.00	0.00	0.00	0	0	0	Nil	Nil	Nil
F2E MC10	control	10/12/2018	30/01/2019	15/04/2019	Y	Y	Y	0.3	0.3	0.16	0	0	0	0.00	1.30	0.00	10.1	17.9	46.5	Cattle	Cattle	Cattle

Site Name	Design	Inspection Date			Maundia Present			% Maundia cover average cover in 100 m^2			Water Depth (mm)			% Flowering/ Seeding			Recruitment %			Signs of disturbance		
		Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn	Summer 1	Summer 2	Autumn
R11	reference	10/12/2018	30/01/2019	15/04/2019	Y	Y	Y	11.4	1.2	0.38	0	0	0	0.00	0.00	0.00	6.40	36.9	64.2	Nil	Nil	Nil
R12	reference	11/12/2018	29/01/2019	16/04/2019	Y	Y	Y	17.3	12.4	2.08	0	0	0	0.50	2.90	0.00	13	25	38	Cattle	Cattle	Cattle
R14	reference	11/12/2018	29/01/2019	16/04/2019	Y	N	N	0.04	0.0	0.00	0	0	0	0.00	0.00	0.00	0	0	0	Nil	Cattle	Cattle

Y = Yes; N = No

Annex B. 2018/2019 photo monitoring

Site ID	December 2018	January 2019	April 2019
MI01			
MC01			

Site ID	December 2018	January 2019	April 2019
MI02			
MC02			

Site ID	December 2018	January 2019	April 2019
MI03E			
MI03W			

Site ID	December 2018	January 2019	April 2019
MI04			
MI05			

Site ID	December 2018	January 2019	April 2019
MC05			
MI06			

Site ID	December 2018	January 2019	April 2019
MC06			
MI07			

Site ID	December 2018	January 2019	April 2019
MI08			
MI09	NA		

Site ID	December 2018	January 2019	April 2019
MI10			
MC10			

Site ID	December 2018	January 2019	April 2019
R11			
R12			

Site ID	December 2018	January 2019	April 2019
R14			

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Appendix C Aerial Crossing Structures

Aerial Crossing Monitoring 2019

Frederickton to Eungai Pacific Highway Upgrade

Prepared for Transport for NSW

February 2020

Document control

Project no.:	1702 (PI 6.5)
Project client:	Transport for NSW
Project office:	Port Macquarie
Document description:	Frederickton to Eungai Aerial Crossing Monitoring Report 2019
Project Director:	Rhidian Harrington
Project Manager:	Radika Michniewicz
Authors:	Jodie Danvers, Radika Michniewicz
Internal review:	Radika Michniewicz, Amanda Griffith
Document status:	Rev1
Local Government Area:	Kempsey

Document revision status

Author	Revision number	Internal review	Date issued
Jodie Danvers	D1	Radika Michniewicz	6/01/2020
Jodie Danvers	D2	Radika Michniewicz	30/1/2020
Radika Michniewicz	D3	Amanda Griffith	12/02/2020
Radika Michniewicz	R0		21/02/2020

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Brisbane
Cairns

Cover photograph: Sugar Glider caught in arboreal trap Site 2 (left), Sugar Glider using the eastern glider pole at site 1 (GP1, camera 1) (middle) and Feathertail Glider using the eastern glider pole at site 2 (GP2, camera 8) (right).

Executive summary

Context

This report documents the results of the 2019 monitoring period, the final of three monitoring cycles for the aerial crossing structures, as required by the Frederickton to Eungai (F2E) Ecological Monitoring Program (EMP, RMS 2016). Transport for NSW (TfNSW) is required to manage and monitor the effectiveness of biodiversity mitigation measures implemented as part of the Project.

Aims

The aim of this report is to summarise the methods and results of the autumn and spring 2019 monitoring and determine if performance measures have been met, as per the EMP.

Methods

In accordance with the EMP, each of the three aerial crossing zones (Sites 1, 2 and 3) was monitored in autumn and spring of 2019. Monitoring involved the use of automated cameras for a period of 60 consecutive days and arboreal tree trapping (20 traps at each zone) in residual habitat adjacent to each crossing zone (10 traps either side of the carriageway) over four consecutive nights in autumn and spring. Equipment theft in autumn 2019 resulted in the loss of autumn 2019 camera data. In consultation with TfNSW, the Department of Planning Industry and Environment (DPIE) and the NSW Environment Protection Authority (EPA), it was determined that an additional 60-day aerial camera monitoring period would be conducted in autumn 2020. The autumn 2020 data will be provided in a separate report.

Key results

- Remote cameras detected three glider species using the aerial crossings; the Feathertail Glider, Sugar Glider and the threatened Yellow-bellied Glider.
- Gliders were detected on the median glider poles at all three sites, indicating assumed complete crossings.
- One arboreal mammal, the Feathertail Glider, was recorded on the canopy rope crossing at Site 3.
- Complete crossings were not detected on canopy rope crossings.
- Four species were captured during arboreal tree trapping, Sugar Glider, *Melomys* sp., *Rattus* sp. and Brown Antechinus. There were no recaptures of previously tagged individuals.
- There were no records of road kill glider species from the 2018/2019 road kill monitoring results.

Conclusions

Glider poles: As gliders have been recorded using both eastern and western poles and the median poles at all sites on multiple occasions it is considered that indicators of success in relation to successful complete crossings of the glider poles by glider species have been met, despite the absence of recapture data and quick succession records for a full crossing. Neither sign of unsuccessful mitigation has been met for the glider crossings as gliders have been detected on all median poles and gliders have not been recorded as road kill.

Rope bridges: While arboreal fauna have been recorded on the canopy rope bridges at all sites, successful complete crossings have not been confirmed using remote cameras or recaptures during arboreal trapping. As such, indicators of success have not been met for canopy rope bridges.

Management implications

In relation to the relevant contingency measures and performance indicators that have not been met, a number of recommendations have been made, including:

- A review of the vegetation status immediately adjacent to the crossing poles should be considered, with the aim of determining if additional lead/lure ropes from neighbouring trees to the rope ladder canopy bridges would improve fauna access to the rope ladder, notably for small scansorial species, or if additional planting would be suitable/beneficial.
- A test of the sensitivity of the sensors and functionality of the cameras should be completed prior to the autumn 2020 monitoring period.
- As the cameras have been installed and are designed to function continually throughout the year, consideration should be given to continue downloading camera images in an effort to capture additional crossings by fauna.
- Further trapping is not recommended as a means of determining successful crossing of the rope bridges as it is unlikely to provide additional useful data.

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1. Introduction

1.1 Context

As part of the Frederickton to Eungai (F2E) Pacific Highway Upgrade Project (the Project), Transport for NSW (TfNSW) have implemented an Ecological Monitoring Program in accordance with the Minister for Planning's Condition of Approval (MCoA) No. 3.1. This Ecological Monitoring Program (RMS 2016) (hereafter referred to as the EMP) combines the approval conditions provided within the Ministers Conditions of Approval (MCoA) and Statement of Commitments (SoC), and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project.

Aerial crossings have been installed to reduce the impacts on fauna, facilitate movement and maintain connectivity for existing glider/arboreal mammal populations (RMS 2016). These structures are to be monitored to assess their effectiveness.

1.1.1 Monitoring framework

The EMP states the following regarding monitoring:

"It is proposed that monitoring of the glider crossings be undertaken in order to provide long term insights into the mitigation effectiveness once the carriageway becomes operational. With this in mind, monitoring would commence 6 months after the structures have been installed and focus on a 4 week sampling period in autumn and spring in 2017, 2018, and 2019, after which the need for further monitoring would be reviewed in consultation with EPA".

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

- *Autumn and spring 2017*: Aerial Crossing Monitoring 2017 (Niche 2018a)
- *Autumn and spring 2018*: Aerial Crossing Monitoring 2018 (Niche 2019a)
- *Autumn and spring 2019*: Aerial Crossing Monitoring 2019 (current report).

The 2019 monitoring therefore represents the final of three monitoring cycles required by the EMP for aerial crossing monitoring. However, equipment theft in autumn 2019 resulted in the loss of autumn 2019 camera data. In consultation with TfNSW, the Department of Planning Industry and Environment (DPIE) and the NSW Environment Protection Authority (EPA), it was determined that an additional 60-day aerial camera monitoring period would be conducted in autumn 2020. The autumn 2020 data will be reported in a separate report.

1.1.2 Baseline data

The EMP provides the following background information:

"Table A3 provides results of surveys in the vicinity of the three nominated aerial crossing locations. Yellow-bellied Glider has been recorded at or near each of the three crossing locations as have Brush-tailed Phascogale and other common arboreal fauna including Common Brushtail Possum, Sugar Gliders and Feathertail Glider".

Table A3 is provided in the original EMP (Lewis 2013) and presents the results of systematic surveys for the Kempsey to Eungai Environmental Assessment (Lewis 2005).

1.1.3 Purpose of this report

This report complies with the monitoring requirements described within the approved EMP and details the findings of the third monitoring event.

The aims of this report are to summarise the methods and results of the autumn and spring 2019 monitoring and determine if performance measures have been met, as per the EMP.

1.2 Performance Measures

The EMP specifies the performance indicators for the aerial crossing structures as follows:

***Indicators of success for the glider poles would include one or more of the following**:*

- *Evidence of use by any glider species using the median pole.*
- *Photographic evidence of a glider using both the eastern and western poles.*
- *One or more gliders with left ear tag/notch occurring on the western side of the carriageway and fauna with right ear tag/notch occurring on the eastern side of the carriageway*.

Signs of the glider poles being unsuccessful will be based on the:

- *Absence of gliders being recorded using the median pole or other evidence of complete crossings.*
- *Unacceptable levels of road strike (presence of deceased individuals during each sampling period for either year). For example, recording one or more gliders as road strike in both monitoring seasons would be considered as unsuccessful and require contingency measures.*

Indicators of success for the rope canopy bridges would include one or more of the following:

- *Photographic evidence of any arboreal species using both sides of the rope ladder to indicate a successful passage.*
- *One or more arboreal species with left ear tag/notch occurring on the western side of the carriageway and arboreal fauna with right ear tag/notch occurring on the eastern side of the carriageway.*

Signs of the canopy rope bridges being unsuccessful will be based on:

- *No photographic evidence of arboreal fauna successfully crossing the rope bridge or other evidence of complete crossings (i.e. ear tags, notches).*
- *Unacceptable levels of road strike (presence of deceased individuals during each sampling period for either year). For example, recording one or more gliders as road strike in both the winter and spring would be considered as unsuccessful and require contingency measures.*

Note, PIT tagging of captured animals was used in place of ear notching as an alternative (and ethically more sound) approach to identifying individual animals during the mark-recapture component of the monitoring. This change in methodology was undertaken in consultation with TfNSW, DPIE and the EPA.

1.3 Monitoring Timing

As per the EMP, monitoring was undertaken in autumn and spring of 2017, 2018 and 2019.

1.4 Reporting

As per the EMP, annual reporting of monitoring results includes:

- A description of the monitoring methodology employed
- Results, including field data, of the monitoring surveys
- A discussion of the results, including how the results compare against key performance criteria
- General recommendations including the need for any corrective actions/contingency measures.

All reports prepared under the EMP will be submitted to the Director General of the NSW Department of Planning, Industry and Environment and the NSW EPA.

1.5 Limitations

The following limitations to the monitoring procedure were encountered:

- The camera detection system is designed to maximise the likelihood that any animal using the structures is photographed, i.e. the cameras are fitted with motion detectors triggered to take photographs as animals pass by and the glider poles have collars to force the animals through a single gap where the camera is trained. However, the highly mobile nature of gliders may result in their arrival on the structures at a variety of locations, all of which cannot be captured by the cameras. As a result complete passage across the structure/road may not always be captured. This limitation applies to both glider poles and rope bridges.

2. Survey Methods

2.1 Survey Sites

Three aerial crossing zones (hereafter Sites 1, 2 and 3) are specified in the EMP. Site 1 and 2 each have a single canopy rope bridge and a set of glider poles consisting of a pole on each opposing road verge and a single median pole. Site 3 has a single canopy rope bridge and a single glider pole crossing, consisting of two median poles and one road verge pole (east), due to existing suitable trees to glide from/to on the opposing (western) road verge. The location of each crossing structure is provided in Figure 1.

2.2 Survey Method

2.2.1 Remote cameras

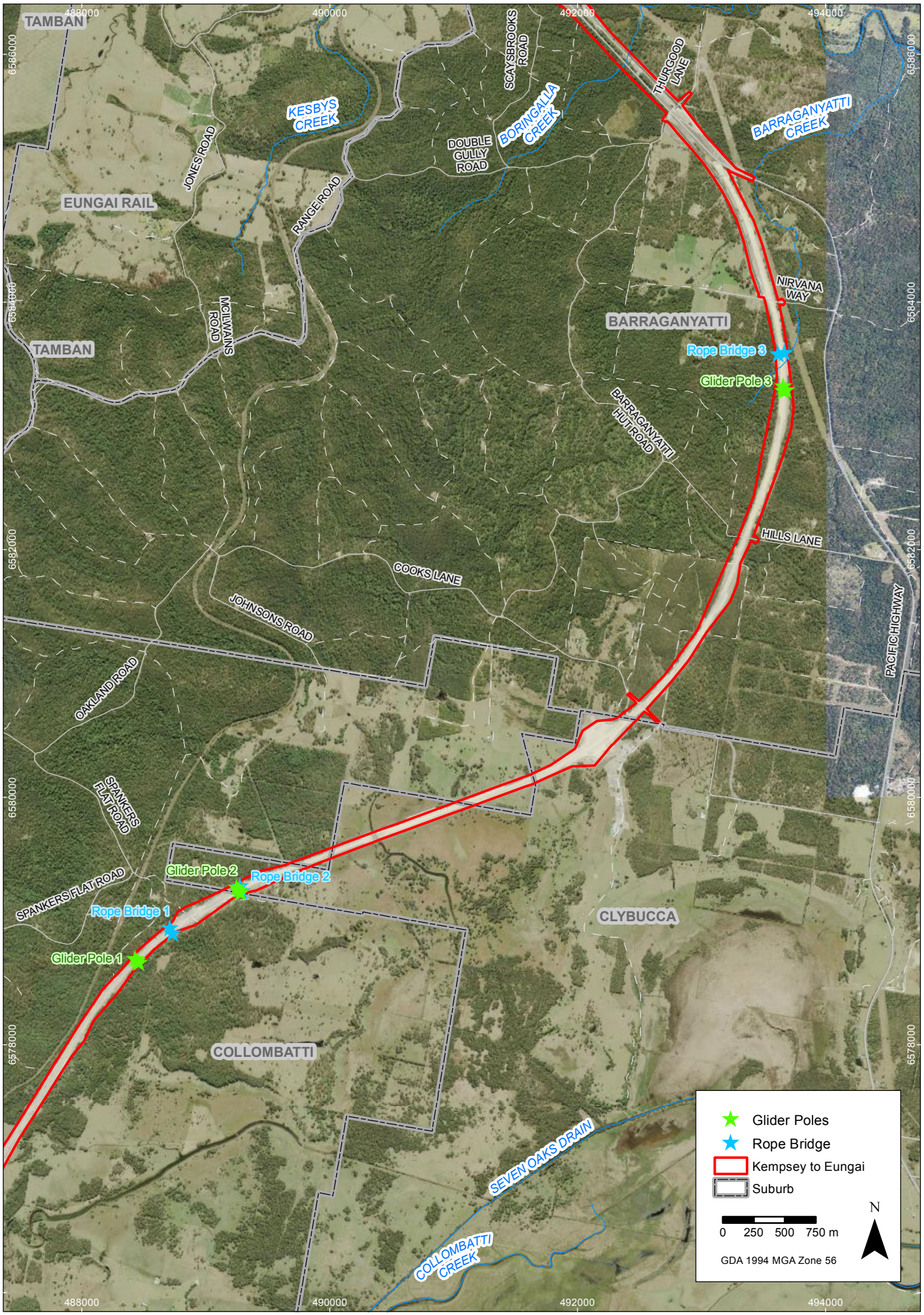
Automated cameras were installed at the top of each crossing structure pole. A single camera was installed on each glider pole and a single camera was installed at each end of the canopy rope bridges. Customised surveillance systems were installed at glider crossings and canopy rope bridges using BuckEye Cam X7D Covert IR wireless surveillance cameras (minimum response time 200 milliseconds) and standard antennae. Cameras were mounted on a customised adjustable camera mount or strut. Power is provided via a solar panel and extension power cable connected to a battery housing near ground level, which is mounted on each pole. Each glider pole was fitted with a collar to direct animals toward the camera in order to capture their image. Rope bridges were fitted with an external dual active infrared sensor to trigger cameras. All cameras were calibrated for short focus and reduced infrared output to maximise species identification. Images were downloaded wirelessly to ground level via X-Manager software installed on a laptop.

2.2.2 Arboreal trapping

Trapping was undertaken in residual habitat adjacent to the crossing zones over four nights. A total of 20 traps were deployed at each crossing zone; 10 traps were placed on either side of the carriageway and grouped around the crossing structure poles (i.e. the 10 traps were distributed between the canopy rope bridges and glider pole crossings where these structures were not immediately adjacent to each other). Figure 2 to Figure 4 show the trap locations. A range of arboreal trap types were used including pipe, Elliott and cage traps (Table 1). Details recorded of captured individuals included species, weight, gestation and sex where possible. Larger species that were captured (i.e. any arboreal marsupial greater than 100 grams in weight) were implanted with a passive integrated transponder (PIT) microchip to allow for individual identification. As mentioned previously, this was used in place of ear notching to allow identification of individual animals. Given spring 2019 surveys were the final trapping surveys, PIT tagging was not employed in spring. Traps were baited with a mixture of rolled oats and peanut butter and positioned on brackets two metres above the ground. The host tree was sprayed with a mixture of honey water above and below the trap as an additional attractant. The traps were left operating over four consecutive nights. Traps were checked within two hours of sunrise each morning, re-baited and re-sprayed with honey water.

Table 1: Trapping effort 2019

Trap type	Site 1		Site 2		Site 3	
	Autumn	Spring	Autumn	Spring	Autumn	Spring
Elliott B	6	6	6	6	6	6
Cage	4	4	4	4	4	4
Pipe	10	10	10	10	10	10



Drawn by: RJ Project Manager: CMcE Project Number: 1702 6.5 Date: 28/09/2018

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Location of Aerial Crossings

Frederickton to Eungai Pacific Highway Upgrade

FIGURE 1

Imagery: (c) LPI 2014-09-18

Drawn by: MH Project Manager: CMcE Project Number: 1702 6.5 Date: 12/16/2019

Path: T:\spatial\projects\a1700\a1702_OH2K_EcologyMaps\PI_6_EcoIMonit_F2E\PI_65_AerialCrossings\1702_PI65_20191216\1702_65_Figures_234_TrappingZones_123.mxd

Site 1 trap location

Frederickton to Eungai Pacific Highway Upgrade

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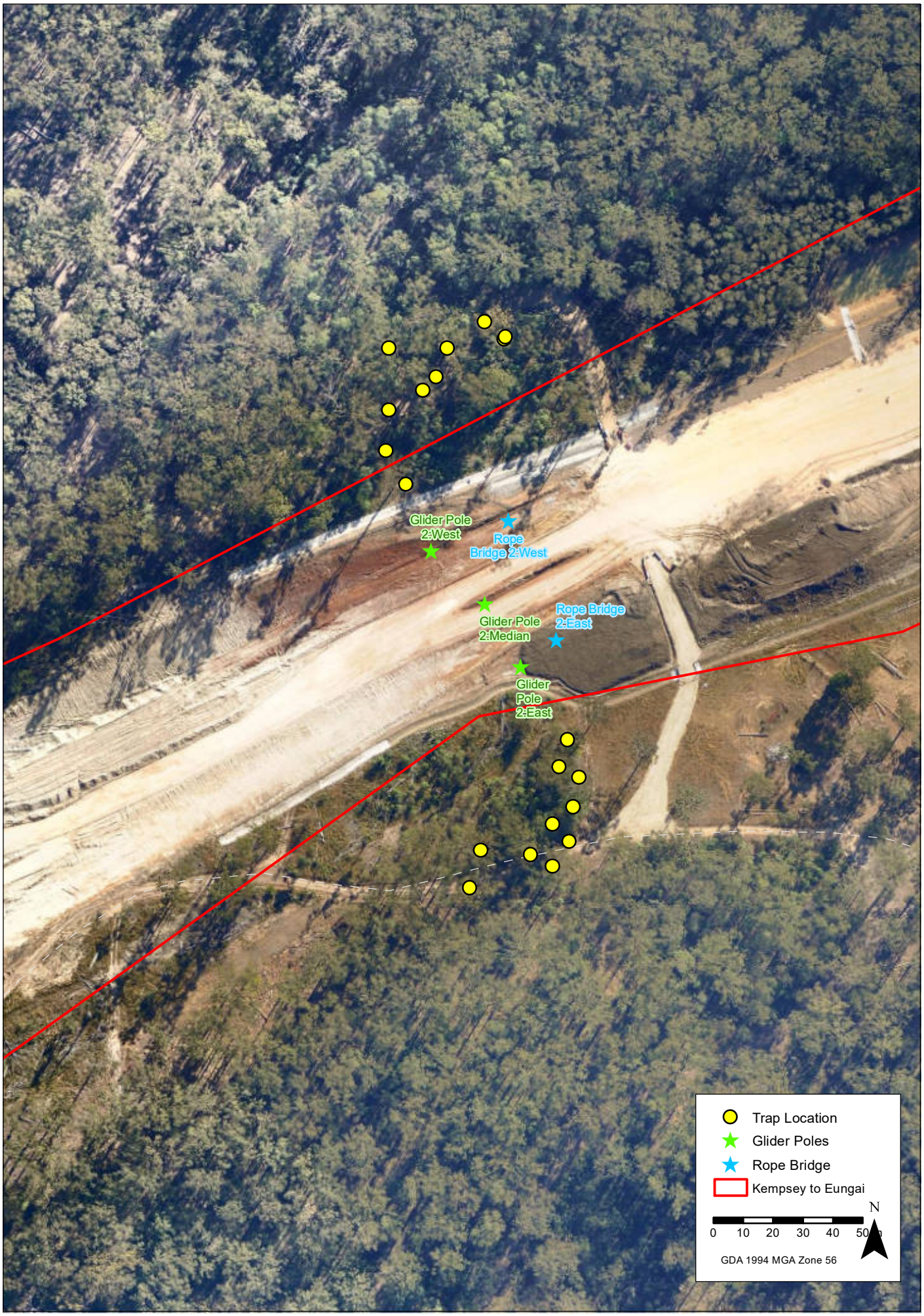
FIGURE 2

Imagery: (c) LPI 2014-09-18



Drawn by: MH Project Manager: CMcE Project Number: 1702 6.5 Date: 12/16/2019

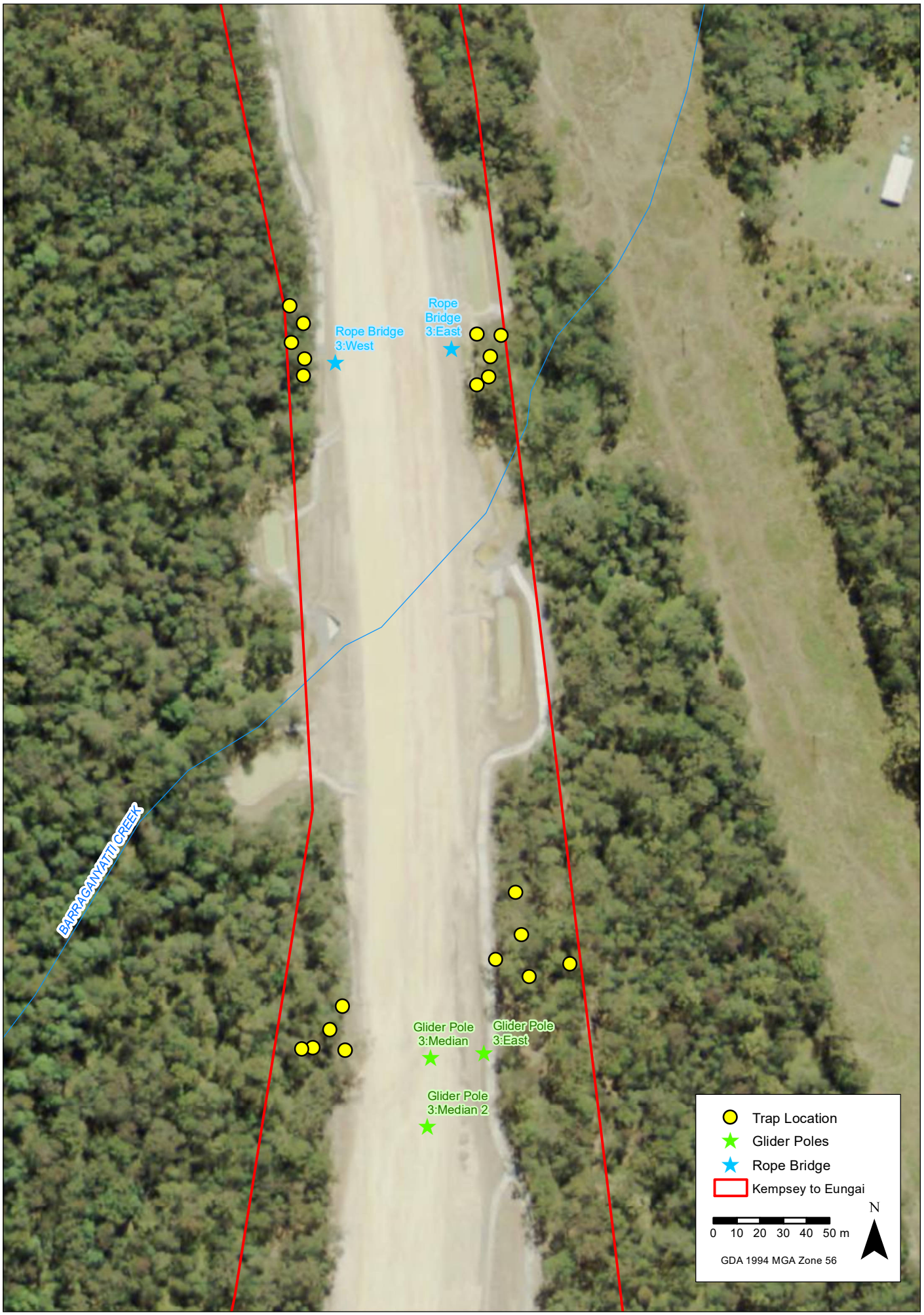
Path: T:\spatial\projects\a1700\a1702_OH2K_EcologyMaps\PI_6_EcoIMonit_F2E\PI_65_AerialCrossings\1702_PI65_20191216\1702_65_Figures_234_TrappingZones_123.mxd

Site 2 trap location

Frederickton to Eungai Pacific Highway Upgrade

FIGURE 3

Imagery: (c) LPI 2014-09-18



Drawn by: MH Project Manager: CMcE Project Number: 1702 6.5 Date: 12/16/2019

Path: T:\spatial\projects\a1700\a1702_OH2K_EcologyMaps\PI_6_EcoIMonit_F2E\PI_65_AerialCrossings\1702_PI65_20191216\1702_65_Figures_234_TrappingZones_123.mxd

Site 3 trap location

Frederickton to Eungai Pacific Highway Upgrade

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FIGURE 4

Imagery: (c) LPI 2014-09-18

3. Results

Detailed survey results for the 2019 autumn and spring monitoring are presented in Annex 1 and Annex 2.

3.1 Remote Cameras

All autumn 2019 data was lost due to a laptop being stolen during data collection, as a result only spring camera data is presented in this report. An additional autumn monitoring period will occur in 2020 to account for this lost data set.

The sixty-day spring monitoring period was 13 September – 15 November 2019. However, given cameras function continuously outside of this period, fauna records obtained before and after the nominated 60-day monitoring period were included in the results as they are considered as value adding data. Camera 4 on the eastern side of rope bridge 1 could not be detected at the end of the spring survey period. TfNSW had previously connected to Camera 4 in August 2019 but there were no photos at this time. Photos are therefore not available for the eastern end of rope bridge 1 for spring 2019. A troubleshoot of cameras will be undertaken by TfNSW prior to autumn 2020 to ensure all cameras are functioning/detectable prior to the final download.

3.1.1 Data summary

A total of 108 fauna records were analysed, of which 36 (33%) were within the 60-day monitoring period. All three target arboreal fauna were recorded within and outside of the 60-day monitoring period, including the Feathertail Glider (*Acrobates pygmaeus*), Sugar Glider (*Petaurus breviceps*) and threatened Yellow-bellied Glider (*Petaurus australis*). Of the 10 Yellow-bellied Glider records from two sites, only one was within the 60-day monitoring period and of the 20 Sugar Glider records from three sites, only two records were within the 60-day monitoring period from two sites. The inclusion of additional data has therefore identified use of an additional crossing zone by these species.

3.1.2 Glider crossings

In accordance with the performance indicators of the EMP, a successful crossing is considered to have occurred if an individual animal is detected using the median pole. Photographic data was also analysed for the detection of the same species in rapid succession on both the western and eastern road verge poles at Sites 1 and 2 as an indication of a successful crossing.

In some cases, it was not possible to definitively distinguish between the threatened Squirrel Glider (*Petaurus norfolcensis*) and the Sugar Glider due to partial or blurred images. Glider images where a Squirrel Glider identification was considered possible but not definite, are referred to as Sugar/Squirrel Glider records.

Sugar Gliders or Sugar/Squirrel Gliders were recorded at all three sites and were noted as using the median glider poles at Site 2 (five occasions) and Site 3 (two occasions). The Feathertail Glider was observed frequently using the road verge poles and was detected on the median poles at all sites. The threatened Yellow-bellied Glider was detected at Site 1 (two occasions on the eastern pole), and Site 2 (eight occasions, including two occasions on the median pole with rapid successive images from the median to the western pole). This species has been recorded using nest boxes on the east and west of the highway in close proximity to aerial crossings at Site 2. The results of the glider pole use by various glider species is summarised below.

Site 1

- Feathertail Gliders were detected using the median pole.
- Feathertail and Sugar Gliders were detected using the east and west road verge poles.
- There was one quick succession record from the west road verge to median pole by a Feathertail Glider.
- The threatened Yellow-bellied Glider was detected on the eastern road verge pole.

Site 2

- Feathertail, Sugar and Yellow-bellied Gliders were detected using the median pole.
- Feathertail, Sugar and Yellow-bellied Gliders were detected using the east and west road verge poles.
- There were two quick succession records from median pole to western road verge pole by a Yellow-bellied Glider.
- The threatened Yellow-bellied Glider was detected on the all three glider poles.

Site 3

- Feathertail and Sugar Gliders were detected using both median poles.
- There were no quick succession records between the east and median poles.
- Feathertail and Sugar Gliders were detected using the eastern verge pole (no western pole).

Table 2: Fauna use of glider crossings during 2019

Species	Site 1			Site 2			Site 3		
	Eastern	Median	Western	Eastern	Median	Western	Eastern	Median1	Median2
Feathertail Glider	Y (8)	Y (4)	Y (13)	Y (4)	Y (5)	Y (8)	Y (16)	Y (9)	Y (2)
Sugar Glider	Y (2)		Y (2)	Y (3)	Y (5)	Y (5)	Y (1)		Y (1)
Sugar/Squirrel Glider								Y (1)	
Yellow-bellied Glider	Y (2)			Y (3)	Y (2)	Y (3)			

(n) = number of separate occasion the species was detected, Y = yes detected.

3.1.3 Canopy rope bridges

As for the glider crossings, photographic data was analysed for the detection of the same species in rapid succession at both the western and eastern ends of the crossing as an indication of a successful crossing.

Only one arboreal mammal species, the Feathertail Glider, was detected using the canopy rope bridges. It was recorded on one occasion at rope bridge 3, eastern side, during spring 2019. A number of birds were recorded at Site 2 including *Corvus* spp., Pied Butcherbird (*Cracticus nigrogularis*), a kite and Laughing Kookaburra (*Dacelo novaeguineae*).

3.1.4 Site summary

Table 3, Table 4 and Table 5 provide a summary of the records from each site for spring 2019. Detection frequency was much higher on glider crossings with only one target species recorded using the canopy rope bridges. 'n' is the number of separate occasions the species was detected.

Table 3: Site 1 remote camera records spring 2019

Camera	Species	Detection frequency (mammals)
GP1 East	Feathertail Glider (8) Sugar Glider (2) Yellow-bellied Glider (2)	12
GP1 Med	Feathertail Glider (4)	4
GP1 West	Feathertail Glider (13) Sugar/Squirrel Glider (2)	15
RB1 East	No fauna	0
RB1 West	No fauna	0

Table 4: Site 2 remote camera records spring 2019

Camera	Species	Detection frequency (mammals)
GP2 East	Feathertail Glider (4) Sugar Glider (3) Yellow-bellied Glider (3)	10
GP2 Med	Feathertail Glider (5) Sugar Glider (2) Sugar/Squirrel Glider (3) Yellow-bellied Glider (2)	12
GP2 West	Feathertail Glider (8) Sugar Glider (3) Sugar/Squirrel Glider (2) Yellow-bellied Glider (3)	16
RB2 East	*Corvus* sp. (1)	0
RB2 West	Pied Butcherbird (2) Kite (1) Laughing Kookaburra (4)	0

Table 5: Site 3 remote camera records spring 2019

Camera	Species	Detection frequency (mammals)
GP3 East	Feathertail Glider (16) Sugar Glider (1)	17
GP3 Med	Feathertail Glider (9) Sugar/Squirrel Glider (1)	10
GP3 Med2	Feathertail Glider (2) Sugar Glider (1)	3
RB3 East	Feathertail Glider (1)	1
RB3 West	No fauna	0

3.2 Arboreal Trapping

Arboreal trapping survey periods were as follows:

- Autumn 2019: 11 – 15 March
- Spring 2019: 2 – 6 September.

Four species were captured in arboreal traps during autumn and spring monitoring, including the Sugar Glider, *Melomys* sp.*, Rattus* sp. and Brown Antechinus (*Antechinus stuartii*). There were no recaptures to indicate successful road crossings by any of these individuals. Note that PIT tagging was not undertaken in spring 2019 due to it being the final trapping event. Trapping results are provided in Annex 2.

3.3 Road Kill

Road kill monitoring results are presented in the Frederickton to Eungai Fauna Underpass and Associated Fauna Fencing Monitoring report 2018/2019 (Niche 2019b). While road strike monitoring was not part of aerial crossing monitoring, the EMP requires specific reporting on the presence of road strike gliders at or in vicinity of aerial crossings. Data presented within Niche 2019b did not show any records of glider species from the 2018/2019 road kill results.

3.4 Cumulative Analysis

3.4.1 Glider poles

To date, the outcome of the glider pole use by various glider species over the course of the three year monitoring period is provided in Table 6 and can be summarised as follows:

Site 1

- Feathertail and Sugar Gliders have been detected using the median, east and west road verge poles.
- There has been one quick succession record from the west road verge to median pole by a Feathertail Glider.
- The median pole has a much lower detection frequency than the eastern and western verge poles (5 *cf* 20 and 41 respectively).
- The threatened Yellow-bellied Glider has been recorded on the eastern pole.

