



## Woolgoolga to Ballina Pacific Highway upgrade

Roads and Maritime Services

Coastal Emu Monitoring Program  
Annual Report 2017

(Construction Phase Year 1)



## Pacific Highway Upgrade Woolgoolga to Ballina

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**Appendix B. Summary of camera trap construction phase data**

## 1. Introduction

### 1.1 Background and objectives

The upgrade of the Pacific Highway from Woolgoolga to Ballina (W2B) was approved in 2014 under the *Environmental Planning and Assessment Act, 1979* and the *Environment Protection and Biodiversity Conservation Act, 1999*. The Environmental Impact Statement reported that the project was likely to impact on the Coastal Emu (*Dromaius novaehollandiae*) listed as an endangered population under the NSW *Threatened Species Conservation Act, 1995* (now *Biodiversity Conservation Act, 2016*). Subsequently, a Coastal Emu Management Plan was prepared to meet the project Conditions of Approval.

The Management Plan outlines a set of objectives and a methodology for undertaking a monitoring program to monitor the effectiveness of mitigation measures for Emus. The program commenced prior to construction of the upgrade to gather baseline (pre-construction) data. The program will continue through the construction and early operational stages of the highway. The results of the monitoring are required to inform an adaptive mitigation strategy and thereby assist with the ongoing management of any identified impacts to emus as a result of the project.

The monitoring program aims to determine if the mitigation measures for emus have been effective in the long-term and therefore achieve the mitigation goals in the plan. The underlying objectives of the program are to:

- Further understand and monitor distribution, abundance and habitat use by emus near the road corridor.
- Identify temporal trends in the relative abundance of emus in impact and control areas during the different stages of the project to identify if the project is having a negative impact on emu presence.
- Evaluate the success of mitigation measures largely designed to allow emu's safe passage across the highway corridor (i.e. temporary and permanent crossing structures, exclusion and hybrid fences and habitat revegetation for emus).

Pre-construction monitoring was conducted between December 2013 and December 2016 and the results reported in three annual reports (Jacobs 2014; 2015; 2016). Construction of the W2B upgrade for section 4 commenced in mid-2016 and in section 3 in January 2017. The construction phase of the emu monitoring program commenced concurrently. This report outlines the methods and results of Emu population monitoring conducted during for the first year of construction and comparing these data with the pre-construction baseline.

### 1.2 Overview of the monitoring program

The Management Plan outlines an adaptive and responsive management approach, whereby information on the occupancy of emus within and adjacent to the project area will be used to inform mitigation measures and ongoing monitoring. The program is based on a BACI approach (Before, After, Control, Impact), monitoring Emu distribution and relative abundance at a set of impact and control site comparing the 3-year baseline dataset with monitoring data collected seasonally during construction and operational monitoring will continue for five years after which will be subject to performance review with possible extension to at least 7 years (RMS 2015, Section 7.2.1).

Results from the monitoring program during construction and operation would be analysed after each sampling period and annually. Regular analysis of the data is conducted to allow improvements and refinements in the survey design to be incorporated into future monitoring activities. Indicative triggers for the monitoring program are reported in the management plan and are to be reviewed and assessed with consideration of baseline data. These triggers relate to a notable decline in emu activity in the project area compared to control sites, the extent of normal decline in activity will be determined using the baseline data.

Impact sites are in the vicinity of Section 3 of the W2B upgrade. Sites have been selected to survey both forest and floodplain grazed habitats within proximity to the project corridor, and particularly east and west of proposed emu crossing zones. Control sites were selected in coastal forest and grassland habitats which resemble the impact sites and are expected to have regular emu presence. Additional observational data is collected and

stored as a register of emu sightings near the project corridor maintained during construction for both section 3 and 4 of the W2B upgrade. These data are also discussed in the annual report and used to inform management decisions.

Aspects of the pre-construction study included an experimental trial to test the effectiveness of temporary fencing for future use as road exclusion mitigation and as a means of directing emus to future crossing zones and a provision of early emu crossing areas to educate emus to cross the future highway at dedicated locations that align with the final bridge designs. It is intended to continue monitoring a subset of the emu crossing zones during construction where purpose built emu races have been provided and this would be expanded to monitoring a larger set of emu crossing structures during operation.

The management plan identifies mitigation goals for each phase of the project from pre-construction, through construction and operation. The degree to which these goals are achieved or fail is referred to as 'performance' and is measured through monitoring and implementing corrective actions where performance criteria are not met. The specific mitigation goals relevant to the coastal emu monitoring program are:

- Zero rate of traffic related emu mortality in Sections 3 and 4 of the Pacific Highway after 10 years.
- Post-mitigation occupation in the study area is similar to pre-road construction occupation after 5 years.
- Post-mitigation presence on both sides of the road is similar to pre-road construction presence.
- Zero or reduced rate of emu deaths from dog attacks in vicinity of crossing structures in Section 3 and 4 of Pacific Highway in years 1-5.

The monitoring program aims to determine if the mitigation measures for emus have been effective in the long-term and therefore achieve these mitigation goals.

## 2. Monitoring methods

### 2.1 Site occupation surveys

#### 2.1.1 Study areas

Monitoring emu occupancy was conducted at impact and control sites that focused on five study areas:

1. Pillar Valley west (PV), including land east and west of the Tucabia-Tyndale Road and portions of the Coldstream wetland, and lower catchment of Pillar Valley Creek and Black Snake Creek (project Section 3).
2. Tucabia south (MR) between Mitchell Road and Firth Heinz Road (project Section 3)
3. Tucabia north (TN) from Bostock Road to Sommervale Road and west to Pine Brush State Forest, including Champions Creek (project Section 3)
4. Yuraygir south (YS) at two locations around Diggers Camp and Minnie Waters (Control)
5. Yuraygir north (YN) at two locations around Brooms Head and Taloumbi (Control).

The intent of the sampling regime was to compare emu presence over time within each of these study areas during the different project phases rather than a comparison between areas. This was achieved by sampling between 2 and 5 transects in each study area using transects that range between 800 and 2000 metres in length. In total 24.7 km of transects were sampled from 13 impact sites and 7 control sites (Table 1). Sites were stratified to sample a range of different habitat types including pastoral land, forest, riparian and wetland areas. The location of survey transects is shown in Figures 1-5.

Table 1 : Study areas, survey sites and details of emu monitoring transects

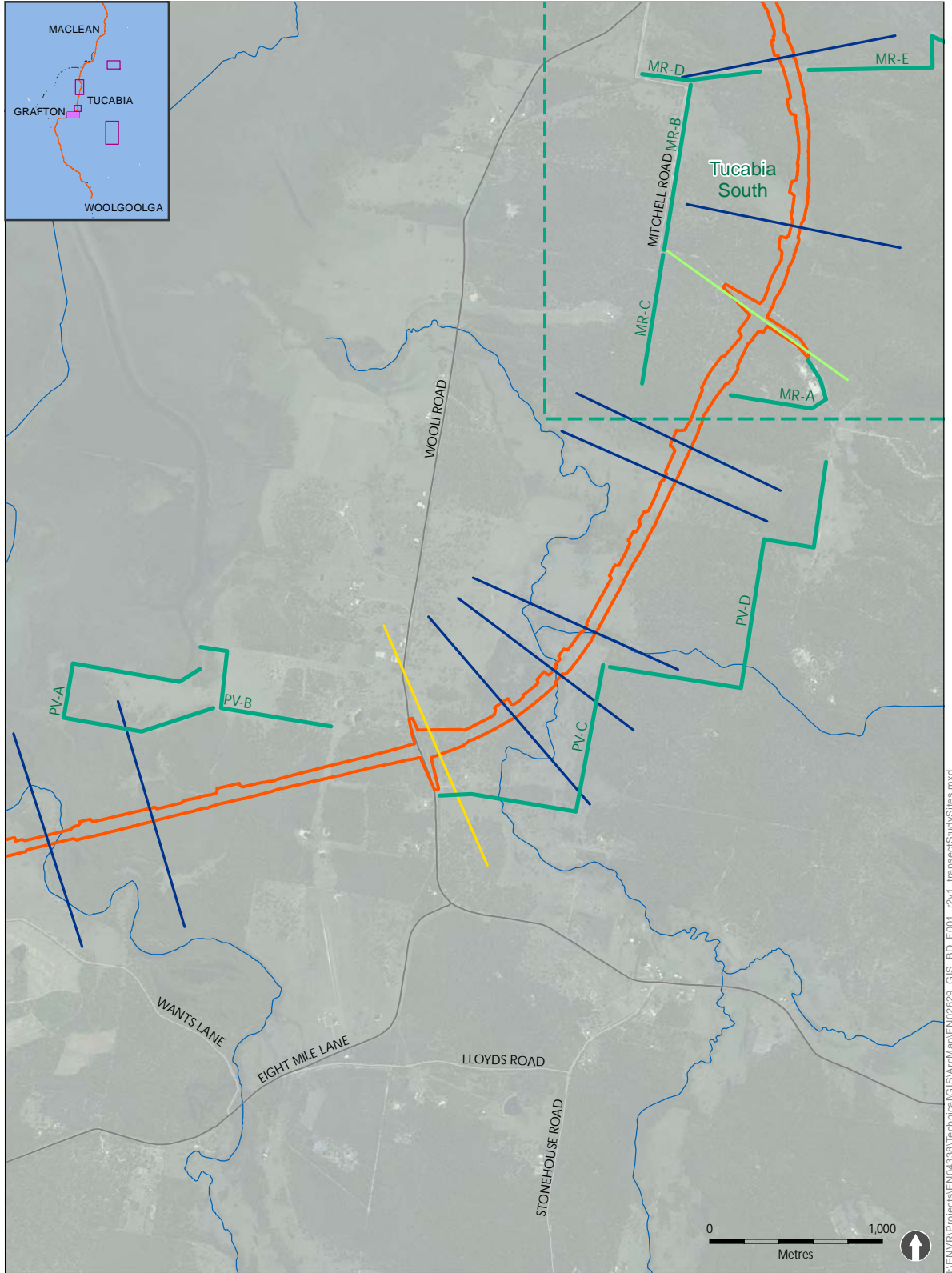
Study area	Survey site	Status	Habitat	Transect length (m)	Search area (ha) based on 10 m transect width	Position relative to future road
Pillar Valley West (PV)	PV-A	Impact	Grazing / forest	840	0.84	West
	PV-B	Impact	Grazing / wetland	1300	1.30	West
	PV-C	Impact	Grazing / forest	1655	1.65	East
	PV-D	Impact	Grazing / forest	2425	2.42	East
	<i>Total</i>			<i>6220 m</i>	<i>6.2 ha</i>	
Tucabia South (MR)	MR-A	Impact	Open forest	825	0.82	East
	MR-B	Impact	Open forest	965	0.96	West
	MR-C	Impact	open forest	755	0.75	West
	MR-D	Impact	Swamp forest	700	0.70	West
	MR-E	Impact	Open forest	1400	1.40	East
<i>Total</i>			<i>4645 m</i>	<i>4.6 ha</i>		
Tucabia North (TN)	TN-A	Impact	Open forest	2080	2.08	West
	TN-B	Impact	Grazing / wetland	645	0.64	West
	TN-C	Impact	Open forest	1365	1.36	East
	TN-D	Impact	Open forest	1200	1.20	East
<i>Total</i>			<i>5290 m</i>	<i>5.28 ha</i>		
Yuraygir South (YS)	YS-A	Control	Forest / heath	1155	1.15	-
	YS-B	Control	Forest / heath	1255	1.25	-
	YS-C	Control	Open forest	1030	1.03	-
	YS-D	Control	Open forest	730	0.73	-
	YS-E	Control	Open forest	1250	1.25	-
<i>Total</i>			<i>5420 m</i>	<i>5.4 ha</i>		
Yuraygir North (YN)	YN-A	Control	Forest / heath	1850	1.85	-
	YN-B	Control	Open forest	1270	1.27	-
<i>Total</i>			<i>3120 m</i>	<i>3.1 ha</i>		