Site 2

- Feathertail, Sugar and Yellow-bellied Gliders have been detected using the median, east and west road verge poles.
- There have been three occurrences of quick succession records; one from the east to west road verge poles in 2017 by a Feathertail Glider (Niche 2018a) and two from the median pole to western road verge pole by a Yellow-bellied Glider.
- The median pole has a similar detection frequency to the eastern and western verge poles (30 *cf* 23 and 40 respectively).
- The threatened Yellow-bellied Glider has been recorded on all three glider poles.
- The threatened Brush-tailed Phascogale (*Phascogale tapoatafa*) has been recorded on the eastern verge pole.

Site 3

- Feathertail and Sugar Gliders have been detected using both median poles, however median pole 2 has a much lower detection frequency (35 *cf* 8).
- Feathertail and Sugar Gliders have been detected using the eastern verge pole (no western pole).
- Median pole 1 has a lower detection frequency than the eastern verge pole (35 *cf* 75).

Table 6: Cumulative glider pole records for the entire three-year monitoring period (excluding autumn 2019)

Species	Site 1			Site 2			Site 3		
	Eastern	Median	Western	Eastern	Median	Western	Eastern	Median1	Median2
Feathertail Glider	✓ (12)	✓ (4)	✓ (33)	✓ (11)	✓ (12)	✓ (26)	✓ (73)	✓ (30)	✓ (7)
Sugar Glider	✓ (5)	✓ (1)	✓ (4)	✓ (5)	✓ (9)	✓ (6)	✓ (1)		✓ (1)
Sugar/Squirrel Glider	✓ (3)				✓ (5)	✓ (5)	✓ (1)	✓ (4)	
Yellow-bellied Glider			✓ (3)	✓ (4)	✓ (3)	✓ (3)			
Unknown mammal			✓ (1)	✓ (2)	✓ (1)			✓ (1)	
Brush-tailed Phascogale				✓ (1)					

'n' is the number of separate occasion the species was detected.

3.4.2 Canopy rope bridges

To date, the outcome of the canopy rope bridge use by arboreal species is provided in Table 7 and can be summarised as follows:

Site 1

- No arboreal species have been detected at **both** the eastern and western ends.
- There have been no quick succession records between the eastern and western ends.
- Only Feathertail Gliders have been detected at the western end.

Site 2

- No arboreal species have been detected at **both** the eastern and western ends.
- There have been no quick succession records between the eastern and western ends.
- Sugar and Feathertail Gliders have been detected at the western end.

Site 3

- Sugar and Feathertail Gliders have been detected at **both** the eastern and western ends.
- There have been no quick succession records between the eastern and western ends.
- Brushtail Possums have been detected at the eastern end.

Table 7: Cumulative canopy rope bridge records for the entire three-year monitoring period (excluding autumn 2019)

Species	Site 1		Site 2		Site 3	
	Eastern	Western	Eastern	Western	Eastern	Western
Feathertail Glider		✓ (27)		✓ (29)	✓ (18)	✓ (17)
Sugar Glider				✓ (1)	✓ (2)	✓ (2)
Brushtail Possum					✓ (2)	
Australian Magpie			✓ (1)	✓ (1)		
Corvus spp.	✓ (55)	✓ (18)	✓ (18)	✓ (54)		
Laughing Kookaburra				✓ (10)		
Small bird				✓ (1)		
Butcher Bird				✓ (2)		
Kite/bird of prey				✓ (1)		

'n' is the number of separate occasion the species was detected.

3.4.3 Arboreal trapping

A total of eight species and 37 individuals have been captured over the monitoring program, including the Sugar Glider, Common Brushtail Possum (*Trichosurus vulpecula*), *Melomys* sp., Black Rat (*Rattus rattus*), Bush Rat (*Rattus fuscipes*), *Rattus* sp., *Antechinus* sp. and Brown Antechinus. Table 8 summarises the species captured at each site during the three year monitoring program.

Table 8: Cumulative arboreal trapping records for the entire three-year monitoring program

Species	Site 1	Site 2	Site 3
Sugar Glider	Y (3)	Y (5)	
Common Brushtail Possum	Y (1)	Y (3)	Y (2)
Melomys sp.			Y (3)
Black Rat	Y (1)	Y (1)	
Bush Rat	Y (1)		
Rattus sp.		Y (1)	Y (2)
Brown Antechinus	Y (4)	Y (2)	Y (5)
Antechinus sp.	Y (2)	Y (1)	

(n) = number of captures, Y = yes.

3.5 Comparison with Baseline Data

Baseline surveys in adjacent bushland detected a number of arboreal and scansorial mammal species near some or all aerial crossing locations, including: Brush-tailed Phascogale, Yellow-bellied Glider, Sugar Glider, Greater Glider (*Petauroides volans*), Feathertail Glider, Common Ringtail Possum (*Pseudocheirus peregrinus*), Common Brushtail Possum, Mountain Brushtail Possum (*Trichosurus cunninghami*), Bush Rat (*Rattus fuscipes*), and Brown Antechinus.

Of these 10 species, four (the Yellow-bellied Glider, Sugar Glider, Feathertail Glider and Brushtail Possum) have been observed using the aerial crossing structures and another two (the Brown Antechinus and Brush-tailed Phascogale) have been recorded in the vicinity of the crossings. Three of the four glider species previously recorded (with the exception of the Greater Glider) have been detected on the glider crossings and canopy rope bridges. There were a number of possible but not definite Squirrel Glider records.

4. Discussion

4.1 Performance Measures

A summary of the current (spring 2019 camera records and autumn and spring 2019 trapping), and the cumulative results in relation to the performance indicators is provided in Table 9 to Table 11. As stated in the EMP, indicators of success for the glider poles and rope bridges would include one or more of the performance indicators.

Table 9: Indicators of success for the glider poles

Indicators of success	Discussion
Evidence of use by any glider species using the median pole.	**This performance indicator of success has been met for all sites.** The median glider poles at Sites 1 and 3 have been used by Feathertail and Sugar Gliders. The median pole at Site 2 has been used by Feathertail, Sugar and Yellow-bellied Gliders.
Photographic evidence of a glider using both the eastern and western poles.	**This performance indicator of success has been met at site 2.** There has been one occurrence of quick succession records from the east to west road verge poles in 2017 by a Feathertail Glider (Niche 2018a).
One or more gliders with left ear tag/notch occurring on the western side of the carriageway and fauna with right ear tag/notch occurring on the eastern side of the carriageway.	**This performance indicator of success has not been met.** Implantation of PIT microchips was implemented (in consultation with TfNSW, DPIE and the EPA) as an alternative method to ear notching to identify individual animals. There have been no captures of individually marked animals on both sides of the road.

Table 10: Signs of the glider poles being unsuccessful

Signs of the glider poles being unsuccessful	Discussion
Absence of gliders being recorded using the median pole or other evidence of complete crossings.	**This sign of unsuccessful mitigation has not been met.** The median glider poles at all sites have been used by at least one glider species.
Unacceptable levels of road strike (presence of deceased individuals during each sampling period for either year). For example, recording one or more gliders as road strike in both monitoring seasons would be considered as unsuccessful and require contingency measures.	**This sign of unsuccessful mitigation has not been met.** There have been no records of road kill glider species from the road kill monitoring results to date.

Table 11: Indicators of success for the canopy rope bridges

Indicators of success	Discussion
Photographic evidence of any arboreal species using both sides of the rope ladder to indicate a successful passage.	**This performance indicator of success has not been met.** No individual has been recorded using both sides of a crossing in rapid succession.
One or more arboreal species with left ear tag/notch occurring on the western side of the carriageway and arboreal fauna with right ear tag/notch occurring on the eastern side of the carriageway.	**This performance indicator of success has not been met.** Implantation of PIT microchips was implemented (in consultation with TfNSW ,DPIE and the EPA) as an alternative method to ear notching to identify individual animals. There were no captures of individually marked animals on both sides of the road.

Table 12: Signs of the rope bridges being unsuccessful

Signs of the rope bridges being unsuccessful	Discussion
No photographic evidence of arboreal fauna successfully crossing the rope bridge or other evidence of complete crossings (i.e. ear tags, notches).	**This sign of unsuccessful mitigation has been met.** No individual has been recorded using both sides of a crossing in rapid succession.
Unacceptable levels of road strike (presence of deceased individuals during each sampling period for either year). For example, recording one or more gliders as road strike in both the winter and spring would be considered as unsuccessful and require contingency measures.	**This sign of unsuccessful mitigation has not been met.** There have been no records of road kill glider species from the road kill monitoring results to date.

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 to be relevant to the aerial crossing monitoring program are listed and discussed in Table 13.

Table 13: Contingency measures

Potential problem	Contingency measure proposed in EMP	Discussion of proposed measure
No fauna recorded using the poles or rope ladder canopy bridges No evidence or marked/tagged gliders crossing the carriageway.	• Review other monitoring data. • Review planting schedules/status of vegetation bordering the poles and/or rope ladder canopy bridges. • Review monitoring program and make necessary adjustments. • Consider placing lead/lure ropes from neighbouring trees to the poles and/or rope ladder canopy bridges.	***Glider poles***: In accordance with the EMP, use of the median pole of glider crossings is considered to represent a successful crossing, despite the absence of recapture data and quick succession records. Glider species have been recorded using median poles at all sites and it is considered likely that resident Yellow-bellied Gliders are using the glider poles to move between habitat and denning sites on either side of the highway. **These contingency measures are therefore not considered relevant for glider pole crossings.** ***Rope bridges***: Successful crossings of canopy rope bridges have not been confirmed. However, the majority of fauna detected using the canopy rope bridges are glider species. As gliders may arrive and depart from the rope bridge at an undefined point, they may do so without triggering the second camera. The absence of scansorial fauna and few records of non-gliding arboreal mammals is however noted. **These contingency measures are therefore considered relevant for canopy rope bridges.**
Unacceptable levels of road strike for gliders (>1 during each monitoring event for Year 1, Year 2, Year 3)	• Review current information of glider pole plane angles. • Consider design adjustment that could improve the usability of the poles and/or rope ladder canopy bridges. • Review the extent of vegetation in the median.	**These contingency measures are not considered relevant.** There have been no road kill records of glider species.

5.2 Recommendations

In relation to the relevant contingency measures noted above (Table 13), and performance indicators that have not been met, a number of recommendations have been made. These are detailed in Table 14 below.

Table 14: Recommendations

Problem identified during monitoring	Relevant contingency measures	Discussion/Recommendation
Successful crossings of canopy rope bridges have not been confirmed.	• Review other monitoring data. • Review planting schedules/status of vegetation bordering the poles and/or rope ladder canopy bridges. • Review monitoring program and make necessary adjustments. • Consider placing lead/lure ropes from neighbouring trees to the poles and/or rope ladder canopy bridges.	Baseline surveys indicate the presence of arboreal fauna at all three crossing zones that might be expected to use canopy rope bridges. Trapping data has confirmed presence of arboreal species the Sugar Glider and Common Brushtail Possum at Sites 1 and 2. Further, *Antechinus* spp. have been detected at all three sites whilst *Melomys* sp. (Site 3) and the Bush Rat (Site 1) were detected at one site. In addition, nest box data (Niche 2019c) shows records of the Sugar Glider and Brushtail Possum occupying nest boxes adjacent to rope bridge 1; the Sugar Glider, Yellow-bellied Glider and Brushtail Possum occupying nest boxes adjacent to rope bridge 2; the Brushtail Possum and Common Ringtail Possum occupying nest boxes adjacent to rope bridge 3. These additional data confirm the presence of arboreal fauna in habitat adjacent to the crossing zones. Therefore the following recommendations should be considered: • A review of the vegetation status immediately adjacent to the crossing poles should be considered, with the aim of determining if additional lead/lure ropes from neighbouring trees to the rope ladder canopy bridges would improve fauna access to the rope ladder, notably for small scansorial species, or if additional planting would be suitable/beneficial. • A test of the sensitivity of the sensors and functionality of the cameras should be completed prior to the autumn monitoring period. • As the cameras have been installed and are designed to function continually throughout the year, consideration should be given to continue to download camera images in an effort to capture additional crossings by fauna. Seasonal downloads could be undertaken, and all photographic records retained, as opposed to defined monitoring periods.
Recaptures of tagged fauna have not been made on either side of the road, therefore there is no evidence of tagged fauna crossing the carriageway.		Due to low capture rate of fauna combined with the limited trapping effort, it is considered that this means of identifying successful crossings is unlikely to result in positive outcomes. It is likely that a substantial increase in trapping effort would be required to obtain the necessary micro chipping numbers to provide results based on mark-recapture surveys. Further trapping is not recommended as a means of determining successful crossing of the rope bridges as it is unlikely to provide additional useful data.
Camera malfunction	• Not applicable	Canopy rope bridge 1 east (Camera 4) could not be detected. TfNSW will troubleshoot and work to resolve this issue prior to the final monitoring.
Lost data	• Not applicable	Equipment theft in autumn 2019 resulted in the loss of autumn 2019 camera data. In consultation with TfNSW, DPIE and the EPA, it was determined that an additional 60-day aerial camera monitoring period would be conducted in autumn 2020. Autumn 2020 data will be reported in a separate report.

6. References

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Niche (2019b). Fauna Underpasses and Associated Fauna Fence Monitoring Report 2018/2019. Prepared for NSW Roads and Maritime Services.

Niche (2019c). Nest Box Monitoring 2018/2019. Prepared for NSW Roads and Maritime Services.

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Annex 1 – Remote camera results

Table 15: Remote camera records - spring 2019

Records occurring within the 60-day monitoring period are highlighted in bold and results are sorted by site and date.

Monitoring period	Site	Season	Pole	Camera	Date	Time	Species
Spring	1	Winter	GP1 east	1	18/06/2019	18:32:23	Sugar Glider
Spring	1	Winter	GP1 east	1	29/06/2019	23:59:59	Feathertail Glider
Spring	1	Winter	GP1 east	1	27/07/2019	22:10:02	Sugar Glider
Spring	1	Winter	GP1 east	1	30/07/2019	2:08:17	Feathertail Glider
Spring	1	Winter	GP1 east	1	8/08/2019	2:18:44	Feathertail Glider
Spring	1	Winter	GP1 east	1	17/08/2019	8:47:17	Yellow-bellied Glider
Spring	1	Winter	GP1 east	1	26/08/2019	1:45:55	Feathertail Glider
Spring	1	Spring	GP1 east	1	1/09/2019	21:41:08	Feathertail Glider
Spring	**1**	**Spring**	**GP1 east**	**1**	**21/10/2019**	**19:16:00**	**Yellow-bellied Glider**
Spring	**1**	**Spring**	**GP1 east**	**1**	**25/10/2019**	**22:04:29**	**Feathertail Glider**
Spring	**1**	**Spring**	**GP1 east**	**1**	**25/10/2019**	**22:25:28**	**Feathertail Glider**
Spring	**1**	**Spring**	**GP1 east**	**1**	**26/10/2019**	**22:42:13**	**Feathertail Glider**
Spring	1	Winter	GP1 mid	2	1/07/2019	1:02:52	Feathertail Glider
Spring	1	Winter	GP1 mid	2	5/08/2019	1:00:24	Feathertail Glider
Spring	1	Winter	GP1 mid	2	26/08/2019	0:55:10	Feathertail Glider
Spring	1	Spring	GP1 mid	2	18/11/2019	20:52:49	Feathertail Glider
Spring	1	Winter	GP1 west	3	2/06/2019	19:24:05	Feathertail Glider
Spring	1	Winter	GP1 west	3	6/06/2019	2:25:07	Feathertail Glider
Spring	1	Winter	GP1 west	3	9/06/2019	1:53:00	Feathertail Glider
Spring	1	Winter	GP1 west	3	9/06/2019	19:57:38	Feathertail Glider
Spring	1	Winter	GP1 west	3	14/06/2019	20:34:49	Sugar Glider
Spring	1	Winter	GP1 west	3	1/07/2019	0:59:40	Feathertail Glider
Spring	1	Winter	GP1 west	3	7/07/2019	23:38:57	Feathertail Glider
Spring	1	Winter	GP1 west	3	24/08/2019	3:38:13	Feathertail Glider
Spring	1	Winter	GP1 west	3	24/08/2019	18:32:05	Feathertail Glider
Spring	1	Winter	GP1 west	3	26/08/2019	5:11:43	Feathertail Glider
Spring	1	Winter	GP1 west	3	30/08/2019	22:13:55	Feathertail Glider
Spring	**1**	**Spring**	**GP1 west**	**3**	**16/09/2019**	**19:08:02**	**Feathertail Glider**
Spring	**1**	**Spring**	**GP1 west**	**3**	**23/09/2019**	**0:15:15**	**Sugar Glider**
Spring	**1**	**Spring**	**GP1 west**	**3**	**24/09/2019**	**0:57:36**	**Feathertail Glider**
Spring	**1**	**Spring**	**GP1 west**	**3**	**24/09/2019**	**1:37:26**	**Feathertail Glider**
Spring	2	Autumn	GP2 east	8	21/05/2019	0:32:07	Yellow-bellied Glider
Spring	2	Autumn	GP2 east	8	21/05/2019	0:32:57	Yellow-bellied Glider
Spring	2	Winter	GP2 east	8	1/06/2019	3:18:56	Sugar Glider
Spring	2	Winter	GP2 east	8	2/06/2019	0:09:38	Sugar Glider
Spring	2	Winter	GP2 east	8	7/06/2019	0:35:56	Sugar Glider
Spring	2	Winter	GP2 east	8	10/06/2019	0:37:07	Feathertail Glider
Spring	2	Winter	GP2 east	8	22/06/2019	19:08:17	Yellow-bellied Glider

Monitoring period	Site	Season	Pole	Camera	Date	Time	Species
Spring	2	Winter	GP2 east	8	27/07/2019	19:42:52	Feathertail Glider
Spring	2	Winter	GP2 east	8	28/07/2019	0:54:50	Feathertail Glider
Spring	2	Winter	GP2 east	8	30/07/2019	22:11:29	Feathertail Glider
Spring	2	Autumn	GP2 mid	9	26/05/2019	23:41:08	Sugar Glider
Spring	2	autumn	GP2 mid	9	29/05/2019	21:15:04	Feathertail Glider
Spring	2	Autumn	GP2 mid	9	29/05/2019	21:15:33	Feathertail Glider
Spring	2	Winter	GP2 mid	9	11/06/2019	5:34:16	Feathertail Glider
Spring	2	Winter	GP2 mid	9	21/06/2019	5:42:41	Yellow-bellied Glider
Spring	2	Winter	GP2 mid	9	19/07/2019	0:21:30	Yellow-bellied Glider
Spring	2	Winter	GP2 mid	9	20/07/2019	21:34:03	Sugar Glider
Spring	**2**	**Spring**	**GP2 mid**	**9**	**6/10/2019**	**19:21:01**	**Sugar Glider**
Spring	**2**	**Spring**	**GP2 mid**	**9**	**7/10/2019**	**2:26:23**	**Sugar Glider**
Spring	**2**	**Spring**	**GP2 mid**	**9**	**12/10/2019**	**1:40:17**	**Sugar Glider**
Spring	**2**	**Spring**	**GP2 mid**	**9**	**23/10/2019**	**20:50:31**	**Feathertail Glider**
Spring	2	Spring	GP2 mid	9	30/11/2019	0:06:17	Feathertail Glider
Spring	2	Autumn	GP2 west	10	30/05/2019	2:42:22	Sugar Glider
Spring	2	Autumn	GP2 west	10	31/05/2019	1:00:55	Sugar Glider
Spring	2	Winter	GP2 west	10	6/06/2019	2:51:50	Sugar Glider
Spring	2	Winter	GP2 west	10	21/06/2019	5:44:02	Yellow-bellied Glider
Spring	2	Winter	GP2 west	10	24/06/2019	20:00:51	Sugar Glider
Spring	2	Winter	GP2 west	10	7/07/2019	23:35:59	Feathertail Glider
Spring	2	Winter	GP2 west	10	19/07/2019	0:23:07	Yellow-bellied Glider
Spring	2	Winter	GP2 west	10	28/07/2019	2:50:00	Feathertail Glider
Spring	2	Spring	GP2 west	10	11/09/2019	2:59:39	Yellow-bellied Glider
Spring	**2**	**Spring**	**GP2 west**	**10**	**21/09/2019**	**23:34:32**	**Feathertail Glider**
Spring	**2**	**Spring**	**GP2 west**	**10**	**30/09/2019**	**1:39:20**	**Sugar Glider**
Spring	**2**	**Spring**	**GP2 west**	**10**	**2/10/2019**	**21:02:45**	**Feathertail Glider**
Spring	**2**	**Spring**	**GP2 west**	**10**	**2/10/2019**	**21:03:29**	**Feathertail Glider**
Spring	**2**	**Spring**	**GP2 west**	**10**	**25/10/2019**	**23:08:42**	**Feathertail Glider**
Spring	**2**	**Spring**	**GP2 west**	**10**	**27/10/2019**	**2:45:39**	**Feathertail Glider**
Spring	2	Spring	GP2 west	10	17/11/2019	23:03:27	Feathertail Glider
Spring	2	Spring	RB2 east	6	1/09/2019	17:15:29	Crow/Raven
Spring	2	Spring	RB2 west	7	7/09/2019	6:09:39	Kookaburra
Spring	**2**	**Spring**	**RB2 west**	**7**	**20/09/2019**	**7:06:38**	**Kookaburra**
Spring	**2**	**Spring**	**RB2 west**	**7**	**21/09/2019**	**5:14:43**	**Kookaburra**
Spring	**2**	**Spring**	**RB2 west**	**7**	**23/09/2019**	**17:23:58**	**Kookaburra**
Spring	**2**	**Spring**	**RB2 west**	**7**	**24/10/2019**	**5:53:48**	**Butcher Bird**
Spring	**2**	**Spring**	**RB2 west**	**7**	**27/10/2019**	**4:59:45**	**Butcher Bird**
Spring	**2**	**Spring**	**RB2 west**	**7**	**6/11/2019**	**6:56:14**	**Kite**
Spring	3	Autumn	GP3 east	11	25/05/2019	22:45:04	Feathertail Glider
Spring	3	Autumn	GP3 east	11	25/05/2019	23:08:05	Sugar Glider
Spring	3	Autumn	GP3 east	11	31/05/2019	23:14:26	Feathertail Glider
Spring	**3**	**Spring**	**GP3 east**	**11**	**22/09/2019**	**22:31:45**	**Feathertail Glider**

Monitoring period	Site	Season	Pole	Camera	Date	Time	Species
Spring	**3**	**Spring**	**GP3 east**	**11**	**23/09/2019**	**22:54:08**	**Feathertail Glider**
Spring	**3**	**Spring**	**GP3 east**	**11**	**25/09/2019**	**20:39:34**	**Feathertail Glider**
Spring	**3**	**Spring**	**GP3 east**	**11**	**27/09/2019**	**0:01:36**	**Feathertail Glider**
Spring	**3**	**Spring**	**GP3 east**	**11**	**27/09/2019**	**20:32:49**	**Feathertail Glider**
Spring	**3**	**Spring**	**GP3 east**	**11**	**29/09/2019**	**3:10:13**	**Feathertail Glider**
Spring	**3**	**Spring**	**GP3 east**	**11**	**29/09/2019**	**20:54:18**	**Feathertail Glider**
Spring	**3**	**Spring**	**GP3 east**	**11**	**29/09/2019**	**23:00:14**	**Feathertail Glider**
Spring	**3**	**Spring**	**GP3 east**	**11**	**29/09/2019**	**23:39:08**	**Feathertail Glider**
Spring	**3**	**Spring**	**GP3 east**	**11**	**30/09/2019**	**0:01:41**	**Feathertail Glider**
Spring	**3**	**Spring**	**GP3 east**	**11**	**30/09/2019**	**0:03:49**	**Feathertail Glider**
Spring	3	Summer	GP3 east	11	3/12/2019	23:23:38	Feathertail Glider
Spring	3	Summer	GP3 east	11	4/12/2019	1:47:30	Feathertail Glider
Spring	3	Summer	GP3 east	11	5/12/2019	0:24:17	Feathertail Glider
Spring	3	Autumn	GP3 mid1	12	25/05/2019	22:32:40	Feathertail Glider
Spring	3	Autumn	GP3 mid1	12	25/05/2019	22:44:34	Feathertail Glider
Spring	3	Winter	GP3 mid1	12	7/06/2019	1:47:12	Feathertail Glider
Spring	3	Winter	GP3 mid1	12	23/06/2019	20:41:11	Sugar/Squirrel Glider
Spring	3	Winter	GP3 mid1	12	27/06/2019	23:20:51	Feathertail Glider
Spring	3	Winter	GP3 mid1	12	2/07/2019	0:59:54	Feathertail Glider
Spring	3	Winter	GP3 mid1	12	12/07/2019	3:21:41	Feathertail Glider
Spring	3	Winter	GP3 mid1	12	30/07/2019	0:23:33	Feathertail Glider
Spring	**3**	**Spring**	**GP3 mid1**	**12**	**27/10/2019**	**22:34:26**	**Feathertail Glider**
Spring	**3**	**Spring**	**GP3 mid1**	**12**	**28/10/2019**	**0:08:29**	**Feathertail Glider**
Spring	3	Spring	GP3 mid2	13	4/08/2019	1:12:22	Feathertail Glider
Spring	3	Spring	GP3 mid2	13	8/08/2019	3:18:00	Sugar Glider
Spring	**3**	**Spring**	**GP3 mid2**	**13**	**6/10/2019**	**23:11:24**	**Feathertail Glider**
Spring	3	Summer	RB3 east	14	4/12/2019	23:42:21	Feathertail Glider

Annex 2 – Arboreal trapping results

Table 16: Arboreal trapping results – autumn and spring 2019

Date	Survey	Site	Side of carriageway	Trap type	Species	Recapture (Y/N)	Sex	Age	Breeding condition	Microchip ID
14/03/2019	Autumn	1	West	Pipe	Brown Antechinus	N	male	adult		
15/03/2019	Autumn	1	West	Elliot	Brown Antechinus	N	unk	juvenile		
13/03/2019	Autumn	2	West	Elliot	Sugar Glider	N	male	adult		0007A3E15D
12/03/2019	Autumn	3	West	Elliot	*Melomys* sp.	N	female	adult		
13/03/2019	Autumn	3	West	Elliot	*Melomys* sp.	N	male	adult		
15/03/2019	Autumn	3	West	Elliot	*Melomys* sp.	N	female	adult	Pregnant	
14/03/2019	Autumn	3	East	Pipe	Brown Antechinus	N	male	adult		
15/03/2019	Autumn	3	East	Pipe	Brown Antechinus	N	unk	adult		
04/09/2019	Spring	3	West	Pipe	Brown Antechinus	N	male	adult		
04/09/2019	Spring	2	East	Elliot	Sugar Glider	N	unk	adult		
05/09/2019	Spring	3	West	Elliot	*Rattus* sp.	N	male	adult		
05/09/2019	Spring	3	West	Cage	*Rattus* sp.	N	unk	adult		
06/09/2019	Spring	2	East	Cage	*Rattus* sp.	N	unk	adult		
06/09/2019	Spring	2	East	Elliot	Brown Antechinus	N	unk	adult		
06/09/2019	Spring	2	East	Pipe	Brown Antechinus	N	unk	adult		
06/09/2019	Spring	2	East	Cage	Sugar Glider	N	unk	adult		Not tagged
06/09/2019	Spring	2	East	Elliot	Sugar Glider	N	male	adult		Not tagged

Unk = unknown

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Appendix D Nest Box

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Nest Box Monitoring 2018/2019

Frederickton to Eungai Pacific Highway Upgrade

Prepared for Transport for NSW

January 2020

Document control

Project no.:	1702 (PI 6.6)
Project client:	Transport for NSW
Project office:	Port Macquarie
Document description:	Frederickton to Eungai Nest Box Monitoring Report 2018/2019
Project Director:	Rhidian Harrington
Project Manager:	Radika Michniewicz
Authors:	Jodie Danvers
Internal review:	Radika Michniewicz, Amanda Griffith
Document status:	Rev1
Local Government Area:	Kempsey

Document revision status

Author	Revision number	Internal review	Date issued
Jodie Danvers	D1	Radika Michniewicz	26/11/19
Jodie Danvers	D2	Radika Michniewicz	2/12/19
Radika Michniewicz	D3	Amanda Griffith	4/12/2019
Radika Michniewicz	R0		5/12/2019
Radika Michniewicz	R1		30/1/2020

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Locations

Sydney

Central Coast

Illawarra

Armidale

Newcastle

Mudgee

Port Macquarie

Brisbane

Cairns

Cover photograph: Yellow-Bellied Gliders in a Large Glider Box in Zone I (left) and Sugar Gliders in a Small Glider Box in Zone K (right) - Winter 2019.

Executive summary

Context

This report documents the findings of the 2018/2019 monitoring period (summer and winter), the final of three monitoring periods for nest boxes, as specified in the Frederickton to Eungai (F2E) Ecological Monitoring Program (EMP, RMS 2016) and required by the Frederickton to Eungai (F2E) Pacific Highway Upgrade Project (the Project). Transport for NSW (TfNSW) is required to manage and monitor the effectiveness of biodiversity mitigation measures implemented as part of the Project.

Aims

The aims of this report are to summarise the methods and results of the summer 2018/2019 and winter 2019 monitoring and determine if performance measures have been met, as per the EMP.

Methods

In accordance with the EMP, a visual inspection of each nest box was undertaken in summer between the 12th and 20th January 2019 and in winter between the 2nd and 23rd July 2019. Using a wireless camera attached to the end of an extendable pole the inside of each box was inspected for signs of use by fauna. Where a nest box was occupied the species was identified where possible. Unoccupied nest boxes were examined for signs of use, such as leaf litter and bark, well-formed nests, feathers, hair or scats. The condition of each box was examined, and any deterioration or maintenance issues were noted. Whilst the majority of nest boxes were inspected using the wireless camera and extendable pole, those few that could not be reached were visually inspected on 18th February and 12th August 2019 by a qualified tree climber with an ecologist on site to collect the appropriate data.

Key results

There were 248 nest boxes monitored in summer and 249 in winter during the 2018/2019 monitoring period. One hundred and fifty-five nest boxes in summer (62.5%) and 169 in winter (67.9%) were occupied or showed signs of use by vertebrate fauna. Eight different species were recorded occupying nest boxes. Of particular note was the detection of the Brush-tailed Phascogale, Squirrel Glider and the Yellow-bellied Glider, all listed as vulnerable under the NSW *Biodiversity Conservation Act* (BC Act).

Over the entire nest box monitoring program fifteen native vertebrate species, representing six (small gliders, large gliders, scansorial fauna, possums, medium sized parrots and microbat) of the eight target fauna groups, have been recorded occupying nest boxes. Five of the eight nest box types recorded use by their target fauna with possum (PO) boxes recording the highest use by target fauna.

Possum (PO), small glider (SG), large glider (LG), scansorial fauna (SF) and microbat (MB) boxes recorded use by their target species. Parrot (P/L), Cockatoo/ Small Owl (CO/SO) and Large Forest Owl (LFO) nest boxes have shown occupation or signs of use by non-target vertebrate fauna only.

The final nest box inspection determined that 44 (17.7%) nest boxes require maintenance, including a minimum of seven nest boxes that require replacement.

Conclusions

The performance measures met include; the use of nest boxes by a wide range of native fauna and low rates of use by exotic species. The use of nest boxes designed for specific species by target species was met by five of the eight nest box types, with SG, LG, PO, MB and SF boxes all being used by target species. The remaining three box types, PL, COSO and LFO, were used by non-target fauna. Cockatoos, parrots and owls were not recorded using any nest boxes.

The performance indicator relating to reduced maintenance requirements (<10% requiring attention) was not met as the final inspection found that 17.7% of the installed nest boxes require maintenance.

Management implications

Ongoing monitoring is not recommended for nest boxes as results have shown high rates of use by a range of vertebrate fauna. However, a number of recommendations have been made to address maintenance issues as well as the apparent low uptake rate of nest boxes by microbats, cockatoos, parrots and owls, including:

- Consideration be given to investigating the use of culverts by microbat species to determine if these structures are providing roosting habitat for microbats
- Discussions with the NSW EPA be undertaken to determine if corrective actions are required to compensate for the loss of potential roosting habitat
- Maintenance actions be undertaken as required
- Rewiring of specific zones/boxes be undertaken using PVC coated wire (approximately 3.15 millimetres).

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1. Introduction

1.1 Context

As part of the Frederickton to Eungai (F2E) Pacific Highway Upgrade Project (the Project), TfNSW have implemented an Ecological Monitoring Program (hereafter referred to as the EMP, RMS 2016) in accordance with the Minister for Planning's Condition of Approval (MCoA) No. 3.1. The EMP combines the approval conditions provided within the Ministers Conditions of Approval (MCoA) and Statement of Commitments (SoC) and defines the mitigation and offsetting requirements for threatened species and ecological communities impacted by the Project.

1.1.1 Monitoring framework

The EMP states the following regarding nest box monitoring.

"It is proposed that monitoring would take place >6 months after the installation period (i.e. 2015) followed by a winter census to account for seasonal variation in the use of the nest boxes. It is proposed that annual monitoring and maintenance is undertaken thereafter and that a pre handover maintenance inspection is undertaken once construction is complete."

As per the EMP, monitoring of the installed nest boxes occurred in summer and winter of 2015, 2017 and 2019. To date, these monitoring events have been reported as follows:

- *Summer 2014/2015, winter 2015*: RMS 2015
- *Summer 2016/2017, winter 2017*: Niche 2018
- *Summer 2018/2019, winter 2019*: Current report.

This report therefore represents the final of three required monitoring cycles.

1.1.2 Baseline data

The EMP provides the following information regarding baseline data for the nest box monitoring program:

"Baseline surveys performed in 2005 occur within or close to 10 of the 13 identified nest box zones in the Nest Box Plan of Management (Lewis 2012). The results of these earlier surveys provide a suitable baseline data set in which to assess performance measures on the types of fauna previously recorded in the project corridor."

1.1.3 Purpose of this report

This report complies with the monitoring requirements described within the EMP and details the findings obtained from the third and final monitoring period.

The aims of this report are to summarise the methods and results of the summer 2018/2019 and winter 2019 monitoring and determine if performance measures have been met, as per the EMP. In addition, maintenance details outlined in this report will address the pre-handover maintenance inspection required at the completion of the monitoring, as prescribed in the EMP and the Nest Box Plan of Management (hereafter NBPoM, Lewis 2012).

1.2 Performance measures

The EMP specifies the following performance indicators for the nest box monitoring program:

The performance of the nest box program would be assessed against the following parameters:

- *Use of nest boxes by a wide range of native fauna*
- *Use of nest boxes designed for specific species by those species (i.e. scansorial fauna nest box being used by these species)*
- *Low rates of exotic fauna using nest boxes*
- *Reduced maintenance requirements (<10% requiring attention).*

1.3 Monitoring timing

As per the EMP, monitoring was undertaken in summer and winter of 2015, 2017 and 2019.