FIGURE 1 | Yuraygir South



- Highway upgrade
- Existing Pacific Highway
- Transect

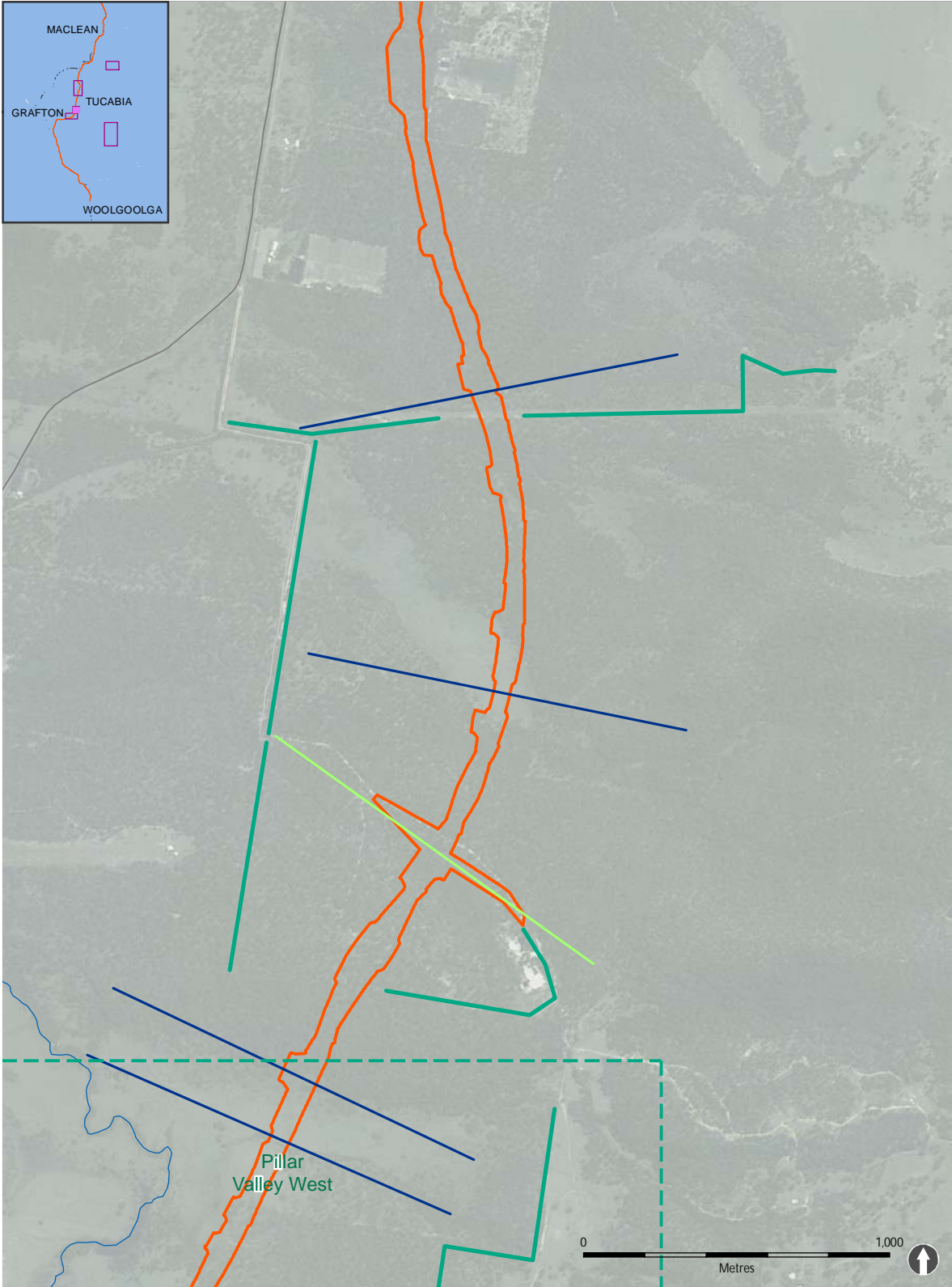
FIGURE 2 | Pillar Valley West



- |  |   |
|--|---|
|  Highway upgrade              |  Combined Emu and Bridge Structure         |
|  Existing Pacific Highway     |  Incidental Emu Structure (road overpass)  |
|  Transect                     |  Incidental Emu Structure (road underpass) |
|  Adjacent transect study site |   |

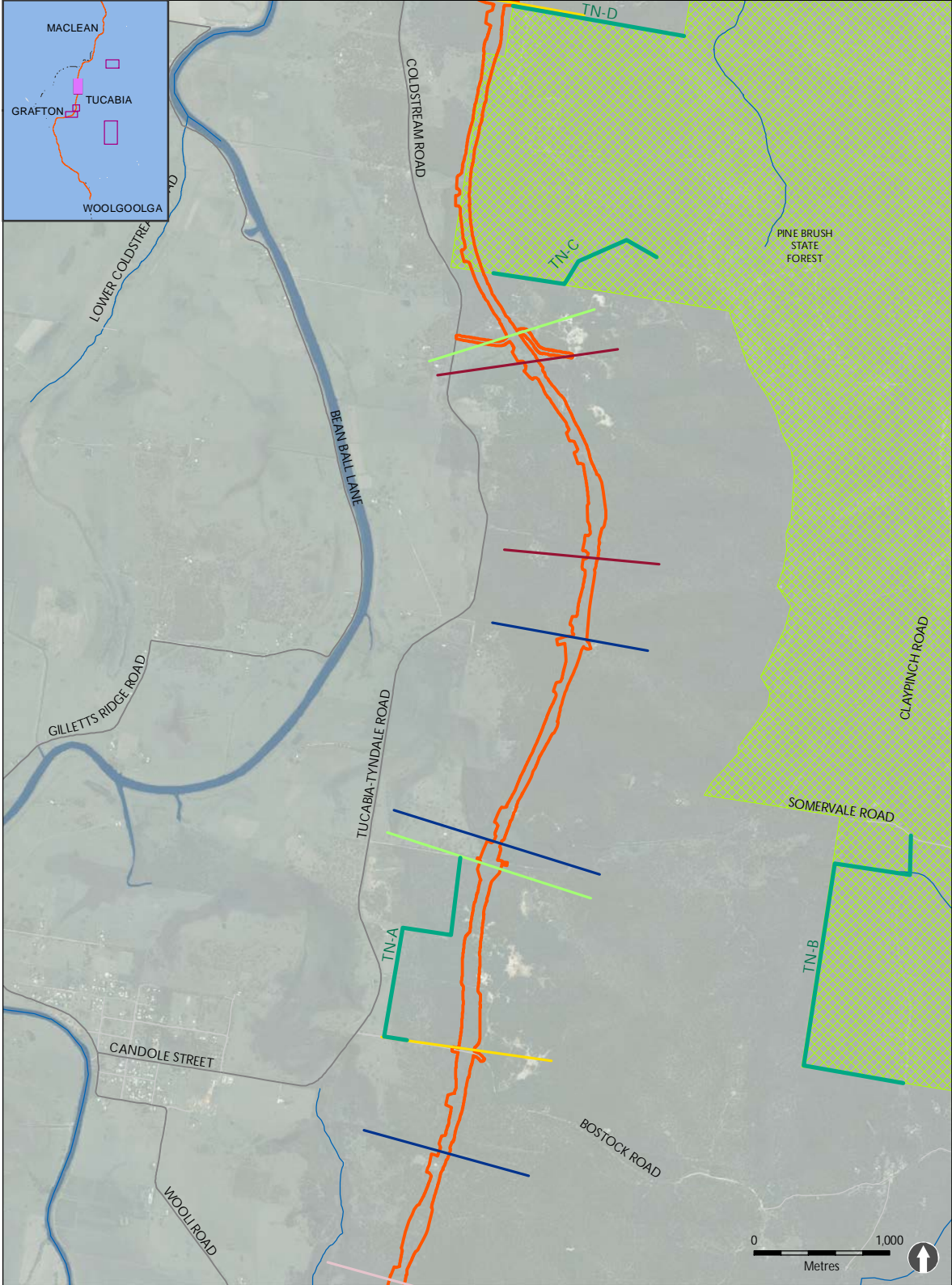


FIGURE 3 | Tucabia South



- Highway upgrade
- Existing Pacific Highway
- Transect
- Adjacent transect study site
- Combined Emu and Bridge Structure
- Incidental Emu Structure (road underpass)

FIGURE 4 | Tucabia North



- Highway upgrade
- Existing Pacific Highway
- Transect
- Combined Emu and Bridge Structure
- Combined Emu and Drainage Structure
- Dedicated Emu Structure
- Incidental Emu Structure (road overpass)
- Incidental Emu Structure (road underpass)

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FIGURE 5 | Yuraygir North



- Highway upgrade
- Existing Pacific Highway
- Transect

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### 2.1.2 Timing

Monitoring of spatial and temporal presence of emus relied on two methods centred on each transect, 1) searches for emu signs and 2) camera trapping. Sign searches and the download of photographs was conducted at four quarterly events in 2017 targeting the end of each season (i.e. February, May, August and November). In this way evidence of emu presence and captured photographs was collated for each season. Data was also collected at the end of the summer season in February 2018, this will be reported in the 2019 annual report, however data from the monitoring of emu crossing zones is included in the current report.

### 2.1.3 Sign searches

Each of the 20 transects was walked once over a week long survey period. Transects were searched throughout daylight hours (0730 to 1700) and involved a single observer walking slowly along the designated transect route and actively searching for signs of emu presence (i.e. droppings, feathers, and footprints) concentrated over a 10 m wide search area centred over the transect (refer plates 1-4 for examples of emu sign). Transects were purposefully positioned along fence lines wherever possible, as barbed wire is known to be very effective means of snagging feathers from emus passing through the fence (refer Jacobs 2014) and hence reliable method of monitoring presence at a site.

The number of signs detected was counted and then removed from each transect. For footprints this meant raking over sand and mud and for feathers and droppings removing from the transect. This was done in order to capture fresh sign over the following season and sampling period. In addition to recording signs, any actual observations of emus in the vicinity of transects during the survey week were recorded and discussions with landowners were conducted when encountered during the course of the survey week to document any observations of emus made by the property owner since the last monitoring period.

When encountered, the contents of scats were recorded and collected to be compared with reference plant material from each location to document dietary items. An updated list of plant species recorded in the diet of emus is maintained to inform the project revegetation and planting design, particular planting of emu food plants at crossing zones.



Plate 1. Example of recent emu feathers 'snagged' on barbed wire



Plate 2. Emu dropping with *Gahnia sieberiana* seed



Plate 3. Example of muddy transect where emu tracks are apparent



Plate 4. Example of sandy transect where emu tracks are apparent

#### 2.1.4 Camera trapping

The use of remote cameras aimed to supplement the sign searches by capturing information on time of confirmed presence in the study area, confirmation of multiple birds present and breeding success through recording images of juveniles. Camera trapping used fixed cameras, triggered by motion sensors, to 'trap' images of passing emus. Up to two camera traps were maintained semi-systematically along each of the transects, to provide a total of between 4-9 cameras per study area. Cameras were occasionally moved to new locations along transects during subsequent surveys if found to be unsuccessful from the preceding survey period or stolen.

Details on camera trapping effort are provided in Appendix B and summarised in Table 2. The summary data shows a comparison of the trap effort in the first year of construction with the 3-year pre-construction baseline dataset. In general, the mean number of trapping days per camera and total camera trap effort recorded during construction was comparable across each study area with the pre-construction surveys.

Traps were placed on trees at a height of approximately 1.5 metres above ground and were not baited. Cameras were set to take pictures 12 hours per day in daylight hours, with a 5 second delay between exposures to minimise repeat photographs of the same animal while allowing continuous recording to capture additional emus in the case of multiple birds or juveniles.

The date and time of each exposure were recorded and used to determine if multiple pictures were taken of the same animal to discard consecutive observations. Cameras were left in the field continuously and batteries and storage cards replaced at each survey week as discussed previously in timing. Broken and stolen cameras were replaced as required.

Table 2: Summary and comparison of camera trapping effort between baseline and Year 1 of construction

Sampling period	Survey effort	Impact			Control	
		Pillar Valley west	Tucabia south	Tucabia north	Yuraygir north	Yuraygir south
Year 1 of construction (data shown is the mean recorded over 4 quarterly monitoring sessions)	Camera monitoring period (days)	89.5	89.5	89.5	89.5	89.5
	No. successful cameras	6.0	8.8	6.5	4.0	6.8
	Mean trapping days per camera	65.7	71.8	84.1	75.1	61.7
	Total camera trap effort (days)	405.5	685.5	538.0	316.5	412.3
Pre-construction (data shown in the means recorded over 13 quarterly monitoring sessions)	Camera monitoring period (days)	90.3	90.3	90.3	90.3	90.3
	No. successful cameras	6.1	8.8	5.1	3.2	6.3
	Mean trapping days per camera	71.9	70.5	71.8	69.2	64.7
	Total camera trap effort (days)	438.5	637.8	380.6	232.6	429.5

### 2.1.5 Data analysis

We correlated trapping rates of emus with densities estimated from counts of signs made along the search transects. Two indexes of relative abundance were calculated using:

- Number of signs for each transect divided by the search area (transect length x 10 m) reported as density of emu signs per hectare.
- Camera trapping rate, defined as the ratio of emu photographs to the number of trap days multiplied by 100. This provided a comparable index of density as individual recognition of photographed emus and hence capture-recapture analysis was unfeasible. Where multiple pictures were taken of the same animal at the same time these were discarded from the trapping rate calculations. Multiple emu photos in the same frame were counted as two independent emu photos.

From the combined sign and camera trapping data we created an emu detection history at each transect consisting of binary values with '1' indicating emu detected during the sampling period and '0' indicating non-detection. We analysed the detection history to identify the proportion of impact and control sites occupied in each study area during each sampling event (i.e. site occupation rates).

Data on density of emu signs, trap and occupation rates of emus during the construction phase were compared with pre-construction baseline data at impact and control sites to identify any significant changes.

## 2.2 Emu crossing zones

A set of eight emu crossing zones were established across the construction corridor in section 3 and maintained during the first year of construction in compliance with the Emu Management Plan. These are referred to in the plan as 'emu races'. An emu race consisted of a temporary fenced passageway running perpendicular and across the width of the construction corridor for the purpose of providing emus an opportunity to cross the road corridor during construction. The objective of the races is to maintain emu connectivity across the alignment in key locations during construction. Specifically, Section 5.3.4 of the Emu Management Plan states:

*Given a potential lengthy construction period for Section 3 of the project, the Stage 2 construction phase must make available a number of options for emus to cross the corridor during construction. The objective is to maintain functional crossing zones during construction where possible.*

The emu races were reportedly closed during construction hours using temporary fencing (gates) positioned along the road boundary, to restrict emus from moving onto the construction corridor while work was being conducted. These gates were then routinely removed outside of construction hours (i.e. each evening through to early morning and every Sunday), effectively opening up the emu race. The eight emu races were aligned with the fence gaps trialled during the pre-construction phase with the exception of two sites (T7 and T8) which are not being monitored during construction (refer Table 3 for details).

Table 3. Details of emu races maintained during construction

Emu Crossing Zone	Station (Chainage)	Description / waterway / habitat	Emu race details (construction -year 1)
T1	46.055	Bridge A10 Pillar Valley Creek Bridge 1 - Floodway adjacent to Pillar Valley Creek / riparian habitat	Established 1 <sup>st</sup> Quarter 2017. Typical width 10 metres (range 2.5 m to 15 m). 4 cameras set 21.2.2017, and maintained continuously.
T2	46.325	Bridge A11 Pillar Valley Creek Bridge 2 - Pillar Valley Creek / riparian habitat	Established 2 <sup>nd</sup> Quarter 2017, typical width 12 metres (range 8 m to 16 m). 4 cameras set 23.05.2017, and maintained continuously.
T3	46.647	Bridge A12 Pillar Valley Creek Bridge 3 - Black Snake Creek / riparian habitat	No, race has been substituted with the race at 47.000. Closed during construction
T4	47.000	North of Black Snake Creek / cleared grazing land habitat	Established 1 <sup>st</sup> Quarter 2017, new race established to compensate for loss of T3 (T4A). Typical with 4 m (range 4 m to 7 m). 2 cameras set 21.02.2017 and maintained continuously.
	47.125	A54 Twin Bridge for Emu Crossing 1 - Floodway / cleared grazing land habitat	Established 3 <sup>rd</sup> Quarter 2017, typical width 3.5 m (range 1.5 m to 5 m) (T4B). 2 cameras set 21.8.2017 and maintained continuously.
T5	47.643	Bridge A13 Pillar Valley Creek Bridge 4 - Floodway / cleared grazing land habitat	Established 4 <sup>th</sup> Quarter, typical width 4 metres (range 2.5 m to 4 m), 2 cameras set 21.08.2017 and maintained continuously.
T6	47.925	Bridge A14 Pillar Valley Creek Bridge 5. Un-named creek / swamp forest habitat.	Established 1 <sup>st</sup> Quarter 2017, typical width 12 metres, 4 cameras set 21.2.2017 and maintained continuously.
T7	48.400	Emu hybrid fence trial / open forest	This temporary fence gap was developed to trial hybrid gate. The site not being used during construction
T8	48.742	Bridge A15 Twin Bridges over Mitchell Road realignment / open forest habitat	Mitchells road not monitored during construction due to heavy vehicle use. Also no temporary fencing used to direct east/west movement, may be monitored during operation
T9	49.246	Bridge A16 North of Pillar Valley Creek Bridge 1 - Floodway / cleared grazing land	Established 4 <sup>th</sup> Quarter, typical width 2.5 metres (range 1.5 m to 8 m), 2 cameras set 21.08.2017 and maintained continuously.
T10	50.280	Bridge A17 North of Pillar Valley Cree Bridge 1 - un-named creek / swamp forest habitat	Established 1 <sup>st</sup> Quarter 2017, typical width 3 metres (range 3 m to 4 m) 2cameras set 21.2.2017 and maintained continuously.

Monitoring of emu usage across each race commenced as installation of the temporary structure was completed. This involved the placement of camera traps at the eastern and western entrance of the race, consisting of between 2-4 cameras depending on the width of the race. The number and configuration of cameras at each race aimed to confirm emu usage and determine the frequency of emu passes through the race. The cameras were set for continuous operation in daylight hours between 0500 and 2000 hours and set to take still images with a trigger interval of 5 seconds in attempt to capture direction of travel and groups of emus.

During the camera checks at each quarterly survey period, the length of race was walked to search for fresh signs of emu activity (scats, tracks and feathers) to determine if emus were present but did not pass through the race or were not photographed in the event of a camera failure.

## 2.3 Emu sightings register

A register of emu sightings has been maintained since the commencement of early works in Section 4 in mid-2016 and for the first year of construction (2017) in Section 3. The register is a database for documenting sightings and observations of emus within or adjacent to the construction corridor that have been made by the constructor contractors, as well as Roads and Maritime and Pacific Complete staff. This information has three objectives:

- provides supplementary data to the monitoring program.
- informs environmental managers where additional mitigation or corrective actions may be required.
- manages potential impacts to emus that may result from a collision with construction vehicles.

Section 5.3.2 of the Management Plan states:

*Workers on site to actively note and report emu sightings daily by recording number and location of emus on map to be provided. Important to identify time and date, and number of birds including which side of the construction corridor emus sighted.*

The register was maintained manually for the majority of 2017, towards the end of the year a mobile spatial application was released by Pacific Complete as a more efficient means of collecting emu sightings data. This app will be maintained through the remainder of construction.



### 3. Results

#### 3.1 Sign searches

Each of the impact and control study areas were occupied by emus during at least one season during the first year of construction with the exception of the Yuraygir south study area, which had not been occupied in the last 18 months of the baseline monitoring period. Signs of emu presence were reported both east and west of the highway corridor during construction confirming emus have occupied habitat on either side of the road corridor in Section 3 during the initial stage of construction.

Absolute densities of emu sign during the first year of construction were lower in all three impact study areas compared with the 3-year pre-construction period (Figure 6). In particular, there was a notable decline in emu activity from sites associated with Pillar Valley Creek and the Coldstream wetlands (Pillar Valley West). A similar pattern of decline in emu activity was also noted in the control areas, with a complete absence of emus recorded in the Yuraygir south control sites during construction (Figure 7).