1.4 Reporting

Annual reporting of monitoring results includes:

- A description of the monitoring methodology employed
- Results of the monitoring surveys
- A discussion of the results, including how the results compare against key performance criteria
- The need for any corrective actions/contingency measures and any general recommendations.

Reports prepared under the EMP will be submitted to the NSW Department of Planning, Industry and Environment (DPIE) and the NSW Environment Protection Authority (EPA).

2. Methods

2.1 Survey sites

The NBPoM describes the number, type and distribution of nest boxes required to mitigate the loss of hollows, and the ongoing management of the nest boxes. The boxes were installed in two phases: 75% (220) of the nominated nest boxes from the NBPoM were installed prior to or during clearing to provide temporal refuge habitat. A post-clearing review was undertaken to determine the need for additional nest boxes. An additional 26 boxes were installed in December 2015, resulting in a total of 246 nest boxes. The 2015/2016 monitoring also resulted in the installation of a number of additional boxes due to loss or non-detection. In 2016/2017, a number of nest boxes were either not located or found to be double records of the same nest box.

In 2018/2019 248 nest boxes were monitored in summer and 249 nest boxes in winter. Nest boxes are distributed throughout thirteen zones (A to M), using a combination of different nest box types designed to target specific species (Table 1). The location of each zone is provided in Figure 1.

Table 1: Next box type and target species.

Nest Box Design / Type	Number inspected 2018/2019		Target species
	Summer	Winter	
Microbats (MB)	32	32	Fluttering and direct flying species that use tree hollows
Small Gliders (SG)	44	44	Feather-tail Glider, Sugar Glider
Large Gliders (LG)	23	23	Squirrel Glider, Yellow-bellied Glider, Greater Glider
Scansorial Fauna (SF)	45	45	Antechinus, Brush-tailed Phascogale
Possums (PO)	43	44	Common Brushtail Possum, Short-eared Possum, Common Ringtail Possum
Medium sized parrots (PL)	41	41	Lorikeets, Rosellas
Cockatoo/Small owl (COSO)	15	15	Black Cockatoos, King Parrot, Boobook Owl, Barn Owl
Large Forest Owls (LFO)	5	5	Masked Owl

2.2 Survey method

In accordance with the EMP, a visual inspection of each nest box was undertaken in summer between the 12th and 20th January 2019 and on the 18th February 2019 and in winter between the 2nd and 23rd July and on the 12th August 2019.

Using a wireless camera attached to the end of an extendable pole the inside of each box was inspected for signs of use by fauna. Where a nest box was occupied the species was identified where possible. Unoccupied nest boxes were examined for signs of use, such as leaf litter and bark, well-formed nests, feathers, hair or scats. The condition of each box was examined, and any deterioration or maintenance issues were noted. The majority of nest boxes were inspected using the extendable pole and those that could not be reached were visually inspected by a qualified tree climber with an ecologist on site to collect the appropriate data.

As required by the EMP, the following details were recorded for each nest box:

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

3. Results

Detailed field results for the summer and winter monitoring events are provided in Annex 1 and Annex 2, weather conditions in Annex 3 and data analysis in Annex 4.

3.1 2018/2019 nest box use

3.1.1 Range of native fauna

Of the 248 (summer) and 249 (winter) inspected nest boxes, a number were either occupied by native fauna (summer 38, 15.3%; winter 45, 18.1%) or showed signs of use (summer 117, 47.2%; winter 124, 49.8%). A total of 155 nest boxes in summer (62.5%) and 169 (67.9%) in winter were therefore occupied or showed signs of use by vertebrate fauna.

A total of eight different species were recorded occupying nest boxes during summer 2018/2019 and winter 2019 and included:

- Mammals:
  - Arboreal mammals: Common Brushtail Possum (*Trichosurus vulpecula*), Yellow-bellied Glider (*Petaurus australis*), Sugar Glider (*Petaurus breviceps*) and Squirrel Glider (*Petaurus norfolcensis*)
  - Scansorial mammals: Brush-tailed Phascogale (*Phascogale tapoatafa*)
  - Microbat: species unknown
- Reptiles: Lace Monitor (*Varanus varius*) and Green Tree Snake (*Dendrelaphis punctulata*).

Of particular note was the detection of the Brush-tailed Phascogale, Squirrel Glider and the Yellow-bellied Glider, all threatened species listed as vulnerable under the NSW *Biodiversity Conservation Act 2016* (BC Act).

Five of the eight target fauna groups (Table 1), small gliders, large gliders, scansorial fauna, possums and microbats, were represented during the 2018/2019 monitoring period. Medium sized parrots, cockatoos/small owls and large forest owls were not recorded.

3.1.2 Design-specific use

Fauna observed to be occupying nest boxes at the time of monitoring have been grouped into the target fauna groups outlined in the NBPoM (as identified in Table 1) and their nest box use is provided in Table 2.

Boxes that recorded use by their target species included possum (PO), small glider (SG), large glider (LG), scansorial fauna (SF) and microbat (MB) boxes. Scansorial fauna (SF) boxes were used on a number of occasions by small gliders and on one occasion by scansorial fauna. Microbat boxes have recorded use by a single microbat on one occasion in the summer monitoring period. Medium parrot (PL) boxes were used by a range of non-target fauna, however representatives of the target fauna group were not observed in either monitoring period. Cockatoo/small owl (COSO) and large forest owl (LFO) boxes recorded use by non-target vertebrate fauna, however the target fauna were not recorded using any nest box type.

The threatened species recorded in the nest boxes were observed using the following nest box types:

- Brush-tailed Phascogale: scansorial fauna and medium parrot.
- Squirrel Glider: scansorial fauna.
- Yellow-bellied Glider: large glider boxes and cockatoo/small owl boxes.

Table 2: Design-specific use: 2018/2019 monitoring period

	Nest box type							
Fauna group	**SF**	**SG**	**LG**	**PO**	**MB**	**P/L**	**CO/SO**	**LFO**
Scansorial fauna	**1**					1		
Small Gliders	15	**3**	2	1				
Large Gliders			**2**				3	
Possums		1	1	**23**		4	15	4
Micro-bats					**1**			
Parrots/lorikeets								
Cockatoos								
Small Owls								
Large Forest Owls								
Other birds								
Reptiles		2	1	1		2		

SF = scansorial fauna, SG = small glider, LG = large glider, PO = possum, MB = microbat, CO/SO = cockatoo/small owl, LFO = large forest owl. Target fauna for each nest box type are shown in bold.

3.1.3 Exotic fauna use

The NBPoM identifies non-native pest species that have the potential to utilise nest boxes, including, the European Bee (*Apis mellifera*), exotic birds including Common Myna (*Acridotheres tristis*) and Common Starling (*Sturnus vulgaris*), and termites and ants. These fauna are considered pests for the nest box program as they compete with native/target fauna for nesting resources, create nests/hives that exclude target fauna, and introduce maintenance and longevity issues.

Exotic birds were not recorded using the nest boxes. Twelve nest boxes (2.4%) showed signs of use by European Bees. Of the 12 nest boxes that showed signs of use by European Bees, six also showed signs of use or were occupied by vertebrate fauna and only one was observed to be fresh or active at the time of monitoring.

Twenty-nine (11.8%) and 14 (5.6%) nest boxes, in summer and winter respectively, were either occupied or showed signs of occupation by non-native pest species. Pest fauna occupying these nest boxes included: European Bees (summer 15, 6.0%; winter 5, 2.0%), wasps (summer 2, 0.8%; winter 0) and ants (summer 4, 1.6%; winter 6, 2.4%).

3.2 Cumulative nest box use over the entire monitoring program

3.2.1 Range of native fauna

Table 3 lists the species recorded during the nest box monitoring program. Fifteen native species, representing six (small gliders, large gliders, scansorial fauna, possums, medium sized parrots and microbat) of the eight target fauna groups, have been recorded occupying nest boxes. Cockatoos/small owls and large forest owls were not recorded during any monitoring event.

Of the 62 hollow-dependent species recorded during baseline surveys (Lewis 2005), the nest box monitoring program recorded ten (seven mammals, two reptiles and one bird). It should be noted that 16 of the hollow-dependent species listed are bats and there has been only a single microbat observed, which occurred during summer 2018/2019 surveys. A further 29 are bird species, only one of which was recorded during the nest box monitoring program (Dollarbird), and six frog species, which were not targeted in the NBPoM. Five hollow-dependent species that were not detected in baseline surveys, Squirrel Glider, Short-eared Brushtail Possum, Crimson Rosella, Northern Mallard (introduced) and Diamond Python, were recorded using the nest boxes.

Rates of occupancy, signs of use, use by pest species, and maintenance requirements for the 2014/2015, 2016/2017 and 2018/2019 monitoring periods are provided in Table 4. The percentage of nest boxes showing signs of use by vertebrate fauna and the occupation rate by native fauna has increased since 2014/2015. Pest activity has also increased since 2014/2015 with the last two monitoring periods remaining similar.

Maintenance requirements show an increasing trend over the three monitoring periods.

Table 3: Species occupying nest boxes in 2014/2015, 2016/2017 and 2018/2019

Target group	Species	Baseline	2014/2015	2016/2017	2018/2019
Scansorial fauna	*Antechinus* sp.	Yes	Yes		
	Brush-tailed Phascogale*	Yes	Yes	Yes	Yes
Small Gliders	Sugar Glider	Yes	Yes	Yes	Yes
	Squirrel Glider*			Yes	Yes
Large Gliders	Yellow-bellied Glider*	Yes		Yes	Yes
Possums	Common Brushtail Possum	Yes	Yes	Yes	Yes
	Common Ringtail Possum (*Pseudocheirus peregrinus*)	Yes	Yes	Yes	
	Short-eared Brushtail Possum (*Trichosurus caninus*)		Yes		
Micro-bats	Unidentified	Yes			Yes
Parrots/lorikeets	Crimson Rosella (*Platycercus elegans*)			Yes	
Cockatoos/ Small Owls					
Large Forest Owls					
Other birds	Northern Mallard^ (*Anas platyrhynchos*)		Yes		
	Dollarbird (*Eurystomus orientalis*)	Yes		Yes	
Reptiles	Green Tree Snake	Yes	Yes	Yes	Yes
	Diamond Python (*Morelia spilota*)		Yes		
	Lace Monitor	Yes	Yes	Yes	Yes

* = Threatened species; ^ = introduced species; Baseline records reflect if a species was recorded during baseline surveys.

Table 4: Nest box monitoring data for 2014/2015, 2016/2017 and 2018/2019

Nest Box Monitoring	2014/2015		2016/2017		2018/2019	
	Summer	Winter	Summer	Winter	Summer	Winter
Occupation by native fauna %	10.6	11.5	16.1	15.3	15.3	18.1
Signs of use %	36.4	23.0	54.6	54.8	47.2	49.8
Total use (occupied and signs) %	47.0	34.0	70.4	70.3	62.5	67.9
Pest activity %	8.5	1.1	11.2	6.0	11.7	5.6
Requiring maintenance %	0	1.6	13.6	8.8	18.1	14.1

3.2.2 Design-specific use

Table 5 shows nest box use by fauna groups for the entire monitoring program. Five of the eight nest box types were used by their target fauna. Possum (PO) boxes have recorded the highest use by target fauna, however possums also favoured cockatoo/small owl and medium parrot (P/L) boxes. Scansorial fauna (SF boxes) were used more frequently by small gliders than scansorial fauna. Small and large gliders used a range of different box types as well as their target box types. An individual microbat was recorded in a Microbat box on a single occasion; and was not recorded using any other nest box type. Cockatoos, small owls and large forest owls were not recorded using any nest boxes.

Table 5: Design-specific use: all monitoring periods

	Nest box type							
Fauna group	**SF**	**SG**	**LG**	**PO**	**MB**	**P/L**	**CO/SO**	**LFO**
Scansorial fauna	**3**		1			2		
Small Gliders	33	**12**	3	1		2		2
Large Gliders	1		**4**				3	
Possums	1	4	4	**55**		10	33	4
Micro-bats					**1**			
Parrots/lorikeets				1				
Cockatoos								
Small Owls								
Large Forest Owls								
Other birds				2				
Reptiles		7	5	6		7		

SF = scansorial fauna, SG = small glider, LG = large glider, PO = possum, MB = microbat, CO/SO = cockatoo/small owl, LFO = large forest owl. Target fauna for each box type are shown in bold.

3.3 Maintenance: pre-handover inspection

A final inspection of the nest boxes was undertaken prior to hand-over of the monitoring program to TfNSW.

Signs of invertebrate pests such as European Bees were observed, however ongoing inspections of nest boxes has found that occupation was temporary. For example, summer records included eight (3.2%) boxes with pest species. All eight boxes no longer showed active pest use in winter, with five of the boxes either showing signs of use or being occupied by native species. It is therefore considered that removing European Bee hives is not a necessary maintenance procedure as occupation is temporary.

Maintenance requirements include lid repair, re-wiring, total box replacement due to deteriorated or broken boxes, and box repositioning. Maintenance requirements are provided in Annex 5 and exclude those boxes that were noted as showing signs of invertebrate pest use, unless it was considered that damage to the box had occurred.

The majority of the maintenance works required is for the re-wiring of boxes, in particular in Zone M where exposed metal wire was used, which has resulted in rusting and a number of fallen boxes.

The final nest box inspection determined that 44 (17.7%) nest boxes require maintenance, including a minimum of seven nest boxes that require replacement.

4. Discussion

4.1 Performance measures

A discussion of the results of all monitoring periods in relation to the performance measures is provided in Table 6.

Table 6: Discussion of results in relation to performance measures

Performance measures	Discussion
Use of nest boxes by a wide range of native fauna.	**This performance measure has been met.** A "wide range" is not defined within the EMP, as such the "range of native fauna" considered here has been related to the target fauna groups and has considered observation of species representing >50% of the target groups as a "wide range". Fifteen native species have been recorded over the three monitoring periods. Representatives from six of the eight target fauna groups were recorded. Owls and cockatoos have not been recorded during any monitoring event.
Use of nest boxes designed for specific species by those species (i.e. scansorial fauna nest box being used by these species).	**This performance measure has been met by 5 of the 8 box types.** Nest box types SF, SG, LG, PO and MB all recorded use by target fauna. Nest box types PL, COSO and LFO did not show signs of use by target fauna. The target fauna of these boxes (cockatoos/small owls and large forest owls) were not recorded using any nest box type, with the exception of a Crimson Rosella record from a PO box in 2016/2017.
Low rates* of exotic fauna using nest boxes.	**This performance measure has been met.** Exotic birds were not recorded using the nest boxes. Pest activity remains low with 11.7% use in summer and 5.6% in winter in 2018/2019 surveys. Use by European Bees accounts for the higher percentage of pest activity during summer surveys (6% of boxes in summer and 2% in winter).
Reduced maintenance requirements (<10% requiring attention).	**This performance measure has not been met.** The final nest box inspection determined that 44 nest boxes require maintenance, including a minimum of seven nest boxes that require replacement. Therefore, 17.7% of the installed nest boxes require maintenance.

*= levels/rates were not specified in the EMP, as such an arbitrary level/rate of ≤10% has been assigned.

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 to be relevant to the nest box monitoring program are listed and discussed in Table 7.

Table 7: Contingency measures

Potential problem	Contingency measure proposed in EMP	Discussion of proposed measure
Nest boxes being used by non-target species	Review the selection and number of nest box designs	All nest box types showed use by non-target vertebrate fauna. As generalists, reptiles were expected, and observed, to use a range of nest box types. Almost all boxes showed use by possums which may exclude/compete with the targeted fauna. However, possums were recorded most frequently in possum boxes (55 occasions) followed by cockatoo/small owl (33 occasions) and parrot boxes (10 occasions). Given that cockatoos and small owls have not been recorded using nest boxes and possums only show occasional use of glider and scansorial fauna boxes, exclusion measures for possums are not considered necessary. Following all monitoring periods, the level of use by non-target vertebrate fauna is not considered to warrant contingency measures as the nest boxes that are not being used by target fauna are also showing lower rates of use in general. Non-target fauna are therefore not considered to be excluding target fauna. The use of <10% of nest boxes by ants and wasps is not considered to warrant contingency measures. **This contingency measure is not considered relevant.**
Nest Boxes become occupied by exotic or invasive fauna (i.e. European Bees, Termites)	Review/modify nest box design to exclude undesirable species, treat if applicable (i.e. Buffalo Fly ear tags for bees) or relocate those boxes to another location	Exotic birds were not recorded using the nest boxes in 2016/2017 or 2018/2019. Less than 10% of nest boxes (2.4%), were either occupied or showed signs of occupation by European Bees in 2018/2019. Ongoing inspections of nest boxes has found that occupation by European Bees is temporary and unlikely to impact use by native fauna in the long-term. **This contingency measure is not considered relevant.**
Poor uptake/usage rate by native fauna	Review the types and number of nest box designs	Fifteen native species were identified using next boxes during the monitoring program. Nest boxes occupied or showing signs of use by vertebrate fauna increased from the first 2014/2015 monitoring period (47% summer and 34% winter) to the final 2018/2019 monitoring (63% summer and 68% winter). Owls and cockatoos were not recorded using nest boxes during any monitoring event. Only one individual microbat was observed using microbat roost boxes. **This contingency measure is considered relevant for MB, PL, COSO and LFO type nest boxes.**
Nest Boxes deteriorating rapidly and requiring maintenance	Identify causes of nest box failure, modify design and construct accordingly	The final nest box inspection determined that 44 nest boxes require maintenance, including a minimum of seven nest boxes that require replacement. Therefore, 17.7% of the installed nest boxes require maintenance. **This contingency measure is considered relevant.**

5.2 Recommendations

Monitoring has shown high rates of use of nest boxes by a range of vertebrate fauna, therefore ongoing monitoring of nest boxes for fauna use is not recommended. Table 8 lists a number of recommendations to address maintenance issues and the apparent low uptake rate of nest boxes by microbats, cockatoos, parrots and owls.

Table 8: Recommendations

Potential problem	Contingency measure proposed in EMP	Recommendation
Poor uptake/ usage rate by native fauna	Review the types and number of nest box designs	**Recommendations relevant for MB roost boxes:** According to the NBPoM (Lewis 2012), target species for microbat roost boxes were those species considered to roost in tree hollows, such as the Little Forest Bat (*Vespadelus vulturnus*), Chocolate Wattled Bat (*Chalinolobus morio*), Gould's Wattled Bat (*Chalinolobus gouldi*), Greater Broad-nosed Bat (*Scoteanax rueppellii*) and the White-striped Mastiff Bat (*Tadarida australis*). The NBPoM remarks that while a number of species were recorded from the area, there is no evidence of them using tree hollows within the clearing footprint. Only one, unidentified individual microbat was recorded using roost boxes. Three of the species mentioned above (Chocolate Wattled Bat, Gould's Wattled Bat and Greater Broad-nosed Bat) have been previously documented using bat roost boxes (Rueegger 2016). As discussed in Niche 2018, a recent review of roost box use by microbats (Rueegger 2016) highlighted the lack of detailed knowledge regarding the factors determining uptake of roost boxes by microbats. Ross Goldingay subsequently undertook a review of TfNSW nest box programs (Goldingay 2019) and found that while the use of bat boxes by microbats appears to be low, there is limited reference data regarding actual hollow use available for comparison. This review concluded that the installation of boxes for bats should be discontinued, except where culverts and bridges are removed or modified and bat species may be impacted. Therefore, it is considered that a review of the design and re-installation of bat boxes would be ineffective and unlikely to achieve the desired outcomes. It is recommended that: • Consideration be given to investigating the use of culverts by microbat species to determine if these structures are providing roosting habitat for microbats. Incidental records obtained during underpass monitoring indicate microbat activity in six of the seven monitored underpasses. • Discussions with the NSW EPA be undertaken to determine if corrective actions are required to compensate for the loss of potential roosting habitat.
		Recommendations relevant for PL, COSO and LFO type nest boxes: According to the NBPoM, target species for these nest boxes were medium sized parrots/lorikeets, cockatoos (Black Cockatoos), small owls (Southern Boobook and Barn Owl), and large forest owls (Masked Owl, Sooty Owl, Powerful Owl). The NBPoM notes that there is limited evidence to suggest that cockatoos will use artificial nest boxes and anecdotal observations and literature, such as Goldingay and Stevens (2009), indicate that research regarding artificial hollow use by native bat and bird species is limited. Goldingay's review (Goldingay 2019) found that very few birds used next boxes and that the general installation of boxes for birds should be discontinued. Therefore, it is considered that a review of the design and re-installation of PL, COSO and LFO boxes would be ineffective and unlikely to achieve the desired outcomes. It is recommended that: • Discussions with the NSW EPA be undertaken to determine if corrective actions are required to compensate for the loss of hollows.

Potential problem	Contingency measure proposed in EMP	Recommendation
Nest Boxes deteriorating rapidly and requiring maintenance	Identify causes of nest box failure, modify design and construct accordingly	Nest boxes were installed in 2014/2015 and were found to mostly be in good condition after five years. Forty-four (17.7%) nest boxes require maintenance, including a minimum of seven (2.8%) nest boxes that require replacement. Most of the required maintenance involves checking of the wire and rewiring if necessary. The need for rewiring was most evident in Zone M, where boxes had been installed using an unprotected wire that has rusted and deteriorated. It is recommended that: • Maintenance actions be undertaken as per Annex 5 • As direct observation of wiring was not possible for all boxes in Zone M, all boxes should be checked and, where exposed metal wire has been used, these should be re-wired using PVC coated wire (approximately 3.15 millimetres) • Any maintenance re-wiring should use PVC coated wire (approximately 3.15 millimetres) with zig zag undulations to allow for tree growth • Wiring should not be continuous, i.e. attachment points should be on the inside of each side of the box or so that when the box corrodes and falls the wire is not left around the tree.

6. References

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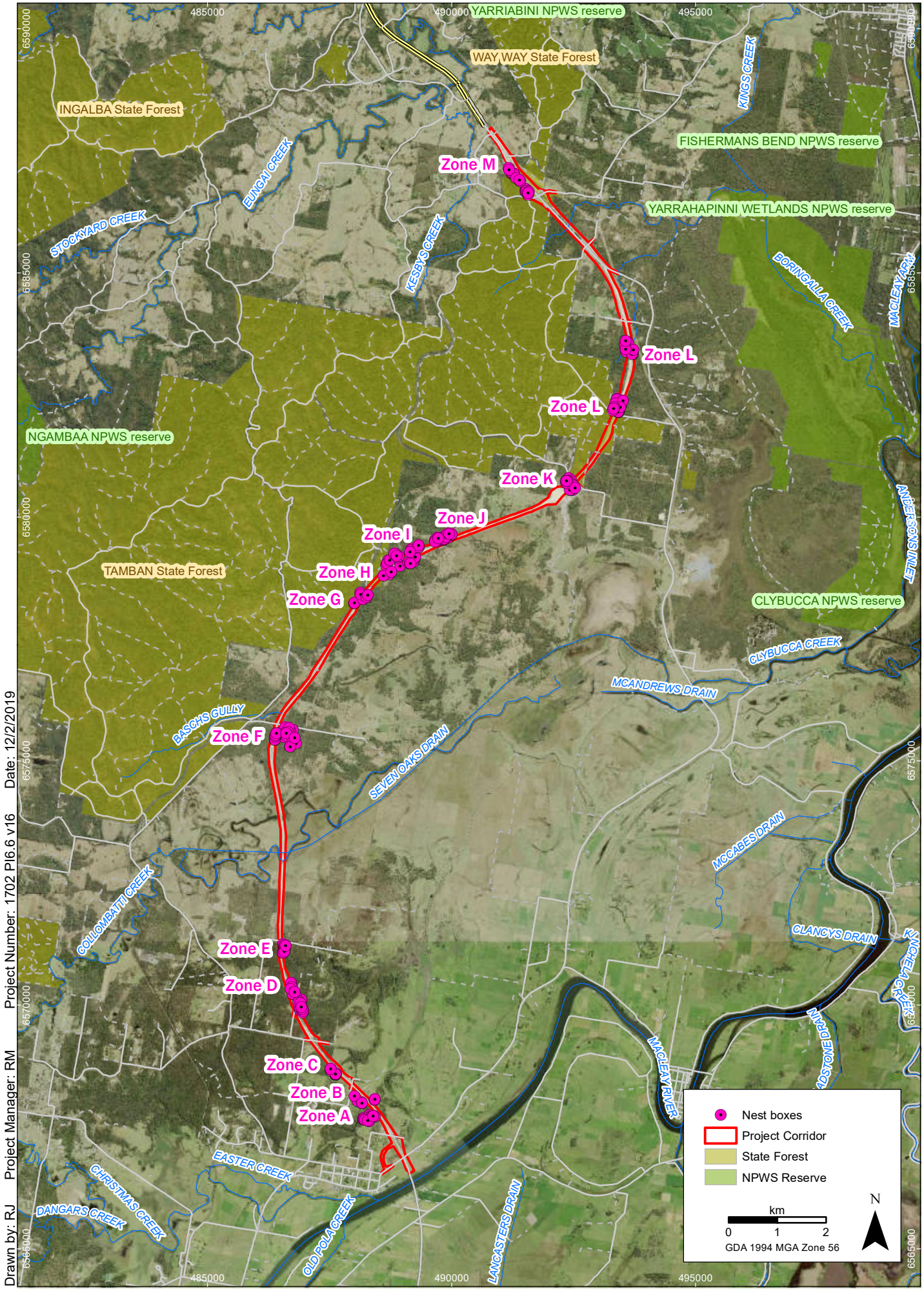

Drawn by: RJ Project Manager: RM Project Number: 1702 PI6.6 v16 Date: 12/2/2019

Nest box locations: overview

Frederickton to Eungai – Nest Box Monitoring

FIGURE 1

niche Environment and Heritage

Imagery: (c) LPI NSW 2014-09-18; Cadastre 2016-10-19

Path: T:\spatial\projects\a1700\a1702_OH2K_Ecology\Maps\PI_6_EcolMonit_F2E\PI_66_NestBox\Monitoring_2017\1702_PI66_NestBoxMonitoring_Fig1.mxd

Annex 1 – Summer field data 2018/2019

Cam = inspection via camera; N = no; Y = yes; Unk = unknown; Euc = eucalyptus

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native / Pest	Signs of use	Species	Landscape change	Comments
1	NBA.MB.01	A	Microbat	08/01/2019	10:30	4m	Broad-leaved Paper Bark	Cam	N		None		Nil	
2	NBA.MB.02	A	Microbat	08/01/2019	10:26	9m	Broad-leaved Paper Bark	Cam	N		None		Nil	
3	NBA.MB.03	A	Microbat	08/01/2019	10:32	5m	Broad-leaved Paper Bark	Cam	N		None		Nil	
4	NBA.MB.04	A	Microbat	08/01/2019	10:33	3m	Broad-leaved Paper Bark	Cam	N		None		Nil	
5	NBA.MB.05	A	Microbat	08/01/2019	10:39	4m	Broad-leaved Paper Bark	Cam	N		None		Nil	
6	NBA.MB.06	A	Microbat	08/01/2019	10:16	5m	Broad-leaved Paper Bark	Cam	N		None		Nil	
7	NBA.MB.07	A	Microbat	08/01/2019	10:16	5m	Broad-leaved Paper Bark	Cam	N		None		Nil	
8	NBA.MB.08	A	Microbat	08/01/2019	10:45	8m	Broad-leaved Paper Bark	Cam	N		None		Nil	
9	NBA.MB.09	A	Microbat	08/01/2019	10:48	6m	Broad-leaved Paper Bark	Cam	N	Pest	Bark	Bees	Nil	Honeycomb
10	NBA.MB.10	A	Microbat	08/01/2019	10:53	13m	Broad-leaved Paper Bark	Cam	N	Pest	None	Wasp	Nil	Old wasp nest
11	NBA.MB.11	A	Microbat	08/01/2019	11:12	7m	Broad-leaved Paper Bark	Cam	N		None		Nil	
12	NBA.PL.01	A	Medium Sized Parrot	08/01/2019	10:21	13m	Broad-leaved Paper Bark	Cam	N		Leaf and bark nest		Nil	
13	NBA.PL.02	A	Medium Sized Parrot	08/01/2019	10:53	8m	Broad-leaved Paper Bark	Cam	Y	Native	Occupied	Brush-tailed Phascogale	Nil	
14	NBA.PL.03	A	Medium Sized Parrot	08/01/2019	11:00	8m	Broad-leaved Paper Bark	Cam	N		Leaf and bark nest		Nil	
15	NBA.PL.04	A	Medium Sized Parrot	08/01/2019	10:42	8m	Broad-leaved Paper Bark	Cam	N		Old leaf litter		Nil	
16	NBA.PL.05	A	Medium Sized Parrot	08/01/2019	11:05	7m	Broad-leaved Paper Bark	Cam	N		Leaf and bark nest		Nil	
17	NBA.PL.06	A	Medium Sized Parrot	08/01/2019	11:03	12m	Broad-leaved Paper Bark	Cam	N		Bark nest		Nil	
18	NBA.PL.07	A	Medium Sized Parrot	08/01/2019	11:15	10m	Swamp Oak	Cam	N		None		Nil	
19	NBA.PL.08	A	Medium Sized Parrot	08/01/2019	11:19	5m	Broad-leaved Paper Bark	Cam	N		Leaf and bark nest		Nil	
20	NBA.PL.09	A	Medium Sized Parrot	08/01/2019	10:11	9m	Swamp Oak	Cam	N	Pest	None	Bees	Nil	Active hive. Bottom of box damp.
21	NBA.PO.01	A	Possum	08/01/2019	10:26	6m	Broad-leaved Paper Bark	Cam	N		Old leaf litter		Nil	
22	NBA.PO.02	A	Possum	08/01/2019	10:35	12m	Broad-leaved Paper Bark	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	With young