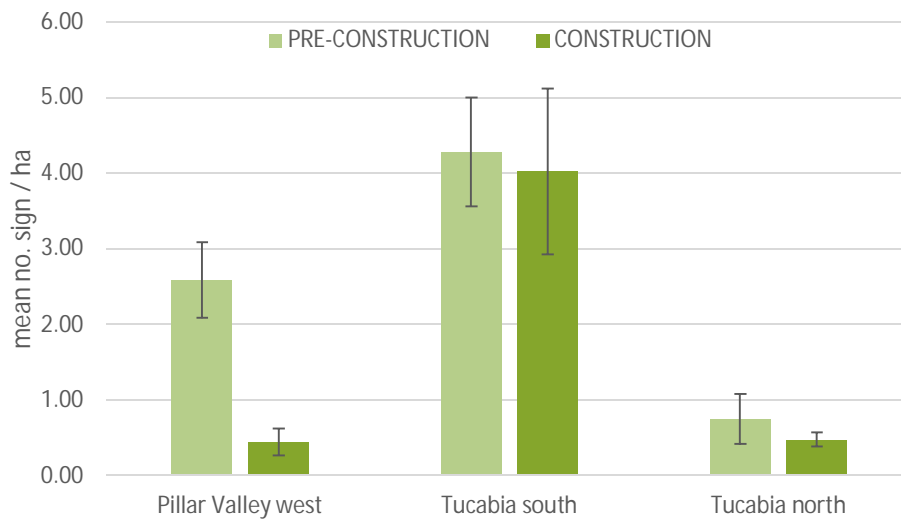


Figure 6: Mean density of emu sign (no./ ha) at impact sites comparing pre-construction (2014-16) and construction (2017)

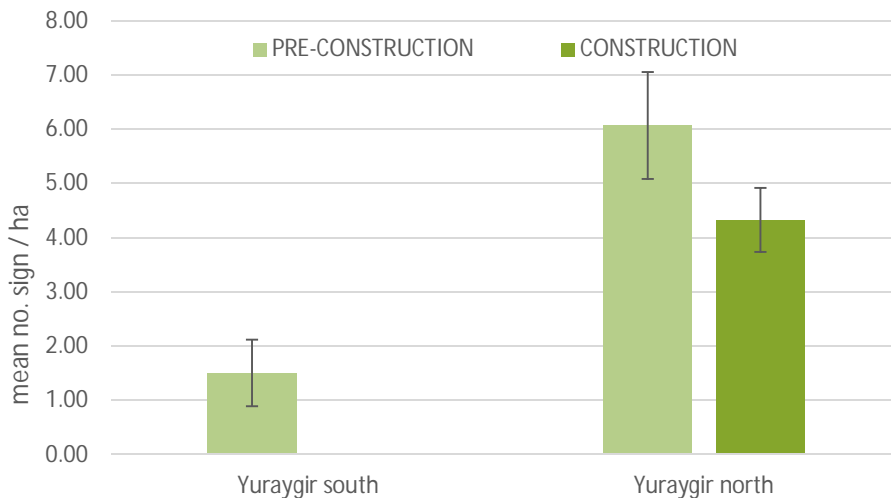


Figure 6 : Mean density of emu sign (no./ ha) at control sites comparing pre-construction (2014-16) and construction (2017)

The sign data from the first year of construction should be interpreted with consideration of the temporal patterns of emu activity observed during the pre-construction phase. The density of emu signs within each study area varied over season and years. For example, pre-construction data was collected over 3 years (2014-16) and showed the pattern in emu presence during this time was consistently lower in 2015 and 2016 across all study areas compared with the start of the monitoring program (2014). Construction data has been collected over 12 months (2017), although commenced during this period of lower emu activity compared with 2014.

The density of emu signs increased in Tucabia north and Tucabia south during the early phase of construction although remained low in Pillar Valley west consistent with the trend in decline in this study area during baseline (Table 4). A one-way ANOVA test of variance was performed on the annual density values comparing each of the four years and then comparing the pre-construction years (2014-2016) and the last two years of pre-construction with the 2017 data. These data indicate a significant decline in emu activity in the Pillar Valley West area which was first noted during the pre-construction years ( $P = 0.004$ ). There was also a significant decline between 2015-16 (pre-construction) and 2017 (year 1 construction) ( $P = 0.03$ ). These data suggest that the decline in emu activity at the Pillar Valley west study area had started prior to construction, and was consistent over the last 4 years. It is unknown whether this decline is due to a direct decline in emu abundance or a shift in activity to other nearby study areas. Indeed, the remaining impact areas showed a gradual decline and then an increase in emu activity in the first year of construction.

Table 4. Density of emu sign per ha recorded at the three impact study areas during pre-construction (2014-16 blue) and the first year of construction (2017 yellow)

Sampling period	Pillar Valley west				Tucabia south				Tucabia north			
	2014	2015	2016	2017	2014	2015	2016	2017	2014	2015	2016	2017
Summer	2.56	2.56	0.64	0.32	6.52	7.61	3.26	6.52	0.00	0.95	0.19	0.57
Autumn	3.68	0.8	1.44	0.96	9.78	5.87	1.52	4.78	0.00	0.19	0.19	0.57
Winter	3.52	2.24	1.28	0.32	5.87	3.26	2.17	3.48	3.22	0.00	0.00	0.19
Spring	6.40	1.92	-	0.16	1.74	3.48	-	1.30	1.52	0.19	-	0.57
Summer	5.60	0.96	-	-	1.96	2.61	-	-	3.22	0.00	-	-
Mean	4.35	1.70	1.12	0.44	5.17	4.57	2.32	4.02	1.59	0.27	0.13	0.48
SE	0.71	0.35	0.19	0.16	1.51	0.94	0.39	0.98	0.72	0.18	0.05	0.08

The density of emu signs declined significantly in the Yuraygir control study area, with a complete absence from early 2015 until the present time (Table 5). This is consistent with the NPWS annual citizen survey which did not record emus in the study area in 2015-2017. A few emu observations have been made in areas adjacent to the study area to the north and south suggesting either a direct decline in abundance or a shift away from the study area. There were no notable changes in density of sign from the Yuraygir north control area.

Table 5. Density of emu sign per ha recorded at the two control study areas during pre-construction (2014-16 blue) and the first year of construction (2017 yellow)

Sampling period	Yuraygir south				Yuraygir north			
	2014	2015	2016	2017	2014	2015	2016	2017
Summer	5.53	0.18	0.00	0.00	1.28	7.37	2.88	5.77
Autumn	4.42	0.00	0.00	0.00	5.13	4.81	5.13	4.49
Winter	3.87	0.00	0.00	0.00	4.81	3.85	6.73	2.88
Spring	4.61	0.00	-	0.00	11.54	5.77	-	4.17
Summer	0.92	0.00	-	-	14.74	4.81	-	-
Mean	3.87	0.04	0.00	0.00	7.50	5.32	4.91	4.33
SE	0.78	0.04	0.00	0.00	2.45	0.59	1.12	0.59

### 3.2 Camera trapping

During the first year of construction emus were photographed at 5 of the 20 transects surveyed (25 %), this is in comparison with 61.1 %, 40 % and 30 % recorded in the 3-year baseline study. Two of the impact study areas and one control study area recorded emu photographs during at least one season during the first year of construction. The exceptions were Pillar Valley west (impact) and Yuraygir south (control). Emus were photographed both east and west of the highway corridor during construction confirming emus have occupied habitat on either side of the road corridor in Section 3 during the initial stage of construction.

Mean camera trap rates per study area are shown in Figure 8, these show an overall comparison of the pre-construction data (2014-2016) with the first year of construction (2017). There were no emu photos captured at Pillar Valley west or Yuraygir south during construction and this reflects the low density of emu sign and activity in these areas. An emu was photographed in Tucabia north for the first time during construction

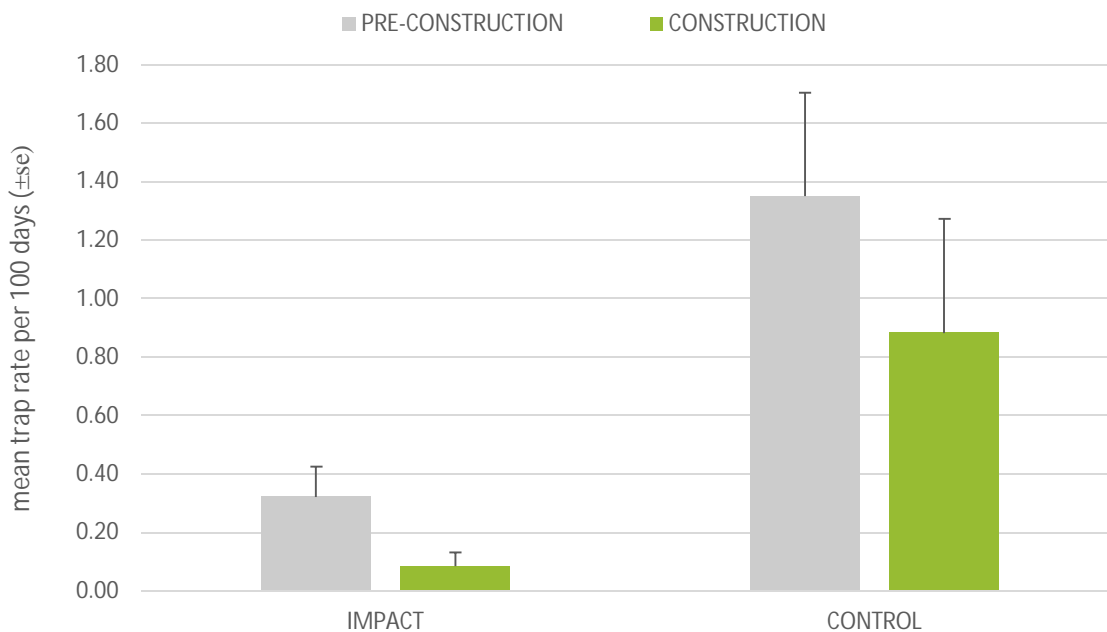


Figure 8: Mean camera trap rates (no. emus photographed per 100 trap days) at impact and control study areas for pre-construction period (2014-16) and construction period (2017)

Photographs were captured of single birds only within the impact areas while an adult male with three juveniles was photographed at the Yuraygir north control study area. It is important to note the temporal change in trapping rates between the pre-construction years (2014-2016) and the first year of construction, which vary annually. These data are presented in Tables 6 and 7 and show a decline in trap rates in the impact areas of between 36 – 80 % was recorded during the pre-construction years. This was consistent with the reported low trap rates in 2017, while the Tucabia north impact area reported a small increase.

A one-way ANOVA test of variance was performed on the annual camera trap rates comparing each of the four years and then comparing the pre-construction years (2014-2016) and the last two years of pre-construction with the 2017 data. These data indicate no significant differences in mean camera trap rates between years, with the exception of the Yuraygir south control study area where no emus have been photographed after 2014.

Table 6. Camera trap rate (no. emu photos / 100 trap days) per study area recorded at the three impact study areas during pre-construction (2014-16) and the first year of construction (2017)

Sampling period	Pillar Valley west				Tucabia south				Tucabia north			
	2014	2015	2016	2017	2014	2015	2016	2017	2014	2015	2016	2017
Summer	0.00	0.00	0.19	0.00	2.99	1.51	0.51	0.17	0.00	0.00	0.00	0.00
Autumn	0.92	0.00	0.00	0.00	0.96	0.12	0.41	0.54	0.00	0.00	0.00	0.00
Winter	1.16	0.00	0.17	0.00	0.24	0.00	0.19	0.00	0.00	0.00	0.00	0.17
Spring	0.13	0.99		0.00	0.54	0.43		0.15	0.00	0.00		0.00
Summer		0.00				0.14				0.00		
Mean	0.55	0.20	0.12	0.00	1.18	0.44	0.37	0.22	0.00	0.00	0.00	0.04
SE	0.29	0.20	0.06	0.00	0.62	0.28	0.09	0.11	0.00	0.00	0.00	0.04

Table 7. Camera trap rate (no. emu photos / 100 trap days) per study area recorded at the two control study areas during pre-construction (2014-16) and the first year of construction (2017)

Sampling period	Yuraygir south				Yuraygir north			
	2014	2015	2016	2017	2014	2015	2016	2017
Summer	1.85	0.00	0.00	0.00	1.75	1.10	0.36	1.23
Autumn	2.23	0.00	0.00	0.00	0.97	2.06	0.00	1.92
Winter	1.54	0.00	0.00	0.00	6.38	0.00	4.35	2.92
Spring	1.01	0.00		0.00	4.67	2.74		0.99
Summer		0.00				1.42		
Mean	1.66	0.00	0.00	0.00	3.44	1.46	1.57	1.77
SE	0.26	0.00	0.00	0.00	1.26	0.46	1.39	0.43

Trap rates of wild dogs were also recorded to monitor change in dog presence in emu study areas. Dogs were found to be present at all sites both during the pre-construction phase and construction phase, suggesting dogs and emus co-exist within impact and control areas. There was a large decrease in dog presence recorded at impact sites during the early phase of construction.

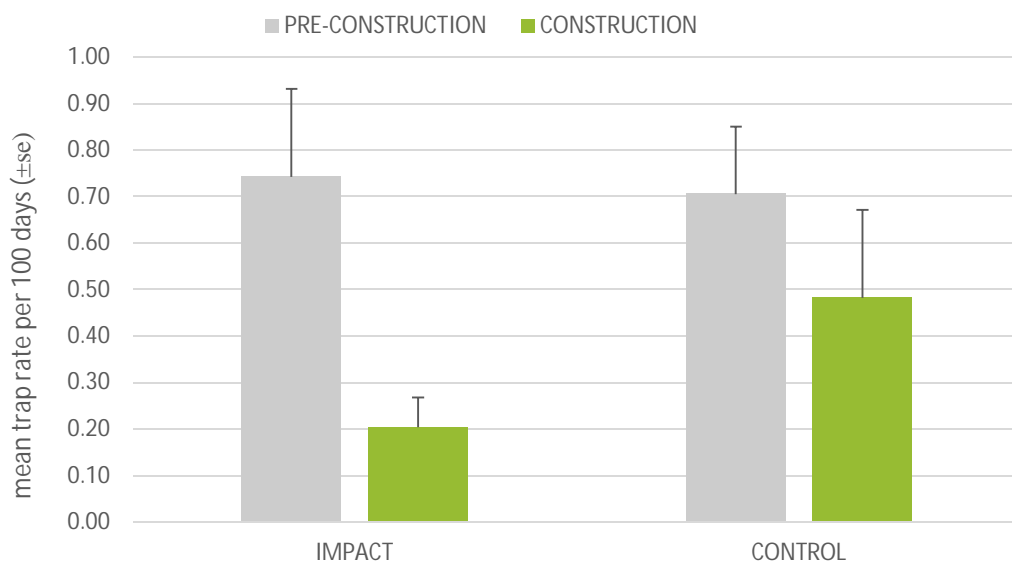


Figure 9: Mean camera trap rates (no. dogs photographed per 100 trap days) at impact and control study areas for pre-construction period (2014-16) and construction period (2017)

### 3.3 Site occupation rates

Data from the sign survey and camera trapping for each period of construction monitoring were combined to identify the proportion of sites occupied by emus within each study area for the control and impact study areas. Field data were used to develop a detection history at each survey site and for control versus impact study areas. As the home range and distance travelled by coastal emus is not well known the data analysis has relied on the assumption that separate groups occupy the impact and control study areas. For example, it is feasible for the three impact study areas that the same emus could be detected on any of the transects sampled across all three impact study areas. Therefore, for the purpose of identifying site occupation rates the impact site data was assessed as one whole study area and the two control areas were assessed as a separate study area. This is because the control areas are spatially separated from the impact area by a considerable distance and therefore a low likelihood that the same emus from the impact area would be detected in the control areas.

The number of survey sites occupied in any one survey period (occupation rate) has varied during the first year of construction ranging from 46.2 % to 61.5 % with a mean of 55.8 % ( $\pm 3.68$  se). This is compared to a pre-construction mean of 65.6 % ( $\pm 6.50$ ). Occupation rates for the control areas were the same as the last 7 surveys for the baseline data in 2015 and 2016 at 28.6 % (Table 8).

There were changes in emu occupation in the Section 3 sites during seasons with peaks in summer and winter. Further discussion on this is provided in Section 3.5 which discusses movements of emus reported from the emu register.

Table 8. Site occupancy rates recorded for Year 1 of construction (2017) from combined sign and camera trapping data (1 = site occupied, 0 = absent)

Study area	Site	Treatment	Summer	Autumn	Winter	Spring
Pillar Valley west	PVA	Impact	0	0	0	0
	PVB	Impact	0	0	0	0
	PVC	Impact	1	1	1	1
	PVD	Impact	1	1	1	1
Tucabia south	MRA	Impact	1	1	1	1
	MRB	Impact	1	1	1	1
	MRC	Impact	1	0	1	1
	MRD	Impact	1	0	1	0
	MRE	Impact	0	1	0	0
Tucabia north	TNA	Impact	1	0	0	0
	TNB	Impact	0	0	0	0
	TNC	Impact	0	1	1	0
	TND	Impact	1	1	1	1
Yuraygir north	YNA	Control	1	1	1	1
	YNB	Control	1	1	1	1
Yuraygir south	YSA	Control	0	0	0	0
	YSB	Control	0	0	0	0
	YSC	Control	0	0	0	0
	YSD	Control	0	0	0	0
	YSE	Control	0	0	0	0
<i>Occupancy rate (impact)</i>			61.5	53.8	61.5	46.2
<i>Occupancy rate (control)</i>			28.6	28.6	28.6	28.6

Figure 10 compares the mean site occupation rate for the 13 pre-construction surveys (baseline) at impact and control sites and the mean rate from the 4 construction phase surveys. These two means were compared using an independent t- test with the dependent variable being occupation rate and the independent variable being time (pre-construction and construction). For the impact sites there has been a slight decrease in around 10 % occupation of survey sites however this change is not considered significant ( $P = 0.212$ ). There has been a significant decline in the number of control sites occupied ( $P = 0.013$ ). This decline was first noted in late 2015 during the pre-construction phase, associated with the absence of emu activity in the Yuraygir south control sites.

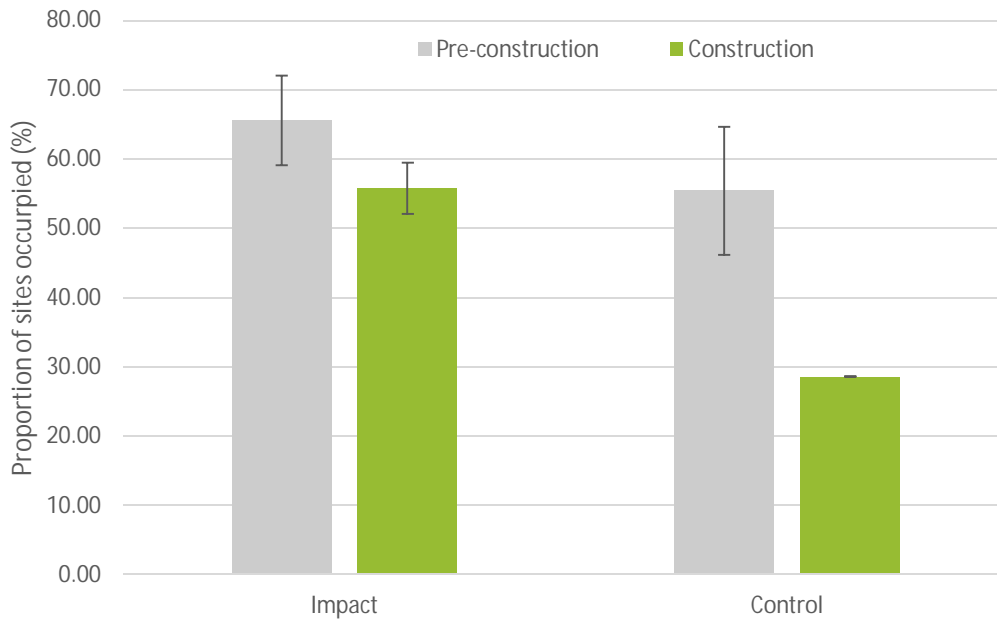


Figure 10. Mean occupation rates (±se) for impact and control sites comparing pre-construction (2014-16) with construction (2017)

Table 9 shows the change in the number of impact and control sites occupied since the start of the monitoring program and illustrates that the mean decline shown in Figure 9 is a factor of the higher occupation rates in the first year of the program commencing in 2014 through the latter two pre-construction years (2015 and 2016). The data also shows an increase in the impact sites occupied in the first year of construction (2017).

Table 9. Site occupation rates recorded seasonally at the impact and control study areas during pre-construction (2014-16) and the first year of construction (2017)

Sampling period	impact				control			
	2014	2015	2016	2017	2014	2015	2016	2017
summer	85.6	84.6	30.8	61.5	91.6	42.9	28.6	28.6
autumn	90.0	46.2	46.2	53.8	100.0	28.6	28.6	28.6
winter	90.9	38.5	46.2	61.5	100.0	28.6	28.6	28.6
spring	92.3	69.2	46.2	46.2	85.7	28.6	28.6	28.6
Mean	89.7	59.6	42.3	55.8	94.3	32.2	28.6	28.6
se	1.45	10.6	3.85	3.68	3.39	3.58	0.0	0.0

### 3.4 Monitoring emu crossing zones

The first year of construction in section 3 involved establishing the fenced emu races, these were subsequently audited, then refined and modified to make them suitable as emu crossing structures. The structures were established throughout 2017, with the majority ready by 1<sup>st</sup> and 2<sup>nd</sup> quarter and others completed by 3<sup>rd</sup> and 4<sup>th</sup> quarter of the year. All eight structures were completed by early 4<sup>th</sup> quarter.