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native / Pest	Signs of use	Species	Landscape change	Comments
23	NBA.PO.03	A	Possum	08/01/2019	10:19	10m	Broad-leaved Paper Bark	Cam	N	Pest	None	Bees	Nil	Honeycomb. unoccupied
24	NBA.PO.04	A	Possum	08/01/2019	11:10	8m	Broad-leaved Paper Bark	Cam	N		None		Nil	
25	NBB.MB.01	B	Microbat	15/01/2019	14:35	6m	Broad-leaved Paper Bark	Cam	N	Pest	None	Wasp	Nil	Mud wasp nest
26	NBB.MB.02	B	Microbat	15/01/2019	14:37	6m	Broad-leaved Paper Bark	Cam	N		None		Nil	
27	NBB.PL.01	B	Medium Sized Parrot	08/01/2019	13:35	12m	Pink Bloodwood	Cam	Unk		Unk		Nil	Lid stuck closed
28	NBB.PL.02	B	Medium Sized Parrot	08/01/2019	13:25	7m	Pink Bloodwood	Cam	N		None		Nil	Bottom coming out
29	NBB.PL.03	B	Medium Sized Parrot	08/01/2019	13:22	8m	Brushbox	Cam	N		Euc leaf nest		Nil	
30	NBB.PO.01	B	Possum	08/01/2019	13:40	12m	Pink Bloodwood	Cam	Y	Native	Occupied	Brushtail Possum	Nil	
31	NBB.SF.01	B	Scansorial mammal	08/01/2019	13:41	9m	Brushbox	Cam	N		Euc leaf nest		Nil	
32	NBC.MB.01	C	Microbat	08/01/2019	12:22	12m	Pink Bloodwood	Cam	N		None		Nil	
33	NBC.MB.02	C	Microbat	08/01/2019	12:17	12m	Ironbark	Cam	N		None		Nil	
34	NBC.PL.01	C	Medium Sized Parrot	08/01/2019	12:30	8m	Greygum	Cam	N		None		Nil	
35	NBC.PL.02	C	Medium Sized Parrot	08/01/2019	12:37	8m	Greygum	Cam	N		Euc leaves		Nil	
36	NBC.PL.03	C	Medium Sized Parrot	08/01/2019	12:18	6m	Ironbark	Cam	N		Leaf and grass nest		Nil	
37	NBC.PO.01	C	Possum	08/01/2019	12:21	8m	Pink Bloodwood	Cam	Y	Native	Occupied	Brushtail Possum	Nil	
38	NBC.PO.02	C	Possum	08/01/2019	11:56	5m	Pink Bloodwood	Cam	N		None		Nil	
39	NBC.SF.01	C	Scansorial mammal	08/01/2019	12:09	9m	Pink Bloodwood	Cam	Y	Native	Occupied	Squirrel Glider x2	Nil	x2 individuals
40	NBC.SF.02	C	Scansorial mammal	08/01/2019	12:27	9m	Ironbark	Cam	N		Euc leaf nest		Nil	
41	NBC.SF.03	C	Scansorial mammal	08/01/2019	12:13	8m	Pink Bloodwood	Cam	Y	Native	Occupied	Squirrel Glider	Nil	
42	NBC.SG.01	C	Small Glider	08/01/2019	12:35	5m	Greygum	Cam	N		Euc leaf and feathers		Nil	
43	NBC.LG.02	C	Large Glider	08/01/2019	11:59	8m	Pink Bloodwood	Cam	Y	Native	Occupied	Green Tree Snake	Nil	
44	NBD.CO.01	D	Cockatoo/Small Owl	08/01/2019	14:42	15m	Scribbly	Cam	Y	Native	Occupied	Brushtail Possum	Nil	x2 individuals
45	NBD.LFO.01	D	Large Forest Owl	18/02/2019	10:17	19m	Scribbly	Tree Climber	Y	Native	Occupied	Common Brushtail Possum	Nil	Arborist advised that current wiring would be insufficient for tree expansion within two years
46	NBD.LG.01	D	Large Glider	08/01/2019	14:12	6m	Scribbly	Cam	N		Euc leaf nest		Nil	
47	NBD.LG.02	D	Large Glider	08/01/2019	14:06	13m	Stringy bark	Cam	Y	Native	Occupied	Sugar Glider	Nil	Multiple
48	NBD.LG.03	D	Large Glider	08/01/2019	15:08	8m	Scribbly	Cam	N		Euc leaf nest		Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native / Pest	Signs of use	Species	Landscape change	Comments
49	NBD.MB.01	D	Microbat	08/01/2019	15:03	6m	Stringy bark	Cam	N		None		Nil	
50	NBD.MB.02	D	Microbat	08/01/2019	14:19	6m	Scribbly	Cam	Y	Native	Occupied	Microbat sp.	Nil	1 individual flew out on approach
51	NBD.PL.01	D	Medium Sized Parrot	08/01/2019	14:03	10m	Scribbly	Cam	N		Euc leaf nest		Nil	
52	NBD.PL.02	D	Medium Sized Parrot	08/01/2019	14:48	7m	Scribbly	Cam	N		Leaf litter		Nil	
53	NBD.PO.01	D	Possum	08/01/2019	14:35	12m	Pink bloodwood	Cam	Y	Native	Occupied	Brushtail Possum	Nil	
54	NBD.PO.02	D	Possum	08/01/2019	14:52	10m	Bloodwood	Cam	Y	Native	Occupied	Brushtail Possum	Nil	x2 individuals
55	NBD.PO.03	D	Possum	08/01/2019	14:16	6m	Stringy bark	Cam	Y	Native	Occupied	Brushtail Possum	Nil	x2 individuals
56	NBD.SF.01	D	Scansorial mammal	08/01/2019	14:33	5m	Pink bloodwood	Cam	N		Euc leaf nest		Nil	
57	NBD.SF.02	D	Scansorial mammal	08/01/2019	14:14	4m	Pink bloodwood	Cam	N		Euc leaf nest		Nil	
58	NBD.SF.03	D	Scansorial mammal	08/01/2019	15:01	8m	Stringy bark	Cam	N		Euc leaf nest		Nil	
59	NBD.SF.04	D	Scansorial mammal	08/01/2019	14:58	6m	Pink bloodwood	Cam	N		Euc leaf nest		Nil	
60	NBD.SG.01	D	Small Glider	08/01/2019	14:30	7m	Pink bloodwood	Cam	N		Euc leaf nest		Nil	
61	NBD.SG.02	D	Small Glider	08/01/2019	15:12	8m	Bloodwood	Cam	N		Euc leaf nest		Nil	
62	NBD.SG.03	D	Small Glider	08/01/2019	14:25	9m	Stringy bark	Cam	N		Leaf nest		Nil	
63	NBE.COSO.01	E	Cockatoo	17/01/2019	9:26	10m	Blackbutt	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	Box sitting in fork not hanging
64	NBE.COSO.02	E	Cockatoo	17/01/2019	9:40	10m	Scribbly	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	SO type
65	NBE.LG.01	E	Large Glider	17/01/2019	9:17	7m	Blackbutt	Cam	N		Euc leaf and bark		Nil	
66	NBE.MB.01	E	Microbat	17/01/2019	9:38	10m	Scribbly gum	Cam	N		None		Nil	
67	NBE.MB.01	E		Duplicate									Nil	
68	NBE.MB.02	E	Microbat	17/01/2019	9:46	10m	Blackbutt	Cam	N		None		Nil	
69	NBE.PL.01	E	Medium Sized Parrot	17/01/2019	9:37	6m	Scribbly gum	Cam	N		Squashed Euc leaves		Nil	
70	NBE.PL.02	E	Medium Sized Parrot	17/01/2019	9:15	8m	Stringy bark	Cam	N		None		Nil	
71	NBE.PO.01	E	Possum	17/01/2019	9:02	7m	Blackbutt	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	
72	NBE.PO.02	E	Possum	17/01/2019	9:25	8m	Blackbutt	Cam	N		Few Euc leaves		Nil	
73	NBE.PO.03	E	Possum	17/01/2019	9:06	8m	Pink bloodwood	Cam	N		Leaf nest		Nil	
74	NBE.SF.01	E	Scansorial mammal	17/01/2019	9:18	7m	Blackbutt	Cam	N		Conical Euc leaf nest		Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native / Pest	Signs of use	Species	Landscape change	Comments
75	NBE.SF.02	E	Scansorial mammal	17/01/2019	9:45	6m	Blackbutt	Cam	N		Conical Euc leaf nest		Nil	
76	NBE.SF.03	E	Scansorial mammal	17/01/2019	9:20	6m	Blackbutt	Cam	Y	Native	Occupied	Sugar Glider	Nil	x3 individuals
77	NBE.SG.01	E	Small Glider	17/01/2019	9:10	8m	Blackbutt	Cam	N		Euc leaf & feather		Nil	
78	NBE.SG.02	E	Small Glider	17/01/2019	9:42	8m	White Mahogany	Cam	Unk		Unk		Nil	Native bees?
79	NBE.SG.03	E	Small Glider	17/01/2019	9:05	7m	Blackbutt	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	
81	NBF.LFO.01	F	Large Forest Owl	10/01/2019	14:21	10m	Bloodwood	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	x2 individuals
82	NBF.LG.01	F	Large Glider	10/01/2019	14:22	8m	Pink bloodwood	Cam	N		Euc leaves		Nil	
83	NBF.PL.01	F	Medium Sized Parrot	10/01/2019	15:18	9m	Stringy bark	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	
84	NBF.PL.02	F	Medium Sized Parrot	10/01/2019	13:45	8m	Bloodwood	Cam	N		Euc leaf and egg shell		Nil	
85	NBF.PO.01	F	Possum	10/01/2019	13:27	8m	Tallowwood	Cam	N		None		Nil	
86	NBF.PO.02	F	Possum	10/01/2019	15:15	10m	Stringy bark	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	
87	NBF.PO.03	F	Possum	10/01/2019	14:47	7m	Pink bloodwood	Cam	N		None		Nil	
88	NBF.PO.04	F	Possum	10/01/2019	13:56	7m	Pink bloodwood	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	
89	NBF.PO.06	F	Possum	10/01/2019	15:49	12m	Pink bloodwood	Cam	Not avail		None		Nil	Box on ground fallen down.
90	NBF.PO.07	F	Possum	10/01/2019	15:56	5m	Black oak	Cam	N		None		Nil	
91	NBF.PO.08	F	Possum	10/01/2019	16:02	5m	Stringy bark	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	
92	NBF.PO.09	F	Possum	10/01/2019	15:51	5m	Bloodwood	Cam	N		None		Nil	
93	NBF.SF.01	F	Scansorial mammal	10/01/2019	15:09	6m	Stringy bark	Cam	N		Euc leaves		Nil	
94	NBF.SF.02	F	Scansorial mammal	10/01/2019	15:22	5m	Pink bloodwood	Cam	Y	Native	Occupied	Sugar Gliders	Nil	x3 individuals
95	NBF.SF.03	F	Scansorial mammal	10/01/2019	14:51	12m	Pink bloodwood	Cam	N		None		Nil	
96	NBF.SF.04	F	Scansorial mammal	18/02/2019	12:20	8m	Bloodwood	Tree Climber	N	Pest	Euc leaf nest	Ants	Nil	
97	NBF.SF.05	F	Scansorial mammal	10/01/2019	15:57	8m	Black oak	Cam	N		None		Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native / Pest	Signs of use	Species	Landscape change	Comments
98	NBF.SF.06	F	Scansorial mammal	10/01/2019	14:01	7m	Stringy bark	Cam	N		Bark leaf nest		Nil	
99	NBF.SG.01	F	Small Glider	10/01/2019	15:11	8m	Ironbark	Cam	N		Euc leaf		Nil	
100	NBF.SG.02	F	Small Glider	10/01/2019	14:57	8m	Pink bloodwood	Cam	N	Pest	Unk	Bees	Nil	Active hive, box not inspected
101	NBF.SG.03	F	Small Glider	10/01/2019	13:52	6m	Pink bloodwood	Cam	N		Conical leaf nest		Nil	
102	NBF.SG.04	F	Small Glider	10/01/2019	15:45	4m	Black oak	Cam	N		Leaf litter		Nil	
103	NBF.SG.05	F	Small Glider	18/02/2019	12:17	13m	Bloodwood	Tree Climber	N	Pest	None	Ants	Nil	
104	NBF.SG.06	F	Small Glider	10/01/2019	15:53	8m	Bloodwood	Cam	N		Euc leaf nest		Nil	
105	NBF.SG.07	F	Small Glider	10/01/2019	15:49	14m	Bloodwood	Tree Climber	Not avail		None		Nil	Box fallen down
106	NBF.SO.01	F	Cockatoo/Small Owl	10/01/2019	15:04	8m	Tallowwood	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	x2 individuals
107	NBF.SO.02	F		Not found									Nil	
108	NBG.PL.01	G	Medium Sized Parrot	15/01/2019	10:00	10m	Red mahogany	Cam	N		Leaf litter		Nil	
109	NBG.PL.02	G	Medium Sized Parrot	15/01/2019	9:38	6m	Tallowwood	Cam	N		Euc leaf		Nil	Wood starting to warp on side
110	NBG.PO.01	G	Possum	15/01/2019	9:40	10m	Red mahogany	Cam	N		Bark, fern & Euc leaf		Nil	
111	NBG.PO.02	G	Possum	15/01/2019	10:04	8m	Swamp mahogany	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	
112	NBG.SF.01	G	Scansorial mammal	15/01/2019	9:30	8m	Broad-leaved Paperbark	Cam	Unk		Unk		Nil	Inside condition unknown
113	NBG.SF.02	G	Scansorial mammal	15/01/2019	10:13	6m	Swamp Oak	Cam	N		Few leaves		Nil	
114	NBG.SF.03	G	Scansorial mammal	15/01/2019	10:06	7m	Swamp mahogany	Cam	N		Conical Euc leaf nest		Nil	
115	NBG.SG.01	G	Small Glider	15/01/2019	9:27	4m	Swamp mahogany	Cam	N		Grass & leaves		Nil	
116	NBG.SG.02	G	Small Glider	15/01/2019	9:52	8m	Swamp mahogany	Cam	N		Leaf litter		Nil	
117	NBG.SG.03	G	Small Glider	15/01/2019	10:16	7m	Swamp oak	Cam	N	Pest	None	Bees	Nil	Old honeycomb
118	NBH.LFO.01	H	Large Forest Owl	10/01/2019	9:45	15m	Blackbutt	Cam	N		Euc leaf		Nil	
119	NBH.LG.01	H	Large Glider	10/01/2019	9:56	7m	Blackbutt	Cam	N	Pest	None	Bees	Nil	Old honeycomb

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native / Pest	Signs of use	Species	Landscape change	Comments
120	NBH.PL.01	H	Medium Sized Parrot	16/01/2019	14:29	10m	Blackbutt	Cam	N		Euc leaf nest		Nil	Lid open
121	NBH.PO.01	H	Possum	16/01/2019	14:41	7m	Tallowwood	Cam	N		None		Nil	
122	NBH.PO.02	H	Possum	16/01/2019	14:47	6m	Pink bloodwood	Cam	N		None		Nil	
123	NBH.SF.01	H	Scansorial mammal	10/01/2019	9:49	8m	Blackbutt	Cam	N		Euc leaf and grass nest		Nil	
124	NBH.SG.01	H	Scansorial mammal	16/01/2019	14:37	8m	Tallowwood	Cam	N		Conical Euc leaf nest		Nil	
125	NBH.SO.01	H	Cockatoo/Small Owl	10/01/2019	9:44	12m	Blackbutt	Cam	Y	Native	Occupied	Brushtail Possum	Nil	
126	NBI.CO.01	I	Cockatoo/Small Owl	18/02/2019	13:50	13m	Blackbutt	Tree Climber	Y	Native	Occupied	Yellow-bellied Glider x 5	Nil	
127	NBI.LFO.01	I	Large Forest Owl	10/01/2019	10:23	13m	Blackbutt	Cam	N		Flattened Euc leaf nest		Nil	
128	NBI.LFO.02	I	Large Forest Owl	01/02/2019	13:35	15m	Blackbutt	Tree Climber	N		Green Euc leaf		Nil	No springs and limited room in wire for expansion
129	NBI.LG.01	I	Large Glider	10/01/2019	10:06	13m	Blackbutt	Cam	N	Pest	None	Bees	Nil	Active hive
130	NBI.LG.02	I	Large Glider	16/01/2019	14:09	11m	Blackbutt	Cam	N		Euc leaf		Nil	
131	NBI.LG.03	I	Large Glider	16/01/2019	14:11	8m	Blackbutt	Cam	N		Euc leaf		Nil	
132	NBI.LG.04	I	Large Glider	10/01/2019	10:53	9m	Blackbutt	Cam	N		Flattened Euc leaf nest		Nil	
133	NBI.MB.01	I	Microbat	10/01/2019	10:06	10m	Blackbutt	Cam	N		None		Nil	
134	NBI.PL.01	I	Medium Sized Parrot	16/01/2019	14;20	9m	Blackbutt	Cam	N		Euc leaf		Nil	
135	NBI.PL.02	I	Medium Sized Parrot	16/01/2019	14:00	11m	Blackbutt	Cam	N		Euc leaf nest		Nil	
136	NBI.PO.01	I	Possum	10/01/2019	10:13	3m	Blackbutt	Cam	N		Wood and bark chips		Nil	
137	NBI.PO.02	I	Possum	Not found		8m	Blackbutt						Nil	
138	NBI.PO.03	I	Possum	10/01/2019	10:57	5m	Brushbox	Cam	N		Euc leaf nest		Nil	
139	NBI.PO.04	I	Possum	10/01/2019	10:51	5m	Ironbark	Cam	N		Bark and leaf		Nil	
140	NBI.SF.01	I	Scansorial mammal	10/01/2019	10:18	7m	Tallowwood	Cam	N	Pest	Conical leaf nest		Nil	Active insects and debris
141	NBI.SF.02	I	Scansorial mammal	10/01/2019	10:48	8m	Tallowwood	Cam	N		Conical leaf nest		Nil	
142	NBI.SF.03	I	Scansorial mammal	10/01/2019	10:59	10m	Blackbutt	Cam	N		None		Nil	
143	NBI.SG.01	I	Small Glider	10/01/2019	10:10	10m	Blackbutt	Cam	N		Conical leaf nest		Nil	
144	NBI.SG.02	I	Small Glider	16/01/2019	14:16	7m	Blackbutt	Cam	N	Pest	Old leaf litter	Bees	Nil	Old honeycomb
145	NBI.SG.03	I	Small Glider	10/01/2019	11:01	10m	Blackbutt	Cam	N		Conical leaf nest		Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native / Pest	Signs of use	Species	Landscape change	Comments
146	NBI.SO.02	I	Cockatoo/Small Owl	10/01/2019	10:36	15m	Blackbutt	Cam	N		Leaf litter		Nil	
147	NBJ.LG.01	J	Large Glider	10/01/2019	11:57	9m	Tallowwood	Cam	N		Old leaf litter		Nil	
148	NBJ.LG.02	J	Large Glider	10/01/2019	11:44	8m	Tallowwood	Cam	N		Leaf litter		Nil	
149	NBJ.LG.03	J	Large Glider	10/01/2019	11:53	7m	Ironbark	Cam	N		Old leaf litter		Nil	
150	NBJ.LG.04	J	Large Glider	10/01/2019	12:25	7m	Ironbark	Cam	N		None		Nil	
151	NBJ.LG.05	J	Large Glider	10/01/2019	11:32	6m	Blackbutt	Cam	N		Chewed up bark and leaf		Nil	
152	NBJ.MB.01	J	Microbat	10/01/2019	11:43	8m	Pink bloodwood	Cam	N		None		Nil	
153	NBJ.MB.01	J		Duplicate									Nil	
154	NBJ.MB.02	J	Microbat	10/01/2019	11:24	5m	Pink bloodwood	Cam	N		None		Nil	
155	NBJ.MB.03	J	Microbat	10/01/2019	11:59	7m	Ironbark	Cam	N		None		Nil	
156	NBJ.PL.01	J	Medium Sized Parrot	10/01/2019	12:09	7m	Tallowwood	Cam	N		Insect and leaf		Nil	
157	NBJ.PL.02	J	Medium Sized Parrot	10/01/2019	11:26	9m	Blackbutt	Cam	N		Leaf litter		Nil	
158	NBJ.PO.01	J	Possum	10/01/2019	12:34	4m	Tallowwood	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	
159	NBJ.PO.01	J		Not found									Nil	
160	NBJ.PO.02	J	Possum	10/01/2019	12:15	8m	Tallowwood	Cam	N		Euc leaves		Nil	
161	NBJ.SF.01	J	Scansorial mammal	10/01/2019	12:10	8m	Tallowwood	Cam	N		Leaf litter		Nil	
162	NBJ.SF.02	J	Scansorial mammal	10/01/2019	12:18	5m	Pink bloodwood	Cam	N		Euc leaf nest		Nil	
163	NBJ.SF.03	J	Scansorial mammal	10/01/2019	11:38	9m	Pink bloodwood	Cam	Y	Native	Occupied	Sugar Glider	Nil	x4 individuals
164	NBJ.SF.04	J	Scansorial mammal	10/01/2019	1:22	8m	Pink bloodwood	Cam	N		Euc leaf nest		Nil	
165	NBJ.SF.05	J	Scansorial mammal	10/01/2019	11:51	6m	Tallowwood	Cam	N		Old leaf litter		Nil	
166	NBJ.SF.05	J		Duplicate									Nil	
167	NBJ.SG.01	J	Small Glider	10/01/2019	11:48	7m	Tallowwood	Cam	N		Leaf litter		Nil	
168	NBJ.SG.02	J	Small Glider	10/01/2019	12:21	6m	Tallowwood	Cam	N		Leaf litter		Nil	
169	NBJ.SG.03	J	Small Glider	10/01/2019	11:20	6m	Blackbutt	Cam	N		Euc leaf nest		Nil	
170	NBJ.SG.04	J	Small Glider	10/01/2019	12:01	10m	Ironbark	Cam	N	Pest	None	Bees	Nil	Full of honeycomb
171	NBJ.SG.05	J	Small Glider	10/01/2019	12:34	8m	Tallowwood	Cam	N		Euc leaves		Nil	
172	NBJ.SO.01	J	Cockatoo/Small Owl	10/01/2019	11:34	10m	Tallowwood	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native / Pest	Signs of use	Species	Landscape change	Comments
173	NBK.CO.02	K	Cockatoo/Small Owl	16/01/2019	12:26	15m	Tallowwood	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	
174	NBK.MB.01	K	Microbat	16/01/2019	13:11	10m	Blackbutt	Cam	N		None		Nil	
175	NBK.MB.02	K	Microbat	16/01/2019	12:11	10m	Blackbutt	Cam	N		None		Nil	
176	NBK.MB.03	K	Microbat	16/01/2019	12:05	7m	Blackbutt	Cam	N		None		Nil	
177	NBK.PL.01	K	Medium Sized Parrot	16/01/2019	13:13	5m	Stringy bark	Cam	N		messy bark nest $ latrine		Nil	
178	NBK.PL.02	K	Medium Sized Parrot	16/01/2019	13:30	6m	Blackbutt	Cam	N		Bark & grass nest		Nil	
179	NBK.PL.03	K	Medium Sized Parrot	16/01/2019	12:06	10m	Blackbutt	Cam	N	Pest	None		Nil	Insect debris
180	NBK.PO.01	K	Possum	16/01/2019	12:08	10m	Blackbutt	Cam	N		None		Nil	
181	NBK.PO.02	K	Possum	16/01/2019	12:49	8m	Blackbutt	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	
182	NBK.SF.01	K	Scansorial mammal	16/01/2019	12:42	4m	Tallowwood	Cam	N		Euc leaf		Nil	No room in wire for expansion
183	NBK.SF.02E	K	Scansorial mammal	16/01/2019	12:20	8m	Blackbutt	Cam	N		Euc leaf		Nil	
184	NBK.SF.03	K	Scansorial mammal	16/01/2019	12:13	7m	Blackbutt	Cam	N		Euc leaf nest		Nil	
185	NBK.SF.04	K	Scansorial mammal	16/01/2019	12:46	6m	Tallowwood	Cam	N		Euc leaf		Nil	
186	NBK.SG.01	K	Small Glider	16/01/2019	12:44	5m	Blackbutt	Cam	N		Conical Euc leaf nest		Nil	
187	NBK.SF.02W	K	Small Glider	16/01/2019	12:51	12m	Blackbutt	Cam	Unk	Pest	Unk		Nil	Native bees?
187	NBK.SG.02	K	Small Glider	is SFo2W		12m	Blackbutt						Nil	
188	NBK.SG.04	K	Small Glider	16/01/2019	13:02	6m	White Mahogany	Cam	N		Euc leaf		Nil	Honeycomb scars
189	NBK.SG.05	K	Small Glider	16/01/2019	13:07	6m	Pink bloodwood	Cam	N		Euc leaf		Nil	
190	NBK.SG.06	K	Small Glider	16/01/2019	13:05	6m	Blackbutt	Cam	N		None		Nil	
191	NBK.SO.01	K	Cockatoo/Small Owl	16/01/2019	12:01	12m	Blackbutt	Cam	N		Leaf litter		Nil	
192	NBL.CO.01	L	Cockatoo/Small Owl	16/01/2019	10:39	9m	Grey Gum	Cam	N		None		Nil	No room in wire for expansion
193	NBL.LG.01	L	Large Glider	16/01/2019	10:51	9m	Pink bloodwood	Cam	N	Pest	None	Bees	Nil	Full of old honeycomb
194	NBL.LG.02	L	Large Glider	15/01/2019	11:27	7m	Pink bloodwood	Cam	N	Pest	None		Nil	Insect debris
195	NBL.LG.03	L	Large Glider	16/01/2019	10:32	8m	Tallowwood	Cam	N		Shredded Euc leaf		Nil	
196	NBL.LG.04	L	Large Glider	16/01/2019	10:29	8m	Ironbark	Cam	N		Euc leaf		Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native / Pest	Signs of use	Species	Landscape change	Comments
197	NBL.LG.05	L	Large Glider	15/01/2019	11:31	8m	Pink bloodwood	Cam	N		Conical Euc leaf nest		Nil	
198	NBL.MB.01	L	Microbat	16/01/2019	11:07	6m	Tallowwood	Cam	N		None		Nil	
199	NBL.MB.02	L	Microbat	16/01/2019	11:00	8m	Pink bloodwood	Cam	N		none		Nil	
200	NBL.MB.02	L		Duplicate									Nil	
201	NBL.MB.03	L	Microbat	16/01/2019	11:10	8m	Bloodwood	Cam	N		None		Nil	
202	NBL.MB.04	L	Microbat	16/01/2019	11:04	8m	Tallowwood	Cam	N		None		Nil	
203	NBL.PL.01	L	Medium Sized Parrot	16/01/2019	11:06	6m	Tallowwood	Cam	N		Leaf litter		Nil	
204	NBL.PL.02	L	Medium Sized Parrot	Not found									Nil	
205	NBL.PL.03	L	Medium Sized Parrot	16/01/2019	11:19	7m	White mahogany	Cam	N	Pest	None	Bees	Nil	Old honeycomb
206	NBL.PL.04	L	Medium Sized Parrot	16/01/2019	9:55	8m	Grey gum	Cam	N		Euc leaf & bark		Nil	
207	NBL.PL.05	L	Medium Sized Parrot	16/01/2019	9:46	6m	Tallowwood	Cam	N		Bark nest		Nil	
208	NBL.PO.01	L	Possum	16/01/2019	11:16	7m	White mahogany	Cam	N		Leaf litter		Nil	
209	NBL.PO.02	L	Possum	16/01/2019	9:33	6m	Pink bloodwood	Cam	N		Leaf & bark litter		Nil	
210	NBL.PO.03	L	Possum	16/01/2019	9:53	8m	White mahogany	Cam	N		None		Nil	
211	NBL.PO.04	L	Possum	16/01/2019	9:50	6m	Pink bloodwood	Cam	N		None		Nil	
212	NBL.PO.05	L	Possum	16/01/2019	11:20	5m	Blackbutt	Cam	N		None		Nil	
213	NBL.SF.01	L	Scansorial mammal	15/01/2019	11:13	5m	Tallowwood	Cam	N	Pest	None	Bees	Nil	Full of old honeycomb
214	NBL.SF.03	L	Scansorial mammal	15/01/2019	11:11	5m	Tallowwood	Cam	N		Euc leaf & latrine		Nil	
215	NBL.SF.04	L	Scansorial mammal	16/01/2019	11:13	7m	Pink bloodwood	Cam	N		Euc leaf		Nil	
216	NBL.SF.05	L	Scansorial mammal	16/01/2019	9:41	8m	Blackbutt	Cam	N		Euc leaf		Nil	
217	NBL.SG.01	L	Small Glider	16/01/2019	10:37	8m	Pink bloodwood	Cam	N		Euc leaf		Nil	
218	NBL.SG.02	L	Small Glider	15/01/2019	11:19	6m	Pink bloodwood	Cam	N	Pest	None	Bees	Nil	Full of old honeycomb
219	NBL.SG.03	L	Small Glider	15/01/2019	10:57	10m	Pink bloodwood	Cam	N		Euc leaf		Nil	
220	NBL.SG.04	L	Small Glider	16/01/2019	9:43	8m	Tallowwood	Cam	N		Euc leaf		Nil	Honeycomb scars
221	NBL.SG.05	L	Small Glider	16/01/2019	9:30	6m	Pink bloodwood	Cam	N	Pest	Euc leaf	Bees	Nil	Old honeycomb
222	NBL.SO.01	L	Cockatoo/Small Owl	15/01/2019	11:36	9m	Grey gum	Cam	N		None		Nil	Old honeycomb scars, tight on tree
223	NBM.LG.01	M	Large Glider	15/01/2019	13:45	6m	Ironbark	Cam	N		None		Nil	
224	NBM.LG.02	M	Large Glider	15/01/2019	13:20	5m	Ironbark	Cam	N		Leaf litter		Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native / Pest	Signs of use	Species	Landscape change	Comments
225	NBM.MB.01	M	Microbat	15/01/2019	13:52	6m	Ironbark	Cam	N		None		Nil	
226	NBM.MB.02	M	Microbat	15/01/2019	13:21	11m	White mahogany	Cam	N		None		Nil	
227	NBM.PL.01	M	Medium Sized Parrot	15/01/2019	13:44	7m	Ironbark	Cam	N		None		Nil	
228	NBM.PL.03	M	Medium Sized Parrot	15/01/2019	12:41	12m	Pink bloodwood	Cam	N		None		Nil	Wiring corroding / lack expansion capacity
229	NBM.PL.04	M	Medium Sized Parrot	15/01/2019	12:22	7m	Blackbutt	Cam	N		None		Nil	Wiring corroding / lack expansion capacity
230	NBM.PL.05	M	Medium Sized Parrot	15/01/2019	12:35	10m	Blackbutt	Cam	N		None		Nil	Boxes in southern M cluster have corroding wire and often lack room for expansion in the wire - there were a few exceptions
231	NBM.PL.06	M	Medium Sized Parrot	15/01/2019	12:31	5m	Blackbutt	Cam	N		None		Nil	Wiring corroding / lack expansion capacity
232	NBM.PO.01	M	Possum	15/01/2019	13:22	4m	White mahogany	Cam	N		None		Nil	
233	NBM.PO.03	M	Possum	15/01/2019	12:39	3m	Tallowwood	Cam	N		None		Nil	Wiring corroding / lack expansion capacity
234	NBM.PO.04	M	Possum	15/01/2019	12:42	5m	Tallowwood	Cam	Not avail		None		Nil	All but two boxes in Zone M WS need new wire.
235	NBM.PO.05	M	Possum	15/01/2019	12:49	4m	Red mahogany	Cam	N		None		Nil	Wiring corroding / lack expansion capacity
236	NBM.PO.06	M	Possum	15/01/2019	12:29	5m	Bloodwood	Cam	N		None		Nil	Wiring corroding / lack expansion capacity
237	NBM.SF.01	M	Scansorial mammal	Not Found		8m	Tallowwood						Nil	
238	NBM.SF.03	M	Scansorial mammal	15/01/2019	12:40	5m	Tallowwood	Cam	N		Leaf litter		Nil	Wiring corroding / lack expansion capacity
239	NBM.SF.04	M	Scansorial mammal	15/01/2019	12:30	8m	Blackbutt	Cam	N		Euc leaf		Nil	Wiring corroding / lack expansion capacity
240	NBM.SF.05	M	Scansorial mammal	15/01/2019	12:58	6m	Tallowwood	Cam	Y	Native	Occupied	Sugar Gliders	Nil	x5 individuals
241	NBM.SF.06	M	Scansorial mammal	15/01/2019	12:44	8m	Blackbutt	Cam	N		Euc leaf nest		Nil	
242	NBM.SF.07	M	Scansorial mammal	15/01/2019	12:38	5m	Tallowwood	Cam	N	Pest	None		Nil	Insect debris

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native / Pest	Signs of use	Species	Landscape change	Comments
243	NBM.SF.08	M	Scansorial mammal	15/01/2019	12:22	4m	Blackbutt	Cam	N	Pest	None	Ants	Nil	
244	NBM.SG.01	M	Small Glider	15/01/2019	13:26	6m	Blackbutt	Cam	N	Pest	None		Nil	Insect debris
245	NBM.SG.03	M	Small Glider	15/01/2019	12:41	6m	Pink bloodwood	Cam	N	Pest	None		Nil	Insect debris
246	NBM.SG.04	M	Small Glider	15/01/2019	12:28	8m	Bloodwood	Cam	N		None		Nil	
247	NBM.SG.05	M	Small Glider	15/01/2019	12:25	6m	Blackbutt	Cam	N	Pest	None	Ants	Nil	Old honeycomb
248	NBM.SG.06	M	Small Glider	15/01/2019	12:47	6m	Tallowwood	Cam	N	Pest	None	Bees	Nil	Consider clean out, active hive
249	NBM.SG.07	M	Small Glider	15/01/2019	13:01	6m	Tallowwood	Cam	N		Euc leaf nest		Nil	
250	NBM.SG.08	M	Small Glider	15/01/2019	12:52	7m	Tallowwood	Cam	Not avail				Nil	Box broken on ground
252	NBF.COSO.02	F	Cockatoo/Small Owl	18/02/2019	11:22	12m	Stringy bark	Tree Climber	Y	Native	Occupied	Common Brushtail Possum	Nil	No springs and limited room in wire for expansion. new waypoint
253	NBF.COSO.03 (SO.03 on tag)	F	Cockatoo/Small Owl	10/01/2019	14:16	12m	Tallowwood	Tree Climber	Y	Native	Occupied	Common Brushtail Possum	Nil	Also known as SO.03
254	NBF.COSO.04	F	Cockatoo/Small Owl	18/02/2019	11:37	9m	Ironbark	Tree Climber	Y	Native	Occupied	Common Brushtail Possum x 2	Nil	
255	NBF.PO.05	F	Possum	Not found									Nil	
256	NBK.SG.03	K	Small Glider	16/01/2019	12:17	9m	Blackbutt	Cam	N		Euc leaf nest		Nil	
257	NBL.SF.02	L	Scansorial mammal	Not found									Nil	
258	NBM.PL.02	M	Medium Sized Parrot	15/01/2019	13:08	8m	Blackbutt	Cam	N		Euc leaf nest		Nil	Wire ok
259	NBM.PO.02	M	Possum	15/01/2019	12:33	7m	Tallowwood	Cam	N		Leaf litter		Nil	Wire ok
260	NBM.SG.02	M	Small Glider	15/01/2019	13:30	5m	Tallowwood	Cam	N		Leaf litter		Nil	
261	NBM.SF.02	M	Scansorial mammal	15/01/2019	13:32	6m	Tallowwood	Cam	N	Pest	Insect hive		Nil	