Camera monitoring equipment was initially installed in the late summer survey period (February 2017) with further cameras set during the year as race construction was completed. Subsequently data was gathered for four monitoring periods in 2017-2018 (autumn C2, winter C3, spring C4, summer C5). A total of 48 cameras functioned during the four periods totalling in 3226 camera trapping days and 144,128 photos. Many of the photos taken were of construction vehicles and workers as well as cattle and kangaroos using the races.

One emu was photographed crossing race T4B. Other fauna found to be using the races included a dog (1 race), cattle (5 races) and kangaroos (3 races). Camera trap rates are not presented for emus because of the limited data and therefore cannot be compared with the pre-construction fence trial.

Of interest is the confirmed crossing of zone T4 which recorded the highest usage during the pre-construction fence trial. This may suggest that the emu has been educated to find the crossing zone. The recorded usage of the crossing zones during construction has been very low, particularly given the high usage of these zones during the pre-construction trial. This could mainly be attributed to the fact that the zones are closed 6 out of 7 week days (open Sunday only), and are open at night when emus are not active. Monitoring will continue through the second year of construction (2018). Considerable time and effort has been deployed into positioning cameras to avoid photographing construction vehicles and workers and this may improve emu detectability. Further to this, a number of modifications have been made to the entrance of the races to improve their functionality for emus and this is hoped to increase usage during 2018.



Plate 5. Emu crossing zone (race T5)



Plate 6. Emu crossing zone (race T4B)



Plate 7. Emu crossing zone (T4A)



Plate 8. Emu crossing zone (race T9)



Table 10. Details and results of camera traps placed on emu crossing zones during construction

Monitoring period	Crossing zone	Camera	Position	Start date	End date	No. functional camera days	No. photos	No. emu photos	Other fauna using race
C2	T1	1	East	21/02/2017	20/04/2017	58	4159	0	1 dog
		2	East	21/02/2017	1/05/2017	69	462	0	
		3	West	21/02/2017	17/03/2017	24	3635	0	
		4	West	21/02/2017	7/03/2017	14	2286	0	
C2	T4B	1	East	21/02/2017	23/05/2017	91	655	1 (Plate 1)	
		2	West	21/02/2017	malfunction	0	0	0	
C2	T6	1	East	21/02/2017	22/02/2017	1	335	0	
		2	West	21/02/2017	3/03/2017	10	4903	0	
		3	Mid	21/02/2017	23/05/2017	91	2068	0	
C3	T1	1 to 4	removed for construction of piling pads		0	0	0		
C3	T2	1	East	23/05/2017	22/08/2017	91	2205	0	
		2	East	23/05/2017	22/08/2017	91	936	0	
		3	West	23/05/2017	15/06/2017	23	3797	0	
		4	West	23/05/2017	14/07/2017	52	2324	0	
C3	T4B	1	East	23/05/2017	22/08/2017	91	526	0	
		2	West	23/05/2017	22/08/2017	91	485	0	
C3	T6	1	East	23/05/2017	22/08/2017	91	405	0	
		2	West	23/05/2017	28/06/2017	36	5913	0	
		3	Mid	23/05/2017	22/08/2017	91	3800	0	
C4	T1	1	East	21/08/2017	22/09/2017	32	4105	0	cattle
		2	East	21/08/2017	7/11/2017	78	7719	0	
		3	West	21/08/2017	5/09/2017	15	5052	0	cattle
C4	T2	1	East	21/08/2017	7/11/2017	78	917	0	cattle and kangaroos
		2	West	21/08/2017	malfunction	0	0	0	
C4	T4A	1	East	22/08/2017	9/10/2017	48	4964	0	
		2	West	22/08/2017	29/10/2017	68	2140	0	
C4	T4B	1	East	21/08/2017	24/08/2017	3	1090		
		2	West	21/08/2017	7/11/2017	78	311	0	cattle
C4	T5	1	East	21/08/2017	7/11/2017	78	2239	0	cattle and kangaroos
		2	West	21/08/2017	20/10/2017	60	9077	0	cattle and kangaroos
C4	T6	1	East	22/08/2017	8/11/2017	78	499	0	
		2	West	22/08/2017	5/10/2017	44	3081	0	
		3	Mid	22/08/2017	27/10/2017	66	1232	0	
C4	T9	1	East	21/08/2017	7/11/2017	78	283	0	cattle and kangaroos
		2	West	21/08/2017	30/09/2017	40	1977	0	cattle and kangaroos
C4	T10	1	East	22/08/2017	5/10/2017	44	901	0	
		2	West	22/08/2017	25/10/2017	64	1924	0	

C5	T1	1	East	removed during construction		0	0	0	
		2	West	7/11/2017	6/02/2018	91	46666	0	
C5	T2	1	East	7/11/2017	12/02/2018	97	2143	0	
		2	West	7/11/2017	12/02/2018	97	1272	0	
C5	T4A	1	East	removed during construction		0	0	0	
		2	West	7/11/2017	6/02/2018	91	106	0	
C5	T4B	1	East	6/11/2017	12/02/2018	98	280	0	cattle
		2	West	6/11/2017	12/02/2018	98	16	0	cattle
C5	T5	1	East	6/11/2017	13/02/2018	99	459	0	cattle
		2	West	malfunction - no data		0	0	0	
C5	T6	1	East	6/11/2017	12/02/2018	98	3081	0	
		2	West	6/11/2017	12/02/2018	98	1232	0	
C5	T9	1	East	6/11/2017	12/02/2018	98	368	0	cattle and kangaroos
		2	West	6/11/2017	12/02/2018	98	2038	0	cattle and kangaroos
C5	T10	1	East	6/11/2017	12/02/2018	98	9	0	
		2	West	6/11/2017	12/02/2018	98	53	0	
						3226	144128		

In addition to the maintenance of emu crossing zones, permanent emu exclusion fencing has been installed in elevated portions of Section 3 as per the requirements of the Emu Management Plan (refer Plate 10).



Plate 9. Image of adult emu crossing the fenced race (T4) during the early stage of construction



Plate 10. Permanent emu exclusion fence erected adjacent to crossing zone T9 on both sides of the highway

### 3.5 Emu sightings during construction

A total of 171 separate emu sightings were recorded in the register between January 2016 and February 2018, this encompasses the early works activities in Section 4 which commenced in 2016 through to clearing and construction activities commencing in 2017. These records account for 350 individual emus sighted, although it should be noted that in some cases, multiple records of the same birds are made on the same or consecutive days by different recorders. There were 21 observations of juveniles with an adult bird, this ranged from between 1 and 6 juveniles and 6 observations of more than one adult bird together. The majority of observations (89.5 %) were recorded in Section 4 of the project in the area between the Tyndale and Maclean interchanges, while 11 % were made south of Tyndale to Pillar Valley (8 Mile Lane) in Section 3. Emus are more readily observed feeding in cane fields and can be more sedentary in this habitat during times when soy beans are cropped and this would account for the larger number of observations. Emus in section 3 are more nomadic in behaviour moving around in search of food.

Emus were recorded in all months of the year, with a peak in May (autumn) and September-October (spring) around the cane properties north of Tyndale. In section 3 more birds were recorded in summer and winter (Figure 11 and Figure 12) and Section 3. Soybean is grown in rotation with the sugarcane crop cycle and is typically sown in summer (Dec-Jan) with crops maturing and developing bean pods in April-May and are harvested early winter. Juveniles may be present with adult birds from June through to November. It appears that birds are less likely to be around cropping areas in summer, where they are sighted in grazing land and natural habitats.

Emus were sighted both east and west of the project corridor sometimes as close as 20 metres from the boundary and birds were observed either on the construction corridor or attempting to cross the corridor on 8 occasions, 6 of these occasions were during the early works phase (June-August 2016) when construction traffic was largely absent, or minimal. The latter two observations were in October 2016 and January 2017, preceding the vegetation clearing stage and increase in construction traffic. All Emus observed near construction areas were managed in accordance with the Emu Management Plan, and there were no reported emu incidents.

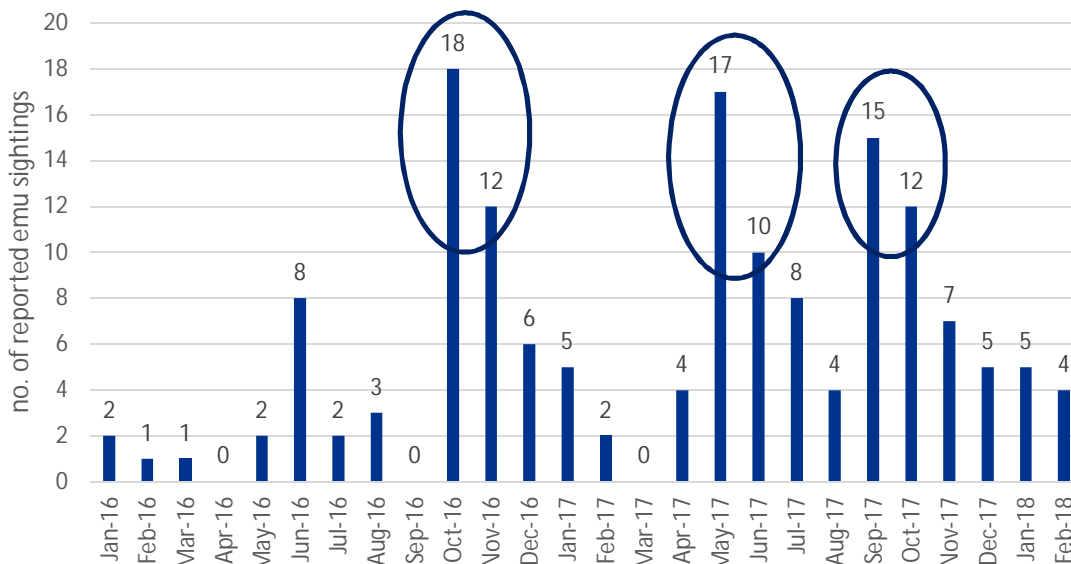


Figure 11. Number of reported emu sightings in Section 4 of the W2B upgrade during construction (Jan 2016 – February 2018)

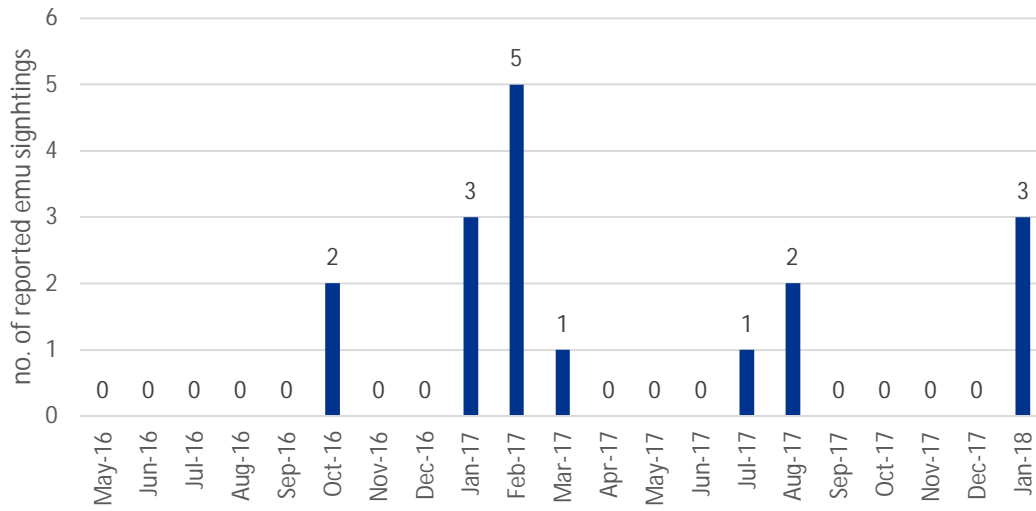


Figure 12. Number of reported emu sightings in Section 3 of the W2B upgrade during construction (Jan 2016 – February 2018)

## 4. Discussion

### 4.1 Distribution and abundance

This report describes the methods and results from emu population monitoring conducted during the first 18 months of the W2B construction phase, associated with early works in Section 4 in 2016 and construction through Section 3 and 4 in 2017. Construction phase data shows emu distribution and relative abundance varied from the baseline data at impact and control sites. The relative abundance of emus declined in the Pillar Valley west study area, although remained stable in the Tucabia south study area and increased slightly in the Tucabia north study area. Evidence of emus occupying survey areas showed no significant difference for the impact area comparing pre-construction and construction.

The data from the first year of construction should be interpreted with consideration of the temporal patterns of emu activity observed during the three-year pre-construction phase. These data also showed that emu abundance within each study area varied over season and years as evidenced by declines in the rates of occupation. Construction phase data has been collected during a period of lower emu activity that was noted at the end of the pre-construction phase, particularly when compared with the early part of the pre-construction phase, where abundance was notably higher. This supports possible evidence of declines that are not related to construction. Indeed, the relative abundance of emus actually increased in the Tucabia north and Tucabia south study areas during the early phase of construction although remained low in Pillar Valley west and this is consistent with the trend in decline in this study area noted during the pre-construction phase.

The relative abundance of emus has declined significantly in the Yuraygir south control study area, with a complete absence noted from early 2015 until the present time. This is consistent with the NPWS annual citizen survey which has not recorded emus in this study area between 2015-2017. A few emu observations have been made in areas adjacent to the study area to the north and south in 2017 suggesting either a direct decline in abundance or more likely a shift away from the study area to other nearby favourable areas. There were no notable changes in abundance from the Yuraygir north control area.

Data from the emu register of sightings maintained during construction shows that emus were regularly observed close to the project corridor in all months of the year, with peaks in autumn and spring in both years, and particularly associated with the sugar cane properties north of Tyndale (section 4). Conversely, in section 3 more birds were observed in summer and winter. These data demonstrate localised shifts in the distribution and relative abundance of emus relating to a semi-nomadic behaviour likely in response to the availability of food resources or breeding activity and have been considered in the context of noted fluctuations in emu activity in impact and control areas.

### 4.2 Effectiveness of mitigation measures

Three key construction mitigation measures documented in the Emu Management Plan were implemented in the monitoring period. This includes 1) the installation of temporary and permanent fencing in important emu areas, 2) the installation of emu races to maintain active crossing zones during construction and 3) the collection of data on emu sightings during construction.

There was evidence showing at least one emu race was used for crossing the corridor during construction, and there were no emu mortalities reported during construction due to poor or absent fencing. From this perspective, the mitigation measures are deemed to be effective. This is in large part to the measures applied to minimise impacts to emus when encountered on the road corridor, which occurred on multiple occasions.

The limited data collected for emu usage of crossing zones compared with the pre-construction phase is of concern. However, this is considered mainly to be attributed to the fact that these zones are closed 6 out of 7 week days (open Sunday only), and are open at night when emus are not active. This is in contrast to the pre-construction phase, where crossing zones were permanently open for 12 months. Monitoring of the emu races will continue through the second year of construction and considerable time and effort has been deployed into improving the monitoring method by positioning cameras to avoid photographing construction vehicles and workers and this may improve detectability of emu usage. Further to this, a number of modifications have been

made to the entrance of the races as a corrective action to improve their functionality for emus and this is also hoped to increase usage during the second year of construction. These corrective actions were made after a formal audit and report recommending improvements to the races were made in the latter half of 2017.

Despite the issues with the crossing zones, Emus were sighted both east and west of the project corridor during the first year of construction, it is unknown whether these were birds moving across the corridor or have remained on one side only.

### **4.3 Performance measures**

The Emu Management Plan documents a set of goals associated with managing emus and respective impact thresholds to be considered during monitoring. Where a threshold is not achieved, corrective actions are required. This applies to both the W2B construction phase as well as the longer-term project monitoring program. Discussion on the reported outcomes from the construction stage monitoring in 2017 and recommended corrective actions where required is provided in Table 11.

Table 11. Appraisal of the reported outcomes of construction phase monitoring against the performance thresholds documented in the Emu Management Plan

Main goals for management	Management measure	Performance thresholds	Reported outcomes in 2017 annual report	Corrective actions if performance threshold not reached
No injuries to emus during clearing of vegetation.	<ul style="list-style-type: none"> <li>Documented procedure for clearing of vegetation.</li> <li>Documented procedure for emergency management if emu is encountered during clearing works.</li> <li>Procedure developed in consultation with WIRES and NPWS.</li> <li>Project ecologist evaluates situation and approach on each occasion.</li> </ul>	Emu injured or killed during clearing works.	Ecologists were used during clearing operations in Section 3 and 4 in 2017. No emus were reported injured or killed	No corrective actions were required
No injuries to emus from collisions with construction vehicles.	<ul style="list-style-type: none"> <li>All vehicles to stay within the construction corridor and no entry into exclusion zones.</li> <li>Comply with construction vehicles speed limits designated in the CEMP.</li> <li>Implement a daily inspection of emu crossing zones and fence integrity.</li> <li>Comply with protocol developed for Wave 3 early works (section 4) Section 5.3.2</li> </ul>	<ul style="list-style-type: none"> <li>Emu injured during construction.</li> <li>Single emu sighted in Wave 3 early works corridor during construction</li> <li>3 emu encounters in one day</li> </ul>	A register of emu sightings has been maintained from 2016-2017, while emus were reported in the construction corridor on 6 occasions, management measures were implemented and there were no reported injuries or mortalities	No corrective actions were required
No damage to emu habitat within exclusion zones in Section 3 and 4 during construction.	<ul style="list-style-type: none"> <li>Implement the emu fencing strategy prior to construction.</li> <li>Fencing to be erected concurrently with clearing procedure in Section 3 and 4.</li> </ul>	Breach in exclusion zone by construction vehicle of personnel.	Temporary and permanent exclusion fences were completed concurrently with the clearing procedure.	No corrective actions were required
No change in pre-construction emu movements across the construction corridor.	<ul style="list-style-type: none"> <li>Adopt emu fencing strategy</li> <li>Construction infrastructure and access tracks located to avoid lengthy interruption to emu movements.</li> <li>Avoid extended activities in or adjacent to known emu habitat, watering points or crossing zones.</li> <li>As soon as bridge construction completed, bridge to be tied in with exclusion fence and site remediated to open the crossing zone.</li> <li>Provide and maintain an emu race across 9 crossing zones between Woolli Road and south of Firth Heinz Road, to be opened outside of work hours</li> </ul>	After four construction monitoring events there is a demonstrated change from pre-construction emu movements across the project corridor.	<p>Emu races have been maintained across 8 crossing zones during the first year of construction. The ninth crossing zone is across Mitchell Road which retains opportunities for emus to cross the corridor, however no formal fence races are required.</p> <p>Emus have been reported east and west of the construction corridor during the construction phase monitoring, however declines in activity have been noted in the Pillar Valley west study area.</p> <p>One emu was photographed using the emu race near Black Snake Creek, this represents a significantly lower rate of usage to the pre-construction phase</p>	<p>The emu races were audited during the first year of construction. A number of refinements and modifications were required and implemented to improve their effectiveness.</p> <p>The monitoring methodology for the emu races has been re-evaluated and revised to improve captures of emus.</p> <p>Monitoring to continue to inform any further declines in emu activity</p>

Main goals for management	Management measure	Performance thresholds	Reported outcomes in 2017 annual report	Corrective actions if performance threshold not reached
				Bridges are near completion and are to be tied into exclusion fences and opened in 2018. Bridges will be opened progressively once final treatments are applied.
Cover crops established within 3 months of completion of the bridge construction in Section 3 and 4.	Implement revegetation and rehabilitation to commence immediately on completion of construction activity completion and to be staged to avoid lengthy disruption to emu movement corridors.	Event based, incident reporting in CEMP	Some planting of riparian vegetation has commenced in Section 3 which includes <i>Lomandra longifolia</i> (confirmed emu food plant), no crops used  Hydro-mulched and planted areas around bridges have included some known emu food plant species	Commence revegetation in crossing zones where bridge construction is complete Plant cover crops within three months  Monitor survivorship of plantings and replace where necessary until established
Methods for rehabilitation of emu habitat adjacent to the road is documented in the landscape design.	<ul style="list-style-type: none"> <li>Roadside plantings in emu habitat (Section 3 and 4) avoid emu food plants to prevent emus being attracted to road edges.</li> <li>Landscape plantings under emu crossing zones in Section 3 and 4 to use native grasses or low ground covers suitable to the location and avoid dense plantings of trees and shrubs.</li> <li>Revegetation in roadside areas disturbed during construction to restore the original habitat type at each location.</li> </ul>	Evidence of emu specific revegetation to be captured in the landscape design.	Not proposed in the first year of construction	No corrective actions required



Discussion on the reported outcomes from the construction stage monitoring in 2017 and recommended corrective actions where this relates to the longer-term emu population monitoring is provided in Table 12.