Annex 2 – Winter field data 2019

Cam = inspection via camera; N = no; Y = yes, Unk = unknown; Euc = eucalyptus

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native/ Pest	Signs of use	Species	Landscape changes	Comments
1	NBA.MB.01	A	Microbat	23/07/2019	13:04	4m	Broad-leaved Paper Bark	Cam	N		Nil		Nil	
2	NBA.MB.02	A	Microbat	23/07/2019	13:01	9m	Broad-leaved Paper Bark	Cam	N		Nil		Nil	
3	NBA.MB.03	A	Microbat	23/07/2019	13:06	5m	Broad-leaved Paper Bark	Cam	N		Nil		Nil	
4	NBA.MB.04	A	Microbat	23/07/2019	13:07	3m	Broad-leaved Paper Bark	Cam	N		Nil		Nil	
5	NBA.MB.05	A	Microbat	23/07/2019	13:09	4m	Broad-leaved Paper Bark	Cam	N		Nil		Nil	
6	NBA.MB.06	A	Microbat	23/07/2019	12:49	5m	Broad-leaved Paper Bark	Cam	N		Nil		Nil	
7	NBA.MB.07	A	Microbat	23/07/2019	12:51	5m	Broad-leaved Paper Bark	Cam	N		Nil		Nil	
8	NBA.MB.08	A	Microbat	23/07/2019	13:16	8m	Broad-leaved Paper Bark	Cam	N		Nil		Nil	
9	NBA.MB.09	A	Microbat	23/07/2019	13:18	6m	Broad-leaved Paper Bark	Cam	N		Melaleuca leaf nest		Nil	
10	NBA.MB.10	A	Microbat	23/07/2019	13:20	13m	Broad-leaved Paper Bark	Cam	N		Nil		Nil	
11	NBA.MB.11	A	Microbat	23/07/2019	13:31	7m	Broad-leaved Paper Bark	Cam	N		Nil		Nil	
12	NBA.PL.01	A	Medium Sized Parrot	23/07/2019	12:55	13m	Broad-leaved Paper Bark	Cam	N		Melaleuca leaf nest		Nil	
13	NBA.PL.02	A	Medium Sized Parrot	23/07/2019	13:20	8m	Broad-leaved Paper Bark	Cam	N		Melaleuca leaf nest		Nil	
14	NBA.PL.03	A	Medium Sized Parrot	23/07/2019	13:23	8m	Broad-leaved Paper Bark	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	
15	NBA.PL.04	A	Medium Sized Parrot	23/07/2019	13:14	8m	Broad-leaved Paper Bark	Cam	N		Melaleuca bark nest		Nil	
16	NBA.PL.05	A	Medium Sized Parrot	23/07/2019	13:25	7m	Broad-leaved Paper Bark	Cam	N		Melaleuca leaf and bark nest		Nil	
17	NBA.PL.06	A	Medium Sized Parrot	23/07/2019	13:27	12m	Broad-leaved Paper Bark	Cam	N		Melaleuca bark nest		Nil	
18	NBA.PL.07	A	Medium Sized Parrot	23/07/2019	13:32	10m	Swamp Oak	Cam	N		Nil		Nil	
19	NBA.PL.08	A	Medium Sized Parrot	23/07/2019	13:11	5m	Broad-leaved Paper Bark	Cam	N		Melaleuca leaf nest		Nil	
20	NBA.PL.09	A	Medium Sized Parrot	23/07/2019	12:47	9m	Swamp Oak	Cam	N		Nil		Nil	
21	NBA.PO.01	A	Possum	23/07/2019	12:59	6m	Broad-leaved Paper Bark	Cam	N		Nil		Nil	
22	NBA.PO.02	A	Possum	23/07/2019	13:02	12m	Broad-leaved Paper Bark	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native/ Pest	Signs of use	Species	Landscape changes	Comments
23	NBA.PO.03	A	Possum	23/07/2019	12:53	10m	Broad-leaved Paper Bark	Cam	N		Old Euc leaf		Nil	
24	NBA.PO.04	A	Possum	23/07/2019	13:29	8m	Broad-leaved Paper Bark	Cam	N		Nil		Nil	
25	NBB.MB.01	B	Microbat	23/07/2019	12:19	6m	Broad-leaved Paper Bark	Cam	N		Nil		Nil	
26	NBB.MB.02	B	Microbat	23/07/2019	12:22	6m	Broad-leaved Paper Bark	Cam	N		Nil		Nil	
27	NBB.PL.01	B	Medium Sized Parrot	03/07/2019	14:35	12m	Pink Bloodwood	Cam	N		Messy Euc leaf		Nil	Lid no longer stuck
28	NBB.PL.02	B	Medium Sized Parrot	03/07/2019	14:43	7m	Pink Bloodwood	Cam	N		Nil		Nil	
29	NBB.PL.03	B	Medium Sized Parrot	03/07/2019	14:45	8m	Brushbox	Cam	N		Euc leaf		Nil	
30	NBB.PO.01	B	Possum	03/07/2019	14:37	12m	Pink Bloodwood	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	
31	NBB.SF.01	B	Scansorial mammal	03/07/2019	14:39	9m	Brushbox	Cam	N		Fresh Euc leaf nest		Nil	
32	NBC.MB.01	C	Microbat	03/07/2019	14:01	12m	Pink Bloodwood	Cam	N		Nil		Nil	
33	NBC.MB.02	C	Microbat	03/07/2019	13:54	12m	Ironbark	Cam	N		Nil		Nil	
34	NBC.PL.01	C	Medium Sized Parrot	03/07/2019	14:07	8m	Greygum	Cam	N		Nil		Nil	
35	NBC.PL.02	C	Medium Sized Parrot	03/07/2019	14:10	8m	Greygum	Cam	N		Euc leaf		Nil	
36	NBC.PL.03	C	Medium Sized Parrot	03/07/2019	13:55	6m	Ironbark	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	
37	NBC.PO.01	C	Possum	03/07/2019	13:59	8m	Pink Bloodwood	Cam	N		Nil		Nil	
38	NBC.PO.02	C	Possum	03/07/2019	13:49	5m	Pink Bloodwood	Cam	N		Nil		Nil	Same tree as LG02
39	NBC.SF.01	C	Scansorial mammal	03/07/2019	13:57	9m	Pink Bloodwood	Cam	N		Euc leaf		Nil	
40	NBC.SF.02	C	Scansorial mammal	03/07/2019	14:13	9m	Ironbark	Cam	N		Euc leaf nest		Nil	
41	NBC.SF.03	C	Scansorial mammal	03/07/2019	13:52	8m	Pink Bloodwood	Cam	Y	Native	Occupied	Sugar/Squirrel Glider	Nil	
42	NBC.SG.01	C	Small Glider	03/07/2019	14:08	5m	Greygum	Cam	N		Euc leaf nest		Nil	
43	NBC.LG.02	C	Large Glider	03/07/2019	13:49	8m	Pink Bloodwood	Cam	N		Euc leaf nest		Nil	
44	NBD.CO.01	D	Cockatoo/Small Owl	02/07/2019	9:27	15m	Scribbly	Cam	N		Nil		Nil	
45	NBD.LFO.01	D	Large Forest Owl	12/08/2019	11:55	19m	Scribbly	Tree Climber	Y	Native	Occupied	Common Brushtail Possum	Nil	Rewire for tree growth.
46	NBD.LG.01	D	Large Glider	02/07/2019	9:54	6m	Scribbly	Cam	N		Euc leaf nest		Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native/ Pest	Signs of use	Species	Landscape changes	Comments
47	NBD.LG.02	D	Large Glider	02/07/2019	9:44	13m	Stringy bark	Cam	Y	Native	Occupied	Poss. Squirrel Glider	Nil	
48	NBD.LG.03	D	Large Glider	02/07/2019	10:37	8m	Scribbly	Cam	N		Conical Euc leaf nest		Nil	
49	NBD.MB.01	D	Microbat	02/07/2019	10:33	6m	Stringy bark	Cam	N		Nil		Nil	
50	NBD.MB.02	D	Microbat	02/07/2019	10:08	6m	Scribbly	Cam	N		Nil		Nil	
51	NBD.PL.01	D	Medium Sized Parrot	02/07/2019	9:39	10m	Scribbly	Cam	N		Conical Euc leaf nest		Nil	
52	NBD.PL.02	D	Medium Sized Parrot	02/07/2019	10:18	7m	Scribbly	Cam	Y	Native	Occupied	Lace Monitor	Nil	
53	NBD.PO.01	D	Possum	02/07/2019	9:29	12m	Pink bloodwood	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	
54	NBD.PO.02	D	Possum	02/07/2019	10:21	10m	Bloodwood	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	
55	NBD.PO.03	D	Possum	02/07/2019	10:03	6m	Stringy bark	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	
56	NBD.SF.01	D	Scansorial mammal	02/07/2019	9:32	5m	Pink bloodwood	Cam	N		Euc leaf and bark nest		Nil	
57	NBD.SF.02	D	Scansorial mammal	02/07/2019	9:57	4m	Pink bloodwood	Cam	Y	Native	Occupied	Sugar Glider	Nil	
58	NBD.SF.03	D	Scansorial mammal	02/07/2019	10:30	8m	Stringy bark	Cam	N		Euc leaf nest		Nil	
59	NBD.SF.04	D	Scansorial mammal	02/07/2019	10:28	6m	Pink bloodwood	Cam	N		Conical Euc leaf nest		Nil	
60	NBD.SG.01	D	Small Glider	02/07/2019	9;36	7m	Pink bloodwood	Cam	N		Conical Euc leaf nest		Nil	
61	NBD.SG.02	D	Small Glider	02/07/2019	10:40	8m	Bloodwood	Cam	N		Conical Euc leaf nest		Nil	
62	NBD.SG.03	D	Small Glider	02/07/2019	9:50	9m	Stringy bark	Cam	N		Euc leaf, bracken, feather nest		Nil	
63	NBE.COSO.01	E	Cockatoo	02/07/2019	11:24	10m	Blackbutt	Cam	N		Nil		Nil	
64	NBE.COSO.02	E	Cockatoo	02/07/2019	11;33	10m	Scribbly	Cam	N		Chewed bark and leaf		Nil	
65	NBE.LG.01	E	Large Glider	02/07/2019	11:14	7m	Blackbutt	Cam	N		Old chewed bark and leaf		Nil	
66	NBE.MB.01	E	Microbat	02/07/2019	11:29	10m	Scribbly gum	Cam	N		Nil		Nil	
67	NBE.MB.01	E		Duplicate									Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native/ Pest	Signs of use	Species	Landscape changes	Comments
68	NBE.MB.02	E	Microbat	02/07/2019	11:40	10m	Blackbutt	Cam	N		Nil		Nil	
69	NBE.PL.01	E	Medium Sized Parrot	02/07/2019	11:29	6m	Scribbly gum	Cam	Y	Native	Occupied	Lace Monitor	Nil	
70	NBE.PL.02	E	Medium Sized Parrot	02/07/2019	11:10	8m	Stringy bark	Cam	N		Nil		Nil	Sitting on stub. Tree growth stretched wire out.
71	NBE.PO.01	E	Possum	02/07/2019	11:00	7m	Blackbutt	Cam	N		Old chewed bark and leaf		Nil	
72	NBE.PO.02	E	Possum	02/07/2019	11:20	8m	Blackbutt	Cam	N		Nil		Nil	
73	NBE.PO.03	E	Possum	02/07/2019	11:08	8m	Pink bloodwood	Cam	N		Old Euc leaf		Nil	
74	NBE.SF.01	E	Scansorial mammal	02/07/2019	11:17	7m	Blackbutt	Cam	N		Conical Euc leaf nest		Nil	
75	NBE.SF.02	E	Scansorial mammal	02/07/2019	11:40	6m	Blackbutt	Cam	N		Euc leaf nest		Nil	
76	NBE.SF.03	E	Scansorial mammal	02/07/2019	11:20	6m	Blackbutt	Cam	Y	Native	Occupied	Sugar Glider	Nil	Possible Squirrel
77	NBE.SG.01	E	Small Glider	02/07/2019	11:03	8m	Blackbutt	Cam	N		Conical Euc leaf nest		Nil	
78	NBE.SG.02	E	Small Glider	02/07/2019	11:38	8m	White Mahogany	Cam	N	Pest	Insect hive		Nil	
79	NBE.SG.03	E	Small Glider	02/07/2019	11:06	7m	Blackbutt	Cam	N		Old Euc leaf		Nil	
81	NBF.LFO.01	F	Large Forest Owl	02/07/2019	12:45	10m	Bloodwood	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	
82	NBF.LG.01	F	Large Glider	02/07/2019	12:40	8m	Pink bloodwood	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	
83	NBF.PL.01	F	Medium Sized Parrot	02/07/2019	13:22	9m	Stringy bark	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	
84	NBF.PL.02	F	Medium Sized Parrot	02/07/2019	12:23	8m	Bloodwood	Cam	N		Euc leaf litter		Nil	
85	NBF.PO.01	F	Possum	02/07/2019	13:30	8m	Tallowwood	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	
86	NBF.PO.02	F	Possum	02/07/2019	13:17	10m	Stringy bark	Cam	N		Flattened Euc leaf		Nil	
87	NBF.PO.03	F	Possum	02/07/2019	12:59	7m	Pink bloodwood	Cam	N		Nil		Nil	
88	NBF.PO.04	F	Possum	02/07/2019	12:54	7m	Pink bloodwood	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native/ Pest	Signs of use	Species	Landscape changes	Comments
89	NBF.PO.06	F	Possum	02/07/2019		12m	Pink bloodwood	Cam	Not avail				Nil	Box still on ground
90	NBF.PO.07	F	Possum	02/07/2019	13:56	5m	Black oak	Cam	N		Nil		Nil	
91	NBF.PO.08	F	Possum	02/07/2019	14:03	5m	Stringy bark	Cam	N		Nil		Nil	
92	NBF.PO.09	F	Possum	02/07/2019	13:54	5m	Bloodwood	Cam	N		Nil		Nil	
93	NBF.SF.01	F	Scansorial mammal	02/07/2019	13:11	6m	Stringy bark	Cam	N		Messy leaf and bark nest		Nil	
94	NBF.SF.02	F	Scansorial mammal	02/07/2019	13:25	5m	Pink bloodwood	Cam	Y	Native	Occupied	Sugar Glider	Nil	multiple
95	NBF.SF.03	F	Scansorial mammal	02/07/2019	13:04	12m	Pink bloodwood	Cam	N	Pest	Euc leaf nest plus old bee hive		Nil	
96	NBF.SF.04	F	Scansorial mammal	12/08/2019	13:54	8m	Bloodwood	Tree Climber	N		Bark and leaves		Nil	Poor wire too thin. No coils.
97	NBF.SF.05	F	Scansorial mammal	02/07/2019	13:56	8m	Black oak	Cam	N		Nil		Nil	
98	NBF.SF.06	F	Scansorial mammal	02/07/2019	14:01	7m	Stringy bark	Cam	N		Full of bark		Nil	
99	NBF.SG.01	F	Small Glider	02/07/2019	13:14	8m	Ironbark	Cam	N		Conical Euc leaf nest - fresh		Nil	
100	NBF.SG.02	F	Small Glider	02/07/2019	13:02	8m	Pink bloodwood	Cam	N	Pest	Euc leaf nest plus old bee hive	Bees	Nil	Hive no longer attached to bottom.
101	NBF.SG.03	F	Small Glider	02/07/2019	12:28	6m	Pink bloodwood	Cam	N		Conical Euc leaf nest		Nil	
102	NBF.SG.04	F	Small Glider	02/07/2019	13:27	4m	Black oak	Cam	N		Old leaf and bark		Nil	
103	NBF.SG.05	F	Small Glider	12/08/2019	13:50	13m	Bloodwood	Tree Climber	N	Pest	Nil	Ants	Nil	Active nest. No coils, wire poor too thin
104	NBF.SG.06	F	Small Glider	02/07/2019	13;52	8m	Bloodwood	Cam	N		Euc and bracken leaf nest		Nil	
105	NBF.SG.07	F	Small Glider	02/07/2019	13:49	14m	Bloodwood	Tree Climber	N		Nil		Nil	
106	NBF.SO.01	F	Cockatoo/Small Owl	02/07/2019	13:08	8m	Tallowwood	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	x2 individuals
107	NBF.SO.02	F		Not found									Nil	
108	NBG.PL.01	G	Medium Sized Parrot	22/07/2019	9:51	10m	Red mahogany	Cam	N		Old leaf litter		Nil	Lid broken
109	NBG.PL.02	G	Medium Sized Parrot	22/07/2019	9:30	6m	Tallowwood	Cam	N		Conical Euc leaf nest		Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Insp ect type	Occupied (Y/N)	Native/ Pest	Signs of use	Species	Landscape changes	Comments
110	NBG.PO.01	G	Possum	22/07/2019	9:31	10m	Red mahogany	Cam	N		Fern, leaf and bark nest		Nil	
111	NBG.PO.02	G	Possum	22/07/2019	9:54	8m	Swamp mahogany	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	
112	NBG.SF.01	G	Scansorial mammal	22/07/2019	9:10	8m	Broad-leaved Paperbark	Cam	Unk		Unknown		Nil	Lid stuck
113	NBG.SF.02	G	Scansorial mammal	22/07/2019	9:44	6m	Swamp Oak	Cam	N		Euc leaf litter		Nil	
114	NBG.SF.03	G	Scansorial mammal	22/07/2019	9:55	7m	Swamp mahogany	Cam	N		Old Euc leaf nest		Nil	
115	NBG.SG.01	G	Small Glider	22/07/2019	9:13	4m	Swamp mahogany	Cam	N		Leaf and stick		Nil	
116	NBG.SG.02	G	Small Glider	22/07/2019	9:49	8m	Swamp mahogany	Cam	N		Old leaf litter		Nil	
117	NBG.SG.03	G	Small Glider	22/07/2019	9:45	7m	Swamp oak	Cam	N		Old leaf litter		Nil	
118	NBH.LFO.01	H	Large Forest Owl	03/07/2019	9:43	15m	Blackbutt	Cam	N		Squashed Euc leaf nest		Nil	
119	NBH.LG.01	H	Large Glider	03/07/2019	10:12	7m	Blackbutt	Cam	N		Squashed Euc leaf nest		Nil	
120	NBH.PL.01	H	Medium Sized Parrot	23/07/2019	11:36	10m	Blackbutt	Cam	N		Euc leaf nest		Nil	
121	NBH.PO.01	H	Possum	23/07/2019	11:45	7m	Tallowwood	Cam	N		Nil		Nil	
122	NBH.PO.02	H	Possum	23/07/2019	11:49	6m	Pink bloodwood	Cam	N		Old Euc leaf		Nil	
123	NBH.SF.01	H	Scansorial mammal	03/07/2019	9:59	8m	Blackbutt	Cam	N		Conical Euc leaf nest		Nil	
124	NBH.SG.01	H	Scansorial mammal	23/07/2019	11:42	8m	Tallowwood	Cam	N		Euc leaf nest		Nil	
125	NBH.SO.01	H	Cockatoo/Small Owl	03/07/2019	9:40	12m	Blackbutt	Cam	N		Squashed Euc leaf nest		Nil	
126	NBI.CO.01	I	Cockatoo/Small Owl	12/08/2019	14:23	13m	Blackbutt	Tree Climber	Y	Native	Occupied	Yellow-bellied Glider x4	Nil	No coils in wire. Last a few more years with tree growth.
127	NBI.LFO.01	I	Large Forest Owl	03/07/2019	10:42	13m	Blackbutt	Cam	N		Fresh Euc leaf nest		Nil	
128	NBI.LFO.02	I	Large Forest Owl	12/08/2019	15:21	15m	Blackbutt	Tree Climber	N		Euc leaf litter		Nil	No coils in wire
129	NBI.LG.01	I	Large Glider	03/07/2019	10:23	13m	Blackbutt	Cam	Y	Native	Occupied	Yellow-bellied Glider x3	Nil	x3
130	NBI.LG.02	I	Large Glider	23/07/2019	10:52	11m	Blackbutt	Cam	Y	Native	Occupied	Yellow-bellied Glider x3	Nil	x3
131	NBI.LG.03	I	Large Glider	23/07/2019	11:13	8m	Blackbutt	Cam	N		Euc leaf nest		Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native/ Pest	Signs of use	Species	Landscape changes	Comments
132	NBI.LG.04	I	Large Glider	03/07/2019	11:05	9m	Blackbutt	Cam	N		Old Euc leaf flat		Nil	
133	NBI.MB.01	I	Microbat	03/07/2019	10:20	10m	Blackbutt	Cam	N		Nil		Nil	
134	NBI.PL.01	I	Medium Sized Parrot	23/07/2019	11:26	9m	Blackbutt	Cam	N		Euc leaf nest		Nil	
135	NBI.PL.02	I	Medium Sized Parrot	23/07/2019	10:56	11m	Blackbutt	Cam	N		Euc leaf		Nil	
136	NBI.PO.01	I	Possum	03/07/2019	10:34	3m	Blackbutt	Cam	N		Bark and debris		Nil	
137	NBI.PO.02	I	Possum	23/07/2019	11:19	8m	Blackbutt		Y	Native	Occupied	Petaurus sp.	Nil	
138	NBI.PO.03	I	Possum	03/07/2019	11:08	5m	Brushbox	Cam	N		Old Euc leaf		Nil	
139	NBI.PO.04	I	Possum	03/07/2019	11:02	5m	Ironbark	Cam	N		Nil		Nil	
140	NBI.SF.01	I	Scansorial mammal	03/07/2019	10:36	7m	Tallowwood	Cam	Y	Native	Occupied	Sugar Glider	Nil	
141	NBI.SF.02	I	Scansorial mammal	03/07/2019	10:59	8m	Tallowwood	Cam	Y	Native	Occupied	Sugar Glider	Nil	
142	NBI.SF.03	I	Scansorial mammal	03/07/2019	11:11	10m	Blackbutt	Cam	N		Conical Euc leaf nest		Nil	
143	NBI.SG.01	I	Small Glider	03/07/2019	10:29	10m	Blackbutt	Cam	Y	Native	Occupied	Sugar Glider	Nil	
144	NBI.SG.02	I	Small Glider	23/07/2019	11:22	7m	Blackbutt	Cam	N		Euc leaf		Nil	
145	NBI.SG.03	I	Small Glider	03/07/2019	11:13	10m	Blackbutt	Cam	N		Conical Euc leaf nest		Nil	
146	NBI.SO.02	I	Cockatoo/Small Owl	03/07/2019	10:56	15m	Blackbutt	Cam	Y	Native	Occupied	Yellow-bellied Glider	Nil	x3 individuals
147	NBJ.LG.01	J	Large Glider	03/07/2019	12:25	9m	Tallowwood	Cam	N		Old leaf litter		Nil	
148	NBJ.LG.02	J	Large Glider	03/07/2019	12:12	8m	Tallowwood	Cam	N		Old chewed leaf litter		Nil	
149	NBJ.LG.03	J	Large Glider	03/07/2019	12:19	7m	Ironbark	Cam	N		Chewed bark		Nil	
150	NBJ.LG.04	J	Large Glider	03/07/2019	12:50	7m	Ironbark	Cam	N		Bark & old leaf litter		Nil	
151	NBJ.LG.05	J	Large Glider	03/07/2019	11:50	6m	Blackbutt	Cam	N		Chewed bark & fresh Euc leaf		Nil	
152	NBJ.MB.01	J	Microbat	03/07/2019	12:07	8m	Pink bloodwood	Cam	N		Nil		Nil	
153	NBJ.MB.01	J		Duplicate									Nil	
154	NBJ.MB.02	J	Microbat	03/07/2019	11:48	5m	Pink bloodwood	Cam	N		Nil		Nil	
155	NBJ.MB.03	J	Microbat	03/07/2019	12:26	7m	Ironbark	Cam	N		Nil		Nil	
156	NBJ.PL.01	J	Medium Sized Parrot	03/07/2019	12:38	7m	Tallowwood	Cam	N		Old leaf litter		Nil	
157	NBJ.PL.02	J	Medium Sized Parrot	03/07/2019	11:45	9m	Blackbutt	Cam	N		Old Euc leaf		Nil	
158	NBJ.PO.01	J	Possum	03/07/2019	11:39	4m	Tallowwood	Cam	N		Nil		Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native/ Pest	Signs of use	Species	Landscape changes	Comments
159	NBJ.PO.01	J		Not found									Nil	
160	NBJ.PO.02	J	Possum	03/07/2019	12:42	8m	Tallowwood	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	
161	NBJ.SF.01	J	Scansorial mammal	03/07/2019	12:37	8m	Tallowwood	Cam	N		Old leaf litter		Nil	
162	NBJ.SF.02	J	Scansorial mammal	03/07/2019	12:42	5m	Pink bloodwood	Cam	N		Old conical Euc leaf nest		Nil	
163	NBJ.SF.03	J	Scansorial mammal	03/07/2019	11:55	9m	Pink bloodwood	Cam	Y	Native	Occupied	Sugar Glider	Nil	
164	NBJ.SF.04	J	Scansorial mammal	03/07/2019	11:45	8m	Pink bloodwood	Cam	N		Euc leaf nest		Nil	
165	NBJ.SF.05	J	Scansorial mammal	03/07/2019	12:19	6m	Tallowwood	Cam	N		Old leaf litter		Nil	
166	NBJ.SF.05	J		Duplicate									Nil	
167	NBJ.SG.01	J	Small Glider	03/07/2019	12:15	7m	Tallowwood	Cam	N		Euc leaf and bark nest		Nil	
168	NBJ.SG.02	J	Small Glider	03/07/2019	12:46	6m	Tallowwood	Cam	N		Conical Euc leaf nest		Nil	
169	NBJ.SG.03	J	Small Glider	03/07/2019	11:41	6m	Blackbutt	Cam	N		Old conical Euc leaf nest		Nil	
170	NBJ.SG.04	J	Small Glider	03/07/2019	12:33	10m	Ironbark	Cam	N		Chewed old leaf litter		Nil	
171	NBJ.SG.05	J	Small Glider	03/07/2019	11:38	8m	Tallowwood	Cam	N		Old Euc leaf		Nil	
172	NBJ.SO.01	J	Cockatoo/Small Owl	03/07/2019	11:51	10m	Tallowwood	Cam	N		Nil		Nil	
173	NBK.CO.02	K	Cockatoo/Small Owl	23/07/2019	9:58	15m	Tallowwood	Cam	N		Euc leaf litter		Nil	
174	NBK.MB.01	K	Microbat	23/07/2019	10:19	10m	Blackbutt	Cam	N		Nil		Nil	
175	NBK.MB.02	K	Microbat	23/07/2019	9:19	10m	Blackbutt	Cam	N		Nil		Nil	
176	NBK.MB.03	K	Microbat	23/07/2019	9:10	7m	Blackbutt	Cam	N		Nil		Nil	
177	NBK.PL.01	K	Medium Sized Parrot	23/07/2019	9:52	5m	Stringy bark	Cam	N		Bark and leaf litter		Nil	
178	NBK.PL.02	K	Medium Sized Parrot	23/07/2019	10:20	6m	Blackbutt	Cam	N		Old leaf litter		Nil	
179	NBK.PL.03	K	Medium Sized Parrot	23/07/2019	9:11	10m	Blackbutt	Cam	N		Chewed bark and feather		Nil	
180	NBK.PO.01	K	Possum	23/07/2019	9:17	10m	Blackbutt	Cam	N		Old leaf litter		Nil	
181	NBK.PO.02	K	Possum	23/07/2019	10:13	8m	Blackbutt	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	
182	NBK.SF.01	K	Scansorial mammal	23/07/2019	10:01	4m	Tallowwood	Cam	Y	Native	Occupied	Petaurus sp.	Nil	Possible wire issue noted in summer

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native/ Pest	Signs of use	Species	Landscape changes	Comments
183	NBK.SF.02E	K	Scansorial mammal	23/07/2019	9:30	8m	Blackbutt	Cam	Y	Native	Occupied	Brush-tailed Phascogale	Nil	Probable
184	NBK.SF.03	K	Scansorial mammal	23/07/2019	9:15	7m	Blackbutt	Cam	N		Old leaf litter		Nil	
185	NBK.SF.04	K	Scansorial mammal	23/07/2019	10:07	6m	Tallowwood	Cam	N		Old leaf litter		Nil	
186	NBK.SG.01	K	Small Glider	23/07/2019	10:03	5m	Blackbutt	Cam	Y	Native	Occupied	Sugar Gliders	Nil	x2 individuals
187	NBK.SF.02W	K	Small Glider	23/07/2019	10:10	12m	Blackbutt	Cam	Unk		Lid stuck		Nil	
187	NBK.SG.02	K	Small Glider	Duplicate		12m	Blackbutt						Nil	
188	NBK.SG.04	K	Small Glider	23/07/2019	10:24	6m	White Mahogany	Cam	N		Euc leaf nest		Nil	
189	NBK.SG.05	K	Small Glider	23/07/2019	10:22	6m	Pink bloodwood	Cam	N	Pest	old Euc leaf nest	Ants	Nil	
190	NBK.SG.06	K	Small Glider	23/07/2019	10:23	6m	Blackbutt	Cam	N	Pest	Nil	Ants	Nil	
191	NBK.SO.01	K	Cockatoo/Small Owl	23/07/2019	9:43	12m	Blackbutt	Cam	Y	Native	Occupied	Common Brushtail Possum	Nil	
192	NBL.CO.01	L	Cockatoo/Small Owl	22/07/2019	11:50	9m	Grey Gum	Cam	N		Nil		Nil	No room for expansion
193	NBL.LG.01	L	Large Glider	22/07/2019	10:59	9m	Pink bloodwood	Cam	N	Pest	Euc leaf old honeycomb	Bees	Nil	Lid broken
194	NBL.LG.02	L	Large Glider	22/07/2019	11:34	7m	Pink bloodwood	Cam	N		Euc leaf and insect debris		Nil	
195	NBL.LG.03	L	Large Glider	22/07/2019	11:44	8m	Tallowwood	Cam	N		shredded Euc leaf and twigs		Nil	
196	NBL.LG.04	L	Large Glider	22/07/2019	11:48	8m	Ironbark	Cam	N		flattened Euc leaf		Nil	
197	NBL.LG.05	L	Large Glider	22/07/2019	11:26	8m	Pink bloodwood	Cam	N		Euc leaf and latrine		Nil	
198	NBL.MB.01	L	Microbat	22/07/2019	14:36	6m	Tallowwood	Cam	N		Nil		Nil	
199	NBL.MB.02	L	Microbat	22/07/2019	14:30	8m	Pink bloodwood	Cam	N		Nil		Nil	
200	NBL.MB.02	L		Duplicate									Nil	
201	NBL.MB.03	L	Microbat	22/07/2019	14:38	8m	Bloodwood	Cam	N		Nil		Nil	
202	NBL.MB.04	L	Microbat	22/07/2019	14:32	8m	Tallowwood	Cam	N		Nil		Nil	
203	NBL.PL.01	L	Medium Sized Parrot	22/07/2019	14:34	6m	Tallowwood	Cam	N		Shredded Euc leaf and bark		Nil	
204	NBL.PL.02	L	Medium Sized Parrot	Not found									Nil	
205	NBL.PL.03	L	Medium Sized Parrot	22/07/2019	14:46	7m	White mahogany	Cam	N		Bark and latrine		Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native/ Pest	Signs of use	Species	Landscape changes	Comments
206	NBL.PL.04	L	Medium Sized Parrot	22/07/2019	10:39	8m	Grey gum	Cam	N		Euc leaf		Nil	
207	NBL.PL.05	L	Medium Sized Parrot	22/07/2019	10:27	6m	Tallowwood	Cam	N		Bark nest		Nil	
208	NBL.PO.01	L	Possum	22/07/2019	14:51	7m	White mahogany	Cam	N		Euc leaf		Nil	
209	NBL.PO.02	L	Possum	22/07/2019	10:16	6m	Pink bloodwood	Cam	N		Flattened Euc leaf		Nil	
210	NBL.PO.03	L	Possum	22/07/2019	10:37	8m	White mahogany	Cam	N	Pest	Nil		Nil	Insect debris
211	NBL.PO.04	L	Possum	22/07/2019	10:32	6m	Pink bloodwood	Cam	N		Nil		Nil	Rotting
212	NBL.PO.05	L	Possum	22/07/2019	14:48	5m	Blackbutt	Cam	N		Nil		Nil	
213	NBL.SF.01	L	Scansorial mammal	22/07/2019	11:13	5m	Tallowwood	Cam	N	Pest	Euc leaf old honeycomb	Bees	Nil	
214	NBL.SF.03	L	Scansorial mammal	22/07/2019	11:10	5m	Tallowwood	Cam	N		Euc leaf and latrine		Nil	
215	NBL.SF.04	L	Scansorial mammal	22/07/2019	14:53	7m	Pink bloodwood	Cam	N		Euc leaf nest		Nil	
216	NBL.SF.05	L	Scansorial mammal	22/07/2019	10:22	8m	Blackbutt	Cam	N		Conical Euc leaf nest		Nil	
217	NBL.SG.01	L	Small Glider	22/07/2019	11:59	8m	Pink bloodwood	Cam	N		Euc leaf and latrine		Nil	
218	NBL.SG.02	L	Small Glider	22/07/2019	11:21	6m	Pink bloodwood	Cam	N	Pest	Nil	Bees	Nil	Old honeycomb
219	NBL.SG.03	L	Small Glider	22/07/2019	11:07	10m	Pink bloodwood	Cam	N		Euc leaf nest		Nil	
220	NBL.SG.04	L	Small Glider	22/07/2019	10:25	8m	Tallowwood	Cam	N		Fresh Euc leaf nest		Nil	
221	NBL.SG.05	L	Small Glider	22/07/2019	10:19	6m	Pink bloodwood	Cam	N		Euc leaf		Nil	
222	NBL.SO.01	L	Cockatoo/Small Owl	22/07/2019	11:30	9m	Grey gum	Cam	N		shredded bark		Nil	
223	NBM.LG.01	M	Large Glider	22/07/2019	14:00	6m	Ironbark	Cam	N		Old leaf litter		Nil	
224	NBM.LG.02	M	Large Glider	22/07/2019	13:55	5m	Ironbark	Cam	N		Old leaf litter		Nil	
225	NBM.MB.01	M	Microbat	22/07/2019	14:03	6m	Ironbark	Cam	N		Nil		Nil	
226	NBM.MB.02	M	Microbat	22/07/2019	13:39	11m	White mahogany	Cam	N		Nil		Nil	
227	NBM.PL.01	M	Medium Sized Parrot	22/07/2019	13:58	7m	Ironbark	Cam	N		Old leaf litter		Nil	
228	NBM.PL.03	M	Medium Sized Parrot	22/07/2019	12:50	12m	Pink bloodwood	Cam	N		Nil		Nil	
229	NBM.PL.04	M	Medium Sized Parrot	22/07/2019	13:09	7m	Blackbutt	Cam	N		Nil		Nil	
230	NBM.PL.05	M	Medium Sized Parrot	22/07/2019	12:42	10m	Blackbutt	Cam	N	Pest	Nil	Ants	Nil	
231	NBM.PL.06	M	Medium Sized Parrot	22/07/2019	13:20	5m	Blackbutt	Cam	N		Nil		Nil	Box fallen on ground
232	NBM.PO.01	M	Possum	22/07/2019	13:38	4m	White mahogany	Cam	N		Nil		Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native/ Pest	Signs of use	Species	Landscape changes	Comments
233	NBM.PO.03	M	Possum	22/07/2019	12:46	3m	Tallowwood	Cam	N		Nil		Nil	
234	NBM.PO.04	M	Possum	22/07/2019	13:21	5m	Tallowwood	Cam	N		Nil		Nil	Box fallen on ground
235	NBM.PO.05	M	Possum	22/07/2019	12:55	4m	Red mahogany	Cam	N		Nil		Nil	
236	NBM.PO.06	M	Possum	22/07/2019	13:24	5m	Bloodwood	Cam	Y	Native	Occupied	Lace Monitor	Nil	
237	NBM.SF.01	M	Scansorial mammal	Not found		8m	Tallowwood						Nil	
238	NBM.SF.03	M	Scansorial mammal	22/07/2019	12:46	5m	Tallowwood	Cam	N	Pest	Old Euc leaf nest	Ants	Nil	
239	NBM.SF.04	M	Scansorial mammal	22/07/2019	13:20	8m	Blackbutt	Cam	N		Old Euc leaf nest		Nil	Box fallen on ground
240	NBM.SF.05	M	Scansorial mammal	22/07/2019	13:01	6m	Tallowwood	Cam	Y	Native	Occupied	Petaurus sp.	Nil	2 individuals
241	NBM.SF.06	M	Scansorial mammal	22/07/2019	12:52	8m	Blackbutt	Cam	N		Old Euc leaf nest		Nil	Rusty wire
242	NBM.SF.07	M	Scansorial mammal	22/07/2019	12:42	5m	Tallowwood	Cam	N		Old leaf litter		Nil	
243	NBM.SF.08	M	Scansorial mammal	22/07/2019	13:10	4m	Blackbutt	Cam	N	Pest	Nil	Ants	Nil	Rusty wire
244	NBM.SG.01	M	Small Glider	22/07/2019	13:43	6m	Blackbutt	Cam	Y	Native	Occupied	Lace Monitor	Nil	
245	NBM.SG.03	M	Small Glider	22/07/2019	12:48	6m	Pink bloodwood	Cam	N		Euc leaf nest		Nil	
246	NBM.SG.04	M	Small Glider	22/07/2019	13:24	8m	Bloodwood	Cam	N		Nil		Nil	Rusty wire
247	NBM.SG.05	M	Small Glider	22/07/2019	13:11	6m	Blackbutt	Cam	N		Nil		Nil	Rusty wire
248	NBM.SG.06	M	Small Glider	22/07/2019	12:53	6m	Tallowwood	Cam	N		Old Euc leaf nest		Nil	
249	NBM.SG.07	M	Small Glider	22/07/2019	12:58	6m	Tallowwood	Cam	N		Old Euc leaf nest		Nil	
250	NBM.SG.08	M	Small Glider	22/07/2019	13:26	7m	Tallowwood	Cam	N		Nil		Nil	Box on ground
252	NBF.COSO.02	F	Cockatoo/Small Owl	12/08/2019	13:18	12m	Stringy bark	Tree Climber	Y	Native	Occupied	Common Brushtail Possum	Nil	No coils in wire
253	NBF.COSO.03 (SO.03 on tag)	F	Cockatoo/Small Owl	12/08/2019	12:50	12m	Tallowwood	Tree Climber	Y	Native	Occupied	Common Brushtail Possum	Nil	
254	NBF.COSO.04	F	Cockatoo/Small Owl	12/08/2019	12:36	9m	Ironbark	Tree Climber	Y	Native	Occupied	Common Brushtail Possum	Nil	No coils in wire
255	NBF.PO.05	F	Possum	Not found									Nil	
256	NBK.SG.03	K	Small Glider	23/07/2019	9:43	9m	Blackbutt	Cam	Y	Native	Occupied	Sugar Gliders	Nil	x4 individuals
257	NBL.SF.02	L	Scansorial mammal	Not found									Nil	
258	NBM.PL.02	M	Medium Sized Parrot	22/07/2019	13:16	8m	Blackbutt	Cam	N		Old Euc leaf		Nil	

Box N.	Nest Box Name	Zone	Type	Date	Time	Box height	Tree species	Inspect type	Occupied (Y/N)	Native/ Pest	Signs of use	Species	Landscape changes	Comments
259	NBM.PO.02	M	Possum	22/07/2019	13:13	7m	Tallowwood	Cam	N		Nil		Nil	
260	NBM.SG.02	M	Small Glider	22/07/2019	13:47	5m	Tallowwood	Cam	Y	Native	Occupied	Lace Monitor	Nil	

Annex 3 –Weather conditions during 2018/2019 survey

Season	Date	Wind	Rain	Cloud Cover	Temperature (˚C)
Summer	08/01/2019	0	0	80	24.8
Summer	10/01/2019	0	0	0	31
Summer	15/01/2019	0	0	0	30
Summer	16/01/2019	0	0	0	33
Summer	17/01/2019	0	0	0	32
Winter	02/07/2019	0	0	0	23.8
Winter	03/07/2019	0	0	0	23
Winter	22/07/2019	1	0	0	23
Winter	23/07/2019	1	0	0	25
Winter	12/08/2019	2	0	5	20.2

Note: wind and rain were recorded on a scale of 0-3, 0= no wind or rain.

Annex 4 - Data analysis for each zone – 2018/2019 monitoring

Zone	No. inspected		% Occupied with native species (n)		% Signs of use (n)		% Pests/signs of pest use (n)		No. requiring maintenance	
	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer	Winter
A	24	24	8.3 (2)	8.3 (2)	33.3 (8)	33.3 (8)	16.7 (4)	0.0 (0)	1	0
B	7	7	14.3 (1)	14.3 (1)	28.6 (2)	42.9 (3)	14.3 (1)	0.0 (0)	2	1
C	12	12	33.3 (4)	16.7 (2)	33.3 (4)	41.7 (5)	0.0 (0)	0.0 (0)	0	0
D	19	19	36.8 (7)	36.8 (7)	57.9 (11)	47.4 (9)	0.0 (0)	0.0 (0)	1	1
E	16	16	31.3 (5)	12.5 (2)	43.8 (7)	50.0 (8)	0.0 (0)	6.3 (1)	2	1
F	29	29	34.5 (10)	34.5 (10)	31.0 (9)	34.5 (10)	10.3 (3)	10.3 (3)	5	7
G	10	10	10.0 (1)	10.0 (1)	70.0 (7)	80.0 (8)	10.0 (1)	0.0 (0)	1	2
H	8	8	12.5 (1)	0.0 (0)	50.0 (4)	87.5 (7)	12.5 (1)	0.0 (0)	0	0
I	20	21	5.0 (1)	38.1 (8)	80.0 (16)	47.6 (10)	15.0 (3)	0.0 (0)	4	2
J	23	23	13.0 (3)	8.7 (2)	65.2 (15)	69.6 (16)	4.3 (1)	0.0 (0)	1	0
K	20	20	10.0 (2)	30.0 (6)	55.0 (11)	45.0 (9)	10.0 (2)	10.0 (2)	2	0
L	29	29	0.0 (0)	0.0 (0)	51.7 (15)	69.0 (20)	20.7 (6)	13.8 (4)	7	6
M	31	31	3.2 (1)	12.9 (4)	25.8 (8)	35.5 (11)	22.6 (7)	12.9 (4)	20	13
Total	248	249	15.3 (38)	18.1 (45)	47.2 (117)	49.8 (124)	11.7 (29)	5.6 (14)	46	33

(n) = number of boxes

Annex 5 – Pre-handover inspection maintenance requirements

Box N.	Nest Box Name	Zone	Type	Fauna	Comments	Maintenance
20	NBA.PL.09	A	Medium Sized Parrot	European Honeybees	Active hive. Bottom of box damp.	Consider replacing.
27	NBB.PL.01	B	Medium Sized Parrot		Lid stuck closed.	Check for native bees. Consider repairing/replacing if damaged.
28	NBB.PL.02	B	Medium Sized Parrot		Bottom detached.	**Replace.**
45	NBD.LFO.01	D	Large Forest Owl	Common Brushtail Possum	Arborist advised that current wiring would be insufficient for tree expansion within two years.	Rewire as limited room for expansion.
63	NBE.COSO.01	E	Cockatoo	Common Brushtail Possum	Box sitting in fork not hanging.	Rehang so that the box is supported by the suspension wire.
78	NBE.SG.02	E	Small Glider	Native bees?	Native bees?	Lid stuck. Check for native bees. Consider repairing/replacing if damaged.
89	NBF.PO.06	F	Possum		Box on ground fallen down.	**Replace.**
96	NBF.SF.04	F	Scansorial mammal		Poor wire, too thin. No coils.	Check wire and rewire if required.
97	NBF.SF.05	F	Scansorial mammal		Bottom has hole and is rotten.	**Replace.**
103	NBF.SG.05	F	Small Glider	Ants	Active nest. No coils, wire poor, too thin.	Check wire and rewire if required.
105	NBF.SG.07	F	Small Glider		Box fallen down.	**Replace.**
252	NBF.COSO.02	F	Cockatoo/Small Owl	Common Brushtail Possum	No springs and limited room in wire for expansion.	Check wire and rewire if required.
254	NBF.COSO.04	F	Cockatoo/Small Owl	Common Brushtail Possum	No coils in wire. Max growth 2 years.	Check wire and rewire if required.
108	NBG.PL.01	G	Medium Sized Parrot		Lid broken.	Fix lid.
112	NBG.SF.01	G	Scansorial mammal		Lid stuck, inside condition unknown.	Check for native bees. Consider repairing/replacing if damaged.
126	NBI.CO.01	I	Cockatoo/Small Owl	Yellow-bellied Glider x4	No coils in wire. Last a few more years with tree growth.	Check wire and rewire if required..
128	NBI.LFO.02	I	Large Forest Owl		No springs and limited room in wire for expansion.	Check wire and rewire if required..
136	NBI.PO.01	I	Possum			Consider moving higher up.
182	NBK.SF.01	K	Scansorial mammal		No room in wire for expansion.	Check wire and rewire if required.
187	NBK.SF.02W	K	Small Glider		Lid stuck, native bees?	Check for native bees. Consider repairing/replacing if damaged.
192	NBL.CO.01	L	Cockatoo/Small Owl		No room in wire for expansion.	Check wire and rewire if required.
193	NBL.LG.01	L	Large Glider	European Honey Bees	Full of old honeycomb, lid broken.	Fix lid & clear out.
210	NBL.PO.03	L	Possum		Beginning to rot- damp inside.	**Replace.**
211	NBL.PO.04	L	Possum		Poor condition - degrading/rotting.	**Replace.**
222	NBL.SO.01	L	Cockatoo/Small Owl		Old honeycomb scars, tight on tree.	Check wire and rewire if required.
228	NBM.PL.03	M	Medium Sized Parrot		Wiring corroding/lack expansion capacity.	Check wire and rewire if required.
229	NBM.PL.04	M	Medium Sized Parrot		Wiring corroding/lack expansion capacity.	Check wire and rewire if required.
230	NBM.PL.05	M	Medium Sized Parrot		Wiring corroding/lack expansion capacity.	Check wire and rewire if required.
231	NBM.PL.06	M	Medium Sized Parrot		Box fallen on ground.	Rehang.
233	NBM.PO.03	M	Possum		Wiring corroding/lack expansion capacity.	Check wire and rewire if required.
234	NBM.PO.04	M	Possum		Box on ground fallen down.	Rehang.
235	NBM.PO.05	M	Possum		Wiring corroding/lack expansion capacity.	Check wire and rewire if required.

Box N.	Nest Box Name	Zone	Type	Fauna	Comments	Maintenance
236	NBM.PO.06	M	Possum	Lace monitor	Wiring corroding/lack expansion capacity.	Check wire and rewire if required.
238	NBM.SF.03	M	Scansorial mammal		Wiring corroding/lack expansion capacity.	Check wire and rewire if required.
239	NBM.SF.04	M	Scansorial mammal		Box fallen on ground.	Rehang.
240	NBM.SF.05	M	Scansorial mammal	Sugar Gliders	Wire tight on tree, replace wire.	Check wire and rewire if required.
241	NBM.SF.06	M	Scansorial mammal			Check wire and rewire if required.
242	NBM.SF.07	M	Scansorial mammal		Insect debris.	Check wire and rewire if required.
243	NBM.SF.08	M	Scansorial mammal	Ants		Check wire and rewire if required.
245	NBM.SG.03	M	Small Glider		insect debris.	Check wire and rewire if required.
246	NBM.SG.04	M	Small Glider			Check wire and rewire if required.
247	NBM.SG.05	M	Small Glider	Ants	Old honeycomb.	Check wire and rewire if required.
249	NBM.SG.07	M	Small Glider			Check wire and rewire if required.
250	NBM.SG.08	M	Small Glider		Box broken on ground.	**Replace.**

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Appendix E Fauna Underpasses (incl Road Kill)

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Fauna Underpass and Associated Fauna Fence Monitoring 2018/2019

Frederickton to Eungai Pacific Highway Upgrade

Prepared for Transport for NSW

January 2020

Document control

Project no.:	1702 (PI 6.4)
Project client:	Transport for NSW
Project office:	Port Macquarie
Document description:	Fauna Underpass and Associated Fauna Fence Monitoring report 2018/2019
Project Director:	Rhidian Harrington
Project Manager:	Radika Michniewicz
Authors:	Jodie Danvers, Radika Michniewicz
Internal review:	Radika Michniewicz, Amanda Griffith
Document status:	Rev2
Local Government Area:	Kempsey

Document revision status

Author	Revision number	Internal review	Date issued
Jodie Danvers	D1	Radika Michniewicz	26/6/2019
Jodie Danvers	D2	Radika Michniewicz	12/8/2019
Jodie Danvers	D3	Radika Michniewicz	21/11/2019
Radika Michniewicz	D4	Amanda Griffith	26/11/2019
Radika Michniewicz	R0		26/11/2019
Radika Michniewicz	R1		
Radika Michniewicz	R2		

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Sydney

Central Coast

Illawarra

Armidale

Newcastle

Port Macquarie

Brisbane

Cairns

Cover photograph: Antechinus sp. (underpass 12 autumn 2019), Echidna (underpass 13B summer 2018/19).

Executive summary

Context

This report documents the findings of the 2018/2019 monitoring period, which includes the final of three monitoring periods for underpasses and associated fauna fences and the final of four monitoring periods for road kill, as specified in the Frederickton to Eungai (F2E) Ecological Monitoring Program (EMP, RMS 2016) and required by the Frederickton to Eungai (F2E) Pacific Highway Upgrade Project (the Project). Transport for NSW is required to manage and monitor the effectiveness of biodiversity mitigation measures implemented as part of the Project.

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 the fauna fence and road kill monitoring program is to determine if the purpose-built fauna fence is stopping fauna from crossing the road surface, thereby reducing road kill. The aims of this report are to summarise the methods and results of the summer 2018/2019 and autumn 2019 monitoring and determine if performance measures have been met, as per the EMP.

Methods

Seven fauna underpass structures were surveyed in summer and autumn in accordance with the monitoring method specified in the EMP, specifically:

- Two remote cameras were placed within each underpass and set to record for 60 consecutive days
- Ten hair tube traps were placed in and around each underpass for 15 consecutive nights
- Walked surveys of the fence line were conducted for a distance of 250 metres north and south of each underpass and on both sides of the carriageway
- Four weekly road kill surveys were carried out along the entire length of the Project.

Key results

Representatives from all six fauna groups identified in the EMP as fauna potentially impacted by the road, and that may benefit from/use the underpasses, were recorded using at least one underpass during 2018/2019 monitoring. Macropods, reptiles and small ground-dwelling mammals have been recorded using all underpasses. Possums and Echidnas have been detected using four of the seven underpasses and frogs have only been detected using underpass 12.

The key target species, the Brush-tailed Phascogale, has been recorded at underpass 7, 10 and 12. All seven underpasses have recorded fauna with low dispersal abilities and non-native predators have been detected at all underpasses over the three monitoring periods.

The weekly road kill rate decreased from the 2016/2017 and 2017/2018 monitoring periods, as did the number of road kill records within 500 metres of the underpasses.

Conclusions

Four of the five performance indicators of success for the underpasses and associated fauna fence have been met, including:

- Use by a range of nominated indicator species
- Use by fauna with low dispersal ability
- No breaches in the fauna fence by target species
- Low rate of fauna strike.

Use by the key target species (Brush-tailed Phascogale) has been met at two underpasses (7 and 12) during monitoring and a deceased individual was recorded in underpass 10 in May 2017. The Brush-tailed Phascogale has not been recorded using underpasses 6, 13B, 14 and 15.

Management implications

Performance indicators of success regarding the use of underpasses by a range of fauna groups have been met and contingency measures identified in the EMP are not considered relevant. However use by the key target species has not been met at all underpasses. Ongoing monitoring of underpasses for use by a range of fauna is not recommended. However, a number of problems that may impact on the efficacy of the mitigation structures were identified during the monitoring program, and as such the following recommendations have been made:

- Regular maintenance of the frog fence to control vegetation encroachments, particularly along grassy drainage channels.
- Consideration be given to further investigating the areas of frog road kill events to determine if additional frog fence is warranted.
- Undertake inspections of the area north and south of underpass 12 and within underpass 12 after heavy rainfall events to identify ongoing large frog road kill events and undertake analyses of frog specimens if a similar event is encountered in the future.
- Address all identified fauna fence maintenance issues.
- Consult with the EPA to determine if ongoing monitoring of the underpasses where the Brush-tailed Phascogale has not been recorded is required.
- Ongoing collaboration with Local land Services would be beneficial to control visitation rates by non-native predators.

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1. Introduction

1.1 Context

As part of the Frederickton to Eungai (F2E) Pacific Highway Upgrade Project (the Project), for NSW (TfNSW) have implemented an Ecological Monitoring Program in accordance with the Minister for Planning's Condition of Approval (MCoA) No. 3.1. This Ecological Monitoring Program (hereafter referred to as the EMP) (RMS 2016) combines the approval conditions provided within the Ministers Conditions of Approval (MCoA) and Statement of Commitments (SoC) 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. Fauna fences were installed to prevent fauna crossing the road surface, thereby reducing road kill and guiding animals towards safe wildlife crossing structures. The fauna underpasses, fauna fence and road kill were monitored to assess their effectiveness in reducing fauna road kill**,** as required by the EMP.

1.1.1 Monitoring framework

The EMP states the following regarding monitoring:

"It is proposed that monitoring of the fauna underpasses and associated fauna fencing be undertaken in order to provide long term insights into the mitigation effectiveness once revegetation and landscaping efforts have developed sufficient cover. Monitoring would commence when the upgrade becomes operational and be undertaken for 4 weeks during early summer 2016, late autumn and early summer in 2017 and 2018 as well as during late autumn 2019. After the conclusion of this monitoring the need for further monitoring would be reviewed in consultation with EPA".

In addition, the EMP specifies that monitoring of road kill fauna was to occur within two months of the road opening, with additional road kill surveys undertaken as part of the underpass and associated fauna fence monitoring. As the specified timing for underpass and fauna fence monitoring did not align with the road opening, a road kill survey was undertaken for the first 21 days of the Project being opened to the public, as specified in the original EMP (Lewis 2013).

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

- *Road opening 21-day road kill monitoring*: Niche 2016
- *Fauna Underpass and Associated Fauna Fence Monitoring 2016/2017*: Niche 2018a
- *Fauna Underpass and Associated Fauna Fence Monitoring 2017/2018*: Niche 2018b
- *Fauna Underpass and Associated Fauna Fence Monitoring 2018/2019*: current report.

The 2018/2019 monitoring therefore represents the final monitoring period for underpasses and associated fauna fences and road kill.

1.1.2 Baseline data

The EMP provides the following background information for the baseline data:

"The baseline data has been obtained from systematic surveys undertaken as part of the Environmental Assessment for the Kempsey to Eungai Project (Lewis 2005; Parson Brinkerhoff 2006)."

The baseline data was used to class fauna recorded at or near (less than one kilometre) underpass locations and determine which fauna underpasses were to be monitored as part of the EMP. Seven of the thirteen fauna underpasses were identified as most suitable for monitoring and the fauna groups/species recorded at these locations are shown in Table 1.

Construction monitoring of road kill was not undertaken, as such baseline road kill data is not available.

Table 1: Fauna classes previously recorded at/near monitored underpass locations (extracted from Table 3-4 of EMP)

	Underpass						
Monitoring Species/Group	**6**	**7**	**10**	**12**	**13B**	**14**	**15**
Frogs	√	√	√	√	√	√	√
Reptiles	√	√	√	√	√	√	√
Small Ground Dwelling Mammals (Antechinus, Rodents, Bandicoots)	√		√	√	√	√	√
Echidna	√		√	√	√	√	√
Possums	√	√	√	√	√	√	√
Macropods (Swamp Wallaby, Red-necked Wallaby, Eastern Grey Kangaroo)	√	√	√	√	√	√	√
Brush-tailed Phascogale*	√		√	√	√	√	√

√ = present, * = key target species.

1.1.3 Purpose of this report

This report complies with the monitoring requirements described within the EMP and details the findings of the final monitoring event for underpasses and associated fauna fences and road kill.

The aims of this report are to summarise the methods and results of the summer 2018/19 and autumn 2019 monitoring and determine if performance measures have been met, as per the EMP. As this represents the final monitoring event, in accordance with the EMP,, the need for further monitoring has been discussed.

1.2 Performance Measures

The EMP specifies the performance indicators for the underpasses and associated fauna fences, as below.

Indicators of success for the fauna underpass and associated fence monitoring includes:

- *Use of fauna underpass by a range of the nominated indicator species*
- *Use of the fauna underpass by key target species*
- *Use by fauna with low dispersal abilities*
- *Low rate of fauna road strike*
- *No breaches in the fauna fence.*

The EMP specifies that the "*degree of success of each underpass will be determined by the complete passage of one or more individuals from a range of the six fauna groups previously recorded in that area*" (Table 1).

The EMP also specifies that *"the degree of success of the floppy top fauna fencing will be determined by the absence of specific road struck fauna including Echidna, Koala, Possums (Common Brushtail, Common Ringtail) and macropods (Swamp Wallaby, Red-necked Wallaby, Eastern Grey Kangaroo) on the highway carriageway in the immediate vicinity (i.e. <500 metres) of the fauna underpasses. Where phascogale fencing has been installed, the degree of success will be based on the absence of road killed Brush-tailed Phascogale and other scansorial fauna (i.e. Antechinus). Similarly, for frog fencing, its success will be based on the absence of Green-thighed Frog fence breaches/road strike."*

1.3 Monitoring Timing

As per Lewis 2013, a 21-day road kill survey was undertaken once the road opened to traffic in 2016 (17 May 2016 to 7 June 2016 inclusive). Underpass and fauna fence monitoring (including four weekly road kill surveys) was undertaken early in the summer of 2016/2017 and 2017/2018, and late autumn of 2017 and 2018. The final surveys were undertaken in early summer 2018/2019, and in late autumn 2019.

1.4 Reporting

As per the EMP, annual reporting includes:

- A description of the monitoring methodology employed
- Results of the monitoring surveys including field data
- A discussion of the results, including how the results compare against key performance criteria
- The need for any corrective actions/contingency measures and any general recommendations.

All reports prepared under the EMP will be submitted to the NSW Department of Planning, Industry and Environment and the NSW Environment Protection Authority (EPA).

1.5 Limitations

The following limitations to the monitoring program were encountered:

- Due to their small size and cryptic nature, frogs and smaller reptiles are difficult to detect within the underpasses using the survey methods prescribed in the EMP and thus if present, may have gone undetected.
- Identification and detection of road kill was limited to what can be observed whilst travelling at 80 km/hr as it is 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.
- Safety issues prevent the removal of road kill following each survey and therefore road kill may have been recorded more than once over the four weekly surveys resulting in double-counting and 'unknown' records as the condition of the animal deteriorates.

2. Methodology

2.1 Survey Sites

The location of the seven monitored underpasses are shown in Figure 1 and are described, including targeted species, in Table 2.

Table 2: Monitored underpasses and targeted species (from Table 3-3 of the EMP)

Underpass	Type	Targeted species	Fauna fence
6	Combined drainage and fauna underpass	Brush-tailed Phascogale*	Standard and Phascogale fence
7	Fauna underpass	General species	Standard fauna fence
10	Twin Bridges over Seven Hills Road	Brush-tailed Phascogale*, Common Planigale, Green-thighed Frog	Standard, Phascogale and frog fence
12	Combined drainage and fauna underpass	Brush-tailed Phascogale*, Green-thighed Frog	Standard, Phascogale and frog fence
13B	Combined drainage and fauna underpass	Brush-tailed Phascogale*, Green-thighed Frog	Standard, Phascogale and frog fence
14	Combined drainage and fauna underpass	Brush-tailed Phascogale*, Green-thighed Frog	Standard, Phascogale and frog fence
15	Combined drainage and fauna underpass	Brush-tailed Phascogale*	Standard and Phascogale fence

* = key target species.

2.2 Survey Methods

2.2.1 Remote cameras

Two automated cameras were installed in each underpass and left operational for a minimum of 60 consecutive days. At each underpass, one camera was directed along the installed fauna furniture and one just above ground level. This maximised the chance of detecting small, medium and large fauna travelling via the ground or using fauna furniture.

2.2.2 Hair tubes and opportunistic searches

Ten hair tubes were deployed at each underpass and left for 14 consecutive nights. The hair tubes were attached to fauna furniture at different heights within the underpasses and placed in habitat adjacent to each underpass. Each hair tube was baited with a mixture of oats and peanut butter. Hair samples were sent to Barbara Triggs ('Dead Finish') for analysis and were identified to species level where possible. Opportunistic searches for scats and tracks were undertaken within each underpass during camera and hair tube deployment and retrieval.

2.2.3 Fauna fence

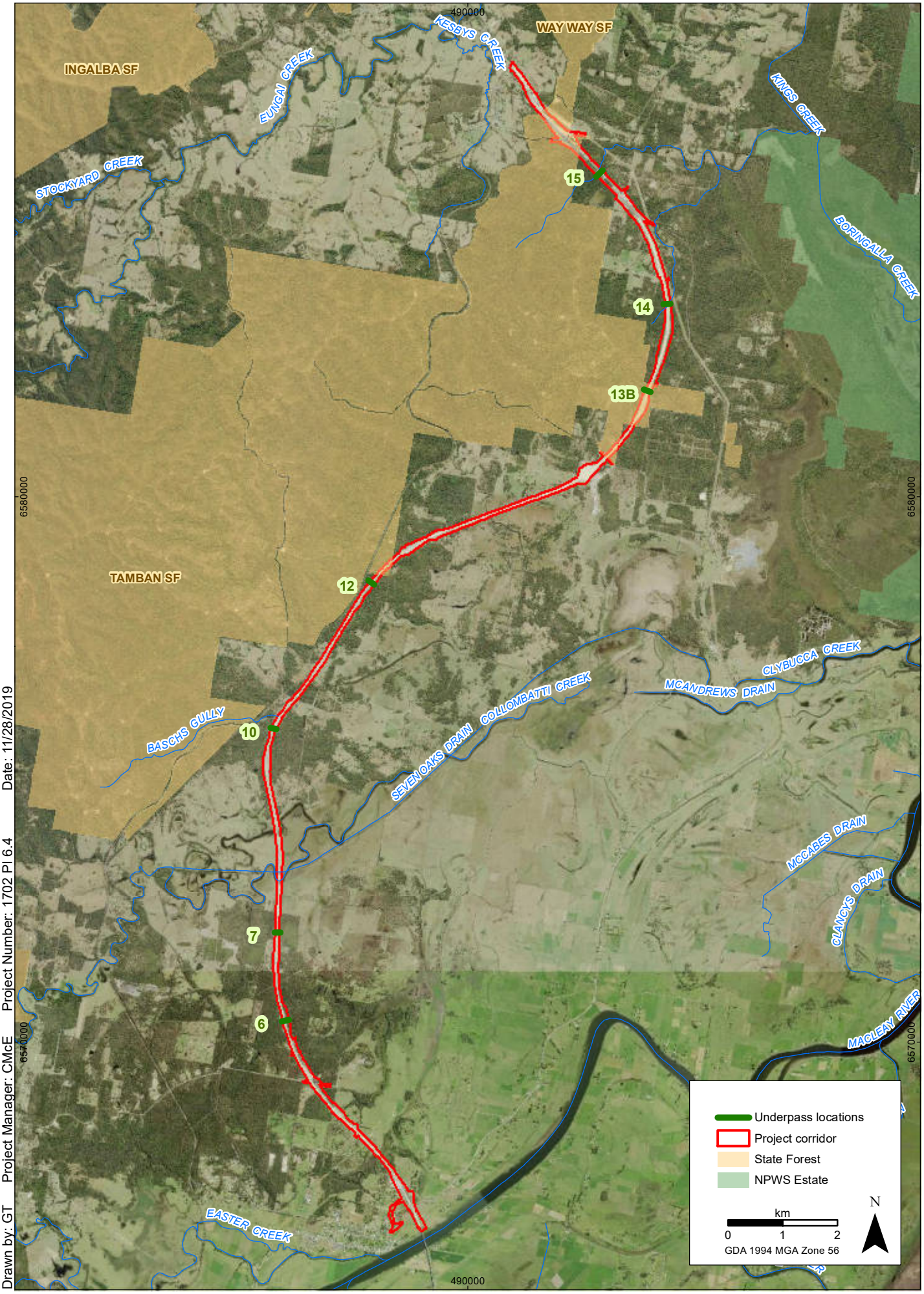
Monitoring of the fauna fence involved surveying the fence line on foot for 250 metres north and south of the underpass and on both sides of the carriageway. Breaches, damage and maintenance issues, such as impinging vegetation growth, were noted and their location recorded.

2.2.4 Road kill

Road kill surveys of the entire Project were undertaken once a week for four weeks during the summer and autumn monitoring events. These 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 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.



Drawn by: GT Project Manager: CMcE Project Number: 1702 PI 6.4 Date: 11/28/2019

Frederickton to Eungai - Underpass locations

Pacific Highway Upgrade - Frederickton to Eungai

FIGURE 1

Path: T:\spatial\projects\a1700\a1702_OH2K_Ecology\Maps\PI_6_EcolMonit_F2E\PI_64_Underpass\20190611_FaunaFence\1702_PI64_Fig1_locations_2018_2019.mxd

3. Results

3.1 2018/2019 Underpass Monitoring Results

Camera details and field data are provided in Annex 1. Results of the different survey methods have been combined to provide an overall assessment of the use of the monitored underpasses. While specific surveys to determine "*complete passage*" of individuals have not been specified in the EMP, it is considered that animals captured on remote cameras within the underpass are using the underpass to complete successful crossings.

3.1.1 Monitoring periods

The 2018/2019 monitoring periods were as follows:

- *Summer 2018/2019*: 3 December 2018 – 1 February 2019
- *Autumn 2018*: 7 March 2019 – 6 May 2019.

Hair tube, fauna fence and road kill surveys were undertaken in the first four weeks of the monitoring period. Due to survey timing, cameras were left operating beyond the minimum 60 days. Species recorded outside of the 60-day monitoring period have been included in the assessment of underpass use as value adding data.

A number of issues were encountered with the cameras during the 2018/2019 surveys, which are detailed in Table 17 and Table 18. Notably, four cameras were stolen, resulting in the loss of autumn 2019 data for underpass 13B and 14.

3.1.2 Camera fauna record summary

Table 3 provides a summary of the fauna records for the monitored underpasses. Cameras captured a total of 808 fauna records over the two monitoring periods. A proportion (0.7%) of records were unidentified, which were mostly partial and unclear images. Of those records that were identified, 48.3% were identified as native fauna. The high percentage of non-native records was primarily due to high numbers of Black Rat (*Rattus rattus*) records at underpass 6.

Table 3: 2018/2019 camera fauna record summary

Underpass	# records	# natives	# unidentified	# introduced predator	% native^	% introduced predator^
6	217	51	1	1	23.6	0.5
7	214	102	2	8	48.1	4.0
10	6	6	0	0	100.0	0.0
12	167	110	0	8	65.9	5.0
13B	78	42	0	7	53.8	9.9
14	51	30	3	0	62.5	0.0
15	75	49	0	8	65.3	11.4
TOTAL	808	390	6	32	48.6	4.2

^ = percentages represent proportion of the identified records.

3.1.3 Use of underpasses by different fauna species

Fauna groups

Representatives of all six fauna groups (Table 1) were recorded using at least one underpass during the 2018/2019 monitoring period (Table 4). The most common native species detected using underpasses included the Lace Monitor (*Varanus varius*) (133 occasions, detected in all underpasses), Brushtail Possum (*Trichosurus* spp.) (102 occasions in four underpasses) and Water Dragon (*Intellagama lesueurii*) (51 occasions, in four underpasses). While frogs were previously recorded in the vicinity of all monitored underpasses (Table 3-4 of the EMP), no frog species were recorded by cameras during the 2018/2019 surveys. This lack of detection could be attributed to the survey methods. Hair tubes, remote cameras and limited opportunistic surveys are generally not very effective at detecting small, and often cryptic, amphibian species. Of particular note, during hair tube collection in December 2018 more than 20 dead Striped Marsh frogs (*Limnodynastes peronii*) were observed in and immediately adjacent to underpass 12. This observation occurred after a significant rainfall event that instigated the large frog road kill event discussed in Section 3.4. It should be noted that cameras were functioning during this time and did not detect the frogs. The cause of death of these frogs was unclear and it is recommended that biological tissue analyses be undertaken of frog specimens if a similar event is encountered in the future.

Table 4: 2018/2019 fauna groups recorded using underpasses

	Underpass						
Monitoring Species/Group	**6**	**7**	**10**	**12**	**13B**	**14**	**15**
Frogs				Y (1)*			
Reptiles	Y (3)	Y (2)	Y (1)	Y (2)	Y (2)	Y (2)	Y (3)
Small Ground Dwelling Mammals	Y (3)	Y (2)^		Y (3)	Y (4)	Y (2)	Y (2)
Echidna		Y (1)^			Y (1)		
Possums		Y (1)		Y (2)		Y (1)	
Macropods	Y (2)	Y (1)	Y (2)	Y (1)	Y (1)	Y (1)	Y (1)
Records (# detected/# relevant)	3/6	3/4	2/6	4/6	4/6	4/6	3/6

Y = recorded, (#) = number of different species detected, ^ = not previously recorded in the vicinity and therefore not considered a relevant fauna group, as per EMP, * = observation of dead frogs within underpass during surveys.

Targeted species

Table 5 presents the records for the targeted species nominated in the EMP (Table 2) recorded at each underpass. It shows the number of targeted groups/species detected out of the number of targeted groups/species that were nominated in the EMP as relevant for each underpass. Targeted species have only been recorded at underpass 7, where *"general species"* are the target group and four of the six fauna groups were nominated as relevant, with three of the four relevant fauna groups (reptiles, possums and macropods) being recorded. Targeted species for the other underpasses include the Brush-tailed Phascogale, Common Planigale and the Green-thighed Frog. As mentioned previously, the likelihood of detecting frog species, including the Green-thighed Frog, using the survey methods prescribed in the EMP is low and the likelihood of detecting the Common Planigale at underpass 10 is also low considering the presence of roadside groundcover.

Table 5: 2018/2019 targeted species recorded

Underpass	Targeted species (as per Table 3-3 in the EMP)	Targeted fauna recorded	Records (# detected / # nominated)
6	Brush-tailed Phascogale*	No	0/1
7	General species	Three of the four target groups (reptiles, possums and macropods) plus ground dwelling mammals and the Echidna.	3/4
10	Brush-tailed Phascogale*, Common Planigale, Green-thighed Frog	No	0/3
12	Brush-tailed Phascogale*, Green-thighed Frog	No	0/2
13B	Brush-tailed Phascogale*, Green-thighed Frog	No	0/2
14	Brush-tailed Phascogale*, Green-thighed Frog	No	0/2
15	Brush-tailed Phascogale*	No	0/1

* = key target species.

Use of underpasses by non-native predators

Non-native predators including cats, dogs and foxes, were detected at five of the seven monitored underpasses (underpass 6, 7, 12, 13B and 15). Table 6 shows the non-native predators recorded using each underpass and the percentage of all identified fauna records that were non-native predators. While the Fox was not recorded during monitoring periods at underpass 7, additional monitoring undertaken by TfNSW in association with a baiting program detected the Fox at underpass 7 in November 2018. The Fox was recorded taking a bait and was subsequently not recorded again at underpass 7. The baiting program is discussed further in Section 3.2.

Table 6: 2018/2019 non-native predator records

	Underpass						
Non-native predator	**6**	**7**	**10**	**12**	**13B**	**14**	**15**
Cat (*Felis catus*)		7					3
Dog (*Canis lupus*)		1		9			1
Fox (*Vulpes vulpes)*	1	1*			7		4
% of identified records	0.5	4.0	0	5.0	9.9	0	11.4

* = recorded by Roads and Maritime as part of bating program.

3.1.4 Use of underpasses by key target species

The key target species nominated in the EMP, the Brush-tailed Phascogale, was not recorded during the 2018/2019 monitoring periods. Previously it was recorded at underpass 7 and 12 and a deceased individual was recorded in underpass 10 in May 2017.

3.1.5 Use of underpasses by fauna with low dispersal abilities

Fauna with low dispersal ability was not defined within the EMP. As such, fauna with low dispersal ability has been assumed to include animals whose dispersal ability is generally limited by their size, i.e. this would include smaller terrestrial fauna species, which have a reduced ability to disperse compared to larger, more mobile species. Fauna with low dispersal abilities has been interpreted as including individuals from four fauna groups (as per Niche 2017a): frogs, reptiles, small ground dwelling mammals and the Echidna. This definition was determined in consultation with TfNSW.

As shown in Table 4, reptiles were recorded using all underpasses, small ground dwelling mammals were recorded using all underpasses except underpass 10, the Echidna was recorded using two underpasses (7 and 13B) and frogs were only recorded within underpass 12.

3.2 Cumulative Use of Underpasses

Combined results from the 2016/2017, 2017/2018 and 2018/2019 monitoring events are presented in Table 8 and Table 9.

3.2.1 Cumulative use of underpasses by a range of species

Fauna groups

Representatives of all six fauna groups (Table 1) have been recorded using at least one underpass during the three monitoring events (Table 7). Macropods, reptiles and small ground dwelling mammals have been recorded using all underpasses on at least one occasion. Possums and Echidnas have been recorded using four of the seven underpasses and frogs have only been detected using underpass 12.

Fauna use of underpasses to date is summarised as follows:

- underpass 7, 12 and 14 have been used by five of the six fauna groups
- underpass 10, 13B and 15 have been used by four of the six fauna groups
- underpass 6 has been used by three of the six fauna groups.

Table 7: Cumulative use of underpasses by native fauna

	Underpass						
Monitoring Species/Group	**6**	**7**	**10**	**12**	**13B**	**14**	**15**
Frogs				Y (1)			
Reptiles	Y (3)	Y (2)	Y (1)	Y (2)	Y (3)	Y (2)	Y (3)
Small Ground Dwelling Mammals	Y (3)	Y (5)^	Y (1)	Y (5)	Y (4)	Y (4)	Y (5)
Echidna		Y (1)^	Y (1)		Y (1)	Y (1)	
Possums		Y (1)		Y (2)		Y (1)	Y (1)
Macropods	Y (2)	Y (1)	Y (3)	Y (1)	Y (3)	Y (1)	Y (2)
Records (# detected/# relevant)	3/6	3/4	4/6	5/6	4/6	5/6	4/6

Y = recorded, (#) = number of different species, ^ = not previously recorded in the vicinity and therefore not considered a relevant fauna group, as per the EMP.

Targeted species

Table 8 presents the records for the target species for each underpass recorded during all monitoring events. Target species have only been recorded at three of the seven underpasses (7, 10 and 12). While the EMP specifies the Brush-tailed Phascogale as a targeted species at all underpasses except underpass 7, it notes that this species is most likely at underpass 6, 10 and 12 (Table 3-4 of the EMP). The Brush-tailed Phascogale has been recorded at three different underpasses (7, 10 and 12), which accounts for two of the underpasses identified as most likely in the EMP (underpass 10 and 12). This species was also recorded at underpass 7, which is approximately 1.7 kilometres north of underpass 6. The Green-thighed Frog has not been detected at any of the underpasses

Table 8: Cumulative use by targeted species

Underpass	Targeted species (as per Table 3-3 in the EMP)	Targeted fauna recorded	# detected / # nominated
6	Brush-tailed Phascogale*	No	0/1
7	General species	Three of the four relevant fauna groups (reptiles, possums and macropods) and Brush-tailed Phascogale*	4/5
10	Brush-tailed Phascogale*, Common Planigale, Green-thighed Frog	Brush-tailed Phascogale*#	1/3
12	Brush-tailed Phascogale*, Green-thighed Frog	Brush-tailed Phascogale*	1/2
13B	Brush-tailed Phascogale*, Green-thighed Frog	No	0/2
14	Brush-tailed Phascogale*, Green-thighed Frog	No	0/2
15	Brush-tailed Phascogale	No	0/1

= deceased individual recorded during other Niche monitoring surveys (Niche 2017b), * = key target species.

Use of underpasses by non-native predators

When considering all monitoring periods, non-native predators including cats, dogs and foxes, have been detected at all of the seven monitored underpasses. Table 9 shows the non-native predators recorded using each underpass and Table 10 shows the percentage of non-native predators for each of the three monitoring periods at each underpass. At least two of the three different non-native predators have been recorded at each underpass, and all three have been recorded at underpass 6, 7 and 15.

TfNSW undertook a trial non-native predator baiting program in consultation with Local Land Services at underpass 7 in October 2018 (Niche 2018b), which extended until 31 January 2019.The baiting program resulted in one bait being taken by a Fox on 6 November 2018. Foxes were not recorded at underpass 7 during summer 2018/2019 and autumn 2019 surveys.

Table 9: Use of underpasses by non-native predators for all monitoring periods

Underpass	6			7			10			12			13B			14			15		
Monitoring period	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Cat	2			16	2	7		13		2											3
Dog	4	4		5		1		1			2	9	3	2							1
Fox			1	3		1*								5	7	1			2		4

Monitoring period 1 = 2016/2017, 2 = 2017/2108, 3 = 2018/2019, n = number of times detected, * = recorded by TfNSW as part of non-native predator baiting trial.

Table 10: Percentage use of underpasses by non-native predators for all monitoring periods

	Underpass						
Monitoring period	**6**	**7**	**10**	**12**	**13B**	**14**	**15**
2016/2017	2.5	21.8	0	1.5	3.8	2.6	3.2
2017/2018	2.6	1.3	51.9	1.3	10.3	0	0
2018/2019	0.5	4.0	0	5.0	9.9	0	11.4

3.2.2 Cumulative use of underpasses by key target species

The key target species nominated in the EMP, the Brush-tailed Phascogale, has been recorded live at two underpasses: 7 and 12. At underpass 7, it was recorded on five occasions during the autumn 2016/2017 and one occasion during summer 2016/2017. At underpass 12 it was recorded on three occasions during the autumn 2017/2018 monitoring period. An incidental record during Brush-tailed Phascogale monitoring surveys undertaken by Niche in May 2017 also noted a deceased male Brush-tailed Phascogale in underpass 10 (Niche 2017b).

3.2.3 Cumulative use of underpasses by fauna with low dispersal abilities

As mentioned above, fauna with low dispersal abilities has been interpreted as including individuals from four fauna groups (as per Niche 2017a): frogs, reptiles, small ground dwelling mammals and the Echidna.

Following the final monitoring event, as per Table 7, reptiles and small ground dwelling mammals have been recorded using all underpasses. The Echidna has been recorded using four underpasses (7, 10, 13B and 14) and frogs have been recorded using underpass 12 only.

3.3 2018/2019 Fauna Fence Inspections

Fauna fence inspection results are provided in Annex 2.

3.3.1 Maintenance

A number of maintenance issues were identified during the 2018/2019 monitoring period (Annex 2). Maintenance is required in relation to vegetation encroachments, damage to the fence by fallen trees and gaps underneath the fence caused by environmental factors such as water or erosion.

Maintenance works undertaken by TfNSW to replace the failing neoprene frog fence were completed in November 2018 (Niche 2018b), just prior to the summer 2018/2019 fence inspections in December 2018. Autumn 2019 inspections of the frog fence noted extensive vegetation encroachment of the newly installed frog fence to the extent that large areas of the frog fence would be considered to be ineffective for many frog species due to their ability to move to the tips of vegetation and traverse the fence, notably at underpass 12. Areas where vegetation encroachment was not an issue were often associated with cemented drainage and cleared areas.

3.3.2 Fence breaches

No signs of possible fence breaches (evident passage by fauna) were recorded during 2018/2019 fence monitoring. 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 any breaches from occurring.

During summer road kill surveys a frog road kill event was recorded in the vicinity of underpass 12, where frog fence is installed and previous frog road kill events have been recorded (Niche 2018b). This road kill event is discussed in detail in Section 3.4.

3.4 2018/2019 Road Kill

Road kill results are provided in Annex 3 and Figure 2 shows the distribution of 2018/2019 road kill records. A total of 13,600 metres (51.3%) of the 26,520 metres of the Project is fenced with a minimum of standard fauna fence (data provided by Roads and Maritime).

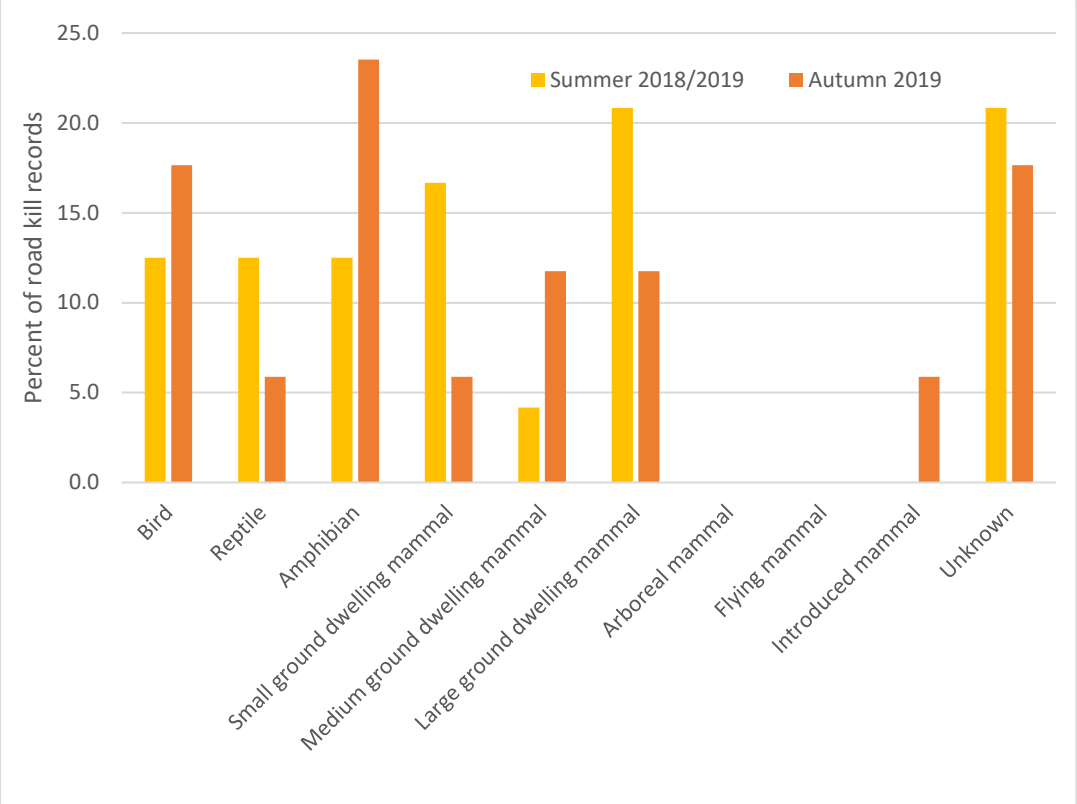
Fauna categories for analysis were defined as follows:

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

3.4.1 Entire alignment

There were a total of 24 and 17 road kill records in summer 2018/2019 and autumn 2019, respectively. The percentage of road kill records for each category for the current monitoring period is presented in Graph 1. When both seasons were grouped, unknown (19.5% of road kill, n = 8), large ground dwelling mammals (kangaroos and wallabies) and amphibians (both 17.1% of road kill, n = 7), and birds (14.9%, n = 6) were the most commonly recorded fauna groups.

It should be noted that the seven amphibian records represent large numbers of road kill individuals. The amphibian road kill recorded in summer 2018 road kill surveys, carried out after a period of heavy rain, included large numbers (over 200) of Striped Marsh Frogs that could not be counted accurately from the vehicle. The location of this frog road kill event is shown in Figure 2a and occurred both south and north of underpass 12 over a distance of approximately five kilometres, within and beyond the extent of the frog fence that is installed at underpass 12 (which extends 250 metres north and south of the underpass). The density of dead frogs varied over the five kilometres. It is important to note that it appeared that not all dead frogs were due to vehicle impact, and that a large number of the dead frogs were within three metres of the road verge and had not made it as far as the carriageway prior to their death. However, as for those frogs observed in and around underpass 12, the cause of death was not clear. This event occurred at approximately the same location as previous frog road kill events, which is discussed in more detail in Section 3.5.



Graph 1: 2018/2019 road kill records

3.4.2 Road kill distribution

Considering the distribution of 2018/2019 road kill records (excluding birds) shown in Figure 2, there are a number of areas where road kill appears to be concentrated; notably in unfenced areas between underpass 12 and 13B and within fenced areas between underpass 10 and 12. These areas are discussed in more detail in Section 3.5.

3.4.3 Location of road kill in relation to fencing

An analysis of the number of road kill events that occurred within and outside of fenced sections of the Project was undertaken. Bird mortalities were excluded from this analysis due to the fact that their occurrence would not be influenced by the presence of the fence. For the analysis, road kill observations made at the edge of a fenced area were considered to be to be outside. The results revealed that 16 (45.7%) records were within and 19 (54.3%) records were outside fenced areas. Considering these data with regard to fencing along the highway, calculation of a *road kill per kilometre* rate found the rate of road kill in unfenced areas (12.92 kilometres; 1.5 records/kilometre) to be slightly higher than the rate in fenced areas (13.60 kilometres; 1.2 records/kilometre).

3.4.4 Road kill within 500 metres of underpasses

As per the EMP, success of the fauna fence is to be determined by "*the absence of specific road struck fauna including Echidna, Koala, Possums (Common Brushtail, Common Ringtail) and macropods (Swamp Wallaby, Red-necked Wallaby, Eastern Grey Kangaroo) on the highway carriageway in the immediate vicinity (i.e. <500 metres) of the fauna underpasses. Where phascogale fencing has been installed, the degree of success will be based on the absence of road killed Brush-tailed Phascogale and other scansorial fauna (i.e. Antechinus). Similarly, for frog fencing, its success will be based on the absence of Green-thighed Frog fence breaches/road strike.*"

Road kill records within 500 metres of the underpasses are provided in Table 11 and shown in Figure 3. Excluding birds, there were six road kill records that occurred within 500 metres of underpasses 6, 10, 13B and 15. There were no road kill records within 500 metres of underpasses 7 and 14.

Results of road kill in relation to fauna-specific fences and specific road struck fauna are as follows:

- Standard floppy top fence: There were no road kill records of Koalas or possums within 500 metres of underpasses. Two road kill records including an Echidna and Macropod were recorded within 500 metres of underpass 10 and underpass 6, respectively.
- Phascogale fence: No Brush-tailed Phascogales were recorded as road kill during the current surveys.
- Frog fence: A large number of frog road kill occurred both south and north of underpass 12 over a distance of approximately five kilometres, within and beyond the extent of the frog fence that is installed at underpass 12 (which extends 250 metres north and south of the underpass). The density of dead frogs varied over the five kilometres. While all frogs could not be checked, the individuals that could be identified were Striped Marsh Frogs.

Table 11: Road kill recorded within approximately 500 metres of an underpass

Underpass	Date	Side of carriageway (E/W)	Animal group	Species
6	07/03/2019	E	Bird	Magpie
6	07/03/2019	W	Large ground dwelling mammal	Eastern Grey Kangaroo
10	07/03/2019	E	Medium ground dwelling mammal	Echidna
12	18/12/2018	W	Amphibian	Striped Marsh Frogs
13B	18/12/2018	E	Unknown	Unidentified
15	03/12/2018	E	Reptile	Reptile
15	10/12/2018	W	Bird	Bird
15	26/12/2018	W	Small ground dwelling mammal	Small Mammal

3.5 Comparison of Road Kill Monitoring Events

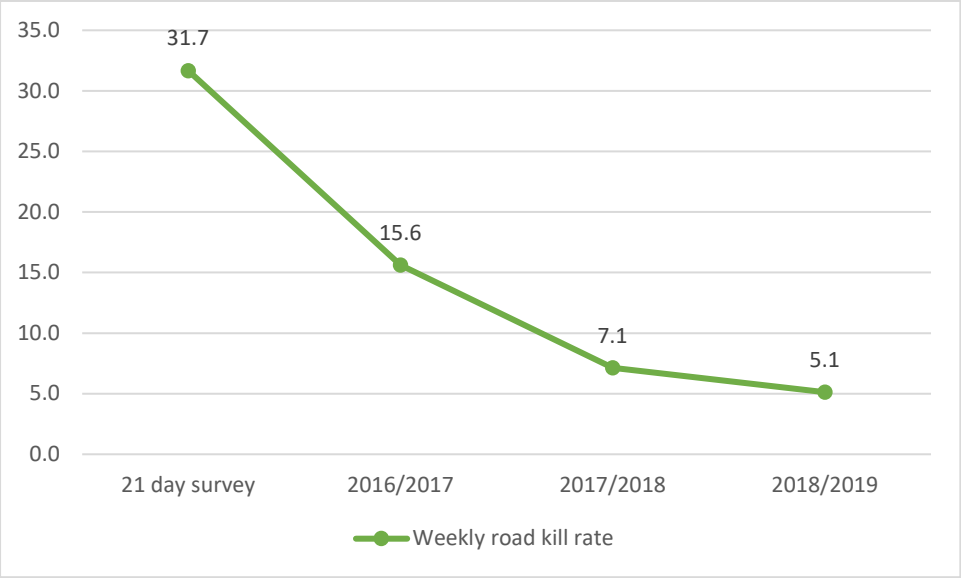
3.5.1 Entire alignment

As baseline data is not available for the Project, rates of road kill cannot be defined as low or high in comparison to the pre-existing environment. Instead, road kill records from the road opening survey (Niche 2017c) were used as an indicator of road kill levels in the area at that time. It is important to note that road kill rates are expected to be higher immediately after road opening and that these rates have been used only as a means for comparison, as opposed to as an indicator of 'usual' levels.

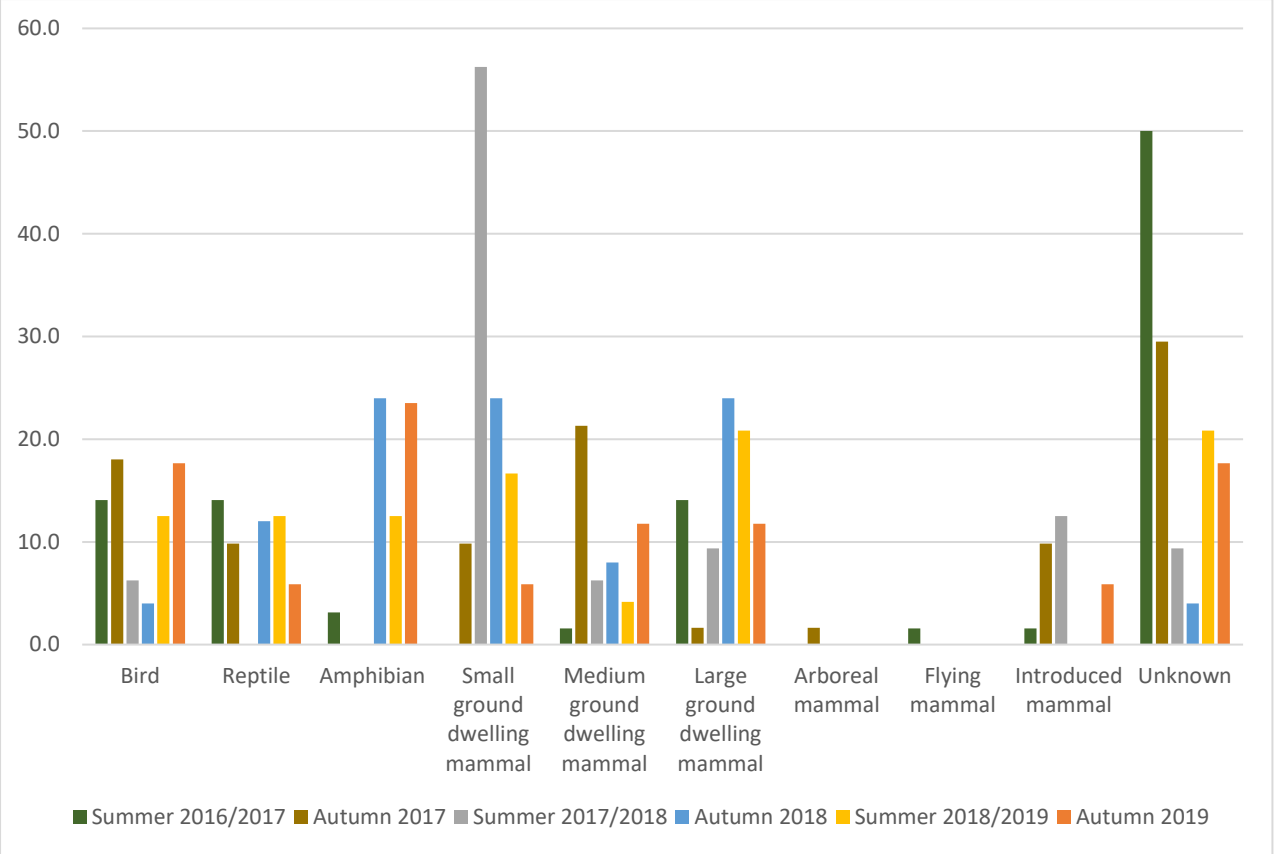
Table 12 shows the weekly road kill rate over the different monitoring periods. The data indicate an overall decline in the weekly road kill rate and in the number of road kill for 2018/2019 compared to previous monitoring events and an apparent decline between the three operational monitoring periods. Graph 2 shows the weekly road kill rate and Graph 3 shows the percentage of road kill records for each fauna group for the 2016/2017, 2017/2018 and 2018/2019 monitoring periods.

Table 12: Weekly road kill rates for all monitoring events

	21 day survey	2016/2017	2017/2018	2018/2019
Summer		16.0 (n = 64)	8.0 (n = 32)	6.0 (n = 24)
Autumn		15.3 (n = 61)	6.3 (n = 25)	4.3 (n = 17)
Total	31.8 (n = 95)	15.6 (n= 125)	7.1 (n = 57)	5.1 (n = 41)



Graph 2: Comparison of weekly road kill rates



Graph 3: Comparison of 2016/2017, 2017/2018 and 2018/2019 road kill records

3.5.2 Road kill distribution

Figure 4 shows the distribution of road kill for the three monitoring periods. Road kill incidence near underpass 6 and south of underpass 10 has reduced while road kill incidence within unfenced areas north of underpass 12 to Cooks Lane and between underpass 14 and 15 appears to be consistent. Frog road kill events have occurred in all three monitoring periods over substantial distances between underpass 12 and 13B.

3.5.3 Location of road kill in relation to fencing

The percentage of road kill and the *road kill per kilometre* rate (excluding birds) was lower within fenced areas compared to unfenced areas in all monitoring periods and has decreased each monitoring period (Table 13). The *road kill per kilometre* rate in 2018/2019 was however similar within fenced areas compared to unfenced areas.

Table 13: Road kill in fenced and unfenced areas for all monitoring events

Monitoring Period	Fenced		Unfenced	
2016/2017	33.3% (35)	2.6 records/km	66.7% (70)	5.4 records/km
2017/2018	44.0% (24)	1.8 records/km	56.0% (30)	2.3 records/km
2018/2019	45.7% (16)	1.2 records/km	54.3% (19)	1.5 records/km

(n) = number of road kill records.

3.5.4 Road kill within 500 metres of an underpass

The total number of road kill within 500 metres of an underpass for all monitoring events is shown in Table 14. There were a total of 25, 11 and six road kill records (not including birds) within 500 metres of an underpass in 2016/2017, 2017/2018 and 2018/2019 respectively. Road kill records within 500 metres of the underpass structures have therefore decreased in 2018/2019 from the previous monitoring events.

Results of road kill in relation to fauna-specific fences and specific road struck fauna are as follows:

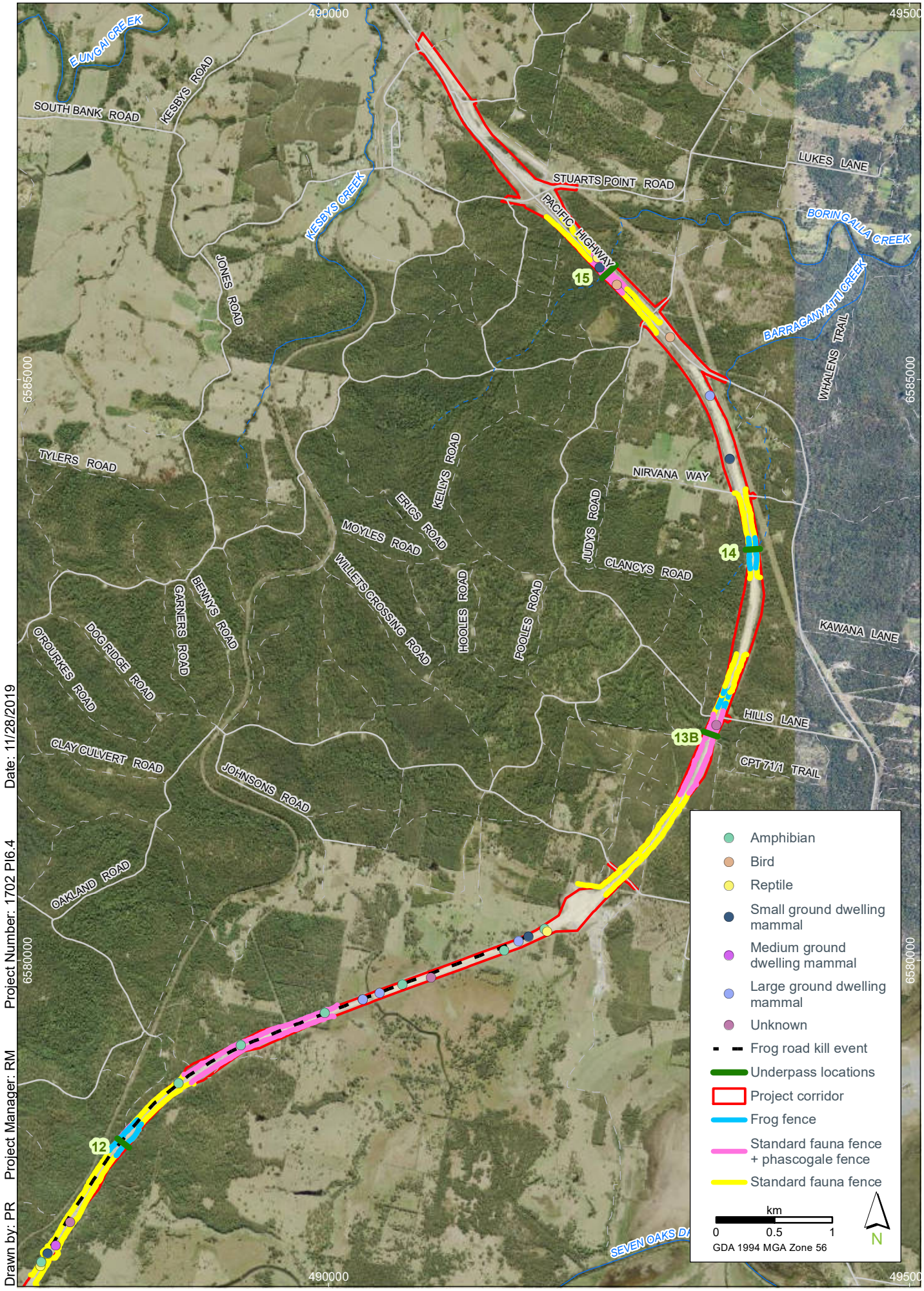
- Standard floppy top fence: There have been no road kill records of Koalas within 500 metres of an underpass. In 2016/2017 four macropods (recorded at underpass 6 and 10) and one possum (recorded at underpass 14) were recorded as road kill within 500 metres of an underpass. Only one macropod was recorded as road kill within 500 metres of an underpass in 2017/2018 (underpass 7) and 2018/2019 (underpass 6). One Echidna was recorded as road kill within 500 metres of underpass 10 in 2018/2019. Macropods, Echidnas and possums have been detected using these underpasses.
- Phascogale fence: No Brush-tailed Phascogales have been recorded as road kill in any monitoring event.
- Frog fence: No amphibian road kill events were recorded within 500 metres of an underpass during 2016/2017 surveys, however, a Dainty Green Tree Frog (*Litoria gracilenta*) road kill event was recorded in March 2018 within 500 metres of underpass 12, and a Striped Marsh Frog road kill event encompassed underpass 12 in December 2018. Frog fence is installed at underpass 12 and extends 250 metres north and south of the underpass. Frogs have been recorded using underpass 12.

A total of eight occurrences of specific road stuck fauna occurred during the three years of monitoring within 500 metres of an underpass, including six macropods, one possum and one echidna.

Table 14: Road kill records within 500 metres of an underpass for all monitoring events

	Underpass						
Monitoring Period	**6**	**7**	**10**	**12**	**13B**	**14**	**15**
2016/2017	5	6	5	4		5	
2017/2018	6	3	1	1*			
2018/2019	1		1	1^	1		2

* = large number of Dainty Green Tree Frogs, ^ = large number of Striped Marsh Frogs.



Drawn by: PR Project Manager: RM Project Number: 1702 PI6.4 Date: 11/28/2019

2018/2019 road kill records

Pacific Highway Upgrade - Frederickton to Eungai

niche Environment and Heritage

Imagery: (c) LPI NSW 2014 **FIGURE 2a**

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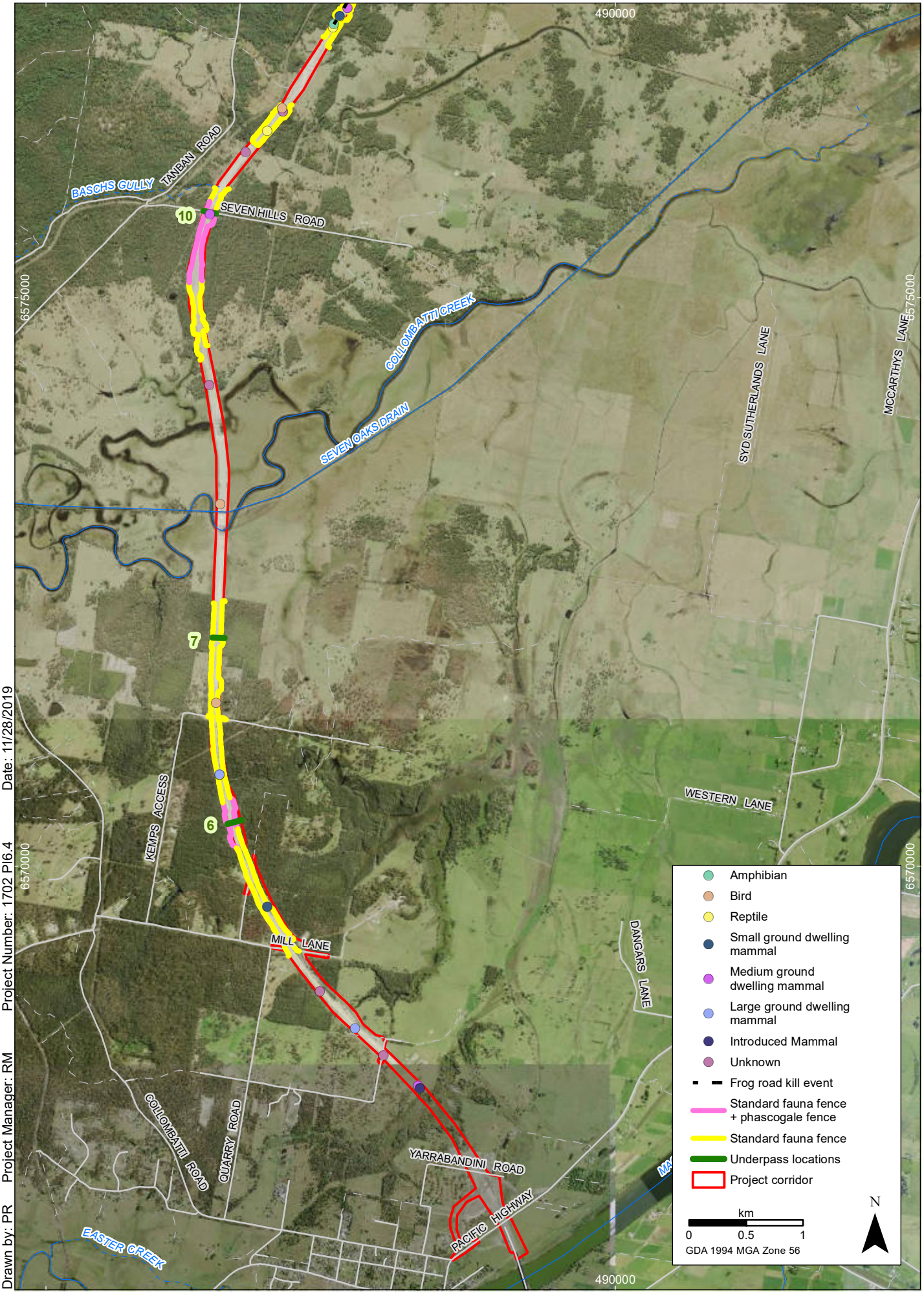

Drawn by: PR Project Manager: RM Project Number: 1702 PI6.4 Date: 11/28/2019

2018/2019 road kill records

Pacific Highway Upgrade - Frederickton to Eungai

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Imagery: (c) LPI NSW 2014 **FIGURE 2b**

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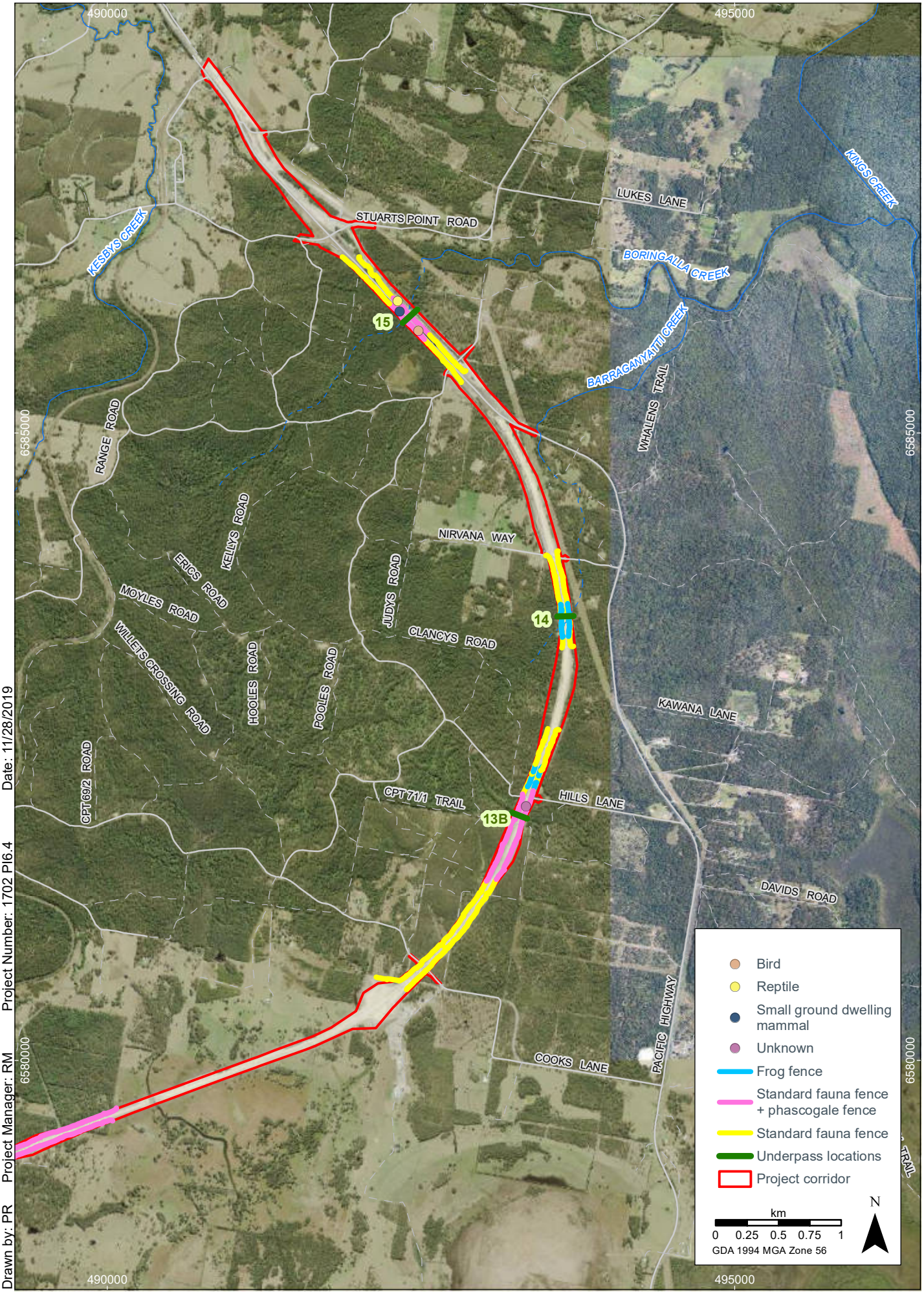

Date: 11/28/2019
Project Number: 1702 PI6.4
Project Manager: RM
Drawn by: PR

2018/2019 road kill within 500 m of underpasses

Pacific Highway Upgrade - Frederickton to Eungai

niche Environment and Heritage

Imagery: (c) LPI NSW 2014 **FIGURE 3a**

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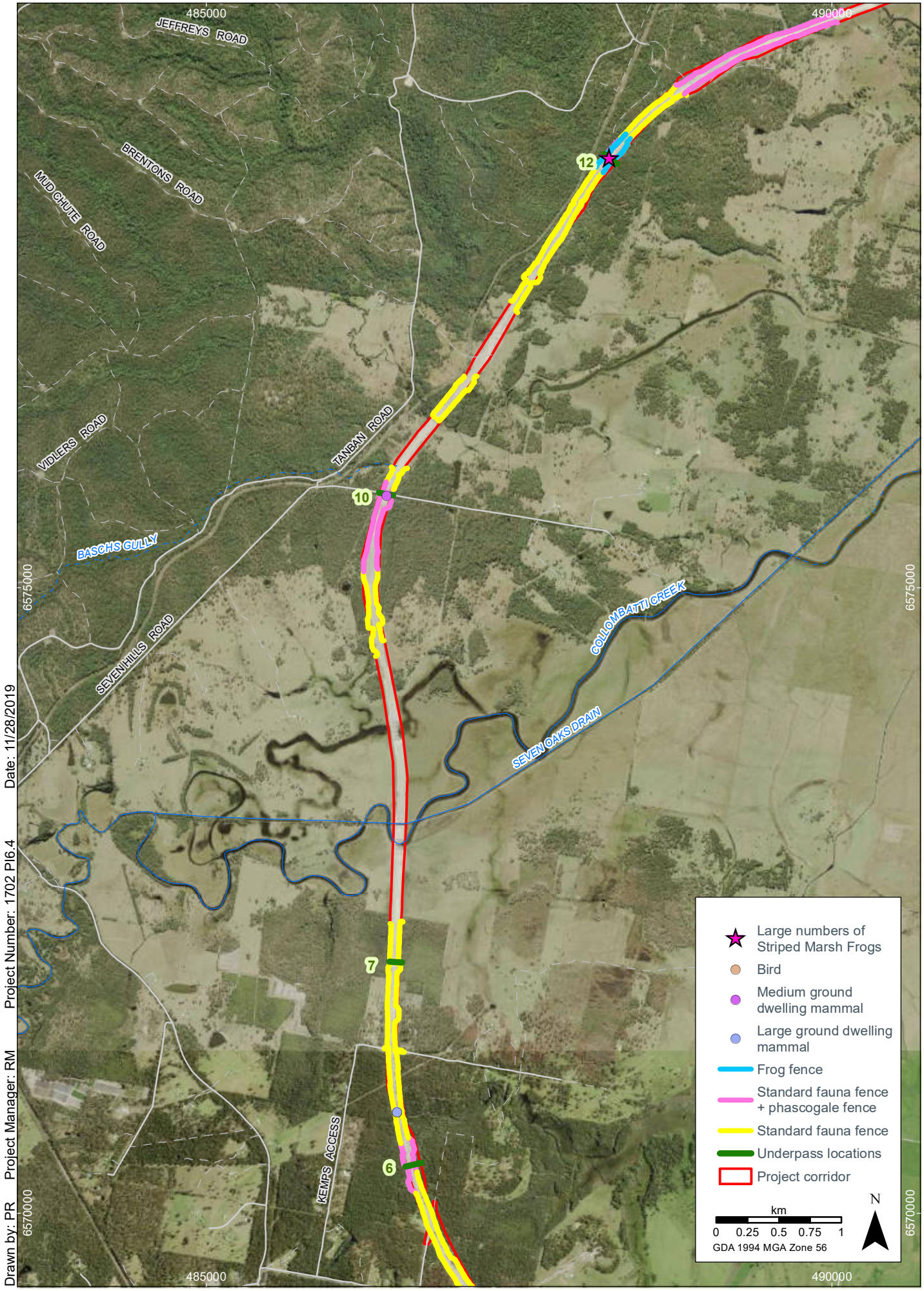

Date: 11/28/2019
Project Number: 1702 PI6.4
Project Manager: RM
Drawn by: PR

2018/2019 road kill within 500 m of underpasses

Pacific Highway Upgrade - Frederickton to Eungai

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Imagery: (c) LPI NSW 2014 **FIGURE 3b**

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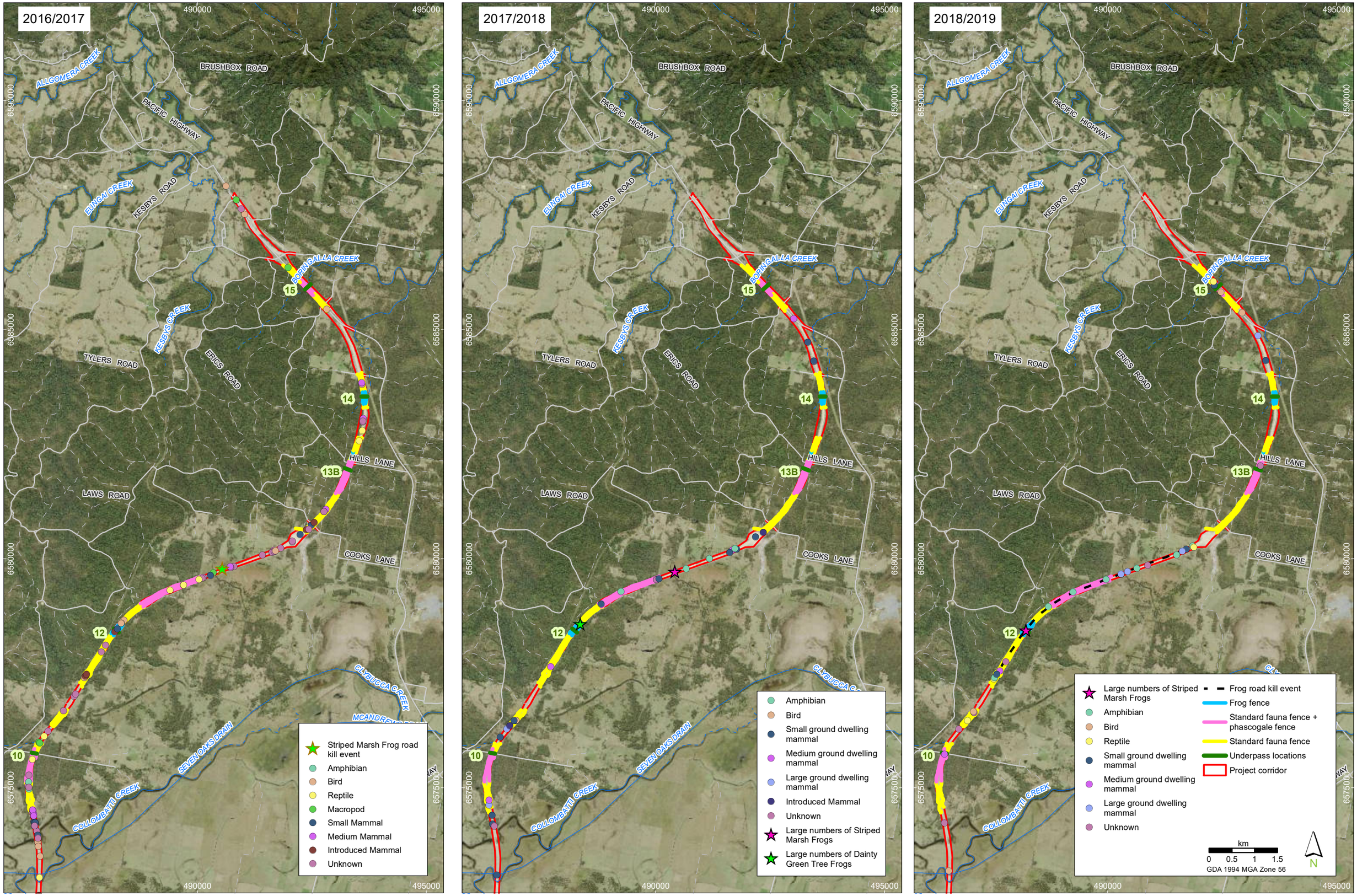
2016/2017

2017/2018

2018/2019



Comparison of 2016/2017, 2017/2018 and 2018/2019 road kill records

Pacific Highway Upgrade - Frederickton to Eungai

Drawn by: MH Project Manager: RM Project Number: 1702 Pl6.4 Date: 11/28/2019

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 FIGURE 4a

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2016/2017

2017/2018

2018/2019

490000
6575000
6570000
TANBAN ROAD
BASCHS GULLY
SEVEN HILLS ROAD
COLLOMBATTI CREEK
SEVEN OAKS DRAIN
SYDSUTHERLANDS LANE
KEMPS ACCESS
WESTERN LANE
MILL LANE
DANGARS LANE
RAYMONDS LANE
COOLLOMBATTI ROAD
QUARRY ROAD
YARRABANDINI ROAD
PACIFIC HIGHWAY
10
7
6

Amphibian
Bird
Reptile
Macropod
Small Mammal
Medium Mammal
Introduced Mammal
Unknown

Small ground dwelling mammal
Medium ground dwelling mammal
Large ground dwelling mammal

Standard fauna fence + phascogale fence
Standard fauna fence
Underpass locations
Project corridor

km
0 0.5 1
GDA 1994 MGA Zone 56
N

Drawn by: MH
Project Manager: RM
Project Number: 1702 Pl6.4
Date: 11/28/2019

Comparison of 2016/2017, 2017/2018 and 2018/2019 road kill records

Pacific Highway Upgrade - Frederickton to Eungai

Imagery: (c) LPI NSW 2014 **FIGURE 4b**

Path: T:\spatial\projects\a1700\a1702_OH2K_Ecology\Maps\PI_6_EcolMonit_F2E\PI_64_Underpass\20190611_FaunaFence\1702_PI64_Fig4b_YearComparison_2018_2019.mxd

4. Discussion

4.1 Performance Measures

A discussion of the results of all monitoring periods in relation to the performance indicators is provided in Table 15.

Table 15: Performance indicators of success

Performance indicators of success	Discussion
Use of fauna underpasses by a range of the nominated indicator species.	**This performance indicator of success has been met at all underpasses.** Each underpass has shown use by a range of the nominated fauna groups, with at least three (maximum five) of the six fauna groups being recorded at each underpass in the current monitoring period and also when considering all three monitoring periods. Three fauna groups, reptiles, small ground dwelling mammals and macropods, have been recorded using all underpasses, while the Echidna and possums have been recorded using four of the seven underpasses and frogs have been recorded only in underpass 12. Use of the underpass is assumed to imply complete passage.
Use of the fauna underpass by key target species.	**This performance indicator of success has been met at underpass 7, 10 and 12.** The key target species nominated in the EMP, the Brush-tailed Phascogale, has been recorded at two underpasses, underpass 7 (where it was not nominated as a targeted species) and 12, during the 2016/2017 and 2017/2018 monitoring periods respectively. An incidental record during Brush-tailed Phascogale monitoring surveys undertaken by Niche in May 2017 also noted a deceased male Brush-tailed Phascogale in underpass 10 (Niche 2017b). Other targeted species, the Common Planigale and Green-thighed Frog, have not been recorded using the underpasses. The likelihood of detecting the Common Planigale at underpass 10 and frog species using survey methods prescribed in the EMP is low.
Use by fauna with low dispersal ability.	Fauna with low dispersal ability has been interpreted as including individuals from four fauna groups: frogs, reptiles, small ground dwelling mammals and the Echidna. **This performance indicator of success has been met at all underpasses.** Frogs have been recorded using one underpass, however survey methods do not favour their detection. The Echidna has been recorded using four of the underpasses and reptiles and small ground dwelling mammals have been recorded at all underpasses.
Low rate of fauna road strike.	**This performance indicator of success has been met.** There has been a reduction in the weekly road kill rate from 2016/2017 and 2017/2018 to 2018/2019 surveys. The percentage of road kill and the *road kill per kilometre* rate (excluding birds) was lower within fenced areas compared to unfenced areas in all monitoring periods and has decreased each monitoring period. The *road kill per kilometre* rate in 2018/2019 was however similar within fenced areas compared to unfenced areas.
No breaches in the fauna fence.	**This performance indicator of success has been met.** There were no recorded possible breaches during 2018/2019 fauna fence surveys. However, the Dainty Tree Frog and Striped Marsh Frog road kill events occurred where frog fence is installed and in the vicinity of constructed Green-thighed Frog ponds. While no Green-thighed Frogs have been identified as road kill, it should be noted that inspecting all road kill individuals would pose a safety issue and was not therefore possible. Breaches of the frog fence in this location are considered to have occurred. However, as the EMP states that the success of the frog fencing is to be determined by the absence specifically of Green-thighed Frog road strike, this performance indicator of success has been met.

Performance indicators of success	Discussion
Additional determinants of success specified the EMP	
Absence of specific road kill fauna within 500 metres of underpasses.	**This performance indicator of success has been met for phascogale fence and frog fence.** One macropod road kill occurred within 500 metres of underpasses in 2017/2018 and 2018/2019 (underpasses 7 and 6). One Echidna road kill occurred with 500 metres of underpass 10 during 2018/2019. Four macropods and one possum road kill occurred within 500 metres of underpass 6, 10 and 14 in 2016/2017. Brush-tailed Phascogales have not been recorded as road kill. As above, despite the presence of road kill frogs within 500 metres of underpass 12, as the EMP states that the success of the frog fence is to be determined by the absence specifically of Green-thighed Frog road strike, this performance indicator of success has therefore been met for frog fence.

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 16.

Table 16: Contingency measures

Potential Problem	Contingency Measure proposed in EMP	Discussion of proposed measure
Low usage rates of native fauna	• Review/modify habitat structure adjoining the underpass	All underpasses have shown use by a range of the nominated fauna groups, with at least three of the six fauna groups being recorded at each underpass. **This contingency measure is not considered relevant.**
A range of indicator species groups not using the underpass structure	• Review/modify underpass fauna furniture or ground cover attributes adjoining the underpass. • Consider additional monitoring • Consult with EPA	All underpasses have been successfully used by a range of fauna groups and nominated species (Table 7). Whilst there are some species/groups missing from certain underpasses they have all been detected using at least one underpass structure. Frogs have been recorded at a single underpass (12) and the key target species has been recorded at three underpasses (7, 10 and 12). **These contingency measures are not considered relevant.**
High visitation/usage rates by exotic predators	• Review/modify design. Seek advice from LHPA concerning control methods.	While "High visitation/usage rates" was not defined in the EMP, high usage rates has been considered as where visitation by exotic predators equates to greater than 25% of visitations to the underpass or as visitations by exotic predators on more than 25% of the days monitored. This is based on previous underpass monitoring outcomes (Sandpiper Ecological 2015, Sandpiper Ecological 2017) and in consultation with North Coast Local Land Services (Biosecurity Manager). The highest use by exotic predators was recorded at underpass 10 (51.9% of records including cats and dogs) in 2017/2018 and at underpass 7 (25% of records in autumn) in 2016/2017. Baiting was undertaken by Roads and Maritime at underpass 7 in 2018/2019, which resulted in the removal of one Fox in November 2018. Foxes were not detected at underpass 7 during summer 2018/2019 and autumn 2019. Exotic predators were recorded using four underpasses in 2018/2019, however visitations did not exceed 10.7% of all records. **This contingency measure is not currently considered relevant, however ongoing collaboration with Local land Services would be beneficial.**
Unacceptable rates of road strike in the vicinity of the underpasses (<250m) [sic]	• Review/modify fauna exclusion fencing design, location or extent depending on road struck species.	While "unacceptable rates" are not defined in the EMP, the EMP specifies that *"the degree of success of the floppy top fauna fencing will be determined by the absence of specific road struck fauna including Echidna, Koala, Possums (Common Brushtail, Common Ringtail) and macropods (Swamp Wallaby, Red-necked Wallaby, Eastern Grey Kangaroo) on the highway carriageway in the immediate vicinity (i.e. <500 metres) of the fauna underpasses. Where phascogale fencing has been installed, the degree of success will be based on the absence of road killed Brush-tailed Phascogale and other scansorial fauna*

Potential Problem	Contingency Measure proposed in EMP	Discussion of proposed measure
		(i.e. Antechinus). Similarly, for frog fencing, its success will be based on the absence of Green-thighed Frog fence breaches/road strike There have been no road kill records of Koalas, Brush-tailed Phascogale or Green-thighed Frogs or Antechinus within 500 metres of an underpass. A total of eight occurrences of specific road stuck fauna occurred during the three years of monitoring within 500 metres of an underpass, including six macropods, one possum and one echidna. **This contingency measure is therefore considered relevant for standard fauna fence as specific road kill fauna the fence is designed to exclude have been recorded within 500 metres of an underpass.** Construction monitoring of road kill was not undertaken, as such baseline road kill data is not available for comparison, against which an acceptable level of road strike might have been established. It should be noted however that there has been a reduction in the weekly road kill rate from 2016/2017 and 2017/2018 to 2018/2019 surveys.
Road strike of species which the fence is designed to exclude	• Inspect fence for breaches and inform maintenance as necessary. • Review fence design.	Road kill records within fenced areas included: • Standard fauna fence: ▪ No koala have been recorded as road kill in any monitoring event. ▪ Three macropods (Red-necked Wallaby and two Swamp Wallabies) and one possum in 2016/2017 ▪ Two Eastern Grey Kangaroos and one bandicoot in 2017/2018 ▪ Two Echidnas and one Eastern Grey Kangaroo in 2018/2019. • Phascogale fence: No Brush-tailed Phascogales have been recorded as road kill in any monitoring event. • Frog fence: Despite the presence of road kill frogs within a frog-fenced area, as the EMP states that the success of the frog fencing is to be determined by the absence specifically of Green-thighed Frog road strike, this contingency measure is not considered relevant for the frog fence. **These contingency measures considered relevant for standard fauna fence as specific road kill fauna the fence is designed to exclude have been recorded.**

5.2 Recommendations

The EMP states that "*After the conclusion of this monitoring the need for further monitoring would be reviewed in consultation with EPA*" and that "*Contingency measures, including additional monitoring may be required in the event the monitoring data suggests a fauna underpass is ineffective and modification/treatments are required.*"

Performance indicators of success regarding the use of underpasses by a range of fauna groups have been met and contingency measures identified in the EMP are not considered relevant, however use by the key target species has not been met at all underpasses. In addition, records of specific road struck fauna within 500 metres of an underpass and of fauna the fences are designed to exclude have occurred. As specified in the EMP, the need for ongoing monitoring is to be reviewed in consultation with EPA. Recommendations are addressed in Table 17.

Table 17: Recommendations

Problem identified	Discussion/Recommendations and actions
Large numbers of road kill/dead frogs in the vicinity of underpass 12 where frog fencing is installed.	• Regular maintenance of frog fencing to control vegetation encroachments, particularly grassy drainage channels. • Undertake inspections of the area north and south of underpass 12 and within underpass 12 after heavy rainfall events to identify whether frog kill events reoccur. If a similar event is encountered in the future, where safe to do so, collect frog specimens in effort to determine cause of death.

Road strike of species the fauna fence is designed to exclude and road kill within 500 metres of underpasses.	• Address all identified fauna fence maintenance issues.
	• In relation to the specific road struck fauna:
	  ○ Macropods: General fence maintenance.
	  ○ Possums: Remove encroaching and overhanging vegetation/branches that may provide passage over the fence.
	  ○ Possums and Echidnas: Secure attachment points and eliminate gaps under fences around rocky areas and where erosion has or may occur.

Lack of evidence of use by frog species.	• The likelihood of detecting the Green-thighed Frog and other amphibians using survey methods prescribed in the EMP is low. In order to determine use of underpasses by amphibians, alternative survey methods would be required, such as frog surveys during/following suitable weather conditions. • Consider alternative survey methods in future fauna underpass monitoring programs.
Lack of evidence of use by key target species at all underpasses (Brush-tailed Phascogale)	• Brush-tailed Phascogales have demonstrated use of two of the three underpasses noted in the EMP as being most likely to be used by this species. It has also been recorded in underpass 7, 1.7 kilometres north of the underpass 6, also noted in the EMP as being most likely to be used by this species. Given the demonstrated use of these three underpasses, it is considered likely that if present, this species would make use of the underpasses. However use of all relevant underpasses has not been demonstrated for this key target species.
High visitation/usage rates by exotic predators	• Baiting was undertaken by Roads and Maritime at underpass 7 in 2018/2019, which resulted in the removal of one Fox in November 2018. While visitations did not exceed 10.7% of all records ongoing collaboration with Local Land Services would be beneficial.

6. References

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Annex 1 – Fauna underpass data

Table 18: Summer 2018/2019 camera details

Site	Camera	Operating for entire period	Total # photos	Install date	Retrieve date	operational days	Location (top/bottom)	Direction facing (E/W)	# of fauna records	Note
6	399	Yes	341	03/12/2018	21/02/2019	80	Top	E	57	
6	387	Yes	141	03/12/2018	21/02/2019	80	Bottom	E	25	
7	393	Yes	592	03/12/2018	21/02/2019	80	Top	E	66	
7	410	Yes	320	03/12/2018	21/02/2019	80	Bottom	E	26	
10	390	Yes	10,194	03/12/2018	21/02/2019	80	Bottom	E	0	Camera false triggered and broken whilst deployed.
10	373	Yes	17,084	03/12/2018	21/02/2019	80	Bottom	W	0	Camera false triggered.
12	422	Yes	372	03/12/2018	21/02/2019	80	Top	E	58	
12	392	No	157	03/12/2018	21/02/2019	25	Bottom	E	42	Last photo 28/12/18 reason unknown
13B	442	Yes	147	03/12/2018	21/02/2019	80	Top	E	30	
13B	397	Yes	298	03/12/2018	21/02/2019	80	Bottom	E	48	
14	388	No	0	03/12/2018	21/02/2019	15	Bottom	E	0	Not operational for 60 days reason unknown.
14	377	Yes	140	03/12/2018	21/02/2019	80	Top	E	51	
15	426	Yes	170	03/12/2018	21/02/2019	80	Top	W	51	
15	430	Yes	38	03/12/2018	21/02/2019	80	Bottom	W	5	

Table 19: Autumn 2019 camera details

Site	Camera	Operating for entire period	Total # photos	Install date	Retrieve date	operational days	Location (top/bottom)	Direction facing (E/W)	# of fauna records	Note
6	398	Yes	621	07/03/2019	15/05/2019	67	top	E	120	
6	428	Yes	49	07/03/2019	15/05/2019	69	bottom	E	10	
7	174	Yes	324	07/03/2019	15/05/2019	69	top	w	106	
7	423	Yes	78	07/03/2019	15/05/2019	66	bottom	W	16	
10	446	No	7572	07/03/2019	15/05/2019	52	bottom	E	4	Issues with wind and grass false triggers
10	448	No	0	07/03/2019	27/3/2018	20	bottom	W	0	Malfunction, replaced 27/3/18 with 401
10	401	No	7123	27/03/2018	15/05/2019	35	bottom	S	2	Issues with wind and grass false triggers
12	400	Yes	96	07/03/2019	15/05/2019	63	bottom	E	16	
12	176	Yes	180	07/03/2019	15/05/2019	68	top	E	51	
13B	436	unknown	unknown	07/03/2019	15/05/2019	unknown	top	E	0	Stolen
13B	445	unknown	unknown	07/03/2019	15/05/2019	unknown	bottom	E	0	Stolen
14	173	unknown	unknown	07/03/2019	15/05/2019	unknown	top	E	0	Stolen
14	370	unknown	unknown	07/03/2019	15/05/2019	unknown	bottom	E	0	Stolen
15	411	Yes	34	07/03/2019	15/05/2019	60	bottom	E	5	
15	386	Yes	48	07/03/2019	15/05/2019	66	top	W	11	

Table 20: 2018/2019 remote camera records

Underpass	Underpass 6		Underpass 7		Underpass 10		Underpass 12		Underpass 13B		Underpass 14		Underpass 15	
Fauna group / Species	**summer**	**autumn**	**summer**	**autumn**	**summer**	**autumn**	**summer**	**autumn**	**summer**	**autumn**	**summer**	**autumn**	**summer**	**autumn**
Frogs														
Reptiles														
Water Dragon *(Intellagama lesueurii)*	Y (10)						Y (3)				Y (6)		Y (30)	Y (5)
Lace Monitor (*Varanus varius*)	Y (12)		Y (18)	Y (1)		Y (1)	Y (49)	Y (8)	Y (29)		Y (6)		Y (8)	Y (1)
Skink/ Land Mullet	Y (1)		Y (8)	Y (8)					Y (1)				Y (3)	
Small ground-dwelling mammals														
Rattus spp.	Y (3)	Y (1)		Y (19)			Y (1)	Y (4)	Y (8)		Y (7)		Y (2)	
Rattus rattus	Y (36)	Y (122)	Y (3)	Y (79)			Y (28)	Y (14)	Y (21)		Y (11)		Y (4)	Y (5)
Rattus fuscipes									Y (1)		Y (1)			
House mouse (*Mus musculus*)													Y (3)	
Unknown rodent/ Marsupial	Y (4)							Y (1)					Y (4)	
Antechinus spp.			Y (5)				Y (11)	Y (2)	Y (4)					
Bandicoot	Y (3)						Y (1)		Y (2)					
Northern Brown Bandicoot *(Isodon macrourus)*														
Echidna														
Echidna (*Tachyglossus aculeatus*)				Y (1)					Y (2)					
Possums														
Brushtail Possum (*Trichosurus* sp.)			Y (5)	Y (50)			Y (1)	Y (25)			Y (9)			
Common Brushtail Possum (*Trichosurus vulpecula*)				Y (4)							Y (6)			
Mountain Brushtail Possum *(Trichosurus caninus)*								Y (2)						
Macropods														

Underpass	Underpass 6		Underpass 7		Underpass 10		Underpass 12		Underpass 13B		Underpass 14		Underpass 15	
Fauna group / Species	**summer**	**autumn**	**summer**	**autumn**	**summer**	**autumn**	**summer**	**autumn**	**summer**	**autumn**	**summer**	**autumn**	**summer**	**autumn**
Swamp Wallaby (*Wallabia bicolor*)						Y (1)								
Red-necked Wallaby *(Macropus rufogriseus)*		Y (5)				Y (1)								
Eastern Grey Kangaroo *(Macropus giganteus)*	Y (1)	Y (1)	Y (1)						Y (3)				Y (1)	
Macropod	Y (8)	Y (2)				Y (3)	Y (1)				Y (2)			
Other														
Microbat		Y (4)		Y (1)			Y (3)	Y (4)						
Bird														Y (1)
Cat (*Felis catus)*			Y (1)	Y (6)										Y (3)
Wild Dog/Dingo (*Canis* spp.)				Y (1)			Y (2)	Y (7)						Y (1)
Hare (*Lepus europeaus*)														
Rabbit				Y (1)										
Fox (*Vulpes vulpes*)	Y (1)								Y (7)				Y (3)	Y (1)
Goat	Y (2)													

(n) = number of records

Table 21: 2018/2019 hair tube results

Underpass	6		7		10		12		13B		14		15	
Species	**S**	**A**	**S**	**A**	**S**	**A**	**S**	**A**	**S**	**A**	**S**	**A**	**S**	**A**
Rattus rattus	Y											Y		
Rattus sp.		Y					Y				Y	Y		
Rodent				Y										
Brushtail Possum (*Trichosurus* sp.)											Y	Y		
Swamp Wallaby (*Wallabia bicolor*)		y												

Table 22: 2018/2019 scats and tracks

Underpass	6		7		10		12		13B		14		15	
Fauna group	**S**	**A**	**S**	**A**	**S**	**A**	**S**	**A**	**S**	**A**	**S**	**A**	**S**	**A**
Possum						C					T			
Rodent		C		C		C				C	T	T		
Macropod		T										T		
Microbat	C	C, I	C	C			C, I	C, I		C		C	C	C
Reptile		C		C				C			C			I
Frog							I							
Wild Dog								T			T			
Bandicoot												T		

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

Annex 2 – Fauna fence field data

Table 23: 2018/2019 250 metre fauna fence inspections

Season	Site	Bearing	Easting	Northing	Observation/maintenance required
summer	10	SE			gap under gate with bottom wire not attached
summer	10	NE	486488	6575778	gate stuck open
summer	10	NE	486559	6575899	vegetation clearing required
summer	10	SW	486386	6575743	vegetation clearing required - long grass
summer	10	NW	486392	6575780	vegetation clearing required - sapling overgrowth
summer	10	NW	486473	6575920	tree fallen on fence
summer	7	SW	486444	6571917	vegetation on highway side encroaching on fence
summer	7	SW	486444	6571917	vegetation/grass clearing required
summer	6	SW	486604	6570358	grass clearing required immediately south
summer	6	NW	486551	6570496	erosion creating passage under the fauna fence
summer	12	SE	488063	6578147	vegetation clearing required
summer	12	SE	488086	6578213	tree fallen over fauna fence from highway side
summer	12	NE	488237	6578427	vegetation clearing required
summer	15	SE	492515	6585844	grass clearing required
summer	15	NW	492335	6585934	tree fallen on fauna fence
autumn	6	NE	486661	6570466	bottom mesh rusted away
autumn	6	NE	486660	6570507	tree fallen on fence
autumn	6	NE	486655	6570555	tree fallen on fence
autumn	6	NE	486617	6570604	gate not secured/closed
autumn	6	SW	486609	6570366	vegetation clearing required from underpass south
autumn	6	SW	486618	6570312	highway side vegetation leaning on fence
autumn	6	NW	486599	6570381	grass removal required in places
autumn	6	NW	486572	6570481	erosion creating gaps under fauna fence
autumn	12	NE			frog fence overgrown
autumn	12	SW	488180	6578431	vegetation overgrown phascogale fence south from underpass
autumn	12	SW	488151	6578402	base mesh rusted/corroding
autumn	12	SW	488132	6578384	vegetation encroaching on frog fence
autumn	12	SW	488004	6578191	sapling removal required
autumn	12	NW	488202	6578455	frog fence completely overgrown with grass
autumn	12	NW	488202	6578455	fauna fence overgrown with grass
autumn	10	SE	486462	6575724	vegetation control required
autumn	10	SE	484617	6575619	grass encroaching frog fence
autumn	10	SE	486401	6575551	patchy vegetation growth over phascogale fence
autumn	10	NE	486490	6575771	phascogale fence overgrown and gate open
autumn	10	NE	486557	6575908	vegetation control
autumn	10	SW	486386	6575740	vegetation control
autumn	10	SW	486368	6575639	frog fence overgrown

Season	Site	Bearing	Easting	Northing	Observation/maintenance required
autumn	10	NW	486430	6575838	phascogale fence overgrown
autumn	7	SW	486470	6571983	vegetation removal required from underpass - mostly highway side of fence
autumn	13	SE	493328	6581934	grass overgrowing phascogale fence
autumn	13	NE	493329	6581947	grass encroaching fauna fence
autumn	14	SE	493693	6583396	tree on fence, patchy grass encroaching on frog and phascogale fence
autumn	14	SW	493617	6583459	grass clearing required from underpass south to end of fauna fence
autumn	14	NW	493606	6583547	grass encroaching on frog fence
autumn	14	NW	493583	6583711	sapling removal required
autumn	15	NE	492466	6585927	vegetation control south
autumn	15	NE	492410	6585944	vegetation control north
autumn	15	NW	492339	6585934	tree over fence

Annex 3 – Road kill field data

Table 24: 2018/2019 road kill data

Season	Date	Latitude	Longitude	Species/vertebrate group	Animal Group
summer	03/12/2018	-31.01855	152.87394	unidentified	Unknown
summer	03/12/2018	-31.01642	152.8713	Kangaroo	Macropod
summer	03/12/2018	-30.96534	152.85794	unidentified	Unknown
summer	03/12/2018	-30.937	152.86936	Snake	Reptile
summer	03/12/2018	-30.91637	152.89841	Macropod	Macropod
summer	03/12/2018	-30.91637	152.89841	Macropod	Macropod
summer	03/12/2018	-30.91586	152.89997	Kangaroo	Macropod
summer	03/12/2018	-30.85876	152.91962	Reptile	Reptile
summer	03/12/2018	-30.93364	152.87206	unidentified	Unknown
summer	03/12/2018	-30.94364	152.86477	unidentified	Unknown
summer	03/12/2018	-30.99057	152.85855	Kookaburra	Bird
summer	03/12/2018	-31.00672	152.86321	Small Mammal	Small Mammal
summer	10/12/2018	-30.91151	152.91336	Small Mammal	Small Mammal
summer	10/12/2018	-30.86087	152.92135	Bird	Bird
summer	18/12/2018	-30.94337	152.86469	Bird	Bird
summer	18/12/2018	-30.93673	152.86945	Striped Marsh Frog	Amphibian
summer	18/12/2018	-30.91186	152.91244	Wallaby	Macropod
summer	18/12/2018	-30.91088	152.9148	Striped Marsh Frog	Amphibian
summer	18/12/2018	-30.89507	152.93031	unidentified	Unknown
summer	18/12/2018	-30.91255	152.91115	Frog	Amphibian
summer	26/12/2018	-30.87437	152.93151	Small Mammal	Small Mammal
summer	26/12/2018	-30.8595	152.9198	Small Mammal	Small Mammal
summer	26/12/2018	-30.93543	152.87073	Echidna	Medium Mammal
summer	26/12/2018	-30.94521	152.8633	Snake	Reptile
autumn	07/03/2019	-31.01345	152.86807	unidentified	Unknown
autumn	07/03/2019	-30.99624	152.85886	Magpie	Bird
autumn	07/03/2019	-30.99624	152.85886	Eastern Grey Kangaroo	Macropod
autumn	07/03/2019	-30.94688	152.86131	unidentified	Unknown
autumn	07/03/2019	-30.91466	152.90455	unidentified	Unknown
autumn	07/03/2019	-30.95178	152.85805	Echidna	Medium Mammal
autumn	07/03/2019	-31.02095	152.87707	Echidna	Medium Mammal
autumn	14/03/2019	-30.86946	152.92973	Swamp Wallaby	Macropod
autumn	14/03/2019	-30.91107	152.91504	Carpet Python	Reptile
autumn	14/03/2019	-30.92283	152.88182	Striped Marsh Frog	Amphibian
autumn	14/03/2019	-30.91988	152.88745	Striped Marsh Frog	Amphibian
autumn	14/03/2019	-30.9174	152.89501	Striped Marsh Frog	Amphibian
autumn	14/03/2019	-30.91518	152.90201	Striped Marsh Frog	Amphibian
autumn	20/03/2019	-30.93609	152.87001	Rodent	Small Mammal

Season	Date	Latitude	Longitude	Species/vertebrate group	Animal Group
autumn	20/03/2019	-31.02113	152.87728	Cat	Introduced
autumn	27/03/2019	-30.97478	152.85897	Raven	Bird
autumn	27/03/2019	-30.86495	152.92615	unidentified	Bird

Niche Environment and Heritage

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All mail correspondence should be through our Head Office