Table 12. Appraisal of the reported outcomes of construction phase monitoring against the performance thresholds documented in the Emu Management Plan for the longer-term monitoring program

Performance thresholds	Timing and corrective actions	Reported outcomes
<ul style="list-style-type: none"> <li>• Greater than 15% decline in emu activity (through signs and detection rates) comparing impact and control areas and before and after data.</li> <li>• No evidence of breeding through sightings of chicks and sub-adults between impact and control areas and before and after data.</li> </ul>	<ul style="list-style-type: none"> <li>• The 15% threshold was set prior to conducting baseline surveys. It will be necessary to review this trigger against pre-construction data to identify normal changes in activity that are occur over time irrespective of the highway disturbance. The threshold would be reviewed and revised where required at the end of the pre-construction monitoring.</li> <li>• Emu activity would be compared with the baseline data at the end of each monitoring event during the construction phase. Regular evaluation and review would be conducted at the end of each monitoring event.</li> <li>• If decline noted after the first 12 months of the post-construction (operational) monitoring, review and modify the monitoring program, to consider different monitoring locations.</li> <li>• Review transects locations and cross reference with performance monitoring of the emu crossing structures and fencing strategy.</li> <li>• Investigate emu habitat adjoining the highway and consider improving habitat condition and connectivity.</li> <li>• If decline still noted after a further 12 months operational monitoring (2-years operation) engage with EPA and consider provisional measures.</li> <li>• Further monitoring of provisional measures would be planned at this stage.</li> </ul>	<ul style="list-style-type: none"> <li>• A decline has been reported from near the southern end of the Section 3, however there has been no declines in the other impact study areas. This decline was also noted from the baseline data prior to construction, and a similar decline is noted from the southern control area.</li> <li>• Evidence of breeding was noted in Section 4 through multiple observations of juvenile birds during 2016-2017 as reported in the emu sightings register</li> <li>• No corrective actions required at this stage</li> </ul>

#### 4.4 Annual citizen-based emu survey

The NPWS coordinated annual citizen-based Coastal Emu survey was not conducted in 2017 due to other responsibilities. However, NPWS did collate emu sightings data provided by landholders, surveillance cameras (RMS and NPWS) and opportunistic sightings. From analysis of these data the following has been noted (G.Hart, NPWS; *pers.comm*):

There appears to have been further contractions in their range and a decline in the Clarence population over the last couple of years (47 recorded in the Clarence in 2016). The reasons for this remain unclear, however the following observations have been drawn from the 2017 data collected:

- larger groups of birds not being seen on cane farms around the Shark Creek area possibly due to some of the cane farmers not planting soy crops this year as part of their crop rotation.
- No adults or chicks seen around Minnie Water, Wooli area since late 2014. This has historically been the hotspot for emu sightings. My personal thoughts were that longer fire intervals in the coastal landscape may have been impeding the movement of the birds. However, there has been a relatively large area around Diggers and Wooli burnt in last 18 months, yet still no birds recorded. There have however been sightings in northern Yuraygir in areas recently burnt in a wildfire earlier this year.
- No birds seen in the Pebbly Beach / Station Creek area since 2011.
- Sightings along the new highway route south of Tyndale have declined since construction commenced earlier this year

Relative population data reported from the annual citizen survey of coastal emus is shown in **Figure 13** and has been divided into the three main sub-populations (Bundjalung, Yuraygir, and Bungawalbin). These data report the actual number of emus observed over the two-day survey and not individuals observed before or after the survey or sign data. The data is only intended to provide a relative abundance estimate and is not based on total counts. This is because the survey is largely restricted to road areas, the number of observers and hence survey effort varied from year to year and also emus are widespread and difficult to count.

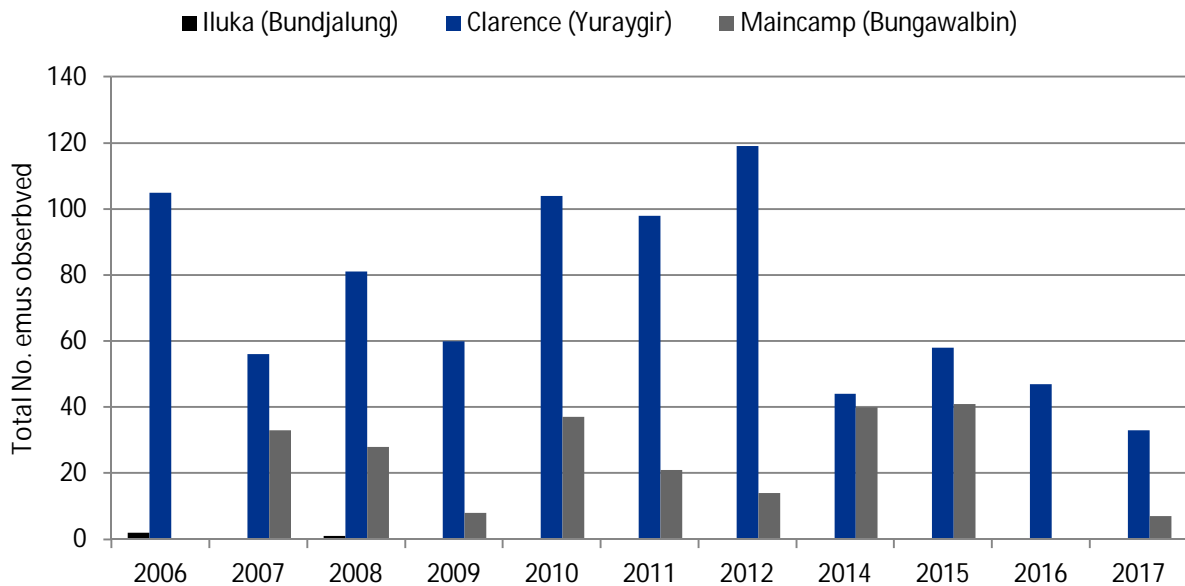


Figure 13: Relative population data collated from the annual coastal emu citizen survey (2006-2017 source: Office of Environment and Heritage)

#### 4.5 Next steps

Construction of the W2B upgrade for section 4 commenced in mid-2016 and in section 3 in January 2017. The construction phase of the emu monitoring program commenced concurrently. This report outlines the methods and results of Emu population monitoring conducted during for the first year of construction (2017) and comparing these data with the pre-construction baseline (conducted during 2014-16).

Monitoring will continue seasonally in Year 2 of construction (2018) and the next annual report provided early 2019. Consistent with the emu management plan, monitoring and reporting will continue for each year of construction (Years 2 and 3) and for the first 5 years of operation.

## 5. References

Roads and Maritime Services, (2016). Woolgoolga to Ballina, Pacific Highway Upgrade, Coastal Emu Management Plan. Prepared by RMS, and SKM.

Jacobs 2014, Pacific Highway Upgrade Woolgoolga to Ballina Coastal Emu Monitoring Study: Phase 1: pre-construction Survey Report (pre-fencing)

Jacobs 2015, Pacific Highway Upgrade Woolgoolga to Ballina Coastal Emu Monitoring Study: Annual Report 2015 (Pre-construction)

Jacobs 2016, Pacific Highway Upgrade Woolgoolga to Ballina Coastal Emu Monitoring Program: Annual Report 2016 (Pre-construction – Baseline)

Underwood, A.J. (1991). Beyond BACI: Experimental designs for detecting human environmental impacts on temporal variations in natural populations. *Australian Journal of Marine and Freshwater Research* 42(5) 569-587.

## Appendix A. Summary of emu sign construction phase data (Density/ha)

SAMPLING PERIOD	IMPACT SITES						CONTROL SITES			
	Pillar Valley west		Tucabia south		Tucabia north		Yuraygir south		Yuraygir north	
	PC 2014-16	C - 2017	PC 2014-16	C - 2017	PC 2014-16	C - 2017	PC 2014-16	C - 2017	PC 2014-16	C - 2017
1	2.56	0.32	6.52	6.52	0.00	0.57	5.53	0	1.28	5.77
2	3.68	0.96	9.78	4.78	0.00	0.57	4.42	0	5.13	4.49
3	3.52	0.32	5.87	3.48	3.22	0.19	3.87	0	4.81	2.88
4	6.40	0.16	1.74	1.30	1.52	0.57	4.61	0	11.54	4.17
5	5.60		1.96		3.22		0.92		14.74	
6	2.56		7.61		0.95		0.18		7.37	
7	0.80		5.87		0.19		0.00		4.81	
8	2.24		3.26		0.00		0.00		3.85	
9	1.92		3.48		0.19		0.00		5.77	
10	0.96		2.61		0.00		0.00		4.81	
11	0.64		3.26		0.19		0.00		2.88	
12	1.44		1.52		0.19		0.00		5.13	
13	1.28		2.17		0.00		0.00		6.73	
<i>Mean (D/ha)</i>	<i>2.58</i>	<i>0.44</i>	<i>4.28</i>	<i>4.02</i>	<i>0.74</i>	<i>0.47</i>	<i>1.50</i>	<i>0.00</i>	<i>6.07</i>	<i>4.33</i>
<i>SE</i>	<i>0.50</i>	<i>0.18</i>	<i>0.72</i>	<i>1.10</i>	<i>0.33</i>	<i>0.09</i>	<i>0.61</i>	<i>0.00</i>	<i>0.99</i>	<i>0.59</i>

## Appendix B. Summary of camera trap construction phase data

Sampling period	Survey effort	Impact			Control	
		Pillar Valley west	Tucabia south	Tucabia north	Yuraygir north	Yuraygir south
C1 (summer) 15.11.16 to 20.02.17	Camera monitoring period (days)	98	98	98	98	98
	No. successful cameras	6	8	5	4	7
	Mean trapping days per camera	65.6	73.8	92.4	65	50.8
	Total trap effort (days)	459	590	462	325	356
C2 (autumn) 20.02.17 – 22.05.17	Camera monitoring period (days)	90	90	90	91	89
	No. successful cameras	5	9	6	4	7
	Mean trapping days per camera	59.7	72.4	90.0	91.0	46.3
	Total camera trap effort (days)	358	743	542	364	311
C3 (winter) 22.05.17 – 21.08.17	Camera trapping days	92	92	92	92	92
	No. successful cameras	6	9	7	4	5
	Mean trapping days per camera	79.0	72.5	81.9	68.5	91.2
	Total camera trap effort (days)	474	725	573	274	456
C4 (spring) 21.08.17 – 6.11.17	Camera monitoring period (days)	77	77	77	77	77
	No. successful cameras	7	9	8	4	8
	Mean trapping days per camera	58.3	68.5	71.9	75.8	58.4
	Total camera trap effort (days)	331	685	575	303	526
Annual average recorded over 4 monitoring sessions	Camera monitoring period (days)	89.3	89.3	89.3	89.5	89.0
	No. successful cameras	6.0	8.8	6.5	4.0	6.8
	Mean trapping days per camera	65.7	71.8	84.1	75.1	61.7
	Total camera trap effort (days)	405.5	685.5	538.0	316.5	412.3
Baseline average (recorded over 13 pre-construction monitoring sessions)	Camera monitoring period (days)	90.3	90.3	90.3	90.3	90.3
	No. successful cameras	6.1	8.8	5.1	3.2	6.3
	Mean trapping days per camera	71.9	70.5	71.8	69.2	64.7
	Total camera trap effort (days)	438.5	637.8	380.6	232.6	429.